A-Level Past Papers – Chemistry
A-Level Examinations October/November 2010
Chemistry

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/11**

Paper 1 Multiple Choice **October/November 2010**

1 hour

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

READ THESE INSTRUCTIONS FIRST

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

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
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This document consists of **15** printed pages and **1** blank page.

Section A

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

1 Every year millions of tonnes each of chlorine and sodium hydroxide are manufactured by the electrolysis of brine using a 'diaphragm cell'.

What is the purpose of the diaphragm in such a cell?

A to prevent chlorine gas escaping into the factory

B to prevent the build up of pressure in the electrolysis cell

C to provide a large surface area of electrode

D to stop the products of electrolysis from reacting together

2 A simple ion X^+ contains eight protons.

What is the electronic configuration of X^+?

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

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

C $1s^2$ $2s^2$ $2p^5$

D $1s^2$ $2s^2$ $2p^7$

3 Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = X$

$Na(s) \rightarrow Na(g)$ $\Delta H = Y$

$Na(s) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = Z$

What is the second ionisation energy of sodium?

A 2W **B** X – W **C** Y – W **D** Z – Y

4 Sulfur dioxide, SO_2, is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2, a sample of wine is titrated with iodine, I_2. In this reaction, **one** mole of SO_2 is oxidised by **one** mole of I_2.

What is the change in oxidation number of sulfur in this reaction?

A +2 to +4 **B** +2 to +6 **C** +4 to +5 **D** +4 to +6

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

Nickel makes up 20 % of the total mass of a coin. The coin has a mass of 10.0 g.

How many nickel atoms are in the coin?

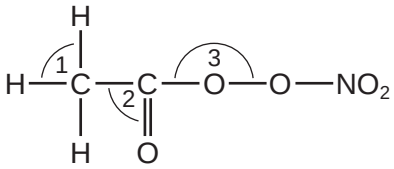
A 2.05×10^{22} **B** 4.30×10^{22} **C** 1.03×10^{23} **D** 1.20×10^{24}

6 Which ion has more electrons than protons and more protons than neutrons?
[H = ${}^{1}_{1}H$; D = ${}^{2}_{1}H$; O = ${}^{16}_{8}O$]

A D^- **B** H_3O^+ **C** OD^- **D** OH^-

7 Organic nitrates in photochemical smog can cause breathing difficulties.

The diagram shows an example of an organic nitrate molecule.



What is the correct order of the bond angles shown in ascending order (smallest first)?

A $1 \rightarrow 2 \rightarrow 3$ **B** $2 \rightarrow 1 \rightarrow 3$ **C** $3 \rightarrow 1 \rightarrow 2$ **D** $3 \rightarrow 2 \rightarrow 1$

8 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for this reaction?

compound	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
carbon	–394
hydrogen	–286
butane	–2877

A –5883 kJ mol^{-1}

B –129 kJ mol^{-1}

C +129 kJ mol^{-1}

D +2197 kJ mol^{-1}

9 In a calorimetric experiment 1.60 g of a fuel is burnt. 45 % of the energy released is absorbed by 200 g of water whose temperature rises from 18 °C to 66 °C. The specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

What is the total energy released per gram of fuel burnt?

A 25 200 J **B** 56 000 J **C** 89 600 J **D** 143 360 J

10 The value of the equilibrium constant, K_c, for the reaction to form ethyl ethanoate from ethanol and ethanoic acid is 4.0 at 60 °C.

$$C_2H_5OH + CH_3CO_2H \rightleftharpoons CH_3CO_2C_2H_5 + H_2O$$

When 1.0 mol of ethanol and 1.0 mol of ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

A $\frac{1}{3}$ **B** $\frac{2}{3}$ **C** $\frac{1}{4}$ **D** $\frac{3}{4}$

11 Which equation represents the change corresponding to the enthalpy change of atomisation of iodine?

A $\frac{1}{2} I_2(g) \rightarrow I(g)$

B $I_2(g) \rightarrow 2I(g)$

C $\frac{1}{2} I_2(s) \rightarrow I(g)$

D $I_2(s) \rightarrow 2I(g)$

12 Camphor is a white solid which was used to make the early plastic celluloid. Camphor contains the same percentage by mass of hydrogen and oxygen.

What is the molecular formula of camphor?

A $C_{10}H_6O_6$ **B** $C_{10}H_8O$ **C** $C_{10}H_{16}O$ **D** $C_{10}H_{10}O_2$

13 Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

A A phosphorus atom has one more proton in its nucleus.

B The atomic radius of a phosphorus atom is greater.

C The outer electron in a phosphorus atom is more shielded.

D The outer electron in a phosphorus atom is paired.

14 When magnesium nitrate, $Mg(NO_3)_2.7H_2O$, is heated, which three gases are given off?

A dinitrogen oxide, oxygen, water vapour

B hydrogen, nitrogen, oxygen

C hydrogen, nitrogen dioxide, oxygen

D nitrogen dioxide, oxygen, water vapour

15 Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.

How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?

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

16 Chile saltpetre, $NaNO_3$, contains sodium iodide as an impurity.

Aqueous silver nitrate is added to an aqueous solution of Chile saltpetre. Concentrated aqueous ammonia is then added.

Which observations are made?

	with acidified silver nitrate	with concentrated aqueous ammonia
A	no precipitate	no further reaction
B	no precipitate	precipitate forms
C	precipitate forms	precipitate dissolves
D	precipitate forms	precipitate remains

[Turn over

17 Which statement describes the halogens chlorine, bromine and iodine?

A Their bond energies decrease with increasing proton number.

B Their first ionisation energies increase with increasing proton number.

C They are all coloured gases at room temperature.

D They are all good reducing agents.

18 Sulfur dioxide is used to bleach wood pulp in the production of paper. It is also used as an additive in the production of jam and marmalade, often in the form of sulfite compounds. When it is present in quantities greater than 10 mg / kg it is required to be listed as an ingredient of the jam.

Why is sulfur dioxide added to jam?

A It is a bleaching agent and removes the undesirable colours from the fruit used in the jam.

B It is a preservative that destroys unwanted bacteria and enzymes.

C It is a reducing agent and removes the acids that give the jam a sharp taste.

D It is an acidic gas and maintains the pH of the jam at a suitable value to give it a sharp taste.

19 Which property of beryllium and its compounds is typical of the elements below it in Group II?

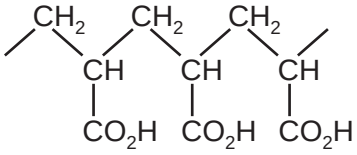
A Be does not react with hot water.

B $BeCl_2$ is covalent.

C $Be(NO_3)_2$ produces BeO on thermal decomposition.

D BeO dissolves in alkalis.

20 One of the characteristics of addition polymerisation is that the empirical formulae of the polymer and of its monomer are the same. The absorbent material in babies' disposable nappies is made from the addition polymer shown.



From which monomer could this addition polymer be obtained?

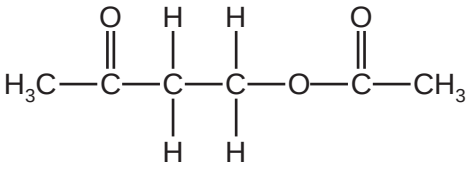
A $CH_3CH(OH)CO_2H$

B $HOCH_2CH_2CO_2H$

C $H_2C{=}CHCO_2H$

D $HO_2CCH{=}CHCO_2H$

21 Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



What is the molecular formula of compound X?

A $C_2H_6O_2$ **B** $C_2H_6O_3$ **C** C_4H_8O **D** $C_4H_8O_2$

22 A compound Y has all of the properties below.

- It is a liquid at 25 °C.
- It mixes completely with water.
- It reacts with aqueous sodium hydroxide.

What could Y be?

A ethanoic acid

B ethanol

C ethene

D ethyl ethanoate

23 Tartaric acid is present in some wines. It may be synthesised in the laboratory in two steps.

$$OHCCHO \xrightarrow{\text{step 1}} \text{intermediate} \xrightarrow{\text{step 2}} HO_2CCH(OH)CH(OH)CO_2H$$

tartaric acid

Which reagents could be used for this synthesis?

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

[Turn over

24 Which alcohol gives only **one** possible oxidation product when warmed with dilute acidified potassium dichromate(VI)?

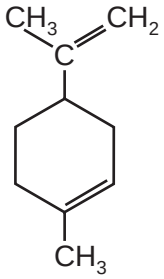
A butan-1-ol

B butan-2-ol

C 2-methylpropan-1-ol

D 2-methylpropan-2-ol

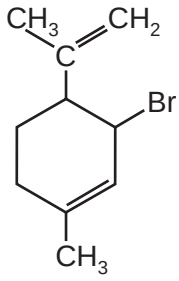
25 Limonene is an oil formed in the peel of citrus fruits.



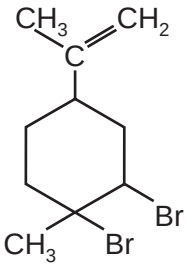
limonene

Which product is formed when an excess of bromine, $Br_2(l)$, reacts with limonene at room temperature in the dark?

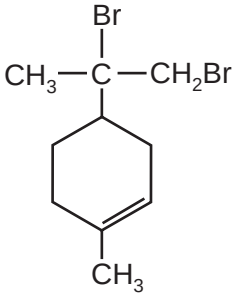
A



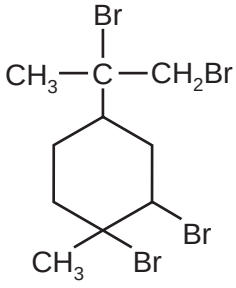
B



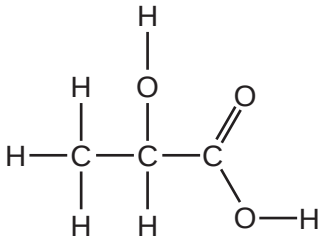
C



D



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



lactic acid

What is a property of lactic acid?

A It decolourises aqueous bromine rapidly.

B It is insoluble in water.

C It reduces Fehling's reagent.

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

27 Which compound would undergo nucleophilic addition?

A bromoethane, C_2H_5Br

B ethanal, CH_3CHO

C ethane, C_2H_6

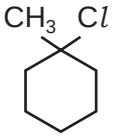
D ethene, C_2H_4

28 Which compound undergoes an S_N1 substitution reaction?

A $CH_3CH_2CH_2Br$

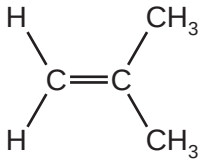
B $(CH_3)_3CCH_2I$

C



D $CH_2{=}CHCl$

29 The compound 2-methylpropene, C_4H_8, is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8, structural or otherwise, which contain a double bond.

What is the value of x?

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

30 Which environmental problem is **not** made worse by the release of oxides of nitrogen from car engines?

A acidification of lakes

B corrosion of buildings

C photochemical smog

D the hole in the ozone layer

Section B

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

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

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

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

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

31 Ethanol is manufactured by reacting ethene gas and steam in the presence of phosphoric(V) acid.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\,kJ\,mol^{-1}$$

The reaction is carried out at 570 K and 60 atm.

