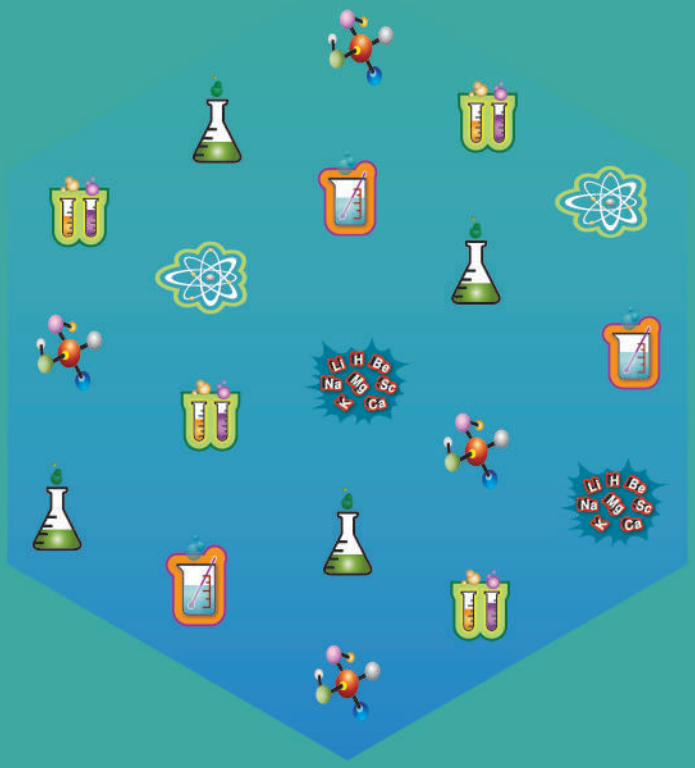
Cambridge International O Level Chemistry

Question Papers

Paper #2



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CONTENTS

Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2021**

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **three** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Any blank pages are indicated.

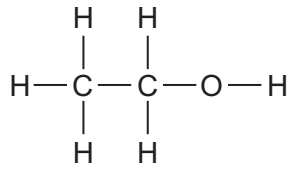
[Turn over

Section A

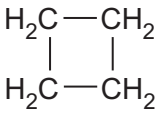
Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the following compounds to answer the questions.



A



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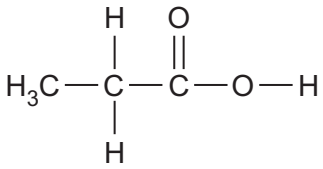

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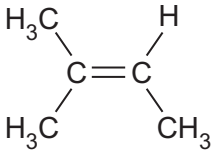

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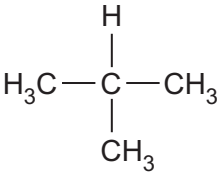

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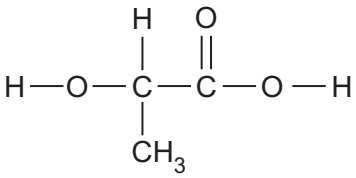

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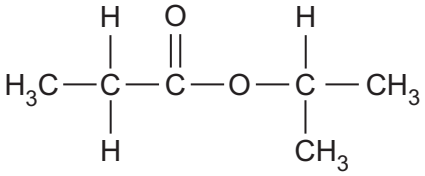

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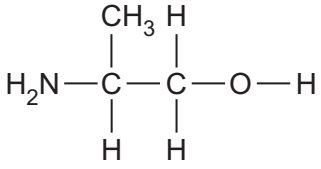


H

Each compound may be used once, more than once or not at all.

(a) State which compound:

(i) has a molecule with only 11 atoms

..... [1]

(ii) is oxidised to form ethanoic acid

..... [1]

(iii) is an isomer of butene

..... [1]

(iv) reacts with hydrogen in the presence of a catalyst to make an alkane

..... [1]

(v) contains four different elements chemically combined.

..... [1]

(b) Identify two compounds that have a pH of less than 7 in aqueous solution.

..... [1]

[Total: 6]

2 Oxygen, sulfur, selenium, tellurium and polonium are in Group VI.

(a) State the percentage composition by volume of oxygen in dry air.

..... [1]

(b) State one large-scale use for oxygen.

..... [1]

(c) Two isotopes of polonium are shown.

$^{209}_{84}Po$ $^{210}_{84}Po$

(i) Explain why both isotopes have the same chemical properties.

..... [1]

(ii) Give one difference in the atomic structure of these two isotopes.

..... [1]

(d) Selenium forms a compound that contains only selenium, oxygen and chlorine.

The compound contains 9.6% oxygen by mass and 42.8% chlorine by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [3]

(e) A sample of oxygen has a volume of 11.5 dm^3 at room temperature and pressure.

(i) The temperature of the sample is decreased.

The pressure remains constant.

Describe and explain, using kinetic particle theory, what happens to the volume of the sample.

.....

..... [1]

(ii) The pressure of the sample is decreased.

The temperature remains constant.

Describe and explain, using kinetic particle theory, what happens to the volume of the sample.

.....

..... [1]

(iii) Calculate the mass of oxygen in the 11.5 dm^3 sample at room temperature and pressure.

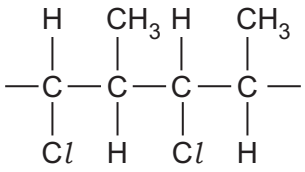
Give your answer to **two** significant figures.

mass ..... g [2]

[Total: 11]

3 There is concern about the disposal of plastics made from non-biodegradable polymers.

(a) The partial structure of a non-biodegradable polymer is shown.



(i) Name the type of polymer shown.

..... [1]

(ii) Draw the structure of the monomer used to make this polymer.

[1]

(iii) This polymer is often disposed of by combustion.

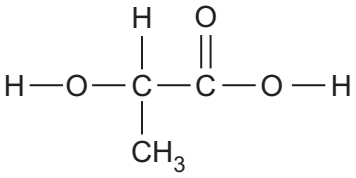
Suggest one problem associated with this method of disposal.

.....

..... [1]

(b) Lactic acid is used to make poly(lactic acid), a biodegradable polymer.

The structure of lactic acid is shown.



(i) Suggest what is meant by the term *biodegradable*.

.....

..... [1]

(ii) Draw the partial structure of poly(lactic acid).

Show at least two repeat units.

[2]

(iii) A factory uses 500 tonnes of lactic acid to make poly(lactic acid).

The percentage yield is 100% but the mass of poly(lactic acid) made is less than 500 tonnes.

Explain why the mass of poly(lactic acid) made is less than 500 tonnes.

.....

..... [1]

(iv) Aqueous lactic acid reacts with acidified potassium manganate(VII).

There is a colour change from purple to colourless.

Suggest what happens to the lactic acid in this reaction.

..... [1]

(v) Aqueous lactic acid is neutralised by aqueous sodium hydroxide.

Write the ionic equation for this neutralisation.

..... [1]

(vi) Aqueous lactic acid reacts with magnesium.

Name the gas made in this reaction.

..... [1]

[Total: 10]

4 Zinc bromide and zinc carbonate are both ionic compounds.

(a) Predict two physical properties, other than electrical conductivity, of zinc bromide.

1. .....

2. .....
[2]

(b) Zinc reacts with bromine to make zinc bromide.

$$Zn + Br_2 \longrightarrow ZnBr_2$$

Zinc bromide contains Zn^{2+} and Br^- ions.

Explain, in terms of the movement of electrons, how $ZnBr_2$ is formed from zinc atoms and bromine molecules.

.....

.....

..... [2]

(c) Aqueous zinc bromide reacts with magnesium as shown.

$$Zn^{2+} + Mg \longrightarrow Mg^{2+} + Zn$$

(i) Use the equation to explain that oxidation takes place.

.....

..... [1]

(ii) Use the equation to explain that reduction takes place.

.....

..... [1]

(d) Zinc carbonate is insoluble in water.

(i) Zinc carbonate can be prepared by reacting aqueous zinc bromide with CO_3^{2-}(aq) ions in a precipitation reaction.

Name a suitable aqueous solution that can provide CO_3^{2-}(aq) ions.

..... [1]

(ii) A sample of zinc carbonate is heated strongly.

Name the products of this reaction.

..... [1]

[Total: 8]

5 Petroleum (crude oil) provides the raw materials for making ethanol and ammonia.

(a) Describe how petroleum (crude oil) is separated to make fractions such as naphtha and petrol (gasoline).

.....

.....

..... [2]

(b) Compounds such as $C_{11}H_{24}$ in the naphtha fraction are cracked to make hydrogen, alkenes and smaller alkanes.

(i) Explain how the molecular formula $C_{11}H_{24}$ shows the compound is an alkane.

.....

..... [1]

(ii) Construct an equation to show the cracking of $C_{11}H_{24}$ to make ethene and an alkane only.

..... [1]

(c) Describe how hydrogen is converted into ammonia in the Haber process.

Include the conditions used in the Haber process.

.....

.....

.....

.....

..... [3]

(d) State one **other** use for hydrogen.

..... [1]

(e) Ethene reacts with a compound to make ethanol.

(i) Name the compound.

..... [1]

(ii) State one condition for this reaction.

..... [1]

[Total: 10]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

6 Sulfur dioxide and oxides of nitrogen are pollutants found in air.

(a) State one environmental problem caused by the presence of sulfur dioxide in the air.

..... [1]

(b) Coal-fired power stations produce sulfur dioxide as a pollutant.

The sulfur dioxide produced is prevented from entering the air by a process called flue gas desulfurisation, FGD.

Name the compound used in FGD that reacts with the sulfur dioxide.

..... [1]

(c) Coal-fired power stations also produce oxides of nitrogen such as NO.

NO is produced when nitrogen, N_2, reacts with oxygen.

(i) Construct the equation for this reaction.

..... [1]

(ii) Draw a dot-and-cross diagram to show the bonding in a molecule of nitrogen.

Only include the outer shell electrons.

[1]

(iii) Explain why the rate of reaction between nitrogen and oxygen increases as the temperature increases.

.....

.....

..... [2]

(d) Nitrogen dioxide, NO_2, reacts with water to form a mixture of dilute nitric acid, HNO_3, and dilute nitrous acid, HNO_2.

$$2NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$$

(i) Nitrogen dioxide reacts with aqueous sodium hydroxide to form two different salts and water.

Construct the equation for this reaction.

..... [2]

(ii) Nitric acid is a strong acid.

Nitrous acid is a weak acid.

Describe the difference between a weak acid and a strong acid.

.....

.....

..... [2]

[Total: 10]

7 Sulfamic acid, NH_2SO_3H, is a white crystalline solid.

It reacts with aqueous sodium nitrite to make nitrogen gas, as shown in the equation.

$$NH_2SO_3H(s) + NaNO_2(aq) \longrightarrow N_2(g) + H_2O(l) + NaHSO_4(aq)$$

(a) An excess of sulfamic acid reacts with a 20.0 cm^3 sample of 0.150 mol / dm^3 $NaNO_2(aq)$.

Calculate the maximum volume, in dm^3, of nitrogen formed, measured at room temperature and pressure.

volume of nitrogen ..... dm^3 [2]

(b) The rate of this reaction can be determined by measuring the volume of nitrogen formed every second.

Draw a labelled diagram of the assembled apparatus that can be used to make, collect and measure the volume of nitrogen formed in this reaction.

[2]

(c) The concentration of $NaNO_2(aq)$ is increased.

The temperature of the reaction remains constant.

State and explain how the rate of reaction changes.

.....

.....

.....

.....

..... [3]

(d) Sulfamic acid forms salts called sulfamates that contain the anion $NH_2SO_3^-$.

Magnesium carbonate, $MgCO_3$, is added to a sample of $NH_2SO_3H(aq)$.

Magnesium sulfamate, water and a gas are formed. The gas turns limewater milky.

Construct the equation for this reaction.

..... [3]

[Total: 10]

8 Lead is a metal with proton number 82.

(a) (i) Use the Periodic Table to state the number of occupied electron shells in an atom of lead.

..... [1]

(ii) Use the Periodic Table to state the number of electrons in the outer shell of an atom of lead.

..... [1]

(b) Describe, with the aid of a labelled diagram, the metallic bonding in lead.

.....

.....

.....

..... [3]

(c) Give two physical properties of lead that are characteristic of all metals.

1. .....

2. .....
[1]

(d) Lead(II) ethanoate is a white crystalline soluble salt.

Name a suitable combination of an acid and an insoluble base which is used to prepare lead(II) ethanoate.

acid .....

base .....
[1]

(e) Aqueous lead(II) ethanoate reacts with aqueous sodium iodide.

A yellow precipitate of lead(II) iodide, PbI_2, is formed.

Construct the ionic equation, with state symbols, for this reaction.

..... [2]

(f) Explain why solid lead(II) iodide cannot be electrolysed.

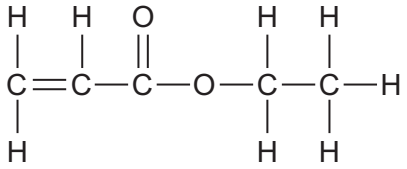
.....

.....

..... [1]

[Total: 10]

9 The structure of ethyl propenoate is shown.



(a) Circle the atoms in the structure that show that ethyl propenoate is an ester. [1]

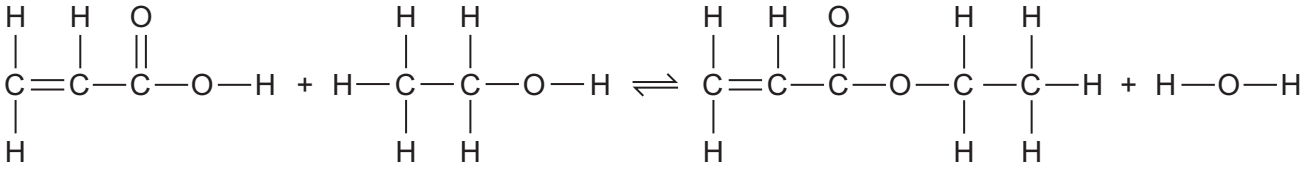
(b) Aqueous bromine is shaken with a sample of ethyl propenoate.

Explain, in terms of the structure of ethyl propenoate, why the aqueous bromine turns colourless.

.....

..... [1]

(c) Ethyl propenoate is prepared by the reversible reaction between a carboxylic acid and an alcohol, as shown.



A mixture of the carboxylic acid and the alcohol is allowed to reach equilibrium.

(i) Name the alcohol used in the reaction.

..... [1]

(ii) The reaction uses an acid catalyst.

State the effect of this catalyst on the position of equilibrium.

..... [1]

(iii) The concentration of the alcohol is increased.

Describe and explain what happens to the position of equilibrium.

.....

.....

..... [2]

(d) In an experiment 10.8 g of the carboxylic acid is reacted with an excess of the alcohol. The experimental yield of ethyl propenoate is 9.45 g.

[The relative formula mass of the carboxylic acid is 72.]

(i) Show that the maximum possible yield of ethyl propenoate is 15.0 g.

[3]

(ii) Calculate the percentage yield of ethyl propenoate in this experiment.

% yield ..... [1]

[Total: 10]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

3630920713

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2021**

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the following chlorides to answer the questions.

aluminium chloride
ammonium chloride
cobalt(II) chloride
hydrogen chloride
iron(III) chloride
potassium chloride
silver chloride
sodium chloride

Each chloride may be used once, more than once or not at all.

State which chloride:

(a) contains a cation with a charge of 2+

..... [1]

(b) reacts with aqueous sodium hydroxide to form a red-brown precipitate

..... [1]

(c) is insoluble in water

..... [1]

(d) reacts with sodium hydroxide when warmed to produce a gas which turns damp red litmus paper blue

..... [1]

(e) when added to water can form an aqueous solution with a pH of 1.

..... [1]

[Total: 5]

2 This question is about pollutant gases.

(a) Hydrocarbons such as octane are used as fuels for cars.

The list shows the gases present in a car exhaust.

carbon dioxide
carbon monoxide
nitrogen
nitrogen dioxide
octane
water vapour

State which two gases in the list show that incomplete combustion has taken place in this car engine.

1 .....

2 .....
[2]

(b) Describe a test for carbon dioxide.

test .....

observation .....
[2]

(c) Two natural sources of methane in the atmosphere are from leaks of natural gas and waste gases from animals.

Give one other natural source of methane in the atmosphere.

..... [1]

(d) Complete this sentence about the effect of an increase in the concentration of methane in the atmosphere.

Methane is a ..... gas because it absorbs and then re-emits infrared radiation. This contributes to an increase in temperature of the atmosphere which is called ....
[2]

(e) Cars are fitted with catalytic converters to reduce the amount of harmful pollutant gases from car exhausts.

Describe how catalytic converters remove pollutant gases from car exhausts.

.....

.....

.....

.....

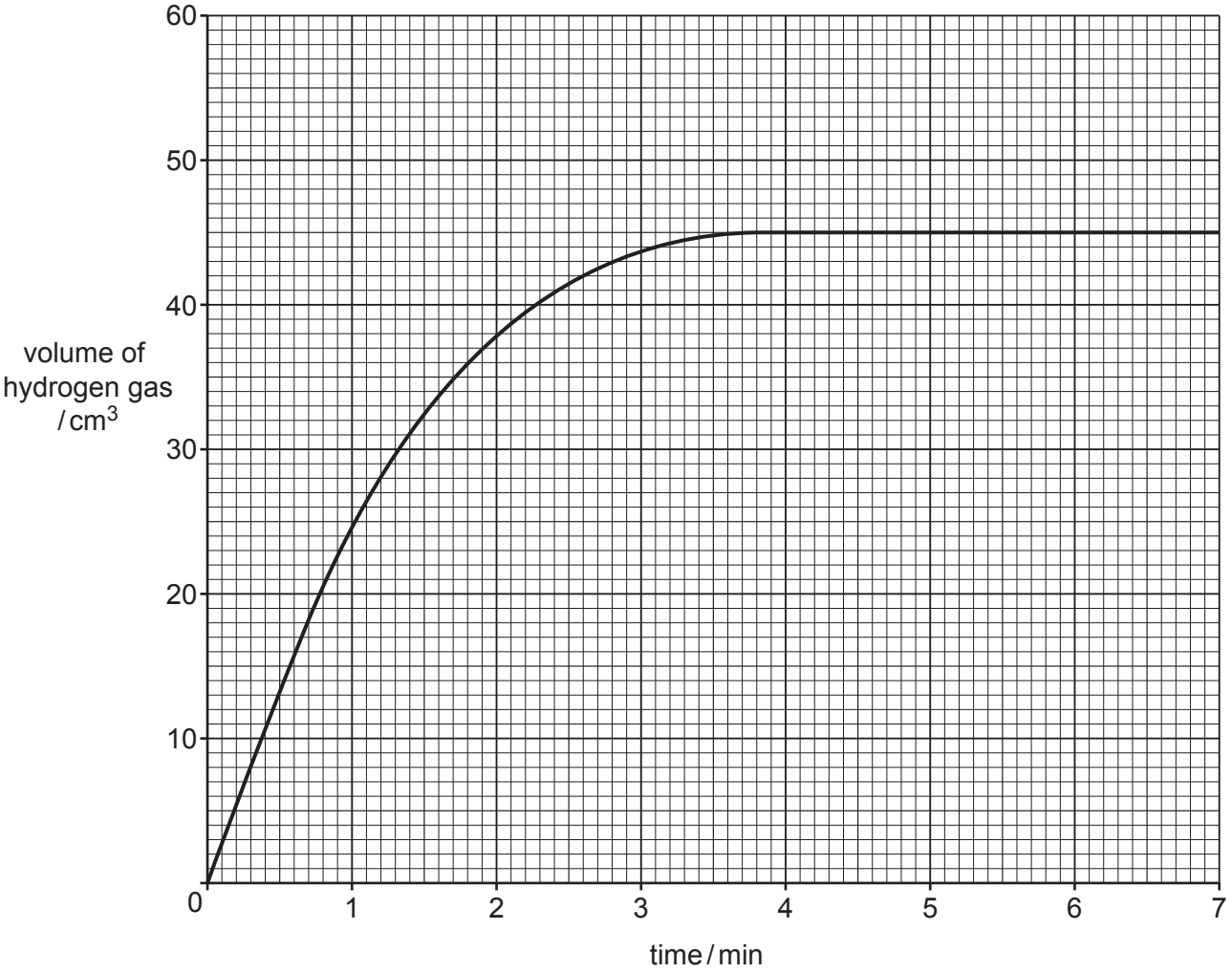
..... [3]

[Total: 10]

3 Magnesium ribbon reacts with dilute hydrochloric acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(a) The graph shows the volume of hydrogen gas produced at 20 °C as the reaction proceeds. The magnesium is in excess.



The experiment is repeated using a lower concentration of hydrochloric acid.

The volume of acid used and all other conditions are the same.

Draw a line **on the grid** to show how the volume of hydrogen gas produced changes with time when the reaction is done with a lower concentration of hydrochloric acid. [2]

(b) **(i)** Describe and explain, using ideas about collisions between particles, how the rate of the reaction changes when magnesium powder is used instead of magnesium ribbon.

All other conditions are the same.

.....

.....

.....

..... [2]

(ii) Describe and explain, using ideas about collisions between particles, how the rate of the reaction changes when the temperature of the reaction mixture is decreased.

All other conditions are the same.

.....

.....

.....

..... [2]

(c) Calculate the maximum volume, in dm^3, of hydrogen formed when 1.68 g of magnesium react with excess dilute hydrochloric acid at room temperature and pressure.
Give your answer to **three** significant figures.

volume = ... dm^3 [2]

(d) Magnesium is a good reducing agent.

Describe a test for reducing agents.

test .....

observations .....

.....
[2]

[Total: 10]

4 Alkanes are a homologous series of hydrocarbons. The boiling point, melting point and density of alkanes increase as the number of carbon atoms increases.

(a) (i) Give one **other** physical property of alkanes which increases as the number of carbon atoms increases.

..... [1]

(ii) Give two **other** characteristics of a homologous series.

1 .....

2 .....
[2]

(b) Two typical reactions of alkanes are combustion and cracking.

State the name of another typical chemical reaction of alkanes and the reactant needed to react with the alkanes.

type of reaction .....

reactant .....
[2]

(c) Alkenes are produced by cracking alkanes.

(i) State two conditions needed for cracking alkanes.

1 .....

2 .....
[2]

(ii) Tridecane, $C_{13}H_{28}$, can be cracked to produce an alkene with four carbon atoms and one other hydrocarbon only.

Construct an equation for this reaction.

..... [1]

(d) A hydrocarbon contains 88.9% carbon by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [2]

[Total: 10]

5 Lithium reacts with aqueous zinc iodide.

$$2Li + ZnI_2 \rightarrow 2LiI + Zn$$

(a) Explain, by referring to the equation, why this reaction involves both oxidation and reduction.

.....

.....

..... [2]

(b) Acidified aqueous silver nitrate is added to aqueous zinc iodide.
State the observations made.

..... [1]

(c) **(i)** When aqueous bromine reacts with aqueous zinc iodide a brown solution is formed.

Name the products of this reaction.

..... and ..... [1]

(ii) Explain why aqueous bromine does not react with aqueous zinc chloride.

..... [1]

[Total: 5]

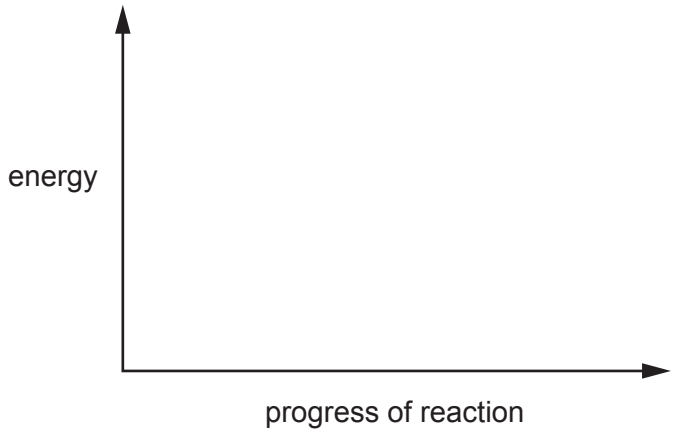
6 Phosphorus reacts with hydrogen to produce phosphine, PH_3.

$$2P + 3H_2 \rightarrow 2PH_3$$

The reaction is endothermic.

(a) Complete the energy profile diagram for this reaction.

Label reactants, products and ΔH.



[2]

(b) Explain, in terms of bond breaking and bond forming, why the reaction is endothermic.

.....

.....

..... [2]

(c) Phosphine reacts with oxygen to form phosphorus(V) oxide, P_4O_{10}, and water.

Complete the equation for this reaction.

..... PH_3 + ... O_2 $\rightarrow$ P_4O_{10} + ... H_2O [1]

[Total: 5]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

7 Sodium is a metal in Group I of the Periodic Table. Diamond (carbon) is a non-metal which is a good conductor of heat.

(a) State two **differences** in the physical properties of sodium and diamond.

1 .....

2 .....
[2]

(b) An ion of sodium has the symbol

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

Deduce the number of protons, neutrons and electrons in this ion.

number of protons .....

number of neutrons .....

number of electrons .....
[3]

(c) Sodium reacts with nitrogen to form sodium nitride.
Complete the equation for this reaction.

..... Na + ... $\rightarrow$ ..... Na_3N [1]

(d) When carbon is heated with steam in a closed container an equilibrium mixture is formed.

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$$

The forward reaction is endothermic.

(i) Describe and explain the effect, if any, on the position of equilibrium when the temperature is increased.

.....

.....

..... [2]

(ii) Describe and explain the effect, if any, on the position of equilibrium when the pressure is decreased.

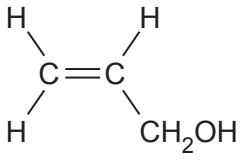
.....

.....

..... [2]

[Total: 10]

8 The structure of an organic compound, **T**, is shown.



(a) Deduce the molecular formula of compound **T**.

..... [1]

(b) Compound **T** is a colourless liquid.

State the colour change when excess compound **T** is added to aqueous bromine.

from ..... to ..... [1]

(c) Compound **T** can be oxidised to a carboxylic acid.

Suggest a suitable oxidising agent for this reaction.

..... [1]

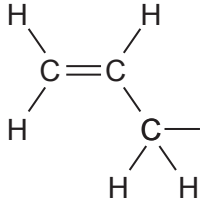
(d) Compound **T** can be polymerised.

Draw the partial structure of the polymer of compound **T**. Show two repeat units.

[2]

(e) Compound **T** reacts with methanoic acid, HCOOH, to form an ester.

Complete the structure of this ester to show all the atoms and all the bonds.



[1]

(f) Methanoic acid is a weak acid. Hydrochloric acid is a strong acid.

(i) Give the formula of the positive ion that is present in all acids.

..... [1]

(ii) Explain why the rate of reaction of 1.0 mol / dm^3 methanoic acid with magnesium is less than the rate of reaction of 1.0 mol / dm^3 hydrochloric acid with magnesium.

.....

..... [1]

(g) Construct the equation for the reaction of methanoic acid with magnesium.

..... [2]

[Total: 10]

9 This question is about sulfuric acid and sulfates.

(a) **(i)** Sulfur is one of the raw materials used in the Contact process to make sulfuric acid. Name two other raw materials used to make sulfuric acid.

..... and ..... [1]

(ii) Name the catalyst used in the Contact process.

..... [1]

(b) The electrolysis of dilute sulfuric acid using inert electrodes produces oxygen at the anode.

(i) Define the term *electrolysis*.

.....

.....

..... [2]

(ii) Construct the equation for the reaction taking place at the cathode.

..... [1]

(c) Dilute sulfuric acid reacts with sodium hydroxide.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

A student adds 0.76 g of solid sodium hydroxide to 45 cm^3 of 0.20 mol / dm^3 sulfuric acid.

Show by calculation that the sodium hydroxide is in excess.

[3]

(d) Aqueous sodium hydroxide is warmed with ammonium sulfate.
State the names of the three products formed in this reaction.

1 .....

2 .....

3 .....
[2]

[Total: 10]

10 This question is about elements in Group V of the Periodic Table.

(a) The table shows some properties of the Group V elements.

element	density at room temperature in g/cm^3	melting point in °C
nitrogen	1.17×10^{-3}	–210
phosphorus	2.34	44
arsenic	5.73	
antimony		631
bismuth	9.80	272

Use the information in the table to:

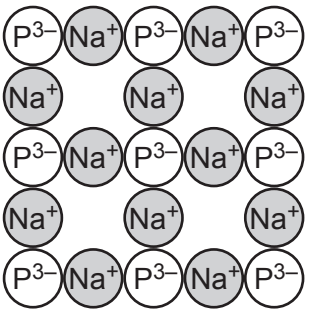
(i) predict the density of antimony

..... [1]

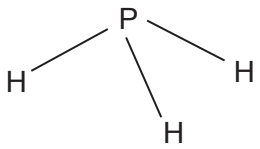
(ii) suggest why it is difficult to predict the melting point of arsenic.

..... [1]

(b) The structure of two compounds of phosphorus, **R** and **S**, are shown.



R



S

(i) Explain in terms of structure and bonding why compound **R** has a high melting point and compound **S** has a low melting point.

compound **R** .....

.....

.....

compound **S** .....

.....

.....

[4]

(ii) Explain why compound **R** conducts electricity when molten.

..... [1]

(iii) Draw a dot-and-cross diagram for a molecule of compound **S**.

Show only the outer shell electrons.

[1]

(c) An oxide of phosphorus has the formula P_4O_{10}.

Calculate the percentage by mass of phosphorus in this compound.

[2]

[Total: 10]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2020**

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **three** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Blank pages are indicated.

DC (ST/CT) 183901/4

[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the following chlorides to answer the questions.

aluminium chloride

ammonium chloride

calcium chloride

hydrogen chloride

iron(III) chloride

silver chloride

sodium chloride

Each chloride may be used once, more than once or not at all.

Which chloride:

(a) contains a cation with a 2+ charge

..... [1]

(b) reacts with warm aqueous sodium hydroxide to form a gas which turns damp red litmus paper blue

..... [1]

(c) is insoluble in water

..... [1]

(d) has a molecule which has only 18 protons

..... [1]

(e) is a coloured solid at room temperature and pressure?

..... [1]

[Total: 5]

2 Hydrogen reacts with oxygen as shown in the equation.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

A sample containing 1.00 mol of hydrogen, H_2, is completely combusted.

This sample releases 286 kJ of heat energy.

(a) Calculate the heat energy released when 25.0 g of hydrogen is completely combusted.

heat energy released ..... kJ [2]

(b) Use ideas about bond breaking and bond forming to explain why this reaction is exothermic.

.....

.....

..... [2]

(c) The reaction shown also represents the overall process that occurs within a hydrogen-oxygen fuel cell.

(i) Describe one advantage of using a hydrogen-oxygen fuel cell to power a motor vehicle rather than burning gasoline.

.....

..... [1]

(ii) Complete the equations for the two electrode reactions that happen in a hydrogen-oxygen fuel cell.

$H_2 \rightarrow$ ..... $+ 2e^-$

$O_2 + 4H^+ + 4e^- \rightarrow$ .....

[2]

[Total: 7]

3 The table shows some properties of five esters.

name	structure	relative molecular mass	melting point / °C	boiling point / °C
methyl methanoate	$HCOOCH_3$	60	−100	32
methyl ethanoate	CH_3COOCH_3	74	−98	57
methyl propanoate	$CH_3CH_2COOCH_3$	88	−88	80
methyl butanoate	$CH_3CH_2CH_2COOCH_3$	102	−95	102
methyl pentanoate	$CH_3CH_2CH_2CH_2COOCH_3$			

(a) These esters are part of a homologous series.

(i) State the relative molecular mass of methyl pentanoate.

..... [1]

(ii) Predict the boiling point of methyl pentanoate

..... °C [1]

(iii) Explain why it is **not** possible to predict the melting point of methyl pentanoate.

.....

..... [1]

(b) At 35 °C methyl methanoate is a gas.

Explain how the data in the table shows this.

.....

..... [1]

(c) Methyl pentanoate is used to flavour food.

Suggest one **other** use for esters.

..... [1]

(d) Methyl propanoate is prepared by the reaction between propanoic acid and methanol.

$$CH_3CH_2CO_2H + CH_3OH \rightleftharpoons CH_3CH_2COOCH_3 + H_2O$$

The forward reaction is exothermic.

(i) Calculate the maximum mass of methyl propanoate that can be made from 11.0 g of propanoic acid and excess methanol.

Give the answer to **three** significant figures.

mass of methyl propanoate ..... g [2]

(ii) The temperature of the reaction mixture is increased.

State and explain, in terms of particles, what happens to the rate of the forward reaction.

.....

.....

.....

.....

..... [3]

(iii) The temperature of the reaction mixture is increased.

State and explain what happens to the position of the equilibrium.

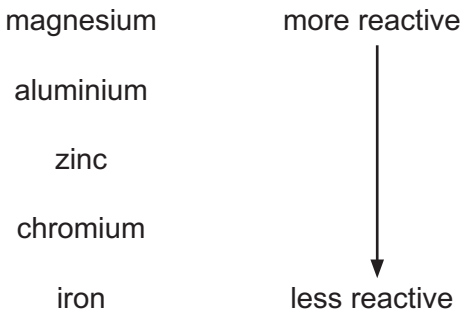
.....

.....

..... [2]

[Total: 12]

4 Part of the reactivity series is shown.



(a) Predict the names of the products formed when chromium reacts with dilute hydrochloric acid.

.....

..... [1]

(b) Powdered zinc is added to aqueous chromium(III) ions, $Cr^{3+}(aq)$.

Construct an ionic equation, with state symbols, for this reaction.

..... [2]

(c) Explain why aluminium does **not** react with water.

.....

.....

..... [2]

(d) Hydrogen peroxide, an oxidising agent, is added to aqueous potassium iodide in a test-tube.

Describe the colour change seen in the test-tube.

..... [1]

(e) Chromium is extracted by the reaction of aluminium with chromium(III) oxide, Cr_2O_3.

(i) Write the equation for this reaction.

..... [1]

(ii) Suggest a **compound** that can reduce chromium(III) oxide to chromium metal.

..... [1]

(f) State one advantage of recycling metals.

..... [1]

[Total: 9]

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5 Sulfuric acid, H_2SO_4, reacts with sodium hydroxide, NaOH, as shown.

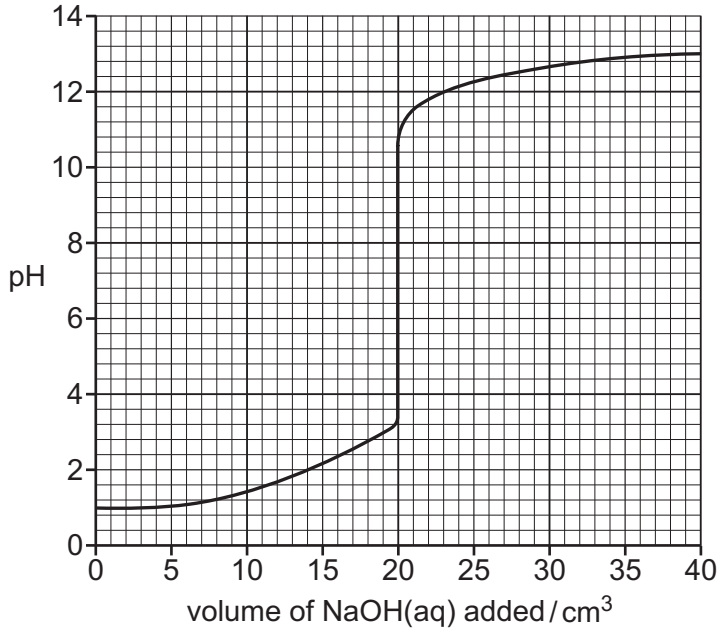
$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

A sample of 25.0 cm^3 of 0.0500 mol/dm^3 H_2SO_4 is placed in a beaker.

NaOH(aq) is added slowly, from a burette, to the H_2SO_4 in the beaker.

A pH probe is used to measure the pH of the solution in the beaker until a total of 40.0 cm^3 of NaOH(aq) is added.

The graph shows how the pH of the solution in the beaker changes.



(a) Explain, in terms of the ions present, why the pH of the solution in the beaker changes from 1.0 to 13.0.

.....

.....

.....

..... [2]

(b) Use the graph to state the volume of NaOH(aq) that just neutralises all of the H_2SO_4.

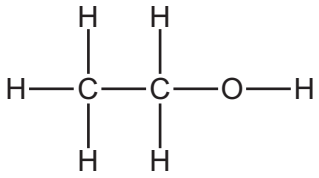
volume of NaOH(aq) ..... cm^3 [1]

(c) Use your answer to **(b)** to calculate the concentration, in mol/dm^3, of the NaOH(aq).

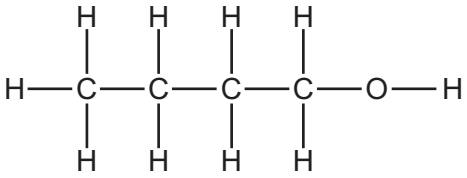
concentration of NaOH(aq) ..... mol/dm^3 [3]

[Total: 6]

6 The structures of two alcohols are shown.



ethanol



alcohol **B**

(a) What is the name of alcohol **B**?

..... [1]

(b) Draw the structure of one other alcohol which is an isomer of **B**.

Show all of the atoms and all of the bonds.

[1]

(c) Ethanoic acid is produced by the oxidation of ethanol.

State the reagent for this reaction.

..... [1]

(d) Ethanol is a simple molecular compound.

Explain why liquid ethanol does **not** conduct electricity.

.....

..... [1]

(e) Ethanol can be dehydrated to form ethene, C_2H_4.

Describe, using a dot-and-cross diagram, the bonding in a molecule of ethene.

Only include the outer shell electrons.

[2]

[Total: 6]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

7 This question is about some of the oxides of the elements in Period 3.

(a) State the electronic configuration of the negative ion in sodium oxide, Na_2O.

..... [1]

(b) Magnesium oxide is an insoluble base that can be used to prepare pure magnesium sulfate crystals.

Describe the essential practical details for the preparation of pure magnesium sulfate crystals from magnesium oxide.

.....

.....

.....

.....

.....

.....

..... [4]

(c) An oxide of phosphorus contains 43.7% by mass of phosphorus.

(i) Show that the empirical formula for this oxide is P_2O_5.

[2]

(ii) A sample of this oxide has a mass of 2.56 g.

The sample contains 0.00901 mol of the oxide.

Calculate the relative molecular mass and hence the molecular formula for this oxide of phosphorus.

relative molecular mass .....

molecular formula .....

[2]

(d) State the structure and bonding in silicon dioxide, SiO_2.

..... [1]

[Total: 10]

8 Copper is a transition element.

(a) State two properties that are typical of the compounds of a transition element.

1 .....

2 .....
[2]

(b) Aqueous copper(II) sulfate reacts with aqueous potassium iodide.

The ionic equation for this reaction is shown.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \longrightarrow 2CuI(s) + I_2(aq)$$

Explain how this equation shows that the reaction involves oxidation.

.....

..... [1]

(c) Anhydrous copper(II) sulfate decomposes when heated strongly.

$$CuSO_4(s) \longrightarrow CuO(s) + SO_3(g)$$

A sample of 6.40 g of $CuSO_4$ is heated until all of the sample has thermally decomposed.

Calculate the volume of sulfur trioxide formed, in dm^3, measured at room temperature and pressure.

volume of sulfur trioxide ..... dm^3 [3]

(d) Iron reacts with aqueous copper(II) sulfate to make aqueous iron(II) sulfate and copper.

(i) Construct the ionic equation for this reaction.

..... [1]

(ii) Suggest one observation that would be seen during this reaction.

.....

..... [1]

(e) Describe a chemical test that can be used to distinguish between aqueous solutions of iron(II) sulfate and copper(II) sulfate.

chemical test .....

result with iron(II) sulfate .....

result with copper(II) sulfate .....
[2]

[Total: 10]

9 Sulfur dioxide is a colourless gas which can be found in air.

(a) State one environmental problem caused by the presence of sulfur dioxide in air.

..... [1]

(b) When heated in air iron pyrite, FeS_2, reacts with oxygen.

Sulfur dioxide and iron(III) oxide, Fe_2O_3, are the products of this reaction.

Construct the equation for this reaction.

..... [2]

(c) Give one use for sulfur dioxide.

..... [1]

(d) Liquid sulfur dioxide is stored in cylinders.

When the cylinder is opened the liquid quickly changes into a gas.

Use the kinetic particle theory to describe the changes in **movement** and **arrangement** of the particles when liquid sulfur dioxide becomes a gas.

.....

.....

.....

.....

..... [2]

(e) Sulfur dioxide has a low melting point.

Suggest, in terms of structure and bonding, why sulfur dioxide has a low melting point.

.....

.....

.....

.....

