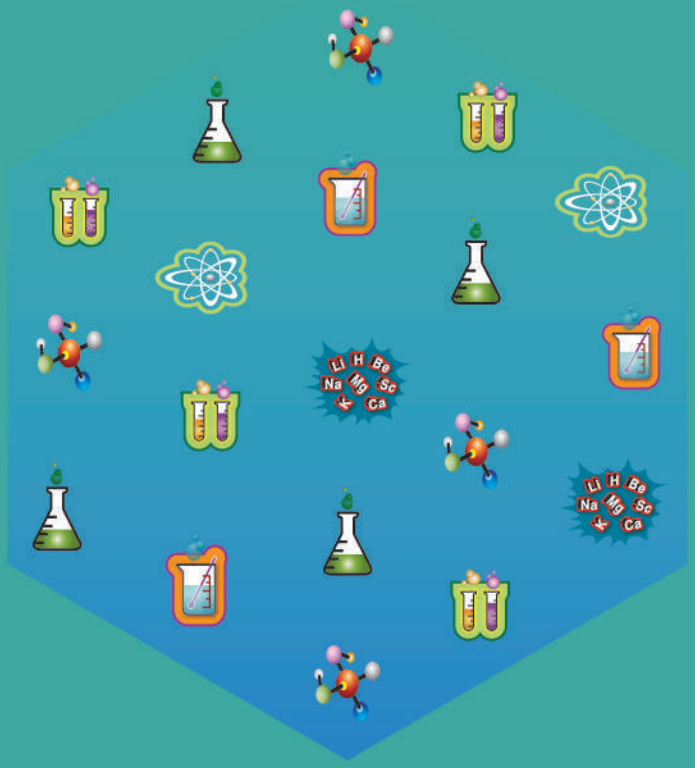
Cambridge International AS Level Chemistry

Question Papers

Paper #1



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CAIE AS Chemistry (9701)
Paper1 Question Papers

Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2021**

1 hour

You must answer on the multiple choice answer sheet.

2669587153

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.

This document has **16** pages.

Section A

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 Which statement about the Avogadro constant is correct?

A It is the mass of one mole of any element.

B It is the mass of 6.02×10^{23} atoms of any element.

C It is the number of atoms in one mole of neon.

D It is the number of atoms in 12 g of any element.

2 Which equation represents the first ionisation energy of iodine?

A $\frac{1}{2}I_2(g) + e^- \rightarrow I^-(g)$

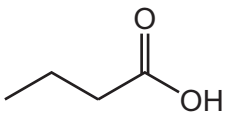
B $I(g) + e^- \rightarrow I^-(g)$

C $\frac{1}{2}I_2(g) \rightarrow I^+(g) + e^-$

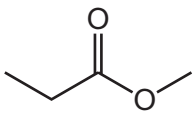
D $I(g) \rightarrow I^+(g) + e^-$

3 The structures represent three compounds, each with four carbon atoms per molecule.

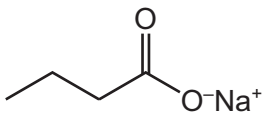
X



Y



Z

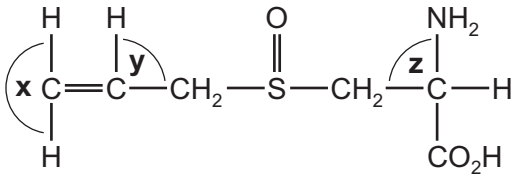


Which row is correct?

	lowest boiling point	→	highest boiling point
A	X	Y	Z
B	Y	X	Z
C	Z	X	Y
D	Z	Y	X

4 The structural formula of alliin is shown.

alliin



What are the approximate bond angles **x**, **y** and **z** in a molecule of alliin?

	x	**y**	**z**
A	90°	90°	109°
B	120°	109°	90°
C	120°	120°	109°
D	180°	109°	109°

5 Flask Q contains 5 dm^3 of helium at 12 kPa pressure. Flask R contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

A 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

6 Sodium chloride, water and air represent three states of matter – solid, liquid and gas.

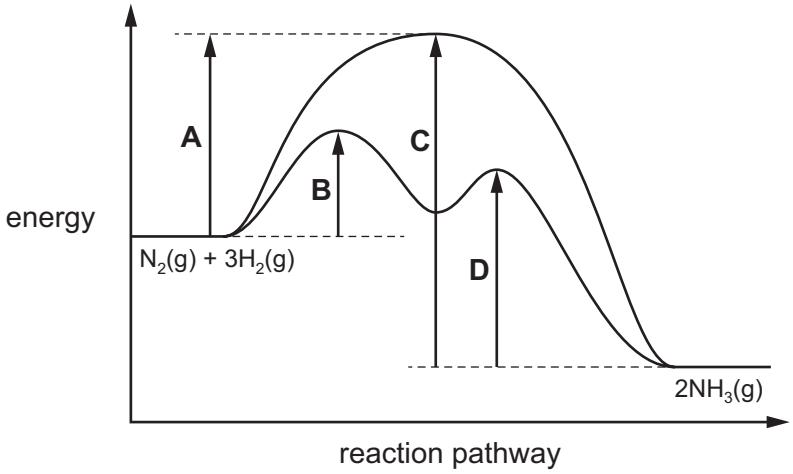
Which row is correct?

	sodium chloride	water	air
A	particles held in rigid structure	can easily be compressed	can easily be compressed
B	particles stationary	particles move	cannot easily be compressed
C	particles stationary	particles stationary	particles move
D	resistant to change of shape	cannot easily be compressed	can easily be compressed

7 The reaction pathway diagram for the catalysed reaction and the uncatalysed reaction between N_2 and H_2 is shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Which letter represents the activation energy for the first step in the decomposition of NH_3 in the presence of a catalyst?



8 Nitrogen and oxygen can react together to form nitrogen monoxide, NO.

$$N_2 + O_2 \rightarrow 2NO \qquad \Delta H = +180\,kJ\,mol^{-1}$$

What is the bond energy of the bond between the atoms in NO?

A $630\,kJ\,mol^{-1}$ **B** $810\,kJ\,mol^{-1}$ **C** $1260\,kJ\,mol^{-1}$ **D** $1620\,kJ\,mol^{-1}$

9 The equation for a redox reaction is shown.

$$SnCl_2(aq) + 2HgCl_2(aq) \rightarrow SnCl_4(aq) + Hg_2Cl_2(s)$$

Which species is being oxidised in this reaction?

A Sn^{2+} **B** Cl^- **C** Hg^+ **D** Hg^{2+}

10 3.60 moles of hydrogen gas and 2.00 moles of iodine vapour are placed in a reaction vessel which is then sealed and maintained at a constant temperature.

The equation for the reaction is shown.

$$H_2 + I_2 \rightleftharpoons 2HI$$

At equilibrium, 3.20 moles of hydrogen remain. All reactants and products are gaseous.

What is the value of K_p under these conditions?

A 0.0313 **B** 0.125 **C** 0.156 **D** 8.00

11 Two chemicals, X and Y, react together in solution to give product Z.

The rate of formation of product Z at the start of the reaction was measured in five experiments, 1–5, using various concentrations of X and Y. The results are shown.

experiment number	starting concentration of X / mol dm^{-3}	starting concentration of Y / mol dm^{-3}	rate of formation of Z at the start / mol dm^{-3} s^{-1}
1	0.10	0.10	0.0001
2	0.10	0.20	0.0004
3	0.10	0.40	0.0016
4	0.20	0.10	0.0001
5	0.40	0.10	0.0001

Which statement is correct?

A The rate of the reaction is directly proportional to the concentration of reagent X.

B The rate of the reaction is directly proportional to the concentration of reagent Y.

C The rate of the reaction is **not** affected by the concentration of reagent X.

D The rate of the reaction is **not** affected by the concentration of reagent Y.

12 A sample of $SiCl_4$ is added to cold water.

Which statement describes the mixture formed at the end of the reaction?

A acidic solution with no precipitate

B acidic solution with white precipitate

C neutral solution with no precipitate

D neutral solution with white precipitate

13 L and M are elements in Period 3 of the Periodic Table.

- The oxide of L is a solid at room temperature. This oxide has a giant structure.
- The chloride of L does not react with water.
- Argon is the only element in Period 3 with a lower melting point than M.

Which formula represents a compound of elements L and M?

A Al_2S_3 **B** MgS **C** $NaCl$ **D** PCl_5

14 A farmer requires a solid compound to raise the pH of the soil in a field from 5.5 to above 6.0.

Which compound could the farmer use?

A $(NH_4)_2SO_4$ **B** NH_4NO_3 **C** $Ca(OH)_2$ **D** $Ca(NO_3)_2$

15 Z is an anhydrous compound of a Group 2 element. When it is heated, Z undergoes thermal decomposition to produce two different gases. Z has relatively low thermal stability compared to other Group 2 compounds containing the same anion as Z.

What is compound Z?

A barium carbonate

B barium nitrate

C magnesium carbonate

D magnesium nitrate

16 Which row gives mixtures that **both** result in the oxidation of a halide ion?

	mixture 1	mixture 2
A	$AgNO_3$(aq) and NaCl(aq)	concentrated H_2SO_4(aq) and HI(aq)
B	Br_2(aq) and NaCl(aq)	concentrated H_2SO_4(aq) and HCl(aq)
C	Cl_2(aq) and NaBr(aq)	$CH_3CHBrCH_3$(l) + NaOH (ethanolic)
D	Br_2(aq) and NaI(aq)	concentrated H_2SO_4(aq) and NaBr(s)

17 Chlorine gas is widely used to treat contaminated water.

When chlorine is added to water, which chemical species present is responsible for killing bacteria?

A ClO_2^- **B** Cl^- **C** HCl **D** ClO^-

18 What is an environmental consequence of the uncontrolled use of nitrate fertilisers?

A acid rain

B low oxygen levels in streams

C ozone depletion

D the greenhouse effect

19 Ammonia gas, NH_3, and hydrogen sulfide gas, H_2S, react together to form the salt ammonium sulfide, $(NH_4)_2S$. Ammonium sulfide dissolves in water to produce an orange alkaline solution.

$$(NH_4)_2S(aq) \rightleftharpoons NH_3(aq) + NH_4SH(aq)$$

The addition of NaOH(aq) to this solution produces a gas, X.
The addition of HCl(aq) to a separate portion of this solution produces a gas, Y.

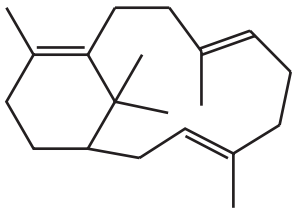
X and Y could represent different gases or identical gases.

What are the identities of X and Y?

	X	Y
A	H_2S	H_2S
B	H_2S	NH_3
C	NH_3	H_2S
D	NH_3	NH_3

20 Compound P is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product Q is fully saturated.

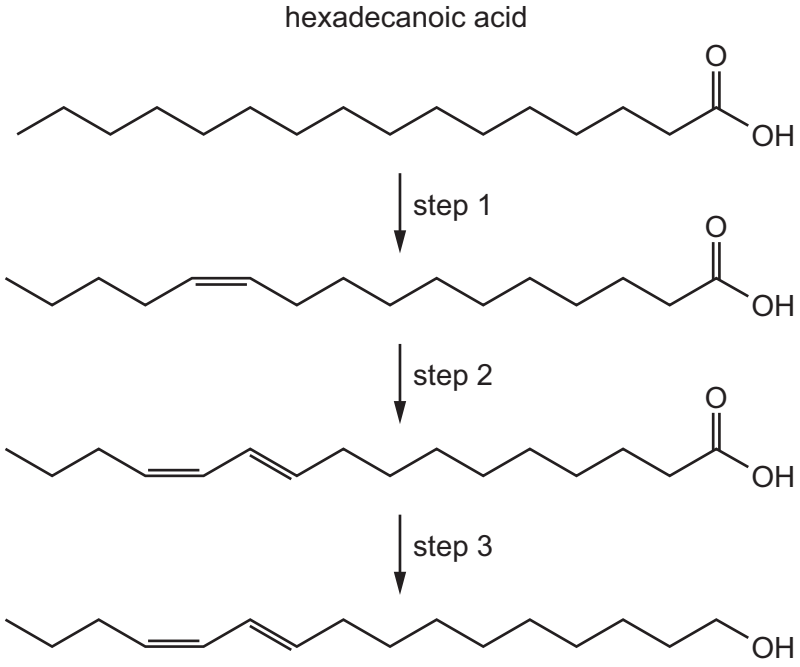
compound P



What is the number of chiral carbon atoms in the product Q?

A 4 **B** 5 **C** 6 **D** 7

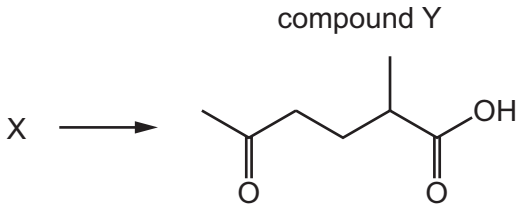
21 Hexadeca-10,12-dien-1-ol is produced by silk moths from hexadecanoic acid in a three-step enzymic process.



Which row contains correct descriptions of the three steps?

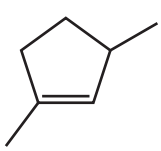
	step 1	step 2	step 3
A	elimination	elimination	dehydration
B	elimination	reduction	reduction
C	oxidation	elimination	oxidation
D	oxidation	oxidation	reduction

22 Compound X can be converted into compound Y in a single step.



What could be the identity of X?

A



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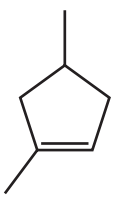

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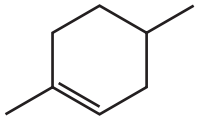

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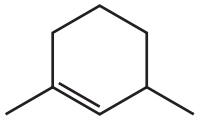


23 Methane and bromine react by free radical substitution.

P and Q are involved in the reaction mechanism.

P and Q:

- are **both** involved in propagation steps as reactants
- are **both** involved in termination steps as reactants.

What could be P and Q?

A Br and H **B** Br and CH_3 **C** Br and C_2H_6 **D** CH_3 and CH_3Br

24 A few drops of 2-bromopropane were placed in a test-tube. An equal volume of aqueous silver nitrate was added. A precipitate was formed.

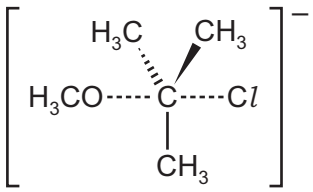
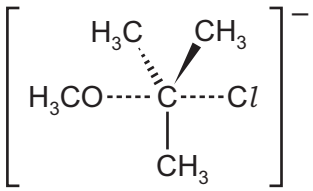
The experiment was repeated with 2-iodopropane.

Which row is correct?

	colour of precipitate from **2-bromopropane** + $AgNO_3(aq)$	faster rate of reaction
A	cream	2-bromopropane + $AgNO_3(aq)$
B	yellow	2-bromopropane + $AgNO_3(aq)$
C	cream	2-iodopropane + $AgNO_3(aq)$
D	yellow	2-iodopropane + $AgNO_3(aq)$

25 Sodium methoxide, $Na^+CH_3O^-$, reacts with 2-chloro-2-methylpropane in a nucleophilic substitution reaction. The nucleophile is the CH_3O^- ion.

Which row is correct?

	intermediate or transition state	product
A	$(CH_3)_3C^+$	$(CH_3)_3COCH_3$
B	$(CH_3)_3C^+$	$(CH_3)_3CCH_2OH$
C		$HOCH_2C(CH_3)_3$
D		$H_3COC(CH_3)_3$

26 Alcohol X reacts with concentrated sulfuric acid to produce a mixture of products.

Two of the products are structural isomers of each other.

What could be X?

A hexan-2-ol

B pentan-1-ol

C pentan-3-ol

D propan-2-ol

27 Which reaction will form a strong organic base?

A ethanol and acidified sodium dichromate

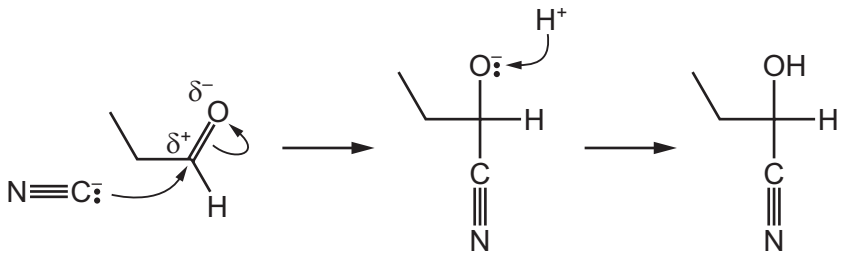
B ethanol and hot aluminium oxide

C ethanol and sodium

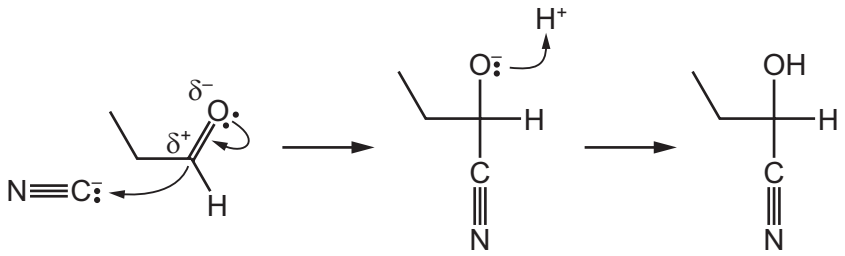
D ethanol and hydrogen chloride

28 Which reaction mechanism for the formation of $C_2H_5CH(OH)(CN)$ is correct?

A



B



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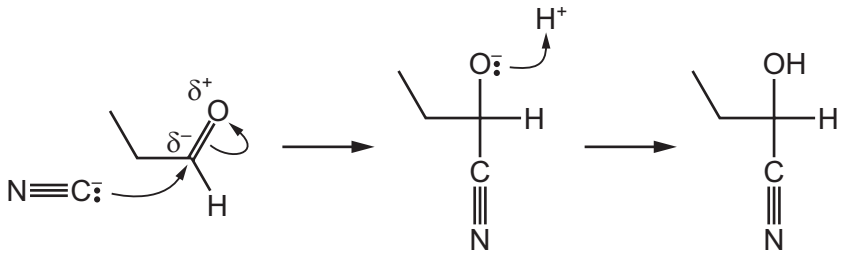

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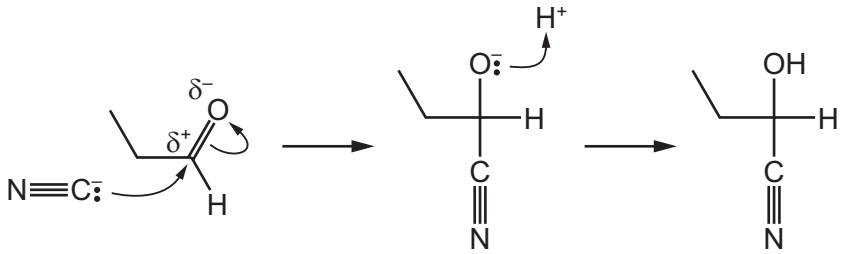
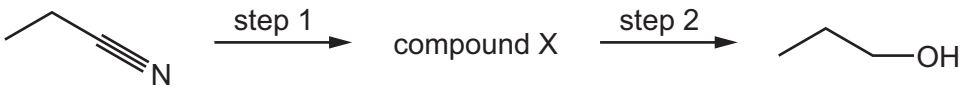


29 The synthesis shown may be used for the production of propan-1-ol.

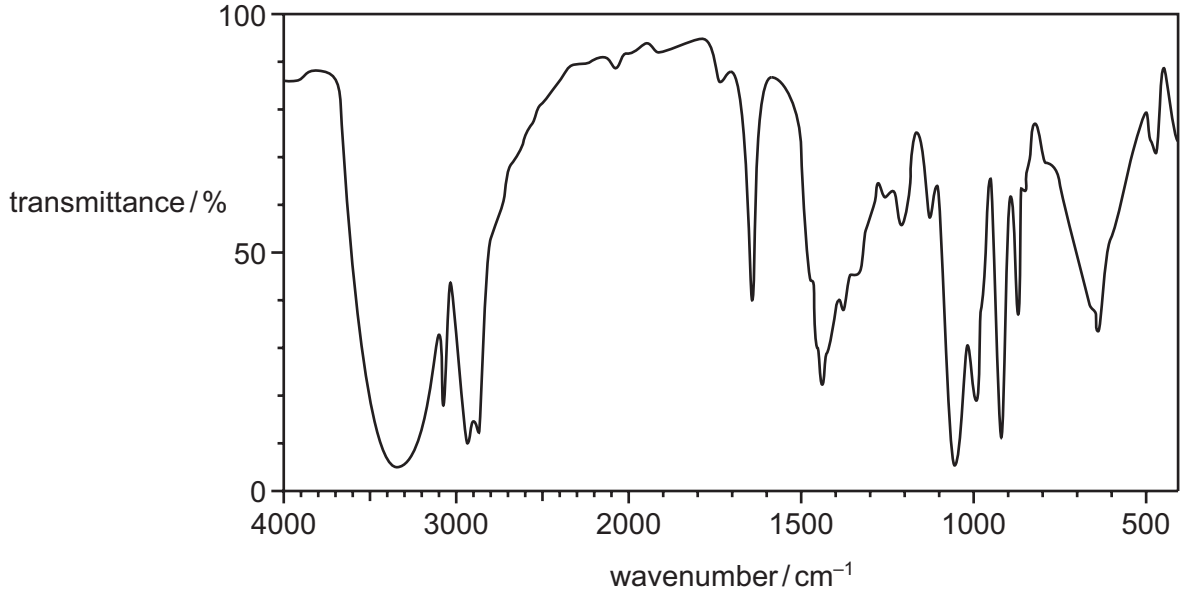


Which row gives the correct reagents for steps 1 and 2?

	step 1	step 2
A	HCl(aq)	H_2 + Ni
B	HCl(aq)	LiA$l$$H_4$
C	NaOH(aq)	H_2 + Ni
D	NaOH(aq)	$NaBH_4$

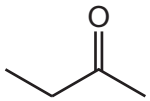
30 The molecular formula of Z is C_4H_8O.

The infra-red spectrum of Z is shown.

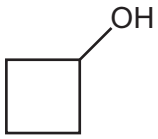


What could be Z?

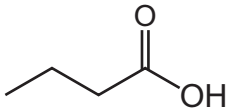
A



B



C



D

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 In which ions are the number of electrons equal to the number of neutrons?

1 $^{19}_{9}F^{-}$

2 $^{31}_{15}P^{-}$

3 $^{23}_{11}Na^{+}$

32 Compound X is a straight chain hydrocarbon with an M_r of 84.

What can be determined about X?

1 empirical formula

2 molecular formula

3 whether X contains a C=C bond or not

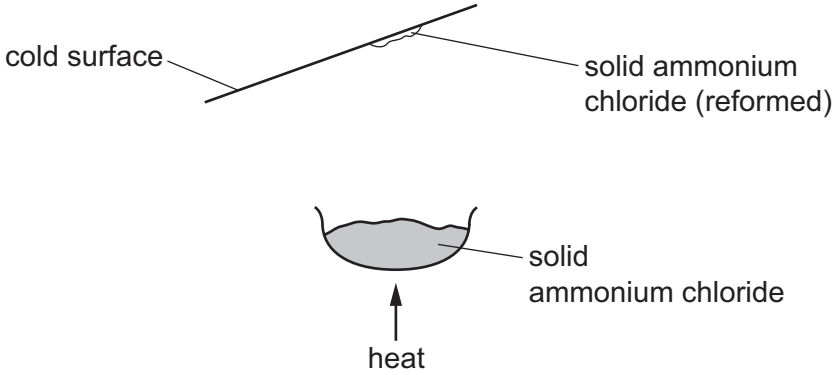
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

33 When a sample of ammonium chloride is warmed it decomposes into ammonia and hydrogen chloride gas.

$$NH_4Cl(s) \rightarrow NH_3(g) + HCl(g) \qquad \text{reaction 1}$$



When the mixture of hot ammonia and hydrogen chloride gases hit a cold surface, a white solid of ammonium chloride reforms.

Which statements are correct?

1 Reaction 1 is in dynamic equilibrium.

2 Reaction 1 is reversible.

3 Reaction 1 is an endothermic reaction.

34 Hydrogen chloride gas is formed by the reaction shown.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

What will change the average kinetic energy of the reacting gas particles?

1 increasing the temperature and increasing the concentration of hydrogen

2 cooling the reaction mixture and adding a catalyst

3 adding a catalyst and increasing the concentration of chlorine

35 Which oxides will cause a change in pH when added to water?

1 CaO

2 Al_2O_3

3 SiO_2

36 Which reaction routes can be used to make a pure sample of barium sulfate?

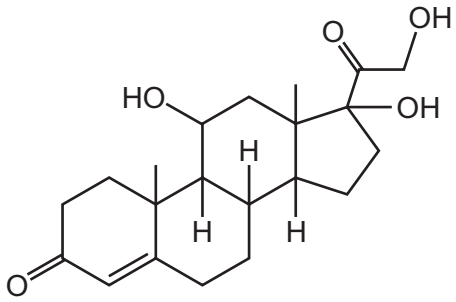
1 Ba $\xrightarrow[\text{in } O_2]{\text{heat}}$ product $\xrightarrow[HCl]{\text{dilute}}$ product $\xrightarrow[H_2SO_4]{\text{dilute}}$ product $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

2 $Ba(NO_3)_2$ $\xrightarrow[\text{heat in air}]{\text{strong}}$ solid product $\xrightarrow[\text{of water}]{\text{an excess}}$ product $\xrightarrow[H_2SO_4]{\text{dilute}}$ product $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

3 $Ba(OH)_2$ $\xrightarrow[HNO_3]{\text{dilute}}$ product $\xrightarrow[H_2SO_4]{\text{dilute}}$ product $\xrightarrow[\text{and dry}]{\text{filter, wash}}$

37 Cortisone is a synthetic hormone.

cortisone



Which classes of alcohol does this molecule contain?

1 primary alcohol

2 secondary alcohol

3 tertiary alcohol

38 Which changes are commonly involved in the formation of an addition polymer?

1 the formation of a σ-bond

2 the breaking of a π-bond

3 the change in hybridisation of the orbitals of a carbon atom from sp^2 to sp^3

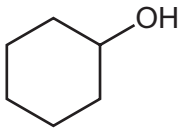
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

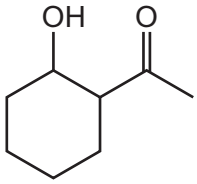
No other combination of statements is used as a correct response.

39 Which alcohols can be oxidised to form an organic compound which will give coloured precipitates with both 2,4-dinitrophenylhydrazine reagent and alkaline aqueous iodine?

1



2



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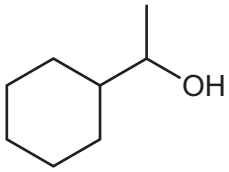
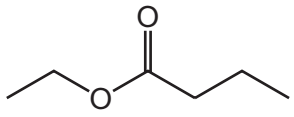


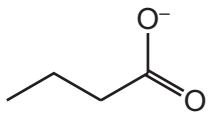
40 Which mixtures form a carboxylic acid as one of the products?

1



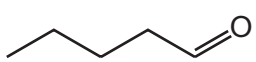
+ $H_2SO_4(aq)$ →

2



+ $H_2SO_4(aq)$ →

3



+ $H_2SO_4(aq)$ →

Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2020**

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.

Section A

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 In which carbon allotrope are all electrons localised?

A buckminsterfullerene

B diamond

C graphite

D graphene

2 A copper ore contains 3.00% of copper carbonate, $CuCO_3$, by mass.

Which mass of copper would be obtained from 1 tonne of the ore?

A 1.91 kg **B** 3.71 kg **C** 15.4 kg **D** 58.4 kg

3 The catalysed formation of ammonia by the Haber process can be represented by the equation shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

Which change in conditions will increase both the rate of formation and the equilibrium yield of ammonia?

A decrease in the temperature

B increase in the temperature

C increase in the pressure

D increase in the surface area of the catalyst

4 Solid sulfur consists of S_8 molecules.

Which equation represents the standard enthalpy of atomisation of sulfur?

A $\frac{1}{8}S_8(s) \rightarrow S(g)$

B $\frac{1}{8}S_8(g) \rightarrow S(g)$

C $S_8(s) \rightarrow 8S(g)$

D $S_8(g) \rightarrow 8S(g)$

5 In this question you should use changes in oxidation numbers to balance a chemical equation.

The following reaction occurs when MnO_2 is warmed with dilute H_2SO_4.

$$a\ MnO_2 + b\ H^+ \rightarrow c\ Mn^{2+} + d\ MnO_4^- + e\ H_2O$$

What is the ratio of c : d in the correctly balanced equation?

A 1 : 1 **B** 1 : 2 **C** 2 : 3 **D** 3 : 2

6 In this question you should assume air contains 21% oxygen.

What is the minimum volume of air required to ensure complete combustion of 10 cm^3 of butane gas, under room conditions?

A 14 cm^3 **B** 27 cm^3 **C** 65 cm^3 **D** 310 cm^3

7 When aqueous bromine is shaken with cyclohexane and allowed to stand, two layers form. The top cyclohexane layer is coloured and the bottom aqueous layer is almost colourless.

What is the most likely explanation for this observation?

A Bromine is reduced to bromide ions in the bottom layer.

B Bromine molecules are non-polar.

C Bromine reacts with water but cannot react with cyclohexane.

D The product of the reaction between bromine and cyclohexane is coloured.

8 In which change are **only** temporary dipole-induced dipole forces overcome?

A $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$

B $H_2O(s) \rightarrow H_2O(l)$

C $O_2(s) \rightarrow O_2(l)$

D $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$

9 The complete combustion of 2 moles of an alkane produces 400 dm^3 of carbon dioxide measured at 301 K and 1×10^5 Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the alkane?

A C_8H_{18} **B** $C_{16}H_{34}$ **C** $C_{20}H_{42}$ **D** $C_{40}H_{82}$

10 In which reaction does an element undergo the largest change in oxidation number?

A $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$

B $3Cl_2 + 6OH^- \rightarrow ClO_3^- + 5Cl^- + 3H_2O$

C $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

D $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

11 PCl_5 decomposes as shown.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

1.0 mol of $PCl_5(g)$, 1.0 mol of $PCl_3(g)$ and 1.0 mol of $Cl_2(g)$ are placed in a container of volume 1 dm^3 at 250 °C and allowed to reach equilibrium.

At this temperature, the equilibrium mixture contains 1.8 moles of PCl_3.

What is the value of K_c at 250 °C?

A 1 **B** 1.8 **C** 9 **D** 16.2

12 The fifth to eighth ionisation energies of four elements in Period 3 of the Periodic Table are shown.

Which row refers to chlorine?

	ionisation energies / kJ mol^{-1}			
	fifth	sixth	seventh	eighth
A	6280	21 200	25 900	30 500
B	6990	8 490	27 100	31 700
C	6540	9 330	11 000	33 600
D	7240	8 790	12 000	13 800

13 Magnesium nitrate, $Mg(NO_3)_2$, decomposes when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

A 1.5 g **B** 2.3 g **C** 3.0 g **D** 4.6 g

14 Which statement explains why iodine is less volatile than chlorine?

A Chlorine is more electronegative than iodine and so has more repulsion between its molecules.

B The greater number of electrons in iodine leads to larger temporary dipole-induced dipole forces.

C The I–I bond energy is smaller than the C*l*–C*l* bond energy.

D The iodine molecules have stronger permanent dipole-permanent dipole forces.

15 Ammonium carbonate is a crystalline solid. On gentle warming a reaction occurs, forming ammonia as one product.

How are the carbonate ions behaving during this reaction?

A Brønsted-Lowry acid

B Brønsted-Lowry base

C oxidising agent

D reducing agent

16 One molecule of an oxide of element Z reacts with six molecules of water to produce an acidic compound.

What is element Z?

A aluminium

B phosphorus

C silicon

D sulfur

17 Which property shows an **increase** from magnesium to barium?

A the first ionisation energy of the elements

B the oxidising power of the metals

C the solubility of the hydroxides

D the solubility of the sulfates

18 A test-tube of HBr(g) and a separate test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

	test-tube of HBr(g)	test-tube of HI(g)
A	a brown vapour appears	no change
B	a purple vapour appears	no change
C	no change	a brown vapour appears
D	no change	a purple vapour appears

19 Most modern cars are fitted with catalytic converters in the exhaust system.

Which three gases are removed by a catalytic converter?

A carbon monoxide, hydrocarbons, nitrogen oxides

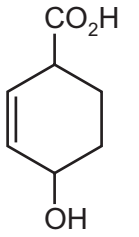
B carbon monoxide, carbon dioxide, nitrogen oxides

C carbon monoxide, nitrogen oxides, sulfur dioxide

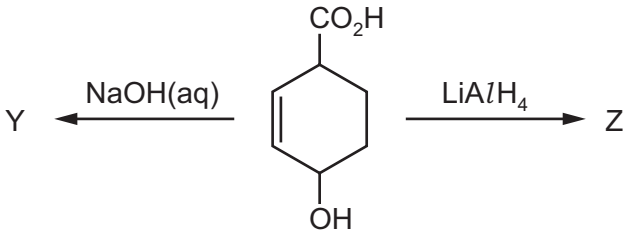
D hydrocarbons, nitrogen oxides, sulfur dioxide

20 Compound X is shown.

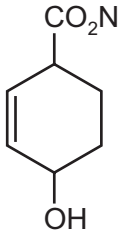
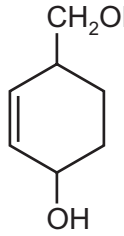
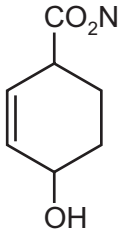
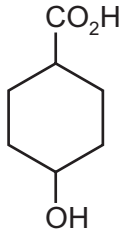
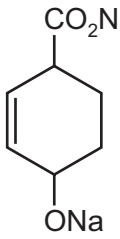
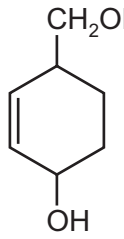
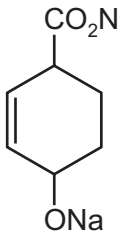
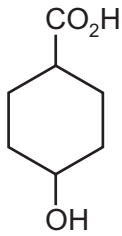
compound X



X is treated separately with NaOH(aq) and LiAlH$_4$ to give Y and Z.



What are Y and Z?

	Y	Z
A		
B		
C		
D		

[Turn over

21 The table shows the molecular formulae of three molecules P, Q and R. None of the molecules are cyclic.

molecule	molecular formula
P	CH_4O
Q	CH_2O_2
R	CH_2O

Which molecules show a strong absorption between 1610 cm^{-1} and 1750 cm^{-1} in their infra-red spectra?

A Q only **B** R only **C** Q and R only **D** P, Q and R

22 Which row correctly shows the type of mechanism of each of the two reactions?

	C_2H_5Br + KCN	CH_3COCH_3 + HCN
A	electrophilic substitution	electrophilic addition
B	electrophilic substitution	nucleophilic addition
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	nucleophilic addition

23 Ester X is shown.

ester X

$CH_3CO_2(CH_2)_7CH_3$

Ester X is hydrolysed using aqueous sodium hydroxide.

What is the molecular formula of one of the products?

A $C_2H_4O_2$ **B** $C_2H_3O_2Na$ **C** $C_8H_{16}O$ **D** $C_8H_{17}O_2Na$

24 Which reagent could be used to distinguish between propane-1,2-diol and ethane-1,2-diol?

A alkaline aqueous iodine

B aqueous acidified dichromate(VI)

C ethanol and a few drops of concentrated sulfuric acid

D sodium metal

25 Which substance forms propanoic acid as one of the products when it reacts with hot concentrated acidified potassium manganate(VII)?

A but-1-ene

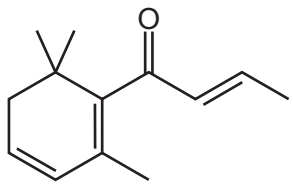
B but-2-ene

C 2-methylpropene

D 2-methylbut-1-ene

26 The structure of damascenone is shown.

damascenone



Including damascenone, how many stereoisomers exist with this structural formula?

A 1 **B** 2 **C** 4 **D** 8

27 How many isomeric esters have the molecular formula $C_4H_8O_2$?

A 2 **B** 3 **C** 4 **D** 5

28 Ethene reacts with aqueous bromine to give two products, CH_2BrCH_2Br and CH_2BrCH_2OH.

Which statement about these products is correct?

A Both products are obtained in this reaction by nucleophilic substitution.

B Both products are obtained in this reaction by nucleophilic addition.

C Both products can be hydrolysed to form the same organic compound.

D Both products can form hydrogen bonds with water.

29 PVC is used as a packaging material.

What holds the different polymer strands together in a piece of solid PVC?

A covalent bonds

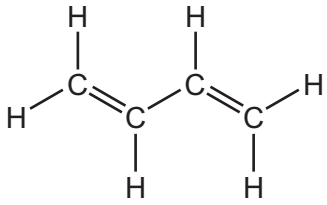
B hydrogen bonds

C ionic bonds

D van der Waals' forces

30 The diagram shows the structure of buta-1,3-diene.

buta-1,3-diene



The addition reaction between buta-1,3-diene and two molecules of hydrogen bromide can produce three structurally isomeric products.

How many of these products have at least one chiral centre?

A 0 **B** 1 **C** 2 **D** 3

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the *Data Booklet* may be appropriate for some questions.

31 Scientists are trying to synthesise a new element with proton number 119. The element is predicted to be a Group 1 element in Period 8 of the Periodic Table.

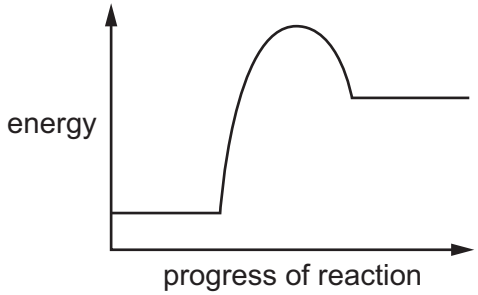
Which predictions are likely to be correct about this element?

1 The outermost occupied orbital of one atom of this element will be an s orbital.

2 The atomic radius will be the largest of the seven elements in Group 1.

3 It will have a greater first ionisation energy than element 118.

32 Which reactions would have the reaction profile shown?



1 $NaOH + HCl \rightarrow NaCl + H_2O$

2 $CaCO_3 \rightarrow CaO + CO_2$

3 $2MgO \rightarrow 2Mg + O_2$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

33 Which factors can lead to an increase in the rate of a reaction?

1 a lower activation energy

2 an increase in temperature

3 an increase in the concentration of a reactant

34 Sodium and fluorine are both reactive elements. Two atoms are described.

	F	Na
atomic number	9	11
nucleon number	19	23

Which statements about these two atoms, and the ions they can form, are correct?

1 One Na atom has two more protons than one F^- ion.

2 One Na atom has two more neutrons than one F atom.

3 One Na^+ ion has the same number of electrons as one F^- ion.

35 In the atmosphere, which transformations can involve sulfur dioxide as either a reagent or a catalyst?

1 NO_2 to NO

2 NO to NO_2

3 CO to CO_2

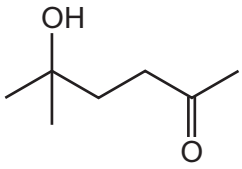
36 The bond .....P..... of the HBr molecule is .....Q..... than that of the HI molecule.

Which pairs of words correctly complete the above sentence?

	P	Q
1	energy	greater
2	length	less
3	polarity	greater

37 Compound X has the structure shown.

compound X



Which statements about compound X are correct?

1 X will decolourise cold, acidified $KMnO_4(aq)$.

2 X gives an orange precipitate with 2,4-DNPH reagent.

3 X does not react with Tollens' reagent.

38 Propanal reacts with hydrogen cyanide.

Which absorptions are present in the infra-red spectrum of the product?

1 a weak absorption in the range 2200–2250 cm^{-1}

2 a strong absorption in the range 3200–3600 cm^{-1}

3 a strong absorption in the range 1040–1300 cm^{-1}

39 Which alcohols **cannot** be dehydrated to form alkenes?

1 CH_3OH

2 $(CH_3)_3COH$

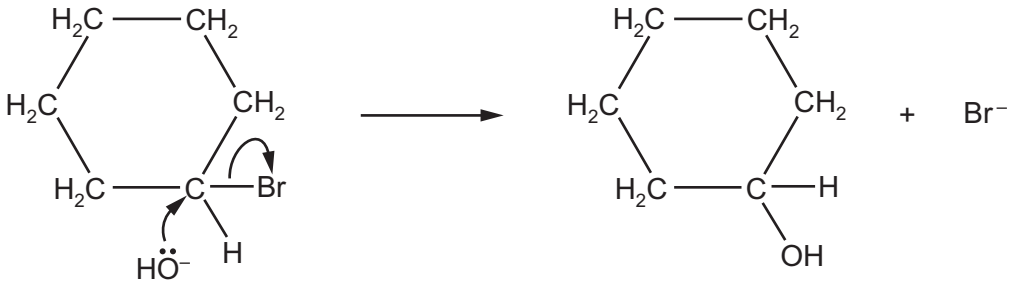
3 $CH_3CH(OH)CH_3$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

40 A reaction mechanism is shown.



Which statements about this reaction are correct?

1 Heterolytic bond fission occurs.

2 It is a substitution reaction.

3 OH^- behaves as an electrophile.

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Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2019**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

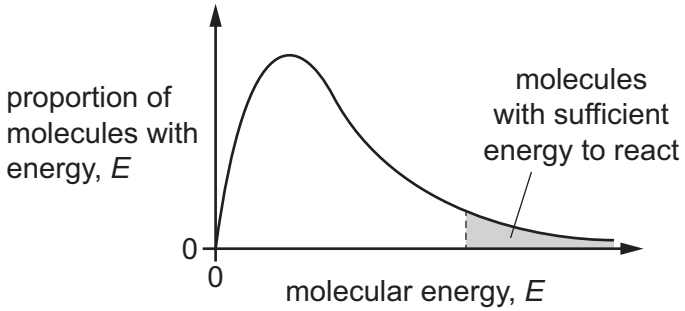
IB19 06_9701_12/3RP

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

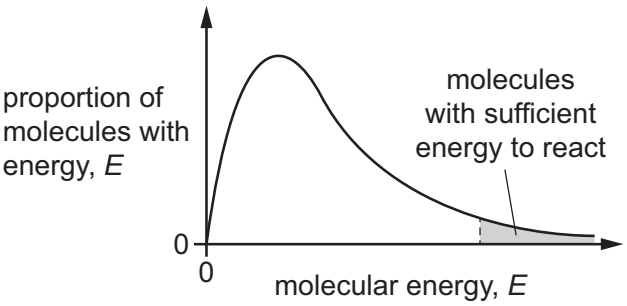
Use of the Data Booklet may be appropriate for some questions.

1 The Boltzmann distribution of molecular energies in a sample of aqueous hydrogen peroxide at room temperature is shown.

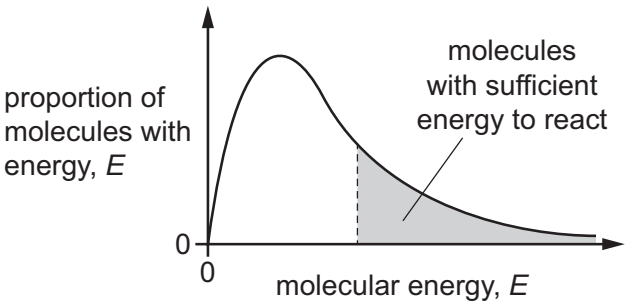


Which diagram shows the Boltzmann distribution of molecular energies of aqueous hydrogen peroxide maintained at room temperature when a catalyst, manganese(IV) oxide, is added?

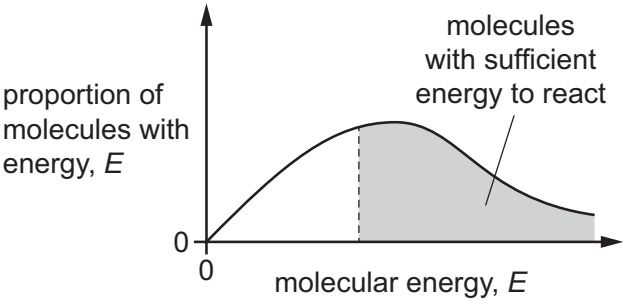
A



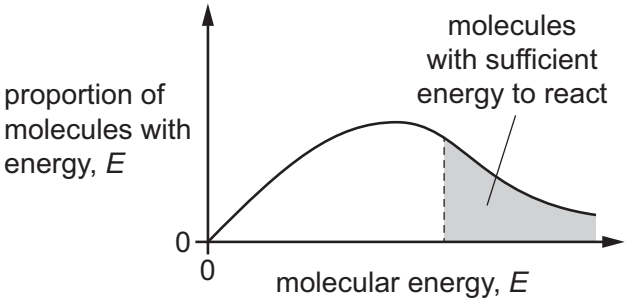
B



C



D

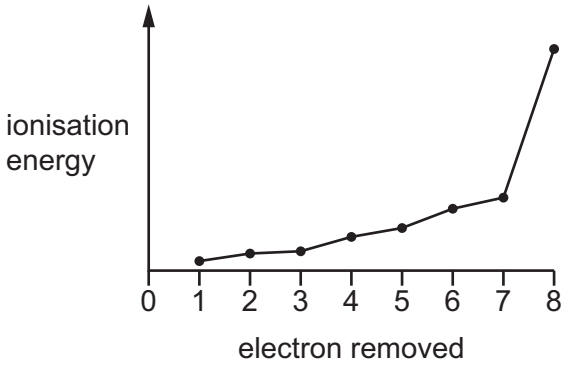


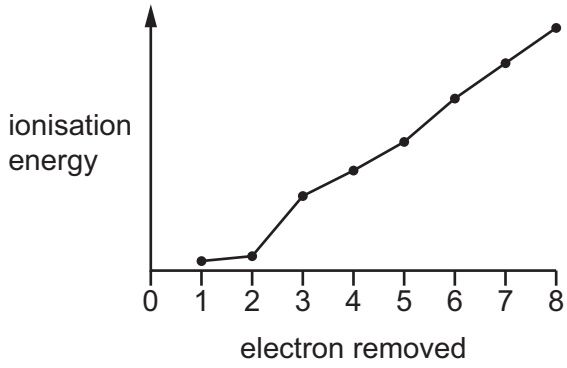
2 Oxygen has three stable isotopes, ^{16}O, ^{17}O and ^{18}O. All three isotopes are present in a sample of oxygen gas, O_2, which was analysed using a mass spectrometer.

How many peaks associated with the O_2^+ ion would be expected?

A 3 **B** 5 **C** 6 **D** 9

3 The first eight successive ionisation energies for two elements of Period 3 of the Periodic Table are shown in the graphs.





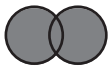
What is the formula of the ionic compound formed from these elements?

A $MgCl_2$ **B** $CaBr_2$ **C** Na_2S **D** K_2Se

4 A σ bond is made between two carbon atoms in a molecule of ethene.

Which diagram shows the orbital overlap that occurs to form this bond?

A



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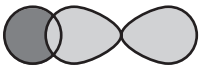

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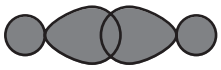

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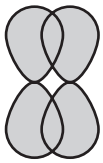


5 The table shows some properties of four substances.

Which substance could be potassium iodide?

	melting point of solid / °C	electrical conductivity when molten
A	–66	poor
B	–39	good
C	680	good
D	1600	poor

6 X, Y and Z are all gases that behave ideally and react according to the equation shown.

$$X(g) + 2Y(g) \rightarrow 2Z(g)$$

When 3.0 mol of X and 3.0 mol of Y are placed inside a container with a volume of 1.0 dm^3, they react to form the maximum amount of Z.

The final temperature of the reaction vessel is 120 °C.

What is the final pressure inside the reaction vessel?

A 4.49×10^6 Pa

B 9.80×10^6 Pa

C 1.47×10^7 Pa

D 1.96×10^7 Pa

7 Which pair of substances are both simple molecular?

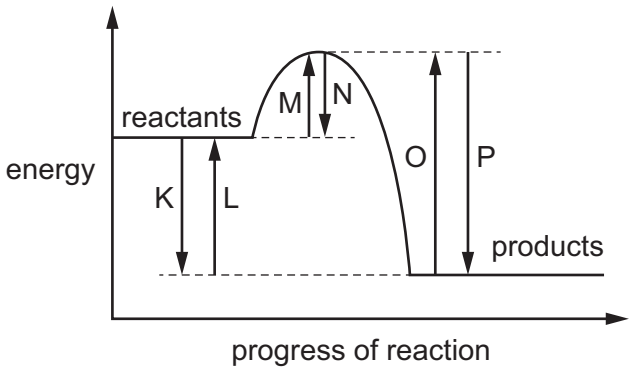
A C_{60} and graphene

B C_{60} and iodine

C graphene and graphite

D graphite and iodine

8 A reaction pathway diagram is shown.



Which row is correct?

	enthalpy change of the forward reaction	activation energy of the reverse reaction
A	K	M
B	K	O
C	L	O
D	P	M

9 X is either chlorine or an oxide of chlorine.

X reacts with water, under suitable conditions, to form the two acids HCl and HClO$_3$ in the mole ratio of 1 (HCl) : 5 (HClO$_3$).

What could be X?

A Cl_2 **B** Cl_2O **C** ClO$_2$ **D** Cl_2O$_7$

10 Ethyl ethanoate undergoes the following reaction.

$$CH_3CO_2C_2H_5 + H_2O \rightleftharpoons C_2H_5OH + CH_3CO_2H \qquad K_c = 0.27$$

Equal amounts of ethanoic acid and ethanol were mixed together and allowed to reach equilibrium.

At equilibrium, the concentrations of both ethanoic acid and ethanol were 0.42 mol dm^{-3}.

What is the concentration of ethyl ethanoate at equilibrium?

A 0.22 mol dm^{-3}

B 0.65 mol dm^{-3}

C 0.81 mol dm^{-3}

D 1.54 mol dm^{-3}

11 Which row is an example of heterogeneous catalysis?

	reaction	catalyst
A	esterification	sulfuric acid
B	the Contact process	divanadium pentoxide
C	destruction of the ozone layer	chlorine radicals
D	atmospheric formation of sulfur trioxide	nitrogen dioxide

12 Element Q readily oxidises in air. The oxide produced reacts with water to form a solution of very low pH.

Where could element Q be found in the Periodic Table?

	period	group
A	2	1
B	2	14
C	3	14
D	3	15

13 The eight elements sodium to argon are in the same period of the Periodic Table.

The equation corresponding to the first ionisation energy is shown.

$$X(g) \rightarrow X^{+}(g) + e^{-}$$

For which of these eight elements is the electron in this equation removed from a filled orbital?

A Mg, A*l*, Si, P, S, C*l* and Ar

B A*l*, Si, P, S, C*l* and Ar only

C Mg, S, C*l* and Ar only

D S, C*l* and Ar only

14 Elements D and E are both in Period 3. Element D has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element E. Elements D and E react together to form compound L.

Which compound could be L?

A $MgCl_2$ **B** MgS **C** Na_2S **D** PCl_3

15 How many of the solutions shown, when added to separate portions of magnesium sulfate solution, produce a white precipitate?

$HCl(aq)$ $NH_3(aq)$ $(NH_4)_2CO_3(aq)$ $Ba(NO_3)_2(aq)$

A 0 **B** 1 **C** 2 **D** 3

16 A white solid, Z, is soluble in water. A sample of Z is heated with a Bunsen burner until there is no further change. When the residue is shaken with water a solution is formed with no solid remaining.

What could Z be?

A $MgCO_3$ **B** $Mg(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$

17 An excess of chlorine was bubbled into 100 cm^3 of hot 6.0 mol dm^{-3} sodium hydroxide.

How many moles of sodium chloride would be produced in the reaction?

A 0.3 **B** 0.5 **C** 0.6 **D** 1.2

18 Ammonium sulfate, $(NH_4)_2SO_4$, and ammonium nitrate, NH_4NO_3, are used as fertilisers.

These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of wet neutral soil.

Which row is correct?

	higher percentage of nitrogen by mass	effect on pH of soil
A	ammonium nitrate	decrease
B	ammonium nitrate	increase
C	ammonium sulfate	decrease
D	ammonium sulfate	increase

19 Which reaction gives a product that is an atmospheric pollutant causing acid rain?

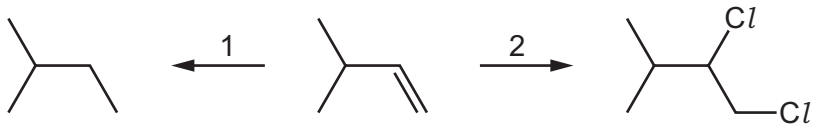
A $3Mg(s) + SO_2(g) \rightarrow MgS(s) + 2MgO(s)$

B $(NH_4)_2SO_4(s) + Ca(OH)_2(s) \rightarrow 2NH_3(g) + CaSO_4(s) + 2H_2O(l)$

C $2MnO_4^-(aq) + 5SO_2(g) + 2H_2O(l) \rightarrow 2Mn^{2+}(aq) + 4H^+(aq) + 5SO_4^{2-}(aq)$

D $2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$

20 3-methylbut-1-ene can undergo different types of reaction.



Which row correctly identifies the reaction types?

	reaction 1	reaction 2
A	oxidation	electrophilic addition
B	oxidation	nucleophilic addition
C	reduction	electrophilic addition
D	reduction	nucleophilic addition

21 Compound X does **not** show cis-trans isomerism.

What could be the identity of compound X?

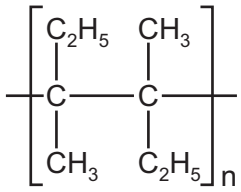
A 1,1,2-trichloropropene

B 1,2,3-trichloropropene

C 1-chlorobut-1-ene

D 1-chlorobut-2-ene

22 The diagram shows the repeat unit of an addition polymer.



What is the correct name for the monomer that would form this polymer?

A cis-1,2-diethyl-1,2-dimethylethene

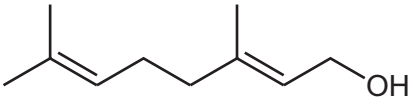
B cis-2-ethyl-3-methylpent-2-ene

C trans-2-ethyl-3-methylpent-2-ene

D trans-3,4-dimethylhex-3-ene

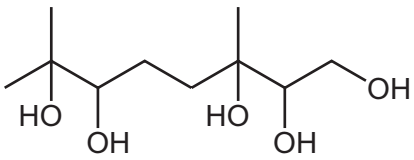
23 A molecule of geraniol is shown.

geraniol



What is formed when geraniol is reacted with an excess of cold, dilute, acidified manganate(VII) ions?

A



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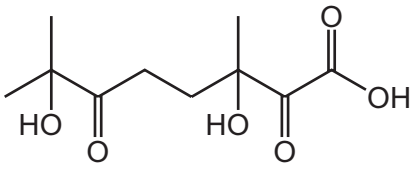

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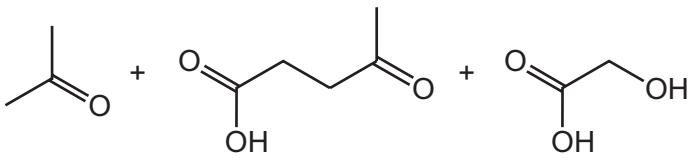
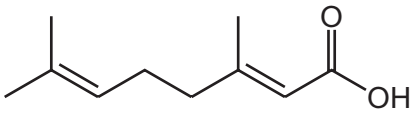


D



24 Alcohol W **cannot** be made by reducing a carboxylic acid with $LiAlH_4$. Alcohol W gives only one product when dehydrated with concentrated sulfuric acid.

What could be the identity of W?

A butan-1-ol

B butan-2-ol

C propan-1-ol

D propan-2-ol

25 Which product can be made from bromoethane by an elimination reaction?

A ethanol

B ethene

C ethylamine

D propanenitrile

26 Propene, bromine and hydrogen bromide are mixed in the dark.

A number of products are formed, some in very small quantities.

Which substance will **not** be present in the mixture of products?

A 1-bromopropane

B 2-bromopropane

C 1,1-dibromopropane

D 1,2-dibromopropane

27 Which reagent could be used to distinguish between ethanal and propanal?

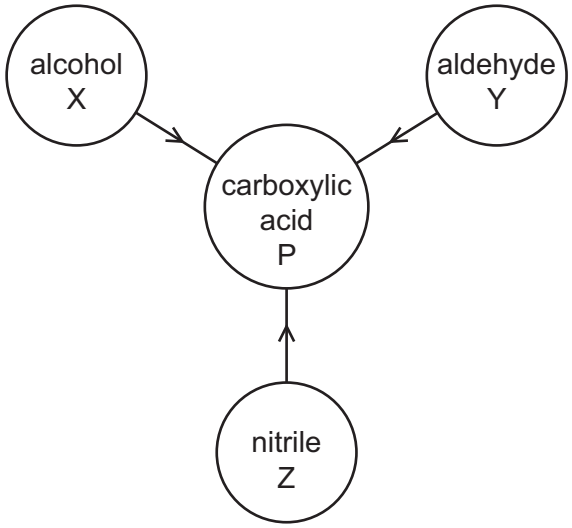
A 2,4-dinitrophenylhydrazine

B I_2 / NaOH(aq)

C $K_2Cr_2O_7$ / H_2SO_4(aq)

D Tollens' reagent

28 The diagram shows that a carboxylic acid P may be formed from X, Y or Z.

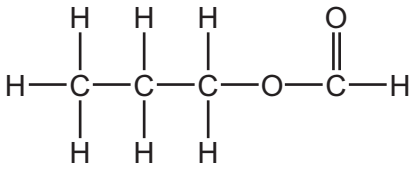


Which row is correct?

	alcohol X is	the change in M_r is greatest for
A	primary	Y to P
B	primary	Z to P
C	secondary	Y to P
D	secondary	Z to P

29 One molecule of compound R is shown.

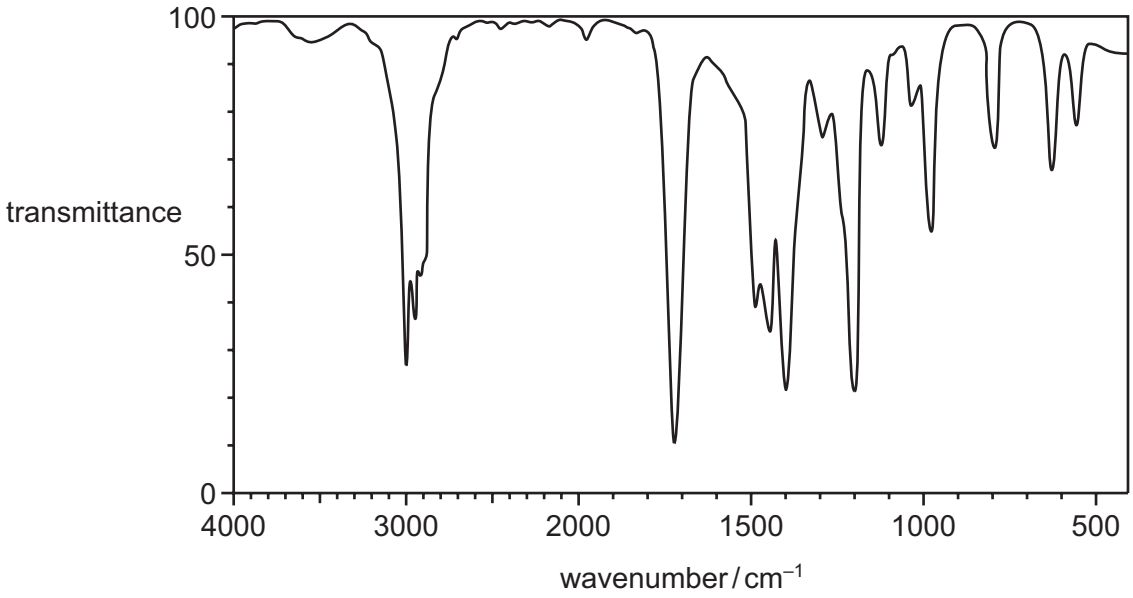
compound R



What is the name of compound R and how does its boiling point compare with that of butanoic acid?

	name of R	boiling point of R
A	methyl propanoate	higher than butanoic acid
B	methyl propanoate	lower than butanoic acid
C	propyl methanoate	higher than butanoic acid
D	propyl methanoate	lower than butanoic acid

30 The diagram shows the infra-red spectrum of Q.



What could be Q?

A butan-1-ol

B butanoic acid

C butanone

D 3-hydroxybutanal

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 When O_2 reacts with H_2S the products are SO_2 and H_2O.

Mixture Y contains an equal number of the two molecules shown, and **no other molecules**.

$^{16}_{8}O = {}^{18}_{8}O$ $\qquad$ $^{1}_{1}H - {}^{32}_{16}S - {}^{1}_{1}H$

Which statements about Y are correct?