What would be the consequences of carrying out the reaction at the same temperature but at a pressure of 200 atm?

1 The manufacturing costs would increase.

2 The maximum yield at equilibrium would be higher.

3 The reaction would proceed at a faster rate.

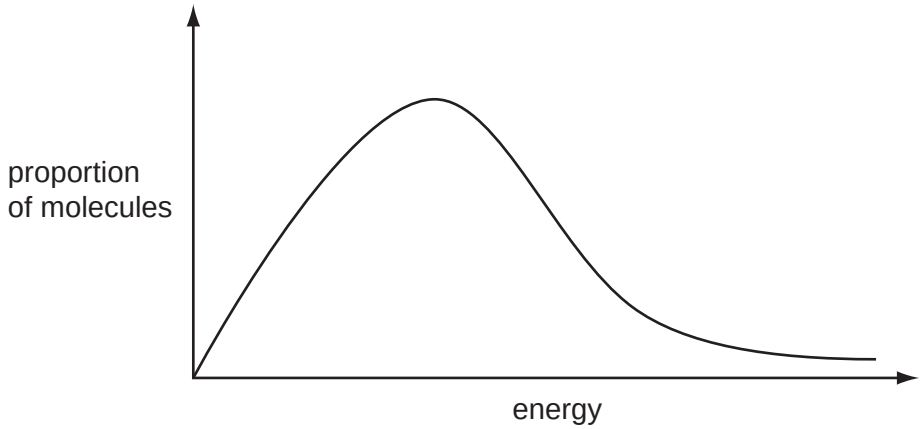
[Turn over

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

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

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

32 The diagram represents the Boltzmann distribution of molecular energies at a given temperature.



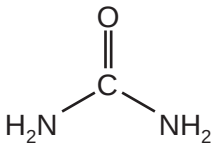
Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

1 increasing the concentration of reactants

2 increasing the temperature

3 the addition of a catalyst

33 Which types of intermolecular forces can exist between adjacent urea molecules?



urea

1 hydrogen bonding

2 permanent dipole-dipole forces

3 temporary induced dipole-dipole forces

34 Samples of calcium and barium are separately added to beakers of cold water containing a few drops of litmus solution.

Which observations will be made with **only** the calcium and **not** with the barium?

1 A white suspension appears in the water.

2 The solution turns blue.

3 A gas is evolved.

35 Disproportionation is the term used to describe a reaction in which a reactant is simultaneously both oxidised and reduced.

To which incomplete equations does the term disproportionation apply?

1 $Cl_2(g) + 2OH^-(aq) \rightarrow H_2O(l) + Cl^-(aq) + \ldots\ldots$

2 $3Cl_2(g) + 6OH^-(aq) \rightarrow 3H_2O(l) + ClO_3^-(aq) + \ldots\ldots$

3 $2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + \ldots\ldots$

36 Element X is a solid. It occurs as a contaminant of carbonaceous fuels.

Its oxide Y is formed in car engines.

Further oxidation of Y to Z can occur in the atmosphere.

Which statements about Y and Z are correct?

1 Molecule Y has lone pairs of electrons.

2 The atmospheric oxidation of Y to Z is a catalysed reaction.

3 Y is a colourless gas.

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

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

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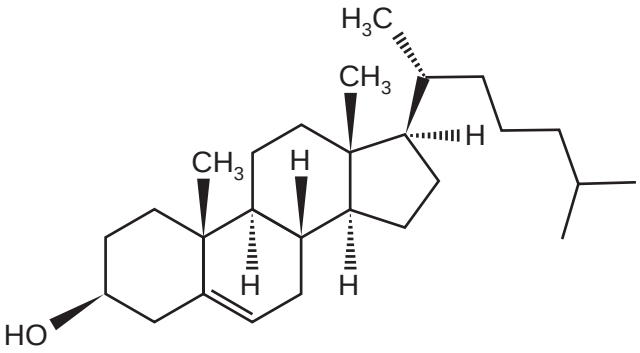
37 The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Which statements about cholesterol are correct?

1 The molecule contains a secondary alcohol group.

2 The molecule contains two π bonds.

3 All carbon atoms in the four rings lie in the same plane.

38 Glyceraldehyde, $HOCH_2CH(OH)CHO$, is formed during photosynthesis, and contains a chiral carbon atom.

Which reagents will react with glyceraldehyde to produce an organic product **without** a chiral carbon atom?

1 warmed acidified $K_2Cr_2O_7$

2 $NaBH_4$

3 Tollens' reagent

39 An organic compound decolourises aqueous bromine and reacts with sodium to produce hydrogen.

Which molecular formula could represent this compound?

1 C_3H_6O

2 $C_3H_4O_2$

3 C_3H_8O

40 Textiles for use in aircraft are treated with a finish containing a halogenoalkane.

What is the reason for this?

1 The textile burns less easily, improving safety.

2 The fabric forms hydrogen bonds to water more readily, making the fabric easier to wash.

3 The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **October/November 2010**

1 hour

Additional Materials: Multiple Choice Answer Sheet
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This document consists of **16** printed pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

Section A

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

1 The ability of an atom in a covalent bond to attract electrons to itself is called its electronegativity.

The greater the difference between the electronegativities of the two atoms in the bond, the more polar is the bond.

Which pair will form the most polar covalent bond between the atoms?

A chlorine and bromine

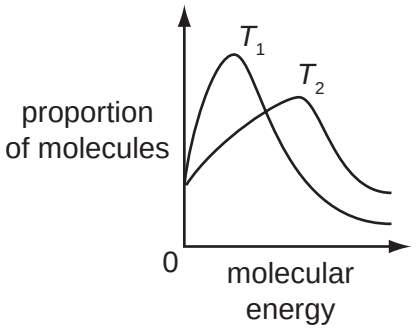
B chlorine and iodine

C fluorine and chlorine

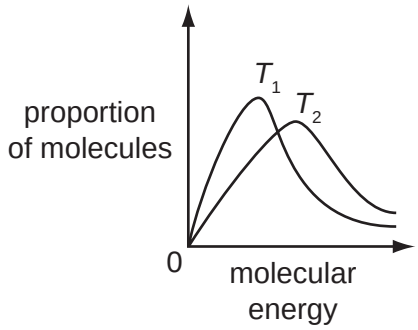
D fluorine and iodine

2 Which diagram correctly represents the Boltzmann distribution of molecular energies at two temperatures T_1 and T_2, where $T_1 = 300\,K$ and $T_2 = 310\,K$?

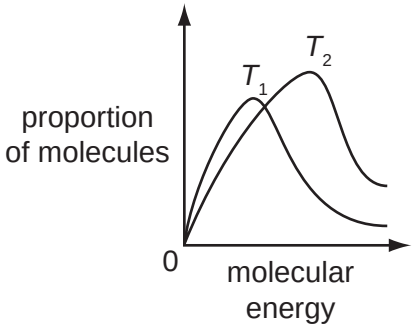
A



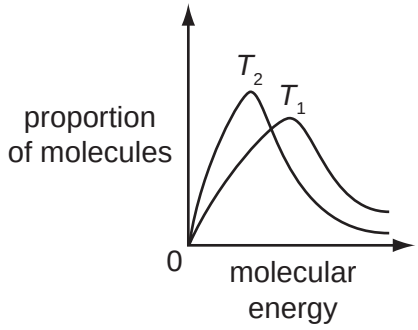
B



C



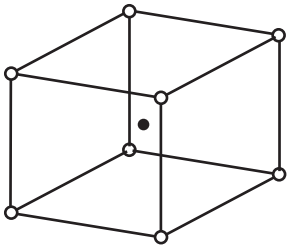
D



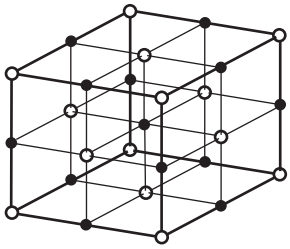
3 The table gives the radii, in pm, of some ions. [1 pm = 10^{-12} m]

ion	radii
Na^+	102
Mg^{2+}	72
Cs^+	167
Cl^-	181
O^{2-}	140

Caesium chloride, CsC*l*, has a different lattice structure from both sodium chloride, NaC*l*, and magnesium oxide, MgO.



CsC*l* lattice



NaC*l* and MgO lattice

Which factor appears to determine the type of lattice for these three compounds?

A the charge on the cation

B the ratio of the ionic charges

C the ratio of the ionic radii

D the sum of the ionic charges

4 Methanol may be prepared by the reaction between carbon monoxide and hydrogen.

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

The relevant average bond energies are given below.

E(C≡O)	1077 kJ mol^{-1}
E(C–O)	360 kJ mol^{-1}
E(C–H)	410 kJ mol^{-1}
E(H–H)	436 kJ mol^{-1}
E(O–H)	460 kJ mol^{-1}

What is the enthalpy change of this reaction?

A –537 kJ mol^{-1}

B –101 kJ mol^{-1}

C +101 kJ mol^{-1}

D +537 kJ mol^{-1}

5 Which solid has a simple molecular lattice?

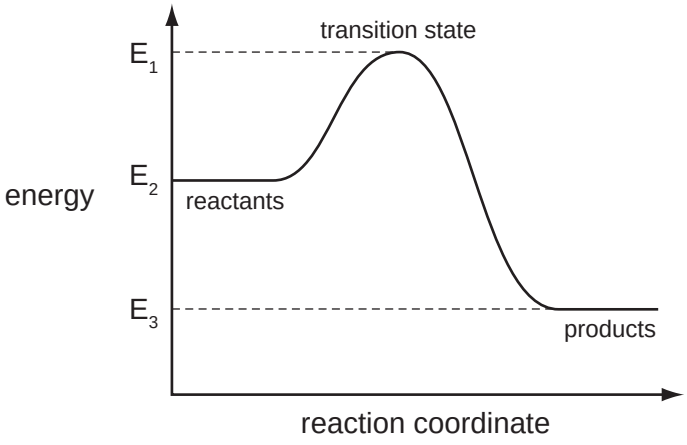
A calcium fluoride

B nickel

C silicon(IV) oxide

D sulfur

6 The reaction pathway diagram below illustrates the energies of reactants, products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

A $E_1 - E_2$ **B** $E_1 - E_3$ **C** $E_2 - E_3$ **D** $(E_1 - E_2) - (E_2 - E_3)$

7 Flask X contains 5 dm^3 of helium at 12 kPa pressure and flask Y contains 10 dm^3 of neon at 6 kPa pressure.

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

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

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

The enthalpy change of formation, ΔH_f, of hydrated calcium ions is the enthalpy change of the following reaction.

$$Ca(s) + aq - 2e^- \rightarrow Ca^{2+}(aq)$$

The following enthalpy changes are **not** quoted in the *Data Booklet*.

$$Ca(s) \rightarrow Ca(g) \qquad \Delta H_a = 177\ kJ\ mol^{-1}$$
$$Ca^{2+}(g) + aq \rightarrow Ca^{2+}(aq) \qquad \Delta H_{hyd} = -1565\ kJ\ mol^{-1}$$

What is the enthalpy change of formation of hydrated calcium ions?