..... [2]

(f) Describe the chemical test for sulfur dioxide.

test .....

observation .....
[2]

[Total: 10]

10 Fractional distillation and cracking are important processes in the conversion of petroleum (crude oil) into useful hydrocarbons.

(a) Fractional distillation separates petroleum (crude oil) into fractions such as bitumen and naphtha.

(i) Which physical property allows the petroleum (crude oil) to be separated into fractions?

..... [1]

(ii) Describe the separation of petroleum (crude oil) by fractional distillation.

.....

.....

.....

..... [2]

(iii) Give one use of the bitumen fraction.

..... [1]

(b) The naphtha fraction is used as a chemical feedstock.

One of the hydrocarbons in naphtha has the molecular formula $C_{10}H_{22}$.

Use the general formula for an alkane to show that $C_{10}H_{22}$ is an alkane.

.....

.....

..... [2]

(c) In an experiment $C_{10}H_{22}$ is cracked to form products **A**, **B** and **C**.

(i) Product **A** gives a squeaky pop when ignited with a burning splint.

Identify product **A**.

..... [1]

(ii) Product **B** has a relative molecular mass of 98 and decolourises aqueous bromine.

Suggest the molecular formula for **B**.

Explain your answer.

molecular formula .....

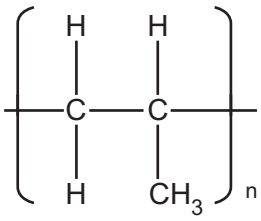
explanation .....

.....

.....

[2]

(iii) Product **C** can be polymerised to give the polymer shown.



Draw the structure of product **C**.

[1]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
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87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2020**

1 hour 30 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **three** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
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INFORMATION

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- The number of marks for each question or part question is shown in brackets [ ].
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This document has **20** pages. Blank pages are indicated.

[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the following compounds to answer these questions.

aluminium sulfate
ammonia
calcium carbonate
carbon dioxide
chlorofluorocarbons
copper(II) sulfate
hydrogen chloride
potassium nitrate
sodium chloride

Each compound may be used once, more than once or not at all.

Which compound:

(a) is a gas which dissolves in water to form an alkaline solution

..... [1]

(b) is an anhydrous solid which is used to test for water

..... [1]

(c) contains ions with a 3+ charge

..... [1]

(d) is a solid used in flue gas desulfurisation

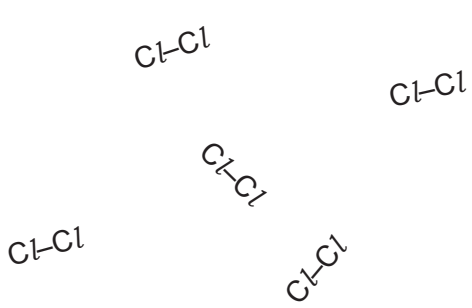
..... [1]

(e) causes eutrophication?

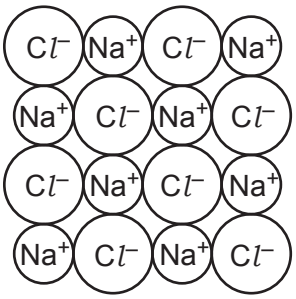
..... [1]

[Total: 5]

2 Part of the structures of chlorine and sodium chloride are shown.



chlorine



sodium chloride

(a) Explain in terms of structure and bonding why chlorine has a low boiling point and sodium chloride has a high boiling point.

.....

.....

.....

.....

.....

..... [3]

(b) Write the electronic configuration of a chlorine atom.

..... [1]

(c) The electrolysis of molten sodium chloride is carried out using graphite electrodes.

(i) State the meaning of the term *electrolysis*.

.....

..... [1]

(ii) State the direction of movement of both the positive and negative ions when molten sodium chloride is electrolysed.

positive ions .....

negative ions .....
[1]

(iii) State one observation that can be made at the positive electrode when molten sodium chloride is electrolysed.

..... [1]

(iv) Give the formulae of the two negative ions present in aqueous sodium chloride.

..... [1]

(d) When aqueous sodium chloride is electrolysed, hydrogen is produced at the negative electrode.

Explain, in terms of transfer of electrons, why hydrogen and **not** sodium is produced at the negative electrode.

.....

..... [1]

(e) A 36.3 g sample of a compound contains 14.4 g carbon, 0.600 g hydrogen and 21.3 g chlorine.

(i) Calculate the empirical formula of this compound.

[2]

(ii) The relative molecular mass of this compound is 181.5.

Deduce the molecular formula of this compound.

[1]

[Total: 12]

3 **(a)** A drop of black ink is placed at the bottom of a beaker of water.

After a time, the colour of the ink spreads throughout the water.

Explain this observation in terms of the kinetic particle theory.

.....

.....

.....

.....

..... [3]

(b) In the past, ink was made from a mixture containing iron(II) ions and tannic acid.

(i) Describe a test for iron(II) ions.

test .....

observations .....
[2]

(ii) The ink darkens when used on paper. This is because iron(II) ions are oxidised to iron(III) ions.

Write the ionic equation for this reaction.

..... [1]

(iii) After a time, the ink fades because of a hydrolysis reaction which is catalysed by acids.

State how a catalyst increases the rate of a chemical reaction.

.....

..... [1]

(c) Paper is made of cellulose.

Cellulose is a complex carbohydrate (polysaccharide).

(i) Name one other complex carbohydrate (polysaccharide).

..... [1]

(ii) Describe how complex carbohydrates can be hydrolysed to simple sugars.

.....

..... [2]

[Total: 10]

[Turn over

4 Water from natural sources contains dissolved substances which are not pollutants, such as mineral salts.

(a) Name another substance found naturally in water which is **not** a mineral salt or a pollutant.

..... [1]

(b) When lithium reacts with water, aqueous lithium hydroxide, LiOH, and hydrogen are formed.

Construct the equation for this reaction.

..... [1]

(c) Sodium and potassium react with water in a similar way to lithium.

(i) Explain, in terms of their electronic configuration, why lithium, sodium and potassium all react in a similar way.

.....

..... [1]

(ii) Describe the trend in reactivity of the Group I elements lithium, sodium and potassium.

..... [1]

(d) Water and oxygen are formed when aqueous hydrogen peroxide decomposes.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

Calculate the maximum volume of oxygen, at room temperature and pressure, which is produced by the complete decomposition of a solution containing 16.0 g of hydrogen peroxide.

Give your answer to **three** significant figures.

volume of oxygen ..... dm^3 [3]

(e) A fuel cell generates electricity when hydrogen and oxygen react on platinum electrodes.

(i) Name a process used in industry to produce hydrogen.

..... [1]

(ii) Some cars use a hydrogen–oxygen fuel cell instead of a petrol (gasoline) engine as a source of energy.

Describe two advantages of a hydrogen–oxygen fuel cell compared with a petrol (gasoline) engine.

1. .....

2. .....
[2]

[Total: 10]

5 Alkenes are made in an oil refinery by cracking hydrocarbons.

(a) (i) Give one **other** reason why petroleum companies carry out cracking.

.....

..... [1]

(ii) Complete the equation for the cracking of tridecane, $C_{13}H_{28}$, to form propene, C_3H_6, and one other hydrocarbon.

$$C_{13}H_{28} \rightarrow C_3H_6 + \text{.....} \quad [1]$$

(b) Propene is an alkene.

(i) Write the general formula for an alkene.

..... [1]

(ii) Propene reacts with steam by an addition reaction.

Predict the molecular formula of the product of this reaction.

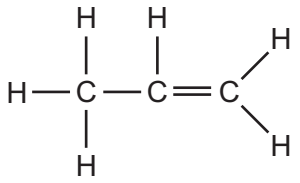
..... [1]

(iii) When propene undergoes incomplete combustion, a small amount of carbon dioxide is formed.

Name two **other** substances formed when propene undergoes incomplete combustion.

..... and .....
[2]

(c) The structure of propene is shown.



Deduce the partial structure of poly(propene) to show three repeat units.

[2]

[Total: 8]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

6 Methanoic acid and ethanoic acid are weak acids.

(a) What does the term *weak* mean, when applied to acids?

.....

..... [1]

(b) Methanoic acid, HCO_2H, reacts with magnesium powder.

(i) Construct the equation for this reaction.

..... [1]

(ii) State and explain how the rate of this reaction changes when the experiment is repeated using a piece of magnesium ribbon with the same mass as the powder.

All other conditions stay the same.

Include in your answer ideas about collisions between particles.

.....

.....

..... [2]

(c) Methanoic acid reacts with propanol, C_3H_7OH, to form an ester.

Name and draw the structure of this ester, showing all of the atoms and all of the bonds.

name .....

structure

[2]

(d) Ethanoic acid is present in vinegar.

(i) Name the organic compound which is converted to ethanoic acid when vinegar is made.

..... [1]

(ii) What type of chemical reaction is this?

..... [1]

(e) The table shows some properties of four carboxylic acids.

carboxylic acid	formula	density in g/cm^3	boiling point in °C
methanoic acid	HCO_2H	1.22	101
ethanoic acid	CH_3CO_2H		118
propanoic acid	$C_2H_5CO_2H$	0.99	141
butanoic acid	$C_3H_7CO_2H$	0.96	164

(i) Predict the density of ethanoic acid.

..... g/cm^3 [1]

(ii) Describe and explain the change in the boiling point as the number of carbon atoms in a molecule increases.

.....

..... [1]

[Total: 10]

7 Iron is extracted from iron ore in a blast furnace using limestone and coke (carbon).

(a) Name a common ore of iron.

..... [1]

(b) The coke burns to form carbon dioxide.

This reaction is exothermic.

Explain, in terms of bond making and bond breaking, why this reaction is exothermic.

.....

.....

..... [2]

(c) Carbon dioxide reacts with hot coke to form carbon monoxide.

The carbon monoxide reduces the iron(III) oxide in the iron ore.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

(i) Use this equation to explain why the Fe_2O_3 is reduced.

.....

..... [1]

(ii) Calculate the maximum mass of iron formed when 12.5 g of iron(III) oxide react with excess carbon monoxide.

mass of iron ..... g
[2]

(d) Silicon dioxide is an impurity in the iron ore.

Explain how the addition of limestone helps remove silicon dioxide from the blast furnace.

.....

.....

.....

..... [2]

(e) Iron is a metal.

Describe metallic bonding.

.....

.....

..... [2]

[Total: 10]

8 This question is about some compounds of sulfur.

(a) Dilute sulfuric acid reacts with aqueous sodium hydroxide as shown.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) A student titrates 25.0 cm^3 of dilute sulfuric acid with sodium hydroxide of concentration 0.0150 mol/dm^3, using litmus as an indicator.

A volume of 24.0 cm^3 of aqueous sodium hydroxide reacts exactly with the dilute sulfuric acid.

Calculate the concentration of the dilute sulfuric acid.

concentration of dilute sulfuric acid ..... mol/dm^3
[3]

(ii) Describe how to prepare pure dry crystals of sodium sulfate from aqueous sodium sulfate.

.....

.....

.....

.....

..... [3]

(b) Concentrated sulfuric acid oxidises arsenic to arsenic(III) oxide.

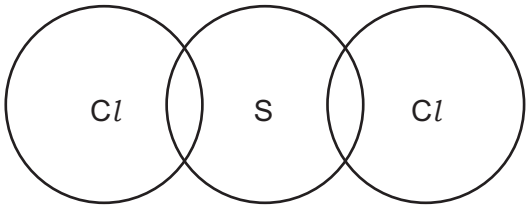
Complete the equation for this reaction.

$$.....As + ...H_2SO_4 \rightarrow As_4O_6 + ...H_2O + 6SO_2$$ [1]

(c) Sulfur dichloride, C*l* — S — C*l*, has a simple molecular structure.

Complete the dot-and-cross diagram for a molecule of sulfur dichloride.

Include only the outer shell electrons.



[1]

(d) The melting point of sulfur dichloride is –121 °C.
The boiling point of sulfur dichloride is 59 °C.

Deduce the state of sulfur dichloride at room temperature.

Give a reason for your answer.

.....

..... [2]

[Total: 10]

Question 9 starts on the next page.

9 Lead is a metal in Group IV of the Periodic Table.

(a) An ion of lead has the symbol

$$^{207}_{82}Pb^{2+}$$

Deduce the number of electrons and neutrons in this ion.

number of electrons .....

number of neutrons .....
[2]

(b) Lead(IV) oxide, PbO_2, is an oxidising agent.

(i) Describe a test for oxidising agents.

test .....

observations .....
[2]

(ii) Lead(IV) oxide reacts with concentrated hydrochloric acid to form lead(IV) chloride, $PbCl_4$, and water.

Construct the equation for this reaction.

..... [1]

(c) When lead(IV) chloride is warmed in a closed container an equilibrium mixture is formed.

The forward reaction is exothermic.

$$PbCl_4(l) \rightleftharpoons PbCl_2(s) + Cl_2(g)$$

lead(IV) chloride lead(II) chloride

(i) Describe and explain the effect, if any, on the position of equilibrium when the concentration of chlorine is increased.

.....

.....

..... [2]

(ii) Describe and explain the effect, if any, on the position of equilibrium when the temperature is increased.

.....

.....

..... [2]

(d) Name a lead salt which is soluble in water.

..... [1]

[Total: 10]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge
O Level

Cambridge Assessment International Education
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3228958698

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2019**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **17** printed pages and **3** blank pages.

Cambridge Assessment International Education

[Turn over

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Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the particles shown to answer the questions.

CH_4	Cl^-
Fe^{2+}	H^+
H_2S	MnO_4^-
NH_4^+	P^{3-}

Each particle can be used once, more than once or not at all.

(a) Which particle has only eighteen protons?

..... [1]

(b) Which particle is used to test for a reducing agent?

..... [1]

(c) Which particle is an ion that contains only ten electrons?

..... [1]

[Total: 3]

2 The table shows some of the properties of the elements in Group III of the Periodic Table.

element	proton (atomic) number	atomic radius /nm	melting point /°C
B	5	0.080	2306
A*l*	13	0.125	660
Ga	31	0.125	30
In	49	0.150	157
T*l*	81	0.155	304
Nh	113		

(a) Nihonium, Nh, has only recently been discovered.

It has not been possible to measure its atomic radius and melting point because it is too radioactive.

(i) Estimate the atomic radius of Nh.

.....nm [1]

(ii) Explain, using data from the table, why it is difficult to estimate the melting point of nihonium.

.....

..... [1]

(b) Boron has a giant covalent structure.

Explain why boron has a high melting point.

.....

..... [1]

(c) Aluminium is produced by the electrolysis of molten aluminium oxide.

Aluminium oxide contains Al^{3+} and O^{2-} ions.

(i) Describe the composition of the electrolyte used in this electrolysis.

..... [1]

(ii) Name the material used for the electrodes in this electrolysis.

..... [1]

(iii) Construct equations for the reactions taking place at the:

negative electrode .....

positive electrode. .....

[2]

(d) Aluminium reacts with aqueous copper(II) chloride in a redox reaction.

$$2Al(s) + 3Cu^{2+}(aq) \longrightarrow 2Al^{3+}(aq) + 3Cu(s)$$

Which particle is oxidised? .....

Explain your answer. .....

..... [1]

(e) Explain why a piece of aluminium in water does not react.

.....

.....

..... [2]

(f) Aluminium chloride is a soluble salt.

Describe how a pure sample of aluminium chloride crystals can be made from aluminium.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 14]

3 Titanium, Ti, is a metallic element.

(a) Suggest one physical property of titanium.

..... [1]

(b) Titanium(IV) chloride, $TiCl_4$, is a colourless liquid that has a low boiling point.

(i) Suggest the structure and bonding in $TiCl_4$.

..... [1]

(ii) Titanium(IV) chloride reacts with water to form hydrochloric acid and a precipitate of titanium(IV) oxide.

Construct the equation, including state symbols, for this reaction.

..... [2]

(c) Titanium is made by reducing $TiCl_4$ using magnesium.

$$TiCl_4 + 2Mg \longrightarrow 2MgCl_2 + Ti$$

Calculate the mass of titanium made from 1000 g of $TiCl_4$.

The reaction has a 90% percentage yield.

Give the answer to **two** significant figures.

[The relative atomic mass of titanium, Ti, is 48.]

mass of Ti ..... g [3]

[Total: 7]

4 Petroleum (crude oil) is an important source of many chemicals.

(a) Outline the separation of petroleum (crude oil) into fractions such as petrol, diesel and bitumen.

.....

.....

.....

.....

.....

..... [3]

(b) State one large scale use of bitumen.

..... [1]

(c) Long chain hydrocarbons can be cracked to produce hydrogen.

(i) A long chain hydrocarbon has the molecular formula $C_{12}H_{26}$.

Explain how the formula shows that this hydrocarbon is an alkane.

.....

..... [1]

(ii) Construct an equation to show the cracking of $C_{12}H_{26}$ to make hydrogen and at least one alkene.

..... [1]

(d) Hydrogen and petrol are both used as fuels.

State and explain one advantage of using hydrogen rather than petrol as a fuel.

.....

.....

.....

..... [2]

[Total: 8]

5 **W** is a compound containing carbon, hydrogen and oxygen.

(a) **W** contains 57.1% carbon and 4.8% hydrogen by mass.

Calculate the empirical formula of **W**.

empirical formula ..... [3]

(b) A 0.194 g sample of **W** reacts completely with 18.5 cm^3 of 0.250 mol/dm^3 KOH.

One mole of **W** reacts with three moles of KOH.

Calculate the relative formula mass of **W**.

relative formula mass ..... [3]

(c) Deduce the molecular formula of **W**.

..... [1]

[Total: 7]

6 Drinking water is obtained by purification of sea water and river water.

(a) Desalination is used to convert sea water into drinking water.

What is desalination?

.....

..... [1]

(b) River water is often polluted by phosphates and nitrates.

(i) Give the source of these two pollutants.

..... [1]

(ii) Name one environmental effect caused by these pollutants in river water.

..... [1]

(c) River water can be converted into drinking water.

(i) Describe how insoluble solids are removed from river water.

.....

..... [1]

(ii) Name the substance used to remove bad tastes and odours from river water.

..... [1]

(iii) Name the substance used to disinfect river water so it is safe to drink.

..... [1]

[Total: 6]

[Turn over

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

7 Ammonium iodide, NH_4I, is a white solid which decomposes when heated.

$$NH_4I(s) \longrightarrow NH_3(g) + HI(g)$$

(a) A small sample of ammonium iodide is heated in a test-tube.

Describe how you would know when all the ammonium iodide has decomposed.

.....

..... [1]

(b) Calculate the volume of gas, measured at room temperature and pressure, formed when 2.90 g of ammonium iodide is completely decomposed.

volume of gas ..... [3]

(c) Describe a chemical test for the iodide ion.

test .....

observation .....

.....
[2]

(d) Aqueous ammonium iodide reacts with aqueous bromine.

Construct the ionic equation, including state symbols, for this reaction.

..... [2]

(e) Solid ammonium iodide does not conduct electricity.

Aqueous ammonium iodide conducts electricity.

Explain these two observations.

.....

.....

..... [2]

[Total: 10]

8 Nitrogen monoxide reacts with oxygen to form nitrogen dioxide.

If this reaction is investigated in a closed system, a dynamic equilibrium is established.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

(a) Explain why it is important to have a closed system to establish a dynamic equilibrium.

.....

.....

..... [1]

(b) The pressure of the equilibrium mixture is decreased.

The temperature of the equilibrium mixture is kept constant.

Predict and explain what will happen, if anything, to the **composition** of the equilibrium mixture.

prediction .....

.....

explanation .....

.....

.....

[2]

(c) The temperature of the equilibrium mixture is decreased.

The pressure of the equilibrium mixture is kept constant.

(i) Suggest why the position of equilibrium moves to the right.

..... [1]

(ii) Explain why the rate of reaction decreases.

.....

.....

..... [2]

(d) Draw the 'dot-and-cross' diagram for a molecule of O_2.

Only include the outer shell electrons.

[1]

(e) Nitrogen dioxide reacts with water to form nitric acid, HNO_3, and nitrous acid, HNO_2.

Construct an equation for this reaction.

..... [1]

(f) Nitric acid is a strong acid and nitrous acid is a weak acid.

Describe the difference between a strong acid and a weak acid.

.....

.....

.....

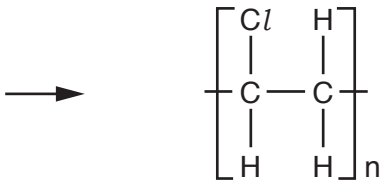
..... [2]

[Total: 10]

9 A sample of waste includes plastic and copper.

(a) One of the plastics is the addition polymer poly(chloroethene).

Complete the equation to show the formation of poly(chloroethene).



[2]

(b) Plastic waste is disposed of by combustion.

(i) Complete the equation to show the complete combustion of poly(chloroethene).

The empirical formula of poly(chloroethene), C_2H_3Cl, is used in the equation.

..... C_2H_3Cl + ... O_2 $\rightarrow$ .....CO_2 + ...H_2O + …… HCl

[1]

(ii) Suggest why the combustion of poly(chloroethene) will contribute to the formation of acid rain.

.....

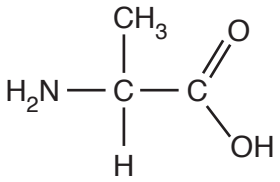
..... [1]

(c) Some waste plastics, such as nylon, are polyamides.

(i) Give one large scale use of nylon.

..... [1]

(ii) The structure shows a monomer that can be used to make a polyamide.



Draw the partial structure of this polyamide. Show two repeat units.

[1]

(d) Copper waste is melted and then cooled to make new objects.

Use the kinetic particle theory to describe the changes in movement and arrangement of the particles when a liquid cools to become a solid.

.....

.....

.....

.....

..... [2]

(e) Explain, in terms of structure and bonding, why copper has a high melting point.

.....

.....

.....

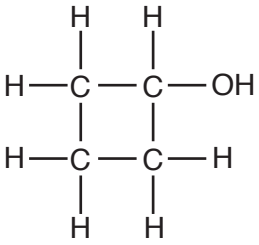
.....

..... [2]

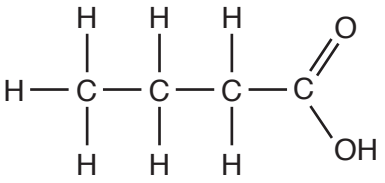
[Total: 10]

[Turn over

10 The structures of cyclobutanol and butanoic acid are shown.



cyclobutanol



butanoic acid

(a) Explain why cyclobutanol is **not** a hydrocarbon.

.....

..... [1]

(b) Explain why butanoic acid is a saturated compound.

.....

..... [1]

(c) Describe a chemical test that can distinguish cyclobutanol from butanoic acid.

test .....

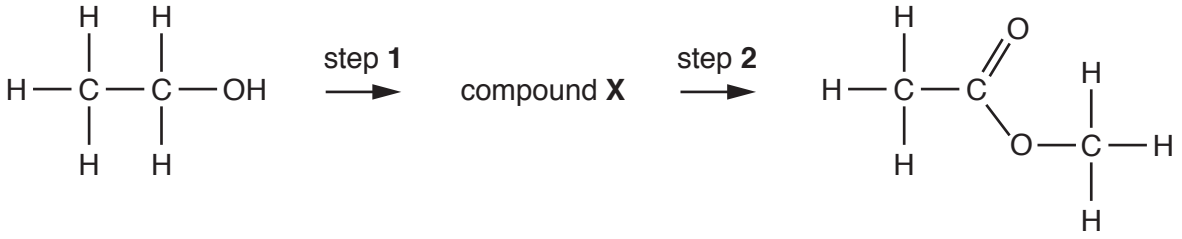
result for cyclobutanol .....

result for butanoic acid .....
[3]

(d) Calculate the percentage by mass of carbon in cyclobutanol.

percentage by mass ..... [2]

(e) Ethanol can be converted into methyl ethanoate in a two-step process.



(i) Identify compound **X**.

..... [1]

(ii) Identify the reagent used in step **1**.

..... [1]

(iii) Identify the reagent used in step **2**.

..... [1]

[Total: 10]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge
O Level

Cambridge Assessment International Education
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2019**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **19** printed pages and **1** blank page.

Cambridge Assessment International Education

[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 The diagram shows part of the Periodic Table.

					He
B	C	N	O	F	Ne
A*l*	Si	P	S	C*l*	Ar
Ga	Ge	As	Se	Br	Kr
				I	Xe

Answer the questions using only the elements shown in the diagram.

Each element may be used once, more than once or not at all.

Write the symbol for an element which:

(a) forms a stable ion of type X^{2-}

..... [1]

(b) is a light green gas at room temperature

..... [1]

(c) forms an ion which gives a yellow precipitate on addition of aqueous silver nitrate

..... [1]

(d) is used to make food containers

..... [1]

(e) is a diatomic gas which forms 78% of dry air.

..... [1]

[Total: 5]

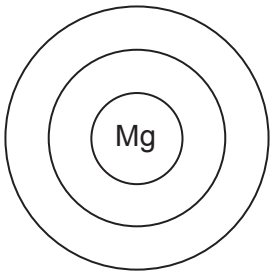
2 Magnesium is a metal.

(a) State two properties which are characteristic of most metals.

1 .....

2 .....
[2]

(b) Complete the electronic configuration of a magnesium atom. Show all electrons.



[1]

(c) Magnesium reacts with bromine to form magnesium bromide, $MgBr_2$.

Magnesium bromide is an ionic solid at room temperature.

(i) Explain, in terms of movement of electrons, how magnesium bromide is formed by the reaction of magnesium with bromine.

.....

.....

.....

..... [3]

(ii) Magnesium bromide is soluble in water.

Suggest one other physical property of magnesium bromide.

..... [1]

(d) Deduce the products formed at the anode and cathode when concentrated aqueous magnesium bromide is electrolysed.

product at anode .....

product at cathode .....
[1]

[Turn over

(e) Chlorine reacts with aqueous magnesium bromide.

The products are aqueous magnesium chloride and aqueous bromine.

(i) Construct the ionic equation for this reaction.

..... [1]

(ii) Explain why aqueous magnesium chloride does not react with aqueous bromine.

..... [1]

[Total: 10]

3 Petroleum (crude oil) is a mixture of hydrocarbons.

(a) Describe and explain how petroleum is separated into different hydrocarbon fractions.

In your answer include a description of fractional distillation in an oil refinery.

You may draw a labelled diagram.

.....

.....

.....

.....

.....

..... [3]

(b) State one use for each of these hydrocarbon fractions:

kerosene .....

naphtha .....

[2]

(c) The refinery gas fraction contains methane, ethane and propane.

(i) To which homologous series do these hydrocarbons belong?

..... [1]

(ii) Give the general formula for the homologous series which contains methane, ethane and propane.

..... [1]

(d) The exhaust from diesel engines contains carbon monoxide.

(i) Explain how carbon monoxide is formed in the diesel engine.

..... [1]

(ii) Describe one effect of carbon monoxide on human health.

..... [1]

[Total: 9]

[Turn over

4 The equation shows the reaction of calcium carbonate with hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) The rate of this reaction can be determined by measuring the decrease in mass of the reaction mixture.

Describe one **other** method of following the progress of this reaction.

.....

.....

..... [2]

(b) Describe and explain, using ideas about collisions between particles, how the rate of reaction changes when the same mass of calcium carbonate is used in **smaller** pieces.

All other conditions stay the same.

.....

.....

..... [2]

(c) Describe and explain, using ideas about collisions between particles, how the rate of reaction changes when the temperature is increased.

All other conditions stay the same.

.....

.....

.....

.....

..... [3]

(d) Calculate the minimum mass of calcium carbonate, in grams, needed to produce 16.8 cm^3 of carbon dioxide at room temperature and pressure.

Give your answer to **three** significant figures.

mass of calcium carbonate ..... g [2]

(e) Describe a test for carbon dioxide.

test .....

observation .....
[2]

(f) Calcium hydroxide can be used to control the pH of the soil.

Explain how calcium hydroxide controls the pH of the soil.

.....

.....

..... [2]

[Total: 13]

5 The table shows some properties of four Group I elements.

element	melting point /°C	relative thermal conductivity	atomic radius /nm
lithium	181	84	0.157
sodium		142	0.191
potassium	63		0.235
rubidium	39	58	

(a) **(i)** Complete the table by estimating:

- the melting point of sodium
- the atomic radius of rubidium. [2]

(ii) Use the information in the table to suggest why it is difficult to predict the relative thermal conductivity of potassium.

.....

..... [1]

(b) Sodium reacts with oxygen to produce sodium oxide, Na_2O.

(i) Construct the equation for this reaction.

..... [1]

(ii) What type of oxide, acidic or basic, is sodium oxide?

Give a reason for your answer.

type of oxide: .....

reason: .....

.....
[1]

(c) Explain, in terms of ease of formation of ions, why copper does not react with aqueous sodium sulfate.

.....

..... [1]

(d) Hydrated sodium iodate(V) has the formula $NaIO_3.xH_2O$.
It has a relative formula mass of 288.

Calculate the value of x in this formula.

x = ... [2]

[Total: 8]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

6 Butanoic acid, C_3H_7COOH, is a carboxylic acid.

(a) Draw the structure of butanoic acid to show all of the atoms and all of the bonds.

[1]

(b) Describe the movement and arrangement of the particles in liquid butanoic acid.

movement .....

arrangement .....

[2]

(c) The melting point of butanoic acid is –4 °C.

The boiling point of butanoic acid is 166 °C.

Deduce the physical state of butanoic acid at 0 °C. Explain your answer.

physical state: .....

explanation: .....

.....

[1]

(d) The equation for the reaction of butanoic acid with sodium carbonate is shown.

$$2C_3H_7COOH + Na_2CO_3 \rightarrow 2C_3H_7COONa + CO_2 + H_2O$$

A student added 5.28 g of butanoic acid to 56.0 cm^3 of 0.500 mol / dm^3 sodium carbonate.

Show by calculation that butanoic acid is in excess.

[3]

(e) Magnesium reacts with butanoic acid.

The products are magnesium butanoate and hydrogen.

Construct the equation for this reaction.

..... [1]

(f) One method of determining the pH of aqueous butanoic acid is by using a pH meter.

Describe a different method of determining the pH of aqueous butanoic acid.

.....

.....

..... [2]

[Total: 10]

[Turn over

7 Sulfuric acid is made by the Contact process.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -197\,kJ/mol$$

(a) Name the catalyst used in the Contact process.

..... [1]

(b) Describe how and explain why the position of equilibrium in the reaction is altered when:

(i) the temperature of the equilibrium mixture is increased at constant pressure

.....

.....

..... [2]

(ii) the pressure of the equilibrium mixture is increased at constant temperature.

.....

.....

..... [2]

(c) The final step in the manufacture of sulfuric acid is an exothermic reaction.

$$H_2S_2O_7 + H_2O \rightleftharpoons 2H_2SO_4$$

On the axes, draw a labelled energy profile diagram for this exothermic reaction.

Show:

- the reactants and product
- the enthalpy change for the reaction
- the activation energy of the reaction.

[3]

(d) Air is a raw material used in the manufacture of sulfuric acid.

Name one other raw material used in the manufacture of sulfuric acid.

..... [1]

(e) State one major use of sulfuric acid.

..... [1]

[Total: 10]

[Turn over

8 Phosphorus is an element in Group V of the Periodic Table.

(a) One of the isotopes of phosphorus is:

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

(i) Deduce the number of electrons, neutrons and protons in this isotope of phosphorus.

number of electrons .....

number of neutrons .....

number of protons .....

[3]

(ii) What is the meaning of the term *isotopes*?

.....

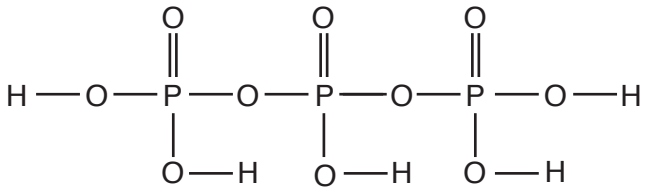
..... [1]

(b) Phosphorus reacts with potassium chlorate(V) to form potassium chloride and phosphorus(V) oxide.

Complete the equation for this reaction.

.... $KClO_3$ + ... P $\rightarrow$ .... KCl + ... P_2O_5 [1]

(c) The structure of a compound of phosphorus is shown.



Deduce the molecular formula of this compound.

..... [1]

(d) Phosphorus reacts with chlorine to form phosphorus trichloride, PCl_3.

Draw a dot-and-cross diagram for a molecule of phosphorus trichloride.
Only include the outer shell electrons.

[2]

(e) The equation for the reaction of phosphorus with copper(II) ions is shown.

$$2P + 5Cu^{2+} + 8H_2O \longrightarrow 5Cu + 2PO_4^{3-} + 16H^+$$

Identify the oxidising agent. Explain your answer.

oxidising agent: .....

explanation: .....

.....

[2]

[Total: 10]

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9 Proteins are natural polymers.

(a) Name one other natural polymer.

..... [1]

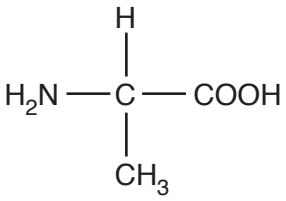
(b) Describe how proteins can be hydrolysed to amino acids.

.....

.....

..... [2]

(c) The structure of the amino acid alanine is shown.

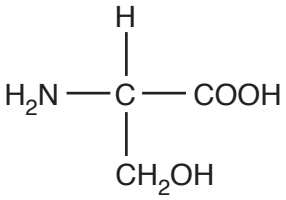


Alanine can be polymerised to form poly(alanine).

Draw the partial structure of poly(alanine) to show **two** repeat units.

[2]

(d) The structure of the amino acid serine is shown.



Serine can form polymers with amide linkages.

Serine can also form polymers with a different linkage.

Name this linkage and explain how it is formed.

linkage .....

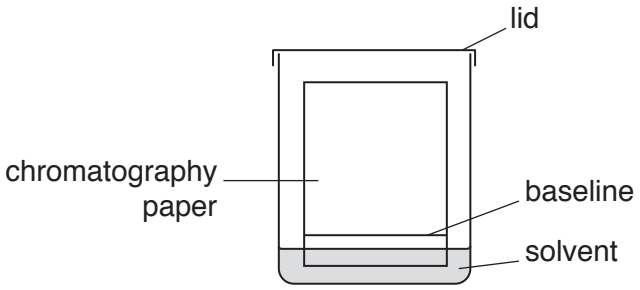
explanation .....

.....

[2]

(e) Paper chromatography can be used to separate a mixture of amino acids.

The apparatus used is shown.



(i) Why should the baseline be drawn in pencil and not in ink?

.....

..... [1]

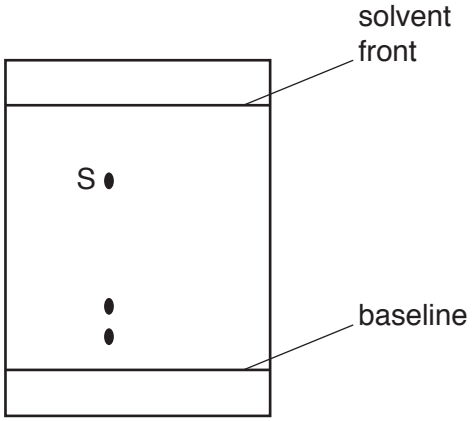
(ii) When the separation of the amino acids is complete, the chromatography paper is sprayed with a locating agent.

Explain why.

.....

..... [1]

(iii) The diagram shows the chromatography paper after it has been sprayed with a locating agent.



Calculate the R_f value of the amino acid labelled S.

R_f value ..... [1]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
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19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
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atomic number
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Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1481331435

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2018**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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This document consists of **18** printed pages and **2** blank pages.

CAMBRIDGE International Examinations

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 Choose from the gases to answer the questions.

ammonia
carbon dioxide
chlorine
butane
hydrogen
nitrogen
oxygen
propane
sulfur dioxide

Each gas can be used once, more than once or not at all.

Which gas:

(a) burns in air to give only water

..... [1]

(b) is used to kill bacteria in the purification of water for domestic use

..... [1]

(c) has a molecule containing only 11 atoms

..... [1]

(d) occupies 78% by volume of dry air

..... [1]

(e) is released when calcium hydroxide is added to soil that contains the fertiliser ammonium nitrate?

..... [1]

[Total: 5]

2 The transition elements occupy the central block of the Periodic Table.

Iron and copper are typical transition elements.

(a) The compounds of transition elements are often coloured.

What is the colour of iron(III) hydroxide?

.....[1]

(b) A redox reaction happens when iron filings are added to aqueous copper(II) sulfate.

$$Fe(s) + Cu^{2+}(aq) \longrightarrow Cu(s) + Fe^{2+}(aq)$$

(i) Describe what is observed during this reaction.

.....

.....[2]

(ii) Use the equation to explain that oxidation takes place in this reaction.

.....

.....[1]

(iii) Use the equation to explain that reduction takes place in this reaction.

.....

.....[1]

(c) Compounds containing ions of transition elements are often used as catalysts.

Name a catalyst that is the compound of a transition element and state the reaction it catalyses.

name .....

reaction .....

.....[1]

(d) Catalysts increase the rate of reaction by providing an alternative reaction pathway with a lower activation energy.

Explain why catalysts are used in industry.

.....

.....[1]

[Total: 7]

3 Silver chloride, AgC*l*, is an insoluble salt and silver nitrate is a soluble salt.

(a) Silver chloride can be prepared by the reaction between aqueous silver nitrate and dilute hydrochloric acid.

(i) Describe the preparation of a pure, dry sample of silver chloride from aqueous silver nitrate and dilute hydrochloric acid.

.....

.....

.....

.....

.....[3]

(ii) Write the ionic equation, including state symbols, for this reaction.

.....[2]

(b) Silver chloride decomposes in the presence of light to make silver and chlorine.

(i) What is the name of the type of reaction that requires light?

.....[1]

(ii) Construct the equation for the decomposition of silver chloride.

.....[1]

(c) Silver nitrate can be prepared by reacting silver oxide with dilute nitric acid.

$$Ag_2O + 2HNO_3 \rightarrow 2AgNO_3 + H_2O$$

Excess silver oxide is reacted with 30.0 cm^3 of 0.150 mol/dm^3 nitric acid.

After purification the percentage yield of silver nitrate is 80.0%.

Calculate the mass of silver nitrate prepared.

Give your answer to **three** significant figures.

[M_r: $AgNO_3$, 170]

mass of silver nitrate ..... g [3]

[Total: 10]

4 Phosphorus is a non-metal in Group V of the Periodic Table.

(a) Phosphorus can be manufactured from calcium phosphate, $Ca_3(PO_4)_2$.

$$2Ca_3(PO_4)_2 + 6SiO_2 + 10C \rightarrow 6CaSiO_3 + 10CO + P_4$$

What is the maximum mass of phosphorus that can be made using 300 g of silicon dioxide, SiO_2?

mass of phosphorus ..... g [2]

(b) Phosphorus, P_4, is a simple molecular substance.

Suggest **two** physical properties of phosphorus.

1 .....

2 .....
[2]

(c) Using ideas about structure and bonding, suggest why calcium phosphate, $Ca_3(PO_4)_2$, has a high melting point.

.....

.....

.....

.....[2]

(d) Complete the table about the number of electrons, neutrons and protons in two particles.

particle	$^{30}_{15}P$	.....
number of electrons	.....	18
number of neutrons	.....	16
number of protons	.....	15

[2]

[Total: 8]

5 Naphtha is a fraction obtained from petroleum (crude oil).

(a) Explain how naphtha is obtained from petroleum (crude oil).

.....

.....

.....

.....

.....

.....[3]

(b) One compound in the naphtha fraction has the formula $C_{12}H_{26}$.

(i) From this formula, how can you deduce that this compound is an alkane?

.....

.....

.....[1]

(ii) The alkane, $C_{12}H_{26}$, can be cracked to form an alkene that has six carbon atoms per molecule.

Construct the equation for this reaction.

.....[2]

(c) Ethene, C_2H_4, can be made by cracking hydrocarbons.

Draw a 'dot-and-cross' diagram for ethene.

You only need to show the outer shell electrons.

[2]

[Turn over

(d) Chlorine reacts with both ethene and ethane.

(i) One molecule of ethene reacts with one molecule of chlorine.

Draw the structure of the product of this reaction. Show all of the atoms and all of the bonds.

[1]

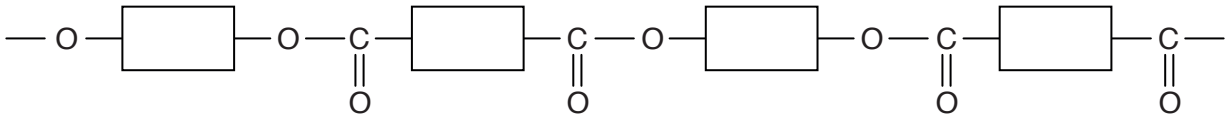
(ii) One molecule of ethane can react with two molecules of chlorine.

What is the molecular formula of the organic product of this reaction?