1 The average M_r in Y is 34.

2 If some oxygen molecules are removed from Y, the average M_r of the mixture remains the same.

3 When mixture Y is ignited, some H_2S remains unreacted.

32 Which statements about an atom of ^{99}Tc are correct?

1 It has 13 fewer protons than neutrons.

2 It forms $^{99}Tc^{2+}$ which has 45 electrons.

3 It has 56 nucleons.

33 In which reactions are nitrogen atoms reduced?

1 $2NO_2 \rightarrow N_2 + 2O_2$

2 $4NO_2 \rightarrow 2N_2O + 3O_2$

3 $4NO_2 + 6H_2O \rightarrow 4NH_3 + 7O_2$

34 The manufacture of ammonia from nitrogen and hydrogen is an important industrial process.

Which of the following would leave the equilibrium constant, K_p, for the formation of ammonia unchanged?

1 addition of an iron catalyst

2 addition of ammonia

3 an increase in pressure

35 Which reactions involving calcium and its compounds produce two gaseous products?

1 heating solid anhydrous calcium nitrate

2 heating solid anhydrous calcium carbonate

3 adding calcium metal to water

36 A small quantity of hot, concentrated sulfuric acid is added separately to solid samples of potassium halides, KX.

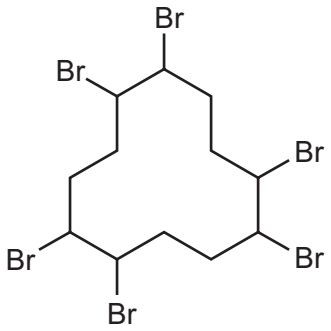
Which potassium halides react and produce a mixture of products that include a halogen, X_2?

1 potassium iodide

2 potassium bromide

3 potassium chloride

37 The diagram shows a compound used as a flame retardant.



Which statements about this structure are correct?

1 The empirical formula is C_2H_3Br.

2 The C_{12} ring is not planar.

3 There are six chiral carbon atoms.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

38 Halogenoalkanes can be hydrolysed using aqueous sodium hydroxide.

Which compounds tend to be hydrolysed by an S_N1 mechanism?

1 $CH_3CH_2CCl(CH_3)CH_2CH_3$

2 $CH_3CH_2CBr(CH_3)CH_2CH_3$

3 $CH_3CH_2CH(CH_3)CH_2CH_2Br$

39 In an organic synthesis, a 62% yield of product is achieved.

Which conversions are consistent with this information?

1 74.00 g of butan-2-ol $\rightarrow$ 44.64 g of butanone

2 74.00 g of butan-1-ol $\rightarrow$ 54.56 g of butanoic acid

3 74.00 g of 2-methylpropan-1-ol $\rightarrow$ 54.56 g of 2-methylpropanoic acid

40 An oxidising agent that can oxidise ethanal to ethanoic acid or ethanoate ions will also oxidise methanoic acid, HCO_2H, to carbon dioxide and water.

Which reagents, on heating, will react differently with HCO_2H and CH_3CO_2H?

1 $Na_2CO_3(aq)$

2 Fehling's reagent

3 dilute acidified $KMnO_4$

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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 Which feature is present in both ethene and poly(ethene)?

A bond angles of 109°

B π covalent bonds

C σ covalent bonds

D sp^3 orbitals

2 The electronic configuration of an atom of sulfur is $1s^2 2s^2 2p^6 3s^2 3p^4$.

How many valence shell and unpaired electrons are present in one sulfur atom?

	valence shell electrons	unpaired electrons
A	2	1
B	4	2
C	6	0
D	6	2

3 In which pair does the second substance have a **lower** boiling point than the first substance?

A C_2H_6 and C_2H_5Cl

B CH_3OCH_3 and C_2H_5OH

C Ne and Ar

D CH_3NH_2 and C_2H_6

4 Compound J burns in excess oxygen to give carbon dioxide and water only. When a 3.00 g sample of compound J is burnt in excess oxygen, 4.40 g of carbon dioxide and 1.80 g of water are formed.

What is the empirical formula of J?

A CH **B** CHO **C** CH_2 **D** CH_2O

5 The gases X and Y react to form Z.

$$X(g) + Y(g) \rightleftharpoons Z(g)$$

An equilibrium mixture of these three gases is compressed at constant temperature.

What will be the changes in the mole fraction of Z and in K_p?

	mole fraction of Z	K_p
A	increase	increase
B	increase	no change
C	no change	increase
D	no change	no change

6 Which gas is likely to deviate most from ideal gas behaviour?

A HC*l* **B** He **C** CH_4 **D** N_2

7 The enthalpy change of reaction 1 is $-114\,kJ\,mol^{-1}$.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) \qquad \text{reaction 1}$$

By using this information, what is the most likely value for the enthalpy change of reaction 2?

$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l) \qquad \text{reaction 2}$$

A $-57\,kJ\,mol^{-1}$ **B** $-76\,kJ\,mol^{-1}$ **C** $-114\,kJ\,mol^{-1}$ **D** $-228\,kJ\,mol^{-1}$

8 Sulfur reacts with concentrated nitric acid in a redox reaction.

$$S + 4HNO_3 \rightarrow SO_2 + 4NO_2 + 2H_2O$$

What are the changes in oxidation number of sulfur and of nitrogen in this reaction?

	sulfur	nitrogen
A	+2	–3
B	+2	–1
C	+4	–3
D	+4	–1

9 Materials can be classified by their chemical structures. Four common types of structure are metallic, ionic, simple molecular and giant molecular.

Some physical properties of four substances are shown in the table.

Which substance has a simple molecular structure?

	melting point / °C	effect of adding water	electrical conductivity
A	64	reacts	good when solid
B	113	insoluble	always poor
C	767	soluble	good when solid
D	1600	insoluble	always poor

10 In a particular reversible reaction the yield of product is increased

- if the temperature is increased;
- if the pressure is decreased.

Which equation could describe this reversible reaction?

A $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$ $\Delta H = +206\,kJ\,mol^{-1}$

B $4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g)$ $\Delta H = -227\,kJ\,mol^{-1}$

C $2NO_2(g) \rightleftharpoons N_2O_4(g)$ $\Delta H = -58\,kJ\,mol^{-1}$

D $3O_2(g) \rightleftharpoons 2O_3(g)$ $\Delta H = +143\,kJ\,mol^{-1}$

11 A chemical company used a catalyst in a chemical process. The company has now decided not to use the catalyst but to increase the temperature so that the rate of the reaction is the same as it was when the catalyst was used.

Which statement about the new conditions compared to the original conditions is correct?

A The activation energy has been decreased.

B The activation energy has been increased.

C There are fewer successful collisions per unit time.

D There are more successful collisions per unit time.

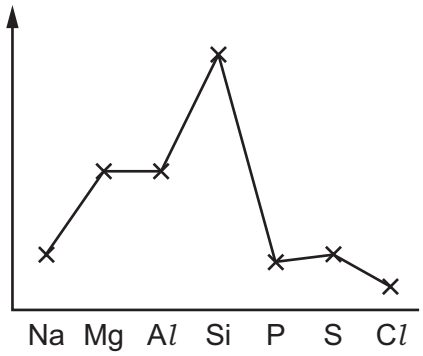
12 Which oxide does **not** react with cold, dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

13 The graphs show trends in four physical properties of elements in Period 3, excluding argon.

Which graph has electronegativity on the *y*-axis?

A



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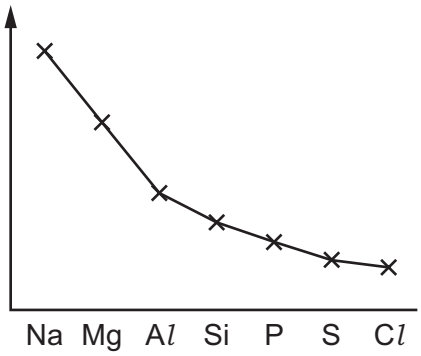

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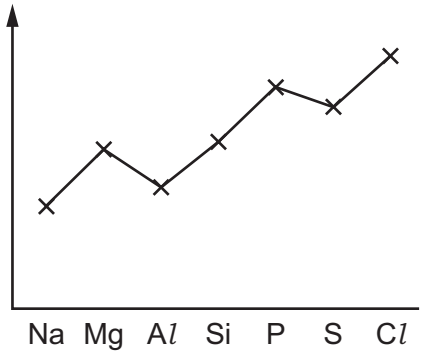

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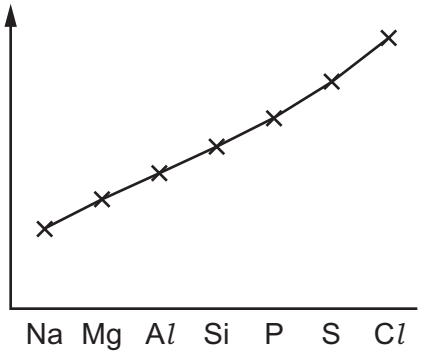


14 In this question, X represents an atom of chlorine, bromine or iodine.

Which explanation for the variation in volatility down Group 17 is correct?

A Instantaneous dipole-induced dipole forces between molecules become stronger.

B Permanent dipole-permanent dipole forces between molecules become stronger.

C The bond energy of the X_2 molecules decreases.

D The first ionisation energy $X(g) \rightarrow X^+(g) + e^-$ decreases.

15 To manufacture cement, 1000 million tonnes of limestone are decomposed each year. To manufacture lime for agriculture, 200 million tonnes of limestone are decomposed each year.

What is the total mass of carbon dioxide in million tonnes produced from these two processes in a year?

A 440 **B** 528 **C** 660 **D** 880

16 In Group 2 of the Periodic Table, the properties of the elements and their compounds show regular change down the group.

Which property shows a **decrease** from magnesium to barium?

A the decomposition temperature of the carbonates

B the decomposition temperature of the nitrates

C the solubility of the hydroxides

D the solubility of the sulfates

17 When concentrated sulfuric acid is added to solid sodium bromide, bromine gas is produced, along with a number of other products. However when concentrated sulfuric acid is added to solid sodium chloride **only** hydrogen chloride and sodium hydrogensulfate are produced.

What is the reason for this difference?

A Bromine is less volatile than chlorine.

B Hydrochloric acid is a weak acid.

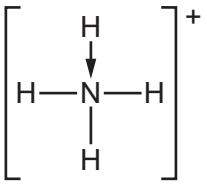
C Sulfuric acid is not an oxidising agent.

D The bromide ion is a stronger reducing agent than the chloride ion.

18 The dative covalent bond can be represented by an arrow, →. The arrow points towards the atom receiving the lone pair.

Which diagram of an ammonium ion is correct?

A



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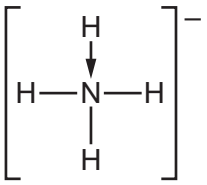

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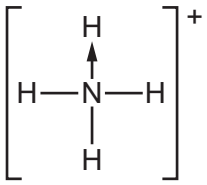
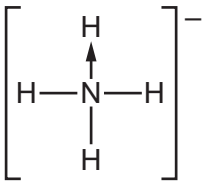


D



19 Sulfur dioxide can be catalytically oxidised by an oxide of nitrogen in the atmosphere.

Which reaction shows the regeneration of the catalyst?

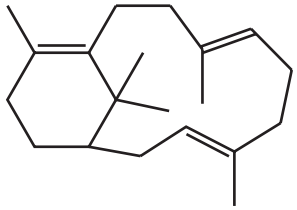
A $N_2 + 2O_2 \rightleftharpoons 2NO_2$

B $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

C $N_2 + O_2 \rightarrow 2NO$

D $NO + \frac{1}{2}O_2 \rightarrow NO_2$

20 Compound Y is treated with an excess of hydrogen gas in the presence of a nickel catalyst. The product is fully saturated.



compound Y

What is the number of chiral carbon atoms in the product?

A 5 **B** 6 **C** 7 **D** 8

21 Which equation represents a valid propagation step in the chlorination of ethane?

A $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

B $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

C $C_2H_5Cl + H\bullet \rightarrow C_2H_5\bullet + HCl$

D $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

22 Maleic acid is used in the food industry and for stabilising drugs. It is the cis-isomer of butenedioic acid and has the structural formula $HO_2CCH{=}CHCO_2H$.

What is the product formed from the reaction of maleic acid with cold, dilute, acidified manganate(VII) ions?

A $HO_2CCH(OH)CH(OH)CO_2H$

B HO_2CCO_2H

C $HO_2CCH_2CH(OH)CO_2H$

D $HO_2CCOCOCO_2H$

23 Primary halogenoalkanes undergo hydrolysis reactions.

Which reaction would occur most rapidly if they are all warmed to the same temperature?

A C_2H_5Br with H_2O

B C_2H_5Br with NaOH(aq)

C C_2H_5Cl with H_2O

D C_2H_5Cl with NaOH(aq)

24 Structural isomerism and stereoisomerism should be considered when answering this question.

A colourless liquid, $C_5H_{11}Cl$, exists as a mixture of two optical isomers.

When heated with sodium hydroxide in ethanol, a mixture of **only** two alkenes is formed.

What could the colourless liquid be?

A $(CH_3CH_2)_2CHCl$

B $CH_3CH_2CH_2CHClCH_3$

C $(CH_3)_2CHCHClCH_3$

D $CH_3CH_2CCl(CH_3)_2$

25 When warm water is added to halogenoalkane X, an S_N1 reaction occurs.

$AgNO_3(aq)$ is then added; a yellow precipitate is formed.

What could be X?

A 1-chlorobutane

B 1-iodobutane

C 2-chloro-2-methylpropane

D 2-iodo-2-methylpropane

26 Which alcohol will react with an acidified solution of potassium dichromate(VI) to produce a ketone containing six carbon atoms?

A 2,2-dimethylbutan-1-ol

B 2-methylpentan-3-ol

C 3,3-dimethylpentan-2-ol

D 3-methylpentan-3-ol

27 Which statement about butanone is correct?

A Butanone can be dehydrated by concentrated sulfuric acid to give $CH_2{=}CHCH{=}CH_2$.

B Butanone gives a positive result with Tollens' reagent.

C Butanone reacts with HCN by an electrophilic addition mechanism.

D Butanone reacts with $NaBH_4$ to give a chiral product.

28 Ethanal, CH_3CHO, is used to make product R in a three-stage synthesis.

$$CH_3CHO \xrightarrow[/\,NaCN]{HCN} \text{product P} \xrightarrow[\text{reflux}]{H_2SO_4(aq),} \text{product Q} \xrightarrow[\text{(a few drops)}]{\text{conc. } H_2SO_4} \text{product R}$$

Two molecules of Q react to give one molecule of R plus two molecules of water.

R has two ester functional groups in each molecule. R does not react with sodium.

What is the empirical formula of R?

A CHO **B** $C_3H_4O_2$ **C** $C_3H_5O_2$ **D** $C_6H_{10}O_5$

29 The ester ethyl butanoate can be hydrolysed using an excess of dilute sodium hydroxide solution.

Which substance is a product of this reaction?

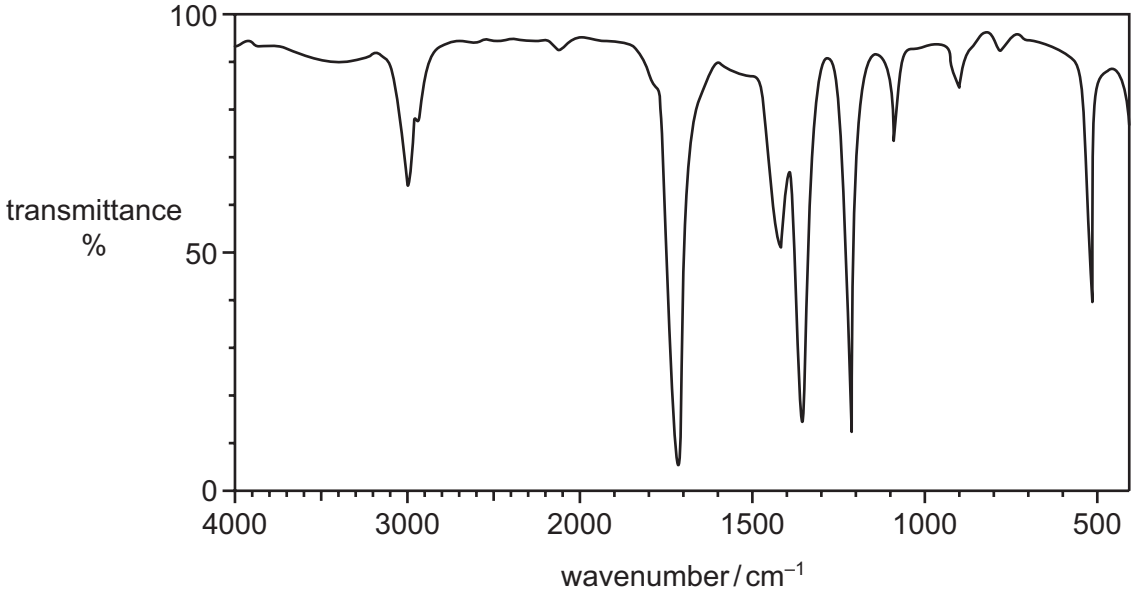
A $CH_3CH_2CH_2CO_2Na$

B CH_3CO_2Na

C CH_3CH_2ONa

D H_2O

30 The infra-red spectrum of an organic compound is shown.



Which compound could give this spectrum?

A $CH_3CH_2CO_2H$

B $CH_3CH(OH)CH_3$

C CH_3COCH_3

D CH_3COCH_2OH

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 For complete combustion, 1 mol of an organic compound X requires 2.5 mol of O_2.

Which compounds could be X?

1 C_2H_5OH

2 C_2H_2

3 CH_3CHO

32 In which pairs do both species have the same number of electrons?

1 ^{35}Cl and ^{37}Cl

2 $^{35}Cl^-$ and ^{40}Ar

3 ^{40}Ar and $^{40}K^+$

33 For which reactions does the value of $\Delta H^\ominus$ represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?

1 $C(s) + O_2(g) \rightarrow CO_2(g)$

2 $2C(s) + O_2(g) \rightarrow 2CO(g)$

3 $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

34 The temperature of a reversible gas phase reaction is increased.

Which statements are **always** correct?

1 More product is present at equilibrium.

2 The average speed of the particles increases.

3 There are more successful collisions per unit time.

35 Three samples of chlorine gas each contain 0.710 g of chlorine. Each sample is reacted with a reagent.

- In the first reaction a sample is reacted completely with hydrogen gas.
- In the second reaction a sample is reacted completely with cold NaOH(aq).
- In the third reaction a sample is reacted completely with hot NaOH(aq).

Which masses of the named products would be formed?

1 Exactly 0.730 g of HC*l* form in the first reaction.

2 Exactly 0.585 g of NaC*l* form in the second reaction.

3 Exactly 0.975 g of NaC*l* form in the third reaction.

36 Solid barium oxide is added to some ammonium sulfate solution in a test-tube and the mixture is warmed. A piece of damp red litmus paper is held over the mouth of the test-tube.

Which observations would be made?

1 The damp litmus paper initially turns from red to blue.

2 A white precipitate forms in the test-tube.

3 A brown gas is evolved with strong heating.

37 Which compounds show geometrical (cis-trans) isomerism?

1 $CH_3CH{=}C(CH_3)C_2H_5$

2 $CH_3CH{=}CHCH_2CH_2CH_3$

3 $C_2H_5CH{=}CHC_2H_5$

38 Which pairs of compounds may be distinguished from each other by testing with alkaline aqueous iodine?

1 ethane-1,2-diol and ethanol

2 propan-2-ol and methylpropan-2-ol

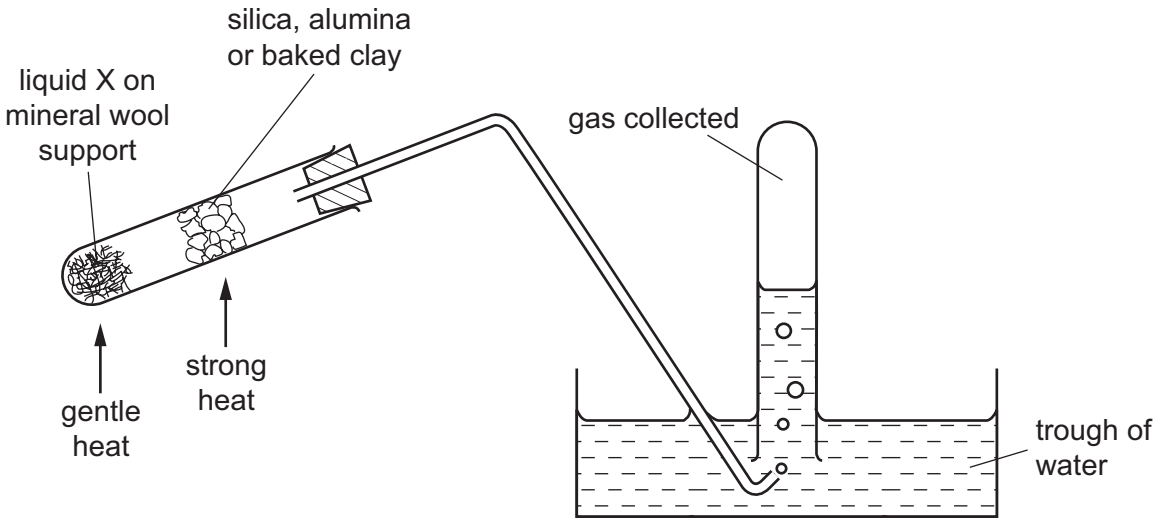
3 ethanol and butan-2-ol

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

39 The diagram shows an experimental set-up which can be used in several different experiments.



Which processes could be demonstrated by using the above apparatus?

1 oxidation of ethanol (liquid X)

2 dehydration of ethanol (liquid X)

3 cracking of paraffin (liquid X)

40 The ester $C_2H_5CO_2CH_2CH_2CH_3$ can be made in a school or college laboratory by a sequence of four reactions or fewer using compound Z as the **only** organic material.

What might be the identity of compound Z?

1 $CH_3CH_2CH_2OH$

2 CH_3CH_2CHO

3 CH_3COCH_3

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2017**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

MODIFIED LANGUAGE

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 In which species are the numbers of protons, neutrons and electrons **all** different?

A $^{19}_{9}F^{-}$ **B** $^{23}_{11}Na^{+}$ **C** $^{31}_{15}P$ **D** $^{32}_{16}S^{2-}$

2 Which would contain 9.03×10^{23} oxygen atoms?

A 0.25 mol aluminium oxide

B 0.75 mol sulfur dioxide

C 1.5 mol sulfur trioxide

D 3.0 mol water

3 In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate. Heat is evolved, an unreactive gas is produced, and all nitrogen atoms are reduced.

What is the equation for this reaction?

A $2Al + Ba(NO_3)_2 \rightarrow Al_2O_3 + BaO + 2NO$

B $4Al + 4Ba(NO_3)_2 \rightarrow 2Al_2O_3 + 4Ba(NO_2)_2 + O_2$

C $10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$

D $10Al + 18Ba(NO_3)_2 \rightarrow 10Al(NO_3)_3 + 18BaO + 3N_2$

4 Which organic compound has the highest boiling point?

A $C(CH_3)_4$

B $CH_3CH_2CH_2CH_2CH_3$

C $CH_3COCH_2CH_3$

D $CH_3CH(OH)CH_2CH_3$

5 At a temperature of 2500 K and a pressure of 1.00×10^{-4} Pa a sample of 0.321 g of sulfur vapour has a volume of $2.08 \times 10^{6}\,m^3$.

What is the molecular formula of sulfur under these conditions?

A S **B** S_2 **C** S_4 **D** S_8

6 Which reaction involves a decrease in the bond angle at a carbon atom?

A bromoethane refluxed with ethanolic sodium hydroxide

B complete combustion of methane in air

C ethanol heated with conc. H_2SO_4

D polymerisation of ethene

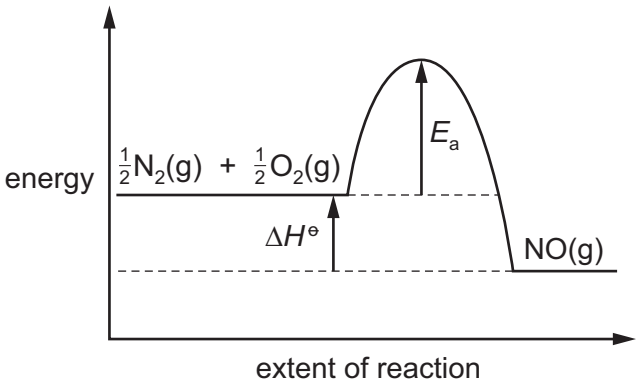
7 In the high temperatures of car engines, nitrogen reacts with oxygen to give nitrogen monoxide.

$$\tfrac{1}{2}N_2(g) + \tfrac{1}{2}O_2(g) \rightarrow NO(g) \qquad \Delta H^{\ominus} = +90\,kJ\,mol^{-1}$$

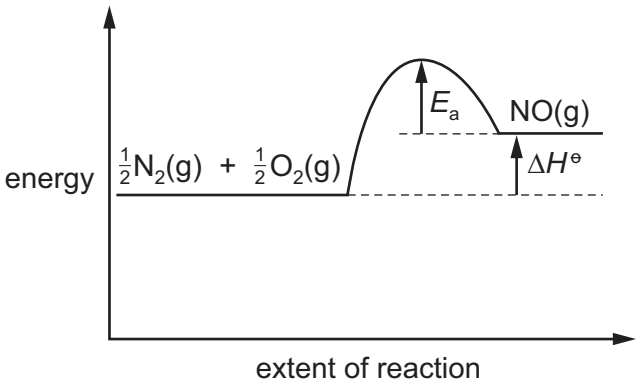
This reaction has activation energy E_a.

Which reaction pathway diagram could correctly represent this reaction?

A



B



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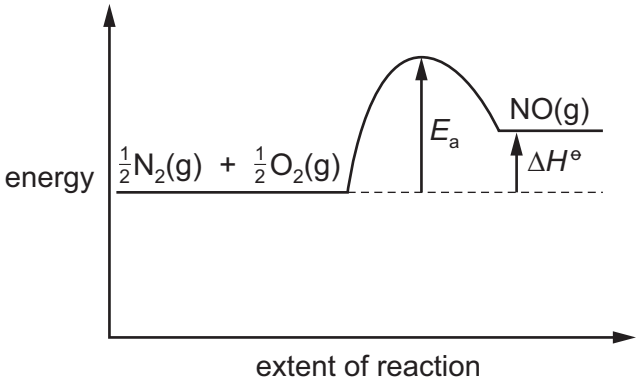

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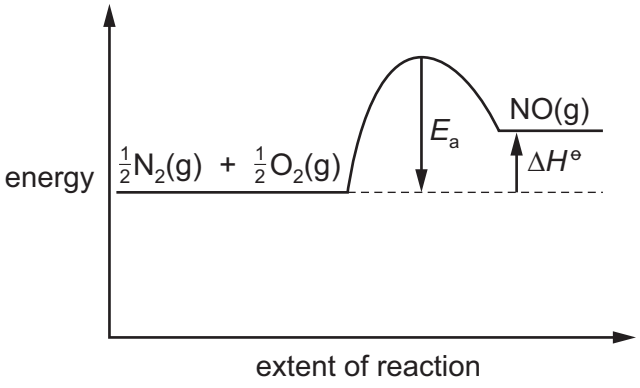


[Turn over

8 A reaction sequence is shown.

$$SO_2 \xrightarrow{1} SO_3 \xrightarrow{2} H_2SO_4 \xrightarrow{3} H_2S \xrightarrow{4} SO_2$$

In each stage of this sequence the sulfur is oxidised, reduced or neither oxidised nor reduced.

Which row is correct?

	1	2	3	4
A	neither	oxidised	reduced	reduced
B	oxidised	neither	reduced	reduced
C	oxidised	neither	reduced	oxidised
D	oxidised	oxidised	reduced	oxidised

9 Hydrogen and carbon dioxide gases are mixed at 800 K. A reversible reaction takes place.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

At equilibrium, the partial pressures of H_2 and CO_2 are both 10.0 kPa. K_p is 0.288 at 800 K.

What is the partial pressure of CO in the equilibrium mixture?

A 5.37 kPa **B** 18.6 kPa **C** 28.8 kPa **D** 347 kPa

10 A reaction involved in the Contact process is shown.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H^{\ominus} = -197\,kJ\,mol^{-1}$$

The reaction is investigated at 200 kPa and 700 K and the value of the equilibrium constant, K_p, is found to be Y. The reaction is then investigated at 1000 kPa and 700 K and the value of K_p is found to be Z.

Which statement comparing Y and Z is correct?

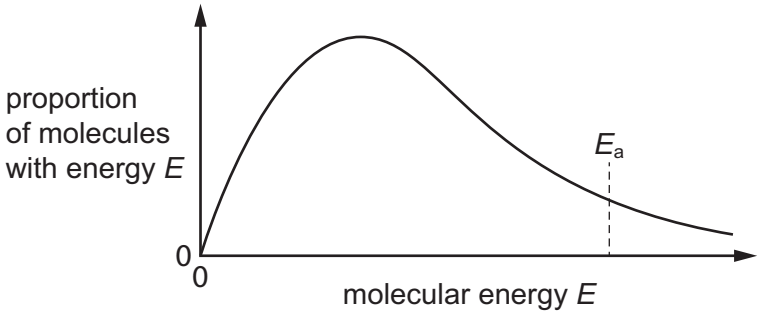
A Y and Z are the same.

B Y is greater than Z.

C Z is 2.2 times greater than Y.

D Z is 5.0 times greater than Y.

11 The Boltzmann distribution for the hydrogenation of an alkene at a particular temperature in the absence of a catalyst is shown.



Which row correctly describes the effects of adding nickel to the reaction vessel?

	the shape of the Boltzmann distribution	activation energy, E_a
A	changes	decreases
B	changes	increases
C	does not change	decreases
D	does not change	increases

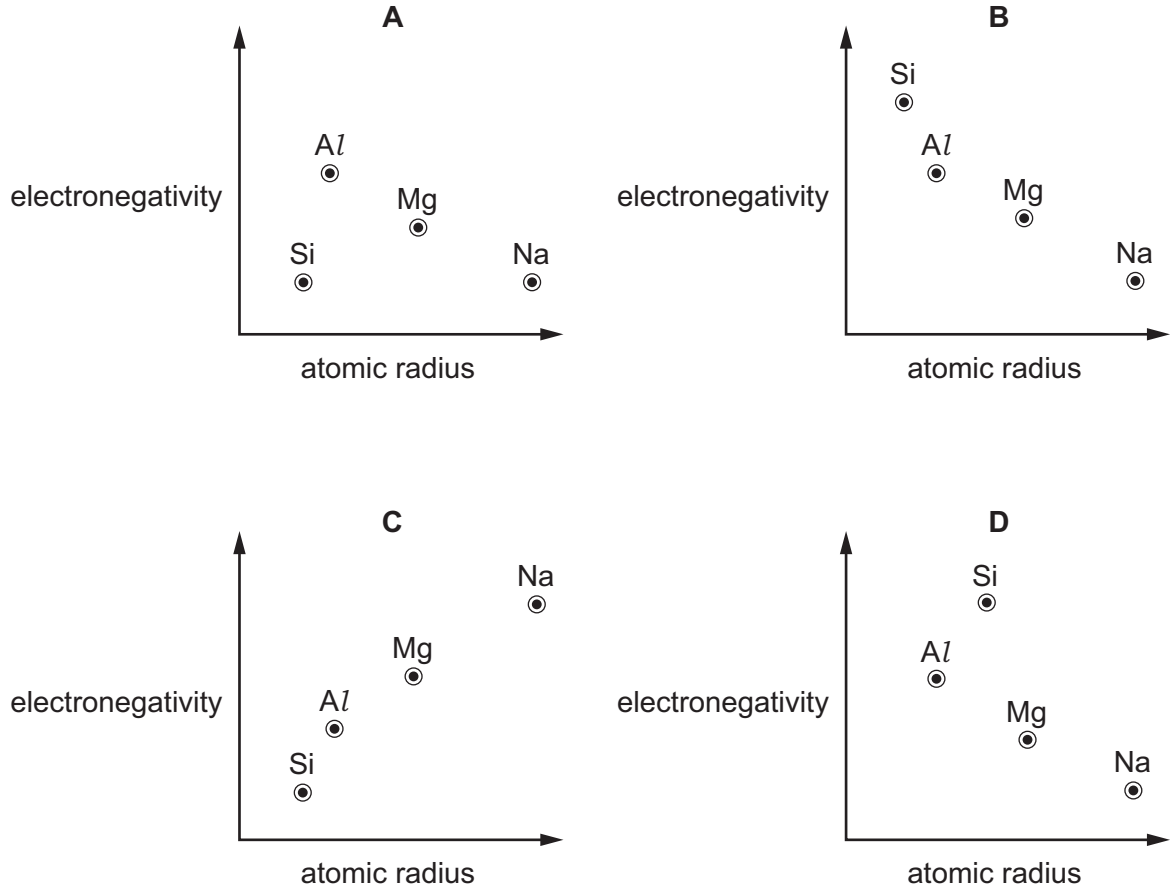
12 The elements magnesium and sulfur each form doubly charged ions.

How do the atomic radii and ionic radii of these elements compare?

	atomic radius		ionic radius	atomic radius		ionic radius
A	Mg	>	Mg^{2+}	S	>	S^{2-}
B	Mg	>	Mg^{2+}	S	<	S^{2-}
C	Mg	<	Mg^{2+}	S	>	S^{2-}
D	Mg	<	Mg^{2+}	S	<	S^{2-}

[Turn over

13 Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, A*l* and Si?



14 Trends are seen in the physical and chemical properties of the elements of Group 2 and their compounds.

Which property shows a **decrease** from magnesium to barium?

A the rate of the reaction between the element and dilute hydrochloric acid

B the solubility of the hydroxides

C the solubility of the sulfates

D the temperature of decomposition of the carbonates

15 Calcium oxide is added to water and the resulting mixture is filtered.

This filtrate is X.

When carbon dioxide is bubbled through filtrate X, a white precipitate is formed.

Which equation for this reaction of filtrate X with carbon dioxide is correct?

A $CaO + CO_2 \rightarrow CaCO_3$

B $Ca(OH)_2 + CO_2 \rightarrow CaO + H_2CO_3$

C $2CaO + H_2O + CO_2 \rightarrow CaCO_3 + Ca(OH)_2$

D $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

16 Element X reacts with cold, dilute, aqueous sodium hydroxide to form two different chlorine-containing products, Y and Z.

What are the oxidation states of chlorine in Y and Z?

	Y	Z
A	0	+1
B	0	+5
C	–1	+1
D	–1	+5

17 A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water.

Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was then added, this precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder be?

A sodium bromide only

B sodium iodide only

C a mixture of sodium chloride and sodium bromide

D a mixture of sodium chloride and sodium iodide

18 The ammonium ion is formed by the following reaction.

$$NH_3 + H^+ \rightarrow NH_4^+$$

Which statement about the species involved in this reaction is correct?

A The ammonia molecule contains a dative covalent bond.

B The ammonium ion is a Brønsted-Lowry base as it has accepted a proton.

C The H–N–H bond angle changes from 107° in ammonia to 90° in the ammonium ion.

D The number of electrons surrounding each nitrogen atom does not change.

19 A chemist took 2.00 dm^3 of nitrogen gas, measured under room conditions, and reacted it with a large volume of hydrogen gas to produce ammonia. Only 15.0% of the nitrogen gas reacted to produce ammonia.

Which mass of ammonia was formed?

A 0.213 g **B** 0.425 g **C** 1.42 g **D** 2.83 g

20 A carbonyl compound **X** will react with HCN in the presence of NaCN to make a compound with M_r 85. Compound **X** does **not** react with Fehling's reagent.

What is **X**?

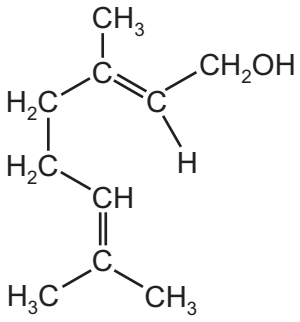
A butanal

B butanone

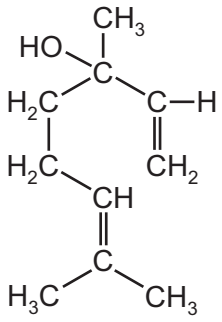
C propanal

D propanone

21 Geraniol and linalool are compounds found in some flower fragrances.



geraniol



linalool

Which statement is correct?

A They are chain isomers of each other.

B They are geometrical isomers of each other.

C They are optical isomers of each other.

D They are positional isomers of each other.

22 Which equation represents the initiation step of the substitution reaction between methane and chlorine?

A $CH_4 \rightarrow CH_3\bullet + H\bullet$

B $CH_4 \rightarrow CH_3^- + H^+$

C $Cl_2 \rightarrow 2Cl\bullet$

D $Cl_2 \rightarrow Cl^+ + Cl^-$

23 Aqueous sodium hydroxide reacts with 1-bromopropane to give propan-1-ol.

What should be included in a diagram of the first step in the mechanism?

A a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 1-bromopropane

B a curly arrow from the $C^{\delta+}$ atom of 1-bromopropane to the OH^- ion

C a curly arrow from the C–Br bond to the C atom

D the homolytic fission of the C–Br bond

24 A sample of 2.76 g of ethanol was mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The required organic product was then collected by distillation.

The yield of product was 75.0%.

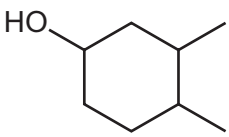
Which mass of product was collected?

A 1.26 g **B** 1.98 g **C** 2.07 g **D** 2.70 g

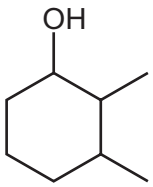
25 Compound X is a single, pure, optical isomer. X is heated with an excess of concentrated H_2SO_4. Only one organic product is formed.

What could X be?

A



B



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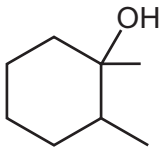
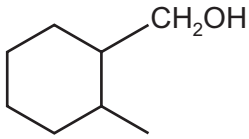


D



26 2-bromo-2-methylpropane undergoes nucleophilic substitution when heated under reflux with an aqueous solution of sodium hydroxide.

Which row is correct?

	mechanism for this reaction	reason
A	S_N1	the hydroxide ion is helped in its approach to the central carbon atom by the methyl groups
B	S_N1	the intermediate carbocation is stabilised by the inductive effect of the methyl groups
C	S_N2	the hydroxide ion is hindered in its approach to the central carbon atom by the methyl groups
D	S_N2	the intermediate carbocation is destabilised by the inductive effect of the methyl groups

27 $H_2NNHC_6H_3(NO_2)_2$ is the structural formula of 2,4-DNPH.

Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20 °C)?

A $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$

B $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$

C $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$

D $(CH_3)_2CO + H_2NNHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C{=}NNHC_6H_3(NO_2)_2 + H_2O$

28 A carboxylic acid, P, has no possible chain isomers. It reacts with an alcohol, Q, that has only one positional isomer.

What could be the ester formed from a reaction between P and Q?

A butyl propanoate

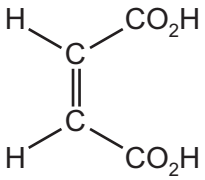
B ethyl butanoate

C pentyl ethanoate

D propyl pentanoate

29 Which compound is chiral and reacts with Na_2CO_3 to give CO_2?

A



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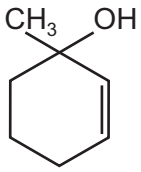

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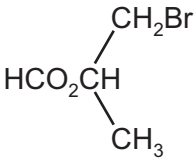

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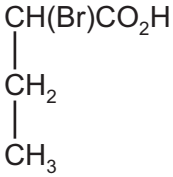


30 Which compound, when hydrolysed, gives propanoic acid and propan-2-ol?

A $CH_3CH_2CO_2CH_2CH(CH_3)CH_3$

B $(CH_3)_2CHCO_2CH_2CH_3$

C $CH_3CH_2CO_2CH(CH_3)CH_3$

D $CH_3CH_2CH_2CO_2CH(CH_3)CH_3$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 An isolated gaseous atom of element X has paired electrons in at least one of its 3d orbitals and has a filled 4s subshell.

What could be the identity of element X?

1 iron

2 gallium

3 copper

32 Which allotropes of carbon have a giant molecular structure?

1 buckminsterfullerene

2 diamond

3 graphite

33 Which statements about endothermic reactions are correct?

1 On the reaction pathway diagram the products of the reaction are lower than the reactants.

2 There is a net transfer of heat energy from the surroundings to the reacting system.

3 the total bond energies of the reactants > the total bond energies of the products

34 The rate of chemical reactions can be increased by the addition of a suitable catalyst.

For which reactions can a heterogeneous catalyst be used?

1 $N_2 + 3H_2 \rightleftharpoons 2NH_3$

2 $2SO_2 + O_2 \rightleftharpoons 2SO_3$

3 $2NO + 2CO \rightleftharpoons N_2 + 2CO_2$

35 Which chlorides, when added to water, can produce a solution with a pH of less than 5?

1 $SiCl_4$

2 $AlCl_3$

3 $MgCl_2$

36 Acid rain continues to be a problem.

Which statements about acid rain are correct?

1 Acid rain is formed when oxides of nitrogen or oxides of sulfur react with water in the atmosphere.

2 Acid rain causes an increase in the concentration of heavy metal ions in water courses.

3 Nitrogen dioxide will catalyse the formation of SO_3 from SO_2 in the atmosphere.

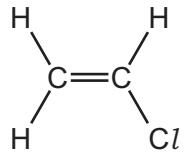
37 Which compounds contain a chiral centre?

1 2-hydroxybutanoic acid

2 3-hydroxybutanoic acid

3 4-hydroxybutanoic acid

38 The diagram shows the monomer used to make polyvinyl chloride, PVC.



Assuming that one particular molecule of the polymer forms from *n* molecules of the monomer (where *n* is many thousands), which statements are correct?

1 The relative molecular mass of this polymer molecule is approximately 62.5*n*.

2 There are *n* chiral carbon atoms in this polymer molecule.

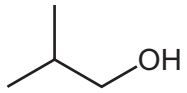
3 There are 5*n* σ bonds in one polymer molecule.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

39 An organic compound, X, has the following skeletal formula.



X

Which statements about X are correct?

1 X is a primary alcohol.

2 X will dehydrate to give a single alkene.

3 X will undergo a substitution reaction with chloride ions.

40 2,2,4-trimethylpentanal is used in the manufacture of adhesives.

Which reagents would 2,2,4-trimethylpentanal react with?

1 2,4-dinitrophenylhydrazine reagent

2 Tollens' reagent

3 alkaline aqueous iodine

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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2016**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

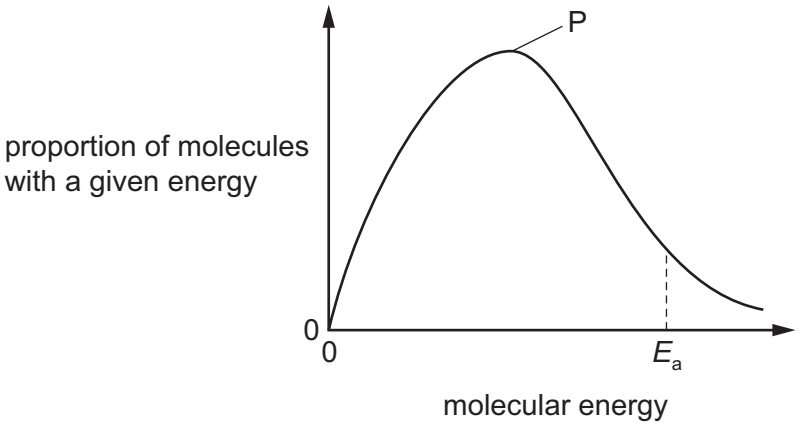
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 The diagram shows the Boltzmann distribution of energies in 1 mole of a gas. The gas can take part in a reaction with an activation energy, E_a.



Which statement correctly describes the effect of an increase in temperature?

A Peak P will be higher and fewer molecules will have energy > E_a.

B Peak P will be higher and more molecules will have energy > E_a.

C Peak P will be lower and fewer molecules will have energy > E_a.

D Peak P will be lower and more molecules will have energy > E_a.

2 Four electronic configurations are shown below. Three of these configurations belong to atoms of the elements chlorine, sodium and vanadium.

Which electronic configuration belongs to an atom of another element?

A $1s^2 2s^2 2p^6 3s^1$

B $1s^2 2s^2 2p^6 3s^2 3p^5$

C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

3 Elements X and Y are in the same group of the Periodic Table.

The table shows the first six ionisation energies of X and Y in $kJ\,mol^{-1}$.

	1st	2nd	3rd	4th	5th	6th
X	800	1600	2400	4300	5400	10400
Y	1000	1800	2700	4800	6000	12300

What could be the identities of X and Y?

	X	Y
A	antimony, Sb	arsenic, As
B	arsenic, As	antimony, Sb
C	selenium, Se	tellurium, Te
D	tellurium, Te	selenium, Se

4 In China, the concentration of blood glucose, $C_6H_{12}O_6$, is measured in mmol / l. In Pakistan, the concentration of blood glucose is measured in mg / dl.

The unit l is a litre ($1\,dm^3$). The unit dl is a decilitre ($0.1\,dm^3$).

A blood glucose concentration of 18.5 mmol / l indicates a health problem.

What is 18.5 mmol / l converted to mg / dl?

A 33.3 mg / dl **B** 178 mg / dl **C** 333 mg / dl **D** 3330 mg / dl

5 Each of the four species in this question are isolated and gaseous.

Which species is **not** planar?

A BF_3 **B** CH_3^+ **C** C_2H_4 **D** NH_3

6 Argon is a gas used to fill electric light bulbs.

Under which conditions of pressure and temperature will argon behave most like an ideal gas?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

7 0.10 g of the volatile liquid X formed 0.025 dm^3 of vapour at 100 °C and atmospheric pressure.

1 mol of vapour occupies 22.4 dm^3 at 0 °C and atmospheric pressure.

What is the relative molecular mass of X?

A $\frac{0.025 \times 273 \times 22.4}{0.10 \times 373}$

B $\frac{0.025 \times 373 \times 22.4}{0.10 \times 273}$

C $\frac{0.10 \times 273 \times 22.4}{0.025 \times 373}$

D $\frac{0.10 \times 373 \times 22.4}{0.025 \times 273}$

8 The equation for the complete combustion of propan-1-ol is shown.

$$CH_3CH_2CH_2OH(l) + 4\tfrac{1}{2}O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Standard enthalpy changes of formation are given.

compound	$CH_3CH_2CH_2OH(l)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f^{\ominus}$	–303 kJ mol^{-1}	–394 kJ mol^{-1}	–286 kJ mol^{-1}

What is the standard enthalpy change of combustion of propan-1-ol, in kJ mol^{-1}?

A –394 – 286 – 303

B 303 – (4 × 286) – (3 × 394)

C 394 + 286 – 303

D (3 × 394) + (4 × 286) + 303

9 In the treatment of domestic water supplies, chlorine is added to the water to form HC*l*O.

$$Cl_2(aq) + H_2O(l) \rightarrow H^+(aq) + Cl^-(aq) + HClO(aq)$$

The HC*l*O reacts further to give C*l*O^- ions.

$$HClO(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO^-(aq)$$

Both HC*l*O and C*l*O^- kill bacteria by oxidation.

What is the change in oxidation number of chlorine when forming the C*l*O^- ion from aqueous chlorine?

A –1 **B** 0 **C** +1 **D** +2

10 When solid ammonium chloride dissociates at a certain temperature in a 0.500 dm^3 container, ammonia and hydrogen chloride are formed.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

The initial amount of ammonium chloride was 1.00 mol, and when the system had reached equilibrium there was 0.300 mol of ammonium chloride.

What is the numerical value of K_c for this reaction under these conditions?

A 0.490 **B** 1.63 **C** 1.96 **D** 3.27

11 Which stage in the free radical substitution of ethane by chlorine has the lowest activation energy?

A $Cl_2 \rightarrow 2Cl\bullet$

B $Cl\bullet + C_2H_6 \rightarrow C_2H_5\bullet + HCl$

C $C_2H_5\bullet + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$

D $Cl\bullet + C_2H_5\bullet \rightarrow C_2H_5Cl$

12 Sodium and sulfur react together to form sodium sulfide, Na_2S.

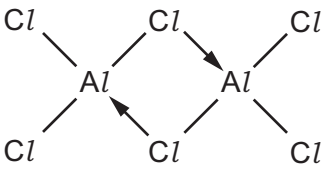
How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
A	sodium < sulfur	sodium > sulfur
B	sodium < sulfur	sodium < sulfur
C	sodium > sulfur	sodium > sulfur
D	sodium > sulfur	sodium < sulfur

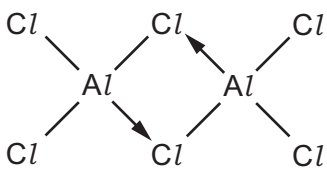
13 Solid aluminium chloride sublimes at 178 °C.

Which structure best represents the species in the vapour at this temperature?

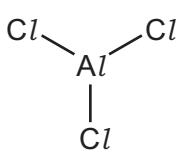
A



B



C



D

$Al^{3+}(Cl^-)_3$

14 A 0.005 mol sample of anhydrous calcium carbonate was completely thermally decomposed to give 100 cm^3 of gas measured at a certain temperature and pressure.

In a separate experiment carried out at the same temperature and pressure, a 0.005 mol sample of anhydrous calcium nitrate was completely thermally decomposed. The volume of gaseous products was measured.

What total volume of gaseous products was produced from the calcium nitrate?

A 50 cm^3 **B** 100 cm^3 **C** 200 cm^3 **D** 250 cm^3

15 Ammonia gas, NH_3, and hydrogen sulfide gas, H_2S, react together to form the salt ammonium sulfide, $(NH_4)_2S$. Ammonium sulfide dissolves in water to produce an orange alkaline solution.

$$(NH_4)_2S(aq) \rightleftharpoons NH_3(aq) + NH_4SH(aq)$$

The addition of NaOH(aq) to this solution produces a gas, **X**.
The addition of HC*l*(aq) to a separate portion of this solution produces a gas, **Y**.

What are the identities of **X** and **Y**?

	X	**Y**
A	H_2S	H_2S
B	H_2S	NH_3
C	NH_3	H_2S
D	NH_3	NH_3

16 A solid, **T**, was placed in an excess of the liquid **U**.

A colourless gas was given off and a white precipitate was seen. The precipitate was not **T**.

What could be the identities of **T** and **U**?

	T	**U**
A	$BaCO_3$	H_2O
B	Ca	dilute H_2SO_4
C	Mg	dilute H_2SO_4
D	$SrCO_3$	dilute HC*l*

17 Nitrogen(II) oxide, NO, nitrogen(IV) oxide, NO_2, carbon monoxide, CO, and unburnt hydrocarbons are present in the exhaust gases of internal combustion engines. When catalytic converters are used to remove these compounds from the exhaust gases, redox reactions occur.

What happens to each compound in the catalytic converter?

	NO	NO_2	CO	hydrocarbons
A	oxidised	oxidised	reduced	oxidised
B	oxidised	oxidised	oxidised	oxidised
C	reduced	reduced	oxidised	oxidised
D	reduced	reduced	reduced	reduced

18 An excess of chlorine gas, Cl_2, is passed through 60 cm^3 of cold aqueous 0.1 mol dm^{-3} sodium hydroxide. In a separate experiment an excess of chlorine gas is passed through 60 cm^3 of hot aqueous 0.1 mol dm^{-3} sodium hydroxide until no further reaction takes place.

How much **more** sodium chloride will be produced by the reaction with hot NaOH than with cold NaOH?

A 0.002 moles

B 0.003 moles

C 0.005 moles

D 0.006 moles

19 Fluorine and iodine are Group 17 elements. Their melting points are different due to differing strengths of van der Waals' forces between molecules.

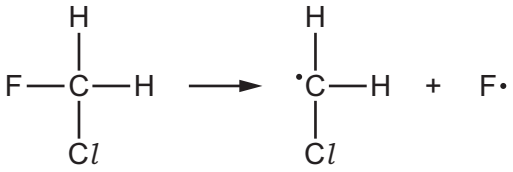
Which row is correct?

	melting point	strength of van der Waals' forces between molecules
A	$F_2 > I_2$	$F_2 > I_2$
B	$F_2 > I_2$	$F_2 < I_2$
C	$F_2 < I_2$	$F_2 < I_2$
D	$F_2 < I_2$	$F_2 > I_2$

20 Chlorofluorocarbons damage the ozone layer by undergoing reactions with a free radical mechanism. The first stage of this is initiation.

Which equation is most likely to be the initiation stage when chlorofluoromethane is involved in such a reaction?

A



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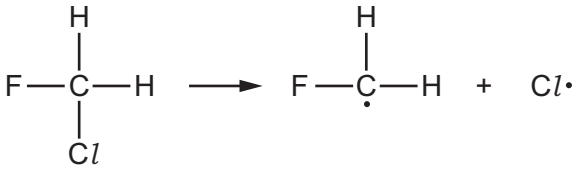

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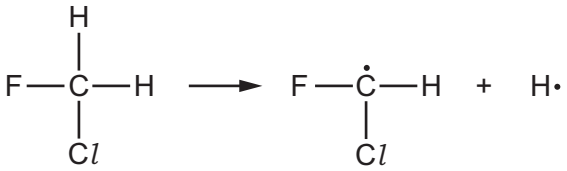

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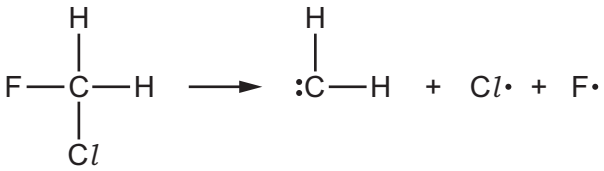


21 Synthetic resins can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $CH_2{=}CHCH_2OH$.

Which structure represents the repeat unit in poly(prop-2-en-1-ol)?

A $\left[CH_2-CH_2-CH_2-O \right]$

B $\left[CH_2-CH(CH_2OH) \right]$

C $\left[CH=C(CH_2OH) \right]$

D $\left[CH_2-CH_2-CH(OH) \right]$

22 Oct-1-ene, $CH_3(CH_2)_5CH=CH_2$, can be thermally cracked.

Which combination of compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?

$CH_2=CH_2$	$CH_3CH=CH_2$	$CH_3CH_2CH_3$	$CH_2=CHCH=CH_2$
W	X	Y	Z

A W, X, Y and Z

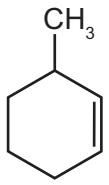
B W, X and Y only

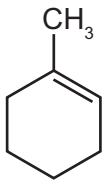
C W, X and Z only

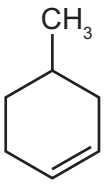
D W and X only

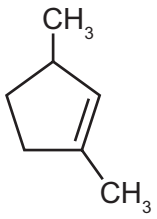
23 A cycloalkene with the molecular formula C_7H_{12} was oxidised by hot concentrated acidified MnO_4^-. The only organic product was 2-methylhexane-1,6-dioic acid.

What is the identity of the cycloalkene?

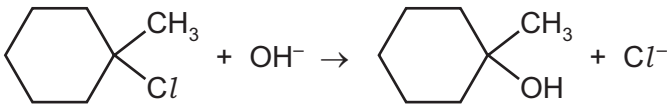
A 

B 

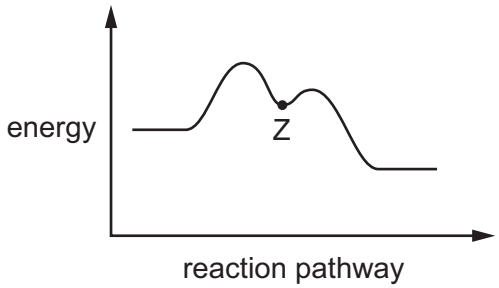
C 

D 

24 1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq).



The reaction pathway is shown.

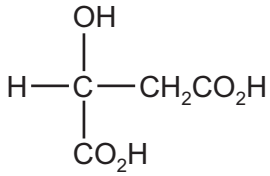


One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.

What is the charge on this carbon atom at point Z?

A $\delta+$ **B** + **C** $\delta-$ **D** –

25 Malic acid is found in apples.



malic acid

Which reagent will react with only one of the –OH groups in the malic acid molecule?

A ethanoic acid in the presence of concentrated sulfuric acid

B sodium

C sodium hydrogen carbonate

D sodium hydroxide

26 Which organic compound would **not** give **either** a yellow precipitate when treated with alkaline aqueous iodine **or** an orange precipitate when treated with 2,4-dinitrophenylhydrazine reagent?

A propanal

B propan-1-ol

C propan-2-ol

D propanone

27 In which reaction is the organic compound oxidised?

A $CH_3CH_2CH_2CHO$ + Tollens' reagent

B $CH_3CH_2CH_2CHO$ + $LiAlH_4$

C $CH_3CH_2CH_2OH$ + concentrated H_3PO_4

D $CH_3CO_2C_2H_5$ + dilute H_2SO_4

28 How many of the following compounds produce a carboxylic acid on heating under reflux with an excess of hot acidified $K_2Cr_2O_7$?

CH_3CH_2CHO

CH_3COCH_3

$CH_3CH_2CH_2OH$

$CH_3CH(OH)CH_3$

A 1 **B** 2 **C** 3 **D** 4

29 How many isomeric esters, including structural isomers and stereoisomers, can be made with the molecular formula $C_5H_{10}O_2$, if methanoic acid is one of the two reactants used?

A 2 **B** 3 **C** 4 **D** 5

30 Compound X, $C_4H_8O_2$, has an unbranched carbon chain. An aqueous solution of X has an approximate pH of 3.

Compound Y, C_3H_8O, is a secondary alcohol.

X and Y are reacted together in the presence of a little concentrated sulfuric acid to form Z as the major organic product.

What is the structural formula of Z?

A $(CH_3)_2CHCO_2CH_2CH_2CH_3$

B $CH_3(CH_2)_2CO_2CH(CH_3)_2$

C $CH_3(CH_2)_2CO_2(CH_2)_2CH_3$

D $(CH_3)_2CHCO_2CH(CH_3)_2$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 In an experiment, 10 cm^3 of an organic compound, **J**, in the gaseous state was sparked with an excess of oxygen. 20 cm^3 of carbon dioxide and 5 cm^3 of nitrogen were obtained among the products. All gas volumes were measured at the same temperature and pressure.

What could be the identity of **J**?

1 $C_2H_6N_2$

2 C_2H_3N

3 C_2H_7N

32 Three elements, X, Y and Z, have electronic configurations as shown.

X	Y	Z
2,6	2,8,1	2,8,7

Which formulae represent compounds that conduct electricity in the liquid state?

1 YZ

2 Y_2X

3 Z_2X

33 In this question, all gases can be assumed to behave ideally.

A chemist heats a mixture of nitrogen and oxygen gases in a sealed container at a constant temperature until the mixture reaches a dynamic equilibrium containing $N_2(g)$, $O_2(g)$ and NO(g).

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

The chemist repeats the experiment at the same temperature using the same initial amounts of $N_2(g)$ and $O_2(g)$, but at a much higher pressure.

Which statements about the second experiment at higher pressure are correct?

1 At higher pressure, there are more particles per unit volume.

2 The composition of the equilibrium mixture does not change.

3 There are more collisions per second so equilibrium is reached faster.

34 An ethanol burner can be used to heat water. If appropriate measurements are taken, a value for the enthalpy of combustion of ethanol can be calculated. The equation

$$\text{heat transferred} = -mc\Delta T$$

is used as part of the calculation.

Which symbols are correctly described?

1 ΔT is the change in temperature of the water.

2 m is the mass of water used in the experiment.

3 c is the specific heat capacity of ethanol.