A $-1388\ kJ\ mol^{-1}$

B $-798\ kJ\ mol^{-1}$

C $-238\ kJ\ mol^{-1}$

D $+352\ kJ\ mol^{-1}$

9 The following equilibrium is set up in a mixture of concentrated nitric and sulfuric acids.

$$HNO_3 + H_2SO_4 \rightleftharpoons H_2NO_3^+ + HSO_4^-$$

Which row correctly describes the behaviour of each substance in the equilibrium mixture?

	HNO_3	H_2SO_4	$H_2NO_3^+$	HSO_4^-
A	acid	acid	base	base
B	acid	base	base	acid
C	base	acid	acid	base
D	base	acid	base	acid

10 Which molecule or structure does **not** contain three atoms bonded at an angle between 109° and 110°?

A ethanoic acid

B graphite

C propane

D silicon(IV) oxide

[Turn over

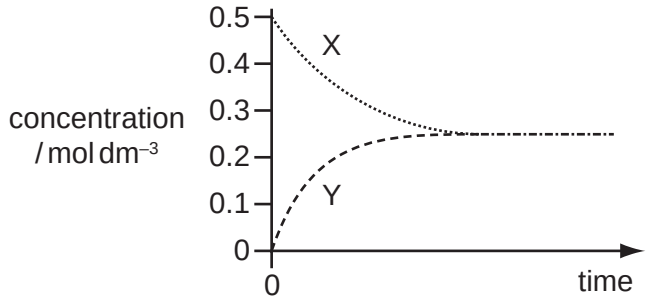
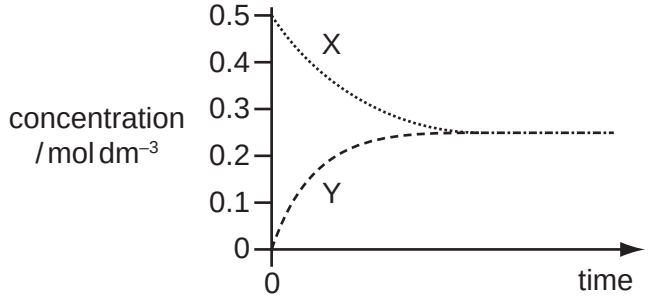
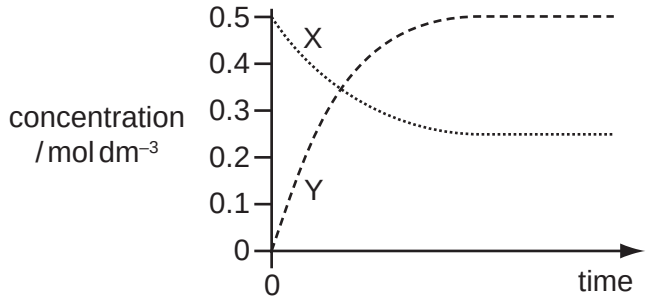
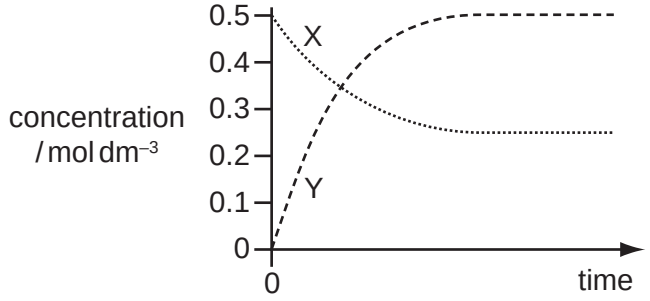
11 A dimer, X, is stable when solid but a dynamic equilibrium is set up in solution.

$$X(aq) \rightleftharpoons 2Y(aq)$$

A solution of X has an initial concentration of $0.50\,mol\,dm^{-3}$. When equilibrium has been reached [X(aq)] has fallen to $0.25\,mol\,dm^{-3}$.

The changes in [X(aq)] and [Y(aq)] are plotted against time until equilibrium is reached. The value of K_c is then calculated.

Which graph and value for K_c are correct?

	graph	K_c / mol dm^{-3}
A		1
B		2
C		1
D		2

12 Equimolar quantities of magnesium carbonate and strontium carbonate are separately heated to bring about complete thermal decomposition. The minimum temperature for this to occur is called T_d.

The cold residues are separately added to equal volumes of water and the change in pH is measured. The change in pH is called ΔpH.

Which metal has the higher value of T_d, and the greater value of ΔpH?

	T_d	ΔpH
A	Mg	Mg
B	Mg	Sr
C	Sr	Mg
D	Sr	Sr

13 In aqueous solution, the acid HIO disproportionates according to the following equation where **m**, **n**, **p** and **q** are simple whole numbers in their lowest ratios.

$$\mathbf{m}HIO \rightarrow \mathbf{n}I_2 + \mathbf{p}HIO_3 + \mathbf{q}H_2O$$

This equation can be balanced using oxidation numbers.

What are the values for **n** and **p**?

	n	**p**
A	1	2
B	2	1
C	4	1
D	4	2

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

Which mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

A 0.70 g **B** 1.00 g **C** 1.40 g **D** 2.25 g

15 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions are isoelectronic (have the same number of electrons).

D The NH_4^+ ion can donate a proton.

[Turn over

16 What happens when chlorine is bubbled through aqueous potassium iodide?

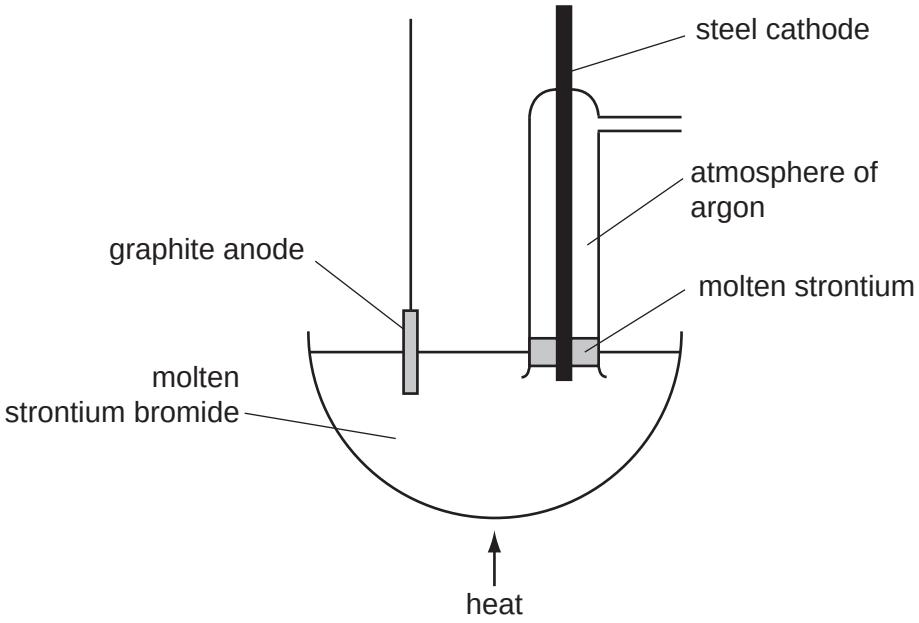
A Chlorine is oxidised to chlorate(V) ions.

B Chlorine is oxidised to chloride ions.

C Iodide ions are oxidised to iodine.

D There is no observable reaction.

17 Strontium metal can be obtained by the electrolysis of molten strontium bromide, $SrBr_2$, using the apparatus shown in the diagram.



Why is an atmosphere of argon used around the cathode?

A A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.

B The argon keeps the strontium molten.

C The argon stops the molten strontium rising too high in the tube.

D Without the argon, strontium oxide would form in the air.

18 Which statement about bromine is correct?

A Bromine is insoluble in non-polar solvents.

B Bromine vapour is more dense than air.

C Bromine will not vapourise significantly under normal conditions.

D Gaseous bromine is purple.

19 Concentrated sulfuric acid reacts with both solid sodium chloride at room temperature and with solid sodium iodide at room temperature.

Which row correctly describes how concentrated sulfuric acid behaves in each of these reactions?

	with sodium chloride	with sodium iodide
A	as an oxidising agent only	as an oxidising agent only
B	as a strong acid and as an oxidising agent	as a strong acid only
C	as a strong acid only	as a strong acid and as an oxidising agent
D	as a strong acid only	as a strong acid only

20 How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

A 3 **B** 4 **C** 5 **D** 6

21 Nine compounds have molecular formula $C_4H_8Br_2$.

Which compound may be synthesised from an alkene by an addition reaction?

A 1,1-dibromobutane

B 1,2-dibromobutane

C 1,3-dibromobutane

D 1,3-dibromomethylpropane

22 When ethanal, CH_3CHO, reacts with HCN and the organic product is hydrolysed by aqueous acid, organic compound Y is formed.

When propanal, C_2H_5CHO, is heated under reflux with acidified potassium dichromate(VI), organic compound Z is formed.

What is the difference in relative molecular mass of compounds Y and Z?

A 12 **B** 14 **C** 16 **D** 17

23 Which sequence of reagents may be used in the laboratory to convert propan-1-ol into 2-bromopropane?

A concentrated sulfuric acid, followed by bromine

B concentrated sulfuric acid, followed by hydrogen bromide

C ethanolic sodium hydroxide, followed by bromine

D ethanolic sodium hydroxide, followed by hydrogen bromide

[Turn over

24 Esters are frequently used as solvents and as flavouring agents in fruit drinks and confectionery.

An ester $C_8H_{12}Br_2O_4$ can be prepared in low yield by the reaction shown.

$$CH_3C(Br)(CH_2Br)CO_2H + (CH_3)_2C(OH)CO_2H \rightleftharpoons C_8H_{12}Br_2O_4 + H_2O$$

What is the structural formula of the ester $C_8H_{12}Br_2O_4$?

A $CH_3C(Br)(CH_2Br)CO_2C(CH_3)_2CO_2H$

B $CH_3C(Br)(CH_2Br)CO_2C(OH)(CH_3)CO_2CH_3$

C $CH_3C(Br)(CH_3)CO_2C(CH_3)_2CO_2CH_2Br$

D $(CH_3)_2C(Br)C(CO_2H)(CH_2Br)CO_2CH_3$

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

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

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

B $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$

C $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$

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

26 Which pair of reagents will take part in a redox reaction?

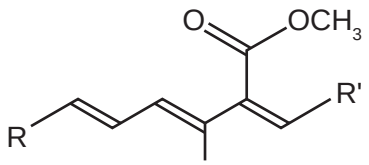
A CH_3CH_2OH + concentrated H_2SO_4

B CH_3CHO + Tollens' reagent

C $CH_3CO_2C_2H_5$ + dilute H_2SO_4

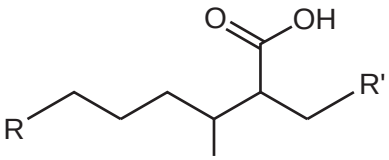
D CH_3COCH_3 + Fehling's solution

27 Part of the structure of strobilurin, a fungicide, is shown. R and R' are inert groups.



If strobilurin is first warmed with aqueous sulfuric acid, and its product then treated with hydrogen in the presence of a palladium catalyst, what could be the structure of the final product?