.....[1]

[Total: 10]

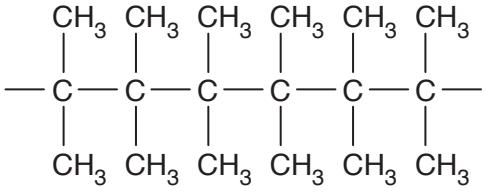
6 The diagram shows the partial structure of a polyester.



(a) Draw the partial structure of nylon.

[1]

(b) The diagram shows the partial structure of an addition polymer.



(i) What is meant by the term *addition polymerisation*?

.....

.....

.....[2]

(ii) Draw the structure of the alkene that can be used to make this addition polymer.

[1]

(iii) Describe one pollution problem associated with the disposal of this addition polymer.

.....

.....[1]

[Total: 5]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

7 Sphalerite is an ore containing compounds of zinc. One of the compounds in the ore is ZnS.

(a) Calculate the mass of zinc in 30.0 tonnes of ZnS.

mass of zinc ..... tonnes [2]

(b) ZnS is heated in air. Zinc oxide and sulfur dioxide are formed.

(i) Construct the equation for this reaction.

.....[2]

(ii) Suggest one environmental problem involved with heating ZnS in air.

.....

.....[1]

(c) Zinc oxide is reacted with dilute sulfuric acid to form aqueous zinc sulfate.

Construct the equation for this reaction.

.....[1]

(d) Pure zinc is made by the electrolysis of aqueous zinc sulfate.

Zinc forms at the negative electrode. Hydroxide ions react at the positive electrode.

Construct the equations for the reactions at both electrodes.

positive electrode (anode) .....

negative electrode (cathode) .....
[2]

(e) Zinc is used to galvanise iron to prevent the iron from rusting.

Explain how galvanising prevents iron from rusting.

.....

.....

.....

.....[2]

[Total: 10]

8 A scientist investigates the thermal decomposition of calcium carbonate in a closed system.

A dynamic equilibrium mixture is established.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

(a) What is meant by the term *dynamic equilibrium*?

.....

.....

.....

.....[2]

(b) The pressure of the equilibrium mixture is decreased.

The temperature of the closed system is kept constant.

Predict and explain what will happen to the composition of the equilibrium mixture.

.....

.....

.....

.....

.....[2]

(c) The temperature of the equilibrium mixture is increased.

The pressure within the closed system is kept constant.

The position of equilibrium shifts to the right hand side.

What conclusion can be made about the enthalpy change of the reaction?

.....

.....[1]

(d) Calcium carbonate reacts with dilute nitric acid to form three compounds, **X**, **Y** and **Z**.

- **X** is a salt.
- **Y** is a colourless gas.
- **Z** is a colourless liquid.

(i) Name **Y** and describe a test for this gas.

name .....

test .....

observation .....

[2]

(ii) Name **Z** and describe a chemical test for this liquid.

name .....

chemical test .....

observation .....

[2]

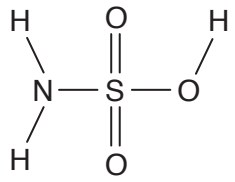
(iii) Construct the equation for the reaction between calcium carbonate and nitric acid.

.....[1]

[Total: 10]

[Turn over

9 Sulfamic acid has the structure shown.



(a) Write the molecular formula for sulfamic acid.

.....[1]

(b) Sulfamic acid is a weak acid.

(i) What is meant by the term *acid*?

.....

.....[1]

(ii) What is the difference between a weak acid and a strong acid?

.....

.....

.....

.....[2]

(c) What mass of sulfamic acid is required to make 250 cm^3 of a 0.150 mol/dm^3 solution?

mass ..... g [3]

(d) In a titration, 0.00250 moles of NaOH is exactly neutralised by 0.150 mol / dm^3 sulfamic acid.

One mole of sodium hydroxide reacts with one mole of sulfamic acid.

Calculate the volume, in cm^3, of sulfamic acid needed in this titration.

volume ..... cm^3 [1]

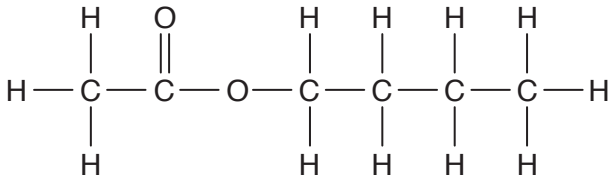
(e) One mole of aqueous sulfamic acid can produce one mole of hydrogen ions.

Construct the equation to show the reaction between sulfamic acid and magnesium.

.....[2]

[Total: 10]

10 Ester **A** has the structure shown.



(a) Name ester **A**.

.....[1]

(b) Ester **A** reacts with hot aqueous sodium hydroxide to give two compounds, **B** and **C**.

(i) Compound **B** has the percentage composition by mass:

29.3% carbon; 3.7% hydrogen; 39.0% oxygen; 28.0% sodium.

Calculate the empirical formula for this compound.

[2]

(ii) Compound **C** has a relative molecular mass of 74 and is oxidised by warm acidified potassium manganate(VII) to give butanoic acid.

Suggest a structure for **C**.

Give reasons for your answer.

.....

.....

.....

.....[2]

(c) **(i)** What is meant by the term *isomerism*?

.....

.....[1]

(ii) Draw an isomer of ester **A**.

[1]

(d) Explain why ester **A** is a saturated compound.

.....

.....[1]

(e) Ester **A** can be used as a fragrance or perfume because it diffuses easily.

(i) Explain why the rate of diffusion of the ester decreases as the temperature decreases.

.....

.....

.....[1]

(ii) Suggest **one** other use for ester **A**.

.....[1]

[Total: 10]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

7139395965

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2018**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **18** printed pages and **2** blank pages.

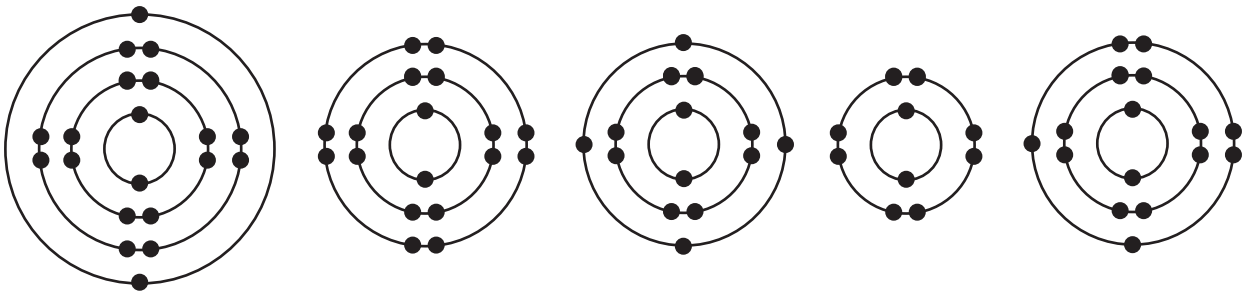
CAMBRIDGE
International Examinations

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

1 The electronic configurations of five atoms are shown.



A B C D E

(a) Which electronic configuration represents each of the following descriptions?

Each electronic configuration may be used once, more than once or not at all.

(i) a sulfur atom

.....[1]

(ii) a metal atom

.....[1]

(iii) an atom with a proton number of 14

.....[1]

(iv) an atom of a noble gas with three occupied electron shells

.....[1]

(v) an atom which forms a noble gas electronic configuration when it loses two electrons

.....[1]

(b) The element germanium has five naturally occurring isotopes.

An isotope of germanium is represented by the symbol shown.

$^{76}_{32}Ge$

(i) What is the meaning of the term *isotopes*?

.....

.....[1]

(ii) Deduce the number of neutrons in one atom of this isotope of germanium.

.....[1]

[Total: 7]

2 Magnesium reacts with aqueous copper(II) sulfate.

$$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$$

(a) (i) Explain by referring to the equation, why this is a redox reaction.

.....

.....[2]

(ii) Construct the ionic equation for this reaction.

.....[1]

(b) Pure copper can be made by the electrolysis of aqueous copper(II) sulfate, using one pure copper electrode and one impure copper electrode.

Draw a labelled diagram of this electrolysis.

[3]

(c) What observations are made when adding aqueous ammonia to a solution containing copper(II) ions, slowly with mixing, until no further change occurs?

.....

.....

.....[2]

(d) Blocks of magnesium are attached to underground pipes made of iron to stop them rusting.

Explain how the magnesium stops the pipes rusting.

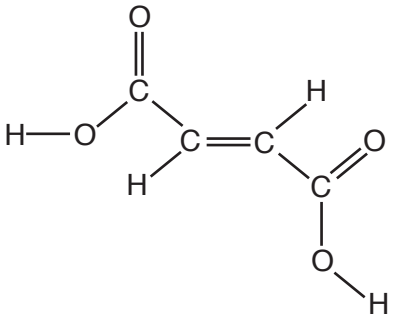
.....

.....

.....[2]

[Total: 10]

3 The structure of fumaric acid is shown.



(a) How does this structure show that fumaric acid is an unsaturated compound?

.....[1]

(b) Fumaric acid is oxidised by acidified aqueous potassium manganate(VII).

What colour change would you observe in the reaction mixture when excess aqueous fumaric acid is added to acidified aqueous potassium manganate(VII)?

from ..... to .....[2]

(c) Fumaric acid is neutralised by aqueous sodium hydroxide.

$$C_2H_2(COOH)_2 + 2NaOH \rightarrow C_2H_2(COONa)_2 + 2H_2O$$

(i) Write the ionic equation for this reaction.

.....[1]

(ii) Calculate the volume of 0.0500 mol / dm^3 sodium hydroxide required to neutralise 20.0 cm^3 of 0.0200 mol / dm^3 fumaric acid.

Give your answer to **three** significant figures.

volume ..... cm^3 [3]

[Total: 7]

4 The alkenes are a homologous series of unsaturated hydrocarbons.

(a) Describe two characteristics of a homologous series.

1. .....

2. .....
[2]

(b) Construct the equation for the complete combustion of butene, C_4H_8.

.....[2]

(c) Draw the structure of a branched alkene with the formula C_4H_8. Show all of the atoms and all of the bonds.

[1]

(d) Butene reacts with hydrogen in the presence of nickel.

(i) Name the product formed.

.....[1]

(ii) What is the purpose of the nickel?

.....[1]

(iii) State one other condition needed for this reaction.

.....[1]

(e) A hydrocarbon contains 85.7% carbon by mass.

(i) Deduce the empirical formula of this hydrocarbon.

[2]

(ii) What other piece of information is needed to deduce the molecular formula of this hydrocarbon?

.....[1]

[Total: 11]

[Turn over

5 The Periodic Table is an arrangement of elements in groups and periods.

(a) What are the factors that determine the position of an element in the Periodic Table?

.....

.....

.....

.....[2]

(b) Phosphorus is an element in Group V of the Periodic Table.

Deduce the electronic configuration of a phosphide ion, P^{3-}.

.....[1]

(c) Phosphine, PH_3, is a covalent compound.

(i) Draw a 'dot-and-cross' diagram of phosphine.

Only draw the outer shell electrons.

[2]

(ii) Some properties of phosphine are listed.

- gas at room temperature
- almost insoluble in water
- reacts with hydrogen chloride
- has no effect on litmus paper
- decomposes to form hydrogen and phosphorus only when warmed gently

Describe two ways in which the properties of ammonia are **different** from those of phosphine.

1. .....

2. .....

[2]

(iii) Construct the equation for the thermal decomposition of phosphine.

.....[1]

(iv) Describe and explain the difference in the rate of diffusion of the gases ammonia and phosphine at the same temperature and pressure.

.....

.....

.....[1]

(v) Phosphine burns in oxygen to form phosphorus(V) oxide.

Is phosphorus(V) oxide an acidic, basic or amphoteric oxide? Give a reason for your answer.

.....

.....[1]

[Total: 10]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

6 Some properties of Group VI elements are shown.

element	density at room temperature in g/cm^3	melting point /°C	boiling point /°C	electrical conductivity of solid
oxygen	0.0013	–219	–183	very poor
sulfur	2.1	115	445	poor
selenium		221	685	poor
tellurium	6.2	450	988	quite good
polonium	9.2	254	962	good

(a) (i) Use the information in the table to suggest the density of selenium at room temperature.

.....[1]

(ii) Use the information in the table to deduce the physical state of oxygen at –190 °C.

Explain your answer.

physical state .....

explanation .....

.....

[2]

(b) (i) Describe the trend in the electrical conductivity of the Group VI elements.

.....

.....[1]

(ii) There is a trend in the melting points of the Group VI elements.

Which element does not follow this trend?

Use the data in the table to explain your answer.

element .....

explanation .....

.....[1]

(c) Use the information in the table to explain how the structure and bonding in oxygen differs from the structure and bonding in polonium.

.....

.....

.....

.....[2]

(d) Sulfur dioxide is an atmospheric pollutant.

(i) State one source of the sulfur dioxide in the atmosphere.

.....[1]

(ii) Describe and explain how sulfur dioxide contributes to acid rain.

.....

.....

.....[2]

[Total: 10]

7 Plants remove carbon dioxide from the air during photosynthesis.

(a) (i) Complete the equation for photosynthesis.

..... + ... → $C_6H_{12}O_6$ + ...O_2 [2]

(ii) State two conditions required for photosynthesis to happen.

1. .....

2. .....
[2]

(iii) Explain how photosynthesis can provide a renewable energy source.

.....

.....[1]

(b) The structure of a simple sugar is shown.

Starch is made by the polymerisation of simple sugars.

During this polymerisation, water is formed.

(i) What type of polymerisation occurs?

.....[1]

(ii) Draw the partial structure of starch.

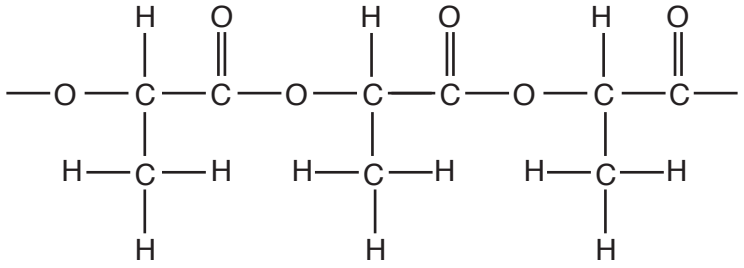
You must show at least two repeat units.

[2]

(iii) Name the process by which starch is converted into simple sugars.

.....[1]

(c) The partial structure of poly(lactic acid) is shown.



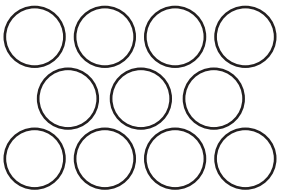
On the diagram, draw a ring around all of the atoms in one ester linkage. [1]

[Total: 10]

8 Bismuth is a metallic element in Group V of the Periodic Table.

(a) Complete the diagram to show the structure and bonding in a typical metal.

Label your diagram.



[2]

(b) Describe three physical properties which are typical of most metals.

1. .....

2. .....

3. .....

[2]

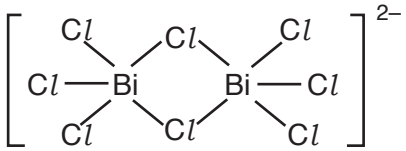
(c) Bismuth reacts with chlorine to form bismuth(III) chloride, $BiCl_3$.

Construct the equation for this reaction.

.....[1]

(d) When bismuth reacts with molten bismuth(III) chloride, an ion is formed.

The structure of this ion is shown.



Write the formula of this ion.

.....[1]

(e) A white precipitate of BiOCl is formed when colourless BiCl_3 is added to water.

$$BiCl_3(aq) + H_2O(l) \rightleftharpoons BiOCl(s) + 2HCl(aq)$$

(i) Describe and explain what you would observe when a few drops of concentrated hydrochloric acid are added to this mixture.

.....

.....

.....[2]

(ii) Suggest why a change in pressure has no effect on the reaction shown.

.....[1]

(f) Bismuth is used in alloys.

What is the meaning of the term *alloy*?

.....

.....[1]

[Total: 10]

[Turn over

9 Sulfuric acid reacts with zinc to form zinc sulfate and hydrogen.

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

(a) Describe and explain, using ideas about collisions between particles, how the rate of this reaction changes when the concentration of sulfuric acid is increased.

All other conditions stay the same.

.....

.....

.....[2]

(b) Describe and explain, using ideas about collisions between particles, how the rate of this reaction changes when the temperature is decreased.

All other conditions stay the same.

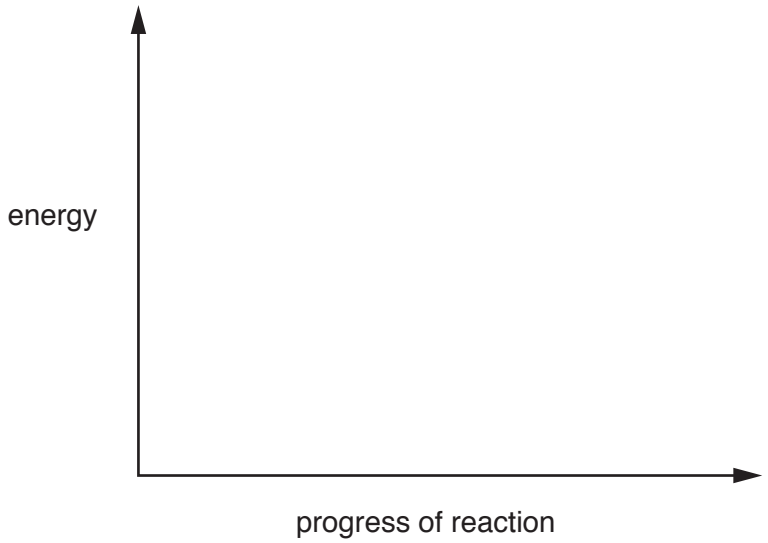
.....

.....

.....[2]

(c) The reaction of zinc with sulfuric acid is exothermic.

Complete the energy profile diagram for this reaction to show the enthalpy change.



[2]

(d) Calculate the maximum volume of hydrogen, in dm^3, formed when 4.55 g of zinc reacts with excess sulfuric acid at room temperature and pressure.

volume ..... dm^3 [2]

(e) The formula of zinc phosphate is $Zn_3(PO_4)_2$.

Calculate the percentage by mass of zinc in zinc phosphate.

..... % [2]

[Total: 10]

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19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
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Key

atomic number
atomic symbol
name
relative atomic mass

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actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

2777059949

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2017**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following chlorides to answer the questions.

ammonium chloride

calcium chloride

carbon tetrachloride

copper(II) chloride

hydrogen chloride

magnesium chloride

zinc chloride

Each chloride can be used once, more than once or not at all.

Which chloride

(a) is a coloured solid,

.....[1]

(b) reacts with warm aqueous sodium hydroxide to produce a gas that turns damp red litmus paper blue,

.....[1]

(c) reacts with water to form a strong acid,

.....[1]

(d) contains a cation with a charge of +1,

.....[1]

(e) has a simple molecular structure similar to methane?

.....[1]

[Total: 5]

A2 The table shows some information about six particles.

(a) Complete the table.

particle	proton (atomic) number	number of neutrons in particle	number of electrons in particle
^{35}Cl	17	18	.....
.....	17	20	17
$^{39}K^{+}$	19	.....	18
$^{79}Br^{-}$	.....	44	36
^{81}Br	35	.....	35
.....	37	48	36

[6]

(b) **(i)** What is meant by the term *isotopes*?

.....

.....

.....[1]

(ii) Identify two **atoms** which are isotopes of the same element.

..... and .....[1]

[Total: 8]

A3 Acids are neutralised by insoluble bases.

(a) Magnesium chloride is a soluble salt that can be prepared from an insoluble base.

(i) Name the acid and an insoluble base that can be used to make magnesium chloride.

.....[1]

(ii) Describe the experimental method used to prepare pure crystals of magnesium chloride from this acid and base.

.....

.....

.....

.....

.....

.....

.....[4]

(b) Aqueous barium chloride and aqueous potassium sulfate can be used to prepare barium sulfate in a precipitation reaction.

Write the ionic equation, including state symbols, for this reaction.

.....[2]

(c) Potassium sulfate can be prepared by reacting aqueous potassium hydroxide with dilute sulfuric acid.

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

In an experiment, 20.0 cm^3 of 0.650 mol/dm^3 sulfuric acid is just neutralised by aqueous potassium hydroxide.

(i) Calculate the maximum mass of potassium sulfate, K_2SO_4, that could be prepared.

[The relative formula mass of K_2SO_4 is 174.]

maximum mass of potassium sulfate = ... g [2]

(ii) After crystallisation, 1.72 g of dry potassium sulfate was obtained. Calculate the percentage yield of potassium sulfate.

percentage yield of potassium sulfate = ... % [1]

[Total: 10]

A4 Sodium oxide, Na_2O, is an ionic compound.

(a) State the electronic configuration for each of the ions in sodium oxide.

sodium ion .....

oxide ion .....
[2]

(b) When **molten** sodium oxide is electrolysed, sodium and oxygen are formed.

Construct equations for the two electrode reactions.

reaction at the negative electrode

.....

reaction at the positive electrode

.....
[2]

(c) Explain how molten sodium oxide conducts electricity.

.....

.....[1]

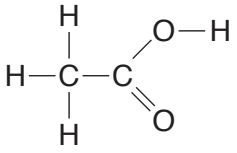
(d) Sodium oxide reacts with water to give sodium hydroxide.

Construct the equation for this reaction.

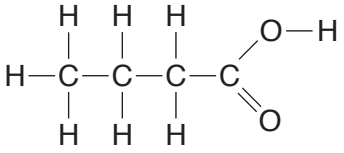
.....[1]

[Total: 6]

A5 Ethanoic acid and butanoic acid are both carboxylic acids.



ethanoic acid



butanoic acid

(a) Name a reagent that can be used to make ethanoic acid from ethanol.

.....[1]

(b) Dilute ethanoic acid reacts with all carbonates and with some metals.

(i) Name one metal that will react with dilute ethanoic acid and name the products of this reaction.

name of metal .....

products .....
[2]

(ii) Construct an equation to show the reaction of dilute ethanoic acid with calcium carbonate.

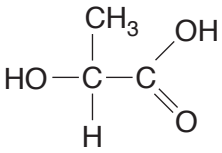
.....[2]

(c) Draw the structure of a carboxylic acid that is an isomer of butanoic acid.

Show all of the atoms and all of the bonds.

[1]

(d) Lactic acid is both an alcohol and a carboxylic acid.



Lactic acid is a monomer that can be polymerised to form a polyester.

(i) What type of polymerisation occurs during this reaction?

.....[1]

(ii) This polyester is biodegradable.

Suggest an advantage of a polymer being biodegradable.

.....

.....[1]

[Total: 8]

A6 Respiration is a reaction that takes place in living cells to release energy.

The overall reaction involves the oxidation of glucose.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

The reaction is exothermic and is catalysed by enzymes.

(a) Draw an energy profile diagram for respiration using the axes shown.

Label
- the axes,
- the enthalpy change,
- the reactants and products.

[3]

(b) Explain how a catalyst such as an enzyme can speed up a chemical reaction.

.....

.....

.....[2]

(c) Respiration, combustion and photosynthesis are important processes in the carbon cycle.

Describe how the carbon cycle regulates the amount of carbon dioxide in the atmosphere.

.....

.....

.....

.....[3]

[Total: 8]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 Copper reacts with hot concentrated aqueous sulfuric acid.

$$Cu(s) + 2H_2SO_4(aq) \rightarrow CuSO_4(aq) + SO_2(g) + 2H_2O(l)$$

(a) Suggest what you would observe when copper reacts with hot concentrated aqueous sulfuric acid.

.....

.....[1]

(b) **(i)** Name the salt of formula $CuSO_4$.

.....[1]

(ii) Copper is oxidised when it reacts with concentrated sulfuric acid.

Use the equation to explain that copper has been oxidised.

.....

.....[1]

(c) An excess of copper is added to 25.0 cm^3 of hot 14.0 mol / dm^3 H_2SO_4.

Use this information, together with the equation, to calculate the maximum volume of SO_2 formed.

The gas volume is measured at room temperature and pressure.

volume of SO_2 = ...[3]

(d) To a small sample of $CuSO_4(aq)$, a student adds aqueous sodium hydroxide drop by drop until it is in excess.

(i) Describe what would be observed.

.....

.....[1]

(ii) The student repeats the experiment but adds aqueous ammonia instead of aqueous sodium hydroxide.

Describe what would be observed.

.....

.....

.....[2]

(e) Copper(I) chloride, CuCl, decomposes to form $CuCl_2$ and Cu.

Construct the equation for this reaction.

.....[1]

[Total: 10]

B8 Nitrogen dioxide, NO_2, reacts with itself to make dinitrogen tetroxide, N_2O_4, in an exothermic reaction.

This reaction is investigated at 140 °C in a sealed container.

A dynamic equilibrium mixture is established.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

$NO_2(g)$ is a dark brown gas.

$N_2O_4(g)$ is a colourless gas.

(a) What is the meaning of the symbol $\rightleftharpoons$?

.....[1]

(b) What is an exothermic reaction?

.....

.....[1]

(c) Suggest why a sealed container must be used to establish any equilibrium.

.....

.....[1]

(d) The pressure of the equilibrium mixture is decreased.

The temperature is kept at 140 °C.

Predict and explain what will happen to the colour of the equilibrium mixture.

.....

.....

.....

.....

.....[2]

(e) The temperature of the equilibrium mixture is increased.

The pressure is kept constant.

Predict and explain what will happen to the colour of the equilibrium mixture.

.....

.....

.....

.....

.....[2]

(f) Nitrogen dioxide reacts with water to make nitric acid, HNO_3, and nitrous acid, HNO_2.

Nitric acid is a strong acid and nitrous acid is a weak acid.

(i) Describe an experiment to distinguish between separate solutions of a strong acid and a weak acid.

.....

.....

.....

.....[2]

(ii) Nitrogen dioxide reacts with aqueous potassium hydroxide.

Give the formula of each of the two salts formed in this reaction.

..... and .....[1]

[Total: 10]

B9 Methane, ethane and propane are all gases at room temperature.

(a) State a use of methane.

.....[1]

(b) Describe one source of methane in the atmosphere.

.....

.....[1]

(c) State one possible environmental consequence of the presence of methane in the atmosphere.

.....

.....[1]

(d) Ethane reacts with chlorine in the presence of ultraviolet light to give a number of different compounds.

A 1.00 g sample of one of these compounds contains 0.040 g of hydrogen, 0.242 g of carbon and 0.718 g of chlorine.

(i) Calculate the empirical formula of this compound.

empirical formula .....[2]

(ii) The relative molecular mass of the compound is 99.

Deduce the molecular formula of the compound.

.....[1]

(e) (i) What is meant by the term *diffusion*?

.....

.....

.....[1]

(ii) Explain why propane diffuses faster at 100 °C than at 60 °C.

.....

.....[1]

(iii) Explain why diffusion could be used to separate a mixture of methane and propane.

.....

.....

.....[2]

[Total: 10]

B10 The table shows some information about the homologous series of unbranched alcohols.

name	structure	boiling point / °C
methanol	CH_3OH	65
ethanol	CH_3CH_2OH	79
propanol	$CH_3CH_2CH_2OH$	97
butanol	$CH_3CH_2CH_2CH_2OH$	117
pentanol	$CH_3CH_2CH_2CH_2CH_2OH$	138

(a) One of the characteristics of a homologous series is that it has a general formula.

(i) What is the general formula for the homologous series of unbranched alcohols?

.....[1]

(ii) Predict the boiling point of hexanol, an alcohol with six carbon atoms per molecule.

..... °C [1]

(b) Describe the manufacture of ethanol by the fermentation of aqueous glucose.

.....

.....

.....

.....

.....

.....[3]

(c) Butanol reacts with ethanoic acid to make an ester.

Name and draw the structure of this ester.

Show all of the atoms and all of the bonds within the ester linkage.

name .....

structure

[2]

(d) Ethanol is a gas at 100 °C.

Describe the changes in the arrangement and movement of the molecules when ethanol is cooled from 100 °C to 25 °C.

.....

.....

.....

.....

.....

[3]

[Total: 10]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

3401069089

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2017**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **19** printed pages and **1** blank page.

CAMBRIDGE International Examinations

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 (a) Choose from the following elements to answer the questions.

aluminium
carbon
hydrogen
iron
magnesium
nitrogen
oxygen
sodium
vanadium

Each element may be used once, more than once or not at all.

Which element:

(i) is a catalyst in the Haber process,

.....[1]

(ii) makes up 21% of dry air,

.....[1]

(iii) can be formed when hydrocarbons are cracked,

.....[1]

(iv) forms aqueous ions with a 3+ charge which give a white precipitate when added to aqueous ammonia,

.....[1]

(v) has an atom with only three electrons in its outer shell?

.....[1]

(b) Complete the table to show the number of electrons and neutrons in the potassium atom and in the oxide ion.

	number of electrons	number of neutrons
$^{41}_{19}K$		
$^{17}_{8}O^{2-}$		

[4]

[Total: 9]

A2 Sodium chloride, NaC*l*, and magnesium chloride, MgCl_2, are both ionic compounds.

(a) Describe the arrangement of the ions and the type of attractive forces between the ions in solid magnesium chloride.

arrangement .....

type of attractive forces .....
[2]

(b) Explain why solid magnesium chloride does not conduct electricity but aqueous magnesium chloride does conduct.

.....

.....

.....[2]

(c) State the electronic configuration of a magnesium ion and of a chloride ion.

magnesium ion .....

chloride ion .....
[2]

(d) Chlorine and hydrogen are manufactured by the electrolysis of concentrated aqueous sodium chloride.

Chlorine is released at the positive electrode and hydrogen is released at the negative electrode.

(i) Why are hydrogen ions and **not** sodium ions discharged at the negative electrode?

.....

.....[1]

(ii) Construct the equation for the reaction at the negative electrode.

.....[1]

(iii) Describe a test for chlorine.

test .....

result .....
[2]

(e) (i) Give the formulae of the four ions present in aqueous sodium chloride.

.....[1]

(ii) Suggest why the solution becomes alkaline as the electrolysis proceeds.

.....

.....[2]

[Total: 13]

A3 Metals have characteristic physical properties such as good electrical and thermal conductivity.

(a) Give two **other** physical properties which are characteristic of metals.

1. .....

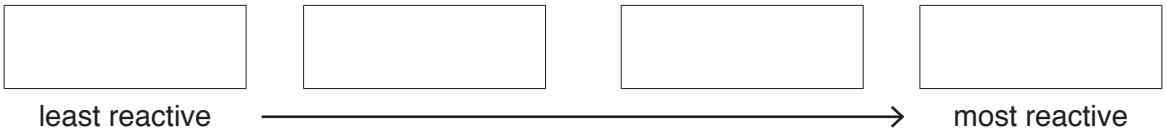
2. .....

[2]

(b) The table gives some observations about the reactions of four metals with water.

metal	observations
cerium	reacts slowly with cold water
iron	reacts with steam when red-hot
magnesium	reacts slowly with hot water
sodium	reacts rapidly with cold water

Put these metals in order of their reactivity with water.



[1]

(c) The equation for the reaction of iron with steam is shown.

$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$$

(i) Calculate the maximum mass of Fe_3O_4 that can be formed when 39.2 g of iron reacts with excess steam.

Give your answer to three significant figures.

mass of Fe_3O_4 = ... g [3]

(ii) Calculate the maximum volume of hydrogen, in dm^3, produced by this reaction, when measured at room temperature and pressure.

volume of hydrogen = ... dm^3 [2]

(d) Pure iron can be obtained by the following reaction.

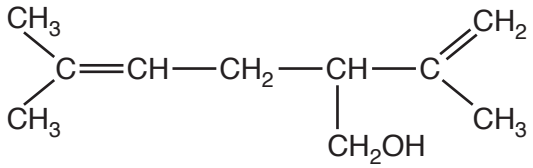
$$Fe(CO)_5 \rightarrow Fe + 5CO$$

Give one hazard associated with this reaction.

.....[1]

[Total: 9]

A4 Lavandulol is found in lavender plants.



(a) **(i)** Give the molecular formula for lavandulol.

.....[1]

(ii) Lavandulol contains an –OH group.

Name the homologous series of compounds which contain the –OH group.

.....[1]

(b) Lavandulol is an unsaturated compound.

Describe a test for an unsaturated compound.

test .....

result .....
[2]

(c) Lavender flowers contain a variety of coloured compounds. These can be extracted from the flowers to give a solution of the coloured compounds.

Describe how to use paper chromatography to identify these coloured compounds.

You may use a labelled diagram in your answer.

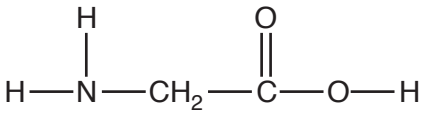
.....

.....

.....

.....[3]

(d) Compound **G** is found in the leaves of lavender plants.



Compound **G** can undergo polymerisation.

Draw a section of the polymer to show two repeat units.

[2]

[Total: 9]

A5 Dilute ethanoic acid reacts with sodium carbonate.

Sodium ethanoate, CH_3COONa, and two other compounds are formed.

(a) Construct the equation for this reaction.

.....[2]

(b) The reaction of dilute ethanoic acid with sodium carbonate is endothermic.

Explain in terms of bond making and bond breaking why this reaction is endothermic.

.....

.....

.....

.....[2]

(c) Ethanoic acid reacts with alcohols to form esters.

Give one use of esters.

.....[1]

[Total: 5]

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Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 At high temperatures, hydrogen reacts with iodine to form hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \quad \Delta H = +53.0\ kJ/mol$$

(a) Describe and explain the effect, if any, on the position of equilibrium when

(i) the pressure is increased,

.....

.....

.....[2]

(ii) the temperature is decreased.

.....

.....

.....[2]

(b) Hydrogen iodide reacts with water to form a strong acid, hydriodic acid, HI(aq).

(i) What is meant by the term *strong acid*?

.....

.....[1]

(ii) Construct the equation for the dissociation of hydrogen iodide molecules into ions.

.....[1]

(c) Hydrogen iodide reacts with ethene to form iodoethane.

$$CH_2{=}CH_2 + HI \rightarrow CH_3\,CH_2I$$

What is the name of this type of reaction?

.....[1]

(d) The table shows some properties of five alkenes.

alkene	formula	melting point /°C	boiling point /°C
ethene	C_2H_4	–168.9	–103.6
propene	C_3H_6		–47.3
butene	C_4H_8	–185.2	–6.2
pentene	C_5H_{10}	–165.0	30.0
hexene	C_6H_{12}	–139.7	63.4

(i) How does the boiling point change as the number of carbon atoms in the formula of the alkenes increases?

.....[1]

(ii) What is the physical state of butene at –7 °C? Explain your answer.

.....

.....[1]

(iii) Why is it difficult to predict the melting point of propene using only the information from the table?

.....[1]

[Total: 10]

[Turn over

B7 The table shows the melting points and relative electrical conductivities of three elements from Period 3 of the Periodic Table.

property	element		
	magnesium	silicon	sulfur
melting point /°C	649	1410	113
relative electrical conductivity	good conductor	poor conductor	does not conduct

(a) Use ideas of structure and bonding to explain

(i) the difference in the melting points of magnesium and sulfur,

.....

.....

.....

.....[2]

(ii) the difference in the electrical conductivity of magnesium and sulfur.

.....

.....

.....[2]

(b) Silicon has a structure similar to diamond.

Explain why silicon has a high melting point.

.....

.....[2]

(c) A 40.5 g sample of a chloride of sulfur contains 21.3 g of chlorine.

(i) Deduce the empirical formula of this chloride of sulfur.

empirical formula .....[3]

(ii) The relative molecular mass of this chloride is 135.

Deduce the molecular formula of this chloride.

molecular formula .....[1]

[Total: 10]

B8 Potassium nitrate, potassium sulfate and potassium phosphate are used in fertilisers.

(a) Calculate the percentage by mass of potassium in potassium sulfate, K_2SO_4.

..... % by mass [2]

(b) Describe a test for sulfate ions.

test .....

result .....
[2]

(c) Explain why nitrates in solid fertilisers spread onto soil are able to leach through the soil easily.

.....[1]

(d) Nitrates are responsible for eutrophication.

What is meant by the term *eutrophication*?

.....

.....

.....[2]

(e) Dilute phosphoric acid, $H_3PO_4(aq)$, reacts with aqueous potassium hydroxide to make potassium phosphate.

$$H_3PO_4(aq) + 3KOH(aq) \rightarrow K_3PO_4(aq) + 3H_2O(l)$$

A student titrates 25.0 cm^3 of $H_3PO_4(aq)$ with 0.200 mol/dm^3 KOH(aq).

12.5 cm^3 of KOH(aq) is required to react exactly with the $H_3PO_4(aq)$.

Calculate the concentration of the $H_3PO_4(aq)$.

concentration of $H_3PO_4(aq)$ = ... mol/dm^3 [3]

[Total: 10]

B9 Nitrogen(V) oxide decomposes on heating to form nitrogen(IV) oxide and oxygen.

$$2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$$

(a) The table shows how the rate of reaction varies with the concentration of N_2O_5.

concentration of $N_2O_5(g)$ in mol/dm^3	rate in $mol/dm^3/s$
3.2	6.39
1.6	3.15
0.8	1.63

(i) Describe how the rate of this reaction changes with the concentration of N_2O_5.

.....

.....[1]

(ii) Explain your answer to **(a)(i)** in terms of collision theory.

.....

.....

.....[2]

(iii) Describe and explain the effect of increasing the temperature on the rate of this reaction.

.....

.....

.....[2]

(b) Sulfur dioxide is an atmospheric pollutant.

(i) Describe one source of the sulfur dioxide in the atmosphere.

.....[1]

(ii) The oxidation of sulfur dioxide to sulfur trioxide in the atmosphere is catalysed by nitrogen(IV) oxide.

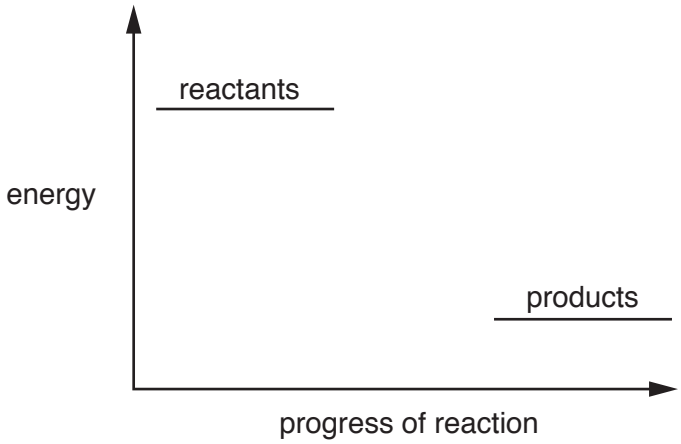
$$SO_2 + NO_2 \rightarrow SO_3 + NO$$

$$NO + \square O_2 \rightarrow NO_2$$

Nitrogen(IV) oxide speeds up the rate of reaction. Which other property of a catalyst is shown by these equations?

.....[1]

(c) (i) An incomplete energy profile diagram for the oxidation of sulfur dioxide to sulfur trioxide is shown.



On the diagram:

- draw and label the pathway for the uncatalysed reaction,
- draw and label the pathway for the catalysed reaction. [2]

(ii) Is the reaction in **(c)(i)** exothermic or endothermic?

Explain your answer.

.....

.....[1]

[Total: 10]

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

0083225865

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2016**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

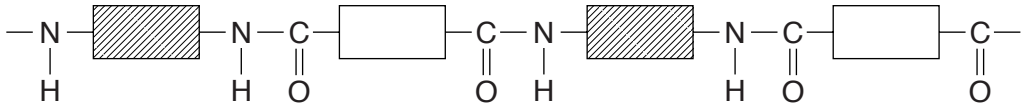
Section A

Answer **all** the questions in this section in the spaces provided.

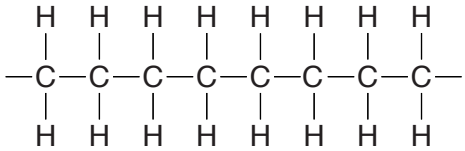
The total mark for this section is 45.

A1 Choose from the following polymers to answer the questions.