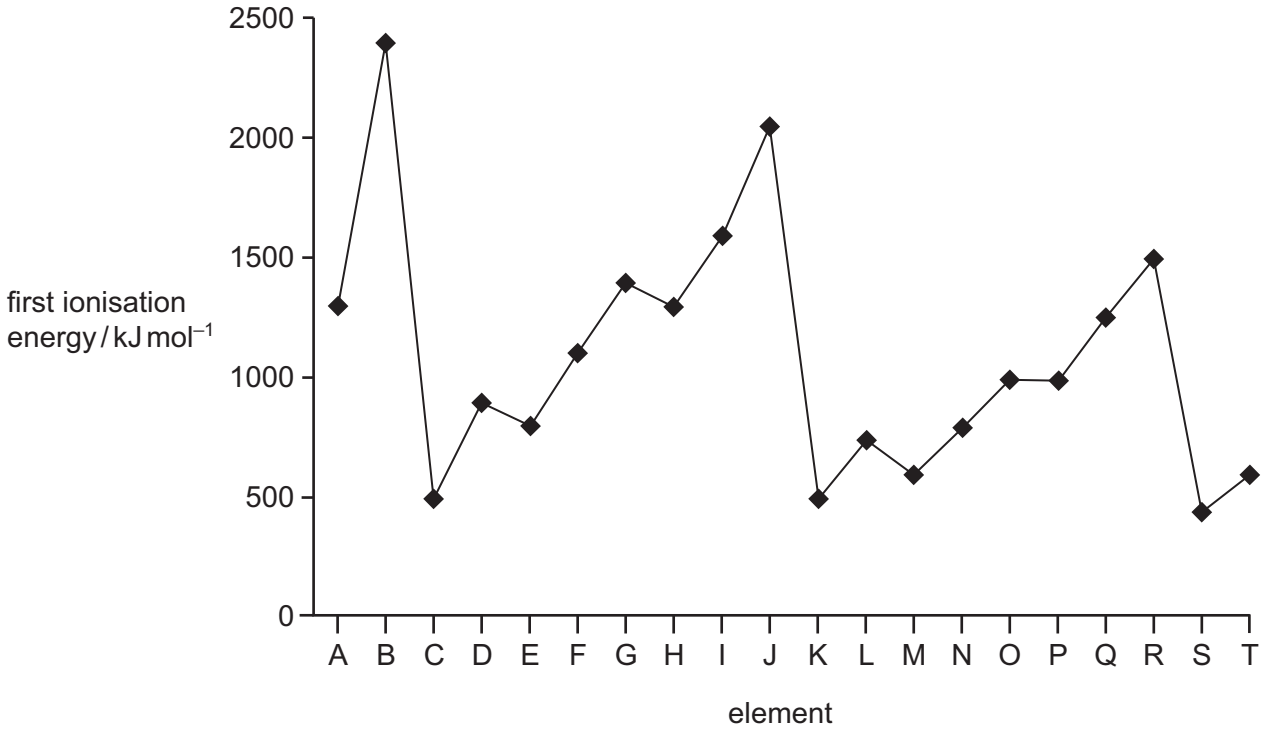
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

35 The first ionisation energies of twenty successive elements in the Periodic Table are represented in the graph.

The letters given are not the normal symbols for these elements.



Which statements about this graph are correct?

1 Elements B, J and R are in Group 18 of the Periodic Table.

2 Atoms of elements D and L contain two electrons in their outer shells.

3 Atoms of elements G and O contain a half-filled p subshell.

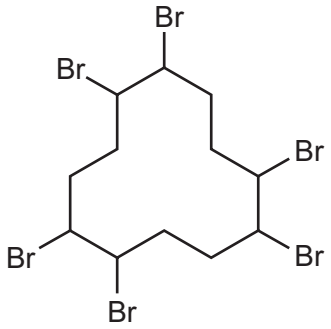
36 Which properties increase in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide?

1 thermal stability

2 bond length

3 ease of oxidation

37 The diagram shows a compound used as a flame retardant.



Which statements about this structure are correct?

1 The empirical formula is C_2H_3Br.

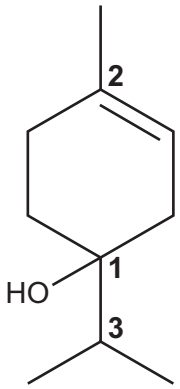
2 The C_{12} ring is not planar.

3 There are six chiral carbon atoms.

38 One of the active ingredients in tea-tree oil is terpinen-4-ol.

In the diagram of the skeletal formula of terpinen-4-ol, three of the carbon atoms are labelled **1**, **2** and **3**.

Which of the labelled carbon atoms are chiral?



terpinen-4-ol

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

39 Propanal reacts with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \xrightarrow{NaCN} CH_3CH_2CH(OH)CN$$

Which statements about the reaction of propanal with hydrogen cyanide are correct?

1 The sodium cyanide provides a stronger nucleophile than HCN.

2 The reaction can be classified as nucleophilic substitution.

3 The hydrogen cyanide molecule attacks the propanal molecule to form an intermediate ion.

40 Which syntheses will be successful?

1 $CH_3CH_2CH_3$ from $CH_3CH{=}CH_2$ + $LiAlH_4$

2 $CH_3CH(OH)CH_3$ from CH_3COCH_3 + $NaBH_4$

3 $CH_3CH_2CH_2OH$ from CH_3CH_2CHO + $NaBH_4$

Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2015**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

* 5 8 8 2 2 6 7 3 8 2 *

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **15** printed pages and **1** blank page.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 *Use of the Data Booklet is relevant to this question.*

In which option do all three particles have the same electronic configuration **and** the same number of neutrons?

A $^{15}N^{3-}$ $^{16}O^{2-}$ $^{19}F^{-}$

B $^{18}O^{2-}$ $^{19}F^{-}$ ^{20}Ne

C $^{19}F^{-}$ ^{20}Ne $^{23}Na^{+}$

D ^{22}Ne ^{23}Na $^{24}Mg^{2+}$

2 The shell of a chicken's egg makes up 5% of the mass of an average egg. An average egg has a mass of 50 g.

Assume the egg shell is pure calcium carbonate.

How many complete chicken's egg shells would be needed to neutralise 50 cm^3 of 2.0 mol dm^{-3} ethanoic acid?

A 1 **B** 2 **C** 3 **D** 4

3 Phosphorus forms a compound with hydrogen called phosphine, PH_3. This compound can react with a hydrogen ion, H^+.

Which type of interaction occurs between PH_3 and H^+?

A dative covalent bond

B dipole-dipole forces

C hydrogen bond

D ionic bond

4 Which solid has a simple molecular lattice?

A calcium fluoride

B nickel

C silicon(IV) oxide

D sulfur

5 *Use of the Data Booklet is relevant to this question.*

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

The volume of a sample of methane is measured at a temperature of 60 °C and a pressure of 103 kPa. The volume measured is 5.37×10^{-3} m^3.

Assume the gas behaves as an ideal gas.

What is the mass of the sample of methane, given to two significant figures?

A 0.00018 g **B** 0.0032 g **C** 0.18 g **D** 3.2 g

6 Metaldehyde, $(CH_3CHO)_4$, is used as a solid fuel for camping stoves. The equation for the complete combustion of metaldehyde is shown.

$$(CH_3CHO)_4(s) + 10\,O_2(g) \rightarrow 8CO_2(g) + 8H_2O(l)$$

$\Delta H_c^{\ominus}$ = standard enthalpy change of combustion.

Which expression will give a correct value for the enthalpy change of formation of metaldehyde?

A $\Delta H_c^{\ominus}$metaldehyde – (8$\Delta H_c^{\ominus}$carbon + 8$\Delta H_c^{\ominus}$hydrogen)

B $\Delta H_c^{\ominus}$metaldehyde – (8$\Delta H_c^{\ominus}$carbon + 16$\Delta H_c^{\ominus}$hydrogen)

C (8$\Delta H_c^{\ominus}$carbon + 8$\Delta H_c^{\ominus}$hydrogen) – $\Delta H_c^{\ominus}$metaldehyde

D (8$\Delta H_c^{\ominus}$carbon + 16$\Delta H_c^{\ominus}$hydrogen) – $\Delta H_c^{\ominus}$metaldehyde

7 In industry, copper metal is purified by electrolysis.

Which changes occur to the masses of the electrodes and to the colour of the electrolyte during this process?

	mass of anode	mass of cathode	colour of electrolyte
A	decrease	increase	little or no change occurs
B	decrease	increase	pale blue to blue
C	increase	decrease	little or no change occurs
D	increase	decrease	blue to pale blue

8 Nitrogen dioxide, NO_2, exists in equilibrium with dinitrogen tetroxide, N_2O_4.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -57\,kJ\,mol^{-1}$$

Which conditions give the greatest percentage of $N_2O_4(g)$ at equilibrium?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

9 When a sample of HI is warmed to a particular temperature the equilibrium below is established.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

At this temperature, it is found that the partial pressure of HI(g) is 28 times the partial pressure of $H_2(g)$.

What is the value of K_p at this temperature?

A 1.28×10^{-3} **B** 0.035 **C** 28 **D** 784

10 Photochromic glass, used for sunglasses, darkens when exposed to bright light and becomes more transparent again when the light is less bright. The darkness of the glass is related to the concentration of silver atoms.

The following reactions are involved.

reaction 1 $Ag^+ + Cl^- \rightleftharpoons Ag + Cl$

reaction 2 $Cu^+ + Cl \rightarrow Cu^{2+} + Cl^-$

reaction 3 $Cu^{2+} + Ag \rightarrow Cu^+ + Ag^+$

Which statement about these reactions is correct?

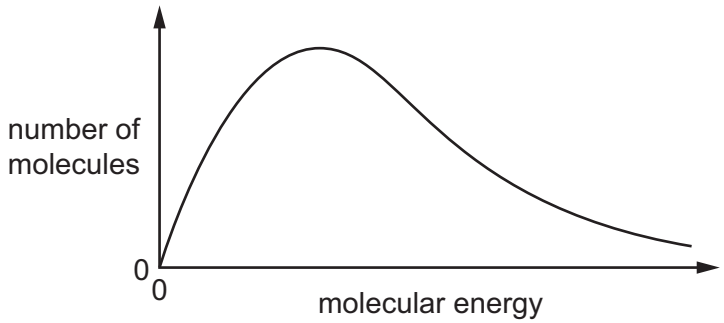
A Cu^+ and Cu^{2+} ions act as catalysts.

B Cu^+ ions act as an oxidising agent in reaction 2.

C Reaction 3 increases the darkness of the glass.

D Silver atoms are reduced in reaction 3.

11 The Boltzmann distribution below shows the distribution of molecular energies in a sample of a gas at a given temperature.



Which statement correctly describes the change in such a distribution if the temperature is increased?

A Fewer molecules possess the most probable energy value and this value shifts to the left.

B Fewer molecules possess the most probable energy value and this value shifts to the right.

C More molecules possess the most probable energy value and this value shifts to the left.

D The area under the curve of the distribution increases.

12 *Use of the Data Booklet is relevant to this question.*

When 3.00 g of an anhydrous nitrate of a Group II metal is decomposed, 1.53 g of gas is produced.

What is the nitrate compound?

A beryllium nitrate

B calcium nitrate

C magnesium nitrate

D strontium nitrate

13 What happens when a piece of magnesium ribbon is placed in cold water?

A A vigorous effervescence occurs.

B Bubbles of gas form slowly on the magnesium.

C The magnesium floats on the surface of the water and reacts quickly.

D The magnesium glows and a white solid is produced.

14 Compound **X** releases carbon dioxide gas and forms a white solid, **Y**, when it is heated. Neither **X** nor **Y** are soluble in water. Compound **Y** is used as a refractory kiln lining.

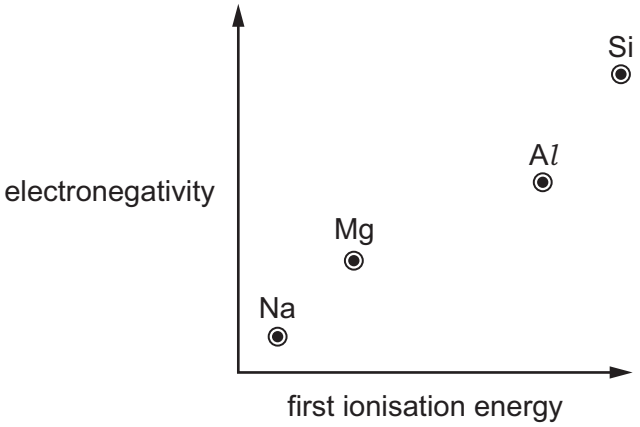
What is compound **X**?

A $CaCO_3$ **B** CaO **C** $MgCO_3$ **D** MgO

15 *Use of the Data Booklet is relevant to this question.*

Which diagram correctly shows the electronegativity of the elements Na, Mg, A*l* and Si plotted against their first ionisation energies?

A



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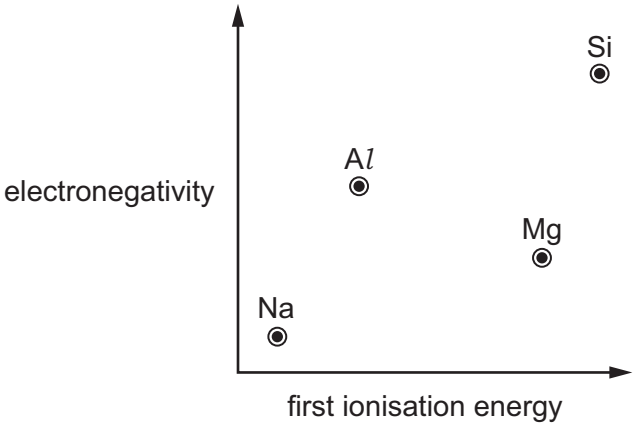

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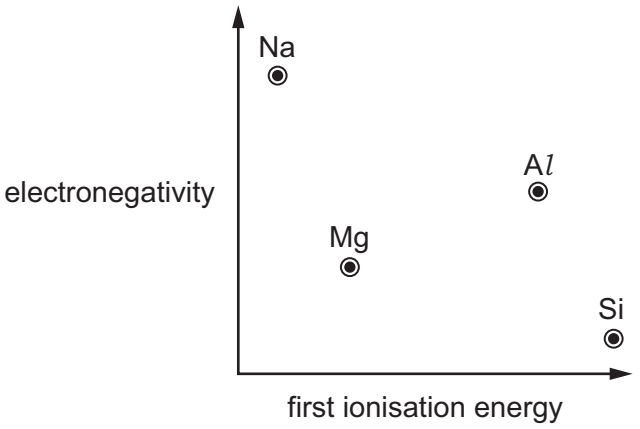
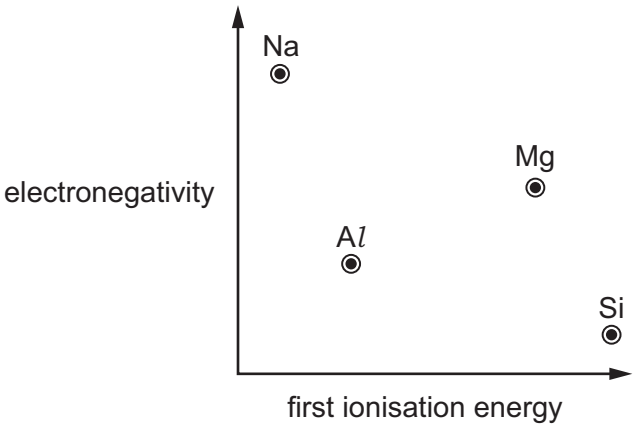
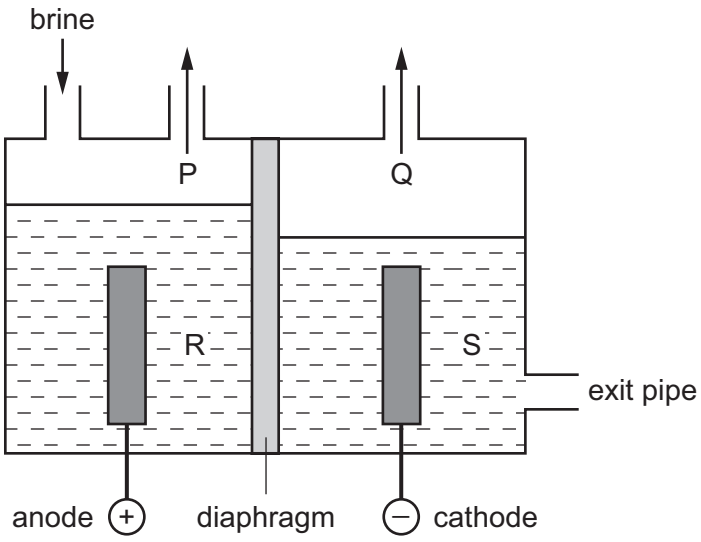


D



16 The diagram shows a diaphragm cell used for the electrolysis of brine. Brine is concentrated aqueous sodium chloride.



A solution of sodium chlorate(I), commonly used as bleach, can be made by mixing which two substances?

A P and R **B** P and S **C** Q and R **D** Q and S

17 Which statement about the ammonium ion, NH_4^+, is correct?

A All bond angles are 107°.

B Ammonium ions are formed when ammonia behaves as an acid.

C Ammonium ions are unreactive when heated with NaOH(aq).

D The bonds are all the same length.

18 Carbon monoxide, CO, nitrogen dioxide, NO_2, and sulfur dioxide, SO_2, are all atmospheric pollutants.

Which reaction concerning these compounds occurs in the atmosphere?

A CO is spontaneously oxidised to CO_2

B NO_2 is reduced to NO by CO

C NO_2 is reduced to NO by SO_2

D SO_2 is oxidised to SO_3 by CO_2

19 Chlorate(V) ions, ClO_3^-, are produced in the redox reaction between chlorine and hot aqueous sodium hydroxide. Oxidation numbers can be used to help balance the equation for this reaction.

What will be the values of coefficients **v**, **x** and **y** in the balanced equation?

$$\mathbf{v}Cl_2(g) + \mathbf{w}OH^-(aq) \rightarrow \mathbf{x}Cl^-(aq) + \mathbf{y}ClO_3^-(aq) + \mathbf{z}H_2O(l)$$

	v	**x**	**y**
A	2	3	1
B	3	4	2
C	3	5	1
D	7	12	2

20 Which alcohol will react with an acidified solution of potassium dichromate(VI) to produce a ketone containing six carbon atoms?

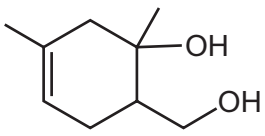
A 2,2-dimethylbutan-1-ol

B 2-methylpentan-3-ol

C 3,3-dimethylpentan-2-ol

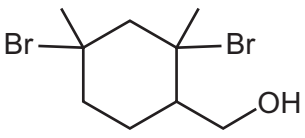
D 3-methylpentan-3-ol

21 What is the major product formed when compound Q is warmed with excess HBr?



Q

A



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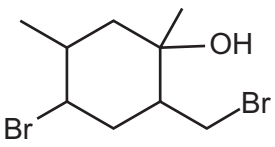

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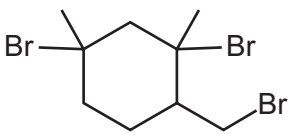

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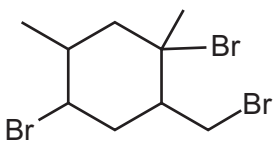


22 Four students, W, X, Y and Z, made the following statements about alkanes and alkenes.

W 'Bromine reacts with alkanes by electrophilic substitution.'

X 'Bromine reacts with alkenes by a free-radical addition mechanism.'

Y 'Alkenes can be oxidised by acidified manganate(VII) ions.'

Z 'Alkenes are formed from alkanes by cracking.'

Which two students are correct?

A W and X **B** W and Z **C** X and Y **D** Y and Z

23 Butanedioic acid may be synthesised in two steps from 1,2-dibromoethane.

$$BrCH_2CH_2Br \xrightarrow{\text{step 1}} X \xrightarrow{\text{step 2}} HO_2CCH_2CH_2CO_2H$$

Which reagents could be used for this synthesis?

	step 1	step 2
A	HCN(g)	HC*l*(aq)
B	HCO_2Na(aq)	HC*l*(aq)
C	KCN(alcoholic)	H_2SO_4(aq)
D	NaOH(aq)	$K_2Cr_2O_7 / H_2SO_4$(aq)

24 Which reaction would **not** give propene?

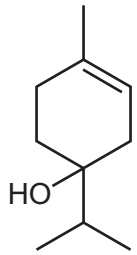
A adding excess hot concentrated sulfuric acid to propan-1-ol

B adding warm aqueous sodium hydroxide to 2-bromopropane

C adding warm ethanolic sodium hydroxide to 1-bromopropane

D passing propan-2-ol vapour over heated aluminium oxide

25 Terpinen-4-ol is one of the active ingredients in tea tree oil.



terpinen-4-ol

What is the molecular formula of terpinen-4-ol?

A $C_7H_{11}O$ **B** $C_{10}H_{16}O$ **C** $C_{10}H_{17}O$ **D** $C_{10}H_{18}O$

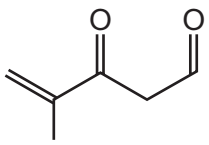
26 *Use of the Data Booklet is relevant to this question.*

2.40 g of propan-2-ol were mixed with excess acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for twenty minutes. The organic product was then collected by distillation. The yield of product was 75.0%.

What mass of product was collected?

A 1.74 g **B** 1.80 g **C** 2.22 g **D** 2.32 g

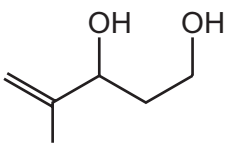
27 The diagram shows the structure of compound X.



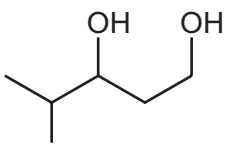
X

What is the product of the reaction between compound X and an excess of $NaBH_4$?

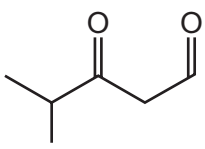
A



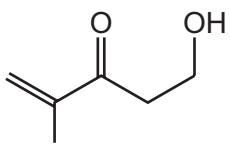
B



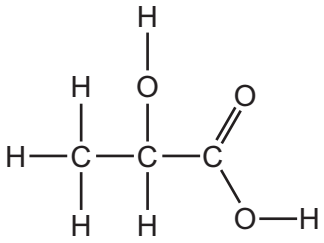
C



D



28 Lactic acid occurs naturally, for example in sour milk.



lactic acid

What is a property of lactic acid?

A It decolourises aqueous bromine rapidly.

B It is insoluble in water.

C It reduces Fehling's reagent.

D Two molecules react with each other in the presence of a strong acid.

29 Citric acid is found in lemon juice.

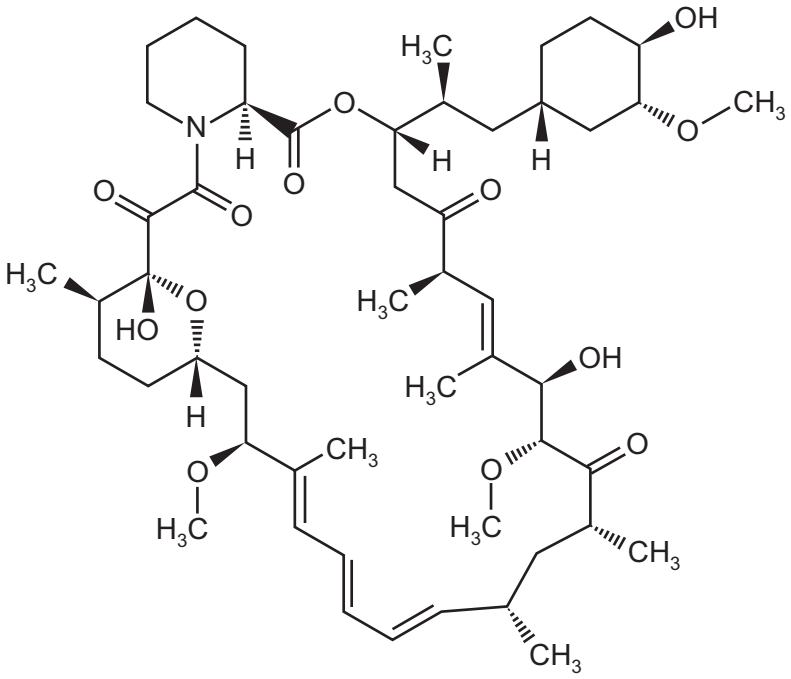
$HO_2CCH_2C(OH)(CO_2H)CH_2CO_2H$

citric acid

What is the volume of 0.4 mol dm^{-3} sodium hydroxide solution required to neutralise a solution containing 0.005 mol of citric acid?

A 12.5 cm^3 **B** 25.0 cm^3 **C** 37.5 cm^3 **D** 50.0 cm^3

30 The drug *Sirolimus* is used to treat patients after kidney transplants.

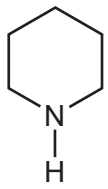


Sirolimus

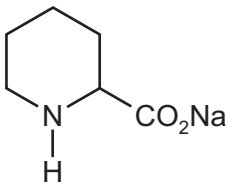
On reaction with hot aqueous sodium hydroxide, *Sirolimus* produces an equimolar mixture of two organic products.

What is the structural formula of the product with the lower relative molecular mass?

A



B



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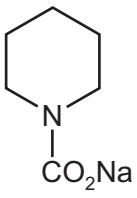

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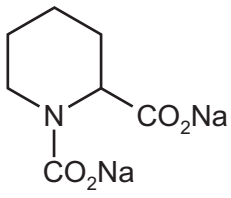


Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 *Use of the Data Booklet is relevant to this question*.

Which statements about the phosphide ion, $^{31}P^{3-}$, and the chloride ion, $^{35}Cl^{-}$, are correct?

1 They have the same number of electrons.

2 They have the same number of neutrons.

3 They have the same number of protons.

32 Why does aluminium chloride, Al_2Cl_6, sublime at the relatively low temperature of 180 °C?

1 The intermolecular forces between the Al_2Cl_6 molecules are weak.

2 The co-ordinate bonds between aluminium and chlorine are weak.

3 The covalent bonds between aluminium and chlorine are weak.

33 Which statements are correct for **all** exothermic reactions?

1 ΔH for the reaction is negative.

2 On a reaction pathway diagram the products are shown lower than the reactants.

3 The reaction will happen spontaneously.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 Which of these reactions are redox reactions?

1 $6NO(g) + 4NH_3(g) \rightarrow 5N_2(g) + 6H_2O(g)$

2 $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

3 $SO_3(g) + H_2O(g) \rightarrow H_2SO_4(g)$

35 When added to water, which oxides will cause a change in the pH of the water?

1 SiO_2

2 CaO

3 SO_2

36 Halogenated hydrocarbons have many uses.

What have halogenated hydrocarbons been used for?

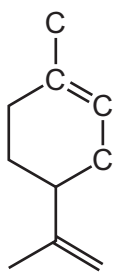
1 solvents

2 refrigerants

3 monomers in polymer manufacture

37 In which structures do the four carbon atoms labelled C lie in the same plane?

1



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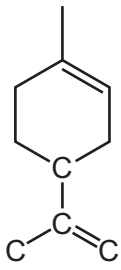

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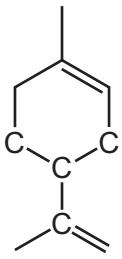


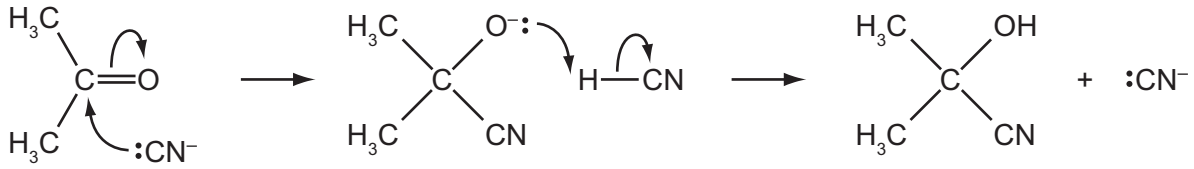
38 Which statements about 2-methylbutan-1-ol are correct?

1 It can give HCl(g) on reaction with PCl_5.

2 It can be oxidised to give an aldehyde.

3 It exists in two optically active forms.

39 Propanone and hydrogen cyanide react together by this mechanism.



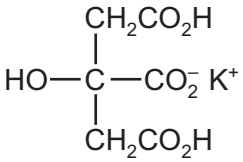
Which statements about this mechanism are correct?

1 CN^- is an electrophile.

2 It is an addition reaction.

3 Heterolytic bond breaking is involved.

40 Monopotassium citrate is used as an emulsifying agent in powdered milk and in powdered soups. It may be represented by the formula shown.



monopotassium citrate

Which statements about monopotassium citrate are correct?

1 It does **not** have a chiral carbon atom.

2 It can act as a dibasic acid.

3 It reacts with $NaHCO_3$ to give CO_2.

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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2014**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

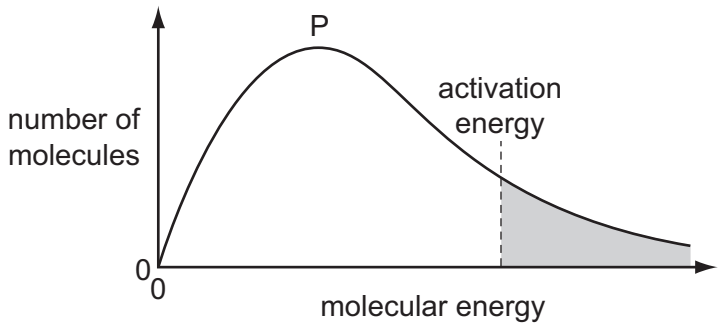
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **14** printed pages and **2** blank pages.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 The diagram shows a Boltzmann distribution of molecular energies for a gaseous mixture. The distribution has a peak, labelled P on the diagram.



What happens when the temperature of the mixture increases?

A The height of the peak, P, decreases and the activation energy moves to the left.

B The height of the peak, P, decreases and the activation energy moves to the right.

C The height of the peak, P, decreases and the activation energy does not change.

D The height of the peak, P, increases and the activation energy moves to the left.

2 Substances X, Y and Z are all solids. Some of their physical properties are given in the table.

substance	X	Y	Z
melting point / °C	772	114	1610
boiling point / °C	1407	183	2205
electrical conductivity of the liquid state	conducts	does not conduct	does not conduct

What type of lattice could each substance have?

	X	Y	Z
A	giant molecular	simple molecular	ionic
B	ionic	giant molecular	simple molecular
C	ionic	simple molecular	giant molecular
D	simple molecular	ionic	giant molecular

3 The enthalpy change of formation of carbon dioxide is –394 kJ mol^{-1}.
The enthalpy change of formation of water is –286 kJ mol^{-1}.
The enthalpy change of formation of methane is –74 kJ mol^{-1}.

What is the enthalpy change of combustion of methane?

A –892 kJ mol^{-1}

B –606 kJ mol^{-1}

C +606 kJ mol^{-1}

D +892 kJ mol^{-1}

4 Hydrogen and carbon dioxide gases are mixed in equal molar amounts at 800 K. A reversible reaction takes place.

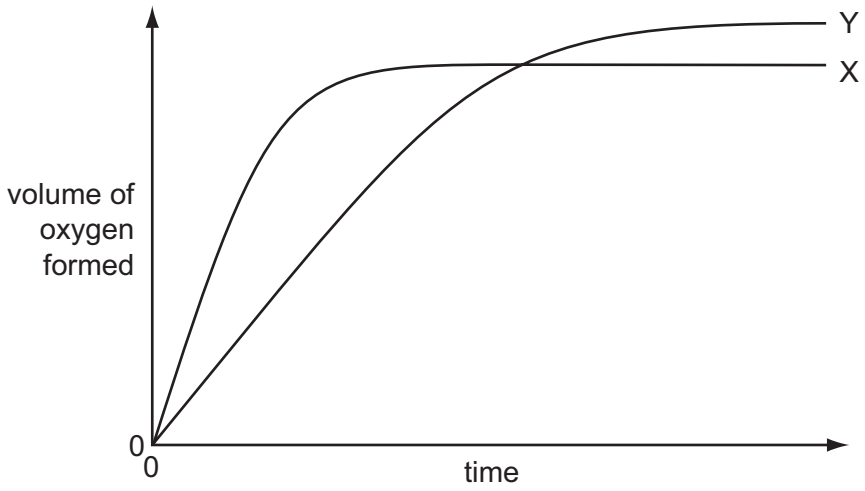
$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$$

At equilibrium, the partial pressures of H_2 and CO_2 are both 10.0 kPa. K_p is 0.288 at 800 K.

What is the partial pressure of CO in the equilibrium mixture?

A 5.37 kPa **B** 18.6 kPa **C** 28.8 kPa **D** 347 kPa

5 In the diagram, curve X was obtained by observing the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve Y?

A adding more manganese(IV) oxide

B adding some 0.1 mol dm^{-3} hydrogen peroxide

C adding water

D raising the temperature

6 In which reaction is the species in **bold** acting as an oxidising agent?

A $\mathbf{2Ca} + O_2 \rightarrow 2CaO$

B $Cr_2O_7^{2-} + 8H^+ + \mathbf{3SO_3^{2-}} \rightarrow 2Cr^{3+} + 4H_2O + 3SO_4^{2-}$

C $Mg + \mathbf{Fe^{2+}} \rightarrow Mg^{2+} + Fe$

D $\mathbf{SO_2} + 2H_2O + 2Cu^{2+} + 2Cl^- \rightarrow H_2SO_4 + 2H^+ + 2CuCl$

7 The formation of hydrogen and ethyne, C_2H_2, from methane reaches dynamic equilibrium.

$$2CH_4(g) \rightleftharpoons 3H_2(g) + C_2H_2(g)$$

What are the units of K_c?

A $mol\,dm^{-3}$ **B** $mol^2\,dm^{-6}$ **C** $mol^3\,dm^{-9}$ **D** $mol^4\,dm^{-12}$

8 Which equation represents the standard enthalpy change of formation of ethanol, C_2H_5OH?

A $2C(g) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

B $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

C $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(g)$

D $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(l)$

9 *Use of the Data Booklet is relevant to this question.*

In an experiment, $12.0\,dm^3$ of oxygen, measured under room conditions, is used to burn completely 0.10 mol of propan-1-ol.

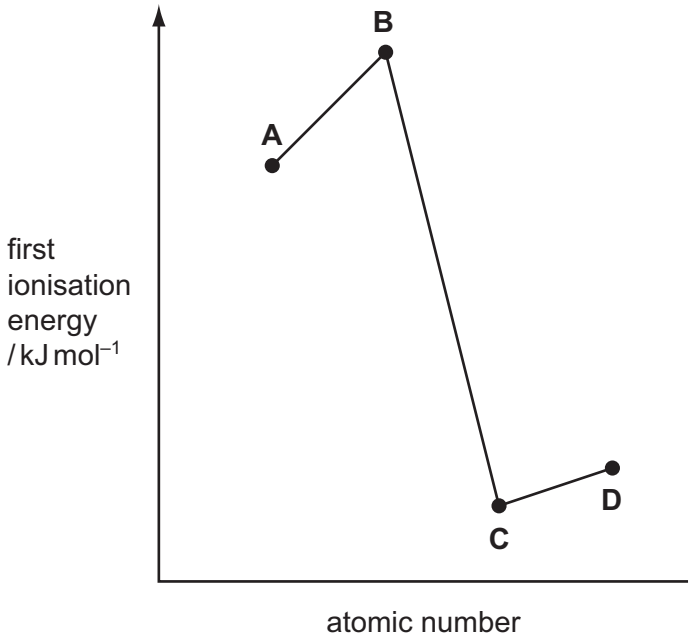
What is the final volume of gas, measured under room conditions?

A $7.20\,dm^3$ **B** $8.40\,dm^3$ **C** $16.8\,dm^3$ **D** $18.00\,dm^3$

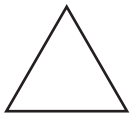
10 Shown on the graph are the relative values of the first ionisation energies of four elements that have consecutive atomic numbers.

One of the elements reacts with hydrogen to form a covalent compound with formula HX.

Which element could be X?



11 The diagram shows the skeletal formula of cyclopropane.



The enthalpy change of formation of cyclopropane is +53.3 kJ mol^{-1} and the enthalpy change of atomisation of graphite is +717 kJ mol^{-1}.

The bond enthalpy of H – H is 436 kJ mol^{-1} and of C – H is 410 kJ mol^{-1}.

What value for the average bond enthalpy of the C – C bond in cyclopropane can be calculated from this data?

A 187 kJ mol^{-1} **B** 315 kJ mol^{-1} **C** 351 kJ mol^{-1} **D** 946 kJ mol^{-1}

12 When barium is burnt in oxygen, what colour is the flame?

A green

B orange

C red

D white

13 X and Y are oxides of different Period 3 elements.

If one mole of Y is added to water, the solution formed is neutralised by exactly one mole of X.

What could be the identities of X and Y?

	X	Y
A	Al_2O_3	P_4O_{10}
B	Al_2O_3	SO_3
C	Na_2O	P_4O_{10}
D	Na_2O	SO_3

14 Ammonium sulfate in the soil is slowly oxidised by air, producing sulfuric acid, nitric acid and water as the only products.

How many moles of oxygen gas are needed for the complete oxidation of one mole of ammonium sulfate?

A 1 **B** 2 **C** 3 **D** 4

15 Which statement about the oxides and hydroxides of the Group II elements Mg, Ca, Sr and Ba is correct?

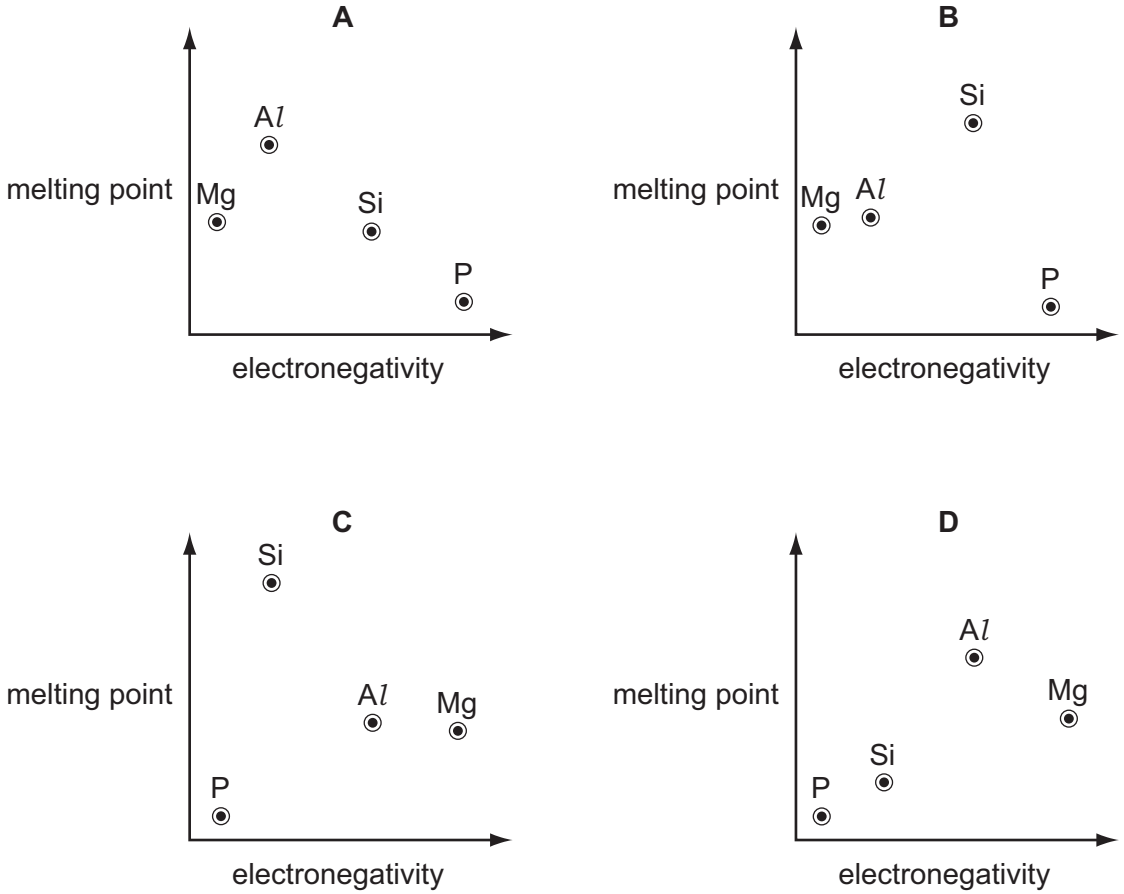
A Each of the oxides reacts readily with water to form a solution of pH 12 or above.

B Magnesium oxide is used as a furnace lining because it has a giant molecular structure and hence a high melting point.

C The hydroxides are produced directly by the thermal decomposition of the corresponding nitrates.

D The solubility of the hydroxides increases from $Mg(OH)_2$ to $Ba(OH)_2$.

16 Which graph correctly shows the relative melting points of the elements Mg, A*l*, Si and P plotted against their relative electronegativities?



17 When solid sodium iodide reacts with concentrated sulfuric acid, the products include $NaHSO_4$, H_2S, SO_2 and S.

In the formation of which product has the oxidation state of sulfur changed by a value of 8?

A H_2S **B** $NaHSO_4$ **C** S **D** SO_2

18 A test-tube of HBr(g) and a test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

	tube of HBr(g)	tube of HI(g)
A	a brown vapour appears	no change is apparent
B	a purple vapour appears	no change is apparent
C	no change is apparent	a brown vapour appears
D	no change is apparent	a purple vapour appears

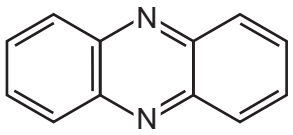
19 *Use of the Data Booklet is relevant to this question.*

In an experiment, 0.125 mol of chlorine gas, Cl_2, is reacted with an excess of cold aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen, and chlorine.

Which mass of this product is formed?

A 9.31 g **B** 13.3 g **C** 18.6 g **D** 26.6 g

20 The diagram shows the skeletal formula of phenazine.



phenazine

What is the empirical formula of phenazine?

A C_6H_4N **B** C_6H_6N **C** $C_{12}H_8N_2$ **D** $C_{12}H_{12}N_2$

21 Halogenoalkanes undergo a range of nucleophilic substitution reactions.

Which reaction proceeds **only** by an S_N1 mechanism?

A $CH_3CH_2Br + NH_3$

B $CH_3CH_2CH_2I + OH^-$

C $CH_3CHBrCH_3 + NH_3$

D $(CH_3)_3CI + OH^-$

22 Which alcohol has a chiral centre **and** can be oxidised to a ketone?

A pentan-2-ol

B pentan-3-ol

C 3-methylhexan-1-ol

D 3-methylhexan-3-ol

23 An ester of structural formula $CH_3CO_2CH_3$ is heated with an aqueous solution of sodium hydroxide.

What are the two organic products of this reaction?

A ethanoic acid and methanol

B methanoic acid and ethanol

C sodium ethanoate and methanol

D sodium methanoate and ethanol

24 Ethene reacts with aqueous bromine to give two products, CH_2BrCH_2Br and CH_2BrCH_2OH.

Which statement about these products is correct?

A Both products are obtained in this reaction by electrophilic substitution.

B Both products are obtained in this reaction by nucleophilic addition.

C Both products can be hydrolysed to form the same organic compound.

D Both products can form hydrogen bonds with water.

25 Which statement does **not** correctly describe a problem related to the disposal of PVC?

A PVC is slowly degraded in the environment by bacteria and fungi.

B PVC is slowly degraded in the environment by sunlight.

C When PVC is burnt, a significant amount of ethene gas is present in the products.

D When PVC is burnt, a significant amount of HC*l* gas is present in the products.

26 Compound X, C_4H_8O, produces an orange precipitate when it is reacted with 2,4-dinitrophenylhydrazine reagent. Compound X produces a carboxylic acid when heated under reflux with an acidified solution of potassium dichromate(VI).

What could be compound X?

A butanal

B butanone

C 2-methylbutanal

D 4-hydroxybut-1-ene

27 Dichlorodifluoromethane, CCl_2F_2, has been used in aerosol propellants and as a refrigerant.

Which statement helps to explain why dichlorodifluoromethane is chemically inert?

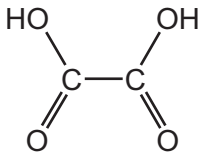
A All fluorine compounds are non-flammable.

B Fluorine is highly electronegative.

C The carbon-fluorine bond energy is large.

D The carbon-fluorine bond has a low polarity.

28 The diagram shows the structure of ethanedioic acid.



Ethanedioic acid reacts with ethanol in the presence of a few drops of concentrated sulfuric acid to form a diester. The molecular formula of the diester is $C_6H_{10}O_4$.

What is the structural formula of the diester?

A $CH_3CH_2CO_2CO_2CH_2CH_3$

B $CH_3CH_2OCOCO_2CH_2CH_3$

C $CH_3CH_2O_2CO_2CCH_2CH_3$

D $CH_3CO_2CH_2CH_2OCOCH_3$

29 When heated with KOH dissolved in ethanol, halogenoalkanes can undergo an elimination reaction to form alkenes.

What are the possible elimination products when 2-bromobutane is heated with KOH dissolved in ethanol?

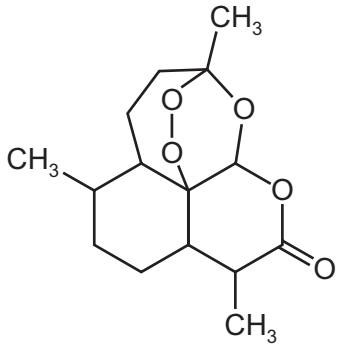
A $CH_3CH{=}CHCH_3$ only

B $CH_3CH_2CH{=}CH_2$ only

C $CH_3CH{=}CHCH_3$ and $CH_3CH_2CH{=}CH_2$

D $CH_3CH{=}CHCH_3$ and $CH_2{=}CHCH{=}CH_2$

30 Artemisinin is a powerful anti-malarial drug.



artemisinin

How many chiral centres are there in each molecule of artemisinin?

A 4 **B** 6 **C** 7 **D** 8

Section B

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Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 P and Q are two compounds with similar M_r values. Molecules of P attract each other by hydrogen bonds. Molecules of Q attract each other by van der Waals' forces only.

A sample of liquid P is compared to a sample of liquid Q.

How will their properties differ?

1 P is more soluble in water than Q.

2 P has a higher melting point than Q.

3 P is more viscous than Q.

32 The reaction

$$E + F \rightleftharpoons G + H$$

is catalysed by platinum.

Which statements about the properties of the catalyst are correct?

1 The catalyst has no effect on the enthalpy change of the reaction.

2 The catalyst increases the rate of the reverse reaction.

3 The catalyst increases the average kinetic energy of the reacting particles.

33 Which elements have atoms which can form π bonds with atoms of other elements?

1 oxygen

2 nitrogen

3 fluorine

34 Sulfuric acid is a Brønsted-Lowry acid.

In which reactions is sulfuric acid behaving as an acid?

1 $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$

2 $H_2SO_4 + CO_3^{2-} \rightarrow CO_2 + H_2O + SO_4^{2-}$

3 $H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

35 Silver chloride dissolves in aqueous ammonia.

What happens in this process?

1 Ammonia forms a complex with the Ag^+ ion.

2 Ammonia acts as a Brønsted-Lowry base.

3 A redox reaction occurs.

36 A car has a catalytic converter fitted to its exhaust. On analysis its exhaust gases are shown to contain small quantities of nitrogen oxides.

Which modifications would result in lower exhaust concentrations of nitrogen oxides?

1 an increase in the surface area of the catalyst in the converter

2 an increase in the rate of flow of the exhaust gases through the converter

3 a much higher temperature of combustion in the engine

37 Which alcohols **cannot** be dehydrated to form alkenes?

1 CH_3OH

2 $(CH_3)_3COH$

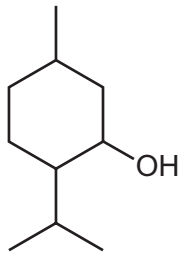
3 CH_3CH_2OH

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

38 Menthol is a naturally-occurring alcohol found in peppermint oil.



menthol

Which reagents will react with menthol?

1 aqueous bromine

2 sodium metal

3 aqueous acidified manganate(VII)

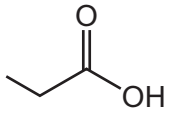
39 Which pairs of reagents will take part in a redox reaction under suitable conditions?

1 $CH_3(CH_2)_4CHO$ + Tollens' reagent

2 $CH_3(CH_2)_4CH_3$ + Br_2

3 $CH_3CO(CH_2)_4CH_3$ + Fehling's reagent

40 Propanoic acid occurs naturally as a result of the bacterial fermentation of milk, and is partly responsible for the flavour of Swiss cheese.



propanoic acid

Which starting materials could be used to synthesise propanoic acid?

1 $CH_3CH_2CH_2OH$

2 CH_3CH_2CHO

3 CH_3CH_2CN

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2013**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

9402429307

READ THESE INSTRUCTIONS FIRST

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Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **14** printed pages and **2** blank pages.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 During the electrolysis of molten aluminium oxide to produce aluminium, using carbon electrodes, two consecutive reactions occur at the anode, each producing a different gas.

How does the oxidation number of oxygen change in these reactions?

A decreases by 2, then increases by 2

B increases by 2, then decreases by 2

C increases by 2, then decreases by 4

D no change, then decreases by 2

2 Equations involving four enthalpy changes are shown.

$$Na(g) \rightarrow Na^{+}(g) + e^{-} \qquad \Delta H = W$$

$$Na(g) \rightarrow Na^{2+}(g) + 2e^{-} \qquad \Delta H = X$$

$$Na(s) \rightarrow Na(g) \qquad \Delta H = Y$$

$$Na(s) \rightarrow Na^{2+}(g) + 2e^{-} \qquad \Delta H = Z$$

What is the second ionisation energy of sodium?

A X **B** X – W **C** Y – W **D** Z – Y

3 Which ion has more electrons than protons and more protons than neutrons?
[H = $^{1}_{1}H$; D = $^{2}_{1}H$; O = $^{16}_{8}O$]

A D^{-} **B** H_3O^{+} **C** OD^{-} **D** OH^{-}

4 Which factor can affect the value of the activation energy of a reaction?

A changes in concentration of the reactants

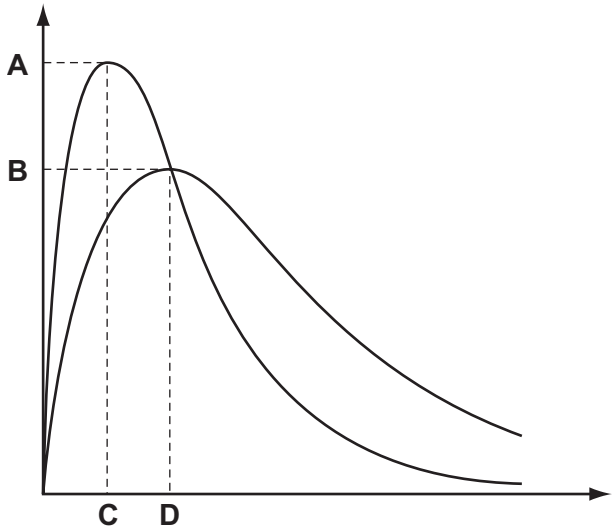
B decrease in temperature

C increase in temperature

D the presence of a catalyst

5 The diagram shows the Maxwell-Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.

Which letter on the axes represents the most probable energy of the molecules at the **lower** temperature?



6 Which pair of elements has chemical bonds of the same type between their atoms in the solid state?

A aluminium and phosphorus

B chlorine and argon

C magnesium and silicon

D sulfur and chlorine

7 Ethanol has a boiling point of 78 °C. At 101 kPa and 79 °C ethanol vapour does not perfectly obey the gas equation $pV = nRT$.

What is the reason for this?

A Ethanol vapour is in equilibrium with ethanol liquid at 79 °C.

B There are intermolecular forces between the molecules of ethanol vapour.

C The vapourisation of ethanol liquid is an endothermic process.

D Vapours will not obey the gas equation perfectly at such a low pressure.

8 The reaction between sulfur dioxide and oxygen is a dynamic equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

What happens when the pressure of the system is increased?

A The rate of reaction will decrease and the position of the equilibrium will move to the left.

B The rate of reaction will decrease and the position of the equilibrium will move to the right.

C The rate of reaction will increase and the position of the equilibrium will move to the left.

D The rate of reaction will increase and the position of the equilibrium will move to the right.

9 Dicarbon monoxide, C_2O, is found in dust clouds in space. Analysis of it shows that the sequence of atoms in this molecule is C – C – O. All bonds are double bonds and there are no unpaired electrons.

How many lone pairs of electrons are present in a molecule of C_2O?

A 1 **B** 2 **C** 3 **D** 4

10 *Use of the Data Booklet is relevant to this question.*

A student mixed 25 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution with 25 cm^3 of 0.10 mol dm^{-3} hydrochloric acid and noted a temperature rise of 2.5 °C.

What is the enthalpy change of the reaction per mole of NaOH?

A –209 kJ mol^{-1}

B –104.5 kJ mol^{-1}

C –209 J mol^{-1}

D –522.5 J mol^{-1}

11 Which energy change corresponds to the enthalpy change of atomisation of hydrogen at 298 K?

A the bond energy of a H – H bond

B half the bond energy of a H – H bond

C minus half the bond energy of a H – H bond

D minus the bond energy of a H – H bond

12 Propanone has molecular formula C_3H_6O.

The enthalpy change of combustion of hydrogen is $-286\,kJ\,mol^{-1}$.

The enthalpy change of combustion of carbon is $-394\,kJ\,mol^{-1}$.

The enthalpy change of formation of propanone is $-254\,kJ\,mol^{-1}$.

Using this information, what is the enthalpy change of combustion of propanone?

A $-2644\,kJ\,mol^{-1}$

B $-2294\,kJ\,mol^{-1}$

C $-1786\,kJ\,mol^{-1}$

D $-426\,kJ\,mol^{-1}$

13 *Use of the Data Booklet is relevant to this question.*

Magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is oxygen.

29.7 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of oxygen is produced?

A 3.2 g **B** 6.4 g **C** 12.8 g **D** 19.2 g

14 In which row of the table are all statements comparing the compounds of calcium and barium correct?

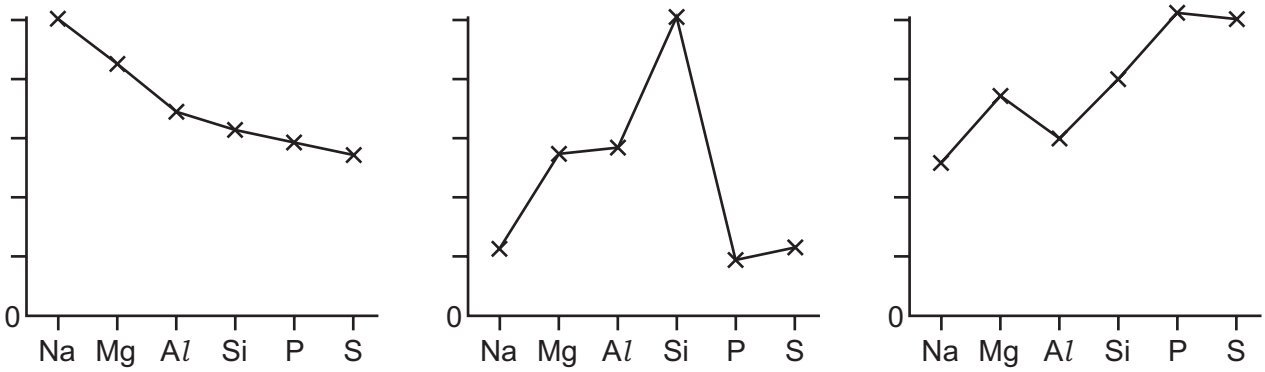
	solubility of calcium hydroxide	solubility of barium hydroxide	thermal stability of calcium carbonate	thermal stability of barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

15 Many modern cars are fitted with halogen lamps. When such lamps are first switched on, a distinct purple colour can be seen.

Which species is responsible for this purple colour?

A $I_2(s)$ **B** $I_2(l)$ **C** $I_2(g)$ **D** $I(g)$

16 The trends in three physical properties of the elements Na, Mg, A*l*, Si, P and S are shown in the graphs.



Which physical property is **not** illustrated?

A atomic radius

B electrical conductivity

C first ionisation energy

D melting point

17 Which statement about ammonia is completely correct?

A Ammonia acts as a nucleophile by accepting a pair of electrons when it reacts with bromoethane.

B Ammonia can form a co-ordinate bond with a hydrogen ion to form an ammonium ion.

C Ammonia is a base and accepts hydroxide ions.

D The shape of the ammonia molecule is pyramidal with bond angles of 109.5°.

18 What happens when bromine solution is added to a solution of sodium iodide?

A A reaction occurs without changes in oxidation state.

B Bromine atoms are oxidised, iodide ions are reduced.

C Bromine atoms are reduced, iodide ions are oxidised.

D No reaction occurs.

19 The halogens exist as diatomic molecules, X_2.

The boiling points of the Group VII elements increase as the group is descended from chlorine to iodine.

Which statement helps to explain this increase in boiling point as Group VII is descended?

A The electronegativity of X decreases as the group is descended.

B The number of electrons in each X_2 molecule increases as the group is descended.

C The size of the permanent dipole in the X_2 molecule increases as the group is descended.

D The X–X bond strength increases as the group is descended.

20 The compound hex-3-en-1-ol, **P**, has a strong 'leafy' smell of newly cut grass and is used in perfumery.

$CH_3CH_2CH{=}CHCH_2CH_2OH$

P

What is produced when **P** is treated with an excess of hot concentrated acidified $KMnO_4$?

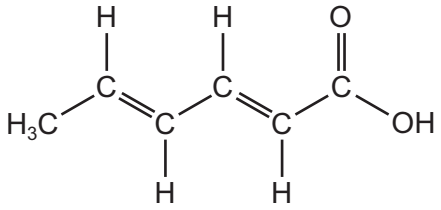
A $CH_3CH_2CH(OH)CH(OH)CH_2CH_2OH$

B $CH_3CH_2CH{=}CHCH_2CO_2H$

C CH_3CH_2CHO and $OCHCH_2CH_2OH$

D $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

21 Sorbic acid is used as a food preservative because it kills fungi and moulds.



sorbic acid

Sorbic acid will react with

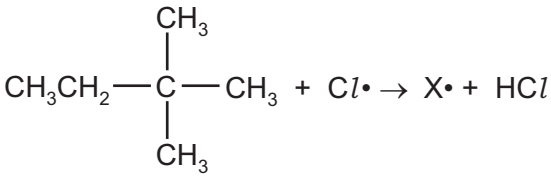
- hydrogen in the presence of a nickel catalyst,
- bromine in an organic solvent.

How many moles of hydrogen and of bromine will be incorporated into one mole of sorbic acid by these reactions?

	moles of hydrogen	moles of bromine
A	2	2
B	2	$2\frac{1}{2}$
C	3	2
D	3	$2\frac{1}{2}$

22 When heated with chlorine, the hydrocarbon 2,2-dimethylbutane undergoes free radical substitution.

In a propagation step a free radical X• is formed.



How many different forms of X• are possible?

A 1 **B** 2 **C** 3 **D** 4

23 Aqueous sodium hydroxide reacts with 2-bromo-2-methylpropane to give 2-methylpropan-2-ol.

The reaction proceeds by an S_N1 mechanism.

How should the first step in the mechanism be described?

A by a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 2-bromopropane

B by a curly arrow from the C–Br bond to the Br atom

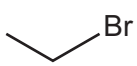
C by a curly arrow from the C–Br bond to the C atom

D by the homolytic fission of the C–Br bond

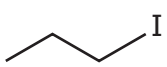
24 Compound **Y** can be hydrolysed by warm aqueous silver nitrate to form a precipitate that is soluble in dilute aqueous ammonia. Compound **Y** can undergo an elimination reaction to form an alkene.

What could be the skeletal formula of compound **Y**?

A



B



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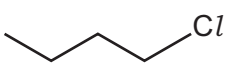

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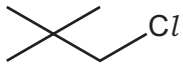
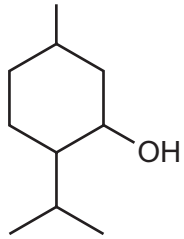


25 The compound shown is menthol, a naturally-occurring alcohol found in peppermint oil.

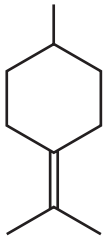


menthol

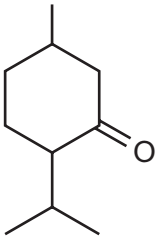
When menthol is heated with concentrated sulfuric acid it reacts. The products that form include compound **T**.

What could be the structure of compound **T**?

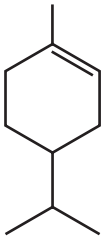
A



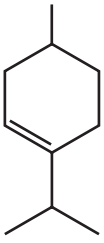
B



C



D



26 *Use of the Data Booklet is relevant to this question.*

Which volume of oxygen measured at room temperature and pressure is needed for complete combustion of 0.1 mol of propan-1-ol?

A 10.8 dm^3 **B** 12.0 dm^3 **C** 21.6 dm^3 **D** 24.0 dm^3

27 Which carbonyl compound reacts with hydrogen cyanide to form a product that has **no** chiral carbon atom?

A butanone

B ethanal

C propanal

D propanone

28 How many of the following compounds produce a carboxylic acid on heating under reflux with hot acidified $K_2Cr_2O_7$?

CH_3CH_2CHO

CH_3COCH_3

$CH_3CH_2CH_2OH$

$CH_3CHOHCH_3$

A 1 **B** 2 **C** 3 **D** 4

29 Compound **Y** has M_r of 88. It does not fizz when added to a solution of sodium hydrogencarbonate. It can be hydrolysed by dilute sulfuric acid to produce two organic products with M_r values of 46 and 60.