A



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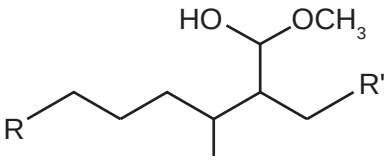

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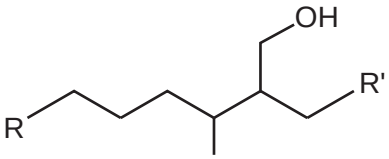

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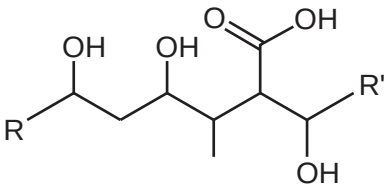
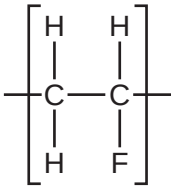


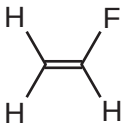
28 Fluoroalkenes are used to make polymers such as poly(vinyl)fluoride (PVF).

PVF is used to make non-flammable interiors for aircraft. The diagram shows the repeat unit of the polymer PVF.



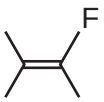
What is the skeletal formula of the monomer of PVF?

A

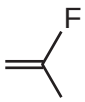


B

C



D



29 $CH_3CH_2COCH_2CH_3$ reacts with hydrogen cyanide to form a cyanohydrin.

Which feature applies to the product?

A It has one chiral centre.

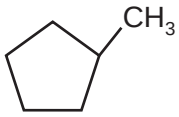
B It is formed by electrophilic addition.

C It is formed via a C–OH intermediate.

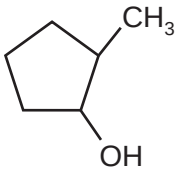
D Its formation requires the use of cyanide ions as a catalyst.

30 Which of the compounds shown have chiral carbon atoms?

1



2



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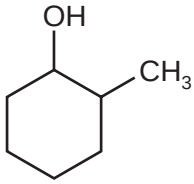
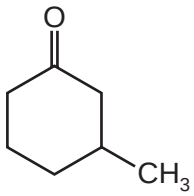


4



A 1, 2, 3 and 4

B 1 and 4 only

C 2 and 3 only

D 2, 3 and 4 only

Section B

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

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

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

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

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

31 When ammonia, NH_3, is produced in a school or college laboratory, it is usually dried before being collected.

Which drying agents may be used to dry ammonia?

1 calcium oxide, CaO

2 phosphorus(V) oxide, P_4O_{10}

3 concentrated sulfuric acid, H_2SO_4

32 Zirconium, Zr, proton number 40, is a metal which is used in corrosion-resistant alloys.

Zirconium metal is extracted from the oxide ZrO_2 by the following sequence of reactions.

reaction 1 $ZrO_2 + 2Cl_2 + 2C \rightarrow ZrCl_4 + 2CO$

reaction 2 $ZrCl_4 + 2Mg \rightarrow Zr + 2MgCl_2$

Which statements about this extraction process are correct?

1 Carbon in reaction 1 behaves as a reducing agent.

2 Magnesium in reaction 2 behaves as a reducing agent.

3 Chlorine in reaction 1 behaves as a reducing agent.

33 Which statements about covalent bonds are correct?

1 A triple bond consists of one π bond and two σ bonds.

2 The electron density in a σ bond is highest along the axis between the two bonded atoms.

3 A π bond restricts rotation about the σ bond axis.

[Turn over

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

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

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

34 A student puts 10 cm^3 of 0.100 mol dm^{-3} sulfuric acid into one test-tube and 10 cm^3 of 0.100 mol dm^{-3} ethanoic acid into another test-tube. He then adds 1.0 g (an excess) of magnesium ribbon to each test-tube and takes suitable measurements. Both acids have the same starting temperature.

Neither reaction is complete after 2 minutes, but both are complete after 20 minutes.

Which statements are correct?

1 After 2 minutes, the sulfuric acid is at a higher temperature than the ethanoic acid.

2 After 2 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

3 After 20 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

35 In which ways are the main reactions in the Haber and Contact processes similar?

1 A higher yield is favoured by higher pressures.

2 The reaction is a redox process.

3 The forward reaction is exothermic.

36 A car burning lead-free fuel has a catalytic converter fitted to its exhaust. On analysis its exhaust gases are shown to contain small quantities of nitrogen oxides.

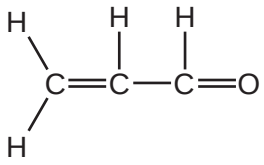
Which modifications would result in lower exhaust concentrations of nitrogen oxides?

1 an increase in the surface area of the catalyst in the converter

2 an increase in the rate of flow of the exhaust gases through the converter

3 a much higher temperature of combustion in the engine

37 The diagram shows a compound present in smoke from burning garden waste.



Which reagents would undergo a colour change on reaction with this compound?

1 aqueous bromine

2 Fehling's reagent

3 warm acidified $K_2Cr_2O_7$

38 Organic acids and alcohols react together to form esters.

Which pairs of compounds could produce a product of molecular formula $C_4H_6O_4$?

1 CH_3CO_2H and C_2H_5OH

2 HCO_2H and $HOCH_2CH_2OH$

3 HO_2CCO_2H and CH_3OH

39 *Use of the Data Booklet is relevant for this question.*

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

Which of these conversions are consistent with this information?

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

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

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

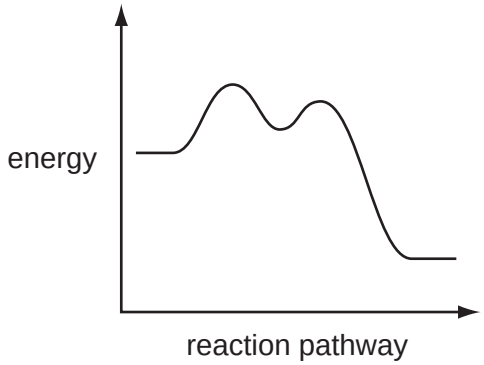
[Turn over

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

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

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

40 A reaction pathway diagram is shown.



Which reactions would have such a profile?

1 $(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$

2 $CH_3CH_2Br + NaOH \rightarrow CH_3CH_2OH + NaBr$

3 $(CH_3)_3CCH_2CH_2Cl + 2NH_3 \rightarrow (CH_3)_3CCH_2CH_2NH_2 + NH_4Cl$

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2010**

1 hour

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

READ THESE INSTRUCTIONS FIRST

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

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

Read the instructions on the Answer Sheet very carefully.

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

This document consists of **13** printed pages and **3** blank pages.

Section A

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

1 A simple ion X^+ contains eight protons.

What is the electronic configuration of X^+?

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

B $1s^2\ 2s^2\ 2p^3$

C $1s^2\ 2s^2\ 2p^5$

D $1s^2\ 2s^2\ 2p^7$

2 Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = X$

$Na(s) \rightarrow Na(g)$ $\Delta H = Y$

$Na(s) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = Z$

What is the second ionisation energy of sodium?

A 2W **B** X – W **C** Y – W **D** Z – Y

3 Which ion has more electrons than protons and more protons than neutrons?
[H = ${}^{1}_{1}H$; D = ${}^{2}_{1}H$; O = ${}^{16}_{8}O$]

A D^- **B** H_3O^+ **C** OD^- **D** OH^-

4 Sulfur dioxide, SO_2, is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2, a sample of wine is titrated with iodine, I_2. In this reaction, **one** mole of SO_2 is oxidised by **one** mole of I_2.

What is the change in oxidation number of sulfur in this reaction?

A +2 to +4 **B** +2 to +6 **C** +4 to +5 **D** +4 to +6

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

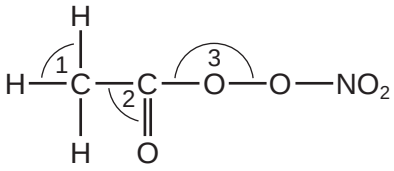
Nickel makes up 20 % of the total mass of a coin. The coin has a mass of 10.0 g.

How many nickel atoms are in the coin?

A 2.05×10^{22} **B** 4.30×10^{22} **C** 1.03×10^{23} **D** 1.20×10^{24}

6 Organic nitrates in photochemical smog can cause breathing difficulties.

The diagram shows an example of an organic nitrate molecule.



What is the correct order of the bond angles shown in ascending order (smallest first)?

A $1 \rightarrow 2 \rightarrow 3$ **B** $2 \rightarrow 1 \rightarrow 3$ **C** $3 \rightarrow 1 \rightarrow 2$ **D** $3 \rightarrow 2 \rightarrow 1$

7 Every year millions of tonnes each of chlorine and sodium hydroxide are manufactured by the electrolysis of brine using a 'diaphragm cell'.

What is the purpose of the diaphragm in such a cell?

A to prevent chlorine gas escaping into the factory

B to prevent the build up of pressure in the electrolysis cell

C to provide a large surface area of electrode

D to stop the products of electrolysis from reacting together

8 Which statement describes the halogens chlorine, bromine and iodine?

A Their bond energies decrease with increasing proton number.

B Their first ionisation energies increase with increasing proton number.

C They are all coloured gases at room temperature.

D They are all good reducing agents.

9 Chile saltpetre, $NaNO_3$, contains sodium iodide as an impurity.

Aqueous silver nitrate is added to an aqueous solution of Chile saltpetre. Concentrated aqueous ammonia is then added.

Which observations are made?

	with acidified silver nitrate	with concentrated aqueous ammonia
A	no precipitate	no further reaction
B	no precipitate	precipitate forms
C	precipitate forms	precipitate dissolves
D	precipitate forms	precipitate remains

[Turn over

10 The value of the equilibrium constant, K_c, for the reaction to form ethyl ethanoate from ethanol and ethanoic acid is 4.0 at 60 °C.

$$C_2H_5OH + CH_3CO_2H \rightleftharpoons CH_3CO_2C_2H_5 + H_2O$$

When 1.0 mol of ethanol and 1.0 mol of ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

A $\frac{1}{3}$ **B** $\frac{2}{3}$ **C** $\frac{1}{4}$ **D** $\frac{3}{4}$

11 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.

$$4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$$

By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, for this reaction?

compound	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
carbon	–394
hydrogen	–286
butane	–2877

A –5883 kJ mol^{-1}

B –129 kJ mol^{-1}

C +129 kJ mol^{-1}

D +2197 kJ mol^{-1}

12 In a calorimetric experiment 1.60 g of a fuel is burnt. 45 % of the energy released is absorbed by 200 g of water whose temperature rises from 18 °C to 66 °C. The specific heat capacity of water is 4.2 J g^{-1} K^{-1}.

What is the total energy released per gram of fuel burnt?

A 25 200 J **B** 56 000 J **C** 89 600 J **D** 143 360 J

13 Which equation represents the change corresponding to the enthalpy change of atomisation of iodine?

A $\frac{1}{2} I_2(g) \rightarrow I(g)$

B $I_2(g) \rightarrow 2I(g)$

C $\frac{1}{2} I_2(s) \rightarrow I(g)$

D $I_2(s) \rightarrow 2I(g)$

14 Camphor is a white solid which was used to make the early plastic celluloid. Camphor contains the same percentage by mass of hydrogen and oxygen.