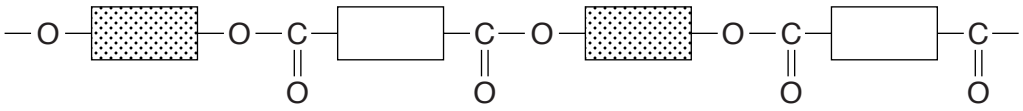
polymer A



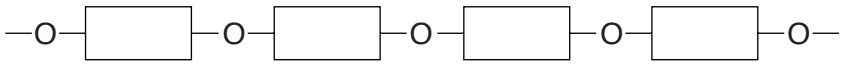
polymer B



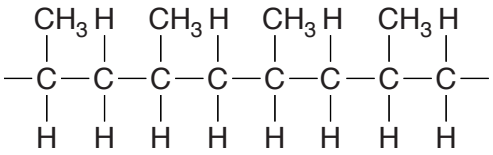
polymer C



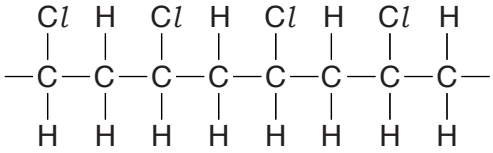
polymer D



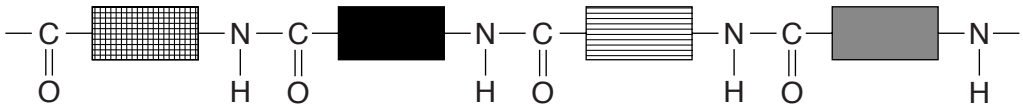
polymer E



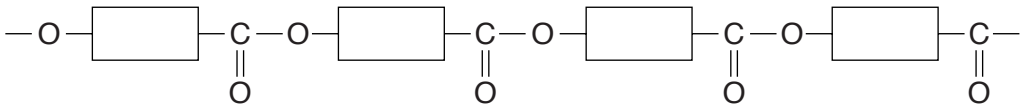
polymer F



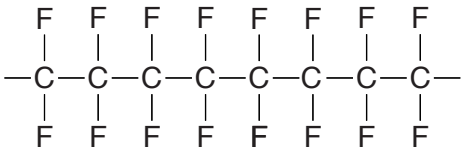
polymer G



polymer H



polymer I



Each polymer can be used once, more than once or not at all.

(a) Which **two** polymers are polyesters?

..... and ..... [1]

(b) Which polymer is used to make both clingfilm and plastic bags?

..... [1]

(c) Give the letter of an addition polymer. .....

Give the letter of a condensation polymer. ..... [1]

(d) Give the letter of a polymer that is a saturated hydrocarbon.

..... [1]

(e) Which polymer could be part of a protein?

..... [1]

[Total: 5]

A2 Hydrogen fluoride, HF, has a simple molecular structure. It is soluble in water.

(a) Suggest **one** other physical property of hydrogen fluoride.

..... [1]

(b) Hydrogen fluoride dissociates in water to form dilute hydrofluoric acid.

(i) Write an equation to show the dissociation of hydrogen fluoride.

..... [1]

(ii) Explain why an acidic solution is formed when hydrogen fluoride dissociates in water.

.....

..... [1]

(c) Dilute hydrofluoric acid reacts with aqueous calcium hydroxide.

$$2HF(aq) + Ca(OH)_2(aq) \longrightarrow CaF_2(aq) + 2H_2O(l)$$

What is the minimum volume, in cm^3, of 0.150 mol / dm^3 $Ca(OH)_2$ required to react completely with a solution containing 0.200 g of HF?

volume of $Ca(OH)_2(aq)$ = ... cm^3 [3]

(d) Magnesium reacts with fluorine to make the ionic compound magnesium fluoride.

(i) Predict **two** physical properties of magnesium fluoride.

1. .....

2. .....
[2]

(ii) Explain, in terms of electrons, how a magnesium atom reacts with a fluorine molecule, F_2, to make a magnesium ion and two fluoride ions.

.....

.....

.....

..... [2]

[Total: 10]

A3 Esters are used as food flavourings and solvents.

(a) Draw the structure of ethyl methanoate, showing all of the atoms and all of the bonds.

[1]

(b) Ethyl ethanoate evaporates at room temperature.

(i) What is meant by the term *evaporation*?

.....

.....

..... [1]

(ii) A sample of ethyl ethanoate in a beaker is moved into a colder room.

Explain, in terms of the kinetic particle theory, why this results in a decrease in the rate of evaporation.

.....

.....

.....

..... [2]

(iii) The table shows some information about different esters.

name	structure	relative molecular mass (M_r)
methyl ethanoate	$CH_3CO_2CH_3$	74
ethyl ethanoate	$CH_3CO_2C_2H_5$	88
propyl ethanoate	$CH_3CO_2C_3H_7$	102
butyl ethanoate	$CH_3CO_2C_4H_9$	116
pentyl ethanoate	$CH_3CO_2C_5H_{11}$	130

Which ester has the **lowest** rate of evaporation at room temperature and pressure?

.....

Explain your answer.

.....

.....

[2]

[Total: 6]

A4 Sulfuric acid is manufactured by the contact process.

(a) State the conditions used in the contact process.

temperature .....

pressure .....

catalyst .....

[2]

(b) In the contact process, sulfur dioxide reacts with oxygen.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Describe and explain the effect of increasing the concentration of oxygen on the **rate** of this reaction.

.....

.....

.....

..... [2]

(c) The catalyst used in the contact process increases the rate of the reaction.
Describe one other advantage of using a catalyst in an industrial process.

.....

..... [1]

(d) Sulfuric acid is used to make the fertiliser potassium sulfate, K_2SO_4.

Calculate the percentage by mass of potassium in this fertiliser.

[2]

[Total: 7]

A5 The statements give some of the chemical properties of cobalt and its compounds.

- Cobalt does not react with cold water.
- Cobalt fizzes slowly with dilute hydrochloric acid.
- Cobalt does not react with aqueous zinc nitrate.
- Cobalt reacts with aqueous silver nitrate.
- Cobalt(II) oxide reacts with magnesium to form cobalt.

(a) Use the information to help arrange the following metals in order of reactivity.

cobalt, magnesium, silver, sodium and zinc

most reactive .....

.....

.....

.....

least reactive ..... [2]

(b) Construct the equation for the reaction between cobalt(II) oxide, CoO, and magnesium.

..... [1]

(c) Predict what happens when cobalt(II) carbonate is heated strongly.

..... [1]

(d) Cobalt has a melting point of 1495 °C.

Explain, in terms of structure and bonding, why a metal such as cobalt has a high melting point. You may use a labelled diagram in your answer.

.....

.....

..... [2]

(e) The symbol for one isotope of cobalt is $^{57}_{27}Co$.

Another isotope of cobalt has a nucleon number of 59.

Write its symbol.

..... [1]

[Total: 7]

A6 River water contains dissolved minerals and gases.

(a) Carbon dioxide is one of the gases dissolved in river water.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of carbon dioxide. Only draw the outer-shell electrons.

[1]

(b) River water often contains dissolved compounds such as ammonium nitrate and calcium phosphate.

(i) State **one** source of both of these compounds.

..... [1]

(ii) Describe and explain the environmental effect of the presence of these dissolved compounds in river water.

.....

.....

.....

.....

.....

.....

..... [3]

(c) River water is often purified for use as drinking water.

Describe **three** processes involved in the purification of river water.

process 1 .....

.....

.....

process 2 .....

.....

.....

process 3 .....

.....

.....

[3]

(d) Water has a low melting point and is neutral (pH = 7).

(i) Explain why water has a low melting point.

.....

..... [1]

(ii) A pH meter can be used to confirm that water is neutral.

Describe another way in which a student can confirm that water is neutral.

.....

.....

..... [1]

[Total: 10]

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Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 The formula of lead(II) nitrate is $Pb(NO_3)_2$.

(a) Describe how a pure sample of lead(II) nitrate crystals can be prepared from lead(II) oxide, which is insoluble in water.

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Aqueous potassium iodide is added to a sample of aqueous lead(II) nitrate. A precipitate of lead(II) iodide is formed.

Construct the ionic equation, with state symbols, for this reaction.

..... [2]

(c) Aqueous lead(II) nitrate is electrolysed using graphite electrodes. Bubbles of colourless gas are formed at both electrodes.

(i) Identify the gas formed at each electrode.

negative electrode (cathode) .....

positive electrode (anode) .....
[2]

(ii) Construct the equation for the reaction at the cathode.

..... [1]

(d) On heating, lead(II) nitrate decomposes to form PbO, NO_2 and O_2.

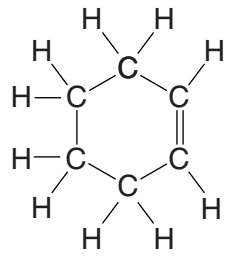
Construct the equation for this reaction.

..... [1]

[Total: 10]

B8 Cyclohexene, C_6H_{10}, is a cycloalkene.

Cycloalkenes react in a similar way to alkenes.



cyclohexene

(a) Cyclohexene is an unsaturated hydrocarbon.

(i) What is meant by the term *unsaturated*?

.....

..... [1]

(ii) What is meant by the term *hydrocarbon*?

.....

..... [1]

(b) Construct the equation for the complete combustion of cyclohexene.

..... [1]

(c) Cyclohexene reacts with bromine.

This is an addition reaction.

(i) Write the molecular formula of the product of this reaction.

..... [1]

(ii) What would be observed in this reaction?

..... [1]

(d) Cyclohexene can be manufactured from hexane as shown in the equation.

$$C_6H_{14} \rightarrow C_6H_{10} + 2H_2$$

Calculate the mass of cyclohexene that can be made from 258 g of hexane.
[M_r of cyclohexene = 82]

mass of cyclohexene = ... g [2]

(e) Another cycloalkene has the following percentage composition by mass.

C, 88.2%; H, 11.8%

(i) Use the percentage composition by mass to show that the empirical formula of this cycloalkene is C_5H_8.

[2]

(ii) The cycloalkene has a relative molecular mass, M_r, of 68.

Draw the structure of the cycloalkene, showing all of the atoms and all of the bonds.

[1]

[Total: 10]

B9 Carbon monoxide reacts with hydrogen in a reversible reaction.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91\,kJ/mol$$

The reaction reaches an equilibrium if carried out in a closed container.

(a) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

.....

.....

.....

..... [2]

(b) When one mole of methanol, CH_3OH, is formed, 91 kJ of energy is released.

Calculate the amount of energy released when 160 g of methanol is formed.
[M_r of methanol = 32]

energy released = ... kJ [2]

(c) Predict, with a reason, how the **position of equilibrium** of this reaction changes as the

(i) pressure is increased at constant temperature,

.....

.....

..... [2]

(ii) temperature is increased at constant pressure.

.....

.....

..... [2]

(d) Methanol and compound **X** react together to form methyl butanoate.

(i) Name **X**.

..... [1]

(ii) The reaction is normally carried out using a catalyst.

Name a suitable catalyst for this reaction.

..... [1]

[Total: 10]

B10 Manganese(IV) oxide, MnO_2, can be used in the preparation of both chlorine and oxygen.

Reaction 1 $MnO_2(s) + 4HCl(aq) \rightarrow Cl_2(g) + 2H_2O(l) + MnCl_2(aq)$

Reaction 2 $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

In **reaction 2** manganese(IV) oxide acts as a catalyst.

(a) **Reaction 1** converts chloride ions into chlorine molecules.

Explain why this is an example of oxidation.

.....

..... [1]

(b) **Reaction 1** is investigated using different masses of MnO_2. The results are shown in the table.

volume of HCl /cm^3	concentration of HCl(aq) in mol/dm^3	mass of MnO_2 used /g	volume of Cl_2 formed at room temperature and pressure /dm^3
100	1.0	1.74	0.48
100	1.0	0.87	0.24

Explain the difference in the volume of chlorine formed.

.....

.....

.....

..... [2]

(c) **Reaction 2** is investigated using different masses of MnO_2. The results are shown in the table.

volume of H_2O_2(aq) /cm^3	concentration of H_2O_2 in mol/dm^3	mass of MnO_2 used /g	volume of O_2 formed at room temperature and pressure /dm^3
100	1.0	1.74	1.20
100	1.0	0.87	

Predict the volume of oxygen, measured at room temperature and pressure, when 0.87 g of MnO_2 is used. Write your answer in the table. [1]

(d) Chlorine is bubbled through aqueous iron(II) chloride to form iron(III) chloride.

Explain, with the aid of equations, how aqueous sodium hydroxide can be used to distinguish between aqueous iron(II) chloride and aqueous iron(III) chloride.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(e) Describe the chemical test for chlorine.

test .....

.....

observation .....

.....

[2]

[Total: 10]

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
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Key

atomic number
atomic symbol
name
relative atomic mass

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actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4121908726

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2016**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **18** printed pages and **2** blank pages.

CAMBRIDGE International Examinations

[Turn over

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following compounds to answer the questions below.

$BaCl_2$
C_2H_4
C_3H_4
C_3H_8
CO
CO_2
K_2SO_4
Na_3PO_4
SO_2
$ZnSO_4$

Each of these compounds can be used once, more than once or not at all.

Give a compound which

(a) is an acidic atmospheric pollutant from volcanic eruptions,

.....[1]

(b) is a saturated hydrocarbon,

.....[1]

(c) dissolves in water to form an aqueous solution which gives a white precipitate on addition of aqueous sodium hydroxide,

.....[1]

(d) reduces iron(III) oxide to iron in the blast furnace,

.....[1]

(e) contributes to the process of eutrophication.

.....[1]

[Total: 5]

A2 Farmers add fertilisers such as ammonium sulfate to the soil to increase the rate of plant growth.

(a) Write the formulae of the ions present in ammonium sulfate.

..... and ..... [2]

(b) Describe a test for ammonium ions.

test .....

observation .....
[2]

(c) When ammonia dissolves in water, ammonium ions and hydroxide ions are formed.

Write the ionic equation for the reaction of aqueous ammonia with sulfuric acid.

.....[1]

[Total: 5]

[Turn over

A3 The alkanes are a homologous series of hydrocarbons.

(a) State **two** properties of a homologous series.

.....

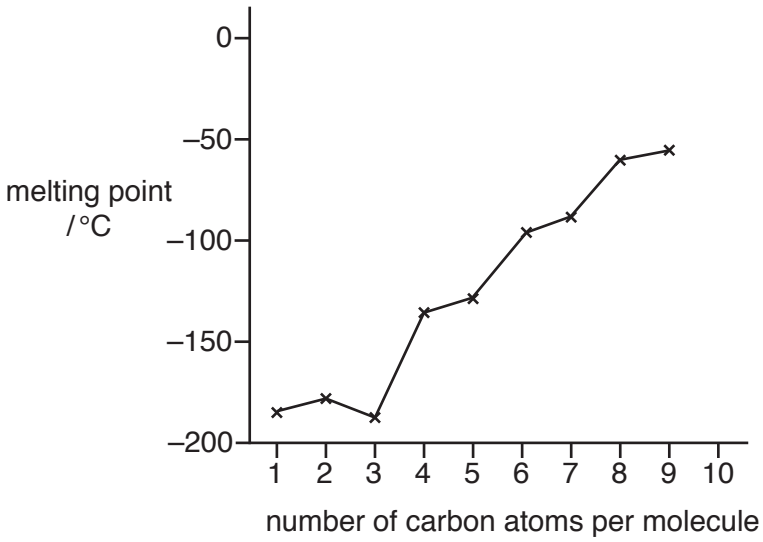
.....[2]

(b) Draw the structures of the branched and unbranched alkanes having four carbon atoms.

Show all the atoms and all the bonds.

[2]

(c) The graph shows how the melting points of the first nine unbranched alkanes vary with the number of carbon atoms per molecule.



(i) Describe how the melting points of these alkanes change with the number of carbon atoms.

.....

.....

.....[2]

(ii) Use the graph to estimate the melting point of the unbranched alkane which has ten carbon atoms.

.....°C [1]

(d) **(i)** Construct the equation for the complete combustion of pentane, C_5H_{12}.

.....[2]

(ii) Name the products of the incomplete combustion of pentane and explain why the incomplete combustion of hydrocarbons is hazardous to health.

.....

.....[2]

[Total: 11]

A4 Propanone, CH_3COCH_3, reacts with iodine, I_2, to form colourless products.

$$CH_3COCH_3 + I_2 \rightarrow CH_3COCH_2I + HI$$

The reaction is catalysed by hydrochloric acid.

The table shows how the relative rate of this reaction changes when different concentrations of propanone, iodine and hydrochloric acid are used.

experiment	concentration of CH_3COCH_3 in mol/dm^3	concentration of I_2 in mol/dm^3	concentration of hydrochloric acid in mol/dm^3	relative rate of reaction
1	0.025	0.024	0.12	5.1
2	0.050	0.024	0.12	10.2
3	0.050	0.024	0.06	5.1
4	0.050	0.012	0.06	5.1

(a) Describe how increasing the concentration of each of these substances affects the relative rate of reaction.

propanone .....

iodine .....

hydrochloric acid .....

[3]

(b) Increasing the temperature increases the rate of this reaction.

Explain why, in terms of kinetic particle theory.

.....

.....

.....[2]

(c) Iodine has several isotopes.

What are isotopes?

.....

.....[1]

(d) Astatine, At, is a halogen.

Aqueous iodine reacts with aqueous astatide ions, At^-, to produce astatine.

Construct the ionic equation for this reaction.

.....[1]

(e) Aqueous hydrogen iodide reduces hydrogen peroxide to water.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

Explain how iodide ions act as a reducing agent in this reaction.

.....

.....[1]

[Total: 8]

A5 Nickel carbonyl, $Ni(CO)_4$, reacts with hydrogen iodide.

$$Ni(CO)_4(l) + 2HI(g) \rightarrow NiI_2(s) + H_2(g) + 4CO(g)$$

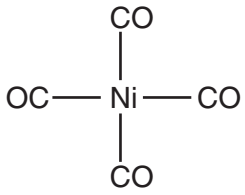
(a) Calculate the percentage by mass of nickel in nickel carbonyl.

..... % [2]

(b) Calculate the maximum volume of gas formed at room temperature and pressure when 1.71 g of nickel carbonyl reacts completely with hydrogen iodide.

maximum volume of gas formed ..... [3]

(c) The structure of a nickel carbonyl molecule is shown.



Predict **two** physical properties of nickel carbonyl.

.....

.....[2]

(d) The proton numbers and accurate relative atomic masses of cobalt and nickel are shown in the table.

	cobalt	nickel
proton number	27	28
relative atomic mass	58.9	58.7

Suggest why cobalt has a higher relative atomic mass than nickel.

.....

.....

.....[2]

(e) An aqueous solution of hydrogen iodide is a strong acid.

What is meant by the term *strong acid*?

.....

.....[1]

[Total: 10]

A6 Sodium and rubidium are alkali metals.

(a) Explain how metals conduct electricity.

.....[1]

(b) State **two** trends in the properties of the alkali metals.

.....

.....[2]

(c) Name the products formed when rubidium reacts with water.

..... and ..... [2]

(d) Titanium is extracted from titanium(IV) chloride by reduction with molten sodium.

$$TiCl_4 + 4Na \rightarrow 4NaCl + Ti$$

Suggest why sodium reduces titanium(IV) chloride.

.....[1]

[Total: 6]

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Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 In the contact process, sulfur trioxide is made by the catalytic oxidation of sulfur dioxide. In a closed container the following equilibrium is set up.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The reaction is exothermic.

(a) Name the catalyst used in this reaction.

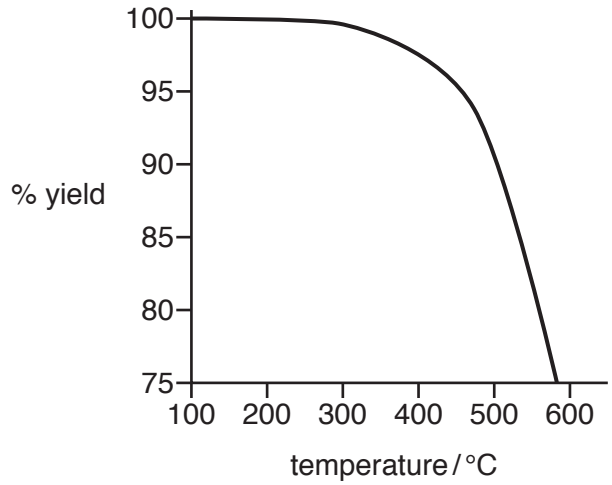
.....[1]

(b) Draw a 'dot-and-cross' diagram of an oxygen molecule.

Show only the outer shell electrons.

[1]

(c) The graph shows the percentage yield of sulfur trioxide at different temperatures.



(i) Describe how, and explain why, the percentage yield of sulfur trioxide changes with temperature.

.....

.....

.....

.....[3]

(ii) Suggest why the reaction is carried out at 450 °C and not at 250 °C.

.....

.....

.....[2]

(d) Describe how, and explain why, the position of equilibrium changes when the pressure increases.

.....

.....

.....[2]

(e) Sulfur trioxide oxidises hydrogen bromide to form sulfur dioxide, bromine and water.

Construct the equation for this reaction.

.....[1]

[Total: 10]

[Turn over

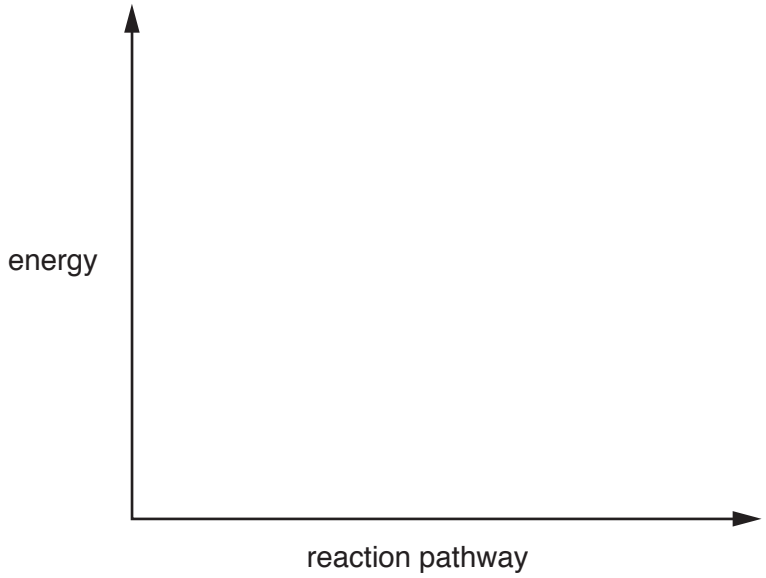
B8 Propenenitrile, CH_2=CHCN, is made by passing a mixture of propene, ammonia and oxygen over a catalyst at 450 °C.

$$CH_3CH=CH_2 + NH_3 + 1\square O_2 \rightarrow CH_2=CHCN + 3H_2O$$

The reaction is exothermic.

(a) Draw an energy profile diagram for this reaction on the axes shown.

On your diagram label
- the reactants and products,
- the enthalpy change for the reaction,
- the activation energy.



[3]

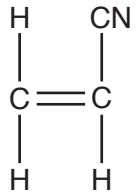
(b) Propenenitrile decolourises aqueous bromine.

Explain why.

.....

.....[1]

(c) The structure of propenenitrile is shown.



Draw the structure of the addition polymer formed from propenenitrile.

[2]

(d) The catalyst used in the reaction to make propenenitrile is molybdenum. Molybdenum is a transition element.

(i) State **two** physical properties of molybdenum.

.....

.....[2]

(ii) Molybdenum reacts with chlorine at room temperature to form molybdenum(VI) chloride, $MoCl_6$. Molybdenum(VI) chloride has a melting point of 254 °C.

Construct an equation for this reaction, including state symbols.

.....[2]

[Total: 10]

B9 Both copper and magnesium are metals.

(a) Explain why magnesium reacts with hydrochloric acid but copper does not.

.....[1]

(b) Brass is an alloy of copper and zinc. The table shows how the composition of brass influences its relative strength.

composition of brass		relative strength
% copper	% zinc	
90	10	2.6
80	20	3.0
70	30	3.3
60	40	3.6

How does the composition of brass affect its strength?

.....

.....[1]

(c) Use your knowledge of the structure of metals to explain why brass is stronger than pure copper.

You may include a labelled diagram in your answer.

.....

.....

.....

.....[3]

(d) Draw a labelled diagram to show how a steel rod can be electroplated with copper.

[3]

(e) A 11.09 g sample of an oxide of copper contains 9.86 g of copper.

Deduce the empirical formula of this oxide of copper.

empirical formula .....[2]

[Total: 10]

B10 A student prepared some crystals of hydrated copper(II) sulfate by reacting excess insoluble copper(II) oxide with dilute sulfuric acid.

$$CuO + H_2SO_4 + 4H_2O \rightarrow CuSO_4.5H_2O$$

(a) Describe how you would obtain pure dry crystals of hydrated copper(II) sulfate from the reaction mixture.

.....

.....

.....

.....

.....

.....[3]

(b) The student used 15.0 cm^3 of 2.00 mol / dm^3 sulfuric acid to prepare the crystals.

Calculate the maximum mass of hydrated copper(II) sulfate crystals that could be made.

..... g [3]

(c) Aqueous ammonia is added to aqueous copper(II) sulfate until the ammonia is in excess.

What is observed as the aqueous ammonia is added?

.....

.....[2]

(d) An aqueous solution of copper(II) sulfate is electrolysed using inert electrodes.

Predict the products of this electrolysis at

the anode (positive electrode), ...

the cathode (negative electrode). .....
[2]

[Total: 10]

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The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

5914817122

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2015**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **20** printed pages.

CAMBRIDGE
International Examinations

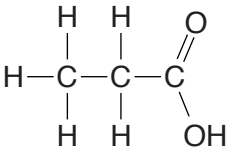
Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following compounds to answer the questions opposite.

A



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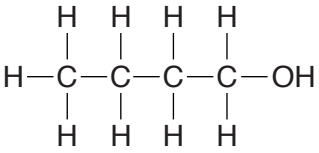

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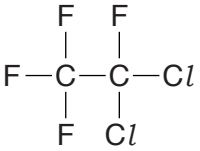

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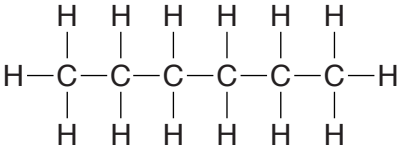

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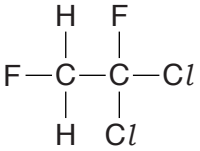

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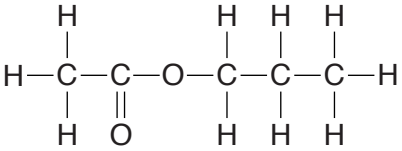

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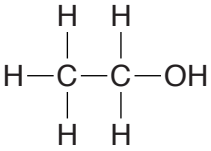

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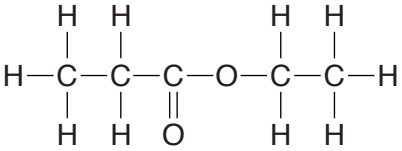


Each compound can be used once, more than once or not at all.

(a) Give the letter of the compound which

(i) is a CFC,

..... [1]

(ii) is propanoic acid,

..... [1]

(iii) is propyl ethanoate,

..... [1]

(iv) can be oxidised to ethanoic acid.

..... [1]

(b) Give the letters of **two** compounds that react together to make an ester.

..... and ..... [1]

[Total: 5]

A2 Hydrogen reacts with halogens to form hydrogen halides.

(a) Predict which halogen reacts most violently with hydrogen.

.....[1]

(b) The reaction between hydrogen and chlorine is exothermic.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \qquad \Delta H = -185\,kJ/mol$$

(i) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

.....

.....

.....

.....[2]

(ii) When one mole of chlorine molecules reacts, 185 kJ of energy is released.

Calculate the amount of energy released when 106.5 g of chlorine reacts.

energy released = ... kJ [2]

(c) Hydrogen reacts with iodine in a reversible reaction.

This reaction reaches an equilibrium if carried out in a closed system.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +53\,kJ/mol$$

(i) The reaction is studied at a temperature of 400 °C.

Describe and explain what happens to the position of equilibrium if the pressure is increased.

.....

.....

.....

.....[2]

(ii) The reaction is studied at 25 atmospheres pressure.

Describe and explain what happens to the position of equilibrium if the temperature is decreased.

.....

.....

.....

.....[2]

(d) Hydrogen iodide dissolves in water to form hydroiodic acid, HI(aq).

Hydroiodic acid is a strong acid.

(i) Write an equation to show the dissociation of hydroiodic acid.

.....[1]

(ii) Hydroiodic acid reacts with calcium.

Write the equation for this reaction.

.....[1]

(iii) Hydroiodic acid reacts with sodium carbonate.

Write the ionic equation for this reaction.

.....[1]

[Total: 12]

A3 Two isotopes of phosphorus are $^{31}_{15}P$ and $^{32}_{15}P$.

(a) State one difference and one similarity between these two isotopes.

difference

.....

.....

similarity

.....

.....
[2]

(b) Phosphorus forms simple molecules which have a relative molecular mass of 124.

Suggest the formula of a phosphorus molecule.

.....[1]

(c) Phosphorus has a low melting point and does not conduct electricity.

(i) Explain why phosphorus has a low melting point.

.....

.....[1]

(ii) Explain why phosphorus does not conduct electricity.

.....

.....[1]

(d) Complete the table for $^{31}_{15}P^{3-}$.

number of neutrons	……
number of protons	……
electronic configuration	……

[3]

(e) Phosphorus forms a compound called phosphine, PH_3.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of phosphine.

Only draw the outer shell electrons.

[2]

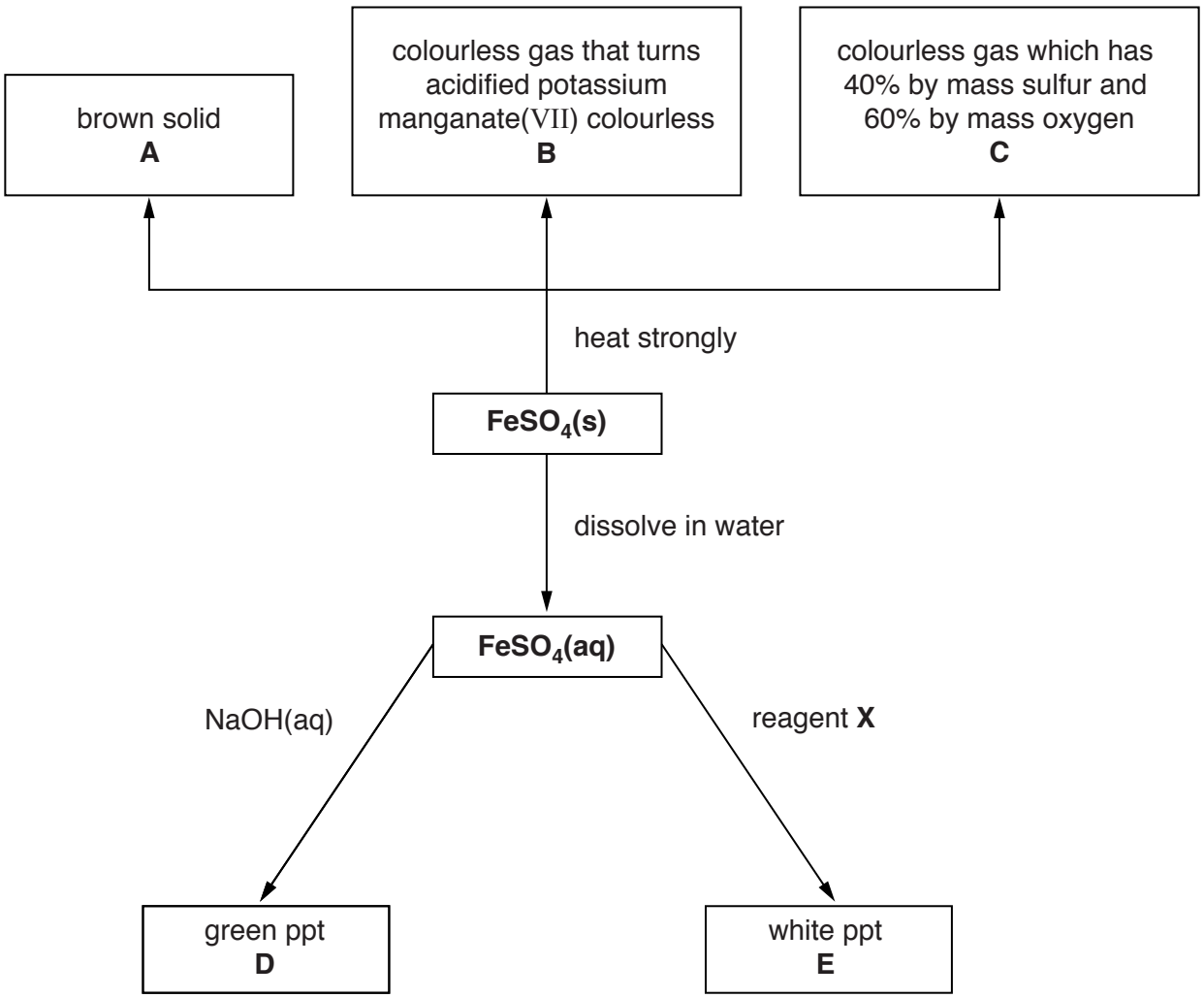
(f) Phosphine ignites in air to make water and phosphorus(V) oxide.

Construct the equation for this reaction.

.....[2]

[Total: 12]

A4 The flow chart shows some reactions of iron(II) sulfate, $FeSO_4$.



(a) Iron(II) sulfate is heated strongly.

(i) Write the formula of gas **B**.

.....[1]

(ii) Calculate the empirical formula of gas **C**.

Name gas **C**.

empirical formula is .....

name .....[3]

(iii) Two moles of iron(II) sulfate decompose to form one mole of solid **A**, one mole of gas **B** and one mole of gas **C**.

Deduce the formula of solid **A**.

formula of **A** .....[1]

(b) Write an ionic equation, including state symbols, for the formation of the green precipitate **D**.

.....[2]

(c) Suggest the name of reagent **X** and give the formula for the white precipitate **E**.

name of reagent **X** .....

formula of precipitate **E** .....[2]

[Total: 9]

A5 Electrolysis is often used in the extraction and purification of elements.

(a) Magnesium is manufactured by the electrolysis of molten magnesium chloride.

Write equations for the two electrode reactions that occur during this electrolysis.

.....

.....[2]

(b) Copper can be purified using the electrolysis of aqueous copper(II) sulfate.

(i) What is used as the anode (positive electrode)?

.....[1]

(ii) What is used as the cathode (negative electrode)?

.....[1]

(c) Chlorine can be made by the electrolysis of concentrated aqueous sodium chloride.

The overall process can be represented by the following equation.

$$2NaCl(aq) + 2H_2O(l) \longrightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$

55 dm^3 of 3.5 mol/dm^3 aqueous sodium chloride is electrolysed.

What is the maximum volume of chlorine that can be formed, measured at room temperature and pressure?

volume of chlorine = ... dm^3 [3]

[Total: 7]

Question B6 begins on page 12.

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 Ammonium carbonate, $(NH_4)_2CO_3$, is a white solid that is a component of 'smelling salts'.

It decomposes when it is heated.

$$(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + H_2O(g) + CO_2(g)$$

(a) A sample of ammonium carbonate is heated strongly until it all decomposes.

Suggest what you would observe during the experiment.

.....

.....[1]

(b) Describe how you would show that both ammonia and carbon dioxide are formed in this decomposition.

.....

.....

.....

.....

.....

.....

.....[4]

(c) Ammonium carbonate is soluble in water but zinc carbonate is insoluble in water.

Describe how you would prepare a sample of pure, dry zinc carbonate using a solution of ammonium carbonate.

.....

.....

.....

.....

.....

.....

.....

.....[3]

(d) Excess ammonium carbonate reacts with phosphoric acid, H_3PO_4.

Construct an equation for this reaction.

.....[2]

[Total: 10]

B7 Titanium can be manufactured by heating titanium(IV) chloride, $TiCl_4$, with magnesium.

(a) Construct the equation for this reaction.

.....[1]

(b) Explain why this reaction involves both oxidation **and** reduction.

.....

.....

.....

.....

.....[2]

(c) What mass of titanium can be made from 125 g of titanium(IV) chloride?

mass of titanium = ... g [3]

(d) Which metal is the less reactive, magnesium or titanium?

Explain your answer.

.....

.....

.....[1]

(e) Titanium(IV) chloride is a liquid with a low boiling point of 126 °C.

Suggest the structure and bonding of titanium(IV) chloride.

.....

.....[2]

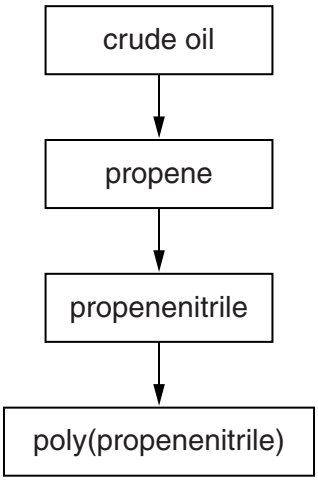
(f) Explain how titanium metal conducts electricity.

.....

.....[1]

[Total: 10]

B8 The flow chart shows the steps involved in the manufacture of poly(propenenitrile).



(a) Long chain alkanes such as $C_{17}H_{36}$ can be cracked to form propene, C_3H_6.

Construct an equation to show the cracking of $C_{17}H_{36}$ to form propene.

.....[1]

(b) The equation shows the reaction to make propenenitrile.

$$2C_3H_6(g) + 2NH_3(g) + 3O_2(g) \rightarrow 2C_3H_3N(g) + 6H_2O(g)$$

Describe and explain what happens to the rate of this reaction if the temperature is increased.

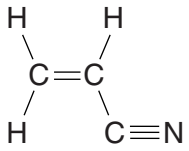
.....

.....

.....

.....[2]

(c) The structure of propenenitrile is shown.



(i) Explain why propenenitrile is unsaturated.

.....

.....[1]

(ii) Describe a chemical test to show that propenenitrile is unsaturated.

.....

.....

.....

.....[2]

(d) Draw part of the structure of poly(propenenitrile).

[2]

(e) A factory uses 1750 tonnes of propenenitrile to produce poly(propenenitrile).

The percentage yield is 95%.

Calculate the mass of poly(propenenitrile) produced.

mass of poly(propenenitrile) = ... tonnes [2]

[Total: 10]

B9 Alkenes are a homologous series of unsaturated hydrocarbons.

The table shows information about some alkenes.

alkene	molecular formula	melting point /°C	boiling point /°C
ethene	C_2H_4	–169	–105
butene	C_4H_8	–185	–6
hexene	C_6H_{12}	–140	63
decene	$C_{10}H_{20}$	–66	171
dodecene	$C_{12}H_{24}$	–35	214

(a) Decene is a liquid at 25 °C.

How can you make this deduction from the data in the table?

.....

.....

.....[2]

(b) Butene boils at –6 °C.

Use the kinetic particle theory to explain what happens when butene boils.

.....

.....

.....

.....[2]

(c) A sample of ethene gas in a gas syringe is heated from 20 °C to 100 °C.

The pressure remains constant.

Describe and explain, in terms of the kinetic particle theory, what happens to the volume of the gas.

.....

.....

.....[2]

(d) At room temperature ethene diffuses faster than butene.

Explain why.

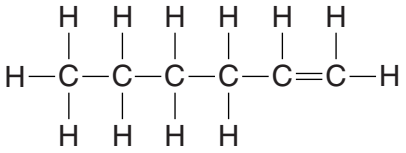
.....

.....[1]

(e) Draw the structure, showing all the atoms and all the bonds, for two isomers with the molecular formula C_4H_8.

[2]

(f) The structure of hexene is shown.



Draw the structure, showing all the atoms and all the bonds, for the product of the reaction of hexene with steam.

[1]

[Total: 10]

DATA SHEET
The Periodic Table of the Elements

Group I	Group II						Group III	Group IV	Group V	Group VI	Group VII	Group 0
					1 **H** Hydrogen 1							4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4						11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12						27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	209 **Po** Polonium 84	210 **At** Astatine 85	222 **Rn** Radon 86
223 **Fr** Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	147 **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	237 **Np** Neptunium 93	244 **Pu** Plutonium 94	243 **Am** Americium 95	247 **Cm** Curium 96	247 **Bk** Berkelium 97	251 **Cf** Californium 98	252 **Es** Einsteinium 99	257 **Fm** Fermium 100	258 **Md** Mendelevium 101	259 **No** Nobelium 102	260 **Lr** Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key: a = relative atomic mass; **X** = atomic symbol; b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

5748052947

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2015**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **20** printed pages.

CAMBRIDGE International Examinations

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following elements to answer the questions below.

aluminium
argon
carbon
copper
iodine
iron
lead
magnesium
nitrogen
oxygen
sulfur

Each of these elements can be used once, more than once or not at all.

Which element

(a) has an ion which, in aqueous solution, reacts with aqueous sodium hydroxide to give a red-brown precipitate,

.....[1]

(b) has an atom with an electronic configuration with only five occupied electron shells,

.....[1]

(c) has an oxide which decolourises acidified potassium manganate(VII),

.....[1]

(d) has a sulfate which is insoluble in water,

.....[1]

(e) provides an inert atmosphere for the extraction of reactive metals,

.....[1]

(f) produces ammonia when it is warmed with an aqueous mixture of sodium nitrate and sodium hydroxide?