What is the identity of compound **Y**?

A butanoic acid

B ethyl ethanoate

C 3-hydroxybutanal

D butyl methanoate

30 Polymerisation of ethene gives poly(ethene).

How does the carbon-carbon bond in poly(ethene) compare with that in ethene?

A The carbon-carbon bond is longer and stronger in poly(ethene).

B The carbon-carbon bond is longer and weaker in poly(ethene).

C The carbon-carbon bond is shorter and stronger in poly(ethene).

D The carbon-carbon bond is shorter and weaker in poly(ethene).

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 *Use of the Data Booklet is relevant to this question.*

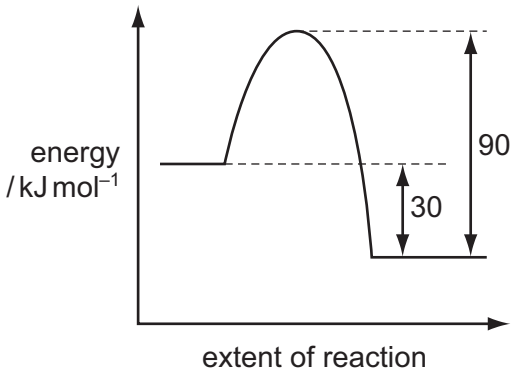
In which pairs do both species have the same number of unpaired p electrons?

1 Al^{2-} and O^{+}

2 N and Cl^{2+}

3 C and Cl^{+}

32 The diagram shows the reaction pathway for a reversible reaction.



Which statements are correct?

1 The enthalpy change for the backward reaction is +90 kJ mol^{-1}.

2 The forward reaction is exothermic.

3 The enthalpy change for the forward reaction is –30 kJ mol^{-1}.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

33 Which substances contain delocalised electrons?

1 cyclohexene

2 graphite

3 sodium

34 Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.

Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**. When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 Adding **W** to water has less effect on pH than adding **Y**.

2 Adding **Z** to soil increases the pH of the soil.

3 The metallic element in **Y** reacts with cold water more quickly than the metallic element in **W**.

35 Which properties increase in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide?

1 thermal stability

2 bond length

3 ease of oxidation

36 Sulfur dioxide is an atmospheric pollutant that causes acid rain. One of the reactions in this process is the oxidation of sulfur dioxide to sulfur trioxide.

This oxidation takes place by a two stage reaction involving oxygen and nitrogen monoxide, NO.

$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2$$

$$NO_2 + SO_2 \rightarrow SO_3 + NO$$

Which statements are correct?

1 Nitrogen monoxide is acting as a catalyst for the oxidation.

2 Nitrogen atoms are oxidised in the second stage.

3 Oxygen atoms are first reduced and are then oxidised.

37 Which are properties of fluoroalkanes?

1 They are less reactive than the corresponding chloroalkanes.

2 They are non-flammable.

3 The C–F bond is stronger than the C–C*l* bond.

38 What can be produced when an aqueous solution of butan-2-ol is oxidised under suitable conditions?

1 butanone

2 butanoic acid

3 butanal

39 The M_r of compound X is 72. The composition by mass of X is 66.7 % carbon, 11.1 % hydrogen and 22.2 % oxygen. X gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent. X does **not** react with Fehling's reagent.

What can be deduced from this information?

1 X is a carbonyl compound.

2 X is a ketone.

3 X is butanone.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

40 An organic compound, **Z**, will react with calcium metal to produce a salt with the empirical formula $CaC_4H_6O_4$.

What could be the identity of **Z**?

1 ethanoic acid

2 butanedioic acid

3 methylpropanedioic acid

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2012**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

7046687152

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

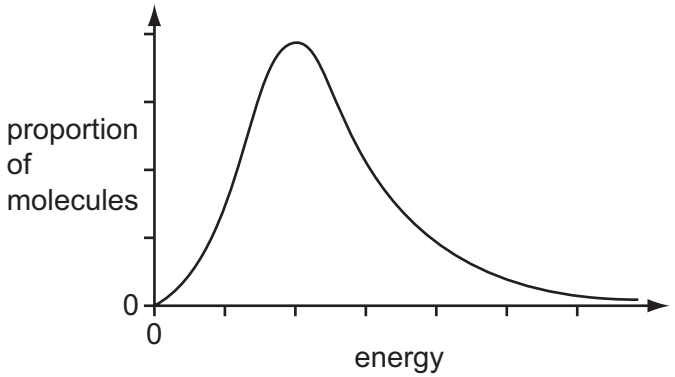
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **14** printed pages and **2** blank pages.

Section A

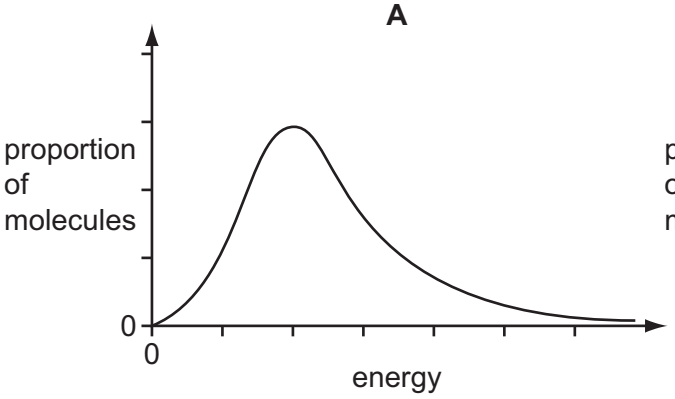
For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.



Which curve applies for the same gas at a lower temperature?

A



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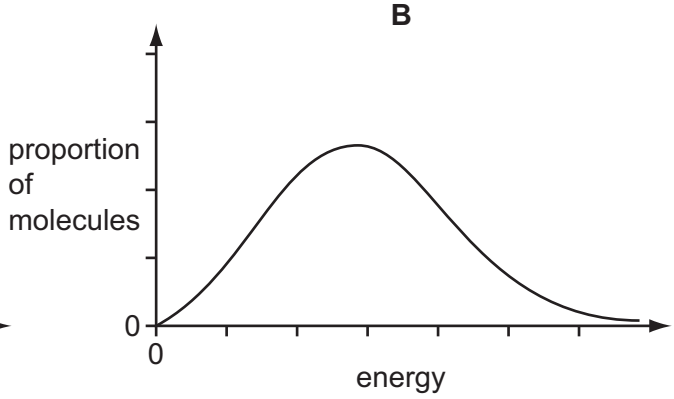

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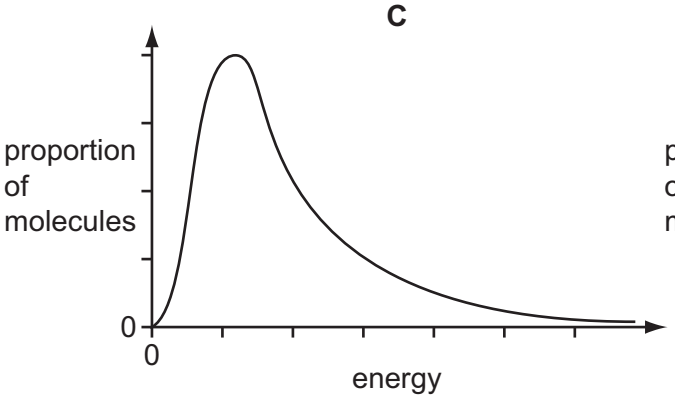

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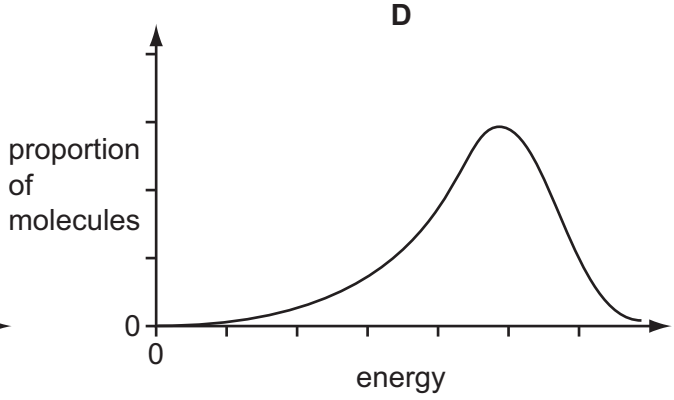
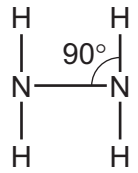


2 In which species are the numbers of protons, neutrons and electrons all different?

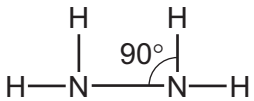
A $^{11}_{5}B$ **B** $^{19}_{9}F^{-}$ **C** $^{23}_{11}Na^{+}$ **D** $^{24}_{12}Mg^{2+}$

3 What is the **most** likely shape of a molecule of hydrazine, N_2H_4?

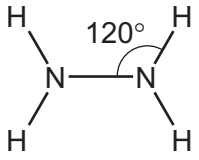
A



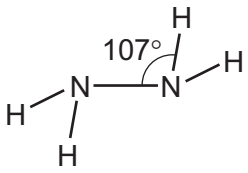
B



C



D



4 In which species does the underlined atom have an incomplete outer shell?

A $\underline{Al}_2Cl_6$ **B** $\underline{C}H_3^+$ **C** $Cl_2\underline{O}$ **D** $H_2\underline{Cl}C\bullet$

5 Which solid contains more than one kind of bonding?

A iodine

B silicon dioxide

C sodium chloride

D zinc

6 *Use of the Data Booklet is relevant to this question.*

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.96 g of oxygen gas is contained in a glass vessel of volume 7000 cm^3 at a temperature of 30 °C.

What is the pressure in the vessel?

A 1.1 kPa **B** 2.1 kPa **C** 10.8 kPa **D** 21.6 kPa

7 Two moles of compound P were placed in a vessel. The vessel was heated and compound P was partly decomposed to produce Q and R. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium *x* moles of R were present and the total number of moles present was $(2 + \frac{x}{2})$.

What is the equation for this equilibrium reaction?

A $P \rightleftharpoons 2Q + R$

B $2P \rightleftharpoons 2Q + R$

C $2P \rightleftharpoons Q + R$

D $2P \rightleftharpoons Q + 2R$

8 The value of the third ionisation energy of aluminium is 2740 kJ mol^{-1}.

Which correctly represents this statement?

A $Al(g) \rightarrow Al^{3+}(g) + 3e^-$ $\Delta H^{\ominus} = -2740\,kJ\,mol^{-1}$

B $Al^{2+}(g) \rightarrow Al^{3+}(g) + e^-$ $\Delta H^{\ominus} = -2740\,kJ\,mol^{-1}$

C $Al(g) \rightarrow Al^{3+}(g) + 3e^-$ $\Delta H^{\ominus} = +2740\,kJ\,mol^{-1}$

D $Al^{2+}(g) \rightarrow Al^{3+}(g) + e^-$ $\Delta H^{\ominus} = +2740\,kJ\,mol^{-1}$

9 Methanol is manufactured by reacting carbon dioxide and hydrogen.

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \qquad \Delta H = -49\,kJ\,mol^{-1}$$

What would increase the equilibrium yield of methanol in this process?

A adding a catalyst

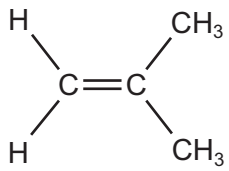
B adding an excess of steam

C increasing the pressure

D increasing the temperature

10 Which molecule has the largest overall dipole?

A



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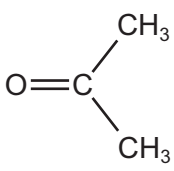

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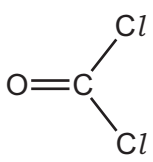

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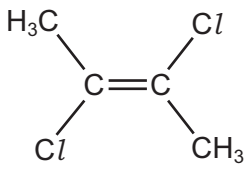


11 In which substance does nitrogen exhibit the highest oxidation state?

A NO **B** N_2O **C** N_2O_4 **D** $NaNO_2$

12 Red lead oxide, Pb_3O_4, is used in metal priming paints. It can be made by heating PbO in air.

$$6PbO(s) + O_2(g) \rightarrow 2Pb_3O_4(s)$$

Which two values are needed to calculate the enthalpy change for this reaction?

A enthalpy change of atomisation of O_2 and enthalpy change of formation of Pb_3O_4

B enthalpy change of formation of O_2 and enthalpy change of formation of Pb_3O_4

C enthalpy change of formation of PbO and enthalpy change of atomisation of O_2

D enthalpy change of formation of PbO and enthalpy change of formation of Pb_3O_4

13 Which gas is present in the exhaust fumes of a car engine in a much greater amount than any other gas?

A carbon dioxide

B carbon monoxide

C nitrogen

D water vapour

14 Slaked lime, $Ca(OH)_2$, may be made from limestone, $CaCO_3$.

On heating in a lime kiln at 1000 °C, limestone decomposes as follows.

reaction 1 $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Water is then reacted with calcium oxide, CaO, as follows.

reaction 2 $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$

What are the enthalpy changes of these reactions?

	reaction 1	reaction 2
A	endothermic	endothermic
B	endothermic	exothermic
C	exothermic	endothermic
D	exothermic	exothermic

15 The period 4 elements gallium (Ga), germanium (Ge), arsenic (As) and selenium (Se) are the elements below aluminium, silicon, phosphorus and sulfur in the Periodic Table, a portion of which is shown below.

period 3 elements	Al	Si	P	S
period 4 elements	Ga	Ge	As	Se

The properties of each period 4 element resemble those of the period 3 element directly above it.

Which period 4 elements form oxides that dissolve in water to give an acid solution?

A As and Se **B** Ga and Ge **C** Ga and Se **D** Se only

16 Chlorine shows oxidation states ranging from –1 to +7 in its compounds.

What are the reagent(s) and conditions necessary for the oxidation of elemental chlorine into a compound containing chlorine in the +5 oxidation state?

A $AgNO_3(aq)$ followed by $NH_3(aq)$ at room temperature

B concentrated H_2SO_4 at room temperature

C cold dilute NaOH(aq)

D hot concentrated NaOH(aq)

17 What can be seen when a piece of magnesium ribbon is placed in cold water?

A A vigorous effervescence occurs.

B Bubbles of gas form slowly on the magnesium.

C The magnesium floats on the surface of the water and reacts quickly.

D The magnesium glows and a white solid is produced.

18 *Use of the Data Booklet is relevant to this question.*

Sodium and sulfur react together to form sodium sulfide, Na_2S.

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
A	sodium > sulfur	sodium > sulfur
B	sodium > sulfur	sodium < sulfur
C	sodium < sulfur	sodium > sulfur
D	sodium < sulfur	sodium < sulfur

19 Which substance does **not** produce a poisonous gas, when burnt in a limited amount of air?

A hydrogen

B methane

C propene

D sulfur

20 *Use of the Data Booklet is relevant to this question.*

A sample of propyl ethanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

Out of the total mass of products obtained, what is the percentage by mass of each product?

A 32.4 % and 67.6 %

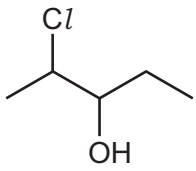
B 38.3 % and 61.7 %

C 42.3 % and 57.7 %

D 50.0 % and 50.0 %

21 Which diagram gives the skeletal formula of 2-chloropentan-3-ol?

A



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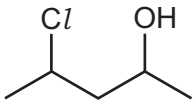

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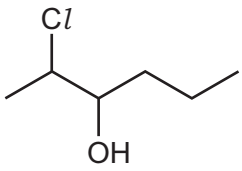

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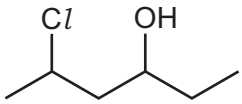
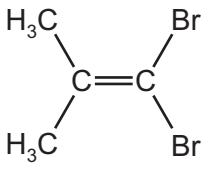


22 When 1-bromopropane is treated in succession with two reagents, X and Y, it produces propanoic acid.

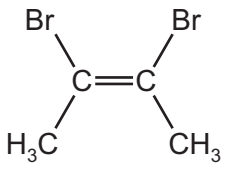
What are reagents X and Y?

	X	Y
A	NaOH(aq)	$H^+ / Cr_2O_7^{2-}$(aq)
B	NaOH(aq)	CO_2
C	KCN in ethanol	HCl(aq)
D	KCN in ethanol	NaOH(aq)

23 Isomers **X** and **Y** both react with HBr.



X



Y

A mixture of **X** and **Y** is reacted with HBr.

Which three structures represent three **different** possible products of this reaction?

A	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CHBrCHBrCH_3$
B	$(CH_3)_2CHCBr_3$	$(CH_3)_2CBrCHBr_2$	$CH_3CBr_2CHBrCH_3$
C	$(CH_3)_2CBrCBr_3$	$(CH_3)_2CHCBr_3$	$CH_3CBr_2CHBrCH_3$
D	$(CH_3)_2CBrCHBr_2$	$CHBr_2CBr(CH_3)CH_3$	$CH_3CHBrCBr_2CH_3$

24 Oct-1-ene, $CH_3(CH_2)_5CH{=}CH_2$, is subjected to thermal cracking.

Which combination of compounds W, X, Y and Z can be obtained?

$CH_2{=}CH_2$	$CH_3CH{=}CH_2$	$CH_3CH_2CH_3$	$CH_2{=}CHCH{=}CH_2$
W	X	Y	Z

A W, X, Y and Z

B W, X and Y only

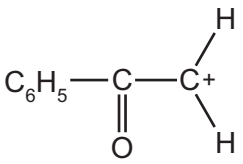
C W, X and Z only

D W and X only

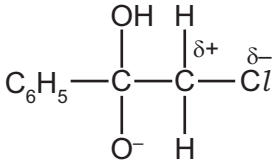
25 When phenacyl chloride, $C_6H_5COCH_2Cl$, is reacted with aqueous NaOH, the substitution reaction follows an S_N2 mechanism.

Which structure represents a species formed during the reaction?

A



B



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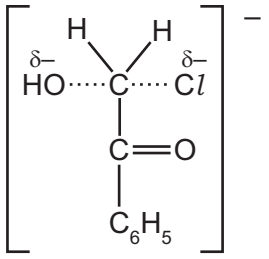
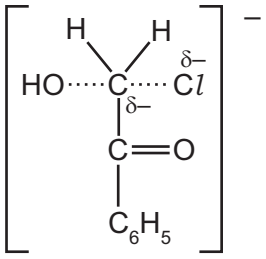


D



26 Complete combustion of compound X gives carbon dioxide and water only. A sample of X is mixed with aqueous potassium(V) dichromate and boiled under reflux for one hour. The mixture is then distilled and the only organic substance present is collected.

The organic substance collected reacts with sodium to give hydrogen, but does not react with 2,4-dinitrophenylhydrazine reagent and does not react with ethanol in the presence of concentrated sulfuric acid to give an ester.

What can be deduced from this information?

A X is a carboxylic acid.

B X is a ketone.

C X is an alcohol.

D X is an alkane.

27 A compound **Y** has the following properties.

- It is a liquid at room temperature and atmospheric pressure.
- It does not mix completely with water.
- It does not give steamy fumes with PCl_5.

What could **Y** be?

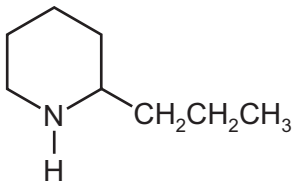
A ethane

B ethanoic acid

C ethanol

D ethyl ethanoate

28 Coniine is the major constituent of the poison 'oil of hemlock'.



coniine

Coniine can be synthesised by reacting ammonia with a dibromo compound, **X**.

$$NH_3 + C_8H_{16}Br_2 \rightarrow \text{coniine} + 2HBr$$

X

What is the name of compound **X**?

A 1,1-dibromo-2-propylcyclopentane

B 1,2-dibromo-2-propylcyclopentane

C 1,4-dibromooctane

D 1,5-dibromooctane

29 A common industrial solvent is a mixture of propanone, CH_3COCH_3, and pentyl ethanoate $CH_3CO_2(CH_2)_4CH_3$.

Which reagent would have **no** reaction with this industrial solvent?

A HCl(aq)

B HCN(aq) with a little KCN

C Na(s)

D $NaBH_4$

30 An organic compound will decolorise dilute acidified aqueous potassium manganate(VII) on warming, but will not decolorise bromine water.

What could the organic compound be?

A butane

B ethanol

C ethene

D ethanoic acid

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 Which of the following molecules and ions have a regular trigonal planar shape?

1 BF_3

2 CH_3^+

3 $AlCl_3$

32 Ammonia and chlorine react in the gas phase.

$$8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Which statements are correct?

1 Each nitrogen atom is oxidised.

2 Each chlorine atom is reduced.

3 Ammonia behaves as a base.

33 Concentrated sulfuric acid behaves as a strong acid when it reacts with water.

$$H_2SO_4(l) + aq \rightarrow H^+(aq) + HSO_4^-(aq)$$

The HSO_4^- ion formed behaves as a weak acid.

$$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$$

Which statements are true for 1.0 mol dm^{-3} sulfuric acid?

1 $[H^+(aq)]$ is high

2 $[SO_4^{2-}(aq)]$ is high

3 $[HSO_4^-(aq)] = [SO_4^{2-}(aq)]$

34 Silver chloride dissolves in aqueous ammonia.

What happens in this process?

1 A co-ordinate bond is formed.

2 The oxidation number of nitrogen is unchanged.

3 Ammonia acts as a Brønsted-Lowry base.

35 Compared with the HC*l* molecule, the bond ……**X**…… of the HBr molecule is ……**Y**……

Which pairs of words correctly complete the above sentence?

	X	**Y**
1	energy	less
2	polarity	less
3	length	greater

36 Which statements are true about the Haber process for the manufacture of ammonia?

1 At higher temperatures, the yield goes down but the rate of production of ammonia is faster.

2 At higher pressures, the yield goes down but the rate of production of ammonia is faster.

3 In the presence of a catalyst, the yield goes down but the rate of production of ammonia is faster.

37 Which compounds can be obtained from propene in a **single** reaction?

1 $CH_2OHCHOHCH_3$

2 $(CH_2CH(CH_3))_n$

3 $CH_2BrCH_2CH_2Br$

38 What are the same for a pair of optical isomers?

1 their empirical formula

2 their functional groups

3 their structural formula

39 Which statements about the photochemical chlorination of ethane are correct?

1 Hydrogen gas is one of the products.

2 A propagation step in the mechanism is $C_2H_6 + Cl\bullet \rightarrow C_2H_5\bullet + HCl$.

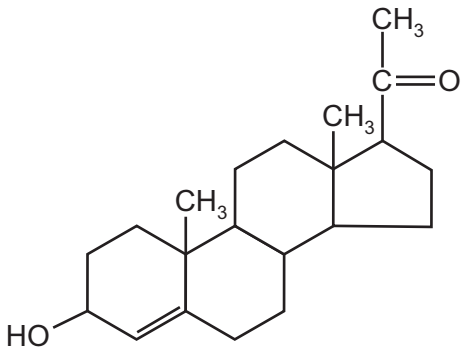
3 The initiation step is the homolytic fission of chlorine.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

40 The compound shown is a hormone produced during pregnancy to suppress ovulation.



Which reagents would give positive results with this compound?

1 aqueous bromine

2 2,4-dinitrophenylhydrazine

3 Fehling's reagent

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2011**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

IB11 06_9701_12/2RP

UNIVERSITY of CAMBRIDGE International Examinations

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 Helium, He, is the second element in the Periodic Table.

Tritium is the isotope of hydrogen ^{3}H.

What is the same in an atom of ^{4}He and an atom of ^{3}H?

A the number of electrons

B the number of neutrons

C the number of protons

D the relative atomic mass

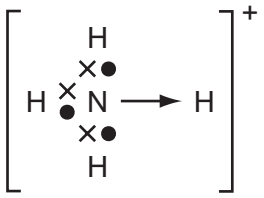
2 Which diagram correctly shows the bonding in the ammonium ion, NH_4^+?

key

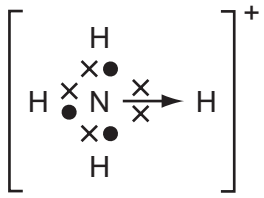
● N electron

× H electron

A



B



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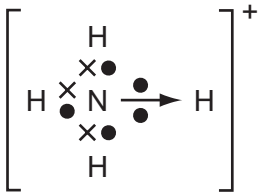
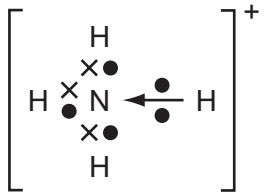


D



3 Aluminium is the most abundant metal in the Earth's crust. The extraction of aluminium is carried out by the electrolysis of aluminium oxide dissolved in molten cryolite.

Which material is used for each of the electrodes in this electrolysis?

	anode	cathode
A	aluminium	carbon
B	carbon	carbon
C	carbon	steel
D	steel	aluminium

4 The esterification reaction

$$\text{ethanol + ethanoic acid} \rightleftharpoons \text{ethyl ethanoate + water}$$

is an equilibrium. The forward reaction is exothermic.

How can the value of the equilibrium constant K_C be increased?

A by adding a little concentrated sulfuric acid as a catalyst

B by increasing the initial concentration of ethanol

C by lowering the temperature

D by raising the temperature

5 Ammonia is manufactured on a large scale by the Haber process.

In a particular plant, conditions of 400 °C and 250 atm in the presence of an iron catalyst are used.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H^{\ominus} = -92\,\text{kJ mol}^{-1}$$

What could contribute most to increasing the equilibrium yield of ammonia?

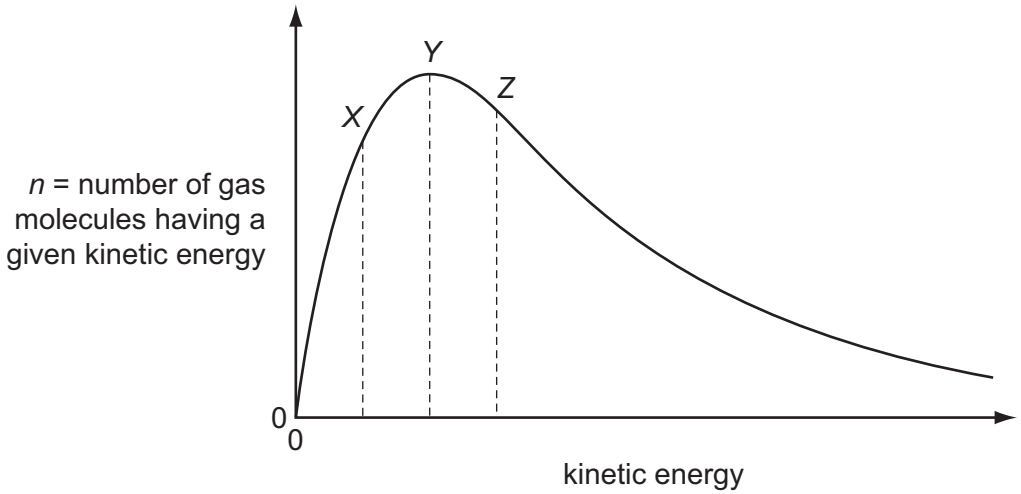
A adding more catalyst

B increasing the pressure to 400 atm

C increasing the temperature to 1000 °C

D using air rather than nitrogen

6 The Boltzmann distribution for a gas at constant temperature is shown below.



If the temperature of the gas is **reduced** by 10 °C the graph changes shape.

What happens to the values of *n* for the points marked *X*, *Y* and *Z*?

	X	*Y*	*Z*
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

7 Titanium occurs naturally as the mineral rutile, TiO_2. One possible method of extraction of titanium is to reduce the rutile by heating with carbon.

$$TiO_2(s) + 2C(s) \rightarrow Ti(s) + 2CO(g)$$

The standard enthalpy changes of formation of $TiO_2(s)$ and $CO(g)$ are –940 kJ mol^{-1} and –110 kJ mol^{-1} respectively.

What is the standard enthalpy change of this reaction?

A –830 kJ mol^{-1}

B –720 kJ mol^{-1}

C +720 kJ mol^{-1}

D +830 kJ mol^{-1}

8 Which reaction has an enthalpy change equal to the standard enthalpy change of formation of propane?

A $3C(g) + 4H_2(g) \rightarrow C_3H_8(g)$

B $3C(g) + 8H(g) \rightarrow C_3H_8(g)$

C $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$

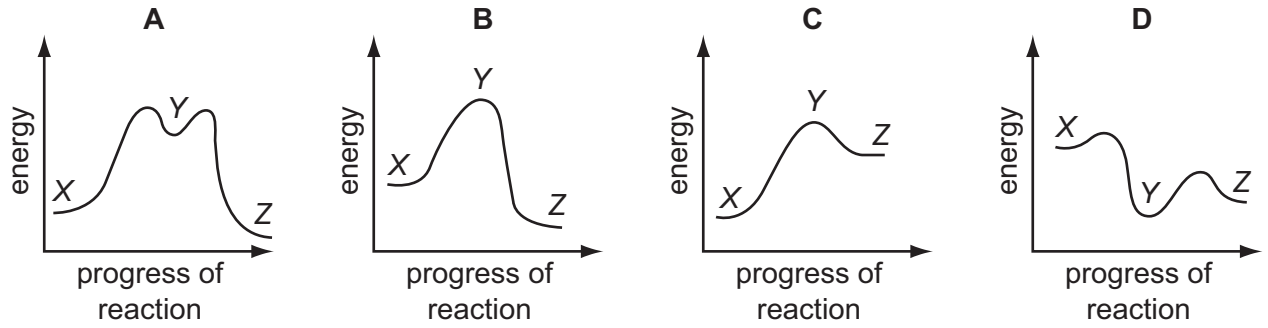
D $3C(s) + 4H_2(g) \rightarrow C_3H_8(l)$

9 In the conversion of compound *X* into compound *Z*, it was found that the reaction proceeded by way of compound *Y*, which could be isolated. The following steps were involved.

$X \rightarrow Y$; ΔH, positive

$Y \rightarrow Z$; ΔH, negative

Which reaction profile fits these data?



10 Tanzanite is used as a gemstone for jewellery. It is a hydrated calcium aluminium silicate mineral with a chemical formula $Ca_2Al_xSi_yO_{12}(OH).6½H_2O$. Tanzanite has M_r of 571.5.

Its chemical composition is 14.04 % calcium, 14.17 % aluminium, 14.75 % silicon, 54.59 % oxygen and 2.45 % hydrogen.

(A_r values: H = 1.0, O = 16.0, Al = 27.0, Si = 28.1, Ca = 40.1)

What are the values of x and y?

	x	y
A	1	1
B	2	3
C	3	3
D	6	1

11 0.144 g of an aluminium compound **X** react with an excess of water, to produce a gas. This gas burns completely in O_2 to form H_2O and 72 cm^3 of CO_2 only. The volume of CO_2 was measured at room temperature and pressure.

What could be the formula of **X**?
[C = 12.0, Al = 27.0; 1 mole of any gas occupies 24 dm^3 at room temperature and pressure]

A Al_2C_3 **B** Al_3C_4 **C** Al_4C_3 **D** Al_5C_3

12 *Use of the Data Booklet is relevant to this question.*

Which element is likely to have an electronegativity similar to that of aluminium?

A barium

B beryllium

C magnesium

D strontium

13 In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic configuration.

$$[Rn]\ 5f^{14}6d^{10}7s^{2}7p^{6}$$

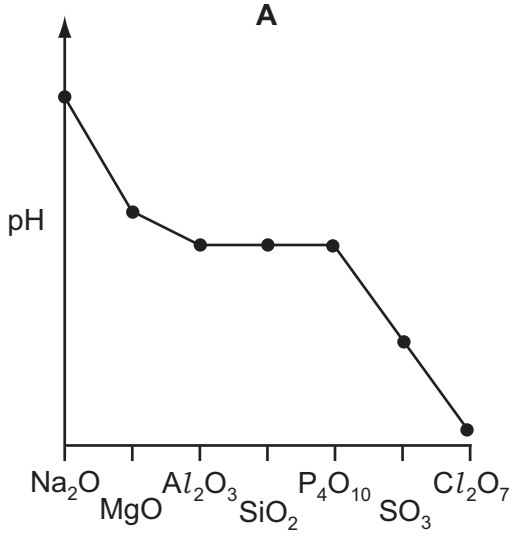
In which Group of the Periodic Table would you expect to find this element?

A II **B** IV **C** VI **D** 0

14 The highest oxides of the elements sodium to chlorine are separately added to water.

Which diagram best represents the pH of the resulting mixtures?

A



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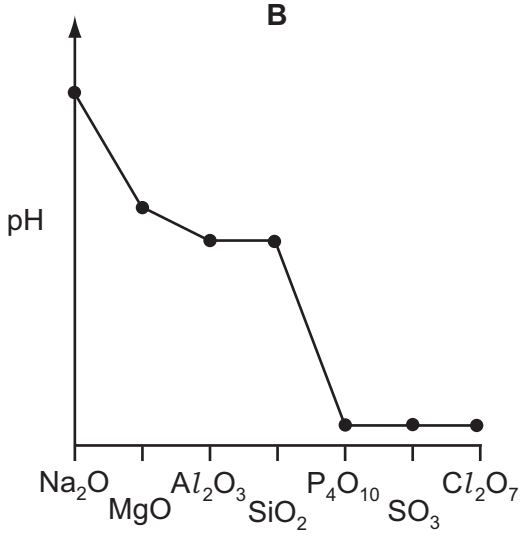

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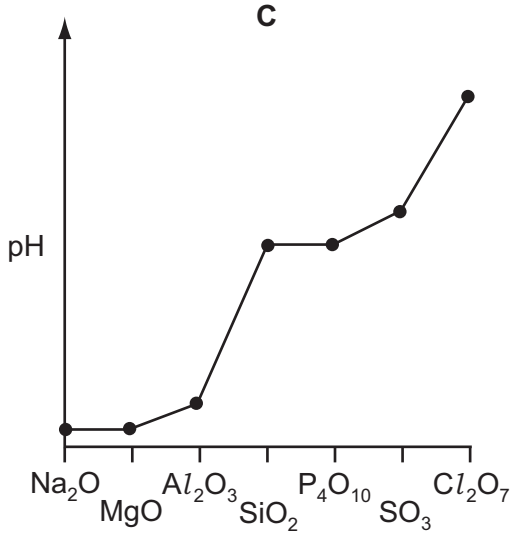

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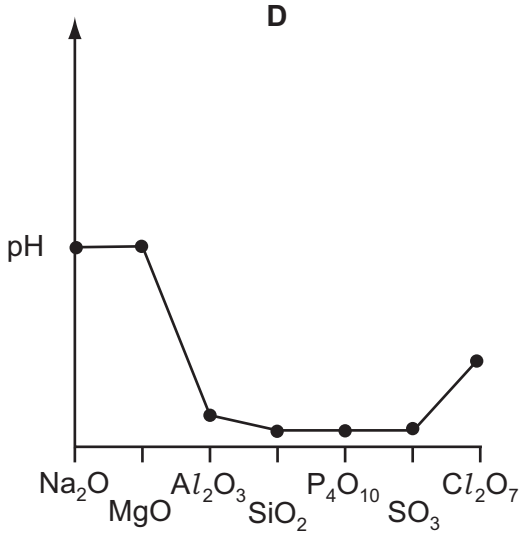
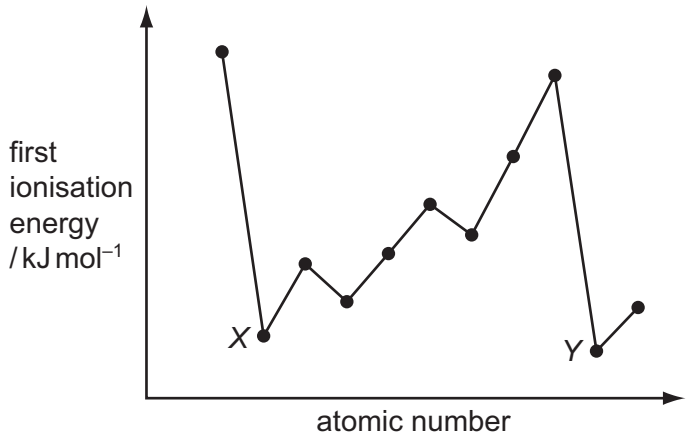


[Turn over

15 The diagram shows the first ionisation energies of 11 consecutive elements.



Which type of elements are labelled *X* and *Y*?

A Group I metals

B Group II metals

C halogens

D noble gases

16 Why does aluminium oxide dissolve in sodium hydroxide solution?

A Aluminium oxide can behave as a base.

B Aluminium oxide can behave as an acid.

C Aluminium oxide has a giant structure.

D The bonding in aluminium oxide is ionic.

17 Concentrated sulfuric acid can behave **both** as a strong acid **and** as an oxidising agent.

With which compound does concentrated sulfuric acid react in this way?

A ethanol

B magnesium carbonate

C propanenitrile

D sodium bromide

18 In the Contact process, what is the nature of the gaseous product and what is the identity of the catalyst?

	nature of gaseous product	catalyst
A	acidic	Fe
B	acidic	V_2O_5
C	basic	Fe
D	basic	V_2O_5

19 Which compound contains two different elements with identical oxidation states?

A HC*l*O **B** $Mg(OH)_2$ **C** Na_2SO_4 **D** NH_4Cl

20 Which reagent gives the same visible result with propanal and with propan-2-ol?

A 2,4-dinitrophenylhydrazine reagent

B acidified potassium dichromate(VI)

C sodium

D Tollens' reagent

21 Which halogenoalkane will undergo an S_N1 reaction and produce a yellow precipitate when $AgNO_3$(aq) is added to it?

A 1-chlorobutane

B 1-iodobutane

C 2-chloro-2-methylpropane

D 2-iodo-2-methylpropane

22 Which reaction will give 2-chloropropane in the best yield?

A propane gas with chlorine gas in the presence of ultraviolet light

B propan-2-ol with dilute NaC*l*(aq)

C propan-2-ol with $SOCl_2$

D propene with dilute HC*l*(aq)

23 The products obtained by cracking an alkane, **X**, are methane, ethene and propene.

The mole fraction of ethene in the products is 0.5.

What is the identity of **X**?

A C_6H_{14} **B** C_8H_{18} **C** C_9H_{20} **D** $C_{11}H_{24}$

24 Which compound does **not** show cis-trans isomerism?

A 2-methylpent-2-ene

B 3-methylpent-2-ene

C 3,4-dimethylhex-3-ene

D pent-2-ene

25 Which formulae show propanone and propanal as different compounds?

A empirical, molecular, structural **and** displayed formulae

B molecular, structural and displayed formulae **only**

C structural and displayed formulae **only**

D displayed formulae **only**

26 How many isomers with the formula C_5H_{10} have structures that involve π bonding?

A 3 **B** 4 **C** 5 **D** 6

27 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.

$$CH_3CH_2CHCl_2 \xrightarrow{NaOH(aq)} CH_3CH_2CHO$$

Which term describes the first step of this reaction?

A electrophilic addition

B elimination

C nucleophilic substitution

D oxidation

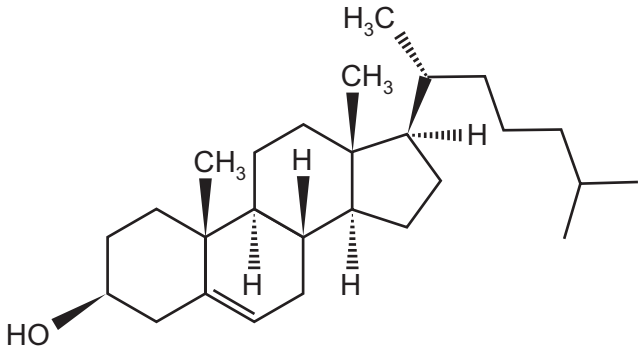
28 The ester $CH_3CH_2CH_2CO_2CH_3$ is responsible for the aroma of apples.

When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?

A CH_2O **B** CH_4O **C** C_2H_4O **D** $C_3H_6O_2$

29 This question should be answered by considering the reactions of $KMnO_4$ with different functional groups under the stated conditions.

The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Cholesterol is separately treated with

- cold, dilute acidified $KMnO_4$,
- hot, concentrated acidified $KMnO_4$.

What is the change in the **number** of chiral carbon atoms in the molecule during each reaction?

	cold, dilute acidified $KMnO_4$	hot, concentrated acidified $KMnO_4$
A	+1	0
B	+1	–1
C	+2	0
D	+2	–1

30 Which reaction would **not** give ethanoic acid as a product?

A heating ethanenitrile under reflux with dilute sodium hydroxide

B heating ethanenitrile under reflux with dilute sulfuric acid

C heating ethanal under reflux with acidified sodium dichromate(VI)

D heating ethanol under reflux with acidified sodium dichromate(VI)

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 Solid calcium carbonate is added to 100 cm^3 of dilute hydrochloric acid and the rate of the reaction is measured. 100 cm^3 of distilled water is then added to a second 100 cm^3 portion of the acid, and the experiment repeated under the same conditions.

Why does the addition of water decrease the rate of the reaction?

1 Adding water reduces the frequency of collisions between reactant molecules.

2 Adding water reduces the proportion of effective collisions between reactant molecules.

3 Adding water reduces the proportion of reactant molecules possessing the activation energy.

32 When a sample of a gas is compressed at constant temperature from 1500 kPa to 6000 kPa, its volume changes from 76.0 cm^3 to 20.5 cm^3.

Which statements are possible explanations for this behaviour?

1 The gas behaves non-ideally.

2 The gas partially liquefies.

3 Gas is adsorbed on to the vessel walls.

33 Which equations apply to an ideal gas?
[p = pressure, V = volume, M = molar mass, ρ = density, c = concentration, R = gas constant, T = temperature]

1 $p = \frac{\rho RT}{M}$ **2** $pV = MRT$ **3** $pV = \frac{cRT}{M}$

34 What is involved when a hydrogen bond is formed between two molecules?

1 a hydrogen atom bonded to an atom less electronegative than itself

2 a lone pair of electrons

3 an electrostatic attraction between opposite charges

35 When the yellow liquid NCl_3 is stirred into aqueous sodium hydroxide, the reaction that occurs can be represented by the following equation.

$$2NCl_3(l) + 6NaOH(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3NaOCl(aq) + 3H_2O(l)$$

What will be the result of this reaction?

1 The nitrogen undergoes a redox reaction.

2 A bleaching solution remains after the reaction.

3 The final solution gives a precipitate with acidified silver nitrate.

36 In a car engine pollutant oxide **Y**, which contains non-metallic element **X**, is formed.

Further oxidation of **Y** to **Z** occurs in the atmosphere. In this further oxidation, 1 mol of **Y** reacts with 0.5 mol of gaseous oxygen.

X could be either nitrogen or sulfur.

Which statements about **X**, **Y** and **Z** can be correct?

1 The oxidation number of **X** increases by two from **Y** to **Z**.

2 **Y** may have an unpaired electron in its molecule.

3 **Y** is a polar molecule.

37 Which compounds can be obtained from ethene in a **single** reaction?

1 CH_3CH_3

2 $-(-CH_2CH_2-)_n-$

3 $HOCH_2CH_2OH$

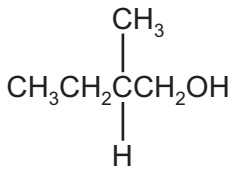
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

38 Which compounds when heated under reflux with an excess of hot acidified potassium dichromate(VI), give a product with a chiral centre?

1



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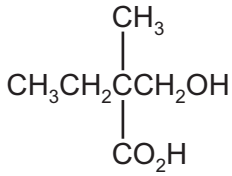

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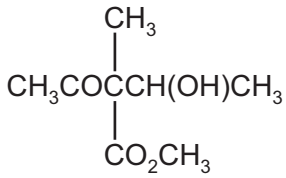

39 In the reaction between an aldehyde and HCN, catalysed by NaCN, which statements about the reaction mechanism are correct?

1 A new carbon-carbon bond is formed.

2 In the intermediate, the oxygen carries a negative charge.

3 The last stage involves the formation of a hydrogen-oxygen bond.

40 An organic compound, **X**, will react with an excess of calcium metal to produce a salt with the empirical formula $CaC_4H_6O_4$.

What could be the identity of **X**?

1 ethanoic acid

2 butanedioic acid

3 methylpropanedioic acid

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2010**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

* 3 4 9 2 9 2 3 3 2 4 *

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **13** printed pages and **3** blank pages.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 Which gas closely approaches ideal behaviour at room temperature and pressure?

A ammonia

B carbon dioxide

C helium

D oxygen

2 *Use of the Data Booklet is relevant to this question*.

What could be the proton number of an element that has three unpaired electrons in each of its atoms?

A 5 **B** 13 **C** 15 **D** 21

3 *Use of the Data Booklet is relevant to this question*.

The elements radon (Rn), francium (Fr) and radium (Ra) have consecutive proton numbers in the Periodic Table.

What is the order of their first ionisation energies?

	least endothermic ⟶		most endothermic
A	Fr	Ra	Rn
B	Fr	Rn	Ra
C	Ra	Fr	Rn
D	Rn	Ra	Fr

4 Some bond energy values are listed below.

bond	bond energy / kJ mol^{-1}
C–H	410
C–C*l*	340
C*l*–C*l*	244
Br–Br	193

These bond energy values relate to the following four reactions.

P $Br_2 \rightarrow 2Br$

Q $2C\mathit{l} \rightarrow C\mathit{l}_2$

R $CH_3 + C\mathit{l} \rightarrow CH_3C\mathit{l}$

S $CH_4 \rightarrow CH_3 + H$

What is the order of enthalpy changes of these reactions from most negative to most positive?

A P → Q → R → S

B Q → R → S → P

C R → Q → P → S

D S → P → Q → R

5 Given the following enthalpy changes,

$$I_2(g) + 3C\mathit{l}_2(g) \rightarrow 2IC\mathit{l}_3(s) \qquad \Delta H^{\ominus} = -214\,kJ\,mol^{-1}$$

$$I_2(s) \rightarrow I_2(g) \qquad \Delta H^{\ominus} = +38\,kJ\,mol^{-1}$$

What is the standard enthalpy change of formation of iodine trichloride, $IC\mathit{l}_3(s)$?

A +176 kJ mol^{-1}

B –88 kJ mol^{-1}

C –176 kJ mol^{-1}

D –214 kJ mol^{-1}

6 Ammonium nitrate, NH_4NO_3, can decompose explosively when heated.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

What are the changes in the oxidation numbers of the two nitrogen atoms in NH_4NO_3 when this reaction proceeds?

A –2, –4 **B** +2, +6 **C** +4, –6 **D** +4, –4

7 Which mass of gas would occupy a volume of 3 dm^3 at 25 °C and 1 atmosphere pressure?
[1 mol of gas occupies 24 dm^3 at 25 °C and 1 atmosphere pressure.]

A 3.2 g O_2 gas

B 5.6 g N_2 gas

C 8.0 g SO_2 gas

D 11.0 g CO_2 gas

8 *Use of the Data Booklet is relevant to this question.*

2.920 g of a Group II metal, **X**, reacts with an excess of chlorine to form 5.287 g of a compound with formula **X**Cl_2.

What is metal **X**?

A barium

B calcium

C magnesium

D strontium

9 The table gives the concentrations and pH values of the aqueous solutions of two compounds, X and Y. Either compound could be an acid or a base.

	X	Y
concentration	2 mol dm^{-3}	2 mol dm^{-3}
pH	6	9

Student P concluded that X is a strong acid.

Student Q concluded that the extent of dissociation is lower in X(aq) than in Y(aq).

Which of the students are correct?

A both P and Q

B neither P nor Q

C P only

D Q only

10 The Haber process for the manufacture of ammonia is represented by the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

Which statement is correct about this reaction when the temperature is increased?

A Both forward and backward rates increase.

B The backward rate only increases.

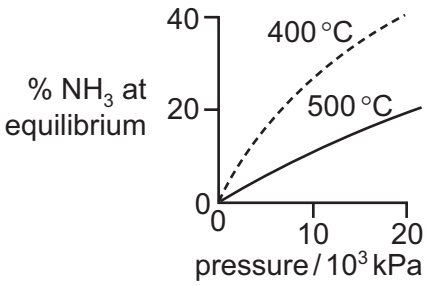
C The forward rate only increases.

D There is no effect on the backward or forward rate.

11 The percentage of ammonia obtainable, if equilibrium were established during the Haber process, is plotted against the operating pressure for two temperatures, 400 °C and 500 °C.

Which diagram correctly represents the two graphs?

A



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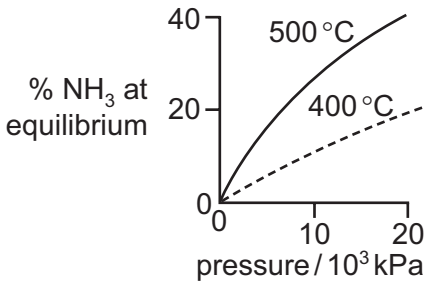

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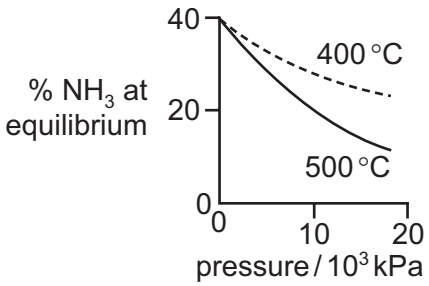

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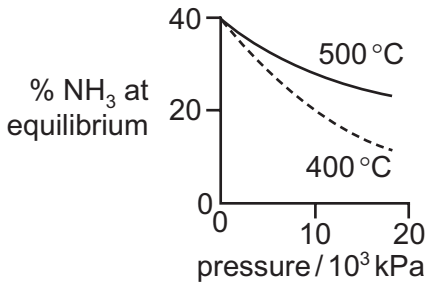

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12 Swimming pool water can be kept free of harmful bacteria by adding aqueous sodium chlorate(I), NaOC*l*. This reacts with water to produce HOC*l* molecules which kill bacteria.

$$OCl^-(aq) + H_2O \rightleftharpoons OH^-(aq) + HOCl(aq)$$

In bright sunshine, the OCl^- ion is broken down by ultra-violet light.

$$OCl^-(aq) + \text{uv light} \rightarrow Cl^-(aq) + \tfrac{1}{2}O_2(g)$$

Which method would maintain the highest concentration of HOC*l*(aq)?

A acidify the pool water

B add a solution of chloride ions

C add a solution of hydroxide ions

D bubble air through the water

13 $Na_2S_2O_3$ reacts with dilute HC*l* to give a pale yellow precipitate. If 1 cm^3 of 0.1 mol dm^{-3} HC*l* is added to 10 cm^3 of 0.02 mol dm^{-3} $Na_2S_2O_3$ the precipitate forms slowly.

If the experiment is repeated with 1 cm^3 of 0.1 mol dm^{-3} HC*l* and 10 cm^3 of 0.05 mol dm^{-3} $Na_2S_2O_3$ the precipitate forms more quickly.

Why is this?

A The activation energy of the reaction is lower when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

B The reaction proceeds by a different pathway when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

C The collisions between reactant particles are more violent when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

D The reactant particles collide more frequently when 0.05 mol dm^{-3} $Na_2S_2O_3$ is used.

14 How does concentrated sulfuric acid behave when it reacts with sodium chloride?

A as an acid only

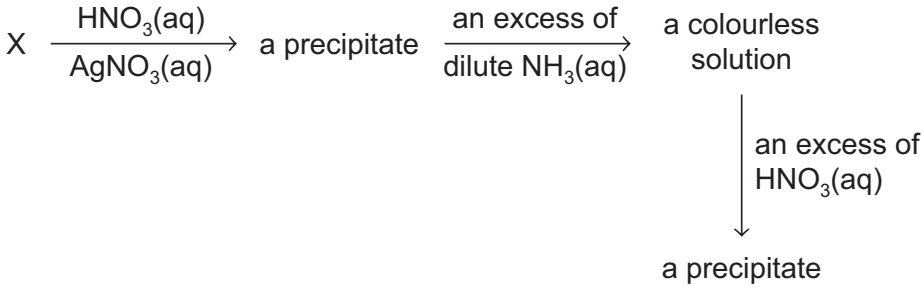
B as an acid and oxidising agent

C as an oxidising agent only

D as a reducing agent only

15 X is a salt of one of the halogens chlorine, bromine, iodine, or astatine (proton number 85).

The reaction scheme shows a series of reactions using a solution of X as the starting reagent.



What could X be?

A sodium chloride

B sodium bromide

C potassium iodide

D potassium astatide

16 Which element of the third period requires the least number of moles of oxygen for the complete combustion of 1 mol of the element?

A aluminium

B magnesium

C phosphorus

D sodium

17 Two properties of non-metallic elements and their atoms are as follows.

property 1 has an oxide that can form a strong acid in water

property 2 has **no** paired 3p electrons

Which properties do phosphorus and sulfur have?

	phosphorus	sulfur
A	1 and 2	1 only
B	1 only	1 and 2
C	1 and 2	1 and 2
D	2 only	1 only

18 Consecutive elements X, Y, Z are in the third period of the Periodic Table. Element Y has the highest first ionisation energy and the lowest melting point.

What could be the identities of X, Y and Z?

A aluminium, silicon, phosphorus

B magnesium, aluminium, silicon

C silicon, phosphorus, sulfur

D sodium, magnesium, aluminium

19 Which property of Group II elements (beryllium to barium) decreases with increasing atomic number?

A reactivity with water

B second ionisation energy

C solubility of hydroxides

D stability of the carbonates

20 When gaseous chemicals are transported by road or by rail they are classified as follows.

flammable non-flammable poisonous

Which commonly transported gas is non-flammable?

A butane

B hydrogen

C oxygen

D propene

21 What will react differently with the two isomeric alcohols, $(CH_3)_3CCH_2OH$ and $(CH_3)_2CHCH_2CH_2OH$?

A acidified aqueous potassium manganate(VII)

B concentrated sulfuric acid

C phosphorus pentachloride

D sodium

22 Which reagent will give similar results with both butanone and butanal?

A acidified aqueous potassium dichromate(VI)

B an alkaline solution containing complexed Cu^{2+} ions (Fehling's solution)

C an aqueous solution containing $[Ag(NH_3)_2]^+$ (Tollens' reagent)

D 2,4-dinitrophenylhydrazine reagent

23 What is formed when propanone is refluxed with a solution of $NaBH_4$?

A propanal

B propan-1-ol

C propan-2-ol

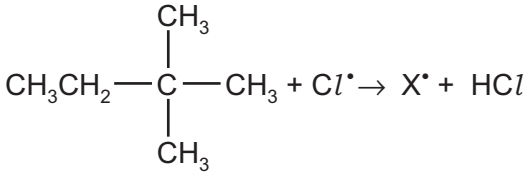
D propane

24 Which compound is a product of the hydrolysis of $CH_3CO_2C_3H_7$ by boiling aqueous sodium hydroxide?

A CH_3OH **B** C_3H_7OH **C** $C_3H_7CO_2H$ **D** $C_3H_7CO_2^- Na^+$

25 When heated with chlorine, the hydrocarbon 2,2-dimethylbutane undergoes free radical substitution.

In a propagation step the free radical $X^\bullet$ is formed.



How many different forms of $X^\bullet$ are possible?

A 1 **B** 2 **C** 3 **D** 4

26 When an isomer Y of molecular formula C_4H_9Br undergoes hydrolysis in aqueous alkali to form an alcohol C_4H_9OH, the rate of reaction is found to be unaffected by changes in the concentration of OH^- ions present.

Which is the most likely molecular structure of Y?

A $CH_3CH_2CH_2CH_2Br$

B $CH_3CH_2CHBrCH_3$

C $(CH_3)_2CHCH_2Br$

D $(CH_3)_3CBr$

27 Which isomer of $C_4H_{10}O$ forms three alkenes on dehydration?

A butan-1-ol

B butan-2-ol

C 2-methylpropan-1-ol

D 2-methylpropan-2-ol

28 Which compound exhibits both *cis-trans* and optical isomerism?

A $CH_3CH{=}CHCH_2CH_3$

B $CH_3CHBrCH{=}CH_2$

C $CH_3CBr{=}CBrCH_3$

D $CH_3CH_2CHBrCH{=}CHBr$

29 In many countries plastic waste is collected separately and sorted. Some of this is incinerated to provide heat for power stations.

Why is pvc, polyvinylchloride, removed from any waste that is to be incinerated?

A It destroys the ozone layer.

B It does not burn easily.

C It is easily biodegradable.

D Its combustion products are harmful.

30 Polymerisation of 1,1-dichloroethene produces a dense, high melting point substance that does not allow gases to pass through. It is used as cling wrapping.

Which sequence appears in a short length of the polymer chain?

A $\dagger CH_2CCl_2CH_2CCl_2CH_2CCl_2\ddagger$

B $\dagger CHClCHClCHClCHClCHClCHCl\ddagger$

C $\dagger CCl_2CCl_2CCl_2CCl_2CCl_2CCl_2\ddagger$

D $\dagger CH_2CCl_2CHClCHClCH_2CCl_2\ddagger$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 Sodium hydrogensulfide, NaSH, is used to remove hair from animal hides.

Which statements about the SH^- ion are correct?

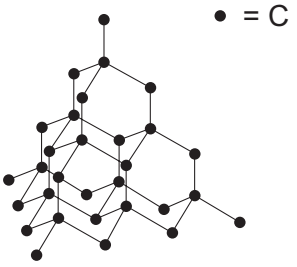
1 It contains 18 electrons.

2 Three lone pairs of electrons surround the sulfur atom.

3 Sulfur has an oxidation state of +2.

32 Which diagrams represent part of a giant molecular structure?

1



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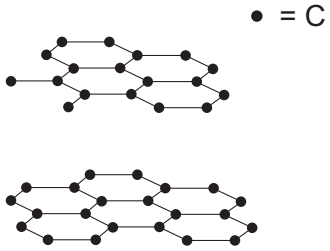

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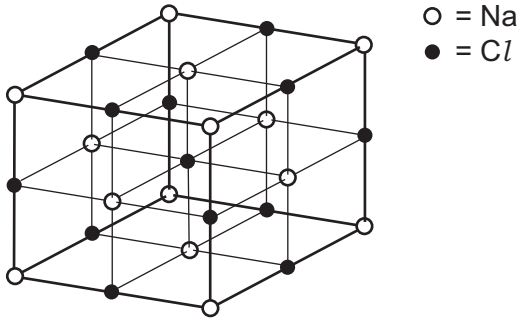


33 Which reactions are redox reactions?

1 $CaBr_2 + 2H_2SO_4 \rightarrow CaSO_4 + Br_2 + SO_2 + 2H_2O$

2 $CaBr_2 + 2H_3PO_4 \rightarrow Ca(H_2PO_4)_2 + 2HBr$

3 $CaBr_2 + 2AgNO_3 \rightarrow Ca(NO_3)_2 + 2AgBr$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 When organic refuse decomposes in water carboxylic acids are formed. The water becomes acidic and aquatic life is destroyed.

Which additives are suitable to remove this acid pollution?

1 calcium carbonate

2 calcium hydroxide

3 potassium nitrate

35 In a car engine, non-metallic element X forms a pollutant oxide Y.

Further oxidation of Y to Z occurs in the atmosphere. In this further oxidation, 1 mol of Y reacts with ½ mol of gaseous oxygen.

What can X be?

1 carbon

2 nitrogen

3 sulfur

36 Sulfur dioxide and sulfites are used in food preservation.

Why are they used for this purpose?

1 They are reducing agents so retard the oxidation of food.

2 They inhibit the growth of aerobic bacteria.

3 They react with $NO_2(g)$ converting it to $NO(g)$.

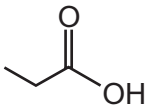
37 Which reactions are examples of nucleophilic substitution?

1 $CH_3CH_2Br + OH^- \rightarrow CH_3CH_2OH + Br^-$

2 $CH_3I + H_2O \xrightarrow{H^+} CH_3OH + HI$

3 $CH_3CH_2CH_2Cl + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HCl$

38 Propanoic acid occurs naturally as a result of the bacterial fermentation of milk, and is partly responsible for the flavour of Swiss cheese.



propanoic acid

Which starting materials could be used to synthesise propanoic acid?

1 $CH_3CH_2CH_2OH$

2 CH_3CH_2CN

3 CH_3CH_2CHO

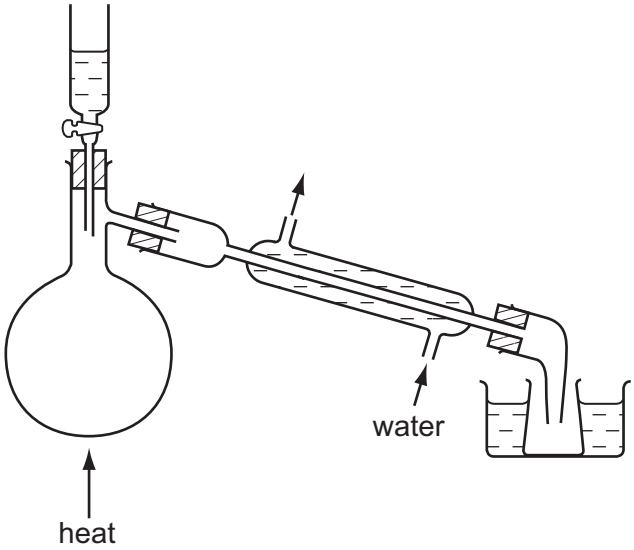
39 Which structural formulae represent 2,2-dimethylpentane?