What is the molecular formula of camphor?

A $C_{10}H_6O_6$ **B** $C_{10}H_8O$ **C** $C_{10}H_{16}O$ **D** $C_{10}H_{10}O_2$

15 Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.

How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?

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

16 Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

A A phosphorus atom has one more proton in its nucleus.

B The atomic radius of a phosphorus atom is greater.

C The outer electron in a phosphorus atom is more shielded.

D The outer electron in a phosphorus atom is paired.

17 When magnesium nitrate, $Mg(NO_3)_2.7H_2O$, is heated, which three gases are given off?

A dinitrogen oxide, oxygen, water vapour

B hydrogen, nitrogen, oxygen

C hydrogen, nitrogen dioxide, oxygen

D nitrogen dioxide, oxygen, water vapour

18 Sulfur dioxide is used to bleach wood pulp in the production of paper. It is also used as an additive in the production of jam and marmalade, often in the form of sulfite compounds. When it is present in quantities greater than 10 mg / kg it is required to be listed as an ingredient of the jam.

Why is sulfur dioxide added to jam?

A It is a bleaching agent and removes the undesirable colours from the fruit used in the jam.

B It is a preservative that destroys unwanted bacteria and enzymes.

C It is a reducing agent and removes the acids that give the jam a sharp taste.

D It is an acidic gas and maintains the pH of the jam at a suitable value to give it a sharp taste.

[Turn over

19 Which property of beryllium and its compounds is typical of the elements below it in Group II?

A Be does not react with hot water.

B $BeCl_2$ is covalent.

C $Be(NO_3)_2$ produces BeO on thermal decomposition.

D BeO dissolves in alkalis.

20 A compound Y has all of the properties below.

- It is a liquid at 25 °C.
- It mixes completely with water.
- It reacts with aqueous sodium hydroxide.

What could Y be?

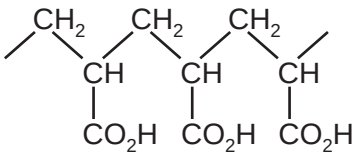
A ethanoic acid

B ethanol

C ethene

D ethyl ethanoate

21 One of the characteristics of addition polymerisation is that the empirical formulae of the polymer and of its monomer are the same. The absorbent material in babies' disposable nappies is made from the addition polymer shown.



From which monomer could this addition polymer be obtained?

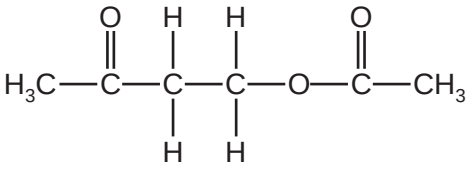
A $CH_3CH(OH)CO_2H$

B $HOCH_2CH_2CO_2H$

C $H_2C{=}CHCO_2H$

D $HO_2CCH{=}CHCO_2H$

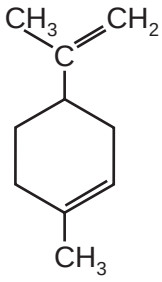
22 Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



What is the molecular formula of compound X?

A $C_2H_6O_2$ **B** $C_2H_6O_3$ **C** C_4H_8O **D** $C_4H_8O_2$

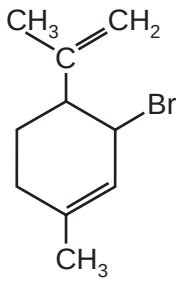
23 Limonene is an oil formed in the peel of citrus fruits.



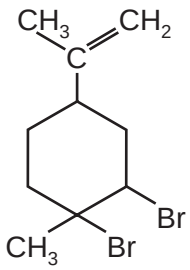
limonene

Which product is formed when an excess of bromine, $Br_2(l)$, reacts with limonene at room temperature in the dark?

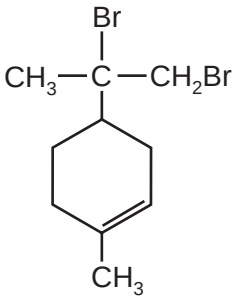
A



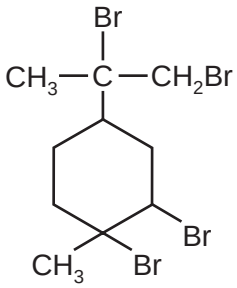
B



C



D



24 Tartaric acid is present in some wines. It may be synthesised in the laboratory in two steps.

$$OHCCHO \xrightarrow{\text{step 1}} \text{intermediate} \xrightarrow{\text{step 2}} HO_2CCH(OH)CH(OH)CO_2H$$

tartaric acid

Which reagents could be used for this synthesis?

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

25 Which alcohol gives only **one** possible oxidation product when warmed with dilute acidified potassium dichromate(VI)?

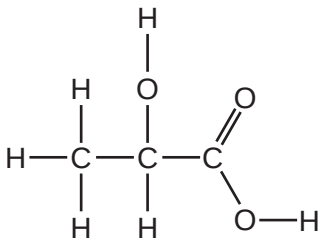
A butan-1-ol

B butan-2-ol

C 2-methylpropan-1-ol

D 2-methylpropan-2-ol

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



lactic acid

What is a property of lactic acid?

A It decolourises aqueous bromine rapidly.

B It is insoluble in water.

C It reduces Fehling's reagent.

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

27 Which compound would undergo nucleophilic addition?

A bromoethane, C_2H_5Br

B ethanal, CH_3CHO

C ethane, C_2H_6

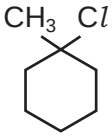
D ethene, C_2H_4

28 Which compound undergoes an S_N1 substitution reaction?

A $CH_3CH_2CH_2Br$

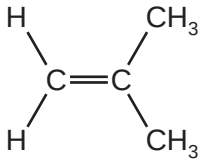
B $(CH_3)_3CCH_2I$

C



D $CH_2{=}CHCl$

29 The compound 2-methylpropene, C_4H_8, is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8, structural or otherwise, which contain a double bond.

What is the value of x?

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

30 Which environmental problem is **not** made worse by the release of oxides of nitrogen from car engines?

A acidification of lakes

B corrosion of buildings

C photochemical smog

D the hole in the ozone layer

[Turn over

Section B

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

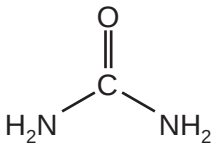
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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

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

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

31 Which types of intermolecular forces can exist between adjacent urea molecules?



urea

1 hydrogen bonding

2 permanent dipole-dipole forces

3 temporary induced dipole-dipole forces

32 Ethanol is manufactured by reacting ethene gas and steam in the presence of phosphoric(V) acid.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45\,kJ\,mol^{-1}$$

The reaction is carried out at 570 K and 60 atm.

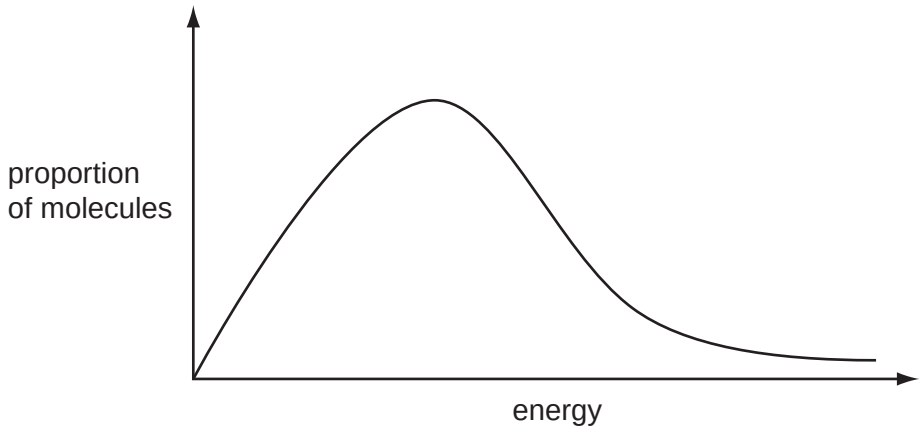
What would be the consequences of carrying out the reaction at the same temperature but at a pressure of 200 atm?

1 The manufacturing costs would increase.

2 The maximum yield at equilibrium would be higher.

3 The reaction would proceed at a faster rate.

33 The diagram represents the Boltzmann distribution of molecular energies at a given temperature.



Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

1 increasing the concentration of reactants

2 increasing the temperature

3 the addition of a catalyst

34 Disproportionation is the term used to describe a reaction in which a reactant is simultaneously both oxidised and reduced.

To which incomplete equations does the term disproportionation apply?

1 $Cl_2(g) + 2OH^-(aq) \rightarrow H_2O(l) + Cl^-(aq) + \ldots\ldots$

2 $3Cl_2(g) + 6OH^-(aq) \rightarrow 3H_2O(l) + ClO_3^-(aq) + \ldots\ldots$

3 $2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + \ldots\ldots$

35 Samples of calcium and barium are separately added to beakers of cold water containing a few drops of litmus solution.

Which observations will be made with **only** the calcium and **not** with the barium?

1 A white suspension appears in the water.

2 The solution turns blue.

3 A gas is evolved.

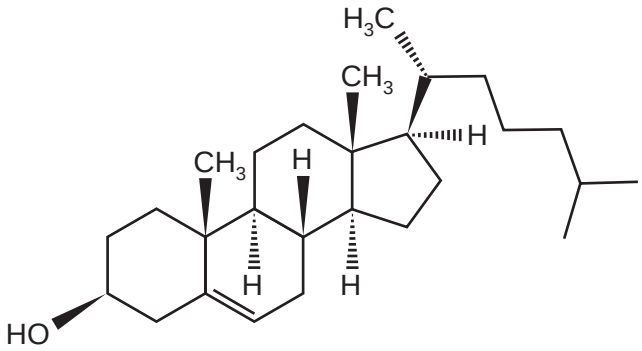
[Turn over

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

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

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

36 The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Which statements about cholesterol are correct?

1 The molecule contains a secondary alcohol group.

2 The molecule contains two π bonds.

3 All carbon atoms in the four rings lie in the same plane.

37 Element X is a solid. It occurs as a contaminant of carbonaceous fuels.

Its oxide Y is formed in car engines.

Further oxidation of Y to Z can occur in the atmosphere.

Which statements about Y and Z are correct?

1 Molecule Y has lone pairs of electrons.

2 The atmospheric oxidation of Y to Z is a catalysed reaction.

3 Y is a colourless gas.

38 An organic compound decolourises aqueous bromine and reacts with sodium to produce hydrogen.

Which molecular formula could represent this compound?

1 C_3H_6O

2 $C_3H_4O_2$

3 C_3H_8O

39 Textiles for use in aircraft are treated with a finish containing a halogenoalkane.

What is the reason for this?

1 The textile burns less easily, improving safety.

2 The fabric forms hydrogen bonds to water more readily, making the fabric easier to wash.

3 The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

40 Glyceraldehyde, $HOCH_2CH(OH)CHO$, is formed during photosynthesis, and contains a chiral carbon atom.

Which reagents will react with glyceraldehyde to produce an organic product **without** a chiral carbon atom?