.....[1]

[Total: 6]

A2 Plants contain many different types of carbon compounds.

(a) Carbon compounds are made in plants by photosynthesis.

Write the overall equation for photosynthesis and state the conditions required for this process.

.....

.....

.....[3]

(b) Starch is a polymer found in plants.
Starch can be hydrolysed.

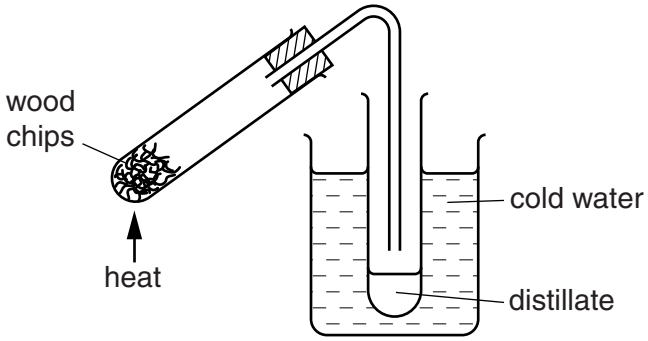
(i) Give the name of the product formed when starch is hydrolysed.

.....[1]

(ii) Give the reagent and conditions needed to hydrolyse starch.

.....[2]

(c) When wood chips are heated in the absence of air, a colourless distillate is formed.



The distillate contains ethanoic acid, esters and other organic compounds.

(i) Ethanoic acid reacts with calcium hydroxide to form a salt and water.

Give the name and formula of the salt formed.

name .....

formula .....[2]

(ii) One of the esters in the distillate has the molecular formula, $C_4H_8O_2$.

Draw the structure of an ester with this formula, showing all the atoms and all the bonds.

[1]

(iii) The distillate also contains a compound with the following composition.

element	percentage by mass
carbon	37.5
hydrogen	12.5
oxygen	50.0

Deduce the empirical formula of this compound.

empirical formula .....[2]

[Total: 11]

A3 Water for use in the home is treated using carbon and chlorine.

(a) Explain the purpose of using carbon and chlorine in water treatment.

carbon.....

chlorine .....[2]

(b) In some parts of the world, drinking water is purified by desalination.

What is meant by the term *desalination*?

.....[1]

(c) River water may contain pollutants from agricultural sources.
These pollutants may cause eutrophication.

Give the names of two anions present in fertilisers which contribute to eutrophication.

..... and ..... [1]

(d) An aqueous solution of barium chloride is added to a sample of water which contains sulfate ions. A white precipitate forms.

Construct an ionic equation, including state symbols, for this reaction.

.....[2]

[Total: 6]

A4 Iron is extracted in a blast furnace. The raw materials required are

- iron ore, which contains iron(III) oxide, Fe_2O_3,
- limestone,
- coke (carbon),
- air.

(a) The coke first burns in air to form carbon dioxide.
The carbon dioxide is then reduced by coke to produce carbon monoxide.
The carbon monoxide reduces the iron(III) oxide to iron.

Write equations for

(i) the reduction of carbon dioxide by coke,

.....[1]

(ii) the reduction of iron(III) oxide to iron by carbon monoxide.

.....[1]

(b) Why is limestone added to the blast furnace?

.....[1]

(c) Another ore of iron contains an oxide with the formula Fe_3O_4.

Calculate the percentage by mass of iron in Fe_3O_4.

[2]

(d) Iron can be obtained by the electrolysis of an aqueous acidified solution of iron(II) sulfate. The reactions at the electrodes are given.

at the anode (positive electrode): $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$

at the cathode (negative electrode): $Fe^{2+} + 2e^- \longrightarrow Fe$

Which reaction is oxidation and which is reduction? Explain your answer.

.....

.....

.....[2]

(e) Attaching magnesium strips to the iron hulls of ships can lower their rate of rusting.

Explain how the magnesium stops the iron from rusting.

.....

.....

.....

.....[2]

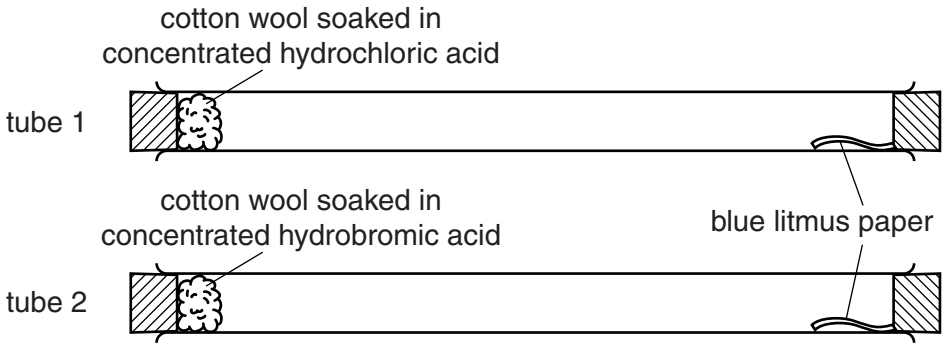
(f) Aqueous iron(II) chloride is one of the products formed when iron reacts with hydrochloric acid.

Construct an equation for this reaction.

.....[1]

[Total: 10]

A5 (a) Two students set up tubes as shown.



Concentrated hydrochloric acid produces fumes of hydrogen chloride.
Concentrated hydrobromic acid produces fumes of hydrogen bromide.

Four minutes after setting up the experiment, the litmus paper in tube 1 turns red.
Seven minutes after setting up the experiment, the litmus paper in tube 2 turns red.

Use the kinetic particle theory to explain

(i) how the gases move through the tubes,

.....

.....

.....

.....[2]

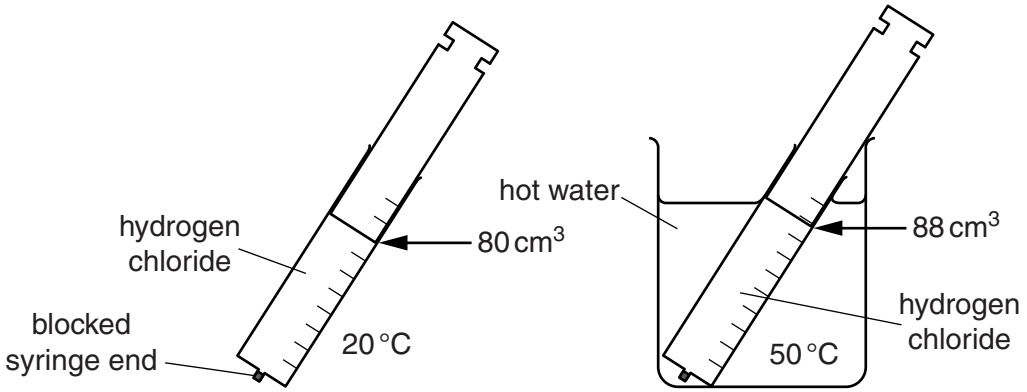
(ii) why the gases take different times to reach the litmus paper.

.....

.....[1]

[Turn over

(b) A gas syringe is filled with 80 cm^3 of hydrogen chloride gas at 20 °C.
The syringe is placed in some hot water at 50 °C.
The atmospheric pressure does not change but the volume of the gas in the syringe increases to 88 cm^3.



Use the kinetic particle theory to explain why the volume increases.

.....

.....

.....

.....[2]

[Total: 5]

A6 When one mole of sulfur burns, 247 kJ of energy is released.

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

(a) Calculate the energy released when 9.60 g of sulfur is burnt.

[2]

(b) When sulfur dioxide is passed through aqueous sodium hydroxide, sodium hydrogensulfite is formed. Sodium hydrogensulfite contains the hydrogensulfite ion, HSO_3^-.

Construct the ionic equation for this reaction.

.....[1]

(c) The hydrogensulfite ion is a weaker acid than ethanoic acid.

Samples of 0.1 g of magnesium are added separately to 0.1 mol / dm^3 ethanoic acid and 0.1 mol / dm^3 hydrogensulfite ions.

Explain why the reaction is faster with ethanoic acid.

.....

.....

.....

.....[2]

(d) Calculate the volume of 0.10 mol / dm^3 sodium hydroxide which contains 3.2 g of sodium hydroxide.

volume of aqueous sodium hydroxide = ... cm^3 [2]

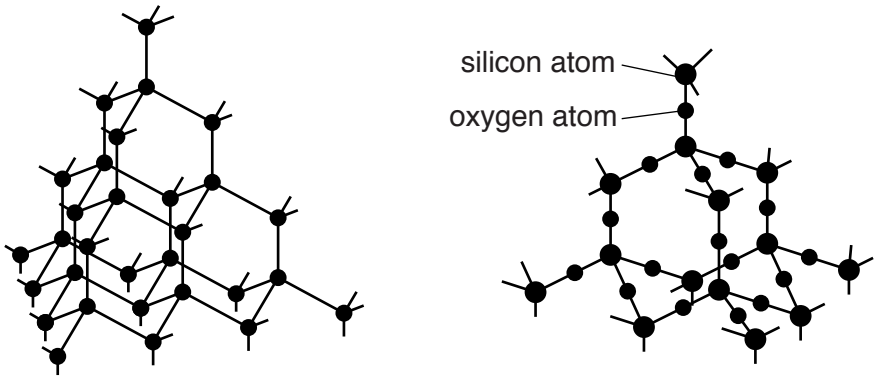
[Total: 7]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 The structures of diamond and silicon dioxide are shown.



diamond silicon dioxide

(a) Describe one similarity in the structures of diamond and silicon dioxide.

.....[1]

(b) Explain why silicon dioxide has a high melting point.

.....

.....[2]

(c) Silicon dioxide reacts with hot concentrated sodium hydroxide to form sodium silicate, Na_2SiO_3.

Deduce the formula of the silicate ion.

.....[1]

(d) Explain why diamond does not conduct electricity.

.....[1]

(e) Graphite is a form of carbon which conducts electricity.
Graphite is used as electrodes in electrolysis.

What is the meaning of the term *electrolysis*?

.....

.....[1]

(f) Aluminium is extracted by the electrolysis of molten aluminium oxide dissolved in cryolite.

Construct the equation for the reaction at

(i) the anode (positive electrode),

.....[1]

(ii) the cathode (negative electrode).

.....[1]

(g) An isotope of silicon is represented by the symbol $^{29}_{14}Si$.

Deduce the number of protons and neutrons in this isotope.

number of protons .....

number of neutrons .....[1]

(h) Silicon has a relative atomic mass of 28.

Define the term *relative atomic mass*.

.....

.....[1]

[Total: 10]

B8 Chlorine reacts with sodium hydroxide.

$$Cl_2(g) + 2NaOH(aq) \longrightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

(a) A volume of 144 cm^3 of chlorine gas, measured at room temperature and pressure, is passed into 38.0 cm^3 of 0.250 mol/dm^3 sodium hydroxide.

Show by calculation which reactant is in excess.

[3]

(b) Chlorine displaces bromine from an aqueous solution of potassium bromide.

(i) Construct the equation for this reaction.

.....[2]

(ii) Explain why bromine does not react with aqueous potassium chloride.

.....

.....[1]

(iii) Give the charge of a chloride ion and its electronic configuration.

charge .....

electronic configuration .....[2]

(c) Explain why sodium chloride does not conduct electricity when solid but does conduct electricity when molten.

.....

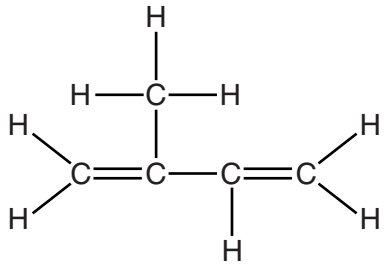
.....

.....[2]

[Total: 10]

Question B9 begins on page 16.

B9 When rubber is heated in the absence of air, a small amount of isoprene is formed. The structure of isoprene is shown.



(a) Isoprene is an unsaturated hydrocarbon.

Describe a test for an unsaturated hydrocarbon.

.....

.....[2]

(b) Isoprene is a liquid at 25 °C.

Describe the arrangement and motion of the particles in isoprene at 25 °C.

.....

.....[2]

(c) Isoprene reacts with sulfur dioxide to form methylsulfolene.

$$\underset{\text{isoprene}}{C_5H_8} + SO_2 \rightarrow \underset{\text{methylsulfolene}}{C_5H_8SO_2}$$

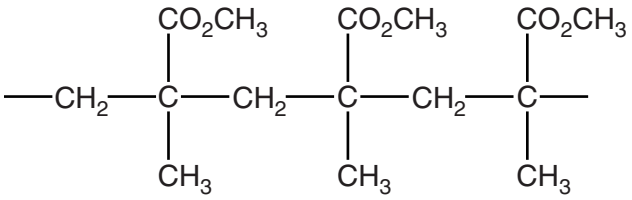
Calculate the maximum mass of methylsulfolene that can be formed from 100 g of isoprene.

mass of methylsulfolene = ... g [3]

(d) (i) What feature of the isoprene molecule is responsible for it forming an addition polymer?

.....[1]

(ii) *Perspex* is also an addition polymer.
The diagram shows part of the polymer chain of *Perspex*.



Deduce the formula of the monomer used to make *Perspex*.

[2]

[Total: 10]

B10 At 200 °C and 200 atmospheres pressure, phosphorus(V) chloride forms an equilibrium mixture with phosphorus(III) chloride and chlorine.

$$\underset{\text{phosphorus(V) chloride}}{PCl_5(g)} \rightleftharpoons \underset{\text{phosphorus(III) chloride}}{PCl_3(g)} + Cl_2(g)$$

(a) Predict and explain the effect of decreasing the pressure on the position of this equilibrium. The temperature remains constant.

.....

.....

.....[2]

(b) Predict and explain the effect of increasing the concentration of chlorine on the position of this equilibrium.

.....

.....

.....[2]

(c) The table shows the percentage of phosphorus(III) chloride in the equilibrium mixture at different temperatures. The pressure is the same in each case.

temperature / °C	% PCl_3 in the mixture
200	48
300	95
400	99

(i) Describe how the composition of this equilibrium mixture changes with temperature.

.....

.....[1]

(ii) Explain what this tells you about the energy change in this reaction.

.....

.....[1]

(d) How is the position of equilibrium affected by the presence of a catalyst?

.....[1]

(e) The rate of this reaction increases with increase in temperature.
Explain why.

.....

.....

.....

.....[2]

(f) Phosphorus(V) chloride reacts with water. Phosphoric acid, H_3PO_4, and hydrogen chloride are formed.

Construct the equation for this reaction.

.....[1]

[Total: 10]

DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radius 88	227 Ac Actinium 89 †															

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* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key

a	a = relative atomic mass
X	X = atomic symbol
b	b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2014**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
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Write your answers in the spaces provided in the Question Paper.

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A copy of the Periodic Table is printed on page 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **18** printed pages and **2** blank pages.

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following gases to answer the questions below.

$CCl F_3$

CH_4

CO

CO_2

H_2

N_2

NH_3

O_2

SO_2

Each gas can be used once, more than once or not at all.

Which gas is

(a) used in making steel,

.....[1]

(b) made by the bacterial decay of vegetable matter,

.....[1]

(c) responsible for ozone depletion in the upper atmosphere,

.....[1]

(d) used to manufacture margarine?

.....[1]

[Total: 4]

A2 Farmers use chemicals to improve crop yield.

Ammonium phosphate, $(NH_4)_3PO_4$, is used as a fertiliser and calcium hydroxide, $Ca(OH)_2$, is used to reduce the acidity of soils.

The relative formula mass of ammonium phosphate is 149.

(a) Calculate the percentage by mass of nitrogen in ammonium phosphate.

percentage = ... % [1]

(b) A farmer adds ammonium phosphate to a field.

He then adds calcium hydroxide to the field because the soil is very acidic.

(i) Calcium hydroxide neutralises the acid in the soil.

Give the ionic equation for this reaction.

.....[1]

(ii) The calcium hydroxide reduces the effectiveness of the ammonium phosphate fertiliser because it reduces the nitrogen content.

Explain why adding calcium hydroxide reduces the nitrogen content.

.....

.....

.....[2]

(c) A sample of ammonium phosphate can be produced by the reaction of aqueous ammonia and phosphoric acid.

$$3NH_3(aq) + H_3PO_4(aq) \rightarrow (NH_4)_3PO_4(aq)$$

25.0 cm^3 of 1.25 mol/dm^3 phosphoric acid is neutralised by 45.3 cm^3 of aqueous ammonia.

(i) Calculate the concentration, in mol/dm^3, of the ammonia used.

concentration of ammonia = ... mol/dm^3 [3]

(ii) Show, by calculation, that 4.66 g of ammonium phosphate would be produced. Assume that the yield is 100%.
[M_r: $(NH_4)_3PO_4$, 149]

[1]

(iii) In practice, the actual mass of ammonium phosphate produced is 2.93 g.

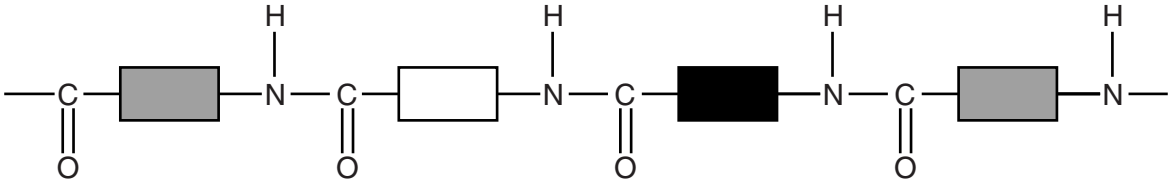
Calculate the percentage yield of ammonium phosphate.

percentage yield = ... % [1]

[Total: 9]

A3 Proteins, carbohydrates and fats are natural macromolecules.

The partial structure of a protein is shown below.



(a) Name the linkage that joins the monomer units in a protein.

..... [1]

(b) Name a synthetic polymer that has the same linkage as a protein.

..... [1]

(c) Proteins are hydrolysed to give a mixture of colourless amino acids.

Describe, with the aid of a labelled diagram, how paper chromatography can be used to identify the amino acids present in a mixture of amino acids.

.....

.....

.....

.....[4]

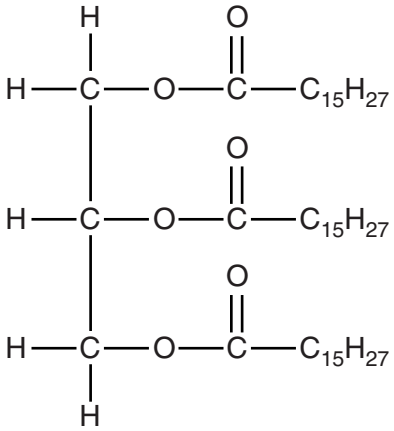
[Turn over

(d) Carbohydrates can be hydrolysed.

Name the class of compound formed when carbohydrates are hydrolysed.

..... [1]

(e) The diagram shows the structure of a simple fat.



(i) This fat is polyunsaturated.

What is the meaning of the term *polyunsaturated*?

.....

.....

.....[2]

(ii) Describe a chemical test to show that the fat is unsaturated.

name of reagent .....

result of test .....[2]

(iii) Name a synthetic macromolecule that contains the same linkage as fats.

.....[1]

[Total: 12]

A4 Only liquids that contain moving ions can be electrolysed. These liquids are called electrolytes.

(a) Complete the following table which shows the products formed when some liquids are electrolysed using inert graphite electrodes.

electrolyte	ions present in electrolyte	product formed at the positive electrode	product formed at the negative electrode
aqueous copper(II) sulfate	Cu^{2+}, H^+, OH^- and SO_4^{2-}	.....	.....
concentrated aqueous sodium chloride	H^+, Na^+, Cl^- and OH^-	chlorine	hydrogen
molten lead(II) bromide	Pb^{2+} and Br^-	.....	.....

[3]

(b) When concentrated aqueous sodium chloride is electrolysed, chlorine is formed at the positive electrode (anode) and hydrogen at the negative electrode (cathode).

(i) Construct the ionic equation to show the formation of chlorine at the positive electrode.

.....[1]

(ii) Explain why hydrogen is formed at the negative electrode rather than sodium.

.....

.....[1]

(c) Name a metal manufactured by the electrolysis of a molten ionic compound.

.....[1]

[Total: 6]

[Turn over

A5 Haematite, limestone and coke are heated together in a blast furnace in the manufacture of iron.

(a) State why each of the following compounds are needed in a blast furnace.

haematite .....

.....

limestone .....

.....

coke .....

.....[3]

(b) Iron has a high melting point because it has strong metallic bonding.

Describe, using a labelled diagram, metallic bonding.

.....

.....[2]

(c) When iron is made into the alloy steel, the properties of iron are changed.

High carbon steels are stronger than iron but are brittle.

State a property of low carbon steels.

.....[1]

(d) When magnesium powder is added to aqueous iron(II) sulfate, the following reaction occurs.

$$Mg(s) + Fe^{2+}(aq) \rightarrow Mg^{2+}(aq) + Fe(s)$$

(i) Explain, using electron transfer, why iron(II) ions are reduced in this reaction.

.....

.....[1]

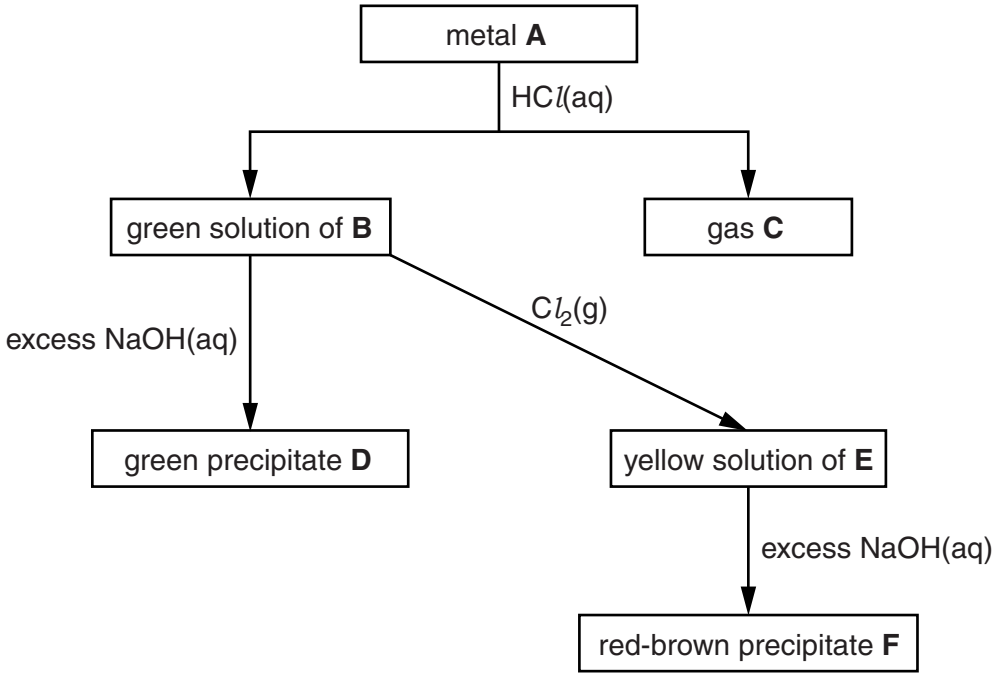
(ii) What would you observe in this reaction?

.....

.....[1]

[Total: 8]

A6 The flow chart shows the reactions of metal **A** and some of its compounds.



Identify, by name, each of the substances.

A .....

B .....

C .....

D .....

E .....

F .....

[Total: 6]

Section B

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 Alkanes are a homologous series of hydrocarbons.

(a) There are two alkanes with the molecular formula C_4H_{10}.

Draw the structures, showing all the atoms and all the bonds, of these two alkanes.

[2]

(b) One of the alkanes with the molecular formula C_4H_{10} is butane.

Butane is used as a fuel.

(i) Construct the equation for the **complete** combustion of butane.

.....[1]

(ii) Describe one problem associated with the **incomplete** combustion of butane.

.....

.....[1]

(c) Butane reacts with chlorine in the presence of ultraviolet radiation.

Write an equation for this reaction.

.....[1]

(d) Nonane, C_9H_{20}, is heated strongly in the presence of a catalyst. Two products are made: an alkane, **G**, and an alkene, **H**.

(i) Name this type of reaction.

.....[1]

(ii) Alkane **G** contains 84% carbon by mass.

Calculate the molecular formula for **G**.

molecular formula ..... [3]

(iii) Suggest a molecular formula for **H**.

.....[1]

[Total: 10]

[Turn over

B8 Butan-1-ol, $CH_3CH_2CH_2CH_2OH$, and ethanol, CH_3CH_2OH, are both alcohols.

Alcohols, such as ethanol, react with sodium to form hydrogen.

$$2CH_3CH_2OH + 2Na \rightarrow 2CH_3CH_2ONa + H_2$$

(a) Construct the equation to show the reaction of butan-1-ol with potassium.

.....[1]

(b) Describe the chemical test for hydrogen.

.....[1]

(c) A sample containing 0.233 g of an unknown Group I element is added to excess ethanol. The volume of hydrogen gas formed at room temperature and pressure is 400 cm^3.

Calculate the relative atomic mass, A_r, of the Group I element and suggest the identity of the element.

relative atomic mass = ...

identity of the element = ...[4]

(d) Ethanol reacts with ethanoic acid to make an organic compound.

Draw the structure, showing all the atoms and all the bonds, of this organic compound.

[1]

(e) Describe the manufacture of ethanol starting from glucose. Include an equation and the conditions needed.

.....

.....

.....

.....

.....[3]

[Total: 10]

B9 When iron is heated with steam in a sealed container, an equilibrium mixture is obtained.

$$3Fe(s) + 4H_2O(g) \rightleftharpoons 4H_2(g) + Fe_3O_4(s) \qquad \Delta H = +35\,kJ/mol$$

(a) The forward reaction is endothermic. What is the meaning of the term *endothermic*?

.....

.....[1]

(b) Describe and explain what happens to the rate of the forward reaction when the temperature is increased. The pressure remains constant.

.....

.....

.....

.....[2]

(c) Describe and explain what happens, if anything, to the position of equilibrium when the pressure is increased. The temperature remains constant.

.....

.....

.....

.....[2]

(d) Calculate the mass of Fe_3O_4 formed when 2.80 g of iron completely reacts with excess steam.

mass of Fe_3O_4 = ... g [3]

(e) At room temperature iron will rust in moist air.

Describe and explain how galvanising iron prevents rusting.

.....

.....

.....

.....[2]

[Total: 10]

B10 Astatine, At, is an element in Group VII of the Periodic Table.

The table shows some information about two isotopes of astatine.

symbol	number of protons	number of electrons	number of neutrons
$^{210}_{85}At$	.....	.....	.....
$^{211}_{85}At$	.....	.....	.....

(a) (i) Complete the table. [2]

(ii) What is meant by the term *isotopes*?

.....

.....

.....[1]

(b) Astatine forms a diatomic molecule with the same type of bonding as in a chlorine molecule.

Draw the 'dot-and-cross' diagram for an astatine molecule.

Only draw the outer shell electrons.

[1]

(c) Astatine reacts with magnesium to form magnesium astatide, $MgAt_2$, which contains Mg^{2+} and At^- ions.

(i) Describe how a magnesium ion and an astatide ion are formed from a magnesium atom and an astatine atom.

.....

.....

.....

.....[2]

(ii) Predict **two** physical properties of magnesium astatide.

1. .....

2. .....[2]

(d) **(i)** Bromine reacts with aqueous magnesium astatide. Construct the ionic equation for this reaction.

.....[1]

(ii) Explain why astatine does not react with aqueous magnesium iodide.

.....

.....[1]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key

a	a = relative atomic mass
X	X = atomic symbol
b	b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge
O Level

Cambridge International Examinations
Cambridge Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5806414091

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2014**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

A copy of the Periodic Table is printed on page 20.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **20** printed pages.

CAMBRIDGE International Examinations

Section A

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 The diagram shows part of the Periodic Table. Only some of the elements are shown.

							H										
													C	N		F	
													Si	P	S	Cl	
			Ti				Fe			Cu	Zn			As		Br	

(a) Answer each of the following questions using only those elements shown in the diagram. Each element may be used once, more than once or not at all.

Give one element which

(i) is a simple molecular solid at room temperature and pressure,

.....[1]

(ii) oxidises in the presence of water and air to form rust,

.....[1]

(iii) has an atom with three occupied electron shells, the outer of which has only 5 electrons,

.....[1]

(iv) has an oxide which is amphoteric,

.....[1]

(v) has a chloride of type XCl_3 whose aqueous solution forms a reddish-brown precipitate on addition of aqueous ammonia,

.....[1]

(vi) is a colourless diatomic gas.

.....[1]

(b) (i) Arsenic reacts with oxygen to form arsenic(III) oxide, As_2O_3.

Construct the equation for this reaction.

.....[1]

(ii) Arsenic(III) oxide is slightly soluble in water. A weak acid, arsenous acid, H_3AsO_3, is formed.

Use kinetic particle theory to explain why a 0.05 mol / dm^3 solution of arsenous acid reacts much more slowly with magnesium ribbon than a 0.05 mol / dm^3 solution of hydrochloric acid.

.....

.....

.....

.....[2]

[Total: 9]

A2 The table shows some properties of the Group I metals.

metal	density in g/cm^3	melting point /°C	boiling point /°C
lithium	0.53	181	1342
sodium	0.97	98	883
potassium	0.86	63	
rubidium	1.53	39	686
caesium	1.88	29	669

(a) (i) Describe the general trend in the density of the Group I metals.

.....[1]

(ii) Predict the boiling point of potassium.

.....[1]

(iii) What is the physical state of caesium at 35 °C? Explain your answer.

.....

.....[1]

(b) (i) Describe the trend in reactivity of the Group I metals with water.

.....[1]

(ii) Construct the equation for the reaction of rubidium with water.

.....[1]

(iii) The reaction of rubidium with water is exothermic.
What is meant by the term *exothermic*?

.....[1]

(c) Sodium and calcium form ionic hydrides containing the hydride ion, H^-.
Sodium and calcium hydrides react with water to form the hydroxide and hydrogen.

$$NaH + H_2O \rightarrow NaOH + H_2$$

$$CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2$$

Deduce the general ionic equation for these reactions.

.....[1]

(d) Sodium is a soft metal with little catalytic activity.
Nickel is a hard metal which is often used as a catalyst.

(i) Describe two **other** differences in the physical properties of sodium and nickel.

1 .....

.....

2 .....

.....
[2]

(ii) State one industrial use of nickel as a catalyst.

.....[1]

(iii) Explain why an alloy of nickel and copper is less malleable than copper alone.

.....

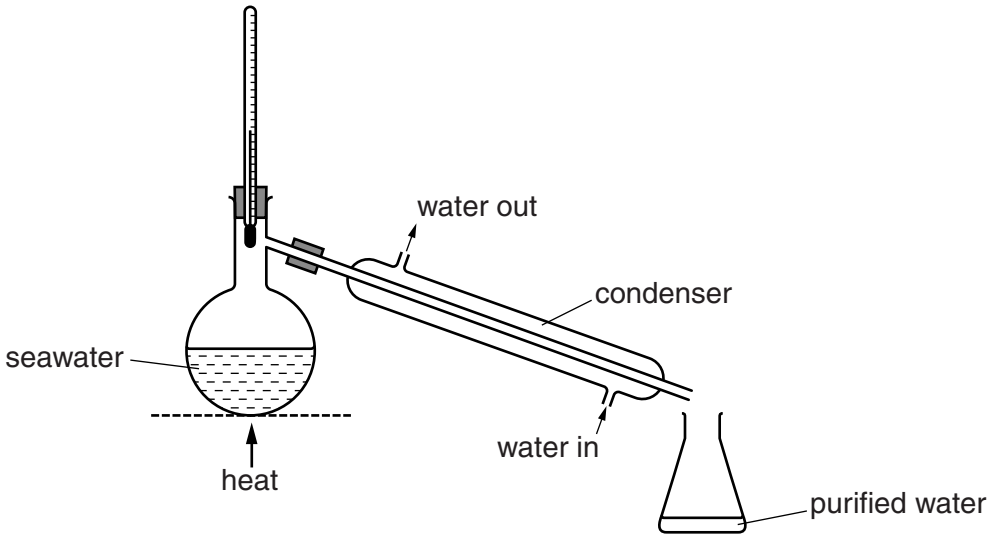
.....

.....[2]

[Total: 12]

A3 Seawater contains a variety of dissolved salts.

(a) The diagram shows a simple distillation apparatus that can be used to produce purified water from seawater.



Explain how distillation purifies seawater.

.....

.....

.....

.....[3]

(b) Magnesium chloride, $MgCl_2$, is present in seawater at a concentration of $1.26\,g/dm^3$.

(i) Write the formulae for the ions present in magnesium chloride.

.....[1]

(ii) Calculate the concentration of chloride ions, in mol/dm^3, arising from the magnesium chloride in seawater.

concentration = ... mol/dm^3 [1]

(iii) Aqueous silver nitrate is added to a small sample of seawater.
Describe what you would observe.

.....[1]

(c) The concentration of sulfate ions in seawater is $1.24\,g/dm^3$.
Excess aqueous barium chloride is added to a $50.0\,cm^3$ sample of seawater.

Calculate the mass of barium sulfate precipitated in this reaction.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

mass = ... g [3]

[Total: 9]

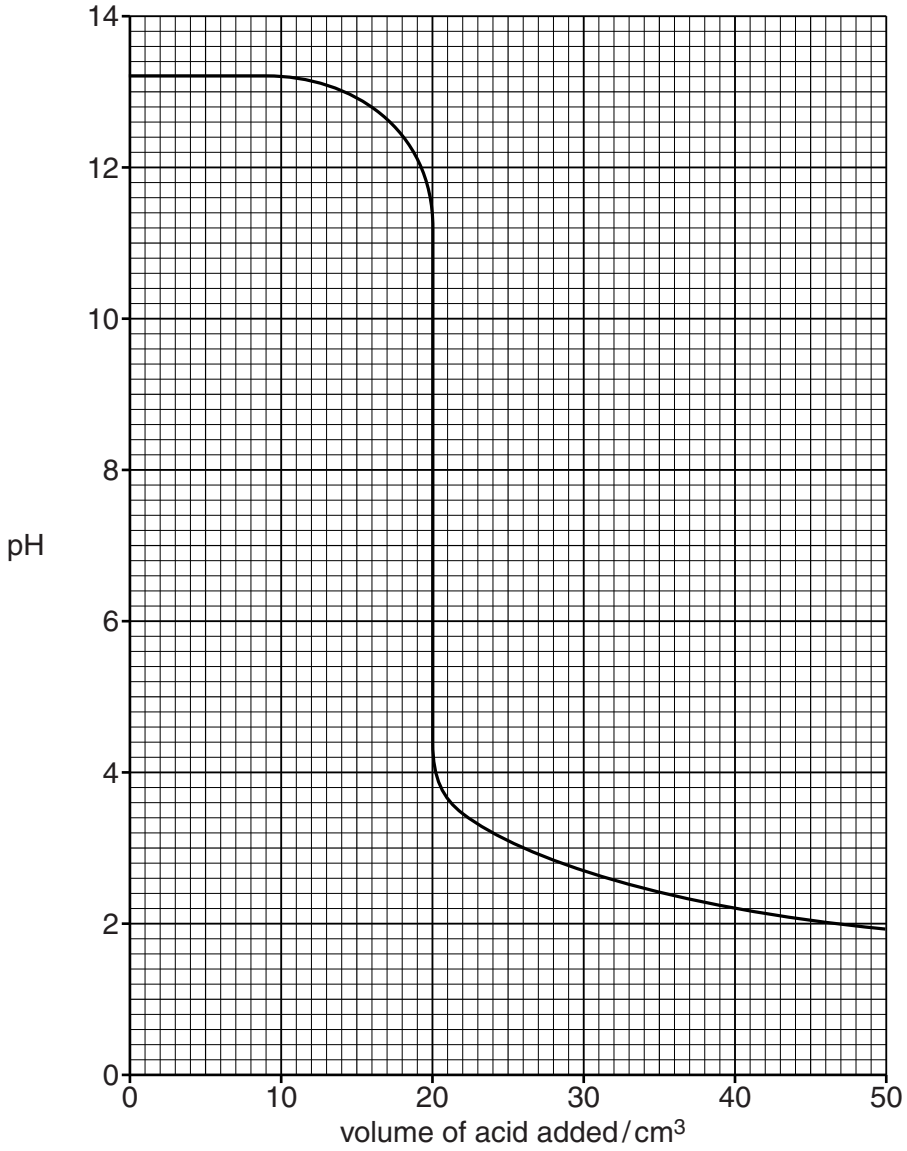
A4 Sulfuric acid reacts with the alkali sodium hydroxide.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(a) Write the ionic equation for this reaction.

.....[1]

(b) The graph below shows how the pH changes when aqueous sulfuric acid is added slowly to 45.0 cm^3 of 0.150 mol/dm^3 sodium hydroxide until the acid is in excess.



(i) What volume of acid has been added when the pH is 7?

.....[1]

(ii) Use your answer to part **(i)** to calculate the concentration, in mol/dm^3, of the sulfuric acid.

concentration = ... mol/dm^3 [3]

(c) The experiment was repeated using ethanoic acid of the same concentration as the sulfuric acid. The same volume and concentration of aqueous sodium hydroxide was used.

(i) The volume of ethanoic acid required to neutralise the aqueous sodium hydroxide was twice as great compared with the volume of sulfuric acid.

Explain why.

.....

.....[1]

(ii) Suggest the value of the pH after excess ethanoic acid has been added.

.....[1]

(d) Sulfuric acid is one of the acids present in acid rain.

(i) Suggest how sulfuric acid is formed in the atmosphere.

.....

.....

.....[2]

(ii) State one effect of acid rain on human health.

.....[1]

[Total: 10]

[Turn over

A5 The table below shows the reactivity of five metals with either cold water or steam or with both.

metal	reactivity
barium	reacts rapidly with cold water
copper	no reaction with steam or cold water
magnesium	reacts very slowly with cold water but reacts with steam
sodium	reacts very rapidly with cold water
nickel	only reacts when powdered and heated strongly in steam

(a) Deduce the order of reactivity of these metals using the information in the table.

most reactive .....

.....

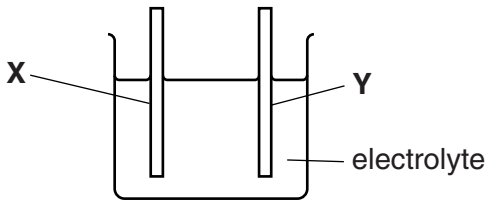
.....

.....

least reactive ..... [1]

(b) A simple electrochemical cell contains two electrodes in an electrolyte.

(i) Complete the diagram below to show how you could measure the voltage between the two different metal electrodes **X** and **Y**.



[1]

(ii) The order of reactivity of some metals is shown below.

iron	cobalt	tin	copper	silver
most reactive	←			least reactive

Which combination of metals from this list would produce the highest voltage when used as electrodes in an electrochemical cell?

.....[1]

(c) Strips of zinc can be attached to the hull of a ship to stop the steel from rusting.
Explain how these strips of zinc stop the steel from rusting.

.....

.....

.....[2]

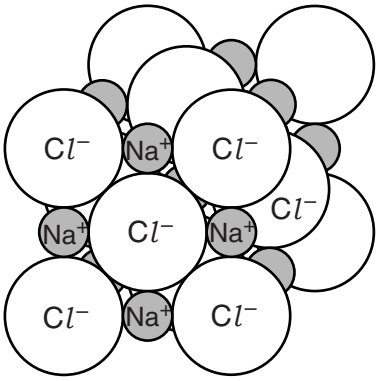
[Total: 5]

Section B

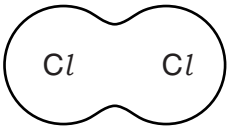
Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 The structures of sodium chloride and chlorine are shown below.



sodium chloride



chlorine

(a) The melting point of sodium chloride is 801 °C.
The melting point of chlorine is –101 °C.

Explain, in terms of structure and bonding, the difference between the melting points of these two substances.

.....

.....

.....

.....

.....

.....[4]

(b) Explain why molten sodium chloride conducts electricity but solid sodium chloride does not.

.....

.....

.....[1]

(c) Draw a 'dot-and-cross' diagram for sodium chloride, showing all the electron shells.

[2]

(d) The electrode reactions occurring when molten sodium chloride is electrolysed are shown below.

negative electrode $Na^+ + e^- \longrightarrow Na$

positive electrode $2Cl^- \longrightarrow Cl_2 + 2e^-$

Refer to these equations to explain why this electrolysis involves both oxidation and reduction.

.....

.....

.....[2]

(e) Chlorine reacts with excess ammonia, NH_3, to form hydrogen chloride and nitrogen. Construct an equation for this reaction.