1 $(CH_3)_2CHCH_2CH(CH_3)_2$

2 $(CH_3)_3CCH_2CH_2CH_3$

3 $CH_3CH_2CH_2C(CH_3)_3$

40 The diagram shows some laboratory apparatus.



Which preparations could this apparatus be used for?

1 bromoethane, from ethanol, sodium bromide and concentrated sulfuric acid

2 ethanal, from ethanol, sodium dichromate(VI) and sulfuric acid

3 1,2-dibromoethane, from bromine and ethene

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Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2021**

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.

This document has **16** pages. Any blank pages are indicated.

Section A

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 Compound X consists of 40.0% carbon, 6.7% hydrogen and 53.3% oxygen by mass.

What is the empirical formula of compound X?

A CH_2O **B** C_2H_2O **C** C_2H_4O **D** CHO

2 Which statement is correct?

A 1.0 g of hydrogen gas contains 3.0×10^{23} atoms.

B 4.0 g of helium gas contains 1.2×10^{24} atoms.

C 16 g of methane gas contains 3.0×10^{24} atoms.

D 44 g of carbon dioxide gas contains 6.0×10^{23} atoms.

3 Technetium (Tc) is a second row transition element that does not occur naturally on Earth. One of its isotopes has 56 neutrons.

What is the nucleon number of this isotope?

A 43 **B** 56 **C** 99 **D** 112

4 Which atom has more unpaired electrons than paired electrons in orbitals of principal quantum number 2?

A carbon

B nitrogen

C oxygen

D fluorine

5 Atom X is the central atom in a molecule.

In this molecule, atom X has four pairs of valence electrons in its outer shell.

The four pairs of valence electrons include at least one bond pair and at least one lone pair.

What could be a possible shape for the molecule?

A linear

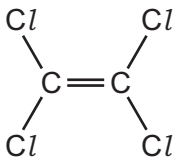
B non-linear

C trigonal bipyramidal

D trigonal planar

6 Which molecule has the largest overall dipole?

A



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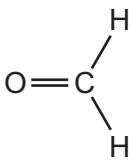

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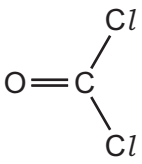


D

7 The strength of hydrogen bonding increases as the electronegativity of the element bonded to hydrogen increases.

Some information for a range of hydrides is given.

hydride	boiling point / K
PH_3	185
HCl	188
HF	293
H_2O	373

Which statement and reason about these hydrides is correct?

A The boiling point of PH_3 is much lower than the boiling point of H_2O because PH_3 does not form hydrogen bonds or instantaneous dipole-induced dipole forces between its molecules.

B The boiling point of HF is higher than the boiling point of HCl because the bond energy of H–F is greater than the bond energy of H–Cl.

C The boiling point of H_2O is higher than the boiling point of HF because each hydrogen bond between the H_2O molecules is stronger than each hydrogen bond between HF molecules.

D The boiling points of PH_3 and HCl are similar because the molecules of PH_3 and HCl have the same number of electrons and similar intermolecular forces.

8 The general gas equation can be used to calculate the value of the M_r of a gas.

For a sample of a gas of mass m grams, which expression will give the value of M_r?

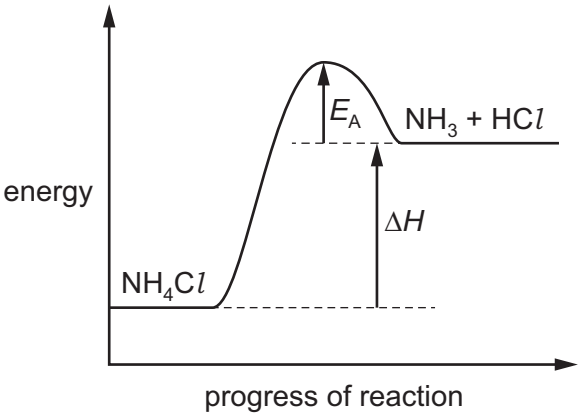
A $M_r = \frac{mRT}{pV}$ **B** $M_r = \frac{pVRT}{m}$ **C** $M_r = \frac{mpV}{RT}$ **D** $M_r = \frac{pV}{mRT}$

9 The equation for the formation of ammonium chloride is shown.

$$NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s) \qquad \Delta H = -314\,kJ\,mol^{-1}$$

Which diagram shows the correctly labelled reaction pathway diagram for the decomposition of ammonium chloride?

A



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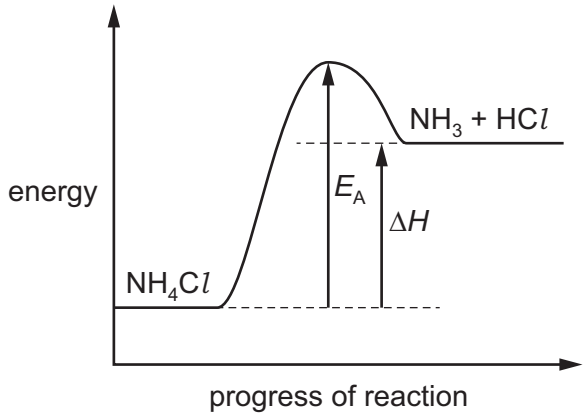

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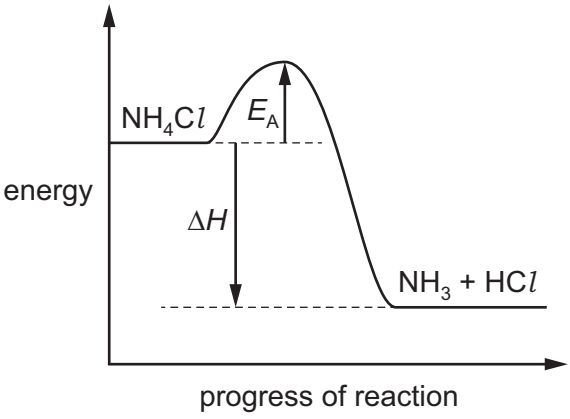

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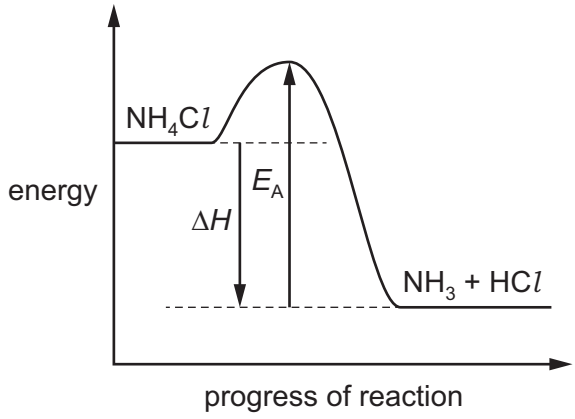


10 In a catalytic converter in the exhaust system of a car, carbon monoxide is oxidised to carbon dioxide, and nitrogen monoxide is reduced to nitrogen.

What are the changes in oxidation number of carbon and nitrogen in these two processes?

	carbon	nitrogen
A	–2	+2
B	–1	+1
C	+1	–1
D	+2	–2

11 NO and NO_2 are both present in the lower atmosphere as pollutants.

The reaction sequence shows the production of ozone from oxygen in the lower atmosphere.

This sequence repeats many times.

$$NO_2(g) \rightarrow NO(g) + O(g)$$

$$NO(g) + \tfrac{1}{2}O_2(g) \rightarrow NO_2(g)$$

$$O_2(g) + O(g) \rightarrow O_3(g)$$

Which statement about this reaction sequence is correct?

A NO is acting as a catalyst, but NO_2 is not acting as a catalyst.

B NO_2 is acting as a catalyst, but NO is not acting as a catalyst.

C Neither NO nor NO_2 are acting as catalysts.

D Both NO and NO_2 are acting as catalysts.

12 A mixture of two Period 3 oxides are added to water. A solution forms with a pH of just below 7.

What could be the constituents of the mixture?

A Al_2O_3 and MgO

B Na_2O and MgO

C Na_2O and P_4O_{10}

D SO_3 and P_4O_{10}

13 Which statement about the compounds of the Group 2 metals is correct?

A Barium carbonate is less thermally stable than strontium carbonate.

B Barium sulfate is less soluble than magnesium sulfate.

C Calcium hydroxide is less soluble than magnesium hydroxide.

D Calcium nitrate is more thermally stable than strontium nitrate.

14 A 0.005 mol sample of anhydrous calcium carbonate is completely thermally decomposed to give 100 cm^3 of gas.

In a separate experiment carried out under the same conditions, a 0.005 mol sample of anhydrous calcium nitrate is completely thermally decomposed. The volume of gaseous products is measured.

What total volume of gaseous products is produced from the calcium nitrate?

A 50 cm^3 **B** 100 cm^3 **C** 200 cm^3 **D** 250 cm^3

15 Redox reactions are common in the chemistry of Group 17 elements.

Which statement is correct?

A Br^- ions will reduce Cl_2 but not I_2.

B Cl_2 will oxidise Br^- ions but not I^- ions.

C F_2 is the weakest oxidising agent out of F_2, Cl_2, Br_2 and I_2.

D I^- ions are the weakest reducing agent out of F^-, Cl^-, Br^- and I^-.

16 Silver chloride and silver iodide form equilibria when added to water.

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq) \qquad K_c = K_1$$

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq) \qquad K_c = K_2$$

Each equilibrium position lies well to the **left**.

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq) \qquad K_c = K_3$$

The position of this equilibrium lies to the **right**.

What is the order of magnitude for these three equilibrium constants?

	smallest ⟶		largest
A	K_3	K_2	K_1
B	K_3	K_1	K_2
C	K_2	K_1	K_3
D	K_1	K_2	K_3

17 X is the ion of a metal which burns with a red flame.

Y is an ion that reacts with concentrated H_2SO_4 to produce H_2S.

What could be the formula of a compound containing X and Y?

A $BaBr_2$ **B** BaI_2 **C** $SrBr_2$ **D** SrI_2

18 Oxides of nitrogen are present in the environment due to natural and man-made sources.

Which row is correct?

	natural source of nitrogen oxides	man-made source of nitrogen oxides
A	electrical discharges in the atmosphere	internal combustion engines
B	electrical discharges in the atmosphere	as a by-product of the Haber process
C	decomposition of dead plants in rivers	internal combustion engines
D	decomposition of dead plants in rivers	as a by-product of the Haber process

19 Magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride.

Which statement explains this observation?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

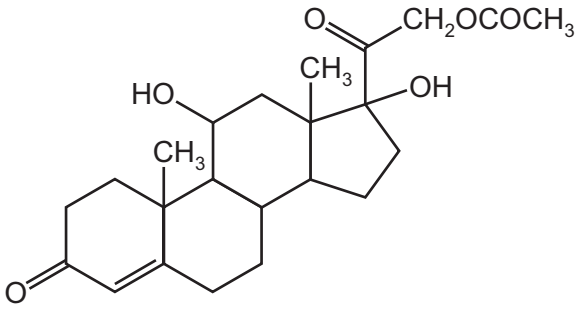
B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions have the same number of electrons.

D The NH_4^+ ion can donate a proton.

20 The formula of hydrocortisone acetate is shown.

hydrocortisone acetate



Which row is correct?

	number of C atoms in one molecule	number of chiral atoms in one molecule
A	22	7
B	22	8
C	23	7
D	23	8

21 Bromomethane, CH_3Br, decomposes in the stratosphere forming methyl free radicals and bromine free radicals.

Which row correctly describes this decomposition?

	type of bond fission	number of electrons in a bromine free radical
A	homolytic	35
B	heterolytic	35
C	homolytic	36
D	heterolytic	36

22 Structural and stereoisomerism should be taken into account when answering this question.

Y is a gaseous hydrocarbon which decolourises aqueous bromine. It contains no rings.

10.0 g of Y occupies a volume of 3.43 dm^3 under room conditions.

How many isomeric structures are possible for Y?

A 4 **B** 5 **C** 6 **D** 7

23 Which equation represents a valid propagation step in the chlorination of ethane?

A $C_2H_5Cl + Cl\bullet \rightarrow C_2H_4Cl\bullet + HCl$

B $C_2H_6 + Cl\bullet \rightarrow C_2H_5Cl + H\bullet$

C $C_2H_5Cl + H\bullet \rightarrow C_2H_5\bullet + HCl$

D $C_2H_5\bullet + Cl\bullet \rightarrow C_2H_5Cl$

24 Butanoic acid can be made from 1-bromopropane in two stages.

stage 1 $CH_3CH_2CH_2Br \rightarrow CH_3CH_2CH_2CN$

stage 2 $CH_3CH_2CH_2CN \rightarrow CH_3CH_2CH_2CO_2H$

Which types of reaction are stage 1 and stage 2?

	stage 1	stage 2
A	electrophilic addition	hydrolysis
B	electrophilic addition	oxidation
C	nucleophilic substitution	hydrolysis
D	nucleophilic substitution	oxidation

25 A halogenoalkane has the molecular formula $C_5H_{11}Br$. The halogenoalkane does **not** form an alkene when treated with ethanolic sodium hydroxide.

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D 1-bromo-2,2-dimethylpropane

26 Compound P is heated under reflux with an excess of acidified potassium dichromate(VI) to form compound Q.

Compound Q has a **lower** boiling point than compound P.

What could be compound P?

A 2-methylbutan-1-ol

B 2-methylbutan-2-ol

C pentan-1-ol

D pentan-2-ol

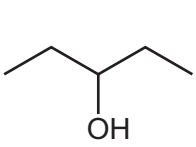
27 Structural and stereoisomerism should be taken into account when answering this question.

An organic compound, X, is dehydrated by heating with concentrated phosphoric(V) acid.

Only **two** organic products are formed.

What could be X?

A



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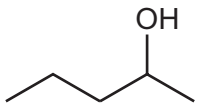

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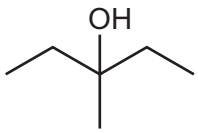
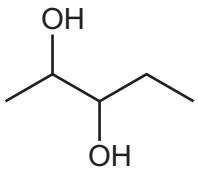


D



28 Which compound produces a precipitate with 2,4-dinitrophenylhydrazine reagent **and** also with alkaline aqueous iodine?

A butan-2-ol

B butanal

C butanone

D pentan-3-one

29 Organic compound Z has an alcohol group and a carboxylic acid group.

Compound Z reacts with magnesium carbonate to make a salt with a relative formula mass of 230.3.

Compound Z does **not** react with acidified potassium manganate(VII).

What could be the identity of compound Z?

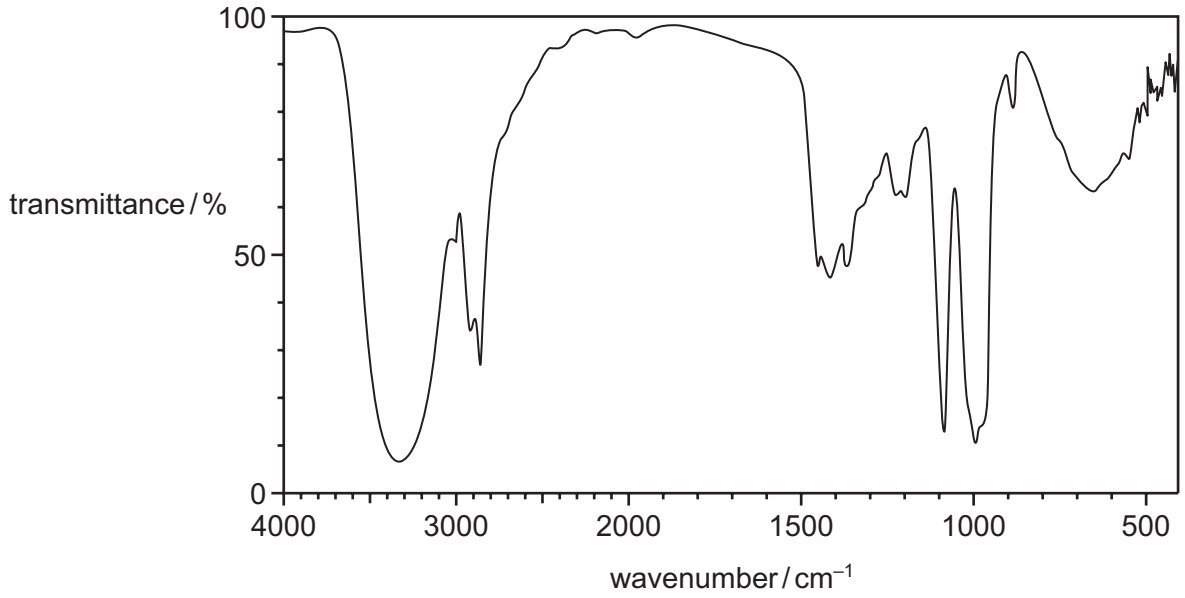
A 2-hydroxy-2-methylbutanoic acid

B 2-hydroxy-2-methylpropanoic acid

C 3-hydroxy-2-methylbutanoic acid

D 3-hydroxy-2-methylpropanoic acid

30 The infra-red spectrum of Y is shown.



What could Y be?

A $CH_3CO_2C_2H_5$

B $CH_2(OH)CH{=}CHCH_2OH$

C $CH_3(CH_2)_2CO_2H$

D $CH_2(OH)(CH_2)_2CHO$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

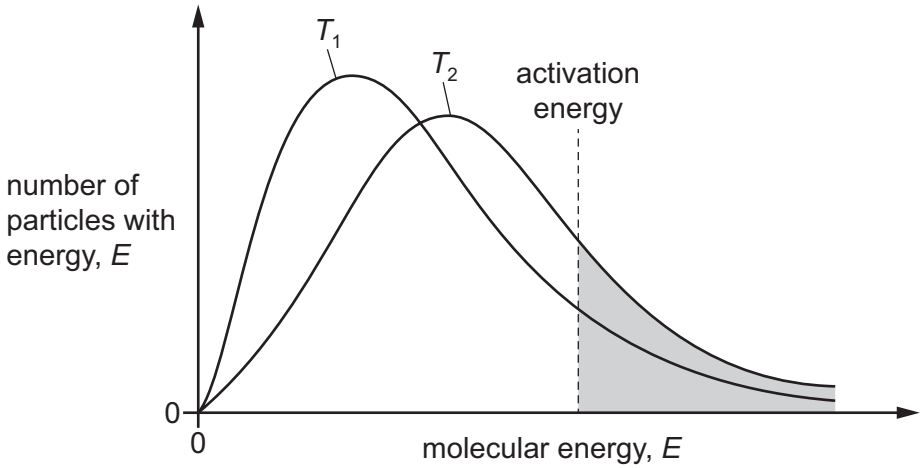
The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 The Boltzmann distribution diagram shows a fixed amount of a gas at two different temperatures, T_1 and T_2.



Which statements correctly describe the features of this diagram?

1 Temperature T_1 is lower than temperature T_2.

2 The shaded area indicates the particles that have sufficient energy to react at T_2.

3 The total area under each curve is the same for both temperatures.

32 Four solutions, each of concentration 0.1 mol dm^{-3}, were tested with a pH meter. The results are shown.

solution	formula of acid or base	pH
acid 1	CH_3CO_2H	4
acid 2	HNO_3	1
base 1	CH_3NH_2	11
base 2	NaOH	14

Which statements explain these results?

1 Acid 2 has a lower pH than acid 1 because it is more soluble.

2 Base 2 has a higher concentration of hydroxide ions in solution than base 1.

3 Acid 1 dissociates less than acid 2.

33 Which reactions are redox reactions?

1 $Mg + 2HCl \rightarrow MgCl_2 + H_2$

2 $2K_2CrO_4 + 2H^+ \rightarrow K_2Cr_2O_7 + 2K^+ + H_2O$

3 $CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$

34 When the liquid N_2F_4 is heated, it decomposes into a **single** product, X.

Which statements are correct?

1 N–F bonds are broken during this decomposition.

2 The enthalpy change when N_2F_4 decomposes into X is approximately +160 kJ mol^{-1}.

3 Molecules of X are non-linear.

35 The following statements compare some properties of the oxides and chlorides of sodium and silicon.

Which statements are correct?

1 The melting point of $SiCl_4$ is higher than the melting point of SiO_2.

2 $SiCl_4$ reacts with water, NaCl does not.

3 The melting point of $SiCl_4$ is lower than the melting point of NaCl.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

36 Which statements about ammonium chloride are correct?

1 It reacts with hot aqueous sodium hydroxide to produce an alkaline gas.

2 In solution, it reacts with aqueous silver nitrate to produce a white precipitate.

3 When solid, it reacts with concentrated sulfuric acid to produce chlorine.

37 What is the same for a pair of optical isomers?

1 their empirical formula

2 their functional groups

3 their structural formula

38 Which of the molecular formulae represent at least one compound that can undergo addition polymerisation?

1 C_4H_8

2 C_2H_3Cl

3 C_3H_6O

39 Which of the reactions give products containing a chiral centre?

1 $CH_2(OH)COCO_2H$ + an excess of HCN

2 $CH_2(OH)COCO_2H$ + an excess of $NaBH_4$

3 $CH_2(OH)COCO_2H$ + an excess of $LiAlH_4$

40 Ethyl butanoate is heated with a dilute aqueous solution of sodium hydroxide.

Which substances are products of this reaction?

1 sodium butanoate

2 water

3 sodium ethanoate

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Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2020**

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.

Section A

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 What is the average oxidation number of sulfur in each compound?

	$Ca(HSO_3)_2$	$Na_2S_2O_3$
A	4	2
B	4	4
C	6	2
D	6	4

2 An ore of manganese contains 4% by mass of MnO_2 and no other manganese compound.

Which mass of manganese would be obtained from 1 tonne of this ore?

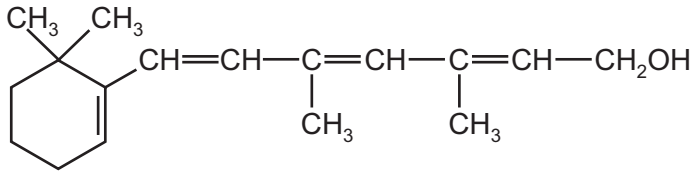
A 25.3 kg **B** 40.0 kg **C** 63.3 kg **D** 632 kg

3 Which atomic orbitals are occupied in an atom of phosphorus?

A 1p 2s 2p **B** 2s 2p 2d **C** 2s 2p 3s **D** 2p 3s 3d

4 The structure of compound A is shown.

compound A



Some of the carbon atoms in compound A have a tetrahedral arrangement of bonds.

Some of the carbon atoms in compound A have a trigonal planar arrangement of bonds.

How many carbon atoms are there of each type?

	tetrahedral	trigonal planar
A	5	12
B	8	8
C	9	6
D	9	8

5 A white powder is known to be a mixture of magnesium oxide and aluminium oxide.

$100\,cm^3$ of $2\,mol\,dm^{-3}$ NaOH(aq) is just enough to dissolve the aluminium oxide in *x* grams of the mixture.

The reaction is shown.

$$Al_2O_3 + 2OH^- + 3H_2O \rightarrow 2Al(OH)_4^-$$

$800\,cm^3$ of $2\,mol\,dm^{-3}$ HCl(aq) is just enough to dissolve **all** of the oxide in *x* grams of the mixture.

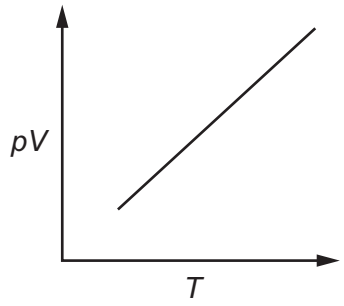
The reactions are shown.

$$Al_2O_3 + 6H^+ \rightarrow 2Al^{3+} + 3H_2O$$
$$MgO + 2H^+ \rightarrow Mg^{2+} + H_2O$$

How many moles of each oxide are present in *x* grams of the mixture?

	aluminium oxide	magnesium oxide
A	0.05	0.25
B	0.05	0.50
C	0.10	0.25
D	0.10	0.50

6 A graph of *pV* against *T* is shown for a fixed mass of gas. (*p* = pressure, *V* = volume and *T* = temperature in K.)



Which gas gives this graph over the widest range of temperatures and pressures?

A hydrogen, H_2

B hydrogen chloride, HCl

C hydrogen fluoride, HF

D oxygen, O_2

7 A weather balloon is filled with 12.0 kg helium. The weather balloon reaches a height of 20 km, the pressure inside the balloon is 6000 Pa and the temperature is 216 K.

What is the volume of the weather balloon at this height, correct to three significant figures?

A 897 dm^3 **B** 1790 dm^3 **C** 897 000 dm^3 **D** 1 790 000 dm^3

8 Which pair of enthalpy changes will **always** share the same sign (i.e. both are always exothermic **or** both are always endothermic)?

A enthalpy change of atomisation and enthalpy change of neutralisation

B enthalpy change of atomisation and enthalpy change of solution

C enthalpy change of combustion and enthalpy change of hydration

D enthalpy change of solution and enthalpy change of hydration

9 Chlorine dioxide, ClO_2, reacts with sodium hydroxide in the reaction shown.

$$2ClO_2 + 2OH^- \rightarrow ClO_2^- + ClO_3^- + H_2O$$

Which statement correctly describes this redox reaction?

A Chlorine atoms are oxidised and oxygen atoms are reduced.

B Chlorine atoms are reduced and oxygen atoms are oxidised.

C Some chlorine atoms are oxidised and some chlorine atoms are reduced.

D Some oxygen atoms are oxidised and some oxygen atoms are reduced.

10 Sulfur dioxide and oxygen react to form sulfur trioxide. The reaction is reversible.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad K_p = 2.96 \times 10^{-9}\ Pa^{-1} \text{ at } 700\,°C$$

The reaction is allowed to reach equilibrium at 700 °C. The partial pressure of $O_2(g)$ is 375 kPa and the partial pressure of $SO_3(g)$ is 20.3 kPa.

What is the partial pressure of $SO_2(g)$?

A 19.3 kPa **B** 609 kPa **C** 18 300 kPa **D** 609 000 kPa

11 Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H \text{ is negative}$$

What will increase the rate of the forward reaction?

A adding argon to the mixture but keeping the total volume constant

B decreasing the temperature

C increasing the total pressure by reducing the total volume at constant temperature

D removing ammonia as it is made but keeping the total volume of the mixture the same

12 Element X, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise HCl(aq).

What is element X?

A Mg **B** Al **C** Si **D** P

13 Which row could refer to barium metal and barium hydroxide?

	colour seen when the metal is burnt in O_2	pH of a saturated solution of the hydroxide
A	green flame	8
B	green flame	13
C	white flame	8
D	white flame	13

14 $AgNO_3(aq)$ is added to a solution of a halide ion, $X^-(aq)$, and aqueous ammonia is then added.

The ionic equations for the two reactions that occur are shown.

$$Ag^+(aq) + X^-(aq) \rightleftharpoons AgX(s) \qquad \text{equilibrium 1}$$

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq) \qquad \text{equilibrium 2}$$

Which statement is correct?

A The position of equilibrium 1 lies to the left when $X^- = I^-$.

B Increasing the concentration of ammonia causes the position of equilibrium 1 to move to the left.

C K_c for equilibrium 2 is larger when $X^- = Cl^-$ than when $X^- = I^-$.

D Equilibrium 2 is a redox reaction.

15 Water and ammonia take part in a reaction that produces the ammonium ion.

Which statement about this reaction is correct?

A The ammonia molecule and the ammonium ion do not have dipole moments.

B The bond angle changes from 109.5° in the ammonia molecule to 107° in the ammonium ion.

C The reaction is a redox reaction.

D The water is acting as an acid.

16 Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.

Which statement about the reactions of lithium or its compounds can be predicted from this statement?

A Lithium burns very slowly in oxygen.

B Lithium carbonate decomposes on heating in a blue Bunsen burner flame, forming lithium oxide and carbon dioxide.

C Lithium nitrate decomposes on heating, forming lithium nitrite, $LiNO_2$, and oxygen.

D Lithium reacts very violently with cold water, producing hydrogen.

17 Which statement about Group 17 elements and their compounds is correct?

A Chlorine reacts with cold concentrated sodium hydroxide to form $NaCl$ and $NaClO_3$.

B HCl is more thermally stable than HBr because chlorine is less electronegative than bromine.

C Iodide ions are oxidised to iodine by concentrated sulfuric acid.

D Silver iodide is soluble in dilute aqueous ammonia.

18 Which substance, when warmed with aqueous ammonium chloride, would produce an alkaline gas?

A CH_3CO_2H **B** CH_3CH_2OH **C** $CH_3CO_2CH_3$ **D** CH_3CH_2ONa

19 Compound X is the oxide of a Period 3 element. Compound X reacts with water to give an acidic solution.

A solution is prepared by reacting 0.100 g of compound X with an excess of water. This solution is neutralised by exactly 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.

What could be the identity of compound X?

A Al_2O_3 **B** MgO **C** P_4O_{10} **D** SO_3

20 The unsaturated hydrocarbon octa-1,3,5,7-tetraene, C_8H_{10}, can display geometric isomerism.

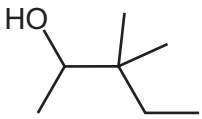
octa-1,3,5,7-tetraene

$CH_2=CHCH=CHCH=CHCH=CH_2$

How many isomers exist?

A 2 **B** 3 **C** 4 **D** 8

21 What is the correct name for the compound shown?



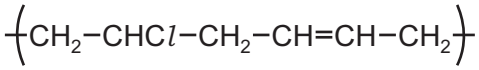
A 1,2,2-trimethylbutan-3-ol

B 2-ethyl-2-methylbutan-2-ol

C 3,3-dimethylpentan-2-ol

D 4-hydroxy-3,3-dimethylpentane

22 A polymer has the following repeat unit. It is made from two different monomers.



Which pair of monomers could be used to make this polymer?

A $CH_2=CHCl$ and $CH_2=CH_2$

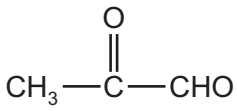
B $CH_2=CHCl$ and $CH_2=CH–CH=CH_2$

C $CH_3–CH_2Cl$ and $CH_3–CH=CH–CH_3$

D $CH_3–CH=CH–CH_3$ and $CH_2=CHCl$

23 Compound X contains two functional groups.

compound X



Which reagent will react with **only one** of the functional groups?

A acidified potassium dichromate(VI)

B 2,4-DNPH reagent

C hydrogen cyanide

D $NaBH_4$

24 Ethanol can be converted into ethene in a single reaction.

Ethanol can be converted into bromoethane in a single reaction.

Under standard laboratory conditions, is a catalyst used in these reactions?

	ethanol to ethene	ethanol to bromoethane
A	yes	yes
B	yes	no
C	no	yes
D	no	no

25 Diols in which both hydroxy groups are bonded to the same carbon atom can spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound, after complete hydrolysis, gives a silver mirror with Tollens' reagent?

A 1,1-dibromobutane

B 1,2-dibromobutane

C 1,3-dibromobutane

D 2,2-dibromobutane

26 Which alcohol will give a yellow precipitate when warmed with alkaline aqueous iodine?

A $(CH_3)_2CHCH_2OH$

B $(CH_3)_3COH$

C $CH_3CH_2C(OH)(CH_3)_2$

D $CH_3CH(OH)CH_2CH_3$

27 How many structural isomers are there of molecular formula $C_5H_{10}O$ that give a red precipitate with Fehling's solution?

A 1 **B** 2 **C** 3 **D** 4

28 Which statement about the use of alkane fuels in internal combustion engines is correct?

A C_8H_{18} is used as fuel in internal combustion engines and reacts with oxygen and nitrogen from the air.

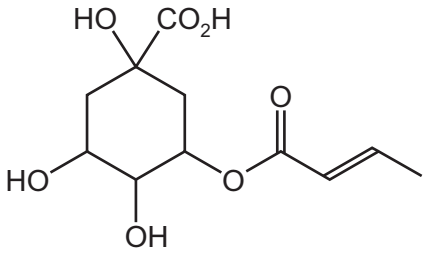
B In limited oxygen, CO is produced which oxidises SO_2 to SO_3 in the atmosphere.

C The catalytic converter removes polluting gases including NO_2 and CO_2.

D Unburnt hydrocarbons and NO_2 can react in sunlight to produce photochemical smog.

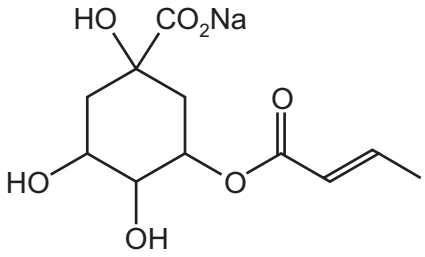
29 Compound Z is shown.

compound Z

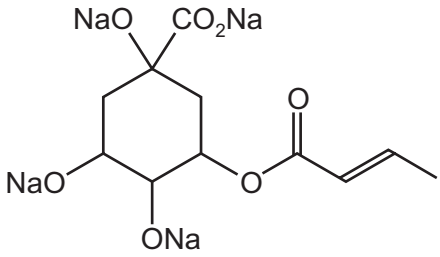


What is produced in good yield when compound Z is treated with an excess of sodium carbonate solution at room temperature?

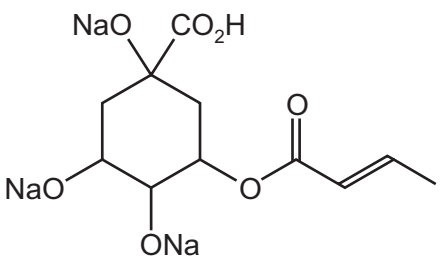
A



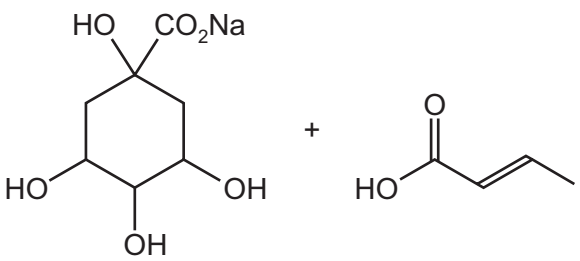
B



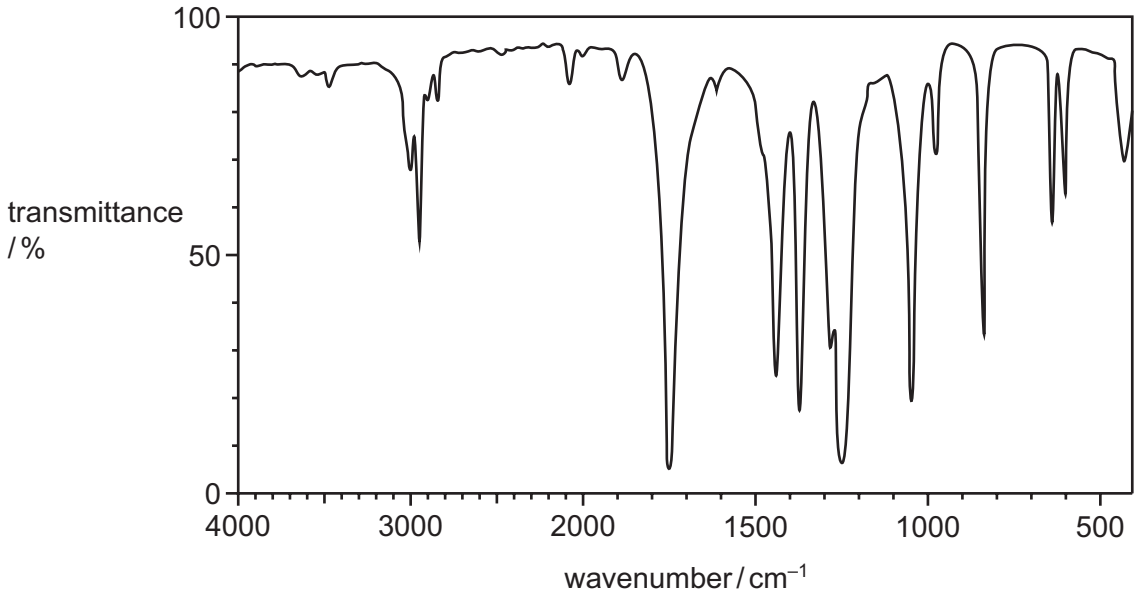
C



D



30 The infra-red spectrum shown was obtained from compound G.



What could be compound G?

A CH_3COCH_2OH

B $CH_3CH_2CO_2H$

C $CH_3CO_2CH_3$

D $CH_3CHCHCH_3$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 The symbol for a phosphorus ion is $^{33}_{15}P^{3-}$.

The symbol for a potassium ion is $^{37}_{19}K^{+}$.

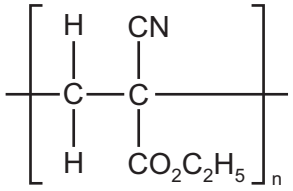
What do these two ions have in common?

1 the same number of electrons

2 the same number of neutrons

3 the same number of protons

32 The repeat unit of a polymer is shown.



Which types of intermolecular forces exist in the solid polymer?

1 temporary dipole – induced dipole interactions

2 permanent dipole – permanent dipole interactions

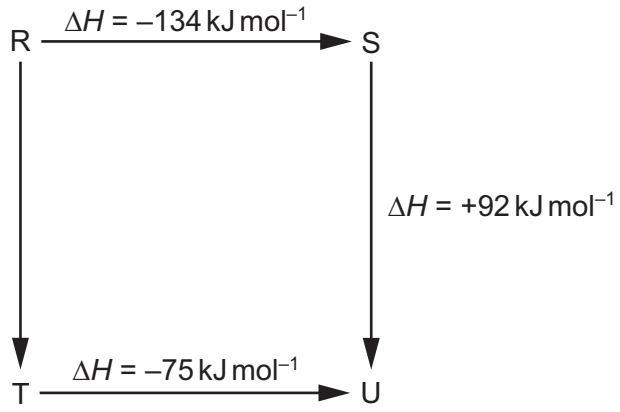
3 hydrogen bonds

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

33 The diagram illustrates the enthalpy changes of a set of reactions.



Which statements are correct?

1 The enthalpy change for the transformation U → R is +42 kJ mol^{-1}.

2 The enthalpy change for the transformation T → S is endothermic.

3 The enthalpy change for the transformation R → T is –33 kJ mol^{-1}.

34 Which statements about a reaction that has reached dynamic equilibrium are correct?

1 The rate of the forward reaction equals the rate of the reverse reaction.

2 There is no overall change in the concentrations of reactants and products.

3 There is no change in the measurable properties of the system.

35 Group 2 elements and their compounds show trends in their physical and chemical properties. Barium is above radium in Group 2 of the Periodic Table.

Which statements are likely to be correct?

1 Barium hydroxide is less soluble than radium hydroxide.

2 Barium reacts less vigorously with water than radium does.

3 Barium sulfate is more soluble than radium sulfate.

36 Which statements are correct?

1 The empirical formula of silicon(IV) oxide is SiO_2.

2 The molecular formula of phosphorus(V) oxide is P_2O_5.

3 Silicon(IV) oxide and phosphorus(V) oxide are both simple molecular compounds.

37 Which reagents could be used, under suitable conditions, to oxidise $CH_3CH_2CH_2OH$ to CH_3CH_2CHO?

1 acidified potassium manganate(VII)

2 acidified potassium dichromate(VI)

3 Tollens' reagent

38 Which free radicals can be generated during a free-radical substitution reaction between chlorine and ethane?

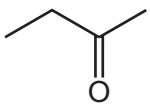
1 CH_3•

2 $CH_2Cl CH_2$•

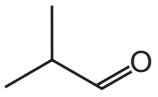
3 CH_3CCl_2•

39 Which substances have molecular formula C_4H_8O?

1



2



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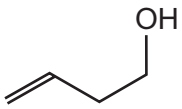

40 Which reactions produce pentanoic acid?

1 $CH_3CH_2CH_2CH(OH)CH_3 + H^+ / MnO_4^-(aq)$

2 $CH_3OCO(CH_2)_3CH_3 + HCl(aq)$

3 $CH_3(CH_2)_3CN + H_2SO_4(aq)$

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Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2019**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

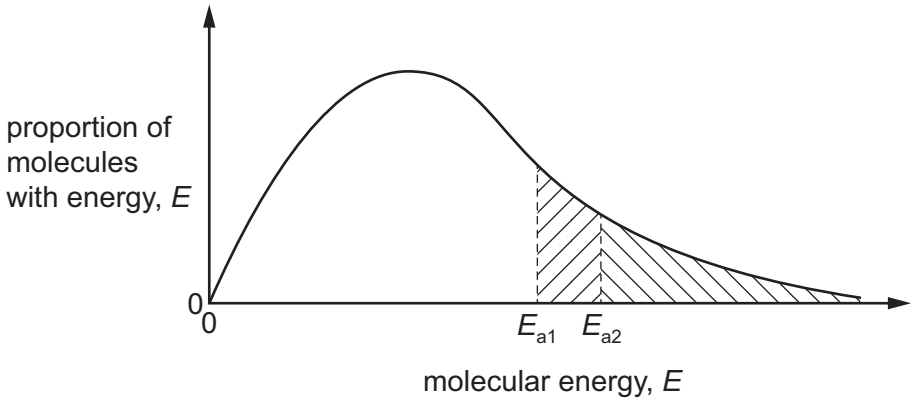
IB19 11_9701_12/3RP

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 The diagram shows a Boltzmann distribution of the energies of gaseous molecules and the activation energies, E_a, of a reaction with and without a catalyst.



Which statement about this distribution curve is correct?

A If the temperature of the gas is increased, the maximum of the curve becomes higher.

B If the temperature of the gas is increased, the maximum of the curve moves to the left.

C The fraction of molecules that react in the presence of a catalyst is shown by ▨.

D The fraction of molecules that react in the absence of a catalyst is shown by ▨.

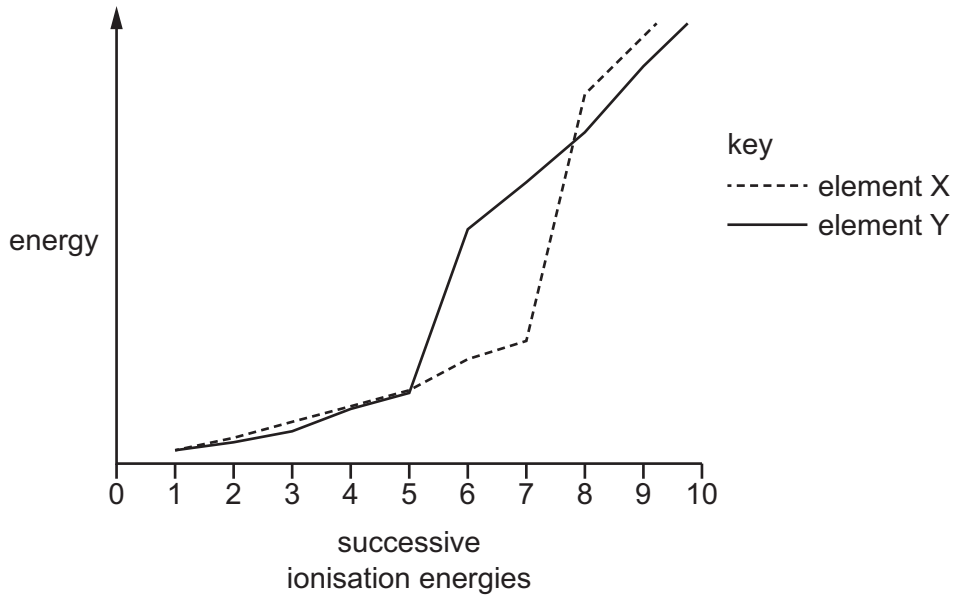
2 In this question it should be assumed that $(NH_4)_2CO_3.H_2O(s)$ dissolves in water without causing an increase in volume.

Which mass of $(NH_4)_2CO_3.H_2O(s)$ should be added to 800 cm^3 of water to form a 0.100 $mol\,dm^{-3}$ solution of NH_4^+ ions?

A 4.56 g **B** 7.13 g **C** 9.12 g **D** 14.3 g

3 The graph shows the successive ionisation energies of element X and element Y.

Both elements are in Period 3.



Which statement is correct?

A An atom of element X needs one extra electron for a full outer shell; an atom of element Y needs three extra electrons for a full outer shell.

B An atom of element Y has five electrons in the 3p subshell.

C Element X has an oxidation number of +7 in most of its compounds.

D When element X combines with element Y, the bonding is ionic.

4 Which statement about the electrons in a ground state carbon atom is correct?

A Electrons are present in four different energy levels.

B There are more electrons in p orbitals than there are in s orbitals.

C The occupied orbital of highest energy is spherical.

D The occupied orbital of lowest energy is spherical.

5 In this question you should assume the vapour behaves as an ideal gas.

0.175 g of a volatile liquid produces a vapour of volume $4.50 \times 10^{-5}\,m^3$ at 100 °C and pressure of 1.013×10^5 Pa.

What is the M_r of the liquid?

A 31.9 **B** 87.1 **C** 119 **D** 127

6 Which reaction is endothermic?

A $Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$

B $2Cl(g) \rightarrow Cl_2(g)$

C $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$

D $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

7 Which equation correctly represents the standard enthalpy change of atomisation of the given element?

A $\frac{1}{2}I_2(g) \rightarrow I(g)$

B $Na(s) \rightarrow Na(g)$

C $Cl_2(g) \rightarrow 2Cl(g)$

D $Na(g) \rightarrow Na^+(g) + e^-$

8 $(NH_4)_2Cr_2O_7$ decomposes when heated.

$$(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3$$

Which element is oxidised and which element is reduced?

	oxidised	reduced
A	chromium	nitrogen
B	hydrogen	chromium
C	nitrogen	chromium
D	nitrogen	hydrogen

9 When lead(II) sulfide, PbS, is heated in air, sulfur dioxide and lead(II) oxide are formed.

What is the equation for the reaction between PbS and oxygen?

A $PbS + 2O_2 \rightarrow SO_2 + PbO_2$

B $PbS + 2\frac{1}{2}O_2 \rightarrow SO_3 + PbO_2$

C $PbS + 1\frac{1}{2}O_2 \rightarrow SO_2 + PbO$

D $PbS + 2O_2 \rightarrow SO_3 + PbO$

10 The decomposition of $SO_3(g)$ is a dynamic equilibrium.

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$$

What happens when the pressure of the system is increased?

A The rate of reaction will decrease and the position of the equilibrium will move to the left.

B The rate of reaction will decrease and the position of the equilibrium will move to the right.

C The rate of reaction will increase and the position of the equilibrium will move to the left.

D The rate of reaction will increase and the position of the equilibrium will move to the right.

11 Hydrated aluminium ions undergo the following reaction.

$$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$$

Which statement about this reaction is correct?

A $H_2O(l)$ and $[Al(H_2O)_5OH]^{2+}(aq)$ are a conjugate acid-base pair.

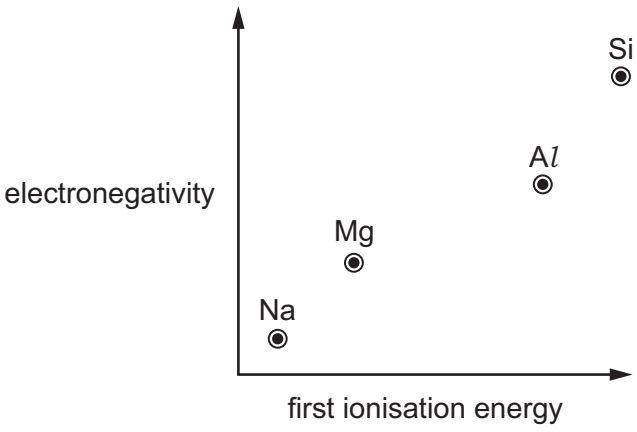
B $H_2O(l)$ is acting as an acid as it is donating H^+ ions.

C If $OH^-(aq)$ is added, the equilibrium will move to the right.

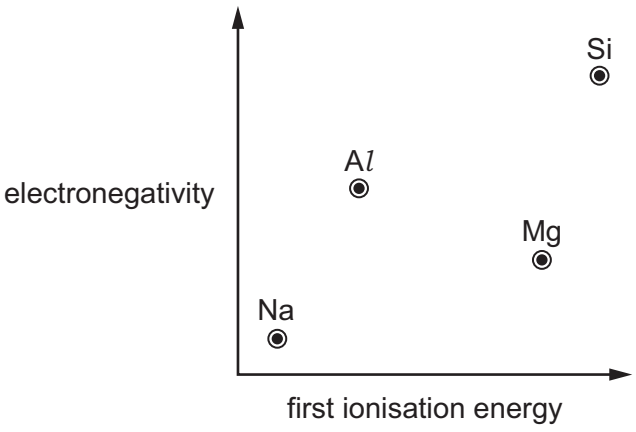
D K_c varies as the pH is varied.

12 Which diagram correctly shows the electronegativity of the elements Na, Mg, A*l* and Si plotted against their first ionisation energies?

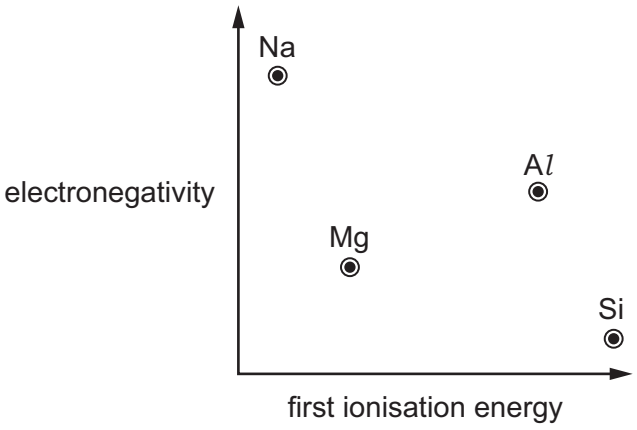
A



B



C



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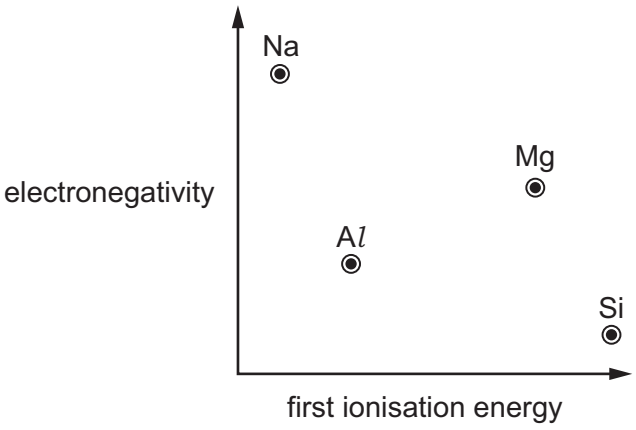


13 Which statement about the compounds of Group 2 elements magnesium to barium is correct?

A Carbonates of Group 2 elements produce bubbles when added to dilute nitric acid.

B Nitrates of Group 2 elements produce nitrogen and oxygen on heating.

C Oxides of Group 2 elements produce bubbles when added to dilute hydrochloric acid.

D The oxides of Group 2 elements are amphoteric.

14 When equal volumes of saturated solutions of barium hydroxide and calcium hydroxide are mixed, a white precipitate, Y, forms. The mixture is filtered and carbon dioxide is bubbled through the filtrate, producing a second white precipitate, Z.

What are Y and Z?

	Y	Z
A	$Ba(OH)_2$	$Ca(OH)_2$
B	$Ba(OH)_2$	$CaCO_3$
C	$Ca(OH)_2$	$BaCO_3$
D	$Ca(OH)_2$	$Ba(OH)_2$

15 Chlorate(V) ions, ClO_3^-, are produced in the redox reaction between chlorine and hot aqueous sodium hydroxide. Oxidation numbers can be used to help balance the equation for this reaction.

$$vCl_2(g) + wOH^-(aq) \rightarrow xCl^-(aq) + yClO_3^-(aq) + zH_2O(l)$$

What are the values of v, x and y in the balanced equation?

	v	x	y
A	2	3	1
B	3	4	2
C	3	5	1
D	7	12	2

16 The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

A bond strength of the hydrogen-halide bond

B first ionisation energy

C solubility of the silver halide in $NH_3(aq)$

D strength of the van der Waals' forces between molecules of the element

17 Solid sodium iodide reacts with concentrated sulfuric acid to form more than one product that contains sulfur.

What is the lowest oxidation number of sulfur in these products?

A –2 **B** 0 **C** +4 **D** +6

18 Which emission from an internal combustion engine contributes to the erosion of marble statues?

A carbon monoxide

B nitrogen

C nitrogen dioxide

D unburnt hydrocarbons

19 Ammonia, carbon dioxide and water react together to form ammonium carbonate.

Which statement about this reaction is correct?

A It is a redox reaction.

B It is an acid-base reaction.

C The H–N–H bond angle decreases as a consequence of this reaction.

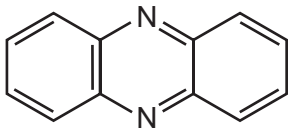
D The three substances react in a 1 : 1 : 1 ratio in this reaction.

20 Structural isomerism and stereoisomerism should be considered when answering this question.

How many isomers with the formula C_5H_{10} have structures that involve π bonding?

A 3 **B** 4 **C** 5 **D** 6

21 The diagram shows the skeletal formula of phenazine.



phenazine

What is the empirical formula of phenazine?

A C_6H_4N **B** C_6H_6N **C** $C_{12}H_8N_2$ **D** $C_{12}H_{12}N_2$

22 An organic compound X reacts with hot, concentrated acidified potassium manganate(VII) solution to give a single carbon-containing product.

What could be X?

A $CH_2C(CH_3)_2$

B $CH_3CHCHCH_3$

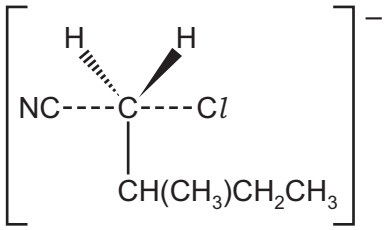
C $CH_2CHCH_2CH_3$

D $CH_3CH_2CH_2CH_3$

23 1-chloro-2-methylbutane reacts with sodium cyanide in ethanol in a nucleophilic substitution reaction.

What is the most likely intermediate or transition state in this reaction?

A



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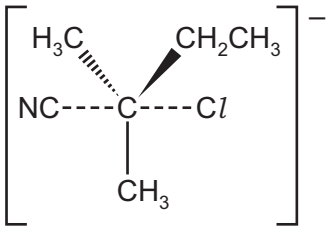

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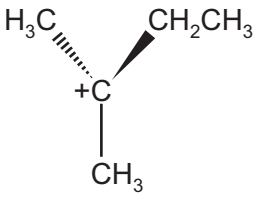

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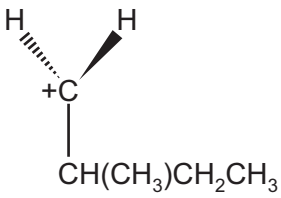
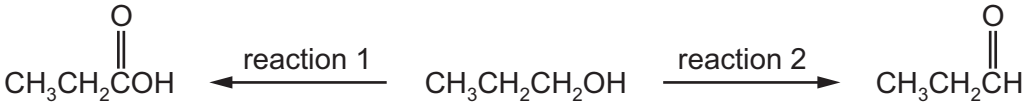


24 Propan-1-ol can be reacted with acidified potassium dichromate(VI) to form propanoic acid, reaction 1, or propanal, reaction 2.



propan-1-ol

How can the reaction be carried out to ensure that reaction 2 occurs rather than reaction 1?

A An excess of acidified potassium dichromate(VI) is used.

B An excess of concentrated sulfuric acid is added.

C The reaction mixture is distilled immediately after mixing.

D The reaction mixture is heated under reflux.

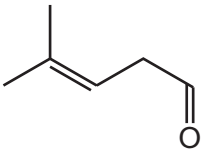
25 What is the smallest amount of oxygen molecules needed for the complete combustion of 40.0 g of methanol?

A 1.88 moles **B** 2.50 moles **C** 3.75 moles **D** 5.00 moles

26 Compound X has stereoisomers and forms a precipitate when warmed with Fehling's reagent.

What could be the structure of compound X?

A



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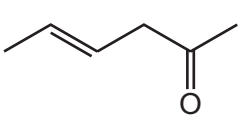

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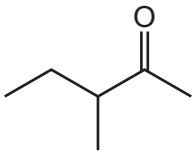

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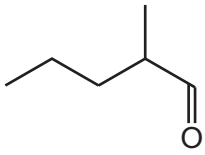
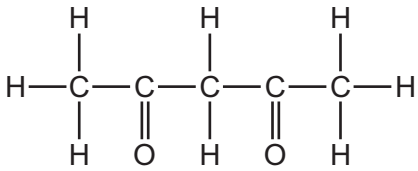


27 The diagram shows the structure of Y.



Two suggestions are made about Y.

1 Y can be oxidised by hot, acidified dichromate(VI) ions.

2 One mole of Y gives one mole of tri-iodomethane when it reacts with an excess of alkaline aqueous iodine.

Which suggestions are correct?

A both 1 and 2

B 1 only

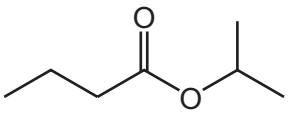
C 2 only

D neither 1 nor 2

28 Esters can be prepared by the reaction of a carboxylic acid with an alcohol in the presence of concentrated sulfuric acid.

Which row gives the correct names of the reagents that would be suitable to prepare ester Z?

Z



	alcohol	carboxylic acid
A	butan-1-ol	methyl propanoic acid
B	propan-1-ol	butanoic acid
C	propan-2-ol	butanoic acid
D	propan-2-ol	propanoic acid

29 Compound Q can be hydrolysed by HCl(aq). The two products of this hydrolysis have the same empirical formula.

What could Q be?

A $CH_3CO_2CH_2CH_2OH$

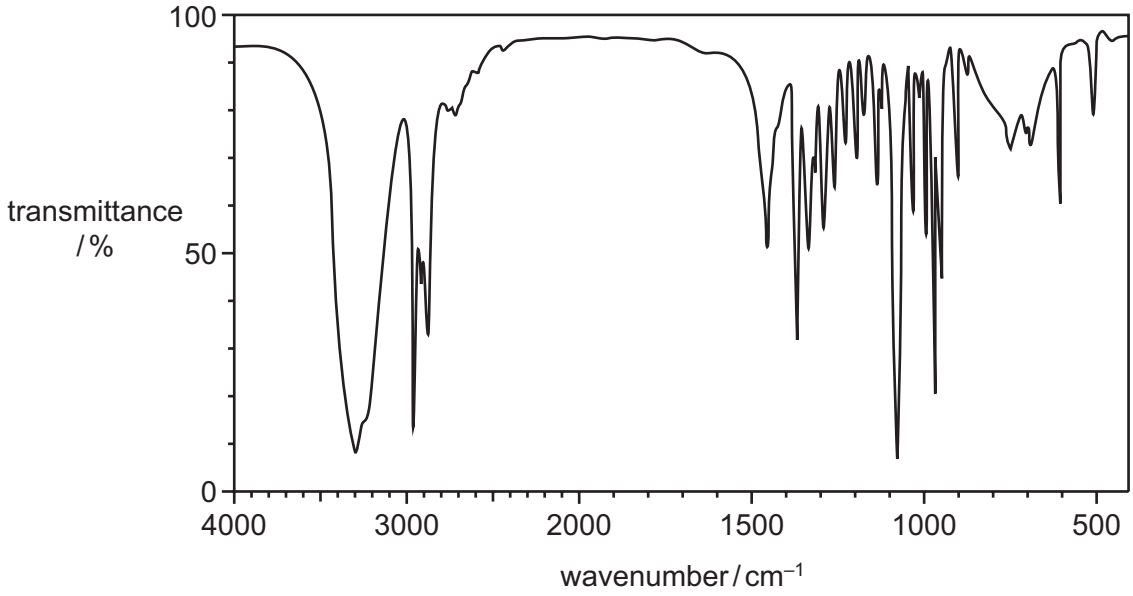
B $CH_3CO_2CH_2CH_2CO_2H$

C $CH_3CH_2CO_2CH_2CH_2CH_3$

D $CH_3CH_2CH(OH)CH(OH)CH_2CH_3$

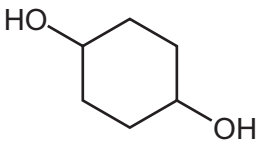
30 Substance T was analysed and found to contain 62.07% carbon, 10.34% hydrogen and 27.59% oxygen.

The infra-red spectrum of substance T is shown.

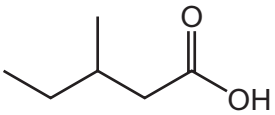


Which substance could be T?