1 warmed acidified $K_2Cr_2O_7$

2 $NaBH_4$

3 Tollens' reagent

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5242495758

CHEMISTRY **9701/21**

Paper 2 Structured Questions AS Core **October/November 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

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

For Examiner's Use	
1	
2	
3	
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5	
Total	

This document consists of **10** printed pages and **2** blank pages.

Answer **all** the questions in the space provided.

For Examiner's Use

1 In 1814, Sir Humphrey Davy and Michael Faraday collected samples of a flammable gas, **A**, from the ground near Florence in Italy.
They analysed **A** which they found to be a hydrocarbon. Further experiments were then carried out to determine the molecular formula of **A**.

(a) What is meant by the term *molecular formula*?

.....

.....

.....[2]

Davy and Faraday deduced the formula of **A** by exploding it with an excess of oxygen and analysing the products of combustion.

(b) Complete and balance the following equation for the complete combustion of a hydrocarbon with the formula C_xH_y.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow \text{.....} + \text{.....}$$

[2]

(c) When 10 cm^3 of **A** was mixed at room temperature with 50 cm^3 of oxygen (an excess) and exploded, 40 cm^3 of gas remained after cooling the apparatus to room temperature and pressure.
When this 40 cm^3 of gas was shaken with an excess of aqueous potassium hydroxide, KOH, 30 cm^3 of gas still remained.

(i) What is the identity of the 30 cm^3 of gas that remained at the end of the experiment?

.....

(ii) The combustion of **A** produced a gas that reacted with the KOH(aq).

What is the identity of this gas?

.....

(iii) What volume of the gas you have identified in **(ii)** was produced by the combustion of **A**?

.....cm^3

(iv) What volume of oxygen was used up in the combustion of **A**?

.....cm^3 [4]

(d) Use your equation in **(b)** and your results from **(c)(iii)** and **(c)(iv)** to calculate the molecular formula of **A**.
Show all of your working.

For Examiner's Use

[3]

[Total: 11]

For Examiner's Use

2 Nitrogen makes up about 79% of the Earth's atmosphere. As a constituent element of proteins, it is present in living organisms.

Atmospheric nitrogen is used in the Haber process for the manufacture of ammonia.

(a) Write an equation for the formation of ammonia in the Haber process.

.....[1]

(b) The Haber process is usually carried out at a high pressure of between 60 and 200 atmospheres (between 60×10^5 Pa and 200×10^5 Pa).
State **two further** important operating conditions that are used in the Haber process.
For **each** of your conditions, explain why it is used.

condition 1 .....

reason .....

condition 2 .....

reason .....[4]

(c) State **one** large-scale use for ammonia, other than in the production of nitrogenous fertilisers.

..... [1]

(d) The uncontrolled use of nitrogenous fertilisers can cause environmental damage to lakes and streams. This is known as 'eutrophication'.

What are the processes that occur when excessive amounts of nitrogenous fertilisers get into lakes and streams?

.....

.....

.....[2]

In many countries, new cars have to comply with regulations which are intended to reduce the pollutants coming from their internal combustion engines.

For Examiner's Use

Two pollutants that may be formed in an internal combustion engine are carbon monoxide, CO, and nitrogen monoxide, NO.

(e) (i) Outline how **each** of these pollutants may be formed in an internal combustion engine.

CO .....

.....

NO .....

.....

(ii) State the main hazard associated with **each** of these pollutants.

CO .....

NO ..... [4]

Pollutants such as CO and NO are removed from the exhaust gases of internal combustion engines by catalytic converters which are placed in the exhaust system of a car.

(f) (i) What metal is most commonly used as the catalyst in a catalytic converter?

.....

(ii) Construct **one** balanced equation for the reaction in which **both** CO **and** NO are removed from the exhaust gases by a catalytic converter.

.....[2]

[Total: 14]

[Turn over

3 Crude oil is a naturally occurring flammable liquid which consists of a complex mixture of hydrocarbons. In order to separate the hydrocarbons the crude oil is subjected to fractional distillation.

For Examiner's Use

(a) Explain what is meant by the following terms.

(i) *hydrocarbon* .....

.....

(ii) *fractional distillation* .....

.....[2]

(b) Undecane, $C_{11}H_{24}$, is a long chain hydrocarbon which is present in crude oil.
Such long chain hydrocarbons are 'cracked' to produce alkanes and alkenes which have smaller molecules.

(i) Give the conditions for **two different** processes by which long chain molecules may be cracked.

process 1 .....

.....

process 2 .....

.....

(ii) Undecane, $C_{11}H_{24}$, can be cracked to form pentane, C_5H_{12}, and an alkene.
Construct a balanced equation for this reaction.

.....[3]

Pentane, C_5H_{12}, exhibits structural isomerism.

(c) **(i)** Draw the three structural isomers of pentane.

isomer **B**	isomer **C**	isomer **D**

(ii) The three isomers of pentane have different boiling points.

Which of your isomers has the highest boiling point?

isomer .....

Suggest an explanation for your answer.

.....

.....

.....[6]

The unsaturated hydrocarbon, **E**, is obtained by cracking hexane and is important in the chemical industry.

The standard enthalpy change of combustion of **E** is –2059 kJ mol^{-1}.

(d) Define the term *standard enthalpy change of combustion*.

.....

.....[2]

When 0.47 g of **E** was completely burnt in air, the heat produced raised the temperature of 200 g of water by 27.5 °C. Assume no heat losses occurred during this experiment.

(e) **(i)** Use relevant data from the *Data Booklet* to calculate the amount of heat released in this experiment.

(ii) Use the data above and your answer to **(i)** to calculate the relative molecular mass, M_r, of **E**.

[4]

(f) Deduce the molecular formula of **E**.

[1]

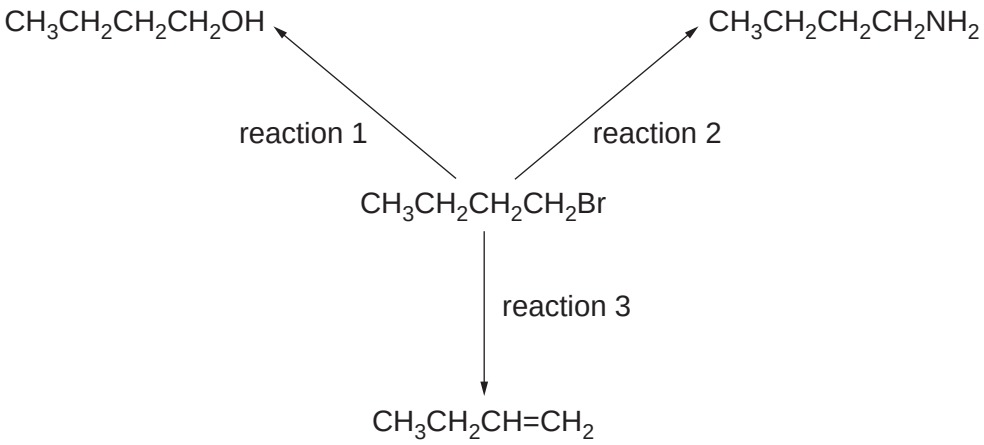
[Total: 18]

[Turn over

4 Halogenoalkanes have many chemical uses, particularly as intermediates in organic reactions.

For Examiner's Use

Three reactions of 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, are shown below.



(a) For **each** reaction, state the reagent and solvent used.

reaction 1 reagent .....

solvent .....

reaction 2 reagent .....

solvent .....

reaction 3 reagent .....

solvent ..... [6]

(b) When 1-iodobutane, $CH_3CH_2CH_2CH_2I$, is reacted under the same conditions as those used in reaction 1, butan-1-ol is formed.

What difference, if any, would there be in the rate of this reaction compared to the reaction of 1-bromobutane?

Use appropriate data from the *Data Booklet* to explain your answer.

.....

.....

.....

..... [3]

Dichlorodifluoromethane, CCl_2F_2, is an example of a chlorofluorocarbon (CFC) that was formerly used as an aerosol propellant. In September 2007, at the Montreal summit, approximately 200 countries agreed to phase out the use of CFCs by 2020.

For Examiner's Use

(c) State two properties of CFCs that made them suitable as aerosol propellants.

1. .....

2. ..... [2]

(d) When CFCs are present in the upper atmosphere, homolytic fission takes place in the presence of ultraviolet light.

(i) What is meant by the term *homolytic fission*?

.....

.....

(ii) Suggest an equation for the homolytic fission of CCl_2F_2.

..... [2]

(e) The most common replacements for CFCs as aerosol propellants are hydrocarbons such as propane and butane.

Suggest **one** disadvantage of these compounds as aerosol propellants.

..... [1]

[Total: 14]

[Turn over

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5 The gaseous hydrogen halides HC*l*, HBr and HI, may be prepared by reacting the corresponding sodium salt with anhydrous phosphoric(V) acid, H_3PO_4.

When the sodium halide Na*X* was used, the following reaction occurred and a sample of gaseous H*X* was collected in a gas jar.

$$NaX + H_3PO_4 \rightarrow NaH_2PO_4 + HX$$

A hot glass rod was placed in the sample of H*X* and immediately a red/orange colour was observed.

(a) What is the identity of Na*X*?

..... [1]

(b) What gas, other than H*X*, would be formed if concentrated sulfuric acid were used with Na*X* instead of phosphoric(V) acid?

..... [1]

(c) Suggest why phosphoric(V) acid rather than concentrated sulfuric acid is used to make samples of H*X* from the corresponding sodium salt.
Explain your answer.

.....

..... [1]

[Total: 3]

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General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/22**

Paper 2 Structured Questions AS Core **October/November 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

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Total	

This document consists of **10** printed pages and **2** blank pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

Answer **all** the questions in the space provided.

For Examiner's Use

1 In 1814, Sir Humphrey Davy and Michael Faraday collected samples of a flammable gas, **A**, from the ground near Florence in Italy.
They analysed **A** which they found to be a hydrocarbon. Further experiments were then carried out to determine the molecular formula of **A**.

(a) What is meant by the term *molecular formula*?

.....

.....

.....[2]

Davy and Faraday deduced the formula of **A** by exploding it with an excess of oxygen and analysing the products of combustion.

(b) Complete and balance the following equation for the complete combustion of a hydrocarbon with the formula C_xH_y.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow \text{.....} + \text{.....}$$

[2]

(c) When 10 cm^3 of **A** was mixed at room temperature with 50 cm^3 of oxygen (an excess) and exploded, 40 cm^3 of gas remained after cooling the apparatus to room temperature and pressure.
When this 40 cm^3 of gas was shaken with an excess of aqueous potassium hydroxide, KOH, 30 cm^3 of gas still remained.

(i) What is the identity of the 30 cm^3 of gas that remained at the end of the experiment?

.....

(ii) The combustion of **A** produced a gas that reacted with the KOH(aq).

What is the identity of this gas?

.....

(iii) What volume of the gas you have identified in **(ii)** was produced by the combustion of **A**?

.....cm^3

(iv) What volume of oxygen was used up in the combustion of **A**?