.....[1]

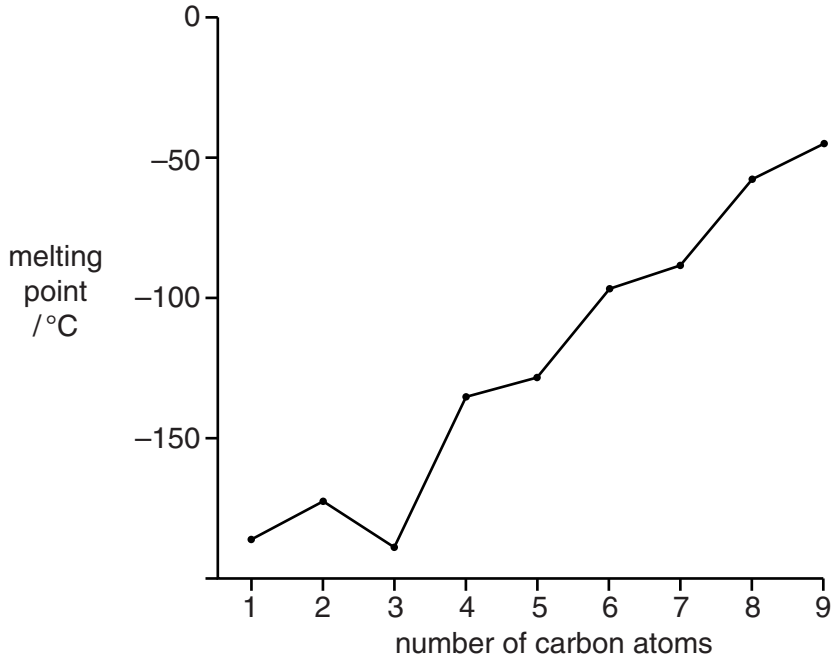
[Total: 10]

B7 The alkanes are a homologous series of hydrocarbons.

(a) Give the name of another homologous series of hydrocarbons.

.....[1]

(b) The graph below shows how the melting points of the first nine alkanes vary with the number of carbon atoms.



Describe how the melting points of the alkanes with more than two carbon atoms vary as the number of carbon atoms increases.

.....

.....

.....[2]

(c) Nonane is an alkane with nine carbon atoms.
Give the molecular formula for nonane.

.....[1]

(d) One mole of undecane, $C_{11}H_{24}$, is cracked to form a mixture containing one mole of ethene, one mole of propene and one mole of another hydrocarbon.

(i) Construct the equation for this reaction.

.....[1]

(ii) Explain why oil companies crack the longer chain hydrocarbons.

.....

.....

.....[2]

(e) Hydrogen cyanide, HCN, is manufactured by reacting methane with ammonia and oxygen.

$$2CH_4 + 2NH_3 + 3O_2 \rightarrow 2HCN + 6H_2O$$

(i) Calculate the mass of hydrogen cyanide that can be formed from 500 g of methane if the percentage yield of hydrogen cyanide is 65%.

mass = ...g [2]

(ii) Hydrogen cyanide reacts with calcium hydroxide to form calcium cyanide and water. The formula of the cyanide ion is CN^-.

Construct the equation for this reaction.

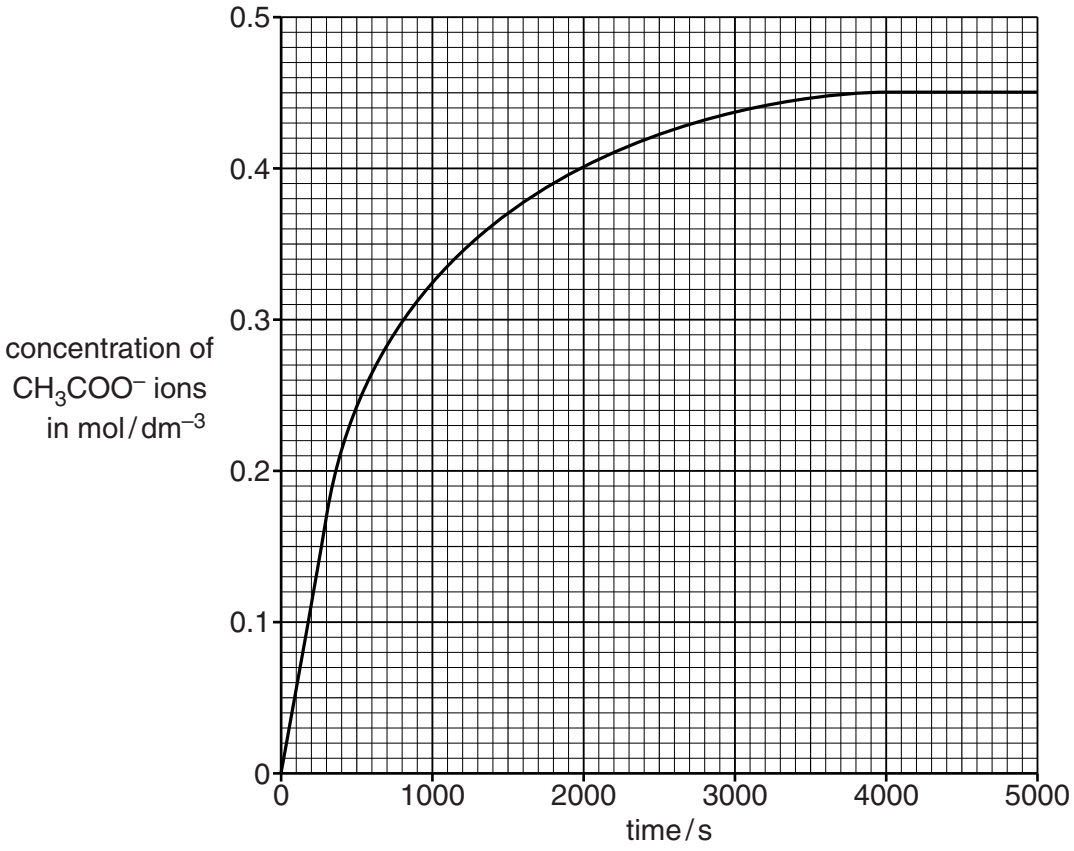
.....[1]

[Total: 10]

B8 The ester, ethyl ethanoate, reacts with hydroxide ions to form ethanoate ions and ethanol.

$$\underset{\text{ethyl ethanoate}}{CH_3COOC_2H_5} + OH^- \rightarrow \underset{\text{ethanoate ions}}{CH_3COO^-} + C_2H_5OH$$

(a) The graph shows how the concentration of ethanoate ions, CH_3COO^-, changes as the reaction proceeds.



(i) Use the information in the graph to deduce the mass of ethanoate ions in 200 cm^3 of solution when the reaction is complete.

mass = ...g [2]

(ii) Use the information in the graph to calculate the average rate of reaction, in mol/dm^3/s, during the first 300 seconds.

average rate of reaction .....mol/dm^3/s [1]

(iii) Describe and explain, using the kinetic particle theory, the change in the rate of reaction with time.

.....

.....

.....

.....

.....[3]

(b) Aqueous sodium hydroxide reacts with aqueous iron(II) sulfate, $FeSO_4$.
Construct the ionic equation, with state symbols, for this reaction.

.....[2]

(c) Iron(II) sulfate can be prepared by reacting excess iron powder with sulfuric acid.
Describe the essential practical details to prepare pure dry crystals of iron(II) sulfate.

.....

.....

.....

.....

.....[2]

[Total: 10]

B9 Ammonia is manufactured by the Haber process.

$$N_2 + 3H_2 \overset{\text{Fe catalyst}}{\rightleftharpoons} 2NH_3 \qquad \Delta H = -92.4\,\text{kJ/mol}$$

The table below shows how the percentage yield of ammonia at equilibrium varies with both temperature and pressure.

pressure /atmospheres	% yield at 200 °C	% yield at 300 °C	% yield at 400 °C	% yield at 500 °C
30	68	32	11	4
100	81	51	25	10
200	86	63	36	18
300	88	69	40	24

(a) Describe how, and explain why, the percentage yield of ammonia at equilibrium changes with temperature.

.....

.....

.....[2]

(b) Describe how, and explain why, the percentage yield of ammonia at equilibrium changes with pressure.

.....

.....

.....[2]

(c) Explain why the conditions for the synthesis of ammonia in most chemical plants are between 350–450 °C and 200–300 atmospheres pressure.

.....

.....

.....

.....[2]

(d) Explain how using a catalyst in the Haber process has an economic advantage.

.....

.....

.....[2]

(e) Ammonia is used to make fertilisers such as ammonium phosphate, $(NH_4)_3PO_4$.
Calculate the percentage by mass of nitrogen in ammonium phosphate.

[2]

[Total: 10]

DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2013**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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This document consists of **19** printed pages and **1** blank page.

Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following elements to answer the questions below.

barium

calcium

carbon

copper

helium

hydrogen

iron

lead

lithium

sulfur

zinc

Each element can be used once, more than once or not at all.

Name an element which

(a) forms two acidic oxides,

..... [1]

(b) has an ion which, in aqueous solution, reacts with aqueous sodium hydroxide to give a green precipitate,

..... [1]

(c) has an atom with an electronic configuration with only four occupied shells,

..... [1]

(d) has two giant molecular structures,

..... [1]

(e) has an ion which, in aqueous solution, is used to test for sulfate ions,

..... [1]

(f) reacts with water to form an alkaline solution.

..... [1]

[Total: 6]

A2 Both respiration and combustion add carbon dioxide to the atmosphere.

For Examiner's Use

(a) Give one reason why scientists are concerned about the increasing use of fossil fuels.

.....

..... [1]

(b) Respiration is a process that occurs in living organisms where glucose, $C_6H_{12}O_6$, reacts with oxygen.

Write the overall equation that represents respiration.

..... [1]

(c) Respiration is an exothermic reaction.

(i) Explain, in terms of the energy changes that occur during bond breaking and bond making, why respiration is an exothermic reaction.

.....

.....

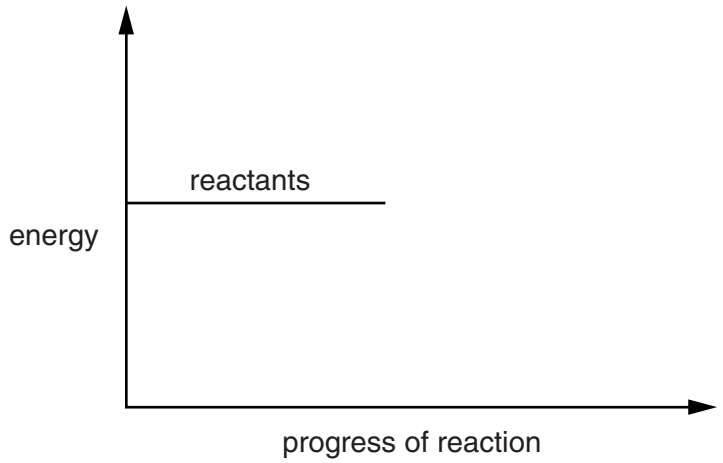
.....

..... [2]

(ii) Complete the energy profile diagram for respiration.

On your diagram label the

- products,
- enthalpy change for the reaction, ΔH,
- activation energy, E_a.



[3]

[Total: 7]

A3 Aluminium is a metal and both iodine and bromine are non-metals.

For Examiner's Use

(a) How does the number of valency electrons help to explain why aluminium is a metal and iodine and bromine are non-metals?

.....

.....

.....

..... [2]

(b) At room temperature iodine is a solid and bromine is a liquid.

Describe the difference between both the arrangement and the motion of particles in a solid and a liquid.

.....

.....

..... [2]

(c) Iodine and bromine form the compound iodine bromide, IBr.

Draw the 'dot-and-cross' diagram for IBr.

Only draw the outer shell electrons.

[1]

(d) Describe how bromine is used to test for unsaturation in organic compounds.

.....

..... [1]

(e) Aluminium is used to make alloys for the aircraft industry. One reason for this is that aluminium does not corrode very easily.

For Examiner's Use

(i) State one other reason why aluminium is used in the manufacture of aircraft.

..... [1]

(ii) Explain why aluminium does not corrode very easily.

.....

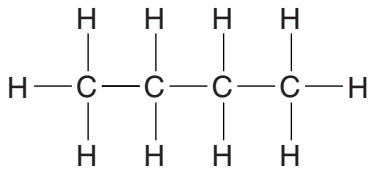
.....

..... [2]

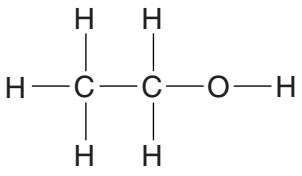
[Total: 9]

A4 The structures of some of the compounds that can be manufactured from crude oil are shown.

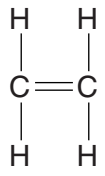
For Examiner's Use



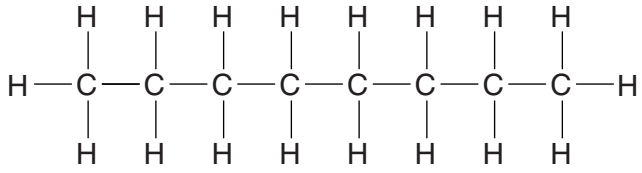
butane



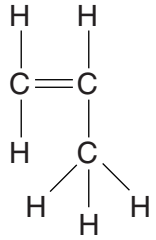
ethanol



ethene



octane



propene

(a) Octane is found in the petrol fraction separated from crude oil.

Name the process by which petrol is separated from crude oil and state the physical property which allows this process to be carried out.

.....

.....

..... [2]

(b) Hexadecane, $C_{16}H_{34}$, can be cracked to produce a mixture of alkanes and alkenes.

Construct an equation to show the cracking of hexadecane to produce octane.

..... [2]

(c) Propene can be polymerised to make poly(propene).

Draw a section of the structure of poly(propene).

[2]

(d) Ethanol is manufactured by a hydration reaction.

State both the reagents and conditions for this reaction.

.....

..... [2]

[Total: 8]

A5 Analysis of compound **X** shows it has the following composition.

For Examiner's Use

element	percentage by mass
hydrogen	3.40
nitrogen	12.0
oxygen	41.0
vanadium	43.6

(a) Show that **X** has the formula H_4NO_3V.

[2]

(b) Suggest one property of aqueous **X** caused by the presence of vanadium.

..... [1]

(c) Aqueous sodium hydroxide is added to solid **X** and the mixture is warmed.

A colourless gas that turns moist red litmus blue is evolved.

Deduce the formula of each of the two ions present in **X**.

.....

..... [2]

(d) An acidified aqueous solution of **X** reacts with aqueous potassium iodide to form iodine.

State and explain what you can deduce about the chemical nature of **X**.

.....

..... [2]

(e) When solid **X** is heated only V_2O_5, water and gas **Z** are formed.

Name gas **Z**.

..... [1]

[Total: 8]

[Turn over

BLANK PAGE

A6 A 0.250 g sample of iron filings is added to 25.0 cm^3 of 0.100 mol / dm^3 aqueous copper(II) sulfate.

For Examiner's Use

$$Cu^{2+}(aq) + Fe(s) \longrightarrow Fe^{2+}(aq) + Cu(s)$$

(a) Explain, using electron transfer, why iron is oxidised in this reaction.

.....

..... [1]

(b) Show, by calculation, which reactant is in excess.

[3]

(c) What would you observe in this reaction?

.....

.....

..... [2]

(d) Copper powder is added to aqueous silver nitrate.

Predict whether or not a reaction will take place. Explain your answer.

.....

..... [1]

[Total: 7]

Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

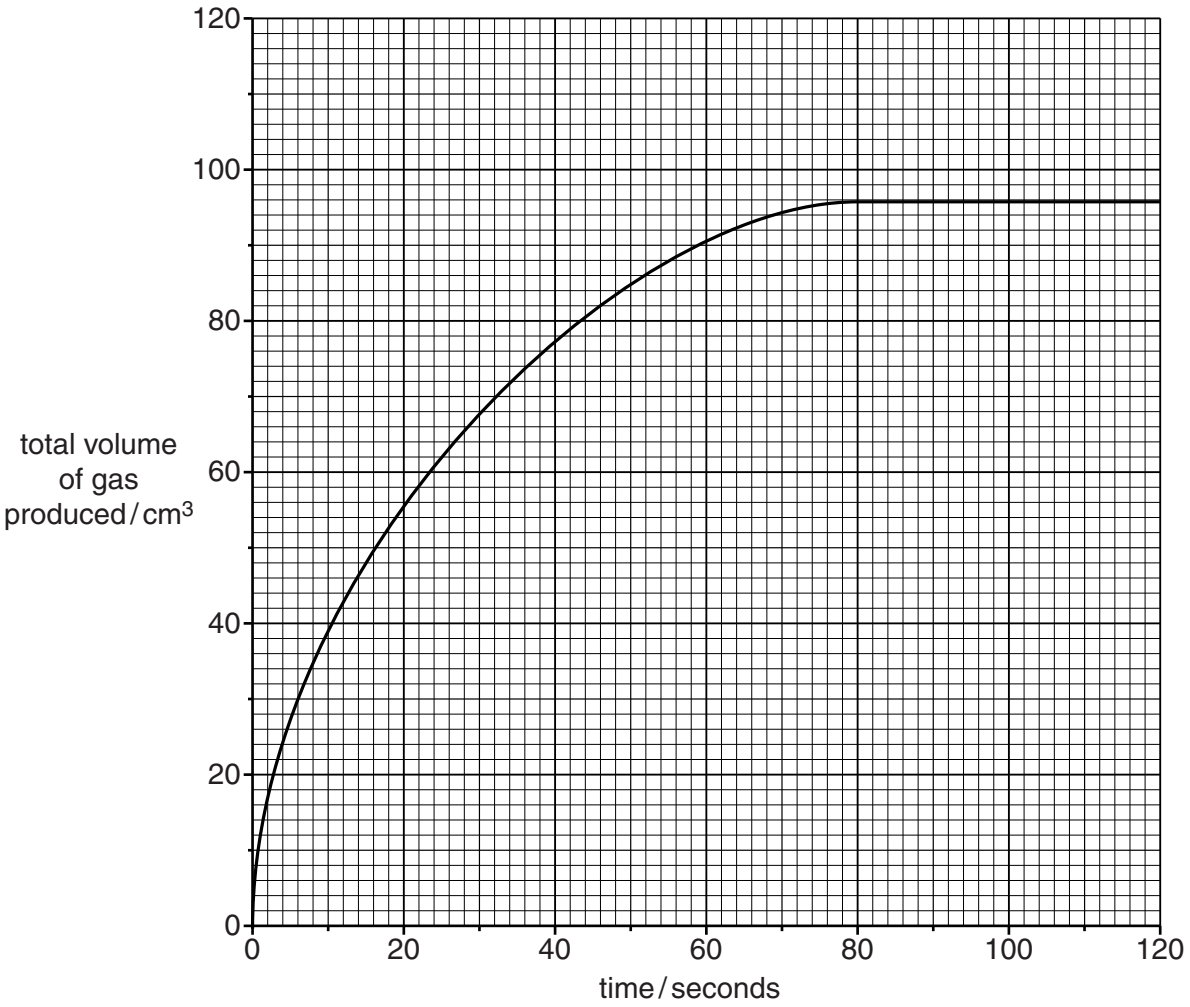
The total mark for this section is 30.

B7 An antacid tablet contains a mixture of magnesium hydroxide, $Mg(OH)_2$, and calcium carbonate, $CaCO_3$.

Stomach acid contains dilute hydrochloric acid.

A student adds a 0.500 g antacid tablet to 50.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid, HCl. The acid is in excess.

The graph shows how the total volume of gas produced at r.t.p. changes with time.



(a) Describe, with the aid of a labelled diagram, the apparatus needed to collect this data.

For Examiner's Use

[2]

(b) (i) Write equations for the reactions of HC*l* with $Mg(OH)_2$ and also with $CaCO_3$.

$Mg(OH)_2$

.....

$CaCO_3$

..... [2]

(ii) Calculate the amount, in moles, of carbon dioxide formed at r.t.p. once the reaction had stopped.

amount in moles = ... [2]

(iii) Calculate the mass of $CaCO_3$ in the tablet.

mass of $CaCO_3$ = ... g [2]

Question B7 continues on page 12.

(c) The student repeats the experiment. This time she uses a 0.500 g antacid tablet and 50.0 cm^3 of **2.00 mol/dm^3** HC*l* instead of 50.0 cm^3 of 1.00 mol/dm^3 HC*l*.

For Examiner's Use

Describe and explain what will happen to the rate of reaction.

.....

.....

.....

..... [2]

[Total: 10]

Question B8 starts on page 14.

B8 Alcohols are a homologous series of organic compounds.

For Examiner's Use

The table shows information about some alcohols.

alcohol	molecular formula	melting point /°C	density /g/cm^3
methanol	CH_4O	–98	0.79
ethanol	C_2H_6O	–114	0.79
	C_3H_8O	–126	0.80
butanol	$C_4H_{10}O$		
decanol		7	0.83

(a) Which group of atoms (functional group) must be present in the homologous series of alcohols?

..... [1]

(b) Name the alcohol with the molecular formula C_3H_8O.

..... [1]

(c) **(i)** Deduce the general formula for an alcohol.

..... [1]

(ii) A molecule of decanol has ten carbon atoms.

What is the molecular formula for decanol?

..... [1]

(d) It is more difficult to estimate the melting point of butanol than to estimate its density. Use the data in the table to explain why.

.....

..... [1]

(e) When warmed in the presence of concentrated sulfuric acid, butanol reacts with ethanoic acid to form an ester.

Name and draw the structure, showing all the atoms and all the bonds, of this ester.

name .....

structure

[2]

(f) Ethanol reacts with oxygen in the air to form ethanoic acid.

Describe another method by which ethanol can be converted into ethanoic acid.

.....

.....

..... [2]

(g) Butanol can burn in a **limited** supply of air.

Name **two** products of this reaction.

..... [1]

[Total: 10]

B9 Methane reacts with water to produce hydrogen and carbon monoxide.

For Examiner's Use

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g) \qquad \Delta H = +210\,kJ/mol$$

This reaction is endothermic.

The reaction is normally carried out at a pressure of 30 atmospheres and a temperature of 850 °C.

(a) The reaction is carried out at 30 atmospheres pressure and at **600 °C** rather than 850 °C.

Predict and explain the effect of lowering the temperature on

(i) the rate of reaction,

.....

.....

..... [2]

(ii) the position of equilibrium.

.....

.....

..... [2]

(b) The reaction is carried out at **50 atmospheres** rather than 30 atmospheres, and at 850 °C.

Predict and explain the effect of raising the pressure on the position of equilibrium.

.....

.....

..... [2]

(c) The reaction uses a catalyst.

(i) What effect does a catalyst have on the position of equilibrium?

..... [1]

(ii) Explain how a catalyst causes the rate of reaction to increase.

.....

..... [1]

(d) Calculate the energy absorbed by the reaction when 560 g of CO is formed.

For Examiner's Use

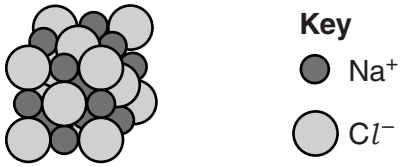
energy absorbed = ... kJ [2]

[Total: 10]

B10 Solid sodium chloride and magnesium oxide have the same structure and bonding.

For Examiner's Use

This is the structure of sodium chloride.



The table shows the melting point of these two compounds.

compound	melting point / °C
magnesium oxide	2852
sodium chloride	801

(a) (i) What are the formulae for a magnesium ion and an oxide ion?

..... [1]

(ii) Suggest why magnesium oxide has a much higher melting point than sodium chloride.

.....

..... [1]

(b) (i) Explain why pure sodium chloride can be electrolysed at 1000 °C but not at 600 °C.

.....

.....

..... [2]

(ii) Construct an equation for the anode reaction in the electrolysis of pure sodium chloride at 1000 °C.

..... [1]

(c) Sodium chloride is dissolved in distilled water.

For Examiner's Use

Excess aqueous silver nitrate is added to this solution and 0.232 g of a white precipitate is formed.

(i) Construct an ionic equation, including state symbols, for the formation of the white precipitate.

..... [2]

(ii) Calculate the mass of sodium chloride present in the solution.

mass of sodium chloride = ... g [3]

[Total: 10]

DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key: a = relative atomic mass; X = atomic symbol; b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4178971357

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2013**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

A copy of the Periodic Table is printed on page 16.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **16** printed pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following elements to answer the questions below.

chlorine
hydrogen
iron
lithium
nickel
nitrogen
oxygen
potassium
silver
sulfur
vanadium
zinc

Each element can be used once, more than once or not at all.

Which element

(a) is liberated at the anode when an aqueous solution of potassium sulfate is electrolysed,

.....[1]

(b) is used as a catalyst in the manufacture of margarine,

.....[1]

(c) is a non-metallic solid, an atom of which contains only six valency electrons,

.....[1]

(d) is higher than sodium in the reactivity series,

.....[1]

(e) is in Period 5 of the Periodic Table,

.....[1]

(f) forms a white oxide which is amphoteric?

.....[1]

[Total: 6]

A2 Carboxylic acids are a homologous series containing the $–CO_2H$ group.
The table shows some properties of the first four carboxylic acids in the series.

For Examiner's Use

carboxylic acid	molecular formula	density in g/cm^3	boiling point in °C
methanoic acid	CH_2O_2	1.220	101
	$C_2H_4O_2$	1.049	118
propanoic acid	$C_3H_6O_2$	0.993	141
butanoic acid	$C_4H_8O_2$	0.958	165

(a) (i) Describe how the density of these carboxylic acids varies with the number of carbon atoms in the molecule.

.....[1]

(ii) Name the carboxylic acid with the molecular formula $C_2H_4O_2$.

.....[1]

(iii) Draw the structure of propanoic acid, showing all atoms and bonds.

[1]

(b) The next carboxylic acid in this homologous series is pentanoic acid.
Pentanoic acid has five carbon atoms.

(i) Deduce the molecular formula for pentanoic acid.

.....[1]

(ii) Suggest a value for the boiling point of pentanoic acid.

.....°C [1]

(c) Butanoic acid, $C_3H_7CO_2H$, reacts with sodium to form a salt and a gas.

(i) Name the gas.

.....[1]

(ii) Give the formula of the salt.

.....[1]

(d) Esters are formed when carboxylic acids react with alcohols.
The reaction is catalysed by hydrogen ions.

(i) Describe and explain the effect of a catalyst on reaction rate.

.....

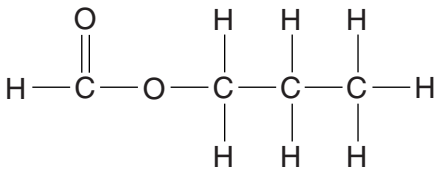
.....

.....[2]

(ii) State one commercial use of esters.

.....[1]

(iii) The structure of an ester is shown below.



Name this ester.

.....[1]

[Total: 11]

A3 Silicon is an element in Group IV of the Periodic Table.

For Examiner's Use

(a) Give the electronic configuration for a silicon atom.

.....[1]

(b) Silicon has three naturally occurring isotopes.

Complete the following table for two of these isotopes.

isotope	^{28}Si	^{30}Si
number of protons		
number of electrons		
number of neutrons		

[3]

(c) Silicon reacts with chlorine on heating to form silicon(IV) chloride, $SiCl_4$.

Construct an equation for this reaction.

[1]

(d) Silicon(IV) chloride is a simple molecular compound.

(i) Suggest **two** physical properties of silicon(IV) chloride other than solubility.

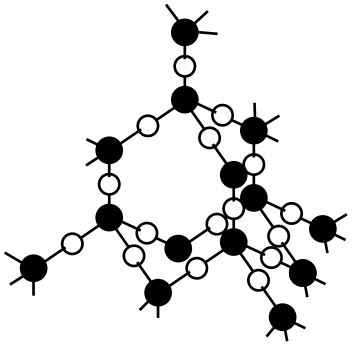
1 .....

2 .....[2]

(ii) Draw a 'dot-and-cross' diagram for silicon(IV) chloride.
You only need to show the outer shell electrons for each atom.

[2]

(e) Silicon(IV) chloride reacts with water to form silicon(IV) oxide.
Part of the structure of silicon(IV) oxide is shown below.



Key
● silicon atom
○ oxygen atom

Explain, in terms of structure and bonding, why silicon(IV) oxide has a very high melting point.

.....

.....

.....

.....[2]

[Total: 11]

A4 The carbon cycle regulates the amount of carbon dioxide in the atmosphere.

For Examiner's Use

(a) (i) State **two** processes which release carbon dioxide into the atmosphere.

1 .....

2 .....[2]

(ii) Name one process which removes carbon dioxide from the atmosphere.

.....[1]

(b) Carbon dioxide is a greenhouse gas.

(i) What is the meaning of the term *greenhouse gas*?

.....

.....[1]

(ii) Name another greenhouse gas and give a natural source of this gas.

name .....

source .....[2]

(c) Carbon dioxide dissolves in water to form a weakly acidic solution.

$$CO_2(g) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H^+(aq)$$

(i) What is the meaning of the term *weak acid*?

.....

.....[1]

(ii) Describe how you could measure the pH of this solution other than by using a pH meter.

.....

.....

.....[2]

(d) Sodium hydrogencarbonate, $NaHCO_3$, decomposes on heating to form a carbonate, water and a gas which turns limewater milky.
Construct an equation for this reaction.

[2]
[Total: 11]

A5 A student reacts magnesium ribbon with excess hydrochloric acid.
She follows the course of the reaction by measuring the volume of gas produced against time.

For Examiner's Use

(a) Write the equation for the reaction of magnesium with hydrochloric acid.

.....[1]

(b) **(i)** On the axes below draw a sketch graph to show how the volume of gas produced during the reaction varies with time and label this line 'A'.
Label the axes with the appropriate units.

[2]

(ii) The student then carries out the experiment at a **lower** temperature. All the other conditions remain the same.

On the axes above draw another line to show how the volume of gas produced varies with time and label this line 'B'. [1]

(c) Magnesium reacts with carbon to form the compound magnesium carbide.

Calculate the percentage by mass of magnesium in magnesium carbide, MgC_2.

[2]

[Total: 6]

Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 Aluminium is extracted from purified bauxite by electrolysis.

(a) Describe how this electrolysis is carried out and construct equations for the reactions occurring at both the anode and cathode.

.....

.....

.....

.....

.....

.....

.....[4]

(b) What properties of aluminium make it useful for

(i) making aircraft, ...

(ii) making electricity cables. .....[2]

(c) Aluminium is high in the reactivity series.

(i) Explain why aluminium does not react with aqueous copper(II) sulfate.

.....

.....[2]

(ii) When a few drops of aqueous sodium chloride are added to a mixture of aluminium and aqueous copper(II) sulfate, a vigorous reaction occurs.

$$\text{copper(II) sulfate} + \text{aluminium} \longrightarrow \text{aluminium sulfate} + \text{copper}$$

What type of reaction is this?

.....[1]

(iii) State the formula of aluminium sulfate.

.....[1]

[Total: 10]

B7 Ethene is an unsaturated hydrocarbon.

For Examiner's Use

(a) What is the meaning of each of these terms?

unsaturated .....

hydrocarbon .....[2]

(b) Ethene can be manufactured by cracking.

(i) State the conditions used for cracking.

.....

.....[2]

(ii) Construct an equation for the cracking of tetradecane, $C_{14}H_{30}$, to form ethene and one other hydrocarbon.

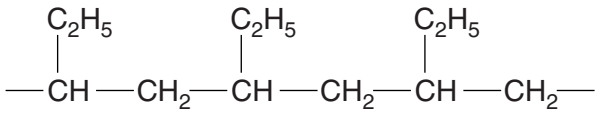
.....[1]

(c) Alkenes such as ethene can undergo addition polymerisation.

(i) State one use of poly(ethene).

.....[1]

(ii) The diagram below shows a section of a polymer chain.



Deduce the structure of the monomer which is used to make this polymer.

[1]

(d) Ethanol can be manufactured by the catalytic addition of steam to ethene.

For Examiner's Use

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

If the reactants are not recycled, only 5% of the ethene is converted to ethanol.

Calculate the mass of ethanol formed from 0.4 tonnes of ethene when only 5% of the ethene is converted to ethanol.
[1 tonne is 1 000 000 grams]

mass of ethanol ..... tonnes [3]

[Total: 10]

B8 When hydrogen iodide, HI, is heated in a closed tube, the following dynamic equilibrium is established.

For Examiner's Use

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \qquad \Delta H = +9.6\ kJ/mol$$

(a) What is meant by the term *dynamic equilibrium*?

.....

.....

.....[2]

(b) The table shows the concentrations of HI(g), $H_2(g)$ and $I_2(g)$ in the equilibrium mixture at 25 °C and 450 °C.

substance	concentration at 25 °C / mol/dm^3	concentration at 450 °C / mol/dm^3
HI(g)	0.94	0.79
$H_2(g)$	0.033	0.11
$I_2(g)$	0.033	0.11

(i) The tube has a volume of 50 cm^3.

Calculate the mass of hydrogen iodide in the equilibrium mixture at 25 °C.

[2]

(ii) Describe and explain the differences in the concentrations of reactant and products at 25 °C and 450 °C.

.....

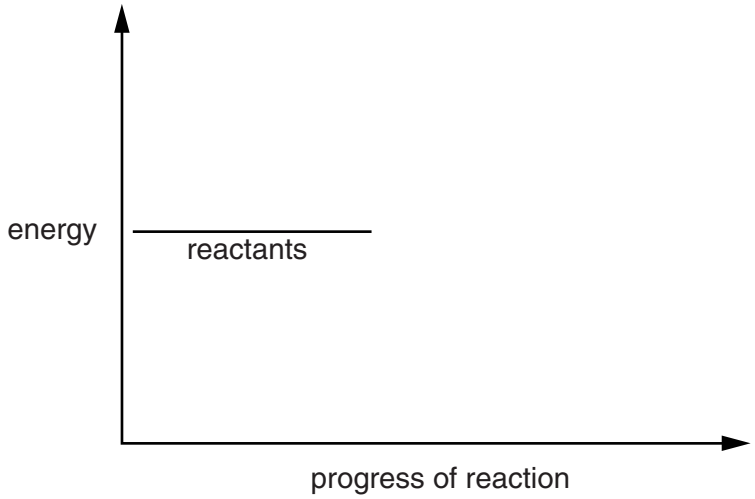
.....

.....

.....[2]

(c) Complete the energy profile diagram for the decomposition of hydrogen iodide.
On your diagram label

- the products,
- the enthalpy change of the reaction, ΔH.



[2]

(d) An aqueous solution of hydrogen iodide contains iodide ions.

Describe a test for iodide ions.

.....

.....[2]

[Total: 10]

B9 The compounds ammonium nitrate and ammonium sulfate are both fertilisers.

For Examiner's Use

(a) Explain why farmers add these fertilisers to soils.

.....

.....[1]

(b) Ammonium sulfate can be prepared by adding sulfuric acid to aqueous ammonia.

Construct the equation for this reaction.

.....[1]

(c) Excess acidity in soils can be treated by adding calcium hydroxide.

(i) Give the formula of the ion present in calcium hydroxide which causes it to be alkaline.

.....[1]

(ii) Explain why adding calcium hydroxide causes loss of nitrogen from fertilisers such as ammonium nitrate, which have been previously added to the soil.

.....

.....

.....[2]

(d) A student titrated 10.0 cm^3 of aqueous calcium hydroxide with hydrochloric acid.

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

It required 4.00 cm^3 of 0.0100 mol/dm^3 hydrochloric acid to neutralise 10.0 cm^3 of aqueous calcium hydroxide.

Calculate the concentration of the calcium hydroxide.

..... mol/ dm^3 [3]

(e) Describe how to obtain pure dry crystals of calcium chloride from an aqueous solution of calcium chloride.

For Examiner's Use

.....

.....

.....

.....

.....[2]

[Total: 10]

DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key: a = relative atomic mass; X = atomic symbol; b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2012**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

A copy of the Periodic Table is printed on page 20.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
B6	
B7	
B8	
B9	
Total	

This document consists of **19** printed pages and **1** blank page.

Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following particles to answer the questions below.

$^{8}_{4}Be$

$^{14}_{6}C$

$^{40}_{20}Ca$

$^{37}_{17}Cl^{-}$

$^{39}_{19}K^{+}$

$^{24}_{12}Mg^{2+}$

$^{20}_{10}Ne$

$^{17}_{8}O$

$^{16}_{8}O^{2-}$

$^{32}_{16}S^{2-}$

$^{28}_{14}Si^{4-}$

Each particle can be used once, more than once or not at all.

Which particle

(a) has only eight electrons,

..... [1]

(b) is attracted to the cathode during electrolysis,

..... [1]

(c) has only four electrons in its outer shell,

..... [1]

(d) has only eight neutrons,

..... [1]

(e) has only ten protons,

..... [1]

(f) has four occupied electron shells?

..... [1]

[Total: 6]

A2 Small pieces of a silver coloured metal, **X**, were added to concentrated nitric acid. A brown gas, **Z**, and a colourless solution containing salt **Y** were formed.

For Examiner's Use

Analysis of a 0.0914 mol sample of **Z** showed it contained 1.28 g of nitrogen and 2.93 g of oxygen.

The small sample of the colourless solution was diluted with water and then divided into two portions.

- To one portion, aqueous sodium hydroxide was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess sodium hydroxide.
- To the other portion, aqueous ammonia was added drop by drop until it was in excess. A white precipitate, **W**, was formed that redissolved in the excess ammonia.

(a) (i) Name the white precipitate, **W**.

..... [1]

(ii) Construct the ionic equation, with state symbols, for the formation of **W**.

..... [2]

(b) Name **X** and **Y**.

X is .....

Y is ..... [2]

(c) (i) Calculate the relative formula mass, M_r, for gas **Z**.

M_r = ... [2]

(ii) Determine the molecular formula for **Z**.

molecular formula is ..... [2]

[Total: 9]

A3 The typical composition of solid domestic waste in a city is shown below.

For Examiner's Use

type of solid waste	percentage by mass
glass	9
metals	8
organic waste including food	22
paper	38
plastics	9
textiles	2
other	12

(a) The most abundant metals in the solid waste are aluminium, copper and iron. Describe **two** advantages of recycling these metals.

.....

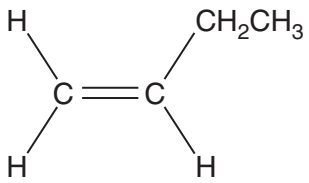
.....

.....

.....

..... [2]

(b) One of the polymer molecules in the plastic waste is made from the monomer shown below.



Draw the partial structure of the polymer formed from this monomer showing two repeats.

[2]

(c) Many of the polymers found in the plastic waste are non-biodegradable.

For Examiner's Use

Describe **two** pollution problems caused by the disposal of non-biodegradable polymers.

.....

.....

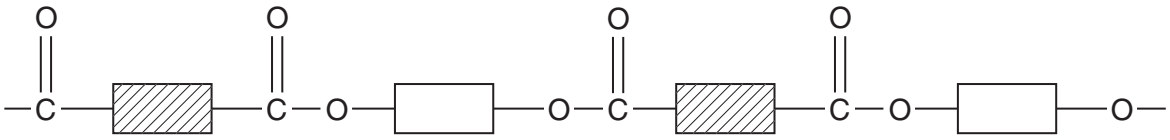
.....

.....

..... [2]

(d) *Terylene* and nylon are two of the textiles present in the solid waste.

The partial structure of *Terylene* is shown below.



(i) *Terylene* is a polyester.

What type of polymerisation is used to make *Terylene*?

..... [1]

(ii) Complete the diagram below to show the partial structure for nylon.

[1]

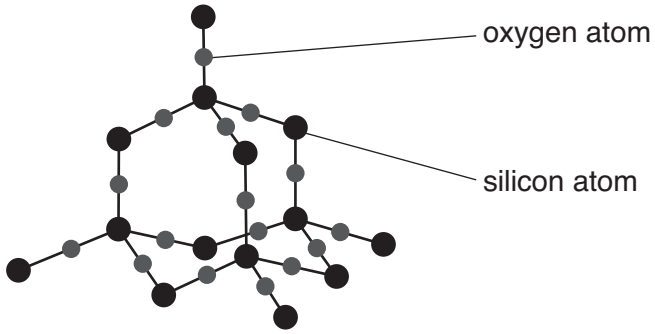
(iii) Give the name of one **type** of food that has molecules containing the same linkages as Terylene.

..... [1]

(e) Glass is made from sand.

For Examiner's Use

Pure sand has a giant molecular structure.



(i) What is the formula for pure sand?

..... [1]

(ii) Explain why sand has a very high melting point.

.....

.....

.....

..... [2]

(iii) Explain why sand does not conduct electricity.

.....

..... [1]

[Total: 13]

A4 Many electricity generating power stations burn fossil fuels. The combustion of these fuels produces waste gases called flue gas.

For Examiner's Use

The flue gas contains nitrogen oxides, sulfur dioxide and carbon dioxide.