A



B



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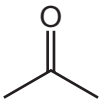

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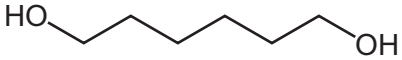


Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 Which gaseous molecules are polar?

1 ammonia

2 hydrogen sulfide

3 boron trifluoride

32 A carbon monoxide molecule, CO, has three bonds between the carbon atom and the oxygen atom.

Which features are present in one CO molecule?

1 two lone pairs of electrons

2 a co-ordinate (dative covalent) bond from oxygen to carbon

3 two π bonds

33 Carbon can exist as allotropes which include graphite, diamond and a fullerene.

Which statements are correct?

1 All three allotropes contain covalent bonds.

2 All three allotropes are giant molecular.

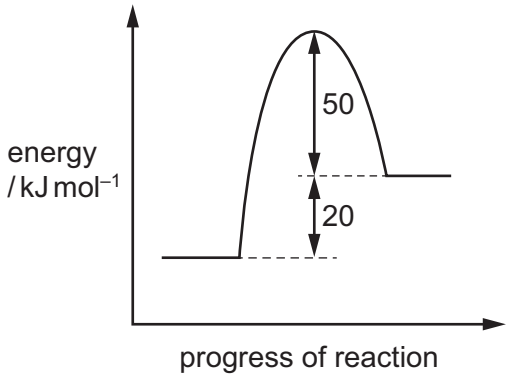
3 All three allotropes have delocalised electrons.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 The reaction pathway diagram for a reversible reaction is shown.



Which statements are correct?

1 The enthalpy change for the backward reaction is –20 kJ mol^{-1}.

2 The forward reaction is endothermic.

3 The activation energy for the forward reaction is +70 kJ mol^{-1}.

35 Silicon forms a tetrachloride, $SiCl_4$.

Which statements are correct?

1 In $SiCl_4$, the Si is δ+ and each Cl is δ–.

2 $SiCl_4$ is a liquid at room temperature.

3 $SiCl_4$ reacts with water to give an acidic solution and a precipitate.

36 Which statements about ammonia are correct?

1 An ammonia molecule has three bond pairs and one lone pair of electrons.

2 When ammonia is bubbled into water the pH of the solution increases.

3 Ammonia gas can be made by warming ammonium sulfate with aqueous hydrochloric acid.

37 Following fractional distillation of crude oil, which processes can be used to produce propene from larger hydrocarbon molecules?

1 cracking

2 reduction

3 polymerisation

38 Bromoethane undergoes nucleophilic substitution reactions.

Which statements are correct?

1 Bromoethane reacts with aqueous NaOH to make ethanol.

2 Bromoethane reacts with ethanolic NH_3 to make ethylamine.

3 Bromoethane reacts with ethanolic KCN to make ethanenitrile.

39 Which reagents, when used in excess, can convert Y into Z?

$$\underset{\text{Y}}{CH_3CH(OH)CO_2H} \rightarrow \underset{\text{Z}}{CH_3CH(OH)CO_2Na}$$

1 Na

2 Na_2CO_3

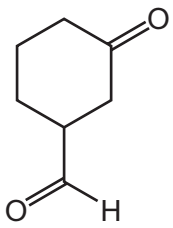
3 NaOH

40 Each of the compounds below is treated separately with an excess of $NaBH_4$.

The product of each reaction is then heated with an excess of concentrated H_2SO_4.

Which compounds give **only one** final product with the molecular formula C_7H_{10}?

1



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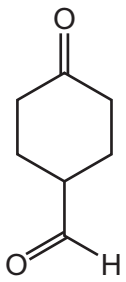
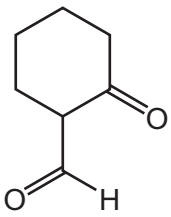


3



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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 Which statement about enthalpy changes is correct?

A Enthalpy changes of atomisation are always negative.

B Enthalpy changes of combustion are always positive.

C Enthalpy changes of formation are always positive.

D Enthalpy changes of neutralisation are always negative.

2 Beams of charged particles are deflected by an electrical field. The angle of deflection of a particle is proportional to its charge / mass ratio.

In an experiment protons are deflected by an angle of +15°. In another experiment under identical conditions $^{2}H^{-}$ ions are deflected by an angle of Y°.

What is the value of Y?

A –30.0 **B** –7.5 **C** +7.5 **D** +30.0

3 Rubidium and bromine form ions that are isoelectronic. Each ion has 36 electrons.

Which row is correct?

	rubidium radii	bromine / bromide radii
A	atomic < ionic	atomic < ionic
B	atomic < ionic	atomic > ionic
C	atomic > ionic	atomic < ionic
D	atomic > ionic	atomic > ionic

4 In which set do all the molecules have all their atoms arranged in one plane?

A $AlCl_3$, BF_3, PH_3

B $AlCl_3$, CO_2, NH_3

C BF_3, C_2H_4, C_3H_6

D C_2H_4, CO_2, H_2O

5 Flask X contains 5 dm^3 of helium at 12 kPa pressure and flask Y contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

A 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

6 Exactly 1.00 g of a metallic element reacts completely with 300 cm^3 of oxygen at 298 K and 1 atm pressure to form an oxide which contains O^{2-} ions.

The volume of one mole of gas at this temperature and pressure is 24.0 dm^3.

What could be the identity of the metal?

A calcium

B magnesium

C potassium

D sodium

7 Ethanol is increasingly being used as a fuel for cars.

The standard enthalpy change of formation of carbon dioxide is $-393\ kJ\ mol^{-1}$.
The standard enthalpy change of formation of water is $-286\ kJ\ mol^{-1}$.
The standard enthalpy change of formation of ethanol is $-277\ kJ\ mol^{-1}$.

What is the standard enthalpy change of combustion of ethanol?

A $-1921\ kJ\ mol^{-1}$

B $-1367\ kJ\ mol^{-1}$

C $-956\ kJ\ mol^{-1}$

D $-402\ kJ\ mol^{-1}$

8 Ammonium metavanadate, NH_4VO_3, can be used to make a solution containing VO_2Cl, which contains chloride ions.

What is the **change** in the oxidation number of vanadium in this reaction?

A –1 **B** 0 **C** +1 **D** +2

9 In this question, all pressures are measured in atm.

The equation represents the equilibrium between three gaseous substances X, Y and Z.

$$X + 3Y \rightleftharpoons 2Z$$

At temperature T_1, the numerical value of K_p, the equilibrium constant, is 2.

At a higher temperature T_2, the partial pressures at equilibrium are as shown.

X	Y	Z
2	3	5

Which row is correct?

	the numerical value of K_p at T_2	the forward reaction is
A	54 / 25	endothermic
B	54 / 25	exothermic
C	25 / 54	endothermic
D	25 / 54	exothermic

10 In a chemical system the particles involved have a range of energies. This can be shown on a graph called the Boltzmann distribution.

Which statement correctly explains the effect of a catalyst on the particles in a chemical system?

A A catalyst enables particles with a lower energy to collide successfully.

B A catalyst increases the number of particles with higher energies.

C A catalyst increases the number of particles with the most probable energy value.

D A catalyst increases the value of the most probable particle energy.

11 Nitrogen and hydrogen can react together to form ammonia.

The formation of ammonia is exothermic.

The rate and yield of the reaction can be altered by changing the conditions under which the reaction is carried out.

Which row shows the effects of adding iron to the mixture **and** increasing the temperature?

	adding iron	increasing the temperature
A	has no effect on the equilibrium yield	reduces the equilibrium yield
B	increases the equilibrium yield	increases the equilibrium yield
C	increases the equilibrium yield	increases the rate
D	increases the rate	has no effect on the equilibrium yield

12 The melting points of the Period 3 elements phosphorus to argon are shown in the table.

element	P	S	Cl	Ar
mp / K	317	392	172	84

Which factor explains the changes in melting points from phosphorus to argon?

A the changes in electronegativity from phosphorus to argon

B the changes in first ionisation energy from phosphorus to argon

C the increase in the number of electrons in each atom from phosphorus to argon

D the number of atoms in each molecule of the element from phosphorus to argon

13 Which observations are made when a sample of silicon chloride, SiCl_4, is added to a beaker of water?

A No visible change is observed.

B Steamy fumes and a precipitate are both observed.

C The appearance of a precipitate is the only observation.

D The appearance of steamy fumes is the only observation.

[Turn over

14 A 4.00 g sample of an anhydrous Group 2 metal nitrate is heated strongly until there is no further change. A solid residue of mass 1.37 g is formed.

Which metal is present?

A barium

B calcium

C magnesium

D strontium

15 In which row are all statements comparing magnesium and barium correct?

	fourth ionisation energy		reaction with water	
	magnesium	barium	magnesium	barium
A	higher	lower	faster	slower
B	higher	lower	slower	faster
C	lower	higher	faster	slower
D	lower	higher	slower	faster

16 Which statement about the halogens is correct?

A Iodine cannot behave as an oxidising agent.

B The volatility of the elements increases from chlorine to iodine because of the increase in molecular size down the group.

C When an equimolar mixture of chlorine and hydrogen is exploded, only one product is formed.

D When concentrated sulfuric acid is added to solid sodium bromide, hydrogen sulfide is one of the products.

17 Chlorine reacts with both hot and cold sodium hydroxide to form products containing chlorine.

Cold sodium hydroxide forms sodium chlorate(X) and hot sodium hydroxide forms sodium chlorate(Y). X and Y are oxidation numbers.

Which equation is correct?

A $Y = X - 6$ **B** $Y = X - 4$ **C** $Y = X + 4$ **D** $Y = X + 6$

18 The product of the Contact process is Z.

Which reaction or process leads to the formation of a gas that can neutralise an aqueous solution of Z?

A atmospheric lightning

B combustion of fuel in an internal combustion engine

C the Haber process

D thermal decomposition of Group 2 nitrates

19 If ammonium cyanate is heated in the absence of air, the only product of the reaction is urea, $CO(NH_2)_2$. No other products are formed in the reaction.

What is the formula of the cyanate ion present in ammonium cyanate?

A CON_2^- **B** CON_2^{2-} **C** OCN^- **D** OCN^{2-}

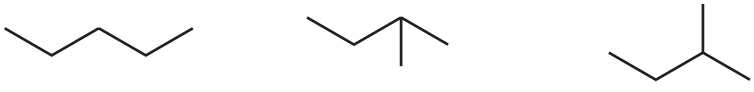
20 There are three structural isomers with the formula C_5H_{12}.

Which formulae correctly represent these three structural isomers?

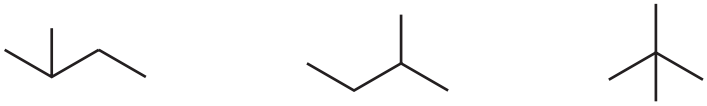
A $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $C(CH_3)_4$

B $CH_3CH_2CH_2CH_2CH_3$ $CH_3CH(CH_3)CH_2CH_3$ $CH_3CH_2CH(CH_3)CH_3$

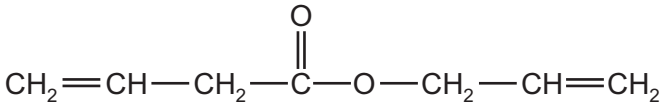
C



D



21 The diagram shows a molecule that has σ bonds and π bonds.



How many σ bonds are present in this molecule?

A 15 **B** 17 **C** 18 **D** 21

22 Polyethene is made by the polymerisation of ethene.

Which statement is correct?

A The monomer and the polymer have different empirical formulae.

B The monomer can be oxidised without heat whereas the polymer cannot.

C The monomer can be used as a fuel whereas the polymer cannot.

D The monomer has greater van der Waals' forces than the polymer.

23 Compound P reacts separately with KOH(aq) and HBr.

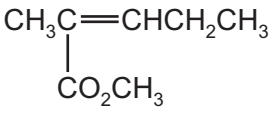
$CH_2CHCH_2CH_2Cl$

compound P

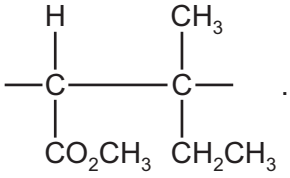
What are the mechanisms of these two reactions?

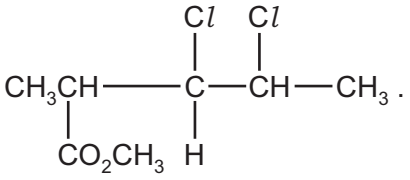
	KOH (aq)	HBr
A	nucleophilic addition	electrophilic addition
B	nucleophilic addition	free radical substitution
C	nucleophilic substitution	electrophilic addition
D	nucleophilic substitution	free radical substitution

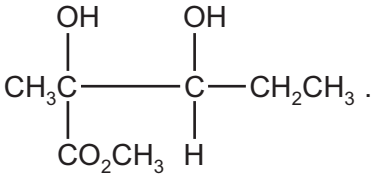
24 Which statement about compound Q is correct?

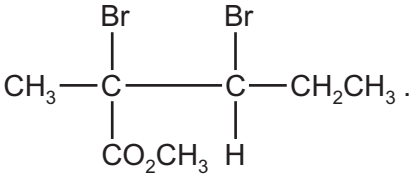


Q

A It could be polymerised to give a polymer with the repeat unit  .

B It reacts with chlorine by a free radical mechanism to give  .

C It reacts with cold, dilute acidified manganate(VII) to give  .

D It reacts with bromine via a free radical mechanism to give  .

25 A halogenoalkane has the molecular formula $C_5H_{11}Br$. The halogenoalkane does **not** form an alkene when treated with ethanolic sodium hydroxide.

What could be the halogenoalkane?

A 1-bromo-2-methylbutane

B 2-bromo-2-methylbutane

C 3-bromopentane

D bromodimethylpropane

26 The reactions of four organic compounds are given in the table.

Which compound could be propan-2-ol?

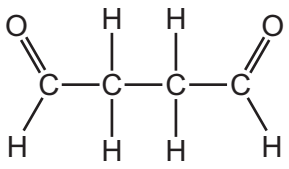
	reagent / observations	
	when oxidised with $Cr_2O_7^{2-}/H^+$, gives an organic product with a boiling point greater than the original compound	when added to ethanoic acid, and a few drops of conc. H_2SO_4, gives a sweet-smelling compound
A	no	no
B	no	yes
C	yes	no
D	yes	yes

27 Compound X has the empirical formula C_2H_3O.

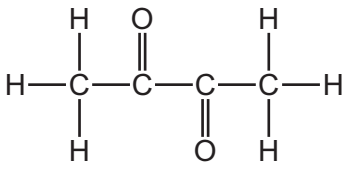
Compound X reacts with 2,4-dinitrophenylhydrazine reagent to give an orange precipitate and also decolourises warmed acidified potassium manganate(VII) solution.

What could be the identity of X?

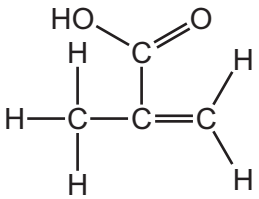
A



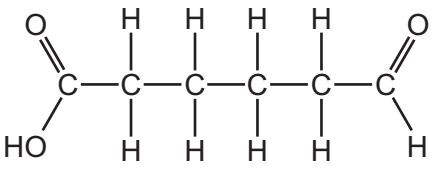
B



C



D



28 Compound **Y** gives methanol and sodium ethanoate on treatment with aqueous sodium hydroxide.

What is the structure of **Y**?

A $CH_3CO_2CH_3$

B $HCO_2C_2H_5$

C HO_2CCH_2CHO

D $HOCH_2CH_2COOH$

29 Which compound can be used to make propanoic acid by treatment with a single reagent?

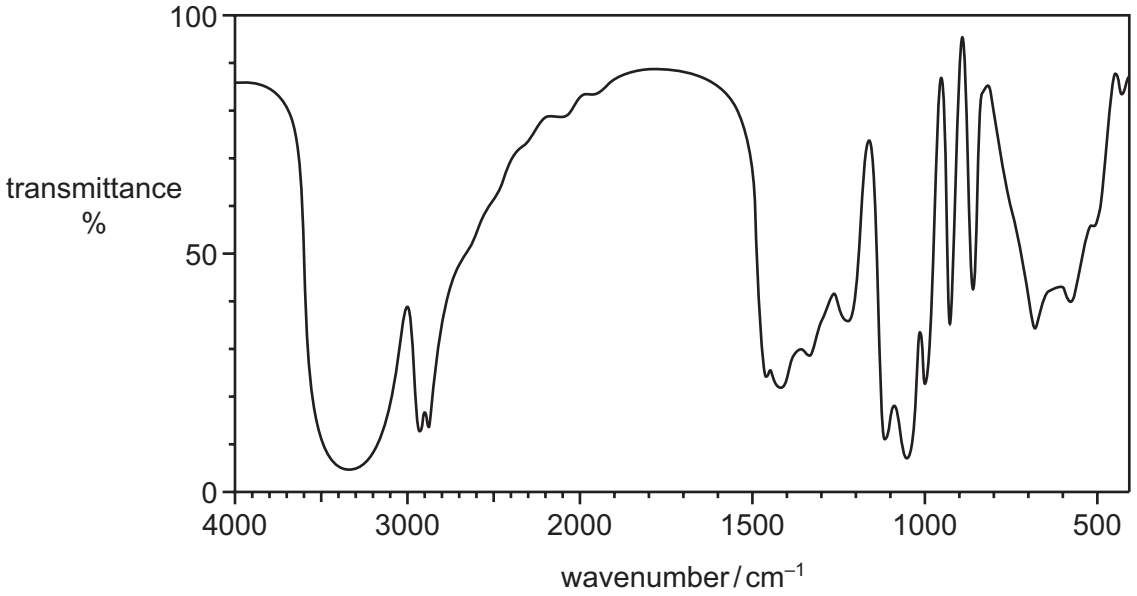
A $CH_2=CHCH_2CH_3$

B $CH_3CH_2CH_2CN$

C $CH_3CH(OH)CN$

D $CH_3CH(OH)CH_3$

30 The infra-red spectrum of compound **L** is shown.



What could be the structure of **L**?

A $HOCH_2COCH_2OH$

B $HOCH_2CH(OH)CHO$

C $HOCH_2CH(OH)CH_2OH$

D $HOCH_2CH_2COOH$

[Turn over

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 Zinc reacts with hydrochloric acid according to the following equation.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Which statements are correct?

1 A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.0500 mol of zinc chloride.

2 A 6.54 g sample of zinc reacts completely with exactly 100 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.

3 A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm^3 of hydrogen, measured at room conditions.

32 The melting point of chlorine is lower than the melting point of iodine.

Which statements help to explain this difference?

1 Iodine has more electrons than chlorine and so has stronger van der Waals' forces.

2 An iodine molecule is more polar than a chlorine molecule.

3 The covalent bonds between iodine atoms are stronger than the covalent bonds between chlorine atoms.

33 Aqueous iron(II) sulfate can take part in redox reactions.

$$6FeSO_4 + 7H_2SO_4 + Na_2Cr_2O_7 \rightarrow 3Fe_2(SO_4)_3 + Cr_2(SO_4)_3 + Na_2SO_4 + 7H_2O$$

Which redox changes occur during this reaction?

1 Fe(II) is oxidised to Fe(III).

2 Cr(VI) is reduced to Cr(III).

3 Oxygen is reduced to water.

34 The equation represents an equilibrium.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -900\,kJ\,mol^{-1}$$

What would increase the concentration of NO at equilibrium?

1 a reduction in the reaction temperature

2 the use of a suitable catalyst

3 an increase in the total pressure

35 A sample containing *x* mol of Al_2Cl_6 is dissolved in water to give solution W.

In order to precipitate all of the aluminium as its hydroxide, *y* mol of sodium hydroxide are required.

More of the alkali is added to re-dissolve the precipitate, giving solution Z.

Which statements are correct?

1 the initial pH of solution W is below 7

2 $y = 3x$

3 Z contains *x* mol of aluminium

36 Which statements concerning calcium hydroxide are correct?

1 It is less soluble in water than strontium hydroxide.

2 When it is added to water an alkaline solution is formed.

3 It is used in agriculture to lower soil pH.

37 Which bromopropenes would react with cold bromine in the dark to form a product containing a chiral carbon atom?

1 $CHBr{=}CHCH_3$

2 $CH_2{=}CHCH_2Br$

3 $CH_2{=}CBrCH_3$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

38 Halogenoalkanes can undergo reaction with hydroxide ions.

$$RBr + OH^- \rightarrow ROH + Br^-$$

The reaction of some halogenoalkanes proceeds by the S_N1 mechanism.

Which statements about the S_N1 mechanism are correct?

1 A carbocation is formed which is stabilised by the inductive effect of the alkyl groups present.

2 Only tertiary halogenoalkanes are hydrolysed in this way.

3 The intermediate formed includes a carbon atom with five bonds attached to it.

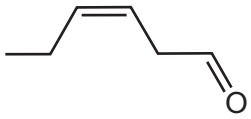
39 Which statements about 2-methylbutan-1-ol are correct?

1 It can give HCl(g) on reaction with PCl_5.

2 It can be oxidised to give an aldehyde.

3 It displays optical isomerism.

40 The compound cis-hex-3-enal is responsible for the characteristic smell of cut grass.



cis-hex-3-enal

Which reagents will react with cis-hex-3-enal?

1 sodium

2 sodium borohydride

3 Fehling's reagent

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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2017**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

IB17 11_9701_12/5RP

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 In which pair do the atoms contain the same number of neutrons?

A ^{11}B and ^{12}C

B ^{7}Li and ^{9}Be

C ^{24}Mg and ^{28}Si

D ^{14}N and ^{16}O

2 Two hydrocarbons have the formulae C_WH_X and C_YH_Z. W, X, Y and Z represent different whole numbers.

$$\frac{W}{X} = \frac{Y}{Z}$$

Which row is correct when comparing the two hydrocarbons?

	empirical formula	molecular formula	relative molecular mass
A	different	same	different
B	different	same	same
C	same	different	different
D	same	different	same

3 The airbags in cars contain sodium azide, NaN_3, and an excess of potassium nitrate, KNO_3.

In a car accident, the reactions shown occur, producing nitrogen. This causes the airbag to inflate rapidly.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

How many moles of nitrogen gas are produced **in total** when 1 mol of sodium azide, NaN_3, decomposes in an airbag?

A 1.5 **B** 1.6 **C** 3.2 **D** 4.0

4 Ethane burns in oxygen to produce carbon dioxide and water vapour.

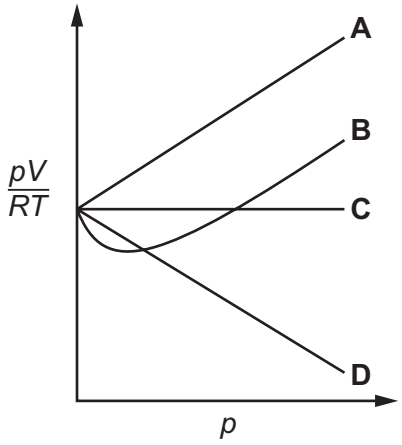
Which bond angles are present in the molecules of ethane and its combustion products?

	ethane	combustion products
A	90°	104.5° and 180°
B	90°	109.5° and 120°
C	109.5°	104.5° and 180°
D	109.5°	109.5° and 180°

5 A sample of an ideal gas is contained at a constant temperature of 300 K in a gas syringe.

The pressure is increased and a graph of $\frac{pV}{RT}$ against pressure is plotted.

Which graph correctly represents the results?



6 In calculating the enthalpy change, ΔH, of an experiment involving solutions, the mass of the solution, m, specific heat capacity of the solution, c, and the temperature change, ΔT, are needed.

$$\Delta T = T_{final} - T_{initial}$$

Which expression for ΔH is correct?

A $\Delta H = \frac{mc}{\Delta T}$ **B** $\Delta H = \frac{-mc}{\Delta T}$ **C** $\Delta H = mc\Delta T$ **D** $\Delta H = -mc\Delta T$

7 The following data are needed for this question.

$\Delta H_f^\ominus (P_4O_{10}(s)) = -3012\,kJ\,mol^{-1}$

$\Delta H_f^\ominus (H_2O(l)) = -286\,kJ\,mol^{-1}$

$\Delta H_f^\ominus (H_3PO_4(s)) = -1279\,kJ\,mol^{-1}$

What is $\Delta H^\ominus$ for the reaction shown?

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$$

A $-9844\,kJ\,mol^{-1}$

B $-388\,kJ\,mol^{-1}$

C $-97\,kJ\,mol^{-1}$

D $+2019\,kJ\,mol^{-1}$

8 Which statement is **always** correct for an oxidation reaction?

A It involves the gain of oxygen by an element.

B For one reactant to be oxidised a different reactant must be reduced.

C The element or ion being oxidised will gain electrons.

D The oxidation number of the element being oxidised will increase.

9 Nitrogen dioxide, NO_2, is a brown gas.

Dinitrogen tetroxide, N_2O_4, is a colourless gas.

An equilibrium is established between NO_2 and N_2O_4 in a closed vessel.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H = -57\,kJ\,mol^{-1}$$

Which row describes the effects of changing conditions on the colour of an equilibrium mixture of NO_2 and N_2O_4?

	increasing the pressure	increasing the temperature
A	colour becomes darker	colour becomes darker
B	colour becomes darker	colour becomes lighter
C	colour becomes lighter	colour becomes darker
D	colour becomes lighter	colour becomes lighter

10 A large excess of marble chips was reacted with 25 cm^3 of 1.0 mol dm^{-3} hydrochloric acid at 40 °C.

How will the result be different when the reaction is repeated with 60 cm^3 of 0.5 mol dm^{-3} hydrochloric acid at 40 °C?

A The reaction is faster and less of the products are made.

B The reaction is faster and more of the products are made.

C The reaction is slower and less of the products are made.

D The reaction is slower and more of the products are made.

11 Which change alters the activation energy of a given reaction?

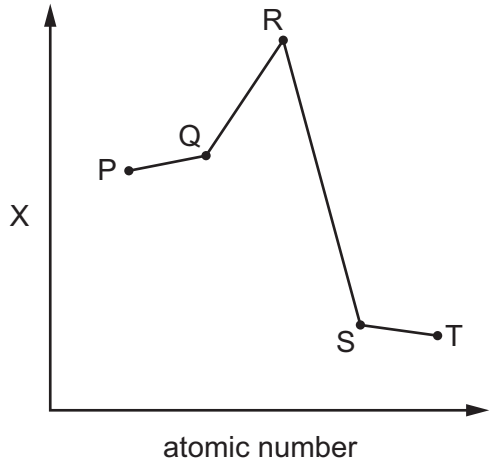
A adding a suitable catalyst

B changing the particle size of the reactants

C changing the pressure at which the reaction is carried out

D changing the temperature at which the reaction is carried out

12 The relative magnitude of the property X of five elements is shown. P, Q, R, S and T are all in Period 3 and have consecutive atomic numbers.



Which row shows a correct pairing of property X and element R?

	property X	element R
A	electrical conductivity	A*l*
B	electronegativity	Si
C	melting point	A*l*
D	second ionisation energy	Si

13 Element Z has a giant structure.

The chloride of Z reacts with water to give a solution with a pH less than 5.

Which row shows two elements which could be Z?

A aluminium, magnesium

B aluminium, silicon

C phosphorus, magnesium

D phosphorus, silicon

14 Radium is an element below barium in Group 2 of the Periodic Table.

Which equation shows what happens when solid radium nitrate, $Ra(NO_3)_2$, is heated strongly?

A $Ra(NO_3)_2(s) \rightarrow RaO(s) + N_2O(g) + 2O_2(g)$

B $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 2N_2(g) + 5O_2(g)$

C $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 4NO_2(g) + O_2(g)$

D $4Ra(NO_3)_2(s) \rightarrow 2Ra_2O(s) + 8NO_2(g) + 3O_2(g)$

15 Exactly 3.705 kg of substance Y are needed to neutralise 100 moles of HCl(aq).

What could be substance Y?

A Ca **B** CaO **C** $Ca(OH)_2$ **D** $CaCO_3$

16 In an experiment, 0.125 mol of chlorine gas, Cl_2, is reacted with an excess of cold, aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen and chlorine.

Which mass of this product is formed?

A 9.31 g **B** 13.3 g **C** 18.6 g **D** 26.6 g

17 Sodium bromide reacts with concentrated sulfuric acid.

Which observation will be made?

A A coloured vapour is produced.

B A purple solid is formed.

C A strong smell of H_2S is detected.

D Yellow sulfur is formed.

18 The reaction of nitrogen and oxygen to produce oxides of nitrogen happens at high temperatures in car engines or lightning strikes during thunderstorms.

What is the main reason for these reactions requiring such high temperatures?

A the lack of reactivity of nitrogen, due to the half-filled 2p subshell in the nitrogen atom

B the lack of reactivity of nitrogen, due to the strength of the bond in N_2

C the lack of reactivity of oxygen, due to electron-electron repulsion in one of its 2p orbitals

D the lack of reactivity of oxygen, due to the strength of the bond in O_2

19 **X** is a mixture of two compounds of Group 2 elements.

X undergoes thermal decomposition to produce a white solid and only two gaseous products. One of the gaseous products relights a glowing splint.

What could be the components of mixture **X**?

A $MgCl_2$ and $CaCO_3$

B $MgCO_3$ and $Ca(NO_3)_2$

C $Mg(NO_3)_2$ and $Ca(NO_3)_2$

D MgO and CaO

20 Which compound does **not** exhibit stereoisomerism?

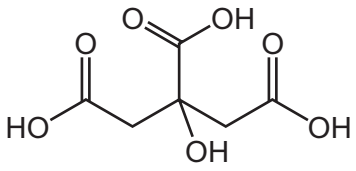
A $CH_3CHClCH_2CHO$

B $CH_3CHCHCH_3$

C $CH_2ClCH_2CCl_2H$

D $CHClCHCl$

21 The diagram shows the skeletal formula of citric acid.



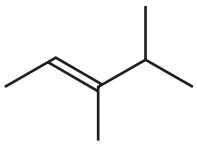
citric acid

What is the molecular formula of citric acid?

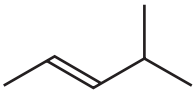
A $C_6H_8O_7$ **B** $C_6H_4O_7$ **C** $C_8H_8O_7$ **D** $C_{10}H_8O_7$

22 Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?

A

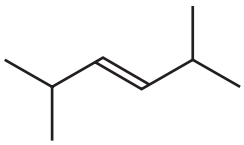


B



C

D



23 Which types of bond are broken and formed in the addition polymerisation of alkenes?

	type of bond broken	type of bond formed
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

24 2,3-dimethylpent-2-ene, $(CH_3)_2C{=}C(CH_3)CH_2CH_3$, is treated with cold, dilute $KMnO_4$. The product of this reaction is treated with an excess of concentrated H_2SO_4 at 180 °C, giving a mixture of isomeric hydrocarbons with molecular formula C_7H_{12}.

What is the name of one of the isomeric hydrocarbons?

A 2,3-dimethylpenta-1,2-diene

B cis-2,3-dimethylpenta-1,3-diene

C 2,3-dimethylpenta-1,4-diene

D 3,4-dimethylpenta-1,3-diene

25 Equal volumes of aqueous silver nitrate were added to separate small volumes of bromoethane and iodoethane in two test-tubes. The test-tubes were shaken.

Which row about the observations made for **bromoethane** is correct?

	colour of precipitate	rate of reaction
A	cream	faster than for iodoethane
B	cream	slower than for iodoethane
C	yellow	faster than for iodoethane
D	yellow	slower than for iodoethane

26 Many, but not all, organic reactions need to be heated before a reaction occurs.

Which reaction occurs quickly at room temperature (20 °C)?

A $CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$

B $CH_3CH_2Br + KCN \rightarrow CH_3CH_2CN + KBr$

C $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$

D $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2CO_2H + NH_3$

27 When compound X is warmed with dilute, acidified potassium dichromate(VI) there is no colour change. X does not give an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

What could X be?

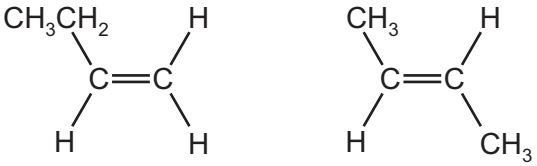
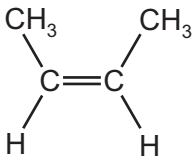
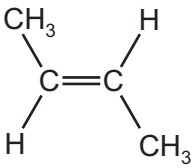
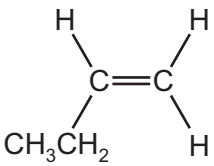
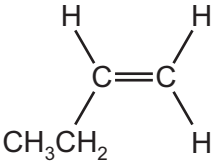
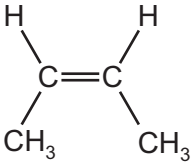
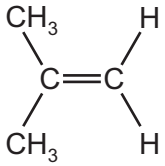
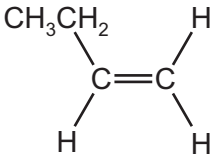
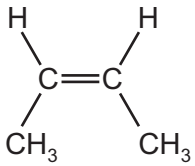
A butan-2-ol

B ethanal

C methylpropan-2-ol

D propanone

28 What are the **only** structures formed when butan-2-ol is heated with concentrated H_2SO_4?

A	
B	  
C	 
D	  

29 Compound G

- has a chiral centre,
- gives a positive result with alkaline aqueous iodine,
- does not give a silver mirror with Tollens' reagent.

What could compound G be?

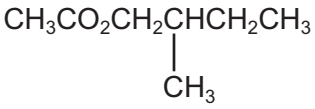
A 1-hydroxybutan-2-one

B 2-hydroxybutanal

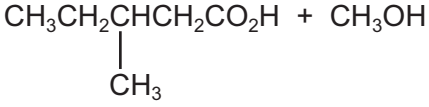
C 3-hydroxybutanal

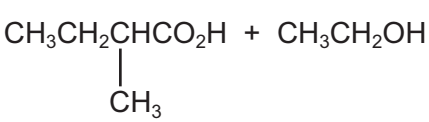
D 3-hydroxybutan-2-one

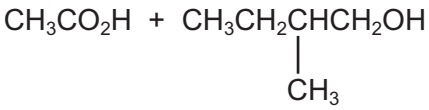
30 An ester with an odour of banana has the following formula.

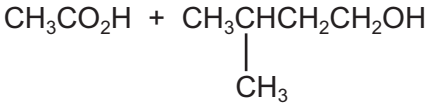


Which pair of reactants, under suitable conditions, will produce this ester?

A 

B 

C 

D 

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and are called flerovium, F*l*, and livermorium, Lv.

	F*l*	Lv
proton number	114	116
nucleon number	289	292

From the information about atoms in the table, which statements are correct?

1 One atom of Lv has one more neutron than one atom of F*l*.

2 One Fl^{2-} ion has the same number of electrons as one atom of Lv.

3 One Lv^{+} ion has the same number of electrons as one Fl^{-} ion.

32 The chlorine oxide free radical, C*l*O•, is produced by the reaction between chlorine atoms and ozone.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

Which features are present in the chlorine oxide free radical?

1 an odd number of electrons

2 a single covalent bond

3 a dative covalent bond from oxygen to chlorine

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

33 Hydrogen sulfide can be oxidised to form sulfur dioxide.

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

Which statements are correct?

1 The oxidation number of sulfur increases by 6.

2 The oxidation number of oxygen increases by 2.

3 The oxidation number of hydrogen decreases.

34 Methanoic acid, HCO_2H, and hydrocyanic acid, HCN, can both behave as acids.

A solution of methanoic acid has a lower pH than a solution of hydrocyanic acid of the same concentration.

Which statements explain this?

1 HCO_2H molecules dissociate more fully than HCN molecules do.

2 Each HCO_2H molecule has two hydrogen atoms; each HCN molecule only has one.

3 Methanoic acid is a weaker acid than hydrocyanic acid.

35 Which statements correctly describe a trend on going down Group 2?

1 Reactivity of the elements increases.

2 First ionisation energy of the elements decreases.

3 The hydroxides become more soluble in water.

36 Modern cars are fitted with catalytic converters to reduce atmospheric pollution caused by unwanted reactions during the combustion of the fuel.

Which statements are correct?

1 Carbon monoxide is oxidised to carbon dioxide in a catalytic converter.

2 Catalytic converters have a very large surface area.

3 Nitrogen dioxide is reduced to nitrogen monoxide in a catalytic converter.

37 Which statements are correct for an S_N2 mechanism?

1 One bond is being broken at the same time as another bond is being formed.

2 The formation of the intermediate involves the collision of two molecules or ions.

3 A carbon atom in the transition state is bonded, either fully or partially, to five atoms.

38 Bromoethane is heated under reflux with concentrated aqueous NaOH.

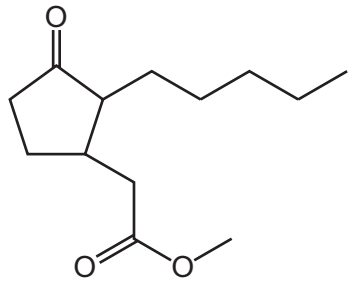
Which statements are correct?

1 The major product is a primary alcohol.

2 The major reaction is hydrolysis by an S_N2 mechanism.

3 The major product would be the same if the NaOH is dissolved in ethanol.

39 Compound M is an important ingredient in perfume.



compound M

M reacts with HCN.

Which statements about this reaction are correct?

1 A small amount of NaOH will speed up the reaction.

2 The reaction is initiated by the transfer of a proton to one of the C=O groups.

3 Both of the C=O groups react with HCN.

40 Carboxylic acids can be converted into their salts by a number of reactions at room temperature.

Which reactions would produce sodium butanoate and a gas?

1 sodium carbonate + butanoic acid

2 sodium + butanoic acid

3 sodium hydroxide + butanoic acid

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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2016**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

8022333632

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

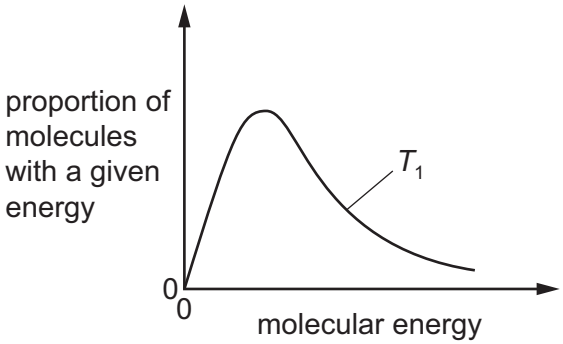
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

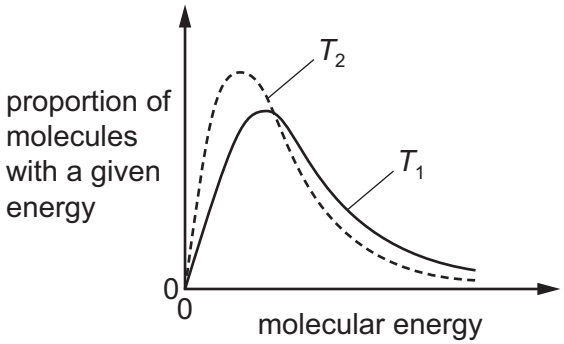
1 The molecules of a gas at a constant temperature, T_1, have the distribution of molecular energies shown in the diagram.



When the temperature is **increased** to T_2, the distribution of molecular energies changes.

Which diagram correctly shows this change?

A



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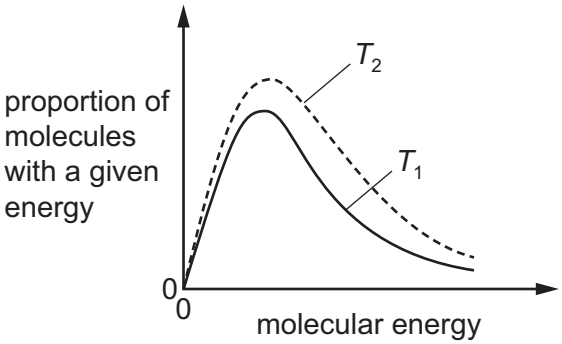
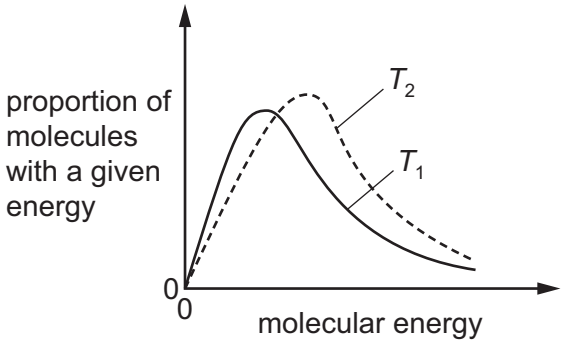
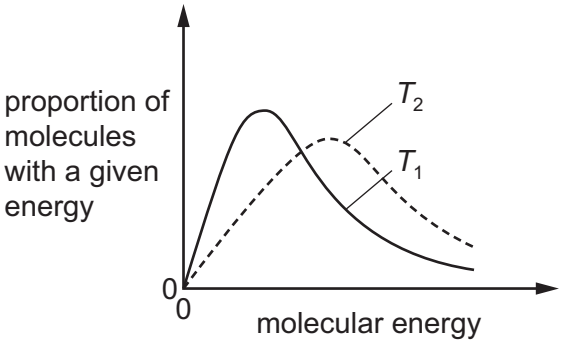


C

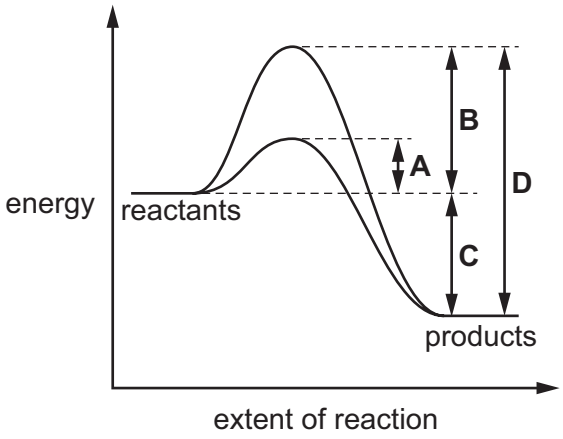


D



2 The diagram shows the pathways of a reaction, with and without a catalyst.

Which letter represents the overall energy change for the reaction?



3 People are advised to eat less than 6.00 g of salt (sodium chloride) per day for health reasons.

Which mass of sodium is present in 6.00 g of sodium chloride?

A 0.261 g **B** 2.36 g **C** 3.64 g **D** 3.88 g

4 When copper reacts with a 50% solution of nitric acid, nitrogen monoxide is evolved and a blue solution results.

The balanced equation for this reaction is shown.

$$p\,Cu + q\,HNO_3 \rightarrow r\,Cu(NO_3)_2 + s\,H_2O + t\,NO$$

What are the values of the integers *p*, *q*, *r*, *s* and *t*?

	p	*q*	*r*	*s*	*t*
A	1	4	1	2	2
B	2	6	2	3	2
C	2	8	2	4	4
D	3	8	3	4	2

5 What is the electronic configuration of an isolated Ni^{2+} ion?

A $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$

D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

6 When solid aluminium chloride is heated, Al_2Cl_6 is formed.

Which bonding is present in Al_2Cl_6?

A covalent and co-ordinate (dative covalent)

B covalent only

C ionic and co-ordinate (dative covalent)

D ionic only

7 In which hydride is the H–X–H bond angle the smallest?

A BH_3 **B** CH_4 **C** C_2H_6 **D** NH_3

8 In an experiment, a sample of a pure gas is put into a gas syringe at a temperature of 300 K and pressure of 16 kPa. The gas is compressed until the volume occupied by the gas is halved.

After compression, the temperature of the gas in the syringe is 375 K and the pressure is 40 kPa.

Which statement is correct?

A Intermolecular forces between the gas molecules are significant.

B It is possible to calculate the number of moles of gas present using these data alone.

C The gas is behaving ideally.

D The pressures used are too high for ideal gas behaviour.

9 In a calorimetric experiment 1.60 g of a fuel are burnt. 45.0% of the energy released is absorbed by 200 g of water. The temperature of the water rises from 18.0 °C to 66.0 °C.

What is the total energy released per gram of fuel burnt (to 3 significant figures)?

A 25 100 J **B** 55 700 J **C** 89 200 J **D** 143 000 J

10 Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c?

A $\dfrac{(1.76)^2}{(2.32)(6.96)^3}$

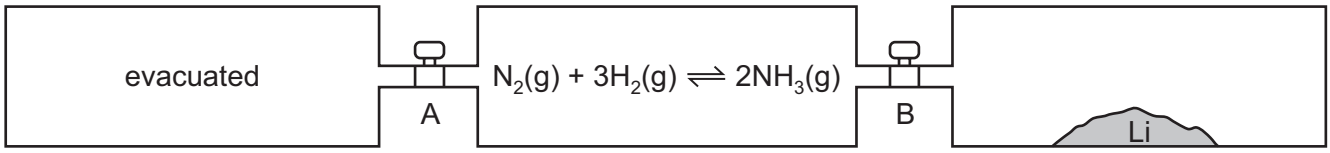
B $\dfrac{(1.76)^2}{(2.32)(6.32)^3}$

C $\dfrac{(2.08)^2}{(2.32)(6.32)^3}$

D $\dfrac{(2.40)^2}{(2.32)(6.00)^3}$

11 Lithium reacts with nitrogen at room temperature to form solid Li_3N.

Three vessels of equal volume are connected by taps, A and B, as shown.



At the start, A and B are closed, the left-hand vessel is evacuated, the middle vessel has the indicated reaction at equilibrium and the right-hand vessel contains lithium only.

Which action would allow the equilibrium mixture to contain the **most** ammonia?

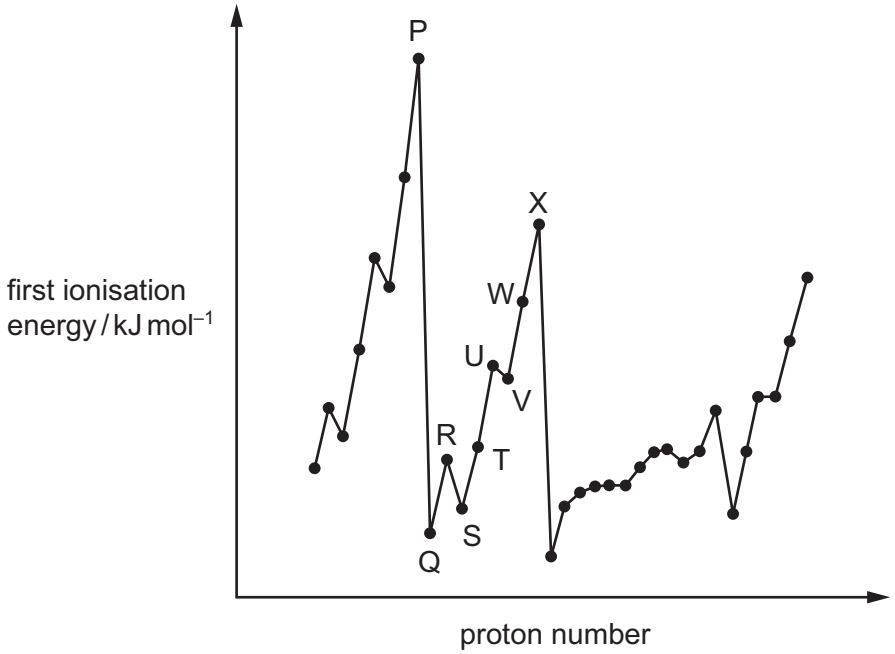
A Keep both A and B closed.

B Open both A and B.

C Open A only.

D Open B only.

12 The graph below shows the variation of the first ionisation energy with proton number for some elements. The letters used are not the usual symbols for the elements.



Which statement about the elements is correct?

A P and X are in the same period in the Periodic Table.

B The general increase from Q to X is due to increasing atomic radius.

C The small decrease from R to S is due to decreased shielding.

D The small decrease from U to V is due to repulsion between paired electrons.

13 Which element shows the greatest tendency to form covalent compounds?

A boron

B magnesium

C neon

D potassium

14 Elements Y and Z are both in Period 3.

When the chloride of Y is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of Z is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

A Both chlorides hydrolyse in water.

B Y is magnesium and Z is sodium.

C Y is phosphorus and Z is aluminium.

D Y is silicon and Z is sodium.

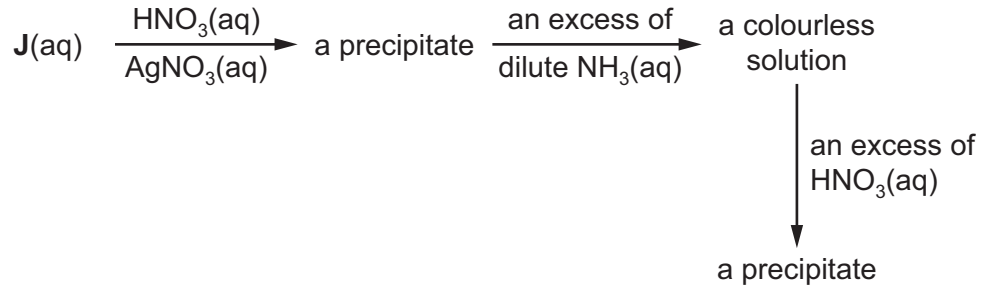
15 When chlorine reacts with hot aqueous sodium hydroxide, two chlorine-containing ions are formed. One of these is the chloride ion, Cl^-.

What is the other ion?

A ClO^- **B** ClO_2^- **C** ClO_3^- **D** ClO_4^-

16 **J** is a salt of one of the halogens chlorine, bromine, iodine or astatine.

The reaction scheme shows a series of reactions using a solution of **J** as the starting reagent.



What could **J** be?

A sodium chloride

B sodium bromide

C potassium iodide

D potassium astatide

17 When heated, magnesium nitrate decomposes.

Which equation for the thermal decomposition of magnesium nitrate is correct?

A $Mg(NO_3)_2 \rightarrow MgO + NO_2 + NO + O_2$

B $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO + 3O_2$

C $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$

D $3Mg(NO_3)_2 \rightarrow Mg_2N_3 + MgO + 3NO + 7O_2$

18 Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

19 Water and ammonia take part in a reaction that produces the ammonium ion.

Which statement about this reaction is correct?

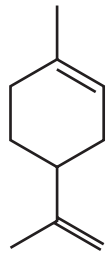
A Neither the ammonia molecule nor the ammonium ion has a dipole moment.

B The bond angle changes from 109.5° in the ammonia molecule to 107° in the ammonium ion.

C The reaction is a redox reaction.

D The water is acting as an acid.

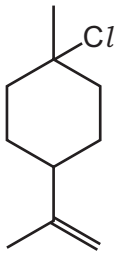
20 Limonene is found in lemon and orange oils.



limonene

What will be the major product when limonene is reacted with an excess of dry hydrogen chloride?

A



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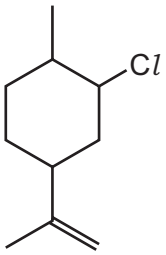
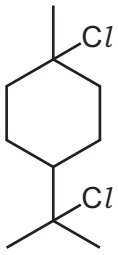
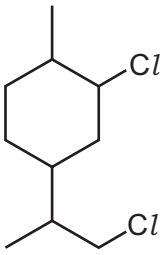


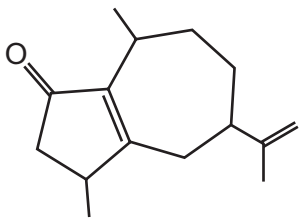
C



D



21 The compound rotundone is responsible for the peppery smell of pepper and is also found in some red wines.



rotundone

How many hydrogen atoms are in one molecule of rotundone?

A 15 **B** 19 **C** 22 **D** 24

22 The reaction $CH_3CH_2CH_2CH_2Br + OH^- \rightarrow CH_3CH_2CH_2CH_2OH + Br^-$ proceeds via an S_N2 mechanism.

The reaction $(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$ proceeds via an S_N1 mechanism.

Which statement about these two reactions is correct?

A Both reactions involve homolytic bond fission.

B Both reactions involve hydroxide ions acting as electron pair donors.

C Both reactions involve the formation of a positively-charged intermediate.

D Both reactions occur in a single step.

23 The equation shows a reaction that occurs between carbon monoxide and nitrogen monoxide in a catalytic converter.

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

Which statement is correct?

A The catalyst used is finely divided iron.

B The reaction prevents greenhouse gas emissions into the atmosphere.

C The reaction reduces the possibility of the formation of photochemical smog.

D The reaction results in increased ozone depletion.

24 Which statement about stereoisomers is correct?

A Cis-trans isomers are mirror images of each other.

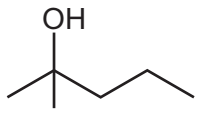
B Optical isomers must contain a double bond that restricts rotation.

C Stereoisomers have the same structural formula as each other.

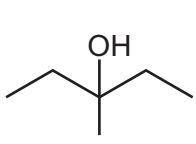
D Stereoisomers must contain a chiral centre.

25 Which compound can be oxidised by acidified potassium manganate(VII) to give 3-methylpentan-2-one?

A



B



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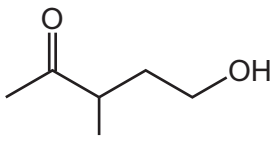

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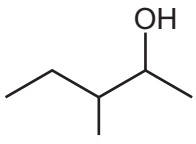


26 Ethane-1,2-diol, $HOCH_2CH_2OH$, reacts with an excess of ethanoic acid, CH_3CO_2H, in the presence of an acid catalyst. A compound is formed with the molecular formula $C_6H_{10}O_4$.

What is the structure of this compound?

A $CH_3OCOCH_2CH_2CO_2CH_3$

B $CH_3CO_2CH_2CH_2CO_2CH_3$

C $CH_3CO_2CH_2CH_2OCOCH_3$

D $HOCH_2CH_2COCH_2OCOCH_3$

27 Compound **X** is heated with a mild oxidising agent. One of the products of the reaction will react with hydrogen cyanide, forming 2-hydroxybutanenitrile.

What is compound **X**?

A butan-1-ol

B butan-2-ol

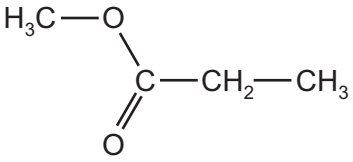
C propan-1-ol

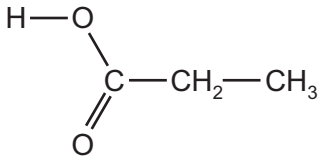
D propan-2-ol

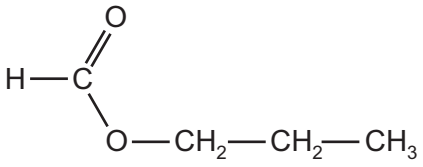
28 Which row correctly describes the reactivity of aldehydes and ketones?

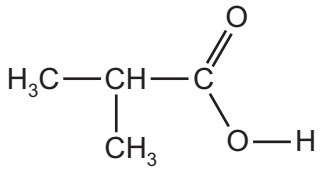
	with $NaBH_4$	with $H^+ / Cr_2O_7^{2-}(aq)$
A	both react	both react
B	both react	only aldehydes react
C	only ketones react	both react
D	only ketones react	only aldehydes react

29 How many of the compounds shown will react with aqueous sodium hydroxide to form the sodium salt of a carboxylic acid?









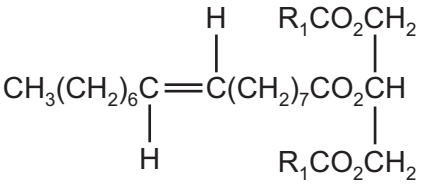
A 1 **B** 2 **C** 3 **D** 4

30 Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood. In these oils the word 'trans' describes, in the usual way, the arrangement of groups at a C=C double bond.

In the diagrams below, R_1 and R_2 are different unbranched hydrocarbon chains.

Which diagram correctly shows an optically active 'trans fat'?

A



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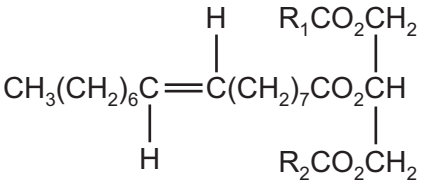

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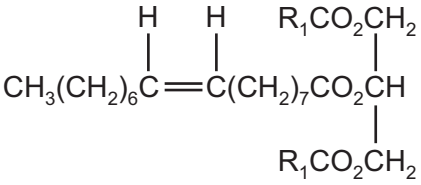

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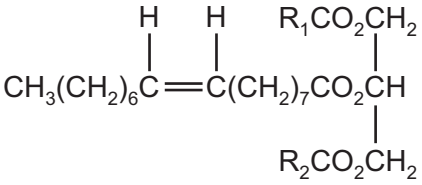


Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 Photochromic lenses in spectacles darken in sunlight because silver crystals are produced by the reaction shown.

$$Ag^+ + Cl^- \rightarrow Ag + Cl$$

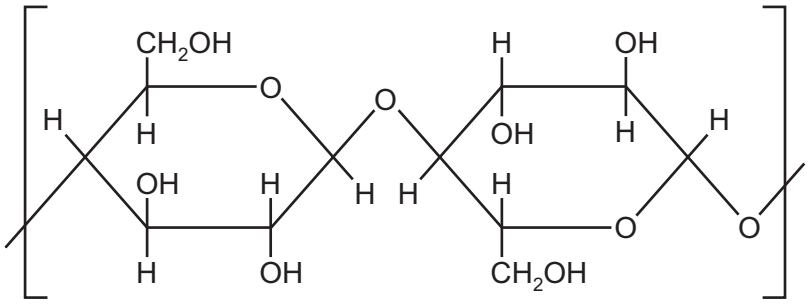
Which statements are correct for this reaction?

1 Both silver and chlorine atoms have an oxidation number of zero.

2 The oxidation number of chlorine increases.

3 Electrons are transferred from Cl^- ions to Ag^+ ions.

32 A cathedral in New Zealand has been constructed from cardboard. Cardboard contains polymer molecules. Part of one such polymer molecule is shown below.



Which statements about this polymer are correct?

1 The polymer molecules can form hydrogen bonds with each other.

2 The polymer can form intermolecular forces with water molecules.

3 The polymer will not burn easily because it is a secondary alcohol.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

33 **X** is an element that has

- its outer electrons in the 4th principal quantum shell,
- a higher 1st ionisation energy than calcium.

What could be the identity of **X**?

1 bromine

2 krypton

3 xenon

34 Methanol, CH_3OH, can be produced industrially by reacting CO with H_2.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91\,kJ\,mol^{-1}$$

The process can be carried out at 4×10^3 kPa and 1150 K.

Which statements about this reaction are correct?

1 Increasing the temperature will increase the rate of reaction because more effective collisions will occur.

2 Lowering the temperature will reduce the rate of reaction because the forward reaction is exothermic.

3 Increasing the pressure will reduce the rate of reaction because there are a larger number of moles on the left-hand side of the equation.

35 Equal masses of barium carbonate and magnesium carbonate powders are mixed together. The mixture is then heated using a Bunsen burner flame until there is no further change. A gas is given off.

Which statements are correct?

1 The residue left after heating reacts with aqueous hydrochloric acid to produce carbon dioxide.

2 The percentage decrease in mass after heating is 26% (to 2 significant figures).

3 The gas given off during heating relights a glowing splint.

36 Oxides of both sulfur and nitrogen are present in the atmosphere.

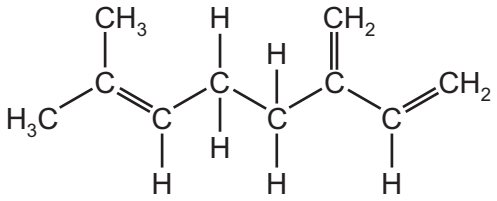
Which statements are correct?

1 Oxides of both sulfur and nitrogen can be formed in internal combustion engines.

2 Oxides of both sulfur and nitrogen can be produced by direct combination of the elements.

3 Oxides of both sulfur and nitrogen are involved in the formation of acid rain.

37 A species of termite produces a chemical defence secretion which contains the molecule shown.



To help determine the structure of this compound, it is treated with hot, concentrated, acidified manganate(VII) ions.

Which compounds are produced in this reaction?

1 CO_2

2 CH_3COCH_3

3 CH_3CO_2H

38 1-bromopropane reacts with NaOH in different ways depending on the solvent used.

Which statements about this reaction are correct?

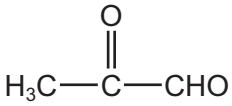
	solvent used	main organic product
1	ethanol	propene
2	water	propan-1-ol
3	ethanol	propane-1-2-diol

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

39 The compound shown is produced when sugar burns.



Which reagents would give a positive result with this compound?

1 alkaline aqueous iodine

2 2,4-dinitrophenylhydrazine

3 Fehling's solution

40 Which statements about the formation of a carboxylic acid are correct?

1 A carboxylic acid can be produced by hydrolysis of a nitrile.

2 A carboxylic acid can be produced by oxidation of a primary alcohol.

3 A carboxylic acid can be produced by reduction of an aldehyde.

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2015**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

6952388323

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **15** printed pages and **1** blank page.