.....cm^3 [4]

(d) Use your equation in **(b)** and your results from **(c)(iii)** and **(c)(iv)** to calculate the molecular formula of **A**.
Show all of your working.

For Examiner's Use

[3]

[Total: 11]

For Examiner's Use

2 Nitrogen makes up about 79% of the Earth's atmosphere. As a constituent element of proteins, it is present in living organisms.

Atmospheric nitrogen is used in the Haber process for the manufacture of ammonia.

(a) Write an equation for the formation of ammonia in the Haber process.

.....[1]

(b) The Haber process is usually carried out at a high pressure of between 60 and 200 atmospheres (between 60×10^5 Pa and 200×10^5 Pa).
State **two further** important operating conditions that are used in the Haber process.
For **each** of your conditions, explain why it is used.

condition 1 .....

reason .....

condition 2 .....

reason .....[4]

(c) State **one** large-scale use for ammonia, other than in the production of nitrogenous fertilisers.

..... [1]

(d) The uncontrolled use of nitrogenous fertilisers can cause environmental damage to lakes and streams. This is known as 'eutrophication'.

What are the processes that occur when excessive amounts of nitrogenous fertilisers get into lakes and streams?

.....

.....

.....[2]

In many countries, new cars have to comply with regulations which are intended to reduce the pollutants coming from their internal combustion engines.

Two pollutants that may be formed in an internal combustion engine are carbon monoxide, CO, and nitrogen monoxide, NO.

(e) (i) Outline how **each** of these pollutants may be formed in an internal combustion engine.

CO .....

.....

NO .....

.....

(ii) State the main hazard associated with **each** of these pollutants.

CO .....

NO ..... [4]

Pollutants such as CO and NO are removed from the exhaust gases of internal combustion engines by catalytic converters which are placed in the exhaust system of a car.

(f) (i) What metal is most commonly used as the catalyst in a catalytic converter?

.....

(ii) Construct **one** balanced equation for the reaction in which **both** CO **and** NO are removed from the exhaust gases by a catalytic converter.

.....[2]

[Total: 14]

[Turn over

3 Crude oil is a naturally occurring flammable liquid which consists of a complex mixture of hydrocarbons. In order to separate the hydrocarbons the crude oil is subjected to fractional distillation.

For Examiner's Use

(a) Explain what is meant by the following terms.

(i) *hydrocarbon* .....

.....

(ii) *fractional distillation* .....

.....[2]

(b) Undecane, $C_{11}H_{24}$, is a long chain hydrocarbon which is present in crude oil.
Such long chain hydrocarbons are 'cracked' to produce alkanes and alkenes which have smaller molecules.

(i) Give the conditions for **two different** processes by which long chain molecules may be cracked.

process 1 .....

.....

process 2 .....

.....

(ii) Undecane, $C_{11}H_{24}$, can be cracked to form pentane, C_5H_{12}, and an alkene.
Construct a balanced equation for this reaction.

.....[3]

Pentane, C_5H_{12}, exhibits structural isomerism.

(c) **(i)** Draw the three structural isomers of pentane.

isomer **B**	isomer **C**	isomer **D**

(ii) The three isomers of pentane have different boiling points.

Which of your isomers has the highest boiling point?

isomer .....

Suggest an explanation for your answer.

.....

.....

.....[6]

The unsaturated hydrocarbon, **E**, is obtained by cracking hexane and is important in the chemical industry.

The standard enthalpy change of combustion of **E** is –2059 kJ mol^{-1}.

(d) Define the term *standard enthalpy change of combustion*.

.....

.....[2]

When 0.47 g of **E** was completely burnt in air, the heat produced raised the temperature of 200 g of water by 27.5 °C. Assume no heat losses occurred during this experiment.

(e) **(i)** Use relevant data from the *Data Booklet* to calculate the amount of heat released in this experiment.

(ii) Use the data above and your answer to **(i)** to calculate the relative molecular mass, M_r, of **E**.

[4]

(f) Deduce the molecular formula of **E**.

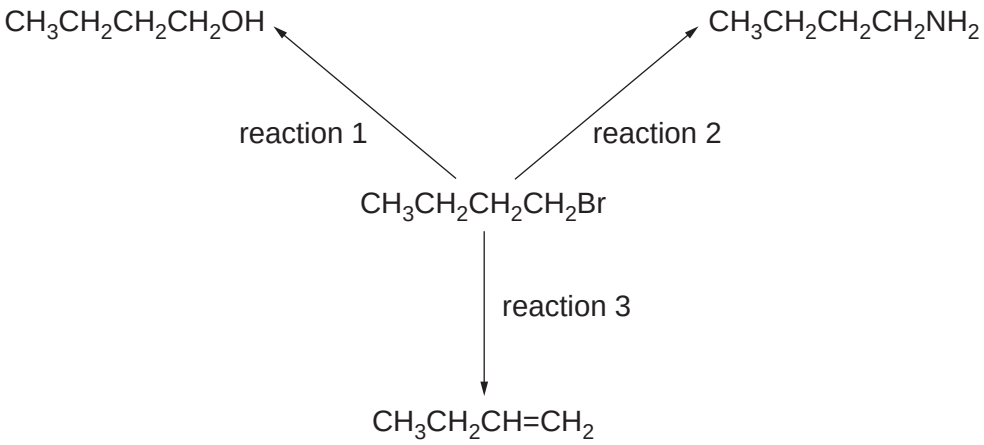
[1]

[Total: 18]

4 Halogenoalkanes have many chemical uses, particularly as intermediates in organic reactions.

For Examiner's Use

Three reactions of 1-bromobutane, $CH_3CH_2CH_2CH_2Br$, are shown below.



(a) For **each** reaction, state the reagent and solvent used.

reaction 1 reagent .....

solvent .....

reaction 2 reagent .....

solvent .....

reaction 3 reagent .....

solvent ..... [6]

(b) When 1-iodobutane, $CH_3CH_2CH_2CH_2I$, is reacted under the same conditions as those used in reaction 1, butan-1-ol is formed.

What difference, if any, would there be in the rate of this reaction compared to the reaction of 1-bromobutane?

Use appropriate data from the *Data Booklet* to explain your answer.

.....

.....

.....

..... [3]

Dichlorodifluoromethane, CCl_2F_2, is an example of a chlorofluorocarbon (CFC) that was formerly used as an aerosol propellant. In September 2007, at the Montreal summit, approximately 200 countries agreed to phase out the use of CFCs by 2020.

For Examiner's Use

(c) State two properties of CFCs that made them suitable as aerosol propellants.

1. .....

2. ..... [2]

(d) When CFCs are present in the upper atmosphere, homolytic fission takes place in the presence of ultraviolet light.

(i) What is meant by the term *homolytic fission*?

.....

.....

(ii) Suggest an equation for the homolytic fission of CCl_2F_2.

..... [2]

(e) The most common replacements for CFCs as aerosol propellants are hydrocarbons such as propane and butane.

Suggest **one** disadvantage of these compounds as aerosol propellants.

..... [1]

[Total: 14]

[Turn over

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5 The gaseous hydrogen halides HC*l*, HBr and HI, may be prepared by reacting the corresponding sodium salt with anhydrous phosphoric(V) acid, H_3PO_4.

When the sodium halide Na*X* was used, the following reaction occurred and a sample of gaseous H*X* was collected in a gas jar.

$$NaX + H_3PO_4 \rightarrow NaH_2PO_4 + HX$$

A hot glass rod was placed in the sample of H*X* and immediately a red/orange colour was observed.

(a) What is the identity of Na*X*?

..... [1]

(b) What gas, other than H*X*, would be formed if concentrated sulfuric acid were used with Na*X* instead of phosphoric(V) acid?

..... [1]

(c) Suggest why phosphoric(V) acid rather than concentrated sulfuric acid is used to make samples of H*X* from the corresponding sodium salt.
Explain your answer.

.....

..... [1]

[Total: 3]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/23**

Paper 2 Structured Questions AS Core **October/November 2010**

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

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

For Examiner's Use	
1	
2	
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Total	

This document consists of **10** printed pages and **2** blank pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

Answer **all** the questions in the space provided.

For Examiner's Use

1 The element magnesium, Mg, proton number 12, is a metal which is used in many alloys which are strong and light.

Magnesium has several naturally occurring isotopes.

(a) What is meant by the term *isotope*?

.....

.....

..... [2]

(b) Complete the table below for two of the isotopes of magnesium.

isotope	number of protons	number of neutrons	number of electrons
^{24}Mg			
^{26}Mg			

[2]

A sample of magnesium had the following isotopic composition:
^{24}Mg, 78.60%; ^{25}Mg, 10.11%; ^{26}Mg, 11.29%.

(c) Calculate the relative atomic mass, A_r, of magnesium in the sample.
Express your answer to an appropriate number of significant figures.

[2]

Antimony, Sb, proton number 51, is another element which is used in alloys.

For Examiner's Use

Magnesium and antimony each react when heated separately in chlorine.

(d) Construct a balanced equation for the reaction between magnesium and chlorine.

.....[1]

When a 2.45 g sample of antimony was heated in chlorine under suitable conditions, 4.57 g of a chloride **A** were formed.

(e) **(i)** Calculate the amount, in moles, of antimony atoms that reacted.

(ii) Calculate the amount, in moles, of chlorine atoms that reacted.

(iii) Use your answers to **(i)** and **(ii)** to determine the empirical formula of **A**.

(iv) The empirical and molecular formulae of **A** are the same.

Construct a balanced equation for the reaction between antimony and chlorine.

.....[5]

(f) The chloride **A** melts at 73.4 °C while magnesium chloride melts at 714 °C.

(i) What type of bonding is present in magnesium chloride?

.....

(ii) Suggest what type of bonding is present in **A**.

.....[2]

[Total: 14]

[Turn over

For Examiner's Use

2 Sulfur and its compounds are found in volcanoes, in organic matter and in minerals.
Sulfuric acid, an important industrial chemical, is manufactured from sulfur by the Contact process.
The Contact process may be considered to be a three-stage process in which sulfur is converted into sulfuric acid. Each stage consists of a single chemical reaction.

(a) Write a balanced equation for **each** of these reactions **in the correct sequence**.
Where appropriate, use $\rightleftharpoons$ to indicate that the reaction is an equilibrium.

first reaction .....

second reaction .....

third reaction .....[4]

(b) Give **three** different operating conditions that are used in the **second** stage.

condition 1 .....

condition 2 .....

condition 3 .....[3]

(c) State **one** large scale use of sulfuric acid.

.....[1]

(d) Most of the sulfur that is used in the Contact process is recovered from sulfur compounds present in crude oil and natural gas by using the Claus process.

(i) In this process, about one third of the hydrogen sulfide, H_2S, present in the oil or gas, is converted into sulfur dioxide, SO_2.

Balance the equation for this reaction.

$$.....H_2S + ...O_2 \rightarrow .....SO_2 + ...H_2O$$

(ii) The SO_2 formed is then reacted catalytically with the remaining H_2S, producing sulfur and water.

$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$

What are the oxidation numbers of each of the sulfur-containing substances in this reaction?

H_2S..... SO_2 ..... S .....