Nitrogen oxides and sulfur dioxide contribute towards acid rain and must be removed from the flue gas before it is allowed to reach the atmosphere.

(a) One of the nitrogen oxides is nitrogen monoxide, NO.

(i) Nitrogen monoxide is formed by the direct reaction between oxygen and nitrogen.

Construct the equation for this reaction.

..... [1]

(ii) When cold nitrogen monoxide comes into contact with oxygen it forms nitrogen dioxide, NO_2.

Construct the equation for this reaction.

..... [1]

(b) Some power stations spray the flue gas with seawater. This removes about 99% of the nitrogen dioxide and sulfur dioxide.
The gases react with water to form aqueous acids. Nitrogen dioxide forms nitric acid and another acid with the formula, HNO_2.

Construct the equation for this reaction.

..... [1]

(c) In other power stations the flue gases are reacted with moist calcium carbonate. This removes about 90% of the nitrogen dioxide and sulfur dioxide from the flue gas.

(i) Sulfur dioxide reacts with calcium carbonate to form solid calcium sulfite, $CaSO_3$.
Suggest the name of the other product of this reaction.

..... [1]

(ii) Nitrogen dioxide reacts with calcium carbonate to form two salts.
Suggest the name and formula of one of these salts.

name .....

formula ..... [2]

[Turn over

(d) Suggest **two** advantages of treating flue gas with seawater rather than calcium carbonate.

For Examiner's Use

.....

.....

.....

..... [2]

(e) Carbon dioxide is a greenhouse gas. This is because its covalent bonds can absorb infra-red radiation.

Draw a 'dot-and-cross' diagram to show the bonding in a molecule of carbon dioxide. Show only the outer shell electrons.

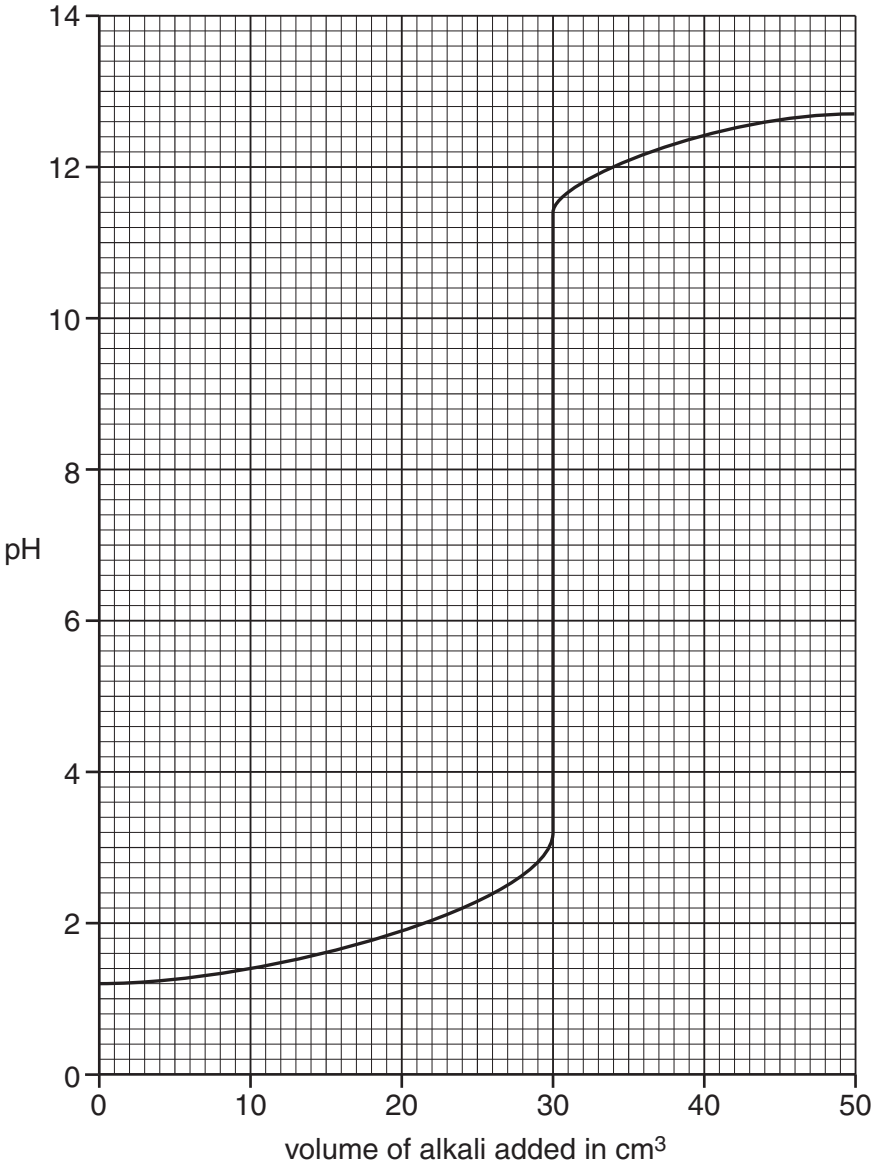
[1]

[Total: 9]

A5 Aqueous potassium hydroxide, KOH, is added slowly from a burette into a flask containing 25.0 cm^3 of 0.0500 mol/dm^3 dilute sulfuric acid, H_2SO_4. At the same time the pH of the contents of the flask is measured until all of the aqueous potassium hydroxide has been added.

For Examiner's Use

The graph shows how the pH changes with the addition of the aqueous potassium hydroxide.



(a) What is the pH of 0.0500 mol/dm^3 sulfuric acid?

..... [1]

(b) Construct the equation for the reaction between sulfuric acid and potassium hydroxide.

..... [1]

(c) **(i)** What volume of aqueous potassium hydroxide has been added when the mixture has a pH of 7?

For Examiner's Use

volume = ... cm^3 [1]

(ii) Calculate the concentration, in mol/dm^3, of the aqueous potassium hydroxide.

concentration = ... mol/dm^3 [3]

(d) The experiment is repeated with 25.0 cm^3 of 0.0500 mol/dm^3 ethanoic acid, CH_3COOH, instead of 25.0 cm^3 of 0.0500 mol/dm^3 sulfuric acid.

Describe and explain any differences in the graph which would be obtained.

.....

.....

.....

..... [2]

[Total: 8]

Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 Hydrogen-oxygen fuel cells are used to generate electricity.
The overall reaction in a hydrogen-oxygen fuel cell is shown below.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

This reaction is exothermic.

(a) Explain the meaning of the term *exothermic*.

.....

..... [1]

(b) Explain, in terms of the energy changes associated with bond breaking and bond forming, why the reaction is exothermic.

.....

.....

.....

..... [2]

(c) A hydrogen-oxygen fuel cell uses 2000 dm^3 of hydrogen measured at room temperature and pressure.
Calculate the volume of oxygen, measured at room temperature and pressure, used by the fuel cell.
[One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

.....

.....

.....

volume of oxygen = ... dm^3 [2]

(d) The electrode reactions in an oxygen-hydrogen fuel shell are shown below.

Equation 1 $O_2(g) + 2H_2O(l) + 4e^- \longrightarrow 4OH^-(aq)$

Equation 2 $H_2(g) + 2OH^-(aq) \longrightarrow 2e^- + 2H_2O(l)$

Explain why the reaction in a fuel cell involves both oxidation **and** reduction.

.....

.....

.....

..... [2]

(e) Name one source of the hydrogen needed for a fuel-cell.

..... [1]

(f) State one advantage and one disadvantage of using an oxygen-hydrogen fuel cell.

advantage .....

.....

disadvantage .....

..... [2]

[Total: 10]

B7 Many carbonates thermally decompose to form carbon dioxide and an oxide.

For Examiner's Use

Copper carbonate forms carbon dioxide and copper oxide.

$$CuCO_3 \rightarrow CuO + CO_2$$

Six 2.00 g samples of carbonates are heated strongly until there is no further change in mass. The table shows the mass of solid remaining at the end of the heating.

carbonate	mass before heating/g	mass after heating/g
calcium carbonate	2.00	1.12
copper(II) carbonate	2.00	1.29
iron(II) carbonate	2.00	1.24
magnesium carbonate	2.00	0.95
sodium carbonate	2.00	2.00
zinc carbonate	2.00	1.30

(a) What is the mass of carbon dioxide formed when 2.00 g of copper(II) carbonate is heated?

mass of carbon dioxide = ... g [1]

(b) The thermal stability of the carbonates is related to the reactivity of the metal.
Which carbonate is the **least** thermally stable?

..... [1]

(c) For each carbonate, a 2.00 g sample was heated.
Explain why the mass of carbon dioxide formed is different for each carbonate.

.....

..... [1]

(d) The decomposition of calcium carbonate forms carbon dioxide and calcium oxide.

(i) Draw the electronic configuration and state the charge on each of the ions in calcium oxide.

[2]

(ii) Explain why calcium oxide is used in a blast furnace.

.....

.....

..... [1]

(e) Copper(II) chloride can be prepared by the reaction between copper(II) carbonate and hydrochloric acid.

(i) Construct the ionic equation for this reaction.

.....

..... [1]

(ii) Describe the essential practical details for the preparation of a crystalline sample of copper(II) chloride.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

B8 Alkenes are a homologous series of organic compounds.
The table shows some information about the first six alkenes.

For Examiner's Use

name	molecular formula	melting point/°C	boiling point/°C
ethene	C_2H_4	–169	–104
propene	C_3H_6	–185	–48
butene	C_4H_8	–185	–6
pentene	C_5H_{10}	–165	30
hexene	C_6H_{12}	–139	63
heptene	C_7H_{14}		

(a) Draw the structure, showing all the atoms and bonds, of propene.

Use the structure to explain why propene is both a *hydrocarbon* and *unsaturated*.

.....

.....

.....

..... [3]

(b) There are several compounds with molecular formula C_4H_8, each has a different structure.
What name is given to compounds with the same molecular formula but different structures?

..... [1]

(c) Deduce the molecular formula for decene, an alkene with 10 carbon atoms per molecule.

..... [1]

(d) Explain why it is easier to predict the boiling point of heptene rather than its melting point.

.....

.....

..... [1]

(e) What is the physical state for butene at room temperature and pressure? Explain your answer.

For Examiner's Use

physical state .....

explanation .....

..... [1]

(f) Many alkenes are manufactured by the cracking of long chain alkanes such as hexadecane, $C_{16}H_{34}$.
Construct an equation to show the cracking of hexadecane to form butane and butene only.

..... [1]

(g) Butene reacts with bromine and with steam.

(i) Give the molecular formula of the product with bromine.

..... [1]

(ii) Suggest the name of the product with steam.

..... [1]

[Total: 10]

B9 Methanol, CH_3OH, is manufactured from carbon dioxide and hydrogen.

For Examiner's Use

$$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \quad \Delta H = -49\,kJ/mol$$

The reaction is carried out in the presence of a catalyst containing copper. The conditions used are 70 atmospheres pressure and a temperature of 250 °C.

(a) If the temperature of the reaction mixture is **increased** to 400 °C, explain, in terms of collisions between reacting particles, what happens to the speed of the forward reaction.

.....

.....

.....

..... [2]

(b) If the pressure of the reaction mixture is **decreased** to 50 atmospheres, explain what happens to the position of equilibrium.

.....

.....

.....

..... [2]

(c) In the reaction when 3.0 moles of hydrogen react, 49 kJ of heat energy is released.

Calculate how much heat energy is released when 500 kg of hydrogen react.

heat energy = ... kJ [2]

(d) Methanol can be used as a fuel.

Construct the equation for the complete combustion of methanol.

..... [1]

[Turn over

(e) Methanol can be oxidised to form methanoic acid.

For Examiner's Use

(i) State the reagents and conditions needed for this reaction.

.....

..... [2]

(ii) Draw the structure of methanoic acid.

[1]

[Total: 10]

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Key

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9383590208

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2012**

1 hour 30 minutes

Candidates answer on the Question Paper.

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For Examiner's Use	
Section A	
B6	
B7	
B8	
B9	
Total	

This document consists of **17** printed pages and **3** blank pages.

Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 **(a)** Define the term *compound*.

.....[1]

(b) Choose from the following compounds to answer the questions below.

calcium carbonate
carbon dioxide
carbon monoxide
ethane
glucose
methane
propane
sodium oxide
sucrose
water
zinc oxide

Each compound can be used once, more than once or not at all.

Which compound

(i) is a product of fermentation,

.....[1]

(ii) reacts with both hydrochloric acid and aqueous sodium hydroxide,

.....[1]

(iii) reacts with hydrochloric acid to form a gas which turns limewater milky,

.....[1]

(iv) is formed by the thermal decomposition of limestone,

.....[1]

(v) is a hydrocarbon formed by the bacterial decay of vegetable matter,

.....[1]

(vi) is a product of the incomplete combustion of a hydrocarbon?

.....[1]

(c) Draw a 'dot-and-cross' diagram for a molecule of water.
Show only the outer shell electrons.

For Examiner's Use

[2]

[Total: 9]

A2 A student heated different mixtures of metals and metal oxides.
The table shows his results.

For Examiner's Use

mixture	reacts or no reaction
iron(III) oxide + zinc	reacts
lead(II) oxide + iron	reacts
lead(II) oxide + zinc	reacts
magnesium oxide + zinc	no reaction

(a) (i) Predict the order of reactivity of the metals iron, lead, magnesium and zinc.

least reactive ⟷ most reactive

.....[1]

(ii) Construct the equation for the reaction of iron(III) oxide, Fe_2O_3, with zinc. The products are zinc oxide, ZnO, and iron.

[1]

(b) Aluminium is high in the reactivity series but does not appear to react with either water or acids.

(i) Explain why aluminium appears to be unreactive.

.....

.....[2]

(ii) Explain why aluminium is used in the manufacture of aircraft.

.....[1]

(iii) Only one naturally-occurring isotope of aluminium is known.
State the number of protons and neutrons in this isotope of aluminium.

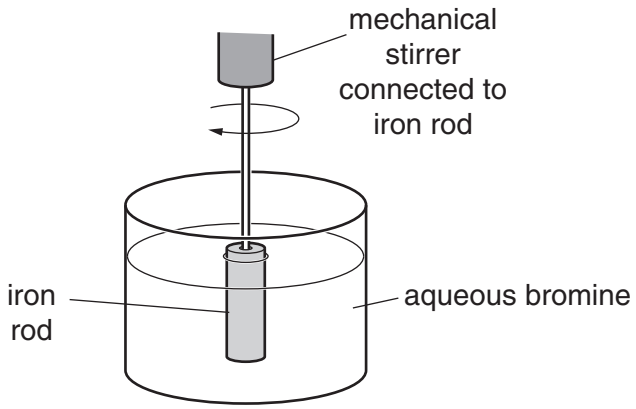
number of protons .....

number of neutrons .....[1]

[Total: 6]

A3 The rate of reaction of iron with aqueous bromine is determined using the apparatus shown below.

For Examiner's Use



The iron is removed at regular intervals. It is washed, dried and then weighed. The iron is then replaced in the solution.
The experiment is repeated twice, each time with a different concentration of aqueous bromine.
The results are shown in the table below.

concentration of aqueous bromine mol/dm^3	speed of reaction mg iron reacted/min
0.050	9.2
0.10	18.1
0.15	27.2

(a) (i) Describe how and explain why the speed of this reaction changes with the concentration of bromine.

.....

.....

.....[2]

(ii) Describe and explain the effect of temperature on the speed of this reaction.

.....

.....

.....[2]

(iii) Suggest another method of measuring the speed of this reaction.

.....

.....[1]

[Turn over

(b) The equation for the reaction is

$$Fe + Br_2 \rightarrow FeBr_2 \qquad \Delta H = -250\,kJ/mol$$

For Examiner's Use

(i) Construct two half-equations for this reaction to show electron loss and gain.

[2]

(ii) Draw a labelled enthalpy profile diagram for the overall reaction.
On your diagram include

- the enthalpy change of reaction,
- the activation energy,
- reactants,
- products.

[3]

[Total: 10]

A4 Wood is made up of many different carbon compounds.

For Examiner's Use

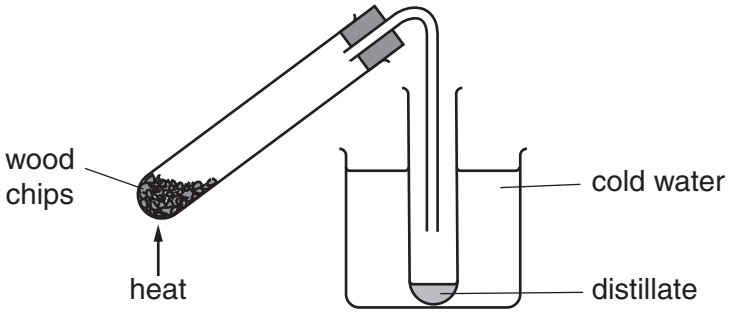
(a) Describe how carbon compounds are made in plants by photosynthesis.

.....

.....

.....[3]

(b) When wood is heated in the absence of air, the carbon compounds in the wood decompose.



The distillate contains a number of organic compounds, including

ethanoic acid

ethanal

ethanol

methanol

(i) When calcium hydroxide is added to the distillate, it neutralises the ethanoic acid. Name the salt formed in this neutralisation.

.....[1]

(ii) Ethanal can be removed from the distillate by a second distillation.
On what physical property of ethanal does this distillation depend?

.....[1]

[Turn over

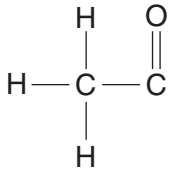
(iii) The composition by mass of ethanal is C 54.5%, H 9.1%, O 36.4%. Calculate the empirical formula of ethanal.

For Examiner's Use

[2]

(c) Ethanol reacts with ethanoic acid to form the ester ethyl ethanoate.

(i) Complete the following formula for ethyl ethanoate.



[1]

(ii) State a commercial use for esters.

.....[1]

[Total: 9]

A5 Nickel can be refined by reacting the impure metal with carbon monoxide. The impurities do not react with carbon monoxide.
A volatile compound called nickel carbonyl is formed.
This is decomposed to give pure nickel and carbon monoxide.

For Examiner's Use

(a) **(i)** Explain the meaning of the term *volatile*.

.....[1]

(ii) Suggest how nickel carbonyl might be decomposed.

.....[1]

(iii) Explain how this method separates nickel from its impurities.

.....[1]

(b) Nickel carbonyl has the formula $Ni(CO)_x$.
The relative molecular mass of nickel carbonyl is 171.
Calculate the value of x.

value of x = ...[1]

(c) Nickel is refined by electrolysis in a similar way to copper.
Draw a labelled diagram of the apparatus you would use to purify nickel by electrolysis in the laboratory.

[4]

(d) Nickel is a metal.
State three physical properties shown by **all** metals.

.....

.....

.....[3]

[Total: 11]

[Turn over

Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 Seawater contains chloride, bromide and iodide ions.
Bromine can be manufactured by bubbling chlorine through seawater.

$$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$$

(a) **(i)** Explain why the reaction of chlorine with bromide ions involves both oxidation and reduction.

.....

.....[2]

(ii) Describe how you could determine the pH of the resulting solution.

.....

.....[1]

(iii) Explain why iodine will not displace bromine from seawater.

.....[1]

(b) Bromine reacts with many elements to form bromides.
The table shows the boiling points and electrical conductivity for the bromides **A**, **B**, **C** and **D**.

bromide	boiling point / °C	electrical conductivity when molten
A	1435	conducts
B	916	conducts
C	154	does not conduct
D	173	does not conduct

Which two bromides are bonded covalently? Give a reason for your answer.

.....[1]

(c) Chlorine reacts with cold dilute sodium hydroxide to form sodium chlorate(I), $NaClO$, sodium chloride and water.
Construct an equation for this reaction.

[1]

(d) The concentration of sodium chlorate(I) in a solution can be found by reacting sodium chlorate(I) with excess acidified potassium iodide and then titrating the iodine liberated with aqueous sodium thiosulfate, $Na_2S_2O_3$.

For Examiner's Use

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$$

A solution of sodium thiosulfate contains 12.4 g of sodium thiosulfate, $Na_2S_2O_3.5H_2O$, in 1.00 dm^3 of solution.

(i) Calculate the concentration of the sodium thiosulfate solution in mol/dm^3.

concentration = ... mol/dm^3 [1]

(ii) 23.6 cm^3 of this sodium thiosulfate solution reacts with exactly 12.5 cm^3 of aqueous iodine.
Calculate the concentration, in mol/dm^3, of the aqueous iodine.

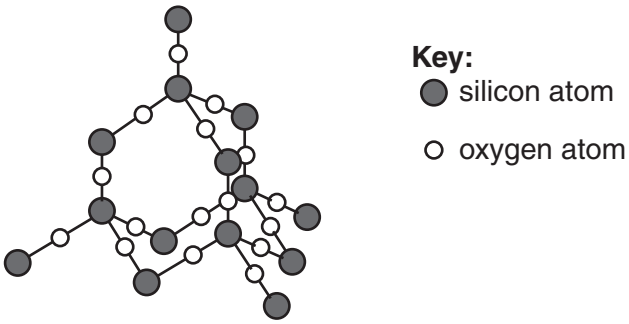
[3]

[Total: 10]

B7 Glass contains silicon(IV) oxide and a number of metal oxides.

For Examiner's Use

(a) The structure of silicon(IV) oxide is shown below.



(i) Describe **two** similarities in the structure of silicon(IV) oxide and diamond.

.....

.....

.....[2]

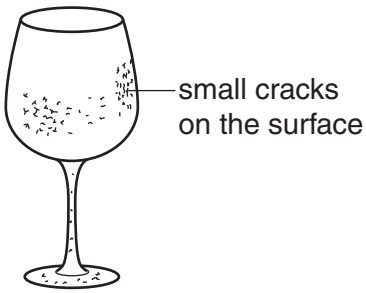
(ii) Explain why silicon(IV) oxide has a high melting point.

.....[2]

(iii) Explain why silicon(IV) oxide does not conduct electricity.

.....[1]

(b) Old wine glasses often appear cloudy because they have many small cracks on their surface.



The cracks are caused by differences in the rate of diffusion of sodium ions and hydrogen ions in the glass.

(i) Explain the meaning of the term *diffusion*.

.....

.....[1]

(ii) Suggest why sodium and hydrogen ions do not diffuse at the same rate.

.....[1]

(c) Sodium oxide is an ionic compound.
Draw a 'dot-and-cross' diagram to show

- the arrangement of the outer shell electrons,
- the charges on the ions and
- the formula of sodium oxide.

For Examiner's Use

[3]

[Total: 10]

B8 Many fertilisers contain phosphate ions and nitrate ions.

For Examiner's Use

(a) Explain why farmers put fertilisers on the soil.

.....[1]

(b) Why should the chemicals in fertilisers be soluble in water?

.....[1]

(c) Ammonium nitrate, NH_4NO_3, and ammonium sulfate, $(NH_4)_2SO_4$, are commonly used in fertilisers.

(i) Calculate the percentage of nitrogen by mass in ammonium nitrate.

[3]

(ii) Describe how crystals of ammonium sulfate can be prepared from aqueous ammonia.

.....

.....

.....

.....

.....[4]

(d) The formula of calcium phosphate is $Ca_3(PO_4)_2$.
Use this formula to deduce the charge on the phosphate ion.

.....[1]

[Total: 10]

B9 Chlorine and sodium hydroxide are manufactured by the electrolysis of concentrated aqueous sodium chloride.

For Examiner's Use

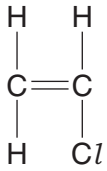
(a) **(i)** Chlorine can be used to bleach wood pulp.
Name another chemical that can be used to bleach wood pulp.

.....[1]

(ii) Explain the purpose of chlorine in water purification.

.....[1]

(b) Chlorine is used to make chloroethene.
The structure of chloroethene is shown below.



(i) Draw the structure of the polymer poly(chloroethene).

[2]

(ii) Chloroethene is an unsaturated compound.
Describe a positive test for an unsaturated compound.

test .....

result .....[2]

(c) Sodium hydroxide is a typical alkali.
It reacts with ethanoic acid to form water and the ionic salt, sodium ethanoate.

(i) Write the formula for the ethanoate ion showing all atoms and bonds.

[1]

(ii) Construct the ionic equation for the reaction of ethanoic acid with sodium hydroxide.

[1]

(d) Compounds containing hydroxide ions can be added to the soil to reduce its acidity.

(i) Explain why adding hydroxide ions to the soil can cause the loss of nitrogen from fertilisers containing ammonium salts.

.....[1]

(ii) Construct an ionic equation for this reaction.

[1]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key: a = relative atomic mass; X = atomic symbol; b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3253603518

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2011**

1 hour 30 minutes

Candidates answer on the Question Paper.

No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

A copy of the Periodic Table is printed on page 20.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
B7	
B8	
B9	
B10	
Total	

This document consists of **17** printed pages and **3** blank pages.

Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following compounds to answer the questions below.

ammonia

carbon monoxide

copper(II) carbonate

copper(II) chloride

copper(II) sulfate

sodium chloride

sodium hydroxide

sodium sulfate

sulfur dioxide

sulfuric acid

zinc carbonate

zinc nitrate

Each compound can be used once, more than once or not at all.

Which compound

(a) is a white solid with a high melting point that dissolves in water to form an alkaline solution,

.....[1]

(b) is a blue solid which, when dissolved in water, gives a white precipitate with aqueous barium nitrate,

.....[1]

(c) is a colourless gas that turns moist red litmus paper blue,

.....[1]

(d) is a white solid that decomposes on heating to form carbon dioxide?

.....[1]

[Total: 4]

A2 Alkanes are a homologous series of saturated hydrocarbons.

For Examiner's Use

(a) What is the general formula of alkanes?

.....[1]

(b) Draw the structures of the two isomers of C_4H_{10}.

[2]

(c) One of the isomers of C_4H_{10}, butane, reacts with chlorine in the presence of ultra-violet light. It forms hydrogen chloride gas and a mixture of liquid compounds.

(i) Name this type of reaction.

.....[1]

(ii) Draw the structure of one of the liquid compounds.

[1]

(d) Name the process by which butane is separated from crude oil.

.....[1]

[Total: 6]

A3 Vegetable oils can be used both to make margarine and as fuels such as bio-diesel.

For Examiner's Use

(a) Many vegetable oils are polyunsaturated.

(i) Explain the meaning of the term *polyunsaturated.*

.....

.....

.....[2]

(ii) Describe how you could distinguish between samples of saturated and unsaturated vegetable oils.

.....

.....

.....

.....[2]

(b) Describe how margarine can be manufactured from unsaturated vegetable oils.

.....

.....[1]

(c) Bio-diesel contains the compound $C_{15}H_{30}O_2$.
Suggest the products of the complete combustion of this compound.

.....[2]

(d) Farmers that grow vegetable oil crops often use large quantities of ammonium nitrate fertiliser, NH_4NO_3.
Calculate the percentage by mass of nitrogen in ammonium nitrate.

percentage = ... % [2]

(e) Microorganisms in the soil convert ammonium nitrate into gaseous nitrous oxide, N_2O. This gas is a greenhouse gas.

For Examiner's Use

(i) Describe **two** possible consequences of an increasing concentration of greenhouse gases in the atmosphere.

.....

.....

.....

.....[2]

(ii) Ammonium nitrate can be thermally decomposed in the laboratory to form nitrous oxide and one other product.
Construct the equation for this decomposition.

[1]

[Total: 12]

A4 Fluorine, chlorine, bromine and iodine are elements in Group VII of the Periodic Table. Scientists are trying to synthesise a new element in Group VII with a proton number of 117.

For Examiner's Use

(a) How many valency electrons will be present in one atom of this new element?

.....[1]

(b) Complete the following table about an isotope of this new element.

nucleon number	280
number of protons	
number of neutrons	

[2]

(c) Predict **two** physical properties of this new element.

1 .....

2 .....[2]

(d) Fluorine reacts with magnesium to form magnesium fluoride.

(i) Write a balanced equation for this reaction.

[1]

(ii) Give both the electronic configuration and the charge on the ions which are present in magnesium fluoride.

[2]

(e) Trifluorochloromethane, CF_3Cl, is a covalent compound.

For Examiner's Use

(i) Draw a 'dot-and-cross' diagram for a CF_3Cl molecule.
You only need to show the outer electrons for each atom.

[2]

(ii) Trifluorochloromethane does not conduct electricity.
Suggest one **other** physical property of trifluorochloromethane.

.....[1]

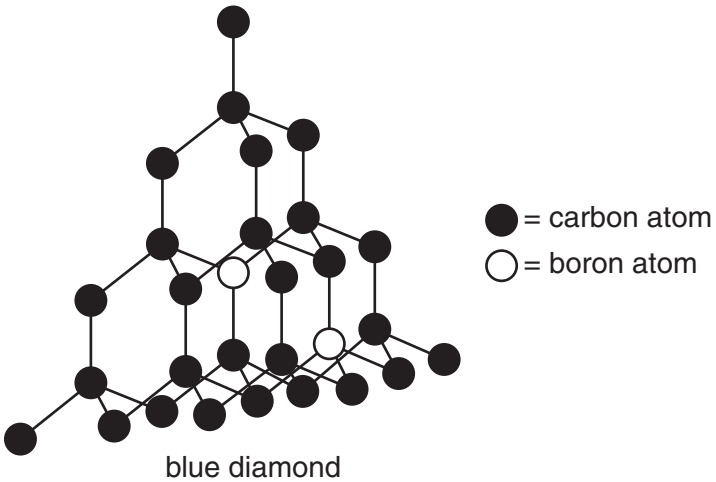
(iii) Suggest one environmental problem associated with the presence of trifluorochloromethane in the atmosphere.

.....[1]

[Total: 12]

A5 Blue diamonds are an impure form of carbon. Part of the structure of a blue diamond is shown below.

For Examiner's Use



blue diamond

Blue diamonds have a high melting point and can conduct electricity.

(a) Explain, in terms of structure and bonding, why blue diamonds have a high melting point.

.....

.....

.....

.....[2]

(b) Normal diamonds are a pure form of carbon. They do not conduct electricity.

(i) Explain, in terms of structure and bonding, why normal diamonds do **not** conduct electricity.

.....

.....[1]

(ii) Suggest why blue diamonds can conduct electricity.

.....

.....[1]

(c) Graphite is another pure form of carbon. Suggest **two** reasons why graphite is often used as an electrode in electrolysis.

1 .....

2 .....[2]

[Total: 6]

A6 Proteins are natural polyamides which can be hydrolysed to form amino acids.

For Examiner's Use

(a) Name a synthetic polyamide.

.....[1]

(b) The hydrolysis of proteins forms a mixture of colourless amino acids.
Describe, with the aid of a labelled diagram, how paper chromatography can be used to identify a mixture of amino acids.

.....

.....

.....

.....

.....

.....[4]

[Total: 5]

Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 Nitric oxide, NO, is an atmospheric pollutant formed inside car engines by the reaction between nitrogen and oxygen.

$$N_2(g) + O_2(g) \rightarrow 2NO(g) \quad \Delta H = +66\,kJ\,mol^{-1}$$

This reaction is endothermic.

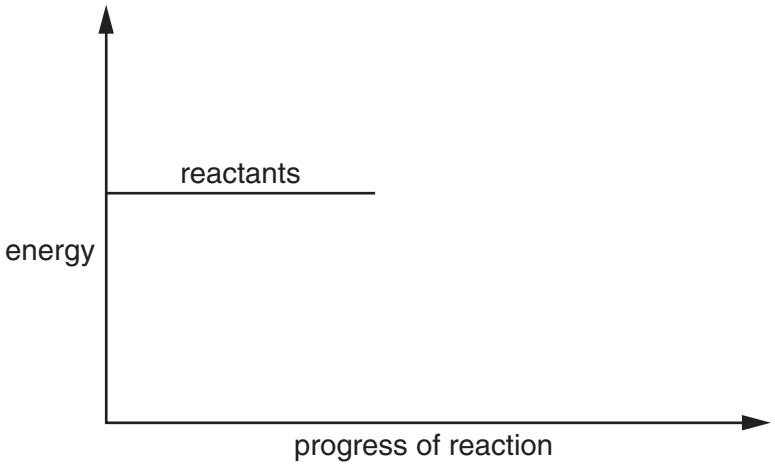
(a) Explain the meaning of the term *endothermic*.

.....

.....[1]

(b) Complete the energy profile diagram for the reaction between nitrogen and oxygen.
On your diagram label the

- product,
- activation energy, E_a,
- enthalpy change for the reaction, ΔH.



[3]

(c) Calculate the mass of nitric oxide formed when 100 g of nitrogen reacts completely with oxygen.

mass of nitric oxide = ... g [3]

(d) Explain how the speed of reaction between nitrogen and oxygen changes when the pressure of the gaseous mixture is increased from 1 atmosphere to 10 atmospheres.

For Examiner's Use

.....

.....

.....

.....[3]

[Total: 10]

B8 Propanoic acid, $C_2H_5CO_2H$, and hydrochloric acid, HCl, both act as acids when dissolved in water.

For Examiner's Use

(a) State the formula of an ion found in both dilute propanoic acid and in dilute hydrochloric acid.

.....[1]

(b) Propanoic acid reacts with magnesium carbonate to form water, a colourless gas and a salt. In this reaction

(i) name the gas,

.....[1]

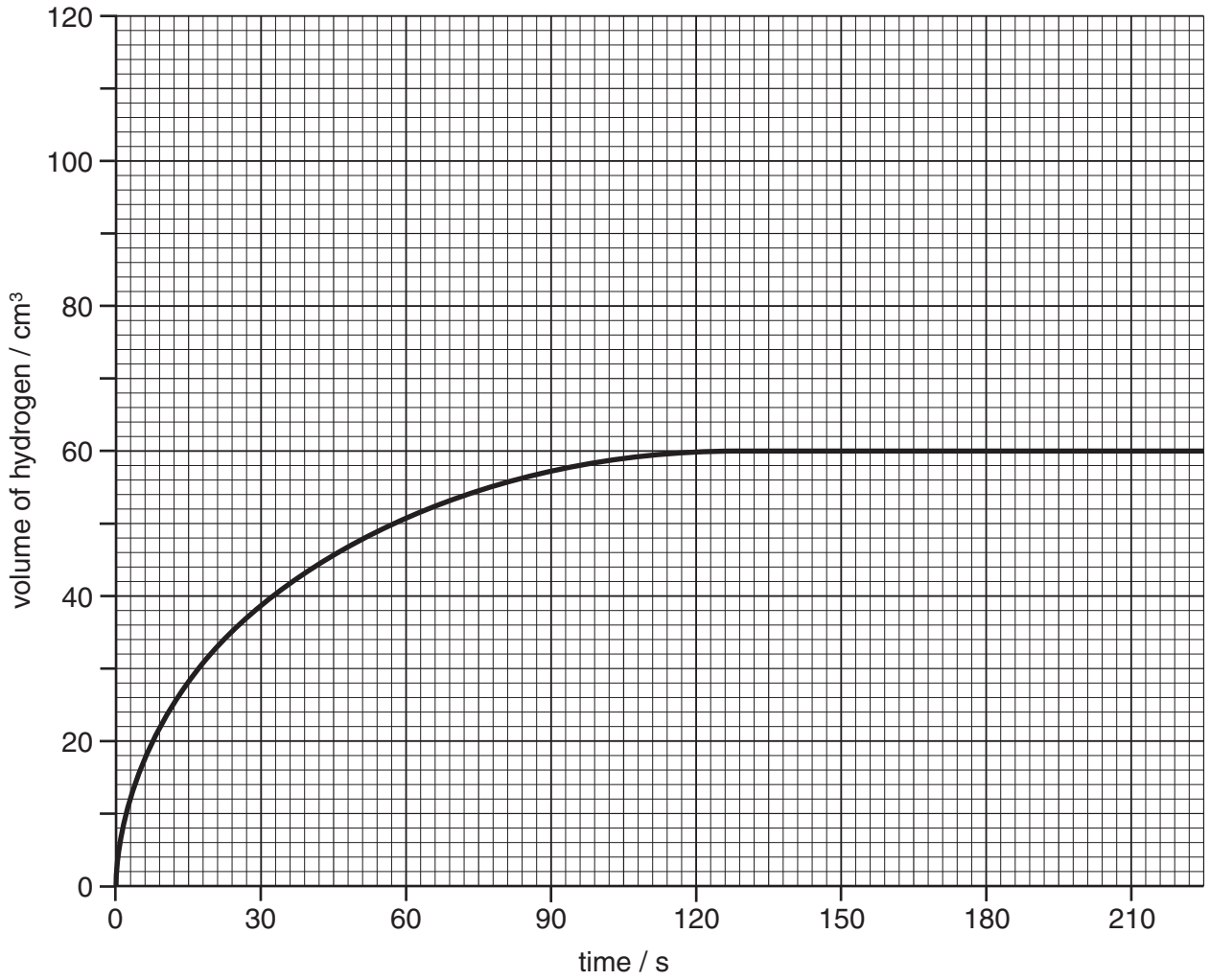
(ii) give the formula of the salt.

.....[1]

(c) In an experiment magnesium ribbon is added to 25.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid, an excess.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Every 30 seconds the total volume of hydrogen formed is measured at room temperature and pressure. The results are shown on the grid below.



(i) Use information from the graph to calculate the mass of magnesium ribbon used in the experiment.
[One mole of any gas at room temperature and pressure occupies a volume of 24 000 cm^3.]

mass of magnesium ribbon = ... g [3]

(ii) The experiment was repeated using the same mass of magnesium ribbon but with 25.0 cm^3 of 1.00 mol/dm^3 propanoic acid, an excess.
Draw on the grid a graph of the results for the reaction between magnesium ribbon and propanoic acid.

[2]

(d) Dilute hydrochloric acid reacts with aqueous silver nitrate to form a white precipitate.
Write an ionic equation, with state symbols, for this reaction.

[2]

[Total:10]

B9 Copper is a transition metal. It is used both in its pure form and in alloys.

For Examiner's Use

(a) The physical properties of copper can be explained in terms of metallic bonding.

Describe, with the aid of a labelled diagram, the metallic bonding in copper.

.....

.....

.....

.....[3]

(b) Pure copper is used to make electrical wires because it is a good electrical conductor.

(i) Explain why copper is a good electrical conductor.

.....

.....[1]

(ii) Describe how impure copper can be purified.

.....

.....

.....

.....[2]

(c) Name an alloy that contains copper.

.....[1]

(d) Many millions of tonnes of copper are recycled every year.
Describe some of the advantages and disadvantages of recycling copper.

For Examiner's Use

.....

.....

.....

.....

.....

.....[3]

[Total: 10]

B10 Glucose, $C_6H_{12}O_6$, is one of the products of photosynthesis.

For Examiner's Use

(a) State the empirical formula for glucose.

.....[1]

(b) **(i)** Write an equation to show how glucose is formed in photosynthesis.

[1]

(ii) Give the essential conditions for this process.

.....

.....

.....[2]

(c) Fermentation converts glucose into ethanol, a biofuel.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

(i) State **two** essential conditions for fermentation to take place.

1 .....

2 .....[2]

(ii) Calculate the maximum mass of ethanol that can be made from 1 tonne of glucose.
[One tonne is one million grams.]

maximum mass of ethanol = ... tonne [3]

(iii) Suggest one possible problem in making biofuels by fermentation.

.....[1]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key

a
X
b

a = relative atomic mass
X = atomic symbol
b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2011**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

A copy of the Periodic Table is printed on page 20.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
B6	
B7	
B8	
B9	
Total	

This document consists of **17** printed pages and **3** blank pages.

Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following list of elements to answer the questions below.

calcium
chlorine
hydrogen
iodine
nickel
sodium
vanadium
zinc

Each element can be used once, more than once, or not at all.

Which element

(a) forms an oxide which is amphoteric,

..... [1]

(b) is a catalyst in the hydrogenation of alkenes,

..... [1]

(c) oxidises aqueous bromide ions to bromine,

..... [1]

(d) is used in water purification to kill bacteria,

..... [1]

(e) is formed at the cathode when a dilute aqueous solution of sodium chloride is electrolysed,

..... [1]

(f) can be used in the sacrificial protection of iron?

..... [1]

[Total: 6]

A2 Pure oxygen for industrial use is obtained from the air.

For Examiner's Use

(a) (i) State the percentage by volume of oxygen in clean air.

..... [1]

(ii) Explain how fractional distillation is used to obtain oxygen from the air.

.....

.....

.....

..... [2]

(b) When acetylene, C_2H_2, burns in oxygen it produces a very hot flame.
State one industrial use for this oxyacetylene flame.

..... [1]

(c) Acetylene has a triple covalent bond between its carbon atoms.
Draw a 'dot-and-cross' diagram for acetylene.
You need only show the outer electrons.

[1]

(d) Oxygen reacts with magnesium to form magnesium oxide.
Draw diagrams to show the complete electronic structure and charges of both ions present in magnesium oxide.

For Examiner's Use

[2]

(e) Oxygen, O_2, in the atmosphere can react to form ozone, O_3.