CAMBRIDGE International Examinations

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 Which type of bonding is **never** found in elements?

A covalent

B ionic

C metallic

D van der Waals' forces

2 Arsenic chloride, $AsCl_3$, reacts with sodium borohydride, $NaBH_4$.

$$\mathbf{p}AsCl_3 + \mathbf{q}NaBH_4 \rightarrow \mathbf{r}AsH_3 + \mathbf{s}NaCl + \mathbf{t}BCl_3$$

What are the numbers **p**, **q**, **r**, **s** and **t** when this equation is balanced correctly?

	p	**q**	**r**	**s**	**t**
A	2	3	2	3	1
B	3	3	3	3	2
C	4	3	4	3	3
D	4	4	4	4	3

3 Three substances have the physical properties shown in the table.

substance	melting point / °C	boiling point / °C	conductivity (solid)	conductivity (liquid)	conductivity (aqueous)
U	420	907	good	good	insoluble
V	993	1695	poor	good	good
W	–70	58	poor	poor	hydrolyses, resulting solution conducts well

What could be the identities of **U**, **V** and **W**?

	U	**V**	**W**
A	Na	KCl	$SiCl_4$
B	Na	NaF	C_2H_5Br
C	Zn	KCl	HCl
D	Zn	NaF	$SiCl_4$

4 Flask X contains 5 dm^3 of helium at 12 kPa pressure and flask Y contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

A 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

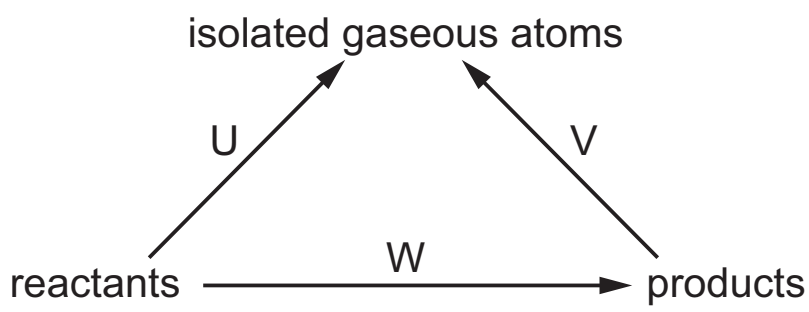
5 Calcium forms an ionic compound with carbon, called calcium carbide. The oxidation number of carbon in calcium carbide is –1.

Calcium carbide is readily hydrolysed by water giving two products only.

What could be the formulae of calcium carbide and the two products of hydrolysis?

	calcium carbide	products
A	Ca_2C	CaO and C_2H_4
B	Ca_2C	$Ca(OH)_2$ and C_2H_2
C	CaC_2	CaO and C_2H_4
D	CaC_2	$Ca(OH)_2$ and C_2H_2

6 Hess' law may be used to determine enthalpy changes using average bond energies, as shown in the diagram.



U is the sum of the average bond energies of the reactants, and V is the sum of the average bond energies of the products.

For the reaction shown below, which expression will give a value for W, the enthalpy change of combustion of methane?

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

A U – V **B** U + V **C** 2(U – V) **D** V – U

7 The process of electrolysis can be used to purify copper, and to extract aluminium from an aluminium oxide / cryolite mixture.

What are the reactions at the anode in each of these processes?

	purification of copper	extraction of aluminium
A	$Cu^{2+} + 2e^- \rightarrow Cu$	$2O^{2-} \rightarrow O_2 + 4e^-$
B	$Cu^{2+} + 2e^- \rightarrow Cu$	$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$
C	$Cu \rightarrow Cu^{2+} + 2e^-$	$2O^{2-} \rightarrow O_2 + 4e^-$
D	$Cu \rightarrow Cu^{2+} + 2e^-$	$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

8 Hydrogen can be obtained by reacting methane with steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H^{\ominus} = +210\,kJ\,mol^{-1}$$

Which conditions of pressure and temperature will give the greatest equilibrium yield of hydrogen?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

9 Nitrogen monoxide reacts with oxygen in a reversible reaction according to the equation shown below.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

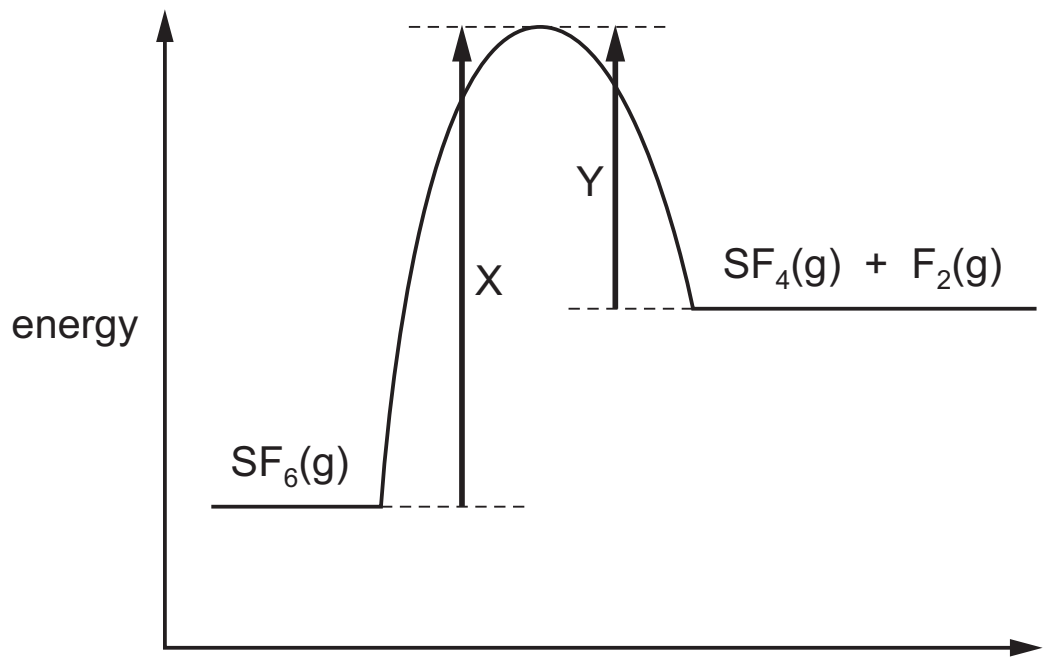
The partial pressures of each of the components in an equilibrium mixture are shown in the table.

partial pressure NO / kPa	partial pressure O_2 / kPa	partial pressure NO_2 / kPa
10	30	20

What is the numerical value of the equilibrium constant, K_p, for this equilibrium?

A 6.67×10^{-2} **B** 1.33×10^{-1} **C** 7.50 **D** 15.0

10 The decomposition reaction $SF_6(g) \rightarrow SF_4(g) + F_2(g)$ can be described by the reaction pathway diagram shown.



What are the values of $\Delta H^{\ominus}$ and E_a for this reaction?

	$\Delta H^{\ominus}$	E_a
A	X	X + Y
B	X	Y
C	X – Y	X
D	Y – X	X

11 Which row correctly describes what happens when the temperature of a chemical reaction is **decreased**?

	activation energy (E_a)	number of successful collisions
A	decreases	decreases
B	decreases	increases
C	remains the same	decreases
D	remains the same	increases

12 Which property decreases on descending Group II?

A radius of the cation, M^{2+}

B reactivity of the element with water

C shielding of outermost electrons

D the ease of thermal decomposition of the carbonates, MCO_3

[Turn over

13 *Use of the Data Booklet is relevant to this question.*

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

Which volume of nitrogen, measured under room conditions, is produced when 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

A 46.8 cm^3 **B** 72.0 cm^3 **C** 93.6 cm^3 **D** 144 cm^3

14 Which chloride of a Period 3 element dissolves in water to form a solution with a pH of 7?

A aluminium chloride

B phosphorus(V) chloride

C silicon(IV) chloride

D sodium chloride

15 *Use of the Data Booklet is relevant to this question.*

Which row correctly compares the electrical conductivity and first ionisation energy of magnesium and aluminium?

	higher electrical conductivity	higher first ionisation energy
A	aluminium	aluminium
B	aluminium	magnesium
C	magnesium	aluminium
D	magnesium	magnesium

16 *Use of the Data Booklet is relevant to this question.*

Brine is concentrated aqueous sodium chloride.

In the commercial electrolysis of brine, the products are chlorine, hydrogen and sodium hydroxide.

What is the maximum yield of each of these products when 58.5 kg of sodium chloride are electrolysed as brine?

	yield of chlorine / kg	yield of hydrogen / kg	yield of sodium hydroxide / kg
A	35.5	1	40
B	35.5	2	40
C	71	1	40
D	71	2	80

17 A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. Some observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

18 A white powder is a mixture of sodium chloride and sodium iodide. It is dissolved in water in a test-tube. Excess aqueous silver nitrate is added to the test-tube. A precipitate, X, is observed.

Excess concentrated ammonia is then added to the test-tube containing X. After the test-tube has been shaken, a precipitate, Y, is observed.

Which statement about X or Y is correct?

A X is a pure white colour.

B X is pure silver iodide.

C Y is pure silver chloride.

D Y is yellow.

19 *Use of the Data Booklet is relevant to this question.*

4.70 g of an ammonium salt is heated with excess aqueous sodium hydroxide. The volume of ammonia gas given off, measured at room temperature and pressure, is 1.41 dm^3.

Which ammonium salt was used?

A ammonium bromide (M_r = 97.9)

B ammonium carbonate (M_r = 96)

C ammonium nitrate (M_r = 80)

D ammonium sulfate (M_r = 132.1)

20 Which ester is formed when the alcohol CH_3CH_2OH is reacted with $CH_3CH_2CH_2CO_2H$?

A butyl ethanoate

B ethyl butanoate

C ethyl propanoate

D propyl ethanoate

21 Which compound shows optical isomerism?

A 2-chloropropane

B 1,2-dichloropropane

C 1,3-dichloropropane

D 2,2-dichloropropane

22 Methanoic acid, HCO_2H, has acidic properties similar to those of other carboxylic acids. In addition it can be oxidised by the same oxidising agents that are capable of oxidising aldehydes.

Which pair consists of two compounds that will give the same observations with Fehling's reagent?

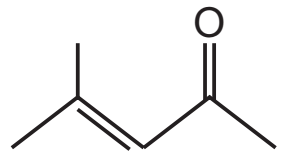
A HCO_2H and CH_3CO_2H

B HCO_2H and $CH_3CO_2CH_3$

C HCO_2H and $CH_3CH_2COCH_3$

D HCO_2H and CH_3CH_2CHO

23 Compound Q can be made from propanone.



Q

Which types of reaction will Q undergo?

A nucleophilic addition and electrophilic addition

B nucleophilic addition and nucleophilic substitution

C nucleophilic addition only

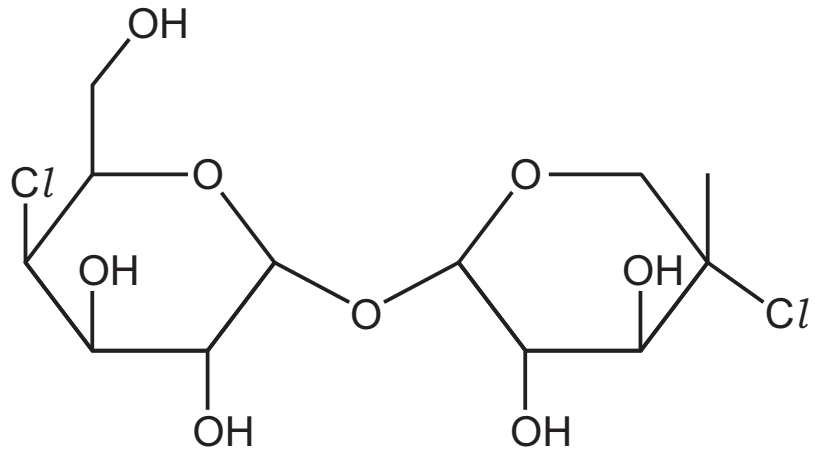
D nucleophilic substitution and electrophilic addition

24 The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.

Which compound would cause the most depletion of the ozone layer?

A CCl_3F **B** CF_4 **C** CO_2 **D** SO_2

25 Compound X has been investigated for use as an artificial sweetener.



X

The two C–C*l* bonds can be hydrolysed by hot NaOH(aq). The C-O-C bonds **cannot** be hydrolysed by hot NaOH(aq).

What are the numbers of specified types of –OH groups before and after hydrolysing the two C–C*l* bonds?

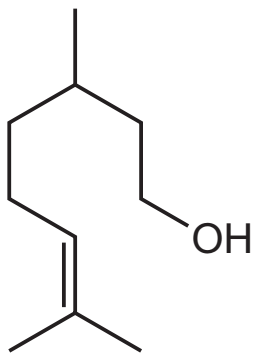
	before hydrolysis	after hydrolysis		
	secondary	primary	secondary	tertiary
A	0	1	2	4
B	0	2	1	4
C	4	1	5	1
D	4	2	4	1

26 The compounds below are all produced by plants.

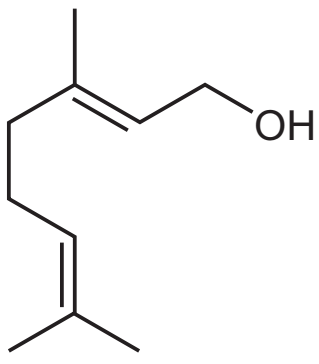
Each compound is warmed with acidified potassium dichromate(VI).

Which compound will give a different observation to the other three?

A



B



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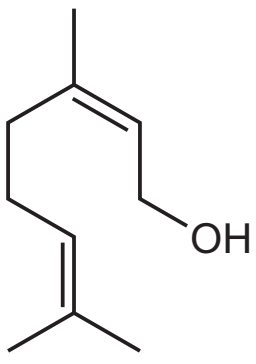

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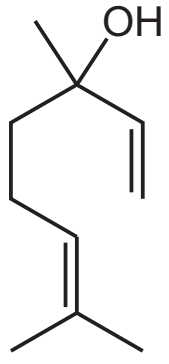
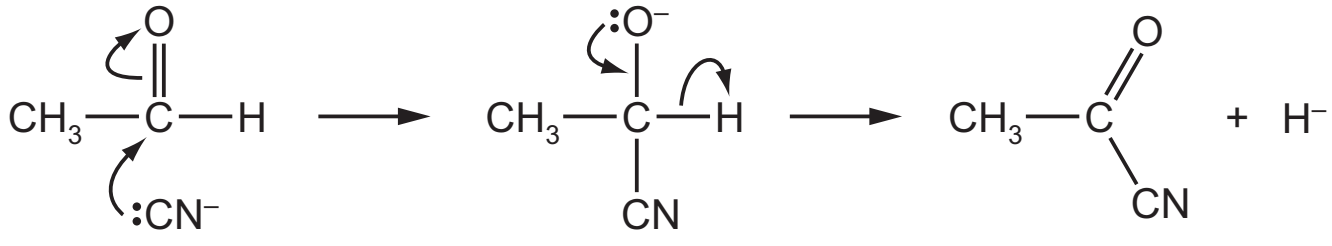
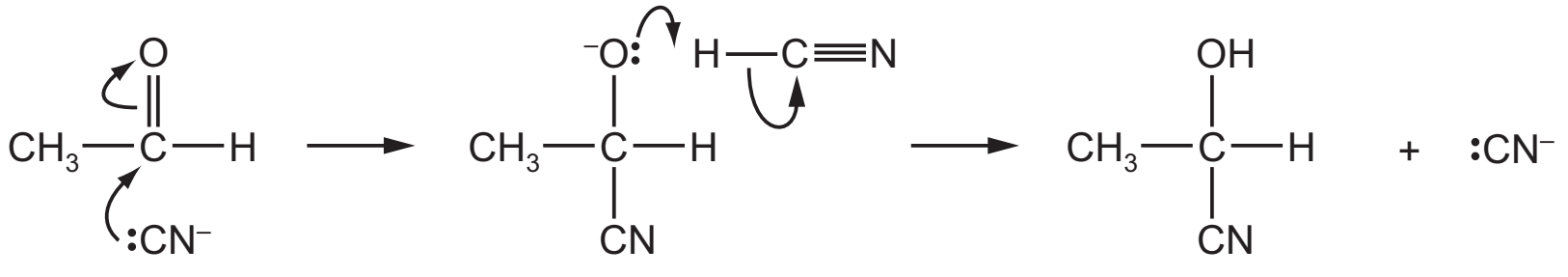


27 What is the mechanism for the reaction of ethanal, CH_3CHO, with hydrogen cyanide, HCN, in the presence of a base?

A



B



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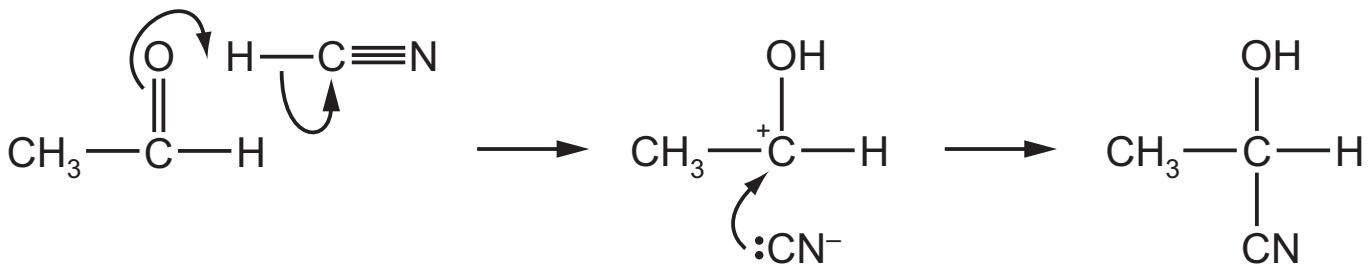
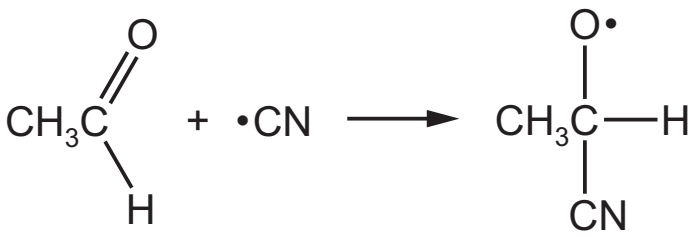
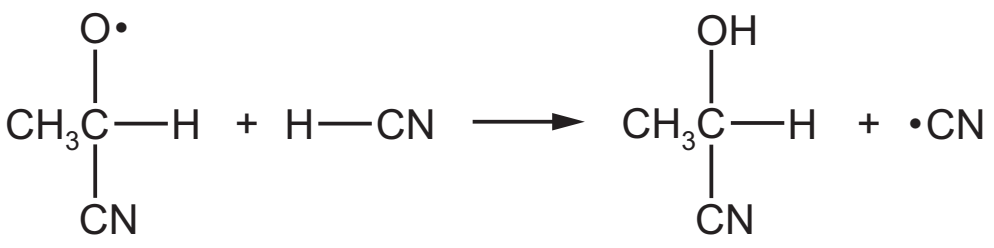


D

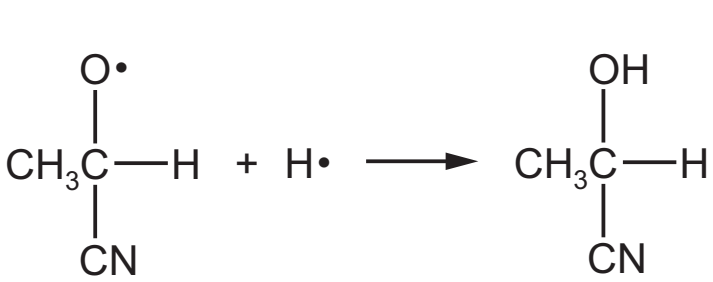
initiation $HCN \longrightarrow H\bullet + \bullet CN$

propagation

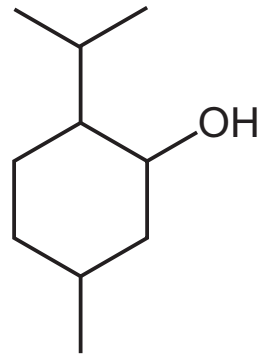




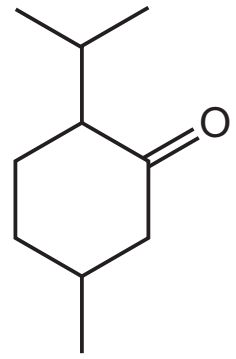
termination



28 Menthol and menthone are both found in peppermint oil.



menthol



menthone

Which statement about these compounds is correct?

A Both compounds can undergo mild oxidation.

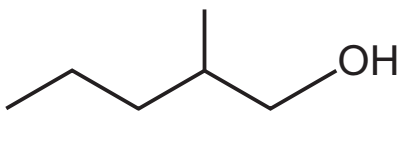
B Both compounds will give an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

C Menthol can be formed from menthone by reaction with $NaBH_4$.

D Menthone gives a positive test when warmed with Tollens' reagent.

29 What is the skeletal formula of 2-methylpentan-1-ol?

A



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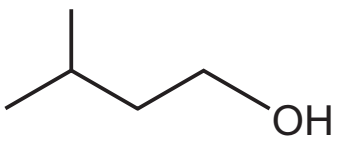

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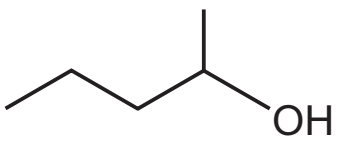

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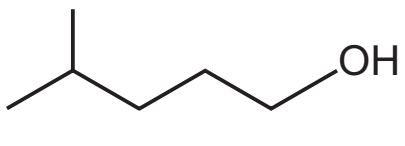
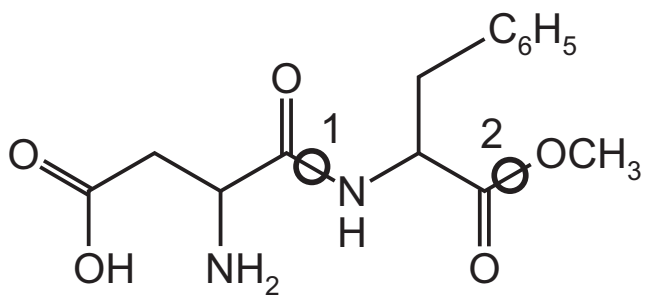


30 The structure of aspartame, which is used as an artificial sweetener, is shown.



aspartame

If aspartame is warmed in aqueous alkali, which of bonds 1 and 2 will be broken?

A both bond 1 and bond 2

B bond 1 only

C bond 2 only

D neither bond 1 nor bond 2

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 The relative molecular mass, M_r, of a particular sample of chlorine is 72.0.

Which properties of the atoms in this sample will be the same for all of the atoms?

1 radius

2 nucleon number

3 isotopic mass

32 Which of the following influence the size of the ionisation energy of an atom?

1 the amount of shielding by the inner electrons

2 the charge on the nucleus

3 the distance between the outer electrons and the nucleus

33 Which equations can apply to an ideal gas?

[p = pressure, V = volume, M = molar mass, ρ = density, c = concentration, R = gas constant, T = temperature]

1 $p = \frac{\rho RT}{M}$ **2** $pV = \frac{cRT}{M}$ **3** $pV = MRT$

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 Ammonia and chlorine react in the gas phase.

$$8NH_3 + 3Cl_2 \rightarrow N_2 + 6NH_4Cl$$

Which statements are correct?

1 Each nitrogen atom is oxidised.

2 Each chlorine atom is reduced.

3 Ammonia behaves as a base.

35 Which statements about calcium and strontium compounds are correct?

1 When calcium oxide and strontium oxide are added to water they both produce alkalis.

2 Calcium hydroxide is more soluble than strontium hydroxide.

3 Calcium sulfate is less soluble than strontium sulfate.

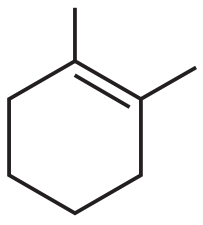
36 Which descriptions of the ammonium ion are correct?

1 It contains ten electrons.

2 It has a bond angle of 109.5°.

3 It has only three bonding pairs of electrons.

37 Compound Q is obtained by adding H_2O across the double bond in compound P.



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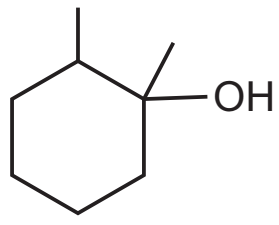


Q

Which statements about these two compounds are correct?

1 P shows *cis-trans* isomerism.

2 Q contains two chiral centres.

3 Q is a tertiary alcohol.

38 **X** is an organic compound. **X** gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when excess dilute aqueous ammonia is added.

What could be the identity of **X**?

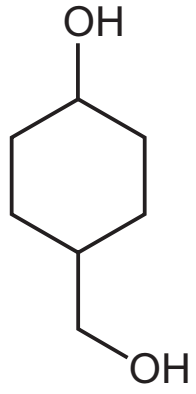
1 2-chlorobutane

2 2-bromobutane

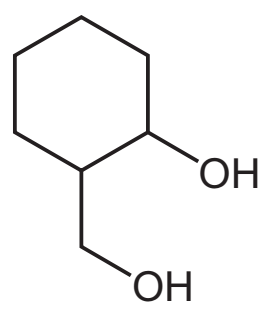
3 iodomethane

39 Which compounds, on heating with excess concentrated sulfuric acid, produce **only one** product with molecular formula C_7H_{10}?

1



2



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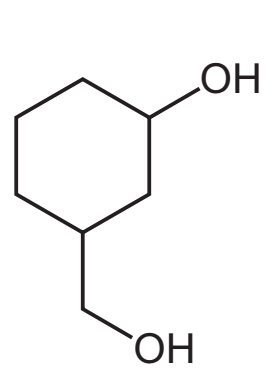
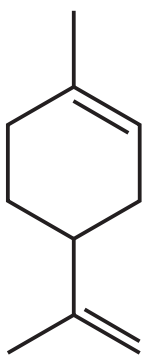


40 Compound **Z** is heated with concentrated acidified potassium manganate(VII). This produces an equimolar mixture of CO_2 and $CH_3COCH_2CH_2CH(COCH_3)CH_2CO_2H$.

What could be the structural formula of **Z**?

1



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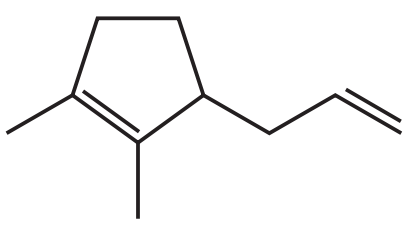

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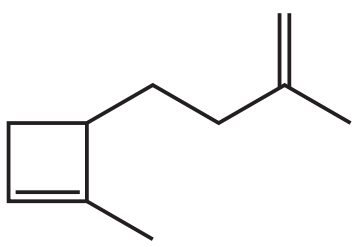

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Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2014**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

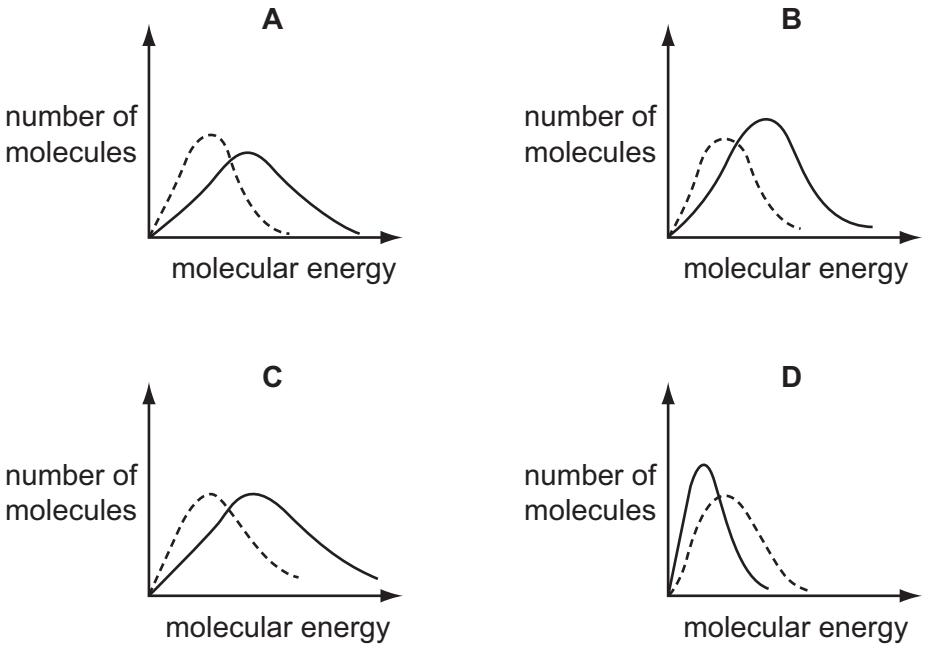
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

IB14 11_9701_12/FP

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 Which solid-line curve most accurately represents the distribution of molecular energies in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?



2 In which reaction does hydrogen behave as an oxidising agent?

A $H_2 + Cl_2 \rightarrow 2HCl$

B $C_2H_4 + H_2 \rightarrow C_2H_6$

C $N_2 + 3H_2 \rightarrow 2NH_3$

D $2Na + H_2 \rightarrow 2NaH$

3 Ethanol is increasingly being used as a fuel for cars.

The standard enthalpy change of formation of carbon dioxide is $-393\,kJ\,mol^{-1}$.
The standard enthalpy change of formation of water is $-286\,kJ\,mol^{-1}$.
The standard enthalpy change of formation of ethanol is $-277\,kJ\,mol^{-1}$.

What is the standard enthalpy change of combustion of ethanol?

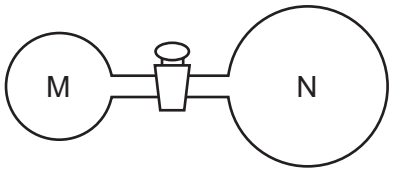
A $-1921\,kJ\,mol^{-1}$

B $-1367\,kJ\,mol^{-1}$

C $-956\,kJ\,mol^{-1}$

D $-402\,kJ\,mol^{-1}$

4 Two glass vessels M and N are connected by a closed valve.



M contains helium at 20 °C at a pressure of 1×10^5 Pa. N has been evacuated, and has three times the volume of M. In an experiment, the valve is opened and the temperature of the whole apparatus is raised to 100 °C.

What is the final pressure in the system?

A 3.18×10^4 Pa

B 4.24×10^4 Pa

C 1.25×10^5 Pa

D 5.09×10^5 Pa

5 The table shows the physical properties of four substances.

Which substance could be hydrogen chloride?

	melting point / °C	electrical conductivity of solid	electrical conductivity of liquid	electrical conductivity of aqueous solution
A	–119	poor	poor	insoluble
B	–115	poor	poor	good
C	–50	poor	poor	poor
D	993	poor	good	good

6 Aluminium carbide, Al_4C_3, reacts readily with aqueous sodium hydroxide. The two products of the reaction are $NaAlO_2$ and a hydrocarbon. Water molecules are also involved as reactants.

What is the formula of the hydrocarbon?

A CH_4 **B** C_2H_6 **C** C_3H_8 **D** C_6H_{12}

7 In an experiment to calculate the enthalpy change of combustion of a fuel, 1.5 g (0.0326 mol) of the fuel was used to heat 200 g of water. The temperature of the water rose from 25 °C to 55 °C. The specific heat capacity of water is $4.18\,J\,g^{-1}\,K^{-1}$.

There is significant heat loss in this experiment. Therefore, the experimental value for the enthalpy change of combustion, ΔH_c, of the fuel will be different from the theoretical value.

Using the information above, what is the experimental value for the enthalpy change of combustion, ΔH_c, of the fuel?

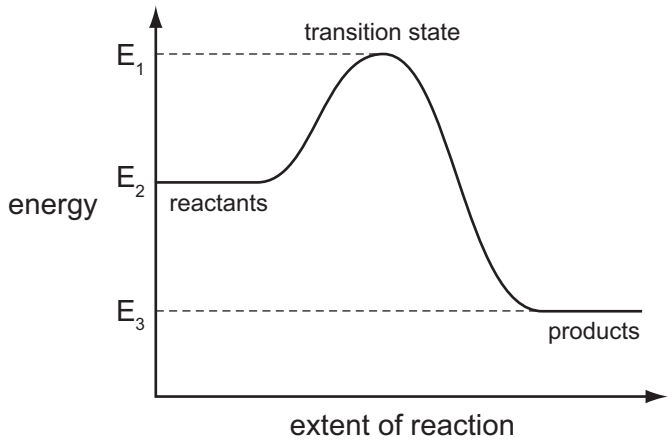
A $-1410\,kJ\,mol^{-1}$

B $-769\,kJ\,mol^{-1}$

C $-30.7\,kJ\,mol^{-1}$

D $-16.7\,kJ\,mol^{-1}$

8 The reaction pathway diagram below illustrates the energies of the reactants, the products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ **B** $E_2 - E_1$ **C** $E_2 - E_3$ **D** $E_3 - E_2$

9 Methylpropan-1-ol and butan-1-ol are structural isomers. Methylpropan-1-ol has a lower boiling point.

Which statement explains why the boiling point of methylpropan-1-ol is lower than that of butan-1-ol?

A Methylpropan-1-ol cannot form hydrogen bonds.

B Methylpropan-1-ol has weaker covalent bonds than butan-1-ol.

C Methylpropan-1-ol has weaker van der Waals' forces than butan-1-ol.

D Methylpropan-1-ol molecules have more surface area than butan-1-ol molecules.

10 Which row correctly describes the electrodes used in the electrolysis cell for the production of aluminium?

	anode	cathode
A	carbon	carbon
B	carbon	steel
C	steel	carbon
D	steel	steel

11 For which equation is the enthalpy change correctly described as an enthalpy change of formation?

A $C(g) + O_2(g) \rightarrow CO_2(g)$

B $C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

C $2N(g) + 4O(g) \rightarrow N_2O_4(g)$

D $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

12 Element **X**, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise $HCl(aq)$.

What is element **X**?

A Mg **B** Al **C** Si **D** P

13 Which property is **not** associated with the element sodium?

A It can react with cold water to form hydrogen.

B It forms a basic oxide.

C It forms a neutral chloride.

D It is an oxidising agent.

14 *Use of the Data Booklet is relevant to this question.*

Sir Humphrey Davy discovered boron, calcium, magnesium and sodium.

Which of these elements has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

A boron

B calcium

C magnesium

D sodium

15 *Use of the Data Booklet is relevant to this question.*

A sample of potassium oxide, K_2O, is dissolved in 250 cm^3 of distilled water. 25.0 cm^3 of this solution is titrated against sulfuric acid of concentration 2.00 mol dm^{-3}. 15.0 cm^3 of this sulfuric acid is needed for complete neutralisation.

Which mass of potassium oxide was originally dissolved in 250 cm^3 of distilled water?

A 2.83 g **B** 28.3 g **C** 47.1 g **D** 56.6 g

16 Chlorine gas reacts with cold aqueous sodium hydroxide. It can also react with hot aqueous sodium hydroxide.

What are the oxidation numbers of chlorine in the products of these reactions?

	cold aqueous sodium hydroxide	hot aqueous sodium hydroxide
A	–1, +1	–1, +5
B	–1, +1	+1, +6
C	–1, +2	–1, +5
D	–1, +2	+1, +6

17 Under standard conditions, which statement is correct?

A Cl^-(aq) can oxidise Br_2(aq).

B Cl^-(aq) can reduce Br_2(aq).

C Cl_2(aq) can oxidise Br^-(aq).

D Cl_2(aq) can reduce Br^-(aq).

18 Total removal of the pollutant sulfur dioxide, SO_2, is difficult. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are reacted with calcium hydroxide to remove the SO_2.

What is the main product formed **initially**?

A $Ca(HSO_4)_2$ **B** CaS **C** $CaSO_3$ **D** $CaSO_4$

19 Which oxide does **not** react with cold dilute sodium hydroxide to produce a salt?

A Al_2O_3 **B** P_4O_{10} **C** SO_2 **D** SiO_2

20 Which row correctly describes the reaction between propene and bromine, $Br_2(l)$?

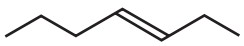
	reaction mechanism	organic product
A	electrophilic addition	$CH_3CHBrCH_2Br$
B	electrophilic addition	$CH_3CH_2CH_2Br$
C	nucleophilic substitution	$CH_3CH_2CH_2Br$
D	nucleophilic substitution	$CH_3CHBrCH_2Br$

21 *Use of the Data Booklet is relevant to this question.*

Which compound has an M_r of 84 and will react with HBr to give a product with an M_r of 164.9?

A

B



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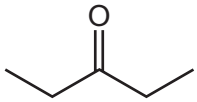

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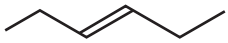


22 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.

$$CH_3CH_2CHCl_2 \xrightarrow{NaOH(aq)} CH_3CH_2CHO$$

Which term describes the first step of this reaction?

A addition

B elimination

C oxidation

D substitution

23 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

24 Lactic acid, $CH_3CH(OH)CO_2H$, causes pain when it builds up in muscles.

Which reagent reacts with **both** of the –OH groups in lactic acid?

A acidified potassium dichromate(VI)

B ethanol

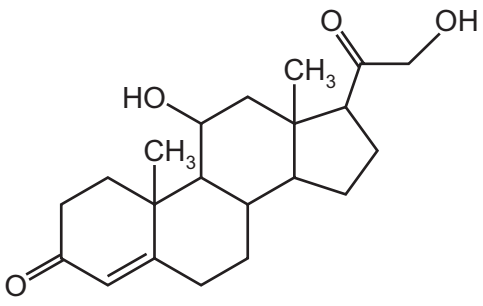
C sodium

D sodium hydroxide

25 In the hydrolysis of bromoethane by aqueous sodium hydroxide, what is the nature of the attacking group and of the leaving group?

	attacking group	leaving group
A	electrophile	electrophile
B	electrophile	nucleophile
C	nucleophile	electrophile
D	nucleophile	nucleophile

26 Corticosterone is a hormone involved in the metabolism of carbohydrates and proteins.



corticosterone

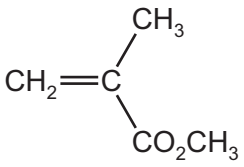
How many chiral centres are there in one molecule of corticosterone?

A 5 **B** 6 **C** 7 **D** 8

27 Methyl methylpropenoate is the monomer used to make *Perspex*.

Which diagram correctly shows methyl methylpropenoate?

A



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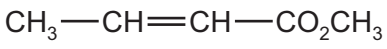

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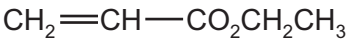
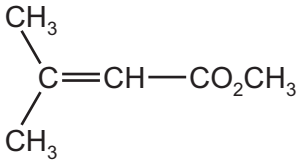


D



28 The ester $CH_3CH_2CH_2CO_2CH_3$ is responsible for the aroma of apples.

When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?

A CH_2O **B** CH_4O **C** C_2H_4O **D** $C_3H_6O_2$

29 Which equation correctly represents the balanced equation for the complete combustion of a hydrocarbon with the formula C_xH_y?

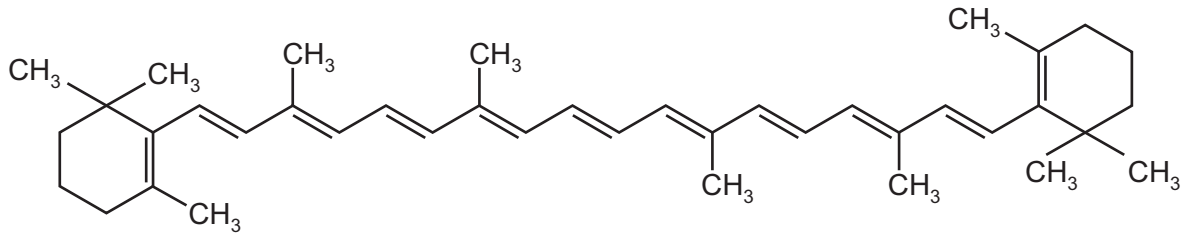
A $C_xH_y + (x + \frac{y}{2})O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

B $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + yH_2O$

C $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + \frac{y}{4}H_2O$

D $C_xH_y + (x + \frac{y}{4})O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

30 β-carotene is responsible for the orange colour of carrots.



β-carotene

β-carotene is oxidised by hot, concentrated, acidified $KMnO_4$.

When an individual molecule of β-carotene is oxidised in this way, many product molecules are formed.

How many of these product molecules contain a ketone functional group?

A 4 **B** 6 **C** 9 **D** 11

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 *Use of the Data Booklet is relevant to this question.*

Which ions contain one or more unpaired electrons?

1 Cu^{2+}

2 Mn^{3+}

3 V^{3+}

32 *Use of the Data Booklet is relevant to this question.*

The bond energy of the Br – O bond is 235 kJ mol^{-1}.

Which reactions are exothermic?

1 $OH\bullet + HBr \rightarrow H_2 + BrO\bullet$

2 $OH\bullet + HBr \rightarrow H_2O + Br\bullet$

3 $H\bullet + HBr \rightarrow H_2 + Br\bullet$

33 A reversible reaction is catalysed.

Which statements about the effects of the catalyst on this system are correct?

1 The catalyst alters the mechanism of the reaction.

2 The catalyst reduces the activation energy for both the forward and the backward reaction.

3 The catalyst alters the composition of the equilibrium mixture.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 A student borrowed a friend's chemistry notes and copied out the notes in the box below.

Which statements are correct?

A gas behaves **less** like an ideal gas when the gas

1 is at low pressure.

2 is at low temperature.

3 can be easily liquefied.

35 On being heated, hydrogen iodide breaks down more quickly than hydrogen chloride.

Which statements explain this faster rate?

1 The HI bond is weaker than the HC*l* bond.

2 The reaction of the breakdown of HI has a smaller activation energy than that of HC*l*.

3 The breakdown of HI is more exothermic than that of HC*l*.

36 Which statements about calcium oxide are correct?

1 It reacts with cold water.

2 It is produced when calcium nitrate is heated.

3 It can be reduced by heating with magnesium.

37 Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.

$$CH_3CH_2CHO + HCN \overset{NaCN}{\rightleftharpoons} CH_3CH_2CH(OH)CN$$

Which statements about the reaction of propanal with hydrogen cyanide are correct?

1 The CN^- ion attacks the propanal molecule to form an intermediate ion.

2 The product of the reaction has a chiral carbon atom.

3 The CN^- ion is a stronger electrophile than the HCN molecule.

38 **X** is an organic compound that gives a precipitate with aqueous silver nitrate. This precipitate remains undissolved when concentrated aqueous ammonia is added.

What is a possible identity for **X**?

1 iodomethane

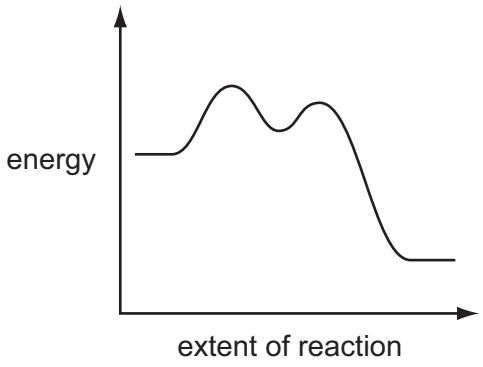
2 2-bromobutane

3 2-chlorobutane

39 For which mixtures of reagents are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

40 A reaction pathway diagram is shown.



Which reactions would have this profile?

1 $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$

2 $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$

3 $(CH_3)_3CCH_2CH_2Cl + 2NH_3 \rightarrow (CH_3)_3CCH_2CH_2NH_2 + NH_4Cl$

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2013**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

9366718608

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.

This document consists of **15** printed pages and **1** blank page.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 At the age of 17, in a woodshed in Ohio, Charles Martin Hall discovered the commercial process for the production of aluminium metal by the electrolysis of a mixture of bauxite, Al_2O_3, and cryolite, Na_3AlF_6.

What is the main purpose of the cryolite?

A Al_2O_3 is covalent, and AlF_6^{3-} ions interact with it to produce Al^{3+} ions which can be discharged at the cathode.

B Cryolite is a base, forming $NaAlO_2$ with bauxite, enabling aluminium to be discharged at the anode.

C Cryolite minimises the release of O^{2-} ions at the graphite anodes, which are otherwise burnt away to CO.

D Cryolite reduces the melting point of the bauxite.

2 In which reaction does a single nitrogen atom have the greatest change in oxidation number?

A $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

B $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

C $2NO + O_2 \rightarrow 2NO_2$

D $4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

3 The following half reactions occur when potassium iodate(V), KIO_3, in hydrochloric acid solution oxidises iodine to ICl_2^-.

$$IO_3^- + 2Cl^- + 6H^+ + 4e^- \rightarrow ICl_2^- + 3H_2O$$

$$I_2 + 4Cl^- \rightarrow 2ICl_2^- + 2e^-$$

What is the ratio of IO_3^- to I_2 in the balanced chemical equation for the overall reaction?

A 1 : 1 **B** 1 : 2 **C** 1 : 4 **D** 2 : 1

4 *Use of the Data Booklet is relevant to this question.*

In which set do all species contain the same number of electrons?

A Co^{2+}, Co^{3+}, Co^{4+}

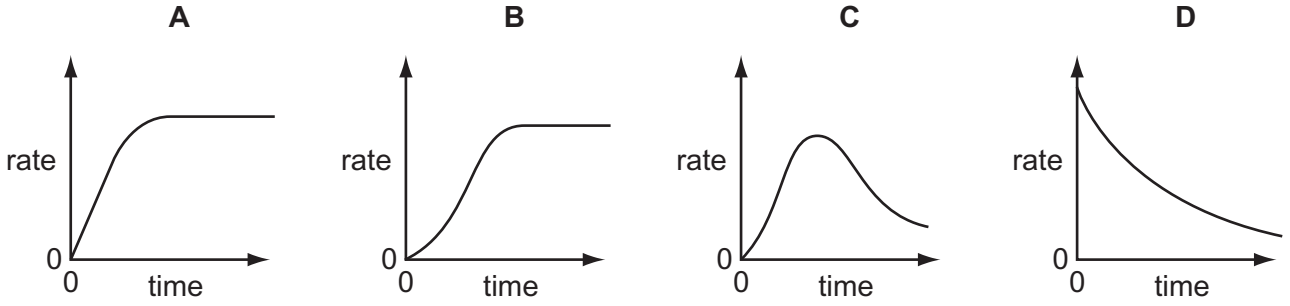
B F^-, Br^-, Cl^-

C Na^+, Mg^{2+}, Al^{3+}

D K_2SO_4, K_2SeO_4, K_2TeO_4

5 An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve was obtained if the rate of reaction was plotted against time for an autocatalytic reaction?

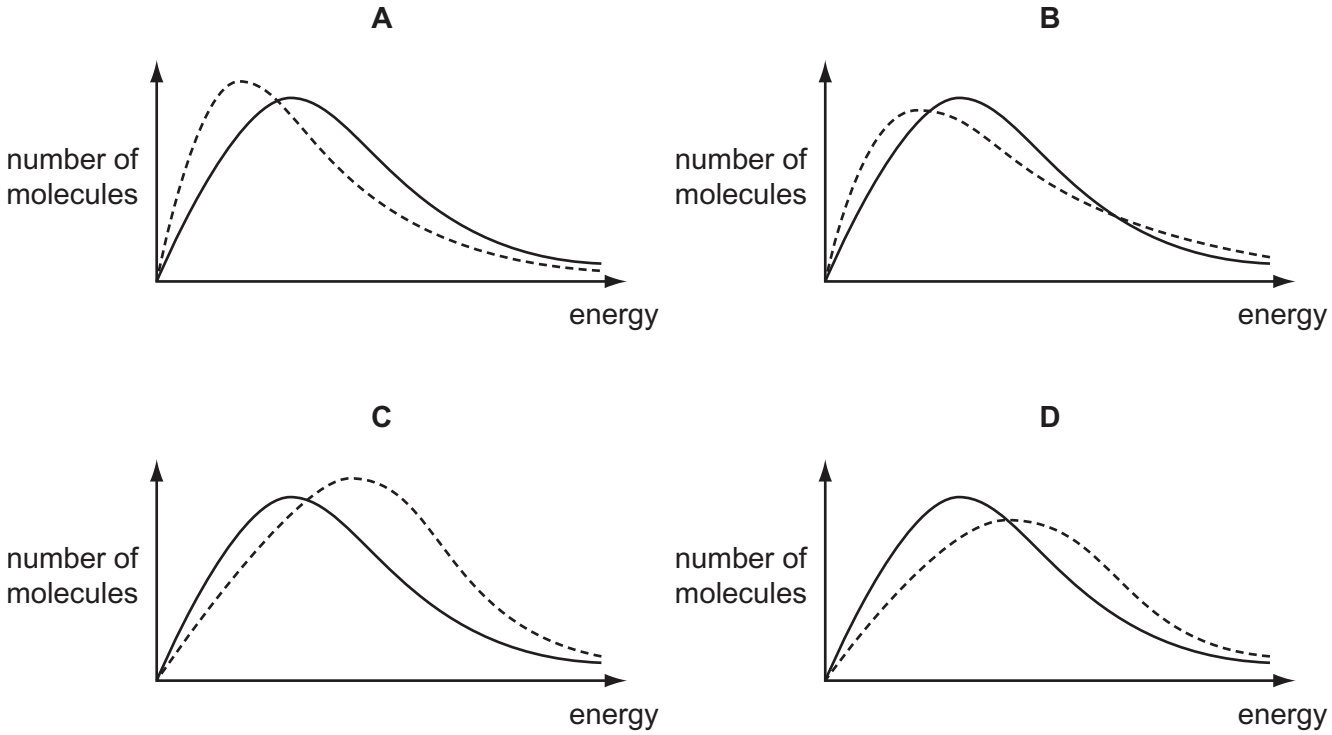


6 The diagrams below show the Boltzmann distribution for air at two temperatures.

The solid line represents the distribution at –20 °C.

The dotted line represents the distribution at –10 °C.

Which diagram is correct?



7 Which stage in the free radical substitution of methane by chlorine will have the lowest activation energy?

A $CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

B $Cl\bullet + Cl\bullet \rightarrow Cl_2$

C $Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$

D $Cl_2 \rightarrow Cl\bullet + Cl\bullet$

8 *Use of the Data Booklet is relevant to this question.*

The approximate percentage composition of the atmosphere on four different planets is given in the table below.

The density of a gas may be defined as the mass of 1 dm^3 of the gas measured at s.t.p.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules
A	Jupiter	H_2 89.8, He 10.2
B	Neptune	H_2 80.0, He 19.0, CH_4 1.0
C	Saturn	H_2 96.3, He 3.25, CH_4 0.45
D	Uranus	H_2 82.5, He 15.2, CH_4 2.3

9 Nitrogen reacts with hydrogen to produce ammonia.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen, and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3 under certain conditions. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c under these conditions?

A $\dfrac{(1.76)^2}{(2.32)(6.96)^3}$

B $\dfrac{(1.76)^2}{(2.32)(6.32)^3}$

C $\dfrac{(2.08)^2}{(2.32)(6.32)^3}$

D $\dfrac{(2.40)^2}{(2.32)(6.00)^3}$

10 *Use of the Data Booklet is relevant to this question.*

Which sodium compound contains 74.2 % by mass of sodium?

A sodium carbonate

B sodium chloride

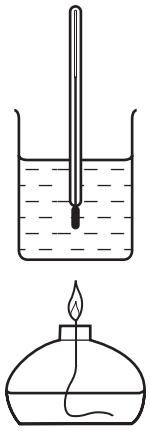
C sodium hydroxide

D sodium oxide

11 *Use of the Data Booklet is relevant to this question.*

A student carried out an experiment to determine the enthalpy change for the combustion of methanol.

The following results were obtained by the student.

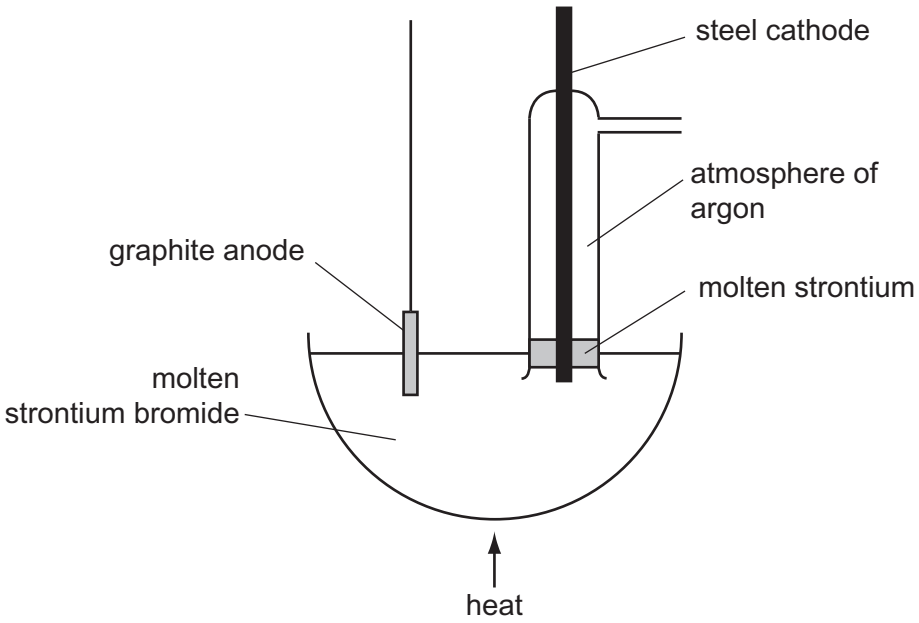


start temperature of the water	20 °C
final temperature of the water	53 °C
mass of alcohol burner before burning	259.65 g
mass of alcohol burner after burning	259.15 g
mass of glass beaker plus water	150.00 g
mass of glass beaker	50.00 g

How much of the heat energy produced by the burning of methanol went into the water?

A 209 J **B** 13 794 J **C** 20 691 J **D** 22 154 J

12 Strontium metal can be obtained by the electrolysis of molten strontium bromide, $SrBr_2$, using the apparatus shown in the diagram.



Why is an atmosphere of argon used around the cathode?

A A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.

B The argon keeps the strontium molten.

C The argon stops the molten strontium rising too high in the tube.

D Without the argon, strontium oxide would form in the air.

13 A metal, **X**, reacts with water to produce a colourless solution which gives a white precipitate when mixed with aqueous sulfuric acid.

What is metal **X**?

A barium

B magnesium

C potassium

D sodium

14 Which property **increases** in value going down Group II?

A electronegativity

B ionic radius

C maximum oxidation number

D second ionisation energy

15 Which row correctly identifies the uses of some of the compounds of Group II metals?

	used as a refractory lining in kilns	used in agriculture to increase the pH of a soil
A	CaO	$Ca(OH)_2$
B	CaO	$Mg(OH)_2$
C	MgO	$Ca(OH)_2$
D	MgO	$Mg(OH)_2$

16 Solid potassium halides react with concentrated sulfuric acid, according to the following equations.

reaction 1 $2KCl + H_2SO_4 \rightarrow K_2SO_4 + 2HCl$

reaction 2 $2KBr + 2H_2SO_4 \rightarrow K_2SO_4 + SO_2 + Br_2 + 2H_2O$

reaction 3 $8KI + 5H_2SO_4 \rightarrow 4K_2SO_4 + H_2S + 4I_2 + 4H_2O$

What is the largest **change** in the oxidation number of sulfur in each of these reactions?

	reaction 1	reaction 2	reaction 3
A	0	0	4
B	0	2	4
C	0	2	8
D	0	4	8

17 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions have the same number of electrons.

D The NH_4^+ ion can donate a proton.

18 Transition metals and their compounds are used as catalysts.

Which row is correct?

	transition metal present in the catalyst used in the Contact process	transition metal present in the catalyst used in the Haber process
A	iron	iron
B	iron	vanadium
C	vanadium	iron
D	vanadium	vanadium

19 Consecutive elements **X**, **Y** and **Z** are in the third period of the Periodic Table. Element **Y** has the highest first ionisation energy and the lowest melting point of these three elements.

What could be the identities of **X**, **Y** and **Z**?

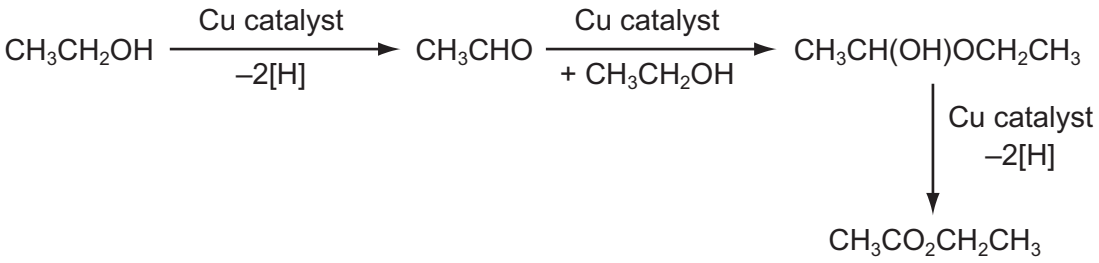
A sodium, magnesium, aluminium

B magnesium, aluminium, silicon

C aluminium, silicon, phosphorus

D silicon, phosphorus, sulfur

20 A new industrial preparation of ethyl ethanoate has been developed using cheap sources of ethanol.



Which process is involved at some stage in this reaction sequence?

A electrophilic addition

B nucleophilic addition

C nucleophilic substitution

D reduction

21 Which reaction will give the best yield of 1-chloropropane?

A chlorine gas with propene gas in the dark

B propan-1-ol with dilute NaCl(aq)

C propan-1-ol with PCl_5

D propene with dilute HCl(aq)

22 The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.

$CH_3CH_2CH{=}CHCH_2CH_2OH$

leaf alcohol

What will be formed when 'leaf alcohol' is oxidised using an excess of hot, acidified $K_2Cr_2O_7$(aq)?

A $CH_3CH_2CH(OH)CH(OH)CH_2CO_2H$

B $CH_3CH_2COCOCH_2CO_2H$

C $CH_3CH_2CH{=}CHCH_2CO_2H$

D $CH_3CH_2CO_2H$ and $HO_2CCH_2CO_2H$

23 Which compound exhibits stereoisomerism?

A $CH_3CHCl CH_3$

B $CH_3CHCl CH_2Cl$

C $CH_3CCl_2CH_3$

D $CH_2ClCH_2CH_2Cl$

24 A carbanion is an organic ion in which a carbon atom has a negative charge. A carbocation is an organic ion in which a carbon atom has a positive charge.

The reaction between aqueous sodium hydroxide and 1-bromobutane proceeds by an S_N2 mechanism.

How should the first step in the mechanism be described?

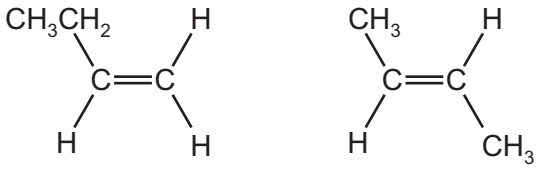
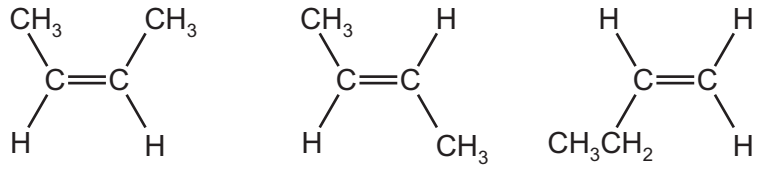
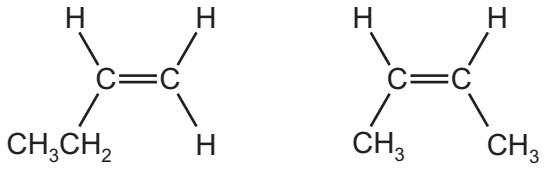
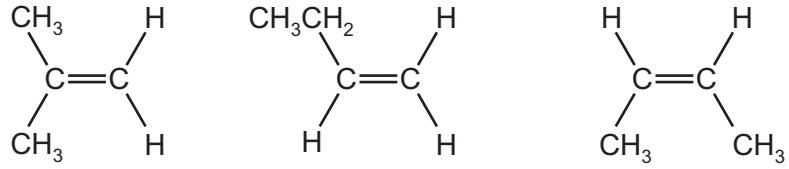
A attack by a nucleophile on a carbon atom with a partial positive charge

B heterolytic bond fission followed by an attack by an electrophile on a carbanion

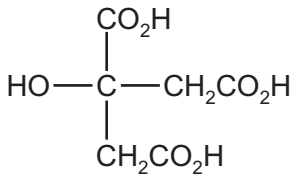
C heterolytic bond fission followed by an attack by a nucleophile on a carbocation

D homolytic bond fission followed by an attack by a nucleophile on a carbocation

25 What are the only structures formed when butan-2-ol is heated with concentrated H_2SO_4?

A	
B	
C	
D	

26 How many moles of hydrogen, H_2, are evolved when an excess of sodium metal is added to one mole of citric acid?



citric acid

A 1 **B** 2 **C** 3 **D** 4

27 Primary alcohols can be oxidised to aldehydes using either acidified potassium dichromate(VI) or acidified potassium manganate(VII). Both these oxidising agents change colour as they are reduced.