Which substance is reduced? Explain your answer.

substance .....

explanation .....[3]

The sulfur present in crude oil is removed in order to prevent the formation of sulfur dioxide when fuels such as petrol (gasoline) or diesel fuel are burned in internal combustion engines.
Other substances that may be present in the exhaust gases of motor vehicles include CO, CO_2, NO/NO_2, and unburnt hydrocarbons.

The emission of sulfur dioxide can produce 'acid rain'.

(e) **(i)** Outline, with the aid of equations, how acid rain is formed from the exhaust gases of motor vehicles.

.....

.....

.....

.....

(ii) State **one** environmental effect of acid rain.

.....[4]

(f) Sulfur dioxide is used to preserve dried fruits and vegetables.

What chemical property of SO_2 enables it to be used as a food preservative?

.....[1]

[Total: 16]

[Turn over

3 Astronomers using modern spectroscopic techniques of various types have found evidence of many molecules, ions and free radicals in the dust clouds in Space. Many of the species concerned have also been produced in laboratories on Earth.

For Examiner's Use

Two such species are the dicarbon monoxide molecule, C_2O, and the amino free radical, NH_2.

(a) (i) Dicarbon monoxide can be produced in a laboratory and analysis of it shows that the sequence of atoms in this molecule is carbon-carbon-oxygen and there are no unpaired electrons, but one of the atoms is only surrounded by six electrons.

Draw a 'dot-and-cross' diagram of C_2O and suggest the shape of the molecule.

shape .....

(ii) What is meant by the term *free radical*?

.....

.....

(iii) Explain why NH_2 is described as a 'free radical'.

.....

..... [5]

Two derivatives of ethene which have been detected in dust clouds in Space are acrylonitrile (2-propenenitrile), CH_2=CHCN, and vinyl alcohol (ethenol), CH_2=CHOH.

(b) Like ethene, acrylonitrile can be polymerised. The resulting polymer can be used to make carbon fibres.

(i) Draw the structural formula of the polymer made from acrylonitrile, showing **two** repeat units.

(ii) What type of polymerisation is this reaction?

..... [2]

Vinyl alcohol cannot be polymerised in the same way as acrylonitrile because it will readily isomerise into another common organic compound, **Z**.

For Examiner's Use

(c) (i) Suggest the structural formula of the organic compound **Z**.

(ii) Suggest the structural formula of another isomer of vinyl alcohol which has a cyclic (ring) structure.

[2]

Acrolein (2-propenal), CH_2=CHCHO, has also been found in Space.

(d) Give the structural formulae of the organic compounds formed when acrolein is reacted separately with **each** of the following reagents.

reagent	product
Br_2 in an inert solvent	
NaCN + dilute H_2SO_4	
Tollens' reagent	
$NaBH_4$	

[4]

[Total: 13]

[Turn over

For Examiner's Use

4 Although few halogenoalkanes exist naturally, such compounds are important as intermediates in organic reactions and as solvents.

The bromoalkane **B** has the following composition by mass: C, 29.3%; H, 5.7%; Br, 65.0%. The relative molecular mass of **B** is 123.

(a) Calculate the molecular formula of **B**.

[3]

Halogenoalkanes such as bromoethane, C_2H_5Br, have two different reactions with sodium hydroxide, NaOH, depending on the conditions used.

(b) **(i)** When hot aqueous NaOH is used, the C_2H_5Br is hydrolysed to ethanol, C_2H_5OH.

Describe the mechanism of this reaction. In your answer, show any relevant charges, dipoles, lone pairs of electrons and movement of electron pairs by curly arrows.

(ii) What will be formed when C_2H_5Br is reacted with NaOH under different conditions?

.....

(iii) What are the conditions used?

.....

(iv) What type of reaction is this?

.....[7]

When 1,4-dichlorobutane, $Cl CH_2CH_2CH_2CH_2Cl$, is reacted with NaOH, two different reactions can occur, depending on the conditions used.

(c) (i) Draw the **displayed** formula of the product formed when 1,4-dichlorobutane is reacted with hot aqueous NaOH as in **(b)(i)**.

(ii) Draw the **skeletal** formula of the product formed when 1,4-dichlorobutane is reacted with NaOH in the way you have described in **(b)(ii)** and **(b)(iii)**.

[2]

[Total: 12]

[Turn over

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For Examiner's Use

5 A student placed separate small samples of 1-chlorobutane, 1-bromobutane and, 1-iodobutane, in three separate test-tubes. To each test-tube, 1 cm^3 of ethanol was added, followed by 1 cm^3 of aqueous silver nitrate, $AgNO_3$. The tubes were then carefully shaken, placed in a test-tube rack and observed for 30 minutes.

A precipitate was formed in each test-tube but **not** at the same time; the fastest taking about two minutes to become opaque and the slowest about 20 minutes.

(a) What is the identity of the precipitate formed when 1-chlorobutane is used?

.....[1]

(b) What will be the colour of this precipitate?

.....[1]

(c) Which of the three halogenoalkanes will produce a precipitate in about two minutes?

.....[1]

(d) Use appropriate data from the *Data Booklet* to explain why this reaction takes place most quickly of the three.

.....

.....

.....[2]

[Total: 5]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/31**

Advanced Practical Skills **October/November 2010**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
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.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 12.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **11** printed pages and **1** blank page.

There are three questions on this paper. Question 2 should not be the last question attempted.

For Examiner's Use

1 You are to determine the concentration of hydrochloric acid, which supplies the H^+ ions in the following reaction.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3H_2O(l) + 3I_2(aq)$$

In the presence of an excess of IO_3^- ions and an excess of I^- ions, the amount of I_2 liberated is directly proportional to the amount of H^+ ions present and can be determined by titration with sodium thiosulfate, $Na_2S_2O_3$.

You are provided with the following reactants.

FA 1 hydrochloric acid
FA 2 containing 15.0 g dm^{-3} sodium thiosulfate, $Na_2S_2O_3.5H_2O$
aqueous potassium iodate(V), KIO_3
aqueous potassium iodide, KI

(a) Method

- Fill a burette with **FA 2**.
- Pipette 25.0 cm^3 of **FA 1** into the conical flask.
- Use a 25 cm^3 measuring cylinder to add to the flask 10 cm^3 of aqueous potassium iodate(V) **and** 10 cm^3 of aqueous potassium iodide. There is an excess of each of these reagents.
- Place the flask on a white tile.
- Titrate the liberated iodine with **FA 2**.
- During the titration the colour of the iodine in the solution will fade from red-brown to orange to yellow. The end-point occurs when the solution just goes colourless with the addition of a single drop of **FA 2**.
- You should perform a **rough titration**.
  In the space below record your burette readings for this rough titration.

The rough titre is ..... cm^3

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record in a suitable form below all of your burette readings and the volume of **FA 2** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your titration results obtain a suitable value to be used in your calculation. Show clearly how you have obtained this value.

For Examiner's Use

25.0 cm^3 of **FA 1** require ..... cm^3 of **FA 2**. [1]

Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(c) **(i)** Calculate the concentration, in mol dm^{-3}, of the sodium thiosulfate in **FA 2**.
FA 2 contains 15.0 g dm^{-3} $Na_2S_2O_3.5H_2O$.
[A_r: H, 1.0; O, 16.0; Na, 23.0; S, 32.1]

The concentration of sodium thiosulfate in **FA 2** is ..... mol dm^{-3}.

(ii) Calculate how many moles of $Na_2S_2O_3$ are contained in the volume of **FA 2** recorded in **(b)**.

..... mol of $Na_2S_2O_3$

(iii) Calculate how many moles of iodine, I_2 reacted with the $Na_2S_2O_3$ in **(ii)**.

$$2Na_2S_2O_3(aq) + I_2(aq) \rightarrow Na_2S_4O_6(aq) + 2NaI(aq)$$

..... mol of iodine reacted with the sodium thiosulfate.

(iv) Calculate how many moles of hydrochloric acid, HC*l*, reacted with an excess of potassium iodate(V) and an excess of potassium iodide to produce the amount of iodine calculated in **(iii)**.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3H_2O(l) + 3I_2(aq)$$

..... mol of HC*l* produced the amount of iodine calculated in **(iii)**.

I	
II	
III	
IV	
V	

[Turn over

(v) Calculate the concentration, in mol dm^{-3}, of HCl in **FA 1**.

For Examiner's Use

The concentration of HCl in **FA 1** is ..... mol dm^{-3}.
[5]

(d)

Each reading with a burette has a maximum error of ±0.05 cm^3.
Grade B volumetric (bulb) pipettes are calibrated to ±0.06 cm^3.

(i) Calculate the maximum error in the volume run from the burette recorded in any titration.

The maximum error is ..... cm^3.

(ii) Express the maximum error calculated in **(i)** as a percentage error for the volume calculated in **(b)**.

The maximum error is ..... %.

(iii) Calculate the percentage error when 25.0 cm^3 of **FA 1** was pipetted into the conical flask.

The error was ..... %.
[2]

[Total: 15]

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2 **FA 3** is powdered basic copper(II) carbonate, a hydrated mixture of copper(II) carbonate and copper(II) hydroxide.
The approximate formula for the basic carbonate is $CuCO_3.Cu(OH)_2.H_2O$.

For Examiner's Use

When heated, basic copper(II) carbonate decomposes.

$$CuCO_3.Cu(OH)_2.H_2O(s) \longrightarrow 2CuO(s) + CO_2(g) + 2H_2O(g)$$

You are to determine the change in mass as the solid is heated and decomposed.

(a) Method – Read through the instructions before starting any practical work.

- Record all weighings in an appropriate form in the space below.
- Weigh and record the mass of an empty boiling-tube.
- Tip the contents of the tube labelled **FA 3** into the weighed boiling-tube. Reweigh and record the total mass of the boiling-tube and **FA 3**.
- Heat **FA 3** in the boiling-tube **very gently** until the vigorous decomposition of the copper carbonate has stopped; then heat more strongly for 1 to 2 minutes. **Take care not to lose any solid from the tube during the initial heating.**
- Warm the upper parts of the boiling-tube to evaporate any water that may have condensed while heating the carbonate.
- Place the hot tube on a heat-proof mat and leave to cool.
- **You are advised to continue with part (d) of this question or to start another question while the tube cools.**
- When cool, reweigh the boiling-tube and the residual copper(II) oxide.
- Reheat, cool and reweigh the tube until you are satisfied decomposition is complete.

Results

In an appropriate form, in the space below, record all of your balance readings, the mass of basic copper(II) carbonate and the mass of residual copper oxide.

I	
II	
III	
IV	
V	
VI	

[6]

Calculations

For Examiner's Use

(b) Calculate the loss in mass during the experiment as a percentage of the mass of solid heated.

[1]

(c) The theoretical loss in mass is 33.5%.

The proportions of $CuCO_3$ and $Cu(OH)_2$ in the basic carbonate can vary from the 1:1 ratio given in the formula.

Make use of the following information to account for the difference between the value you have calculated in **(b)** and the theoretical percentage loss in mass.

1 mol $CuCO_3(s) \rightarrow$ 1 mol $CO_2(g)$
1 mol $Cu(OH)