(i) Write an equation for this reaction.

..... [1]

(ii) In the **upper** atmosphere there is a layer of ozone surrounding the Earth.
Explain the importance of this layer in terms of human health.

.....

..... [1]

[Total: 9]

A3 The alkanes are an homologous series of saturated hydrocarbons with the general formula C_nH_{2n+2}.

For Examiner's Use

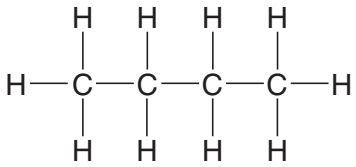
(a) What do you understand by the term *hydrocarbon*?

..... [1]

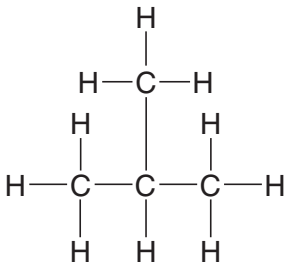
(b) Write the molecular formula for the alkane containing seven carbon atoms.

..... [1]

(c) Two different structural formulae can be written for the alkane having the molecular formula C_4H_{10}.



butane



methylpropane

What term is given to compounds with the same molecular formula but different structural formulae?

..... [1]

(d) A student ignites a mixture of 15 cm^3 of propane and 100 cm^3 of oxygen. The oxygen is in excess. All measurements of volume are taken at room temperature and pressure.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Calculate

the volume of carbon dioxide formed,

..... cm^3 [1]

the volume of unreacted oxygen remaining.

.....cm^3 [1]

(e) Explain why the **incomplete** combustion of an alkane in an enclosed space is hazardous.

.....

..... [2]

[Total: 7]

A4 Coal is largely carbon.

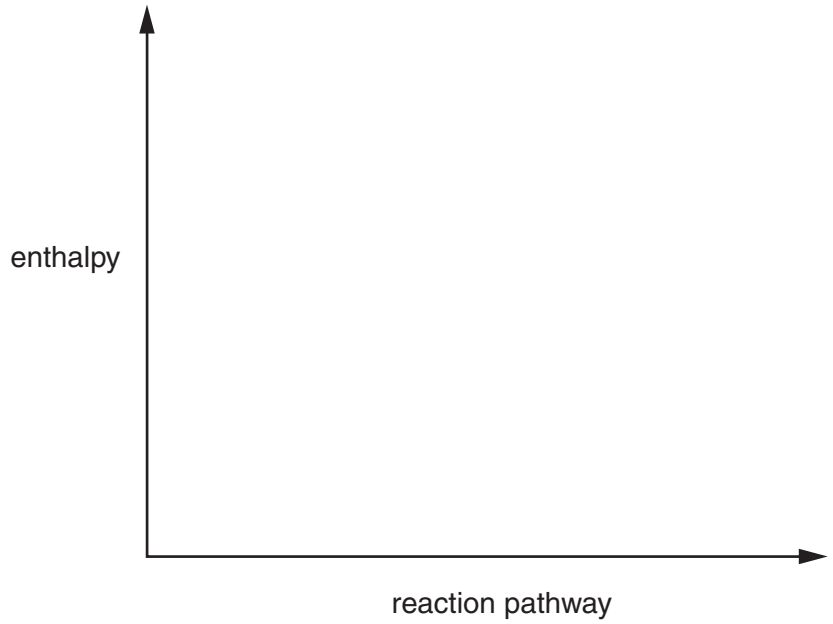
For Examiner's Use

(a) Carbon burns in excess air to form carbon dioxide.

$$C(s) + O_2(g) \longrightarrow CO_2(g) \quad \Delta H = -393.5\,kJ/mol$$

(i) Draw an energy profile diagram for this reaction on the axes below.
On your diagram label

- the reactants and products
- the enthalpy change for the reaction
- the activation energy



[3]

(ii) Give a test for carbon dioxide.

test .....

observation ..... [2]

(b) Coal contains a small amount of sulfur.

(i) Explain how the burning of coal results in the formation of acid rain.

.....

.....

.....

.....

..... [3]

(ii) State one effect of acid rain.

..... [1]

(c) Oxides of nitrogen also contribute to acid rain. They can be formed naturally in the atmosphere from nitrogen and oxygen.

(i) What condition is needed to allow nitrogen and oxygen to combine in the atmosphere?

..... [1]

(ii) Nitric acid in the atmosphere can chemically erode buildings made from carbonate rocks.
Write an equation for the reaction of nitric acid, HNO_3, with calcium carbonate, $CaCO_3$.

[2]

[Total: 12]

A5 Bromine is a halogen. It has two naturally-occurring isotopes.

(a) Define the term *isotopes*.

.....

..... [1]

(b) One isotope of bromine has the symbol $^{81}_{35}Br$.

State the number of protons, neutrons and electrons in this isotope of bromine.

protons .....

neutrons .....

electrons ..... [2]

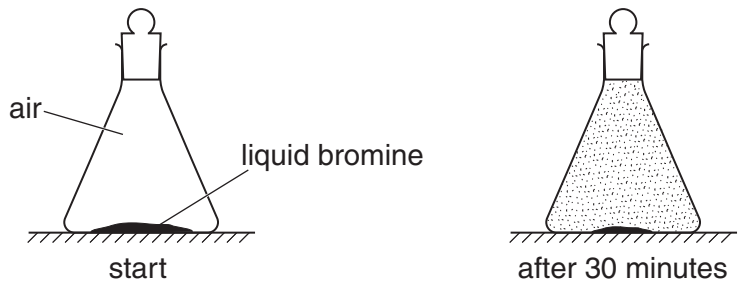
(c) Bromine is a liquid at room temperature.

(i) Draw a diagram to show the arrangement of the molecules in liquid bromine.

Show a bromine molecule as ◯.

[2]

(ii) A small amount of liquid bromine was placed in the bottom of a sealed flask. After thirty minutes the brown colour of the bromine had spread throughout the flask.



Use the kinetic particle theory to explain these observations.

.....

.....

.....

.....

..... [3]

(d) Bromine forms a variety of compounds with other halogens.

For Examiner's Use

(i) Bromine reacts with fluorine to form bromine(I) fluoride, BrF.
Write an equation for this reaction.

..... [1]

(ii) Another compound of bromine and fluorine is bromine(V) fluoride, BrF_5.
Calculate the percentage of bromine by mass in bromine(V) fluoride.

[2]

[Total: 11]

Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 Ammonia is made by the Haber process.

(a) **(i)** Write an equation for the formation of ammonia in the Haber process.

..... [1]

(ii) State the essential conditions for the Haber process.

.....

..... [3]

(b) Ammonia is used to make fertilisers.
Explain why farmers use fertilisers.

.....

..... [1]

(c) Many fertilisers are ammonium salts.
Explain why adding calcium hydroxide to the soil can cause the loss of nitrogen from the ammonium salts added as fertilisers.

.....

.....

..... [2]

(d) Fertilisers such as ammonium nitrate and ammonium phosphate are solids.
They can get into lakes and cause excessive growth of algae.

(i) Explain how these fertilisers get into lakes.

.....

..... [2]

(ii) What name is given to the enrichment of lakes with nitrates and phosphates which leads to the death of plant and animal life in the lakes?

..... [1]

[Total: 10]

B7 Sulfuric acid is a strong acid. Ethanoic acid is a weak acid.

For Examiner's Use

(a) What do you understand by the terms *strong acid* and *weak acid*?

.....

.....

..... [1]

(b) Compare and explain the difference in the electrical conductivity between a strong and a weak acid.

..... [1]

(c) A dilute solution of sulfuric acid contains hydrogen ions, hydroxide ions and sulfate ions. When this solution is electrolysed, hydrogen gas is formed at the cathode and oxygen gas is formed at the anode.

(i) Explain why hydrogen is formed at the cathode.

.....

..... [1]

(ii) Write the ionic equation for the reaction at the anode.

..... [2]

[Turn over

(d) Magnesium reacts with dilute sulfuric acid.

For Examiner's Use

$$Mg(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2(g)$$

(i) Describe how you can follow the progress of this reaction.
What measurements can you use to calculate the speed of the reaction?

.....

.....

.....

.....

.....

..... [3]

(ii) A student reacts 3.0 g of magnesium with 2.5 mol / dm^3 sulfuric acid.
Calculate the minimum volume of sulfuric acid that reacts with all the magnesium.

[2]

[Total: 10]

B8 The table gives some information about the first five members of the carboxylic acid homologous series.

For Examiner's Use

carboxylic acid	formula	boiling point / °C
methanoic acid	HCO_2H	101
ethanoic acid	CH_3CO_2H	118
propanoic acid	$C_2H_5CO_2H$	141
butanoic acid		166
pentanoic acid	$C_4H_9CO_2H$	

(a) (i) Estimate the boiling point of pentanoic acid.

..... [1]

(ii) Draw the structure of butanoic acid.
Show all atoms and bonds.

[1]

(iii) Ethanoic acid reacts with sodium.
Write an equation for this reaction.

..... [1]

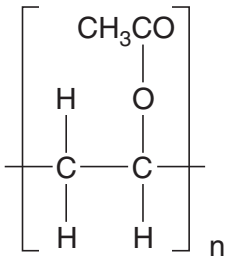
(b) Carboxylic acids react with alcohols to form esters.

For Examiner's Use

(i) Name the ester formed when ethanoic acid reacts with ethanol.

..... [1]

(ii) The diagram shows the repeat unit of poly(ethenyl ethanoate)



Draw the structure of the monomer used to make poly(ethenyl ethanoate).

[1]

(c) Carboxylic acid **X** contains 55.8% carbon, 7.0% hydrogen and 37.2% oxygen.

For Examiner's Use

(i) Calculate the empirical formula of **X**.

[2]

(ii) A molecule of carboxylic acid **X** contains four carbon atoms. What is its molecular formula?

..... [1]

(iii) Carboxylic acid **X** is an unsaturated compound.
Give a test for an unsaturated compound.

test .....

observation ..... [2]

[Total: 10]

B9 Barium is a reactive metal in Group II of the Periodic Table.
Barium reacts with water in a similar way to sodium. The products of the reaction are aqueous barium hydroxide and a colourless gas.

For Examiner's Use

(a) (i) Write an equation, including state symbols, for this reaction.

..... [3]

(ii) Aqueous barium hydroxide is neutralised by hydrochloric acid.
Write the simplest ionic equation for this reaction.

..... [1]

(b) Explain why barium metal conducts electricity.

..... [1]

(c) Barium oxide reacts with aluminium.

$$3BaO + 2Al \rightarrow 3Ba + Al_2O_3$$

Explain how this equation shows that aluminium is a reducing agent.

.....

..... [1]

(d) Barium sulfate is an insoluble compound.
Describe how a pure dry sample of barium sulfate is prepared from aqueous barium nitrate.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total:10]

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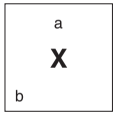
DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key



a = relative atomic mass
X = atomic symbol
b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **5070/22**

Paper 2 Theory **May/June 2010**

1 hour 30 minutes

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For Examiner's Use	
Section A	
B7	
B8	
B9	
B10	
Total	

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Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 Choose from the following compounds to answer the questions below.

$BaSO_4$

CH_4

C_2H_4

C_3H_8

CO_2

$CaCO_3$

CF_3Cl

$K_2Cr_2O_7$

$MgSO_4$

$NaCl$

$ZnSO_4$

Each compound can be used once, more than once or not at all.

Which compound

(a) is responsible for ozone depletion,

..... [1]

(b) is formed by the bacterial decay of vegetable matter,

..... [1]

(c) is used to remove sulfur dioxide in flue gas desulfurisation,

..... [1]

(d) is an insoluble salt,

..... [1]

(e) is orange in colour,

..... [1]

(f) decolourises aqueous bromine?

..... [1]

[Total: 6]

A2 Lithium, sodium and potassium are elements in Group I of the Periodic Table. Francium, Fr, is another element in Group I.

For Examiner's Use

(a) How many electrons are in there in the outer shell of a francium atom?

..... [1]

(b) Complete the following table about an atom of francium.

mass number	223
proton (atomic) number	
number of protons	
number of electrons	
number of neutrons	

[2]

(c) Predict two **physical** properties of francium.

1 .....

2 .....

[2]

(d) A scientist predicts that francium reacts violently with water.
Write the equation for this reaction.

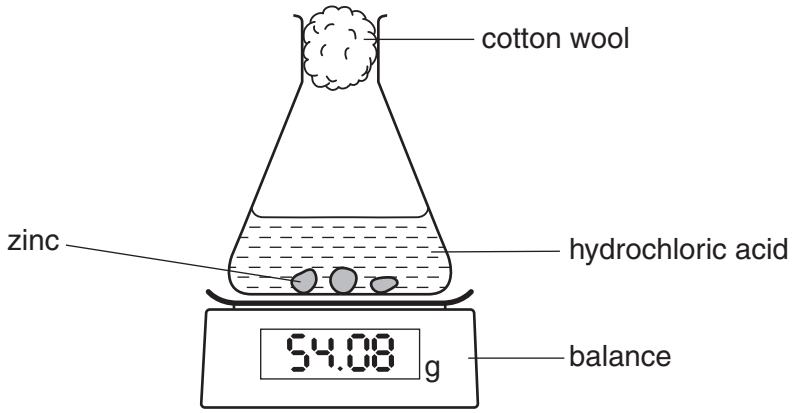
[1]

[Total: 6]

[Turn over

A3 The diagram below shows apparatus that can be used to investigate the rate of reaction between zinc and hydrochloric acid.

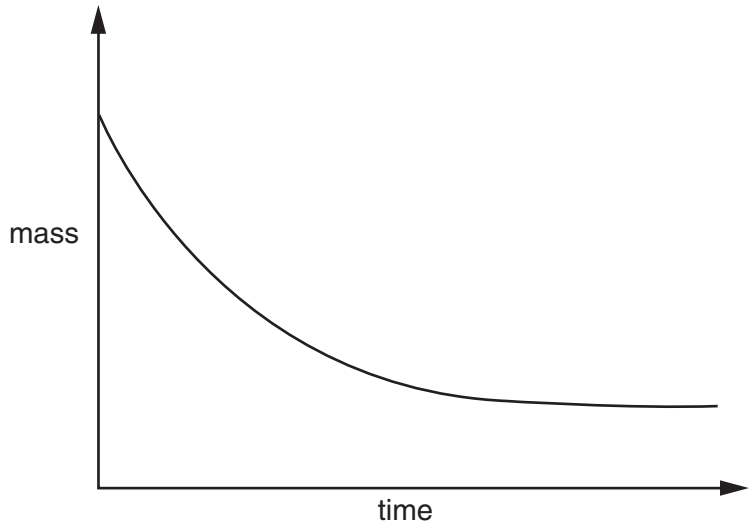
For Examiner's Use



(a) Write the equation, including state symbols, for the reaction between zinc and hydrochloric acid.

[2]

(b) The graph shows the change in mass that occurs during the reaction between zinc and hydrochloric acid.



(i) Explain why the mass decreases during the course of the reaction.

.....

..... [1]

(ii) Exactly the same experiment was repeated but with a catalyst added.
Sketch on the graph the results that would be obtained in the presence of the catalyst. [2]

(c) Explain why zinc reacts more slowly with dilute hydrochloric acid than with concentrated hydrochloric acid.

.....

.....

..... [2]

(d) Explain why hydrochloric acid reacts much faster with zinc powder than with lumps of zinc.

.....

.....

..... [2]

(e) Zinc is added to excess hydrochloric acid. Aqueous sodium hydroxide is added drop by drop to this reaction mixture until it is in excess. Describe what you would observe.

.....

.....

..... [2]

[Total: 11]

[Turn over

A4 The electrical conductivity of a substance is related to its structure and bonding.

For Examiner's Use

(a) Graphite and diamond are both forms of solid carbon. Explain why graphite conducts electricity but diamond does not.

.....

.....

..... [2]

(b) Explain why solid sodium chloride does not conduct electricity whereas aqueous sodium chloride does conduct electricity.

.....

.....

.....

..... [2]

(c) Complete the following table about electrolysis using inert graphite electrodes.

electrolyte	product at cathode	product at anode
molten lead(II) bromide		
aqueous copper(II) sulfate	copper	
dilute sulfuric acid		oxygen

[3]

(d) Describe one commercial use of electrolysis.

use .....

electrolyte used .....

ionic equation for reaction at the cathode .....

[3]

[Total: 10]

A5 Ethanol, C_2H_5OH, can be manufactured by two different processes.

For Examiner's Use

- process **1** – the catalysed addition of steam to ethene
- process **2** – the fermentation of glucose

(a) Name the type of reaction used to manufacture **ethene**.

..... [1]

(b) **(i)** Write the equation for process **1**.

[1]

(ii) Suggest the name of the alcohol made when the alkene C_3H_6 reacts with steam in the presence of a catalyst.

..... [1]

(c) The equation for process **2** is shown below.

$$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

(i) Describe **two** essential conditions required for efficient fermentation.

.....

.....

..... [2]

(ii) Suggest **one** advantage of manufacturing ethanol by process **2** rather than by process **1**.

.....

..... [1]

(d) Process **2** makes an aqueous solution of ethanol. Suggest a method of purification that can be used to remove water from the aqueous ethanol.

..... [1]

(e) Describe a chemical test which could be used to positively identify the carbon dioxide formed during fermentation.

test .....

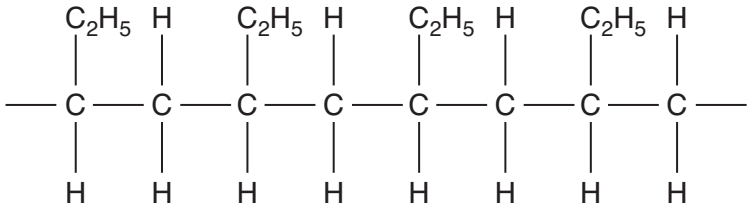
observation ..... [1]

[Total: 8]

A6 Plastics are made of macromolecules called polymers. In the middle of the Pacific Ocean there is a huge area of water that is contaminated with small bits of plastics. The waste plastics have been washed away from coastlines.

For Examiner's Use

(a) Part of the structure of one of the polymers found in the ocean is shown below.



(i) Name this type of polymer.

..... [1]

(ii) Draw the structure of the monomer used in the manufacture of this polymer.

[1]

(iii) Explain why this polymer is described as a saturated hydrocarbon.

.....

..... [1]

(b) Suggest why this polymer is not destroyed in water.

.....

..... [1]

[Total: 4]

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Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B7 Hydrazine, N_2H_4, is a liquid that has been used as a rocket fuel. It reacts with oxygen as shown in the equation.

$$N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$$

This reaction is highly exothermic.

(a) Suggest why the combustion of hydrazine has very little environmental impact.

.....

..... [1]

(b) Explain, in terms of the energy changes which occur during bond breaking and bond forming, why the combustion of hydrazine is exothermic.

.....

.....

.....

..... [2]

(c) **(i)** Calculate the volume of oxygen, measured at room temperature and pressure, needed to completely combust 1.00 tonne of hydrazine.
[One tonne is 10^6 grams. One mole of any gas at room temperature and pressure occupies a volume of 24 dm^3.]

volume of oxygen = ... dm^3 [3]

(ii) A rocket burns hydrazine in an atmosphere of oxygen. Both hydrazine and oxygen are stored in the rocket as liquids. Suggest why oxygen is stored as a liquid rather than as a gas.

.....

..... [1]

(d) Hydrazine, N_2H_4, has similar chemical properties to ammonia.

For Examiner's Use

(i) Hydrazine reacts with hydrochloric acid. Suggest the formula of the product of this reaction.

..... [1]

(ii) Hydrazine is a covalent compound. Draw a 'dot-and-cross' diagram for hydrazine.

[2]

[Total: 10]

[Turn over

B8 An ester is made from a carboxylic acid and an alcohol.

For Examiner's Use

The carboxylic acid has the molecular formula $C_4H_8O_2$. Analysis of the alcohol shows it has the following percentage composition by mass:
52.2% carbon; 13.0% hydrogen; 34.8% oxygen.

(a) (i) Suggest a possible name for the carboxylic acid.

..... [1]

(ii) Draw a possible structure for the carboxylic acid.

[1]

(iii) What is the empirical formula for the carboxylic acid?

..... [1]

(b) Calculate the empirical formula for the alcohol.

.....

.....

.....

.....

..... [2]

(c) (i) Name the ester formed when ethanol reacts with ethanoic acid.

..... [1]

(ii) Suggest **one** commercial use of this ester.

..... [1]

(d) *Terylene* is a polyester used to make clothing materials.

For Examiner's Use

(i) Draw the partial structure of *Terylene*. Include all the atoms and all the bonds in the ester linkage.

[2]

(ii) Which type of natural macromolecule contains the ester linkage?

..... [1]

[Total: 10]

B9 Hydrogen and iodine react together to form hydrogen iodide in a reversible redox reaction. The forward reaction is endothermic.

For Examiner's Use

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +53 \text{ kJ mol}^{-1}$$

Hydrogen and hydrogen iodide are colourless gases whereas iodine gas is purple.

(a) What is meant by the term *redox reaction*?

.....

..... [1]

(b) A mixture of $H_2(g)$, $I_2(g)$ and HI(g) are in dynamic equilibrium at a pressure of 2 atmospheres and 200 °C.

The temperature of the mixture is **increased** to 500 °C but the pressure remains unchanged.
Explain why the mixture becomes less purple in colour.

.....

.....

.....

..... [3]

(c) Calculate the maximum mass of hydrogen iodide that can be made from 45.3 g of hydrogen.

maximum mass of hydrogen iodide = ... g [3]

(d) Hydrogen iodide is dissolved in water to make solution **X**.

For Examiner's Use

(i) **X** is acidified with dilute nitric acid and then aqueous lead(II) nitrate is added. A yellow precipitate is formed.
Write an ionic equation, including state symbols, for this reaction.

[2]

(ii) A small volume of acidified potassium manganate(VII) is added to **X**. The solution changes colour to orange-brown.
From this description what can you deduce about the chemical properties of **X**?

..... [1]

[Total: 10]

B10 Fertilisers are used to promote plant growth and increase crop yield.
Three fertilisers are potassium chloride, potassium nitrate and ammonium phosphate.

For Examiner's Use

(a) Potassium nitrate is a soluble salt that can be prepared by reaction between an acid and an alkali.

(i) Write an equation for the reaction of an acid with an alkali to prepare potassium chloride.

[1]

(ii) Describe the essential experimental details of this preparation of solid potassium chloride.

.....

.....

.....

.....

.....

..... [2]

(b) Ammonium phosphate is an ionic compound containing the phosphate ion, PO_4^{3-}.

(i) Write the formula for ammonium phosphate.

..... [1]

(ii) Calculate the percentage by mass of nitrogen in ammonium phosphate.

% by mass = ... [2]

(c) A farmer adds excess calcium hydroxide to react with hydrogen ions in acidic soils. He then adds fertiliser to increase the nitrogen content of the soil.

(i) Write an ionic equation to show the neutralisation of hydrogen ions by solid calcium hydroxide.

[1]

(ii) Suggest why the farmer should use potassium nitrate rather than ammonium phosphate to increase the nitrogen content of the soil.

.....

..... [1]

(d) A scientist believes a water sample is contaminated by potassium nitrate.
Describe a chemical test to confirm the presence of aqueous nitrate ions.

.....

.....

.....

.....

..... [2]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

Group																	
I	II										III	IV	V	VI	VII	0
							1 H Hydrogen 1									4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	209 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	147 Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	231 Pa Protactinium 91	238 U Uranium 92	237 Np Neptunium 93	244 Pu Plutonium 94	243 Am Americium 95	247 Cm Curium 96	247 Bk Berkelium 97	251 Cf Californium 98	252 Es Einsteinium 99	257 Fm Fermium 100	258 Md Mendelevium 101	259 No Nobelium 102	260 Lr Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key

a
X
b

a = relative atomic mass
X = atomic symbol
b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0637390508

CHEMISTRY **5070/22**

Paper 2 Theory **October/November 2010**

1 hour 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided in the Question Paper.

Section B
Answer any **three** questions.
Write your answers in the spaces provided in the Question Paper.

A copy of the Periodic Table is printed on page 20.
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
B6	
B7	
B8	
B9	
Total	

This document consists of **17** printed pages and **3** blank pages.

Section A

For Examiner's Use

Answer **all** the questions in this section in the spaces provided.

The total mark for this section is 45.

A1 **(a)** Choose from the following list of metals to answer the questions below.

aluminium
iron
lead
magnesium
potassium
silver
vanadium

Each metal can be used once, more than once or not at all.

Which metal

(i) reacts with cold water to form an alkaline solution,

.....[1]

(ii) forms a protective oxide layer on its surface,

.....[1]

(iii) is the catalyst used in the industrial manufacture of ammonia,

.....[1]

(iv) is a sacrificial metal used to prevent iron pipes from rusting,

.....[1]

(v) is in Period 5 of the Periodic Table?

.....[1]

(b) Draw a labelled diagram to show the structure of a typical metal.

[2]

[Total: 7]

A2 Ethanol can be made both by fermentation and by the addition of steam to ethene.

For Examiner's Use

(a) (i) Name the organic compound required for fermentation.

.....[1]

(ii) State the conditions under which fermentation most readily takes place.

.....

.....[2]

(b) Write an equation for the reaction between steam and ethene.

[1]

(c) Ethanol, C_2H_5OH, reacts with ethanoic acid, CH_3COOH.

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

(i) Name the compound $CH_3COOC_2H_5$.

.....[1]

(ii) What name is given to this type of chemical reaction?

.....[1]

(d) (i) Name the third member of the alcohol homologous series.

.....[1]

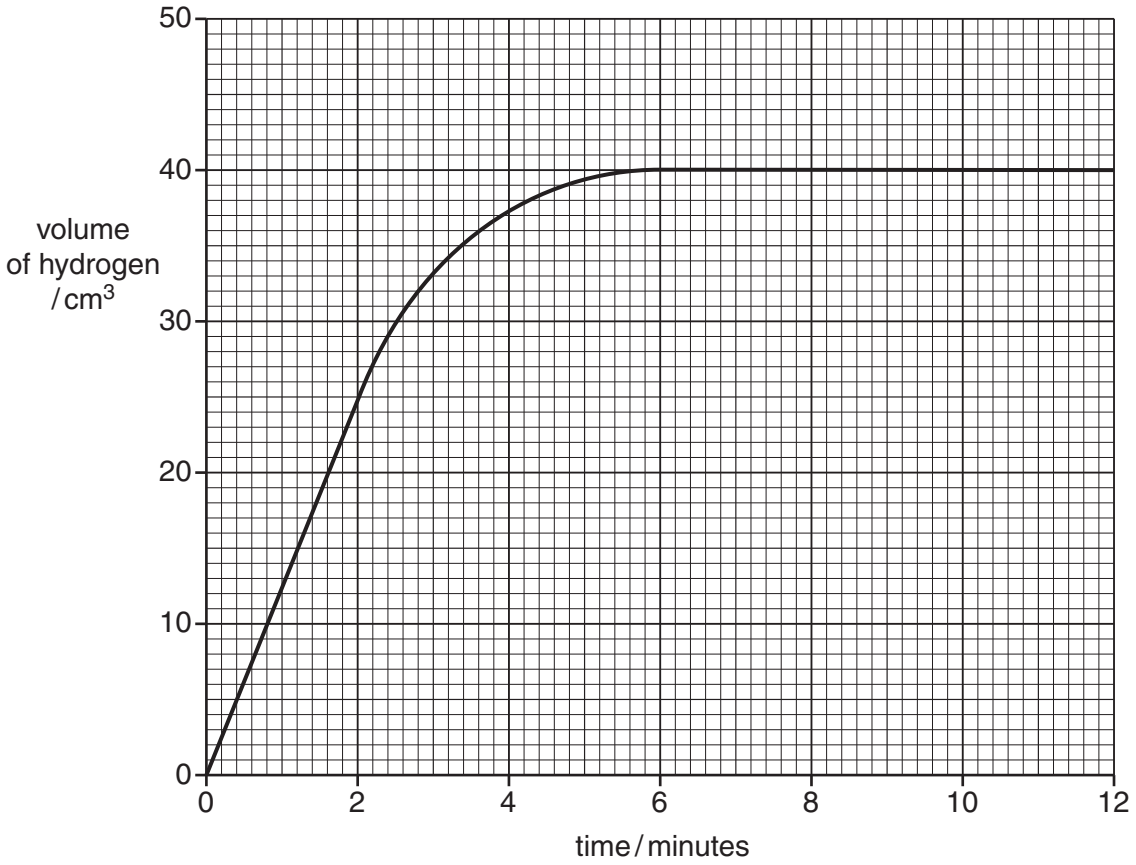
(ii) Draw the structural formula of this compound, showing all atoms and bonds.

[1]

[Total: 8]

A3 A student measured the volume of hydrogen produced over time when small pieces of zinc reacted with excess sulfuric acid.
The results are shown in the graph below.

For Examiner's Use



(a) Use the information from the graph to calculate the average speed of reaction in the first two minutes.

[1]

(b) Explain why the reaction stopped after 6 minutes.

.....[1]

(c) Copper catalyses this reaction.

(i) On the axes above, sketch a line to show the expected results for the catalysed reaction. [1]

(ii) Explain how a catalyst changes the speed of reaction.

.....[1]

(d) Explain, using ideas about colliding particles, what happens to the speed of this reaction when larger particles of zinc are used.

For Examiner's Use

.....

.....

.....[2]

(e) Explain, using ideas about colliding particles, what happens to the speed of this reaction when the temperature of the reaction mixture is increased.

.....

.....

.....[2]

[Total: 8]

A4 Chlorine, bromine and iodine are non-metals in Group VII of the Periodic Table. Their molecules are diatomic.

For Examiner's Use

(a) What do you understand by the term *diatomic*?

.....[1]

(b) **(i)** Describe the trend in colour of the Group VII elements down the Group.

.....[1]

(ii) In what physical state do the following elements exist at room temperature and pressure?

bromine .....

iodine .....[2]

(c) Aqueous bromine reacts with aqueous potassium iodide.

$$Br_2(aq) + 2KI(aq) \longrightarrow 2KBr(aq) + I_2(aq)$$

(i) Write an ionic equation for this reaction.

[1]

(ii) Describe a positive test for iodide ions.

test .....

observation .....[2]

(iii) Explain why aqueous bromine does not react with aqueous potassium chloride.

.....

.....[1]

(d) Hydrochloric acid can be made by burning hydrogen in chlorine, then dissolving the product in water.
Give the formulae for the ions present in hydrochloric acid.

.....[1]

(e) An aqueous solution of calcium hydroxide was titrated with 0.0150 mol / dm^3 hydrochloric acid.

For Examiner's Use

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

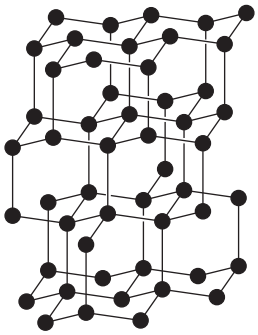
It required 6.00 cm^3 of this aqueous hydrochloric acid to neutralise 20.0 cm^3 of the calcium hydroxide solution.
Calculate the concentration, in mol / dm^3, of the calcium hydroxide solution.

[3]

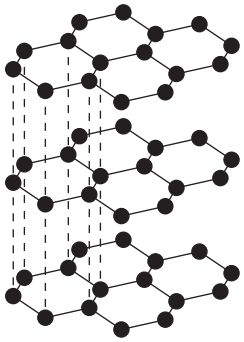
[Total: 12]

A5 Carbon and graphite are two forms of carbon.

For Examiner's Use



diamond



graphite

(a) **(i)** Describe **two** differences in the structure of diamond and graphite.

.....

.....

.....

.....[2]

(ii) Explain, in terms of their structure, why graphite is soft but diamond is hard.

.....

.....

.....[2]

(b) Tin is extracted by heating tin(IV) oxide, SnO_2, with carbon in a furnace.

$$SnO_2 + 2C \longrightarrow Sn + 2CO$$

(i) How does this equation show that tin(IV) oxide gets reduced?

.....

.....[1]

(ii) Explain why carbon monoxide must not be allowed to escape from the furnace.

.....[1]

(c) Carbon monoxide can be formed by the reduction of carbon dioxide with red-hot carbon.

(i) Write an equation for this reaction.

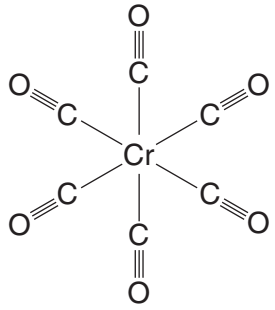
[1]

(ii) Carbon monoxide has a triple covalent bond.
Draw the electronic structure of carbon monoxide. Show only the outer electrons.

For Examiner's Use

[2]

(iii) Carbon monoxide reacts with chromium to form chromium carbonyl.
The structure of chromium carbonyl is shown below.



Write the empirical formula for chromium carbonyl.

.....[1]

[Total: 10]

Section B

For Examiner's Use

Answer **three** questions from this section in the spaces provided.

The total mark for this section is 30.

B6 The carbon cycle regulates the amount of carbon dioxide in the atmosphere.

(a) Explain how the processes of photosynthesis and respiration help to regulate the amount of carbon dioxide in the atmosphere.

.....

.....

.....

.....

.....[3]

(b) Methane is an atmospheric pollutant which contributes to global warming.

(i) Suggest **two** possible consequences of an increase in global warming.

.....

.....[2]

(ii) Write an equation for the complete combustion of methane.

[1]

(iii) Methane is generally unreactive. Apart from combustion, state one other chemical reaction of methane.

.....[1]

(c) Methane is a member of the alkane homologous series.

For Examiner's Use

(i) Describe how the boiling points of unbranched alkanes vary with the size of their molecules.

.....

.....[1]

(ii) Alkanes can be cracked to form alkenes.
State the conditions required for cracking alkanes.

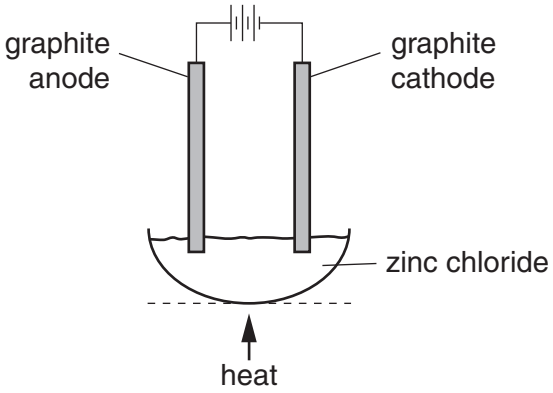
.....

.....[2]

[Total: 10]

B7 Zinc chloride is an ionic solid. It can be electrolysed using the apparatus shown below.

For Examiner's Use



(a) Explain why zinc chloride conducts electricity when molten, but not when solid.

.....

.....[2]

(b) Predict the products of this electrolysis at

the anode, ...

the cathode. .....[1]

(c) When a dilute aqueous solution of zinc chloride is electrolysed, hydroxide ions are converted to oxygen at the anode.
Write the ionic equation for this reaction.

[2]

(d) Describe a positive test for zinc ions.

test .....

observations .....

.....[3]

(e) Solid zinc chloride absorbs ammonia to form tetrammine zinc chloride, $Zn(NH_3)_4Cl_2$.

For Examiner's Use

$$ZnCl_2 + 4NH_3 \longrightarrow Zn(NH_3)_4Cl_2$$

Calculate the maximum yield, in grams, of tetrammine zinc chloride formed when 3.4 g of zinc chloride reacts with excess ammonia.

[2]

[Total:10]

B8 Magnesium is a reactive metal.

For Examiner's Use

(a) **(i)** Name the products formed when magnesium reacts with steam.

.....[1]

(ii) Write the equation for the reaction of magnesium with ethanoic acid, CH_3COOH.

[2]

(b) Magnesium chloride is a soluble salt.
Describe how you can make pure dry crystals of magnesium chloride from magnesium carbonate.

.....

.....

.....

.....

.....[3]

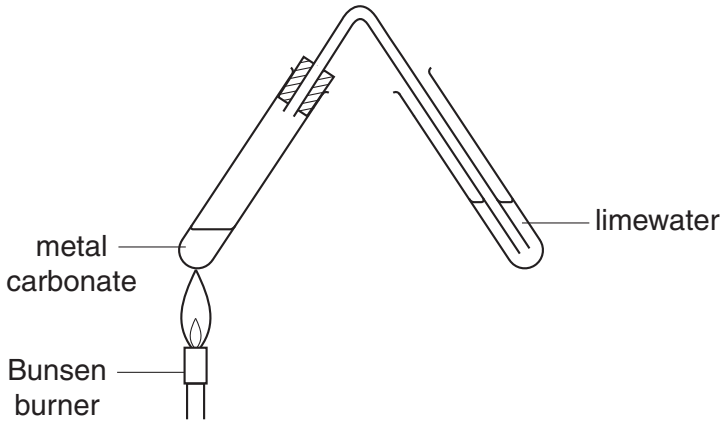
(c) The equation shows the reaction which occurs when magnesium carbonate is heated.

$$MgCO_3 \longrightarrow MgO + CO_2$$

State the name given to this type of chemical reaction.

.....[1]

(d) A student compared the action of heat on three solid metal carbonates.
She heated each carbonate using the apparatus shown below. In each case, she recorded the length of time taken for the limewater to turn milky.



(i) State one factor that must be kept constant if the speeds of reaction are to be compared in a fair way.

.....[1]

(ii) The time taken for the limewater to turn milky for each metal carbonate is shown in the table.

metal carbonate	time taken for the limewater to turn milky / s
copper carbonate	10
magnesium carbonate	40
zinc carbonate	24

Describe and explain these results in terms of the reactivity of the metals.

.....

.....

.....[2]

[Total: 10]

B9 Sulfur dioxide is a gas which contributes to acid rain.

For Examiner's Use

(a) (i) State one source of sulfur dioxide in the atmosphere.

.....[1]

(ii) Acid rain can cause lakes to become acidic. This may cause fish and plants in the water to die.
Describe one **other** environmental problem caused by acid rain.

.....[1]

(b) Acid rain is a solution of dilute sulfuric acid.
The acidity in lakes can be neutralised by adding powdered calcium carbonate.

(i) Write an equation, including state symbols, for the reaction of calcium carbonate with sulfuric acid.

[2]

(ii) State one industrial use of sulfuric acid.

.....[1]

(iii) Sulfuric acid is a strong acid.
What do you understand by the term *strong acid*?

.....

.....[1]

(c) Sulfuric acid is manufactured by the Contact process.
Name the raw materials used in the first stage of the Contact process.

.....[1]

(d) The equation shows the second stage of the Contact process.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 \quad \Delta H = -197\,\text{kJ / mol}$$

(i) State the meaning of the symbol ΔH.

.....[1]

(ii) Predict and explain the effect of increasing the temperature on the position of equilibrium in this reaction.

.....

.....

.....[2]

[Total: 10]

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DATA SHEET
The Periodic Table of the Elements

Group																	
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39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
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223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

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* 58–71 Lanthanoid series
† 90–103 Actinoid series

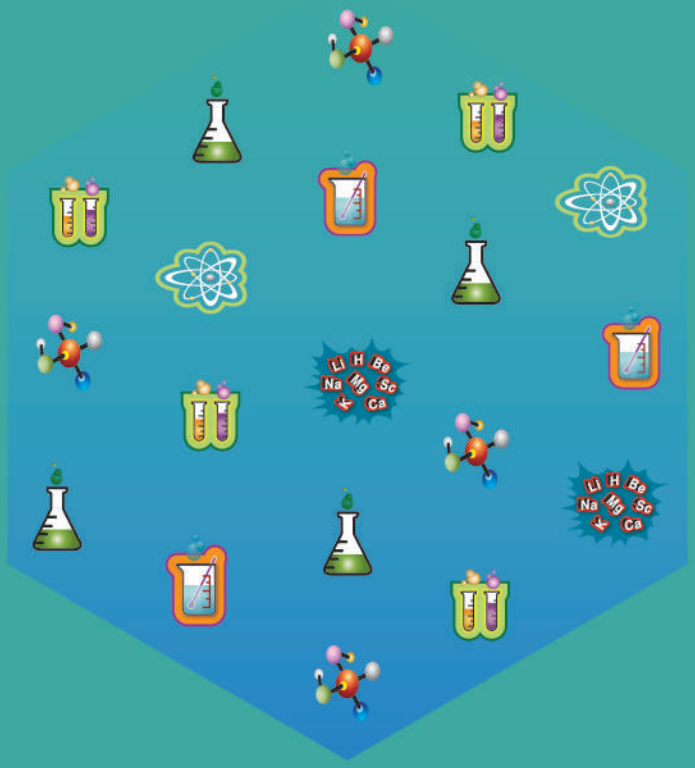
Key: a = relative atomic mass; X = atomic symbol; b = atomic (proton) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Cambridge International O Level Chemistry

Question Papers

Paper #2



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