What is the colour of each oxidising agent before and after it has reacted?

	acidified potassium dichromate(VI)		acidified potassium manganate(VII)	
	before	after	before	after
A	green	orange	purple	colourless
B	orange	green	colourless	purple
C	orange	green	purple	colourless
D	purple	colourless	orange	green

28 In which reaction is the organic compound oxidised?

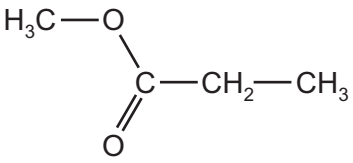
A CH_3CH_2OH + concentrated H_3PO_4

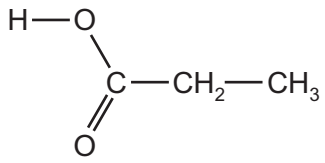
B $CH_3CH_2CH_2CHO$ + Tollens' reagent

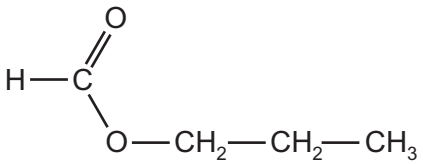
C CH_3COCH_3 + 2,4-dinitrophenylhydrazine reagent

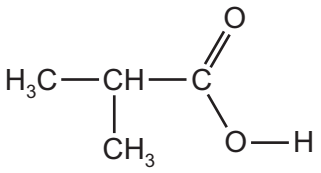
D CH_3CN + dilute H_2SO_4

29 How many of the compounds shown will react with aqueous sodium hydroxide to form the sodium salt of a carboxylic acid?









A 1 **B** 2 **C** 3 **D** 4

30 Which types of bond breakage and bond formation occur in the addition polymerisation of alkenes?

	bond breakage	bond formation
A	π only	σ only
B	π only	σ and π
C	σ and π	σ only
D	σ and π	σ and π

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 X is a particle with 18 electrons and 20 neutrons.

What could be the symbol of X?

1 $^{38}_{18}\text{Ar}$

2 $^{40}_{20}\text{Ca}^{2+}$

3 $^{39}_{19}\text{K}^{+}$

32 *Use of the Data Booklet is relevant to this question.*

Carbon and nitrogen are adjacent in the Periodic Table.

Which properties do they both have?

1 There is an empty 2p orbital in one atom of the element.

2 The principal quantum number of the highest occupied orbital is 2.

3 They form compounds in which their atoms form bonds with four other atoms.

33 What are necessary properties of a dynamic equilibrium?

1 Equal amounts of reactants and products are present.

2 Concentrations of reactants and products remain constant.

3 The rate of the forward reaction is the same as the rate of the reverse reaction.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 If N_2O_4 gas is placed in a sealed vessel the following equilibrium is established.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

The forward reaction is endothermic.

What happens when the temperature is increased?

1 The equilibrium constant increases.

2 The partial pressure of NO_2 increases.

3 The activation energy is unchanged.

35 Which types of bonding are present in ammonium carbonate, $(NH_4)_2CO_3$?

1 ionic

2 covalent

3 co-ordinate (dative covalent)

36 Sulfur dioxide and sulfites are used in food preservation.

Why are they used for this purpose?

1 They are reducing agents which slow down the oxidation of food.

2 They inhibit the growth of aerobic bacteria.

3 They react with $NO_2(g)$ converting it to NO(g).

37 The organic compound **X** gives a precipitate when warmed with aqueous silver nitrate. This precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for **X**?

1 1-bromopropane

2 2-chlorobutane

3 2-iodo,2-methylpropane

38 An organic compound **Y**, molecular formula $C_6H_{14}O$, may be oxidised to compound **Z**, molecular formula $C_6H_{12}O_2$.

What could be the structural formula of **Y**?

1 $CH_3CH_2CH(CH_2OH)CH_2CH_3$

2 $(CH_3)_3CCH_2CH_2OH$

3 $CH_3CH_2CH(CH_3)CH_2CH_2OH$

39 Which reactions can be used to make an alcohol in the laboratory?

1 hydrolysis of a bromoalkane with NaOH(aq)

2 reduction of a ketone with $NaBH_4$

3 reduction of an aldehyde with $NaBH_4$

40 The compounds below are treated with hydrogen cyanide.

Which compounds react and produce a molecule containing a chiral centre?

1 butanal

2 pentan-3-one

3 2-chlorobutane

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General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2012**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

5200319843

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

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This document consists of **13** printed pages and **3** blank pages.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 In which reaction does an element undergo the largest change in oxidation state?

A $Cl_2 + 2OH^- \rightarrow OCl^- + Cl^- + H_2O$

B $3Cl_2 + 6OH^- \rightarrow ClO_3^- + 5Cl^- + 3H_2O$

C $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

D $3MnO_4^{2-} + 4H^+ \rightarrow MnO_2 + 2MnO_4^- + 2H_2O$

2 *Use of the Data Booklet is relevant to this question.*

The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give a gallium isotope, ^{68}Ga, which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus, changing a proton into a neutron.

Which statement about the composition of an atom of the ^{68}Ga isotope is correct?

A It has 4 electrons in its outer p subshell.

B It has 13 electrons in its outer shell.

C It has 37 neutrons.

D Its proton number is 32.

3 Sodium borohydride, $NaBH_4$, and boron trifluoride, BF_3, are compounds of boron.

What are the shapes around boron in the borohydride ion and in boron trifluoride?

	borohydride ion	boron trifluoride
A	square planar	pyramidal
B	square planar	trigonal planar
C	tetrahedral	pyramidal
D	tetrahedral	trigonal planar

4 *Use of the Data Booklet is relevant to this question.*

A reaction which causes the presence of oxides of nitrogen in car exhausts is the formation of NO.

$$N_2 + O_2 \rightarrow 2NO \qquad \Delta H = +180\,kJ\,mol^{-1}$$

What is the bond energy in $kJ\,mol^{-1}$ of the bond between the atoms in NO?

A 655 **B** 835 **C** 1310 **D** 1670

5 In the table below,

- '+' means that this type of standard enthalpy change can **only** have positive values,
- '–' means that this type of standard enthalpy change can **only** have negative values,
- '+/–' means that **either** positive **or** negative values are possible.

Which row is correct?

	atomisation	formation	solution
A	+	+	+/–
B	+	+/–	+/–
C	–	+/–	–
D	–	–	+

6 *Use of the Data Booklet is relevant to this question.*

The volume of a sample of ammonia is measured at a temperature of 60 °C and a pressure of 103 kPa. The volume measured is $5.37 \times 10^{-3}\,m^3$.

What is the mass of the sample of ammonia, given to two significant figures?

A 0.00019 g **B** 0.0034 g **C** 0.19 g **D** 3.4 g

7 Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide. By a similar method, magnesium is extracted by the electrolysis of a molten mixture containing magnesium chloride.

Which statement about the extraction of magnesium is correct?

A Magnesium ions travel to the anode and are oxidised to magnesium metal.

B Magnesium ions travel to the anode and are reduced to magnesium metal.

C Magnesium ions travel to the cathode and are oxidised to magnesium metal.

D Magnesium ions travel to the cathode and are reduced to magnesium metal.

8 Some car paints contain small flakes of silica, SiO_2.

In the structure of solid SiO_2

- each silicon atom is bonded to **x** oxygen atoms,
- each oxygen atom is bonded to **y** silicon atoms,
- each bond is a **z** type bond.

What is the correct combination of **x**, **y** and **z** in this statement?

	x	y	z
A	2	1	covalent
B	2	1	ionic
C	4	2	covalent
D	4	2	ionic

9 John Dalton's atomic theory, published in 1808, contained four predictions about atoms.

Which of his predictions is still considered to be correct?

A All atoms are very small in size.

B All the atoms of a particular element have the same mass.

C All the atoms of one element are different in mass from all the atoms of other elements.

D No atom can be split into simpler parts.

10 A student calculated the standard enthalpy change of formation of ethane, C_2H_6, using a method based on standard enthalpy changes of combustion.

He used correct values for the standard enthalpy change of combustion of ethane ($-1560\ kJ\ mol^{-1}$) and hydrogen ($-286\ kJ\ mol^{-1}$) but he used an incorrect value for the standard enthalpy change of combustion of carbon. He then performed his calculation correctly. His final answer was $-158\ kJ\ mol^{-1}$.

What did he use for the standard enthalpy change of combustion of carbon?

A $-1432\ kJ\ mol^{-1}$

B $-860\ kJ\ mol^{-1}$

C $-430\ kJ\ mol^{-1}$

D $-272\ kJ\ mol^{-1}$

11 Which process could be used to calculate the bond energy for the covalent bond X-Y by dividing its ΔH by n?

A $XY_n(g) \rightarrow X(g) + nY(g)$

B $2XY_n(g) \rightarrow 2XY_{n-1}(g) + Y_2(g)$

C $Y(g) + XY_{n-1}(g) \rightarrow XY_n(g)$

D $nXY(g) \rightarrow nX(g) + \frac{n}{2}Y_2(g)$

12 In which pair do the molecules have the same shape as each other?

A H_2O and CO_2

B H_2O and SCl_2

C NH_3 and BH_3

D SCl_2 and $BeCl_2$

13 Why is the ionic radius of a chloride ion larger than the ionic radius of a sodium ion?

A A chloride ion has one more occupied electron shell than a sodium ion.

B Chlorine has a higher proton number than sodium.

C Ionic radius increases regularly across the third period.

D Sodium is a metal, chlorine is a non-metal.

14 What are the trends in the stated properties as Group II is descended from magnesium to barium?

	decomposition temperature of the carbonate	first ionisation energy
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

[Turn over

15 *Use of the Data Booklet is relevant to this question.*

The nitrates of beryllium, calcium, magnesium, and strontium all decompose in the same way when heated. When 2.00 g of one of these anhydrous nitrates is decomposed, 1.32 g of gas is produced.

What is the nitrate?

A beryllium nitrate

B calcium nitrate

C magnesium nitrate

D strontium nitrate

16 In a car engine, non-metallic element *X* forms a pollutant oxide *Y*. *Y* can be further oxidised to *Z*. Two students made the following statements.

Student P	The molecule of *Y* contains lone pairs of electrons.
Student Q	The oxidation number of *X* increases by 1 from *Y* to *Z*.

X could be carbon or nitrogen or sulfur.

Which student could be correct if *X* were any of these elements?

A P only

B Q only

C both P and Q

D neither P nor Q

17 *Use of the Data Booklet is relevant to this question.*

1.15 g of a metallic element reacts with 300 cm^3 of oxygen at 298 K and 1 atm pressure, to form an oxide which contains O^{2-} ions.

What could be the identity of the metal?

A calcium

B magnesium

C potassium

D sodium

18 Elements **X** and **Y** are both in period three.

When the chloride of **X** is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of **Y** is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

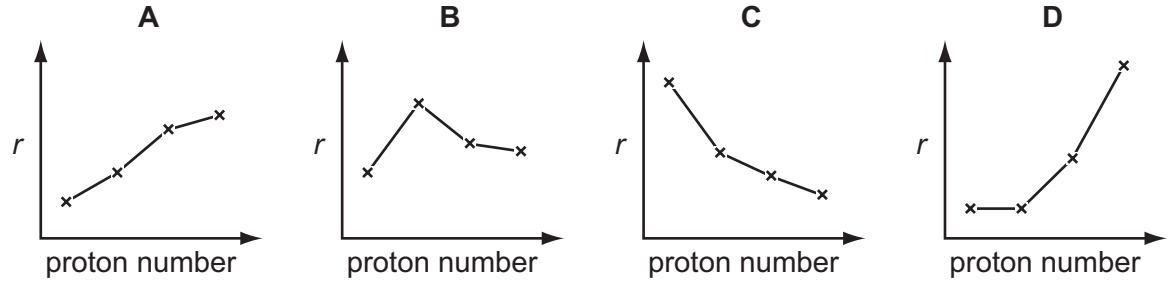
A Both chlorides hydrolyse in water.

B **X** is phosphorus and **Y** is aluminium.

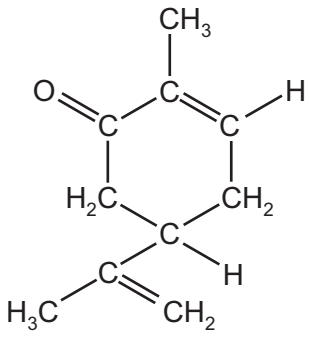
C **X** is silicon and **Y** is sodium.

D **X** is sodium and **Y** is phosphorus.

19 Which diagram shows the variation of the metallic radius *r* of the Group I elements, Li, Na, K and Rb, with increasing proton (atomic) number?



20 Carvone is found in spearmint.



carvone

How many σ and π bonds are present in this molecule?

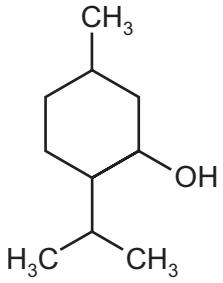
	σ	π
A	13	3
B	22	3
C	22	6
D	25	3

21 An alkene has the formula $CH_3CH{=}CRCH_2CH_3$ and does **not** possess *cis-trans* isomers.

What is *R*?

A H **B** Cl **C** CH_3 **D** C_2H_5

22 Menthol is an important compound extracted from the peppermint plant.



menthol

How many chiral centres are there in one molecule of menthol?

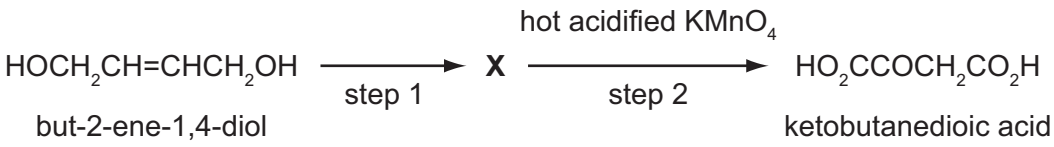
A 1 **B** 2 **C** 3 **D** 4

23 The cracking of a single hydrocarbon molecule, C_nH_{2n+2}, produces two hydrocarbon molecules only. Each hydrocarbon product contains the same number of carbon atoms in one molecule. Each hydrocarbon product has non-cyclic structural isomers.

What is the value of n?

A 4 **B** 6 **C** 8 **D** 9

24 But-2-ene-1,4-diol is converted in two steps through an intermediate **X** into ketobutanedioic acid.



What could be the reagent for step 1 and the intermediate **X**?

	reagent for step 1	**X**
A	cold acidified $KMnO_4$	$HOCH_2CH_2CH(OH)CH_2OH$
B	hot acidified $KMnO_4$	$OHCCH(OH)CH_2CHO$
C	steam and concentrated H_2SO_4	$HOCH_2CH(OH)CH_2CH_2OH$
D	warm acidified $K_2Cr_2O_7$	$HO_2CCH{=}CHCO_2H$

25 One of the reactions taking place in a catalytic converter in a car exhaust system is between nitrogen oxide and octane (unburned petrol). The products of this reaction are non-toxic.

Which is the correct equation for the reaction?

A $C_8H_{16} + 16NO \rightarrow 8CO + 8N_2 + 8H_2O$

B $C_8H_{16} + 24NO \rightarrow 8CO_2 + 12N_2 + 8H_2O$

C $C_8H_{18} + 17NO \rightarrow 8CO + 8\frac{1}{2}N_2 + 9H_2O$

D $C_8H_{18} + 25NO \rightarrow 8CO_2 + 12\frac{1}{2}N_2 + 9H_2O$

26 High-energy radiation in the stratosphere produces free-radicals from chlorofluoroalkanes, commonly known as CFCs.

Which free-radical is most likely to result from the irradiation of $CHFCl\dot{C}FCl$?

A $CHFCl\dot{C}FCl$

B $\dot{C}HClCF_2Cl$

C $\dot{C}HFCF_2Cl$

D $\dot{C}FClCF_2Cl$

27 Which reagent reacts with ethanol and also reacts with ethanoic acid?

A acidified potassium dichromate(VI)

B sodium

C sodium carbonate

D sodium hydroxide

28 In 1903 Arthur Lapworth became the first chemist to investigate a reaction mechanism. The reaction he investigated was that of hydrogen cyanide with propanone.

What do we now call the mechanism of this reaction?

A electrophilic addition

B electrophilic substitution

C nucleophilic addition

D nucleophilic substitution

29 Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at **room** temperature (20 °C)?

A $CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$

B $CH_3CH_2Br + KCN \rightarrow CH_3CH_2CN + KBr$

C $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$

D $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2CO_2H + NH_3$

30 Compound **X**, $C_6H_{12}O$, is oxidised by acidified sodium dichromate(VI) to compound **Y**.

Compound **Y** reacts with ethanol in the presence of a little concentrated sulfuric acid to give liquid **Z**.

What is the formula of **Z**?

A $CH_3(CH_2)_4COCH_2CH_3$

B $CH_3(CH_2)_4CO_2CH_2CH_3$

C $CH_3CH_2CO_2(CH_2)_4CH_3$

D $CH_3CO_2(CH_2)_5CH_3$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 How may nitrogen exist in compounds?

1 bonded by a triple covalent bond

2 as part of a cation

3 having lost 3 electrons to form an anion

32 *Use of the Data Booklet is relevant to this question.*

The isotope ^{99}Tc is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

Which statements are correct about an atom of ^{99}Tc?

1 It has 13 more neutrons than protons.

2 It has 43 protons.

3 It has 99 nucleons.

33 Which of these substances have a giant structure?

1 silicon(IV) oxide

2 baked clay found in crockery

3 phosphorus(V) oxide

[Turn over

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 The element astatine, At, is below iodine in Group VII of the Periodic Table.

Which statements concerning At will be correct?

1 It is a dark-coloured solid at room temperature.

2 It is a more powerful oxidising agent than iodine.

3 Its hydride is thermally stable.

35 Which equations represent stages in the Contact process for manufacturing sulfuric acid?

1 $SO_2 + \frac{1}{2} O_2 \rightarrow SO_3$

2 $SO_2 + H_2O \rightarrow H_2SO_3$

3 $H_2SO_3 + \frac{1}{2} O_2 \rightarrow H_2SO_4$

36 When added to water, which oxides will **not** cause a change in pH?

1 Al_2O_3

2 SiO_2

3 P_4O_{10}

37 Which reagents and conditions will convert propane into 1-chloropropane?

1 Cl_2 and sunlight

2 conc. HCl, reflux

3 PCl_5

38 Chloroethane can be formed from bromoethane in two steps.

$$C_2H_5Br \xrightarrow{\text{step } \mathbf{X}} C_2H_5OH \xrightarrow{\text{step } \mathbf{Y}} C_2H_5Cl$$

Which statements about these steps are correct?

1 Step **X** involves nucleophilic substitution.

2 Hot aqueous sodium hydroxide is the reagent in step **X**.

3 Hot aqueous sodium chloride is the reagent in step **Y**.

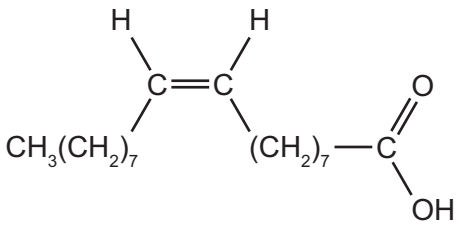
39 Which reagents react with butanone, $C_2H_5COCH_3$?

1 Tollens' reagent

2 sodium borohydride

3 2,4-dinitrophenylhydrazine reagent

40 Oleic acid is found in olive oil. It has the following formula.



Which reagents will give a positive result with oleic acid?

1 aqueous bromine

2 acidified potassium dichromate(VI)

3 Fehling's reagent

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
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Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 In the Haber process for the manufacture of ammonia, why is the heterogeneous catalyst iron in a finely divided state?

A to increase its surface area

B to produce the maximum reduction in the activation energy

C to reduce its loss during the reaction

D to reduce its surface area

2 The following equations the letters **W**, **X**, **Y** and **Z** all represent whole numbers.

When correctly balanced, which equation requires one of letters **W**, **X**, **Y** or **Z** to be 5?

A $\mathbf{W}C_3H_7COOH + \mathbf{X}O_2 \rightarrow \mathbf{Y}CO_2 + \mathbf{Z}H_2O$

B $\mathbf{W}C_4H_8 + \mathbf{X}O_2 \rightarrow \mathbf{Y}CO_2 + \mathbf{Z}H_2O$

C $\mathbf{W}H_3PO_4 + \mathbf{X}NaOH \rightarrow \mathbf{Y}Na_2HPO_4 + \mathbf{Z}H_2O$

D $\mathbf{W}NH_3 + \mathbf{X}O_2 \rightarrow \mathbf{Y}N_2 + \mathbf{Z}H_2O$

3 *Use of the Data Booklet is relevant to this question.*

From which particle is the removal of an electron the most difficult?

A $Cl^-(g)$ **B** $F^-(g)$ **C** $K^+(g)$ **D** $Na^+(g)$

4 *Use of the Data Booklet is relevant to this question.*

560 kg of nitrogen and 120 kg of hydrogen are pressurised, heated and passed over an iron catalyst. When the mixture of gases reaches equilibrium, it contains 96 kg of hydrogen.

Which mass of ammonia does it contain?

A 24 kg **B** 68 kg **C** 136 kg **D** 680 kg

5 The presence of dipoles helps to explain why the element Br_2 and the compound $CHCl_3$ exist as liquids at room temperature.

Which types of dipole are involved?

	Br_2	$CHCl_3$
A	induced dipoles and permanent dipoles	induced dipoles and permanent dipoles
B	induced dipoles and permanent dipoles	induced dipoles only
C	induced dipoles only	induced dipoles and permanent dipoles
D	induced dipoles only	induced dipoles only

6 Three compounds have the physical properties shown in the table.

compound	**P**	**Q**	**R**
melting point / °C	2852	993	–119
boiling point / °C	3600	1695	39
conductivity (solid)	poor	poor	poor
conductivity (liquid)	good	good	poor
conductivity (aqueous)	insoluble	good	insoluble

What might be the identities of **P**, **Q** and **R**?

	P	**Q**	**R**
A	MgO	KCl	NH_3
B	MgO	NaF	C_2H_5Br
C	SiO_2	KCl	C_2H_5Br
D	SiO_2	NaF	HCl

7 For the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, what will change the value of K_p?

A adding a catalyst

B adding more O_2

C increasing the pressure

D increasing the temperature

8 Which pollutant, present in the exhaust fumes of an internal combustion engine, has an element in the +2 oxidation state and an odd number of electrons in one molecule of the pollutant?

A CO **B** H_2S **C** NO **D** NO_2

9 The use of sucrose in food processing depends in part on osmotic pressure, symbol Π.

In dilute solution, Π varies with concentration in a similar way to gas behaviour. The equation $\Pi V = nRT$ can be used, where n is the number of moles of solute molecules contained in volume V at temperature T. The number of moles of solvent molecules should be ignored.

Under aqueous acidic conditions sucrose is hydrolysed.

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{fructose}}{CH_2OH(CHOH)_3COCH_2OH}$$

What can be deduced from this hydrolysis equation?

	the osmotic pressure	glucose and fructose are
A	decreases	optical isomers
B	decreases	structural isomers
C	increases	optical isomers
D	increases	structural isomers

10 Hess's Law can be used to calculate the average C-H bond energy in methane.

$\Delta H^{\ominus}_{at}$ = standard enthalpy change of atomisation

$\Delta H^{\ominus}_{f}$ = standard enthalpy change of formation

$\Delta H^{\ominus}_{c}$ = standard enthalpy change of combustion

Which data values are needed in order to perform the calculation?

A $\Delta H^{\ominus}_{at}$ (C), $\Delta H^{\ominus}_{at}$ (H), $\Delta H^{\ominus}_{f}$ (CH_4)

B $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{c}$ (CH_4)

C $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{f}$ (CH_4)

D $\Delta H^{\ominus}_{f}$ (CH_4) only, as $\Delta H^{\ominus}_{f}$ (C), and $\Delta H^{\ominus}_{f}$ (H_2), are defined as zero

11 The amount of titanium dioxide in an ore can be determined by using the following reaction.

$$3TiO_2 + 4BrF_3 \rightarrow 3TiF_4 + 2Br_2 + 3O_2$$

Which element increases in oxidation number in this reaction?

A bromine

B fluorine

C oxygen

D titanium

12 For the reaction

$$W(aq) + 2X(aq) \rightleftharpoons 2Y(aq) + 3Z(aq)$$

what are the correct units for the equilibrium constant K_c?

A $mol\,dm^{-3}$ **B** $mol^2\,dm^{-6}$ **C** $mol^{-1}\,dm^3$ **D** $mol^{-2}\,dm^6$

13 Methyl mercaptan, CH_3SH, has a foul smell and is often used to impart a smell to natural gas.

What will be formed when CH_3SH is burned in an excess of air?

A CO H_2O SO_2

B CO_2 H_2O H_2S

C CO_2 H_2O SO_2

D CO_2 H_2O SO_3

14 Nitrogenous fertilisers are used extensively in modern farming. If rainwater washes excess fertiliser into a nearby lake, a process called eutrophication may occur.

Three of the stages of eutrophication are described below.

P Water plants growing on the lake bed die due to lack of sunlight.

Q An excessive growth of algae occurs.

R Excessive bacterial activity causes a reduction in oxygen levels.

In which order do these three stages occur?

A P → Q → R

B P → R → Q

C Q → P → R

D Q → R → P

15 Chlorine can be manufactured from brine in a diaphragm cell.

Which row represents the correct electrodes?

	nature of anode	nature of cathode
A	graphite	titanium
B	steel	titanium
C	titanium	graphite
D	titanium	steel

16 Sodium iodide reacts with concentrated sulfuric acid. The equation which represents one of the reactions that takes place is shown.

$$8NaI + 9H_2SO_4 \rightarrow 8NaHSO_4 + 4I_2 + H_2S + 4H_2O$$

Which species has been oxidised in this reaction?

A H^+ **B** I^- **C** Na^+ **D** SO_4^{2-}

17 The standard enthalpy changes of formation of HC*l* and HI are –92 kJ mol^{-1} and +26 kJ mol^{-1} respectively.

Which statement is **most** important in explaining this difference?

A Chlorine is more electronegative than iodine.

B The activation energy for the $H_2 + Cl_2$ reaction is much less than that for the $H_2 + I_2$ reaction.

C The bond energy of HI is smaller than the bond energy of HC*l*.

D The bond energy of I_2 is smaller than the bond energy of Cl_2.

18 Lime mortar is made from quicklime, water and sand. Over a period of time, lime mortar changes into a much harder form. Both fresh and old lime mortar react with aqueous hydrochloric acid but only the old lime mortar effervesces during the reaction.

Which equation describes the change from fresh to old lime mortar?

A $CaO + CO_2 \rightarrow CaCO_3$

B $CaO + H_2O \rightarrow Ca(OH)_2$

C $Ca(OH)_2 \rightarrow CaO + H_2O$

D $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

19 Ar, Ca^{2+} and K^+, contain the same number of electrons.

In which order do their radii increase?

	smallest radius ⟶		largest radius
A	Ar	K^+	Ca^{2+}
B	Ca^{2+}	Ar	K^+
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

20 Bromine and propene undergo an addition reaction.

Which is a property of the product?

A It exists in *cis-trans* isomers.

B It is more volatile than propene.

C It possesses a chiral centre.

D It possesses hydrogen bonding.

21 Buta-1,3-diene is currently obtained from fossil fuel sources. In future it may be obtained from ethanol, which can be produced from non-food agricultural crops. The sequence of reactions is as follows.

$$CH_3CH_2OH \xrightarrow{\text{step 1}} CH_3CHO \xrightarrow{\text{step 2}} CH_3CH(OH)CH_2CHO \xrightarrow{\text{step 3}} CH_2{=}CHCH{=}CH_2$$

buta-1,3-diene

Which term could be used to describe step 1?

A condensation

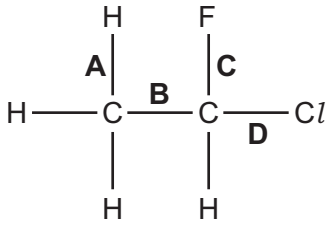
B dehydration

C dehydrogenation

D hydrogenation

22 *Use of the Data Booklet is relevant to this question.*

Which bond in the structure below has the lowest bond energy?



23 Ethanal, CH_3CHO, can be reduced using $NaBH_4$ in aqueous ethanol.

This is a nucleophilic addition reaction.

What could be the first step of this mechanism?

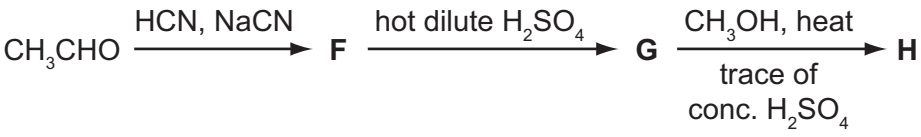
A attack of an H^- ion at the carbon atom of the carbonyl group

B attack of an H^- ion at the oxygen atom of the carbonyl group

C attack of an H^+ ion at the carbon atom of the carbonyl group

D attack of an H^+ ion at the oxygen atom of the carbonyl group

24 In a sequence of reactions, ethanal is converted into a compound **H**.



What could **H** be?

A $CH_3CH_2COOCH_3$

B $CH_3CH(OH)COOCH_3$

C $CH_3CH(OH)OCOCH_3$

D $CH_3CH(OCH_3)COOH$

25 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?

A heterolytic bond fission, attack by an electrophile on a carbanion

B heterolytic bond fission, attack by a nucleophile on a carbocation

C homolytic bond fission, attack by an electrophile on a carbanion

D homolytic bond fission, attack by a nucleophile on a carbocation

26 *Use of the Data Booklet is relevant to this question.*

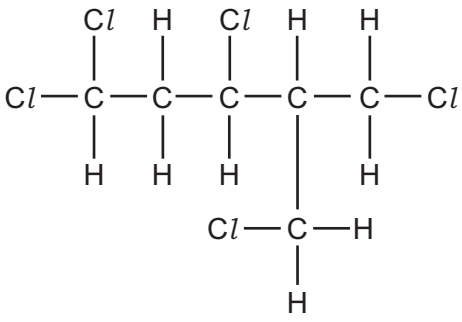
2.30 g of ethanol were mixed with aqueous acidified potassium dichromate(VI). The desired product was collected by immediate distillation under gentle warming.

The yield of product was 70.0 %.

What mass of product was collected?

A 1.54 g **B** 1.61 g **C** 2.10 g **D** 3.14 g

27 The molecule shown is optically active.



How many chiral carbon atoms are present in this molecule?

A 1 **B** 2 **C** 3 **D** 4

28 Which reagent could best be used to distinguish between cyclohexene and cyclohexanol?

A $Ag(NH_3)_2^+$ in H_2O

B Br_2 in CCl_4

C 2,4-dinitrophenylhydrazine in CH_3OH

D $NaBH_4$ in CH_3OH

29 Compound X, molecular formula C_4H_8, undergoes the following reactions.

$$\underset{\textbf{X}}{C_4H_8} \xrightarrow{Br_2} \underset{\textbf{Y}}{C_4H_8Br_2} \xrightarrow{\text{aq.NaOH / heat}} \underset{\textbf{Z}}{C_4H_{10}O_2}$$

$$\underset{\textbf{X}}{C_4H_8} \xrightarrow{H_2 / Ni} \text{methylpropane}$$

What is the formula of compound Z?

A $CH_3CH_2CH(OH)CH_2OH$

B $CH_3CH(OH)CH(OH)CH_3$

C $CH_3CH(CH_2OH)CH_2OH$

D $(CH_3)_2C(OH)CH_2OH$

30 How many of the isomeric alcohols with the formula C_4H_9OH will produce an alkene that has cis and trans isomers, on treatment with conc. H_2SO_4?

A 1 **B** 2 **C** 3 **D** 4

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

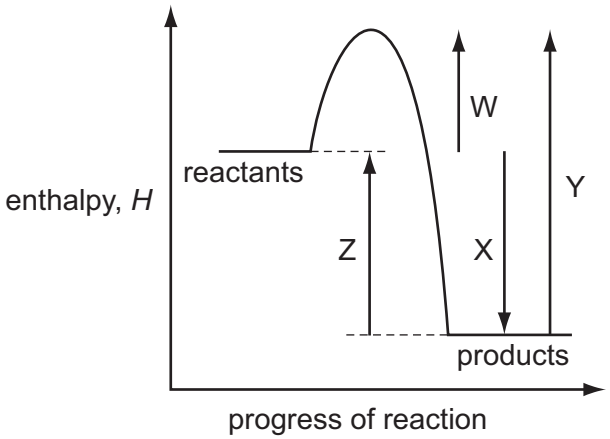
31 Which statements about bond angles are correct?

1 The bond angle in SO_2 is smaller than the bond angle in CO_2.

2 The bond angle in H_2O is smaller than the bond angle in CH_4.

3 The bond angle in NH_3 is smaller than the bond angle in BF_3.

32 An energy profile diagram is shown.



What do the labels on the diagram represent?

1 W = ΔH of the forward reaction, Y = E_a of the backward reaction

2 Z = ΔH of the backward reaction, Y = E_a of the backward reaction

3 X = ΔH of the forward reaction, W = E_a of the forward reaction

33 Which are assumptions of the kinetic theory of gases and hence of the ideal gas equation, $PV = nRT$?

1 Molecules move without interacting with one another except for collisions.

2 Intermolecular forces are negligible.

3 Intermolecular distances are much greater than the molecular size.

34 *Use of the Data Booklet is relevant to this question.*

Which properties would be expected for radium, $_{88}Ra$, or its compounds?

1 Radium carbonate would not decompose at the temperature of a Bunsen flame.

2 Radium hydroxide is very insoluble.

3 Radium does not react with cold water.

35 When a firework is lit, a fuel and an oxidising agent react together.

In one such firework, magnesium is the fuel and barium nitrate is the oxidising agent.

Which solids are produced when the firework is lit?

1 BaO

2 MgO

3 $Mg(NO_3)_2$

36 In a car engine, non-metallic element ***X*** forms a pollutant oxide ***Y***.

Further oxidation of ***Y*** to ***Z*** occurs spontaneously in the atmosphere. In this further oxidation, 1 mol of ***Y*** reacts with 0.5 mol of gaseous oxygen.

Which statements about ***X***, ***Y*** and ***Z*** are correct?

1 The oxidation number of ***X*** increases by 2 from ***Y*** to ***Z***.

2 The molecule of ***Y*** has no unpaired electrons.

3 The molecule of ***Z*** contains three oxygen atoms.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

37 Compound **X** has molecular formula $C_4H_{10}O$. Separate samples of **X** are tested with three different reagents.

Which results could **not** be obtained?

	Tollens' reagent	2,4-dinitrophenylhydrazine reagent	warm acidified potassium dichromate(VI) solution
1	silver mirror forms	orange precipitate forms	colour changes from orange to green
2	no change	no change	no change
3	no change	no change	colour changes from orange to green

38 **Y** is an organic compound. **Y** gives a precipitate with aqueous silver nitrate. All of this precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for **Y**?

1 1-bromopropane

2 chloroethane

3 2-iodo-2-methylpropane

39 Which compounds will produce ethanoic acid when boiled under reflux with dilute alkali followed by acidification?

1 CH_3CH_2Cl

2 $CH_3CO_2CH_3$

3 CH_3CN

40 Which pairs of homologous series have the same C:H ratio in their general formulae?

1 aldehydes and ketones

2 carboxylic acids and esters

3 alkenes and ketones

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2010**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

* 2 8 9 9 4 4 8 6 1 9 *

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of **16** printed pages.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 The ability of an atom in a covalent bond to attract electrons to itself is called its electronegativity.

The greater the difference between the electronegativities of the two atoms in the bond, the more polar is the bond.

Which pair will form the most polar covalent bond between the atoms?

A chlorine and bromine

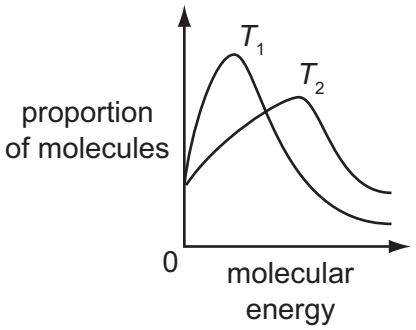
B chlorine and iodine

C fluorine and chlorine

D fluorine and iodine

2 Which diagram correctly represents the Boltzmann distribution of molecular energies at two temperatures T_1 and T_2, where $T_1 = 300\,K$ and $T_2 = 310\,K$?

A



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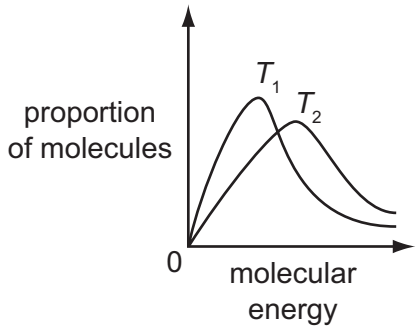

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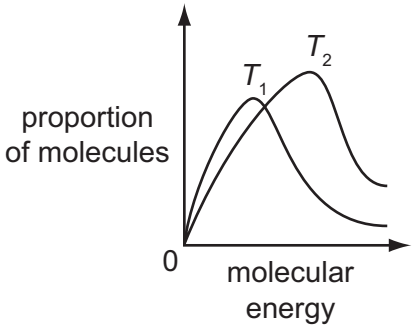
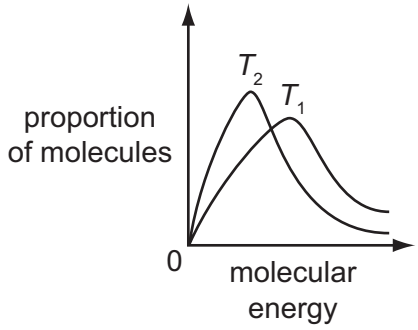


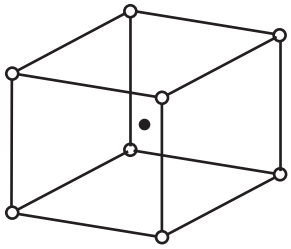
D



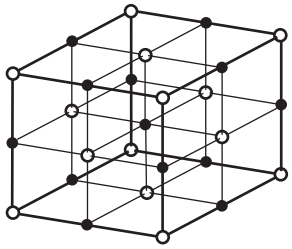
3 The table gives the radii, in pm, of some ions. [1 pm = 10^{-12} m]

ion	radii
Na^+	102
Mg^{2+}	72
Cs^+	167
Cl^-	181
O^{2-}	140

Caesium chloride, CsC*l*, has a different lattice structure from both sodium chloride, NaC*l*, and magnesium oxide, MgO.



CsC*l* lattice



NaC*l* and MgO lattice

Which factor appears to determine the type of lattice for these three compounds?

A the charge on the cation

B the ratio of the ionic charges

C the ratio of the ionic radii

D the sum of the ionic charges

[Turn over

4 Methanol may be prepared by the reaction between carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

The relevant average bond energies are given below.

E(C≡O)	1077 kJ mol^{-1}
E(C–O)	360 kJ mol^{-1}
E(C–H)	410 kJ mol^{-1}
E(H–H)	436 kJ mol^{-1}
E(O–H)	460 kJ mol^{-1}

What is the enthalpy change of this reaction?

A –537 kJ mol^{-1}

B –101 kJ mol^{-1}

C +101 kJ mol^{-1}

D +537 kJ mol^{-1}

5 Which solid has a simple molecular lattice?

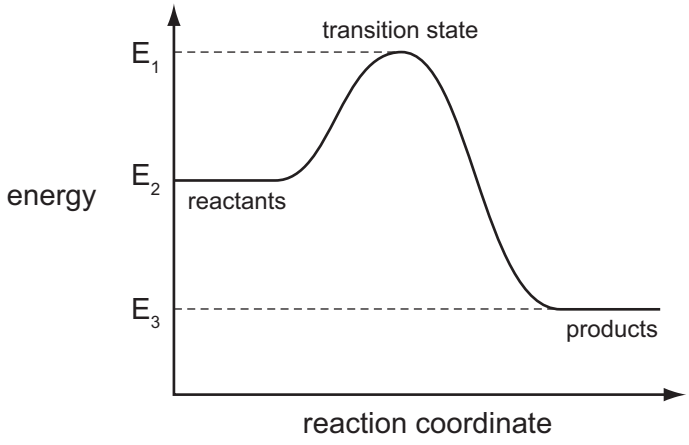
A calcium fluoride

B nickel

C silicon(IV) oxide

D sulfur

6 The reaction pathway diagram below illustrates the energies of reactants, products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ **B** $E_1 - E_3$ **C** $E_2 - E_3$ **D** $(E_1 - E_2) - (E_2 - E_3)$

7 Flask X contains 5 dm^3 of helium at 12 kPa pressure and flask Y contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

A 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

8 *Use of the Data Booklet is relevant to this question.*

The enthalpy change of formation, ΔH_f, of hydrated calcium ions is the enthalpy change of the following reaction.

$$Ca(s) + aq - 2e^- \rightarrow Ca^{2+}(aq)$$

The following enthalpy changes are **not** quoted in the *Data Booklet*.

$$Ca(s) \rightarrow Ca(g) \qquad \Delta H_a = 177\ kJ\ mol^{-1}$$
$$Ca^{2+}(g) + aq \rightarrow Ca^{2+}(aq) \qquad \Delta H_{hyd} = -1565\ kJ\ mol^{-1}$$

What is the enthalpy change of formation of hydrated calcium ions?

A $-1388\ kJ\ mol^{-1}$

B $-798\ kJ\ mol^{-1}$

C $-238\ kJ\ mol^{-1}$

D $+352\ kJ\ mol^{-1}$

9 The following equilibrium is set up in a mixture of concentrated nitric and sulfuric acids.

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

Which row correctly describes the behaviour of each substance in the equilibrium mixture?

	HNO_3	H_2SO_4	$H_2NO_3^+$	HSO_4^-
A	acid	acid	base	base
B	acid	base	base	acid
C	base	acid	acid	base
D	base	acid	base	acid

10 Which molecule or structure does **not** contain three atoms bonded at an angle between 109° and 110°?

A ethanoic acid

B graphite

C propane

D silicon(IV) oxide

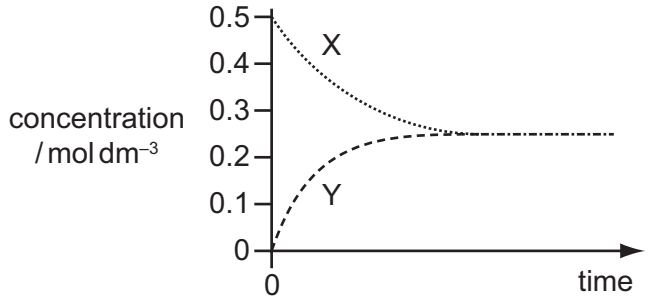
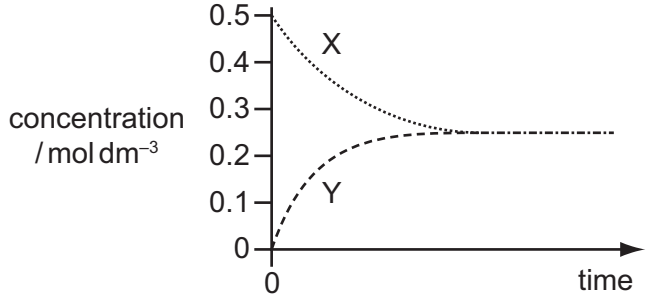
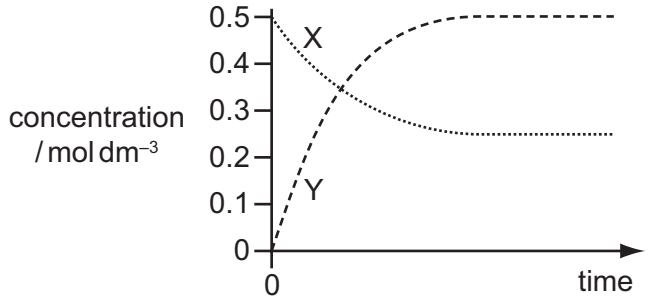
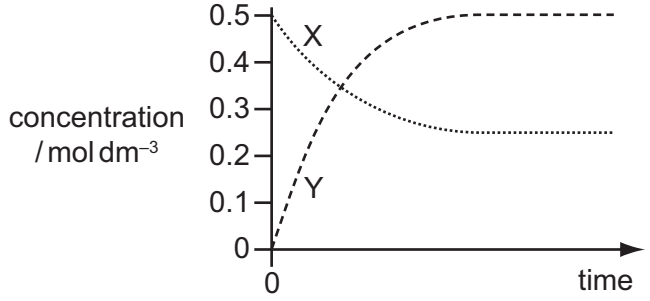
11 A dimer, X, is stable when solid but a dynamic equilibrium is set up in solution.

$$X(aq) \rightleftharpoons 2Y(aq)$$

A solution of X has an initial concentration of $0.50\,mol\,dm^{-3}$. When equilibrium has been reached [X(aq)] has fallen to $0.25\,mol\,dm^{-3}$.

The changes in [X(aq)] and [Y(aq)] are plotted against time until equilibrium is reached. The value of K_c is then calculated.

Which graph and value for K_c are correct?

	graph	K_c / mol dm^{-3}
A		1
B		2
C		1
D		2

12 Equimolar quantities of magnesium carbonate and strontium carbonate are separately heated to bring about complete thermal decomposition. The minimum temperature for this to occur is called T_d.

The cold residues are separately added to equal volumes of water and the change in pH is measured. The change in pH is called ΔpH.

Which metal has the higher value of T_d, and the greater value of ΔpH?

	T_d	ΔpH
A	Mg	Mg
B	Mg	Sr
C	Sr	Mg
D	Sr	Sr

13 In aqueous solution, the acid HIO disproportionates according to the following equation where **m**, **n**, **p** and **q** are simple whole numbers in their lowest ratios.

$$\mathbf{m}HIO \rightarrow \mathbf{n}I_2 + \mathbf{p}HIO_3 + \mathbf{q}H_2O$$

This equation can be balanced using oxidation numbers.

What are the values for **n** and **p**?

	n	**p**
A	1	2
B	2	1
C	4	1
D	4	2

14 *Use of the Data Booklet is relevant to this question.*

Which mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

A 0.70 g **B** 1.00 g **C** 1.40 g **D** 2.25 g

15 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions are isoelectronic (have the same number of electrons).

D The NH_4^+ ion can donate a proton.

16 What happens when chlorine is bubbled through aqueous potassium iodide?

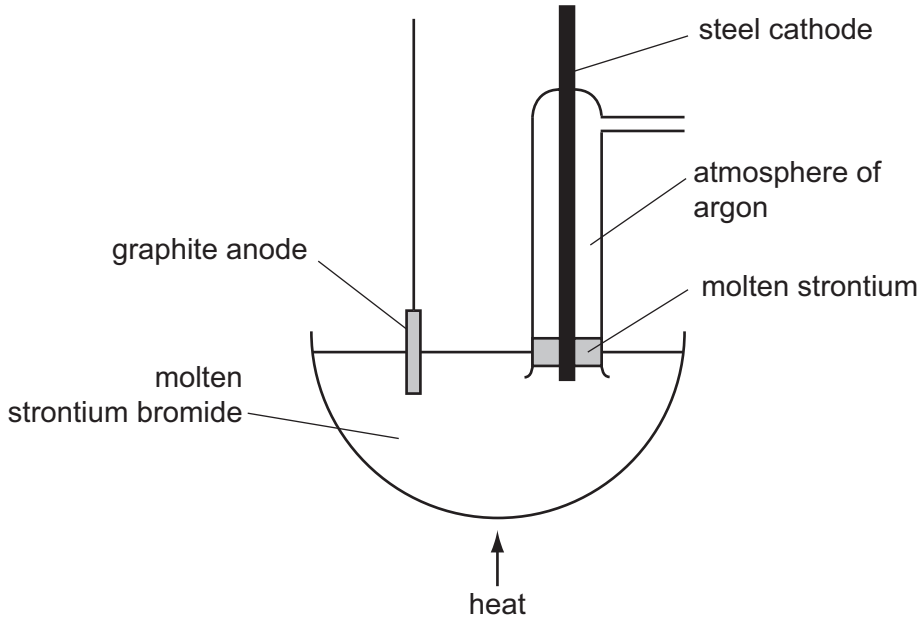
A Chlorine is oxidised to chlorate(V) ions.

B Chlorine is oxidised to chloride ions.

C Iodide ions are oxidised to iodine.

D There is no observable reaction.

17 Strontium metal can be obtained by the electrolysis of molten strontium bromide, $SrBr_2$, using the apparatus shown in the diagram.



Why is an atmosphere of argon used around the cathode?

A A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.

B The argon keeps the strontium molten.

C The argon stops the molten strontium rising too high in the tube.

D Without the argon, strontium oxide would form in the air.

18 Which statement about bromine is correct?

A Bromine is insoluble in non-polar solvents.

B Bromine vapour is more dense than air.

C Bromine will not vapourise significantly under normal conditions.

D Gaseous bromine is purple.

19 Concentrated sulfuric acid reacts with both solid sodium chloride at room temperature and with solid sodium iodide at room temperature.

Which row correctly describes how concentrated sulfuric acid behaves in each of these reactions?

	with sodium chloride	with sodium iodide
A	as an oxidising agent only	as an oxidising agent only
B	as a strong acid and as an oxidising agent	as a strong acid only
C	as a strong acid only	as a strong acid and as an oxidising agent
D	as a strong acid only	as a strong acid only

20 How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

A 3 **B** 4 **C** 5 **D** 6

21 Nine compounds have molecular formula $C_4H_8Br_2$.

Which compound may be synthesised from an alkene by an addition reaction?

A 1,1-dibromobutane

B 1,2-dibromobutane

C 1,3-dibromobutane

D 1,3-dibromomethylpropane

22 When ethanal, CH_3CHO, reacts with HCN and the organic product is hydrolysed by aqueous acid, organic compound Y is formed.

When propanal, C_2H_5CHO, is heated under reflux with acidified potassium dichromate(VI), organic compound Z is formed.

What is the difference in relative molecular mass of compounds Y and Z?

A 12 **B** 14 **C** 16 **D** 17

23 Which sequence of reagents may be used in the laboratory to convert propan-1-ol into 2-bromopropane?

A concentrated sulfuric acid, followed by bromine

B concentrated sulfuric acid, followed by hydrogen bromide

C ethanolic sodium hydroxide, followed by bromine

D ethanolic sodium hydroxide, followed by hydrogen bromide

24 Esters are frequently used as solvents and as flavouring agents in fruit drinks and confectionery.

An ester $C_8H_{12}Br_2O_4$ can be prepared in low yield by the reaction shown.

$$CH_3C(Br)(CH_2Br)CO_2H + (CH_3)_2C(OH)CO_2H \rightleftharpoons C_8H_{12}Br_2O_4 + H_2O$$

What is the structural formula of the ester $C_8H_{12}Br_2O_4$?

A $CH_3C(Br)(CH_2Br)CO_2C(CH_3)_2CO_2H$

B $CH_3C(Br)(CH_2Br)CO_2C(OH)(CH_3)CO_2CH_3$

C $CH_3C(Br)(CH_3)CO_2C(CH_3)_2CO_2CH_2Br$

D $(CH_3)_2C(Br)C(CO_2H)(CH_2Br)CO_2CH_3$

25 Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20 °C)?

A $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$

B $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$

C $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$

D $(CH_3)_2CO + H_2NNHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C{=}NNHC_6H_3(NO_2)_2 + H_2O$

26 Which pair of reagents will take part in a redox reaction?

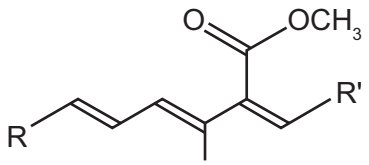
A CH_3CH_2OH + concentrated H_2SO_4

B CH_3CHO + Tollens' reagent

C $CH_3CO_2C_2H_5$ + dilute H_2SO_4

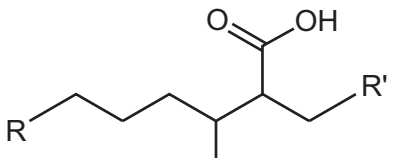
D CH_3COCH_3 + Fehling's solution

27 Part of the structure of strobilurin, a fungicide, is shown. R and R' are inert groups.



If strobilurin is first warmed with aqueous sulfuric acid, and its product then treated with hydrogen in the presence of a palladium catalyst, what could be the structure of the final product?

A



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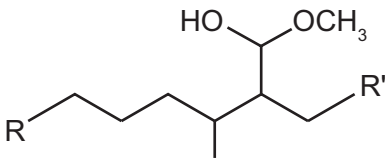
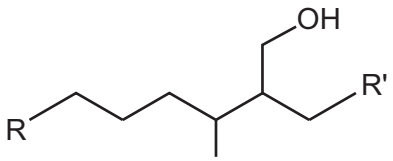


C



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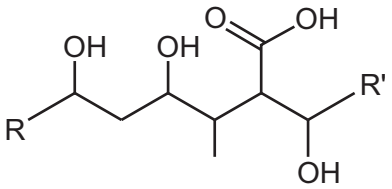
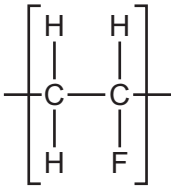


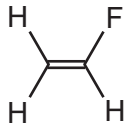
28 Fluoroalkenes are used to make polymers such as poly(vinyl)fluoride (PVF).

PVF is used to make non-flammable interiors for aircraft. The diagram shows the repeat unit of the polymer PVF.



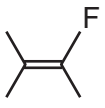
What is the skeletal formula of the monomer of PVF?

A

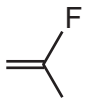


B

C



D



29 $CH_3CH_2COCH_2CH_3$ reacts with hydrogen cyanide to form a cyanohydrin.

Which feature applies to the product?

A It has one chiral centre.

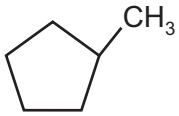
B It is formed by electrophilic addition.

C It is formed via a C–OH intermediate.

D Its formation requires the use of cyanide ions as a catalyst.

30 Which of the compounds shown have chiral carbon atoms?

1



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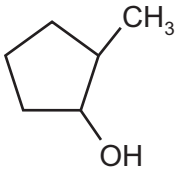

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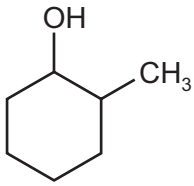
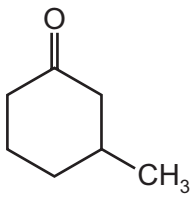


4



A 1, 2, 3 and 4

B 1 and 4 only

C 2 and 3 only

D 2, 3 and 4 only

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

31 When ammonia, NH_3, is produced in a school or college laboratory, it is usually dried before being collected.

Which drying agents may be used to dry ammonia?

1 calcium oxide, CaO

2 phosphorus(V) oxide, P_4O_{10}

3 concentrated sulfuric acid, H_2SO_4

32 Zirconium, Zr, proton number 40, is a metal which is used in corrosion-resistant alloys.

Zirconium metal is extracted from the oxide ZrO_2 by the following sequence of reactions.

reaction 1 $ZrO_2 + 2Cl_2 + 2C \rightarrow ZrCl_4 + 2CO$

reaction 2 $ZrCl_4 + 2Mg \rightarrow Zr + 2MgCl_2$

Which statements about this extraction process are correct?

1 Carbon in reaction 1 behaves as a reducing agent.

2 Magnesium in reaction 2 behaves as a reducing agent.

3 Chlorine in reaction 1 behaves as a reducing agent.

33 Which statements about covalent bonds are correct?

1 A triple bond consists of one π bond and two σ bonds.

2 The electron density in a σ bond is highest along the axis between the two bonded atoms.

3 A π bond restricts rotation about the σ bond axis.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

34 A student puts 10 cm^3 of 0.100 mol dm^{-3} sulfuric acid into one test-tube and 10 cm^3 of 0.100 mol dm^{-3} ethanoic acid into another test-tube. He then adds 1.0 g (an excess) of magnesium ribbon to each test-tube and takes suitable measurements. Both acids have the same starting temperature.

Neither reaction is complete after 2 minutes, but both are complete after 20 minutes.

Which statements are correct?

1 After 2 minutes, the sulfuric acid is at a higher temperature than the ethanoic acid.

2 After 2 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

3 After 20 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

35 In which ways are the main reactions in the Haber and Contact processes similar?

1 A higher yield is favoured by higher pressures.

2 The reaction is a redox process.

3 The forward reaction is exothermic.

36 A car burning lead-free fuel has a catalytic converter fitted to its exhaust. On analysis its exhaust gases are shown to contain small quantities of nitrogen oxides.

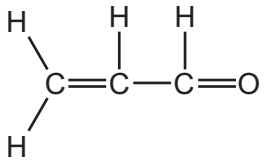
Which modifications would result in lower exhaust concentrations of nitrogen oxides?

1 an increase in the surface area of the catalyst in the converter

2 an increase in the rate of flow of the exhaust gases through the converter

3 a much higher temperature of combustion in the engine

37 The diagram shows a compound present in smoke from burning garden waste.



Which reagents would undergo a colour change on reaction with this compound?

1 aqueous bromine

2 Fehling's reagent

3 warm acidified $K_2Cr_2O_7$

38 Organic acids and alcohols react together to form esters.

Which pairs of compounds could produce a product of molecular formula $C_4H_6O_4$?

1 CH_3CO_2H and C_2H_5OH

2 HCO_2H and $HOCH_2CH_2OH$

3 HO_2CCO_2H and CH_3OH

39 *Use of the Data Booklet is relevant for this question.*

In an organic synthesis, a 62 % yield of product is achieved.

Which of these conversions are consistent with this information?

1 74.00g of butan-2-ol $\rightarrow$ 44.64 g of butanone

2 74.00g of butan-1-ol $\rightarrow$ 54.56 g of butanoic acid

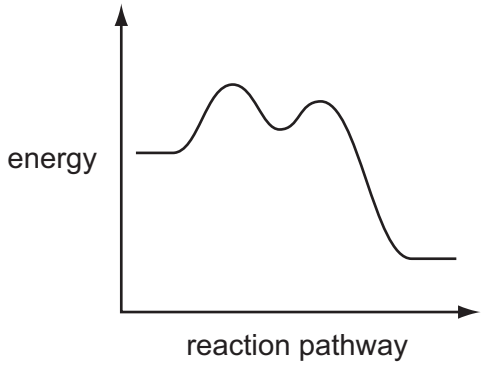
3 74.00g of 2-methylpropan-1-ol $\rightarrow$ 54.56 g of 2-methylpropanoic acid

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

40 A reaction pathway diagram is shown.



Which reactions would have such a profile?

1 $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$

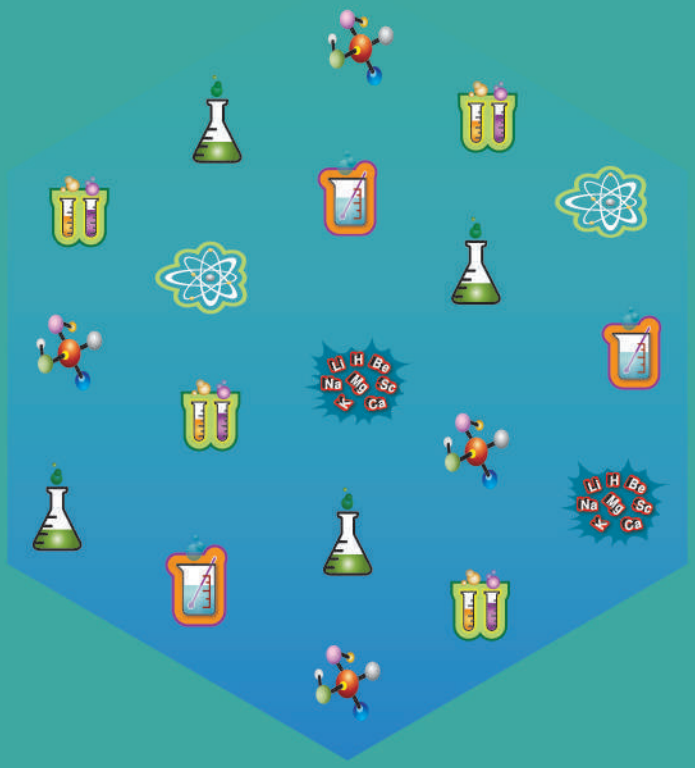
2 $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$

3 $(CH_3)_3CCH_2CH_2Cl + 2NH_3 \rightarrow (CH_3)_3CCH_2CH_2NH_2 + NH_4Cl$

Cambridge International AS Level Chemistry

Question Papers

Paper #1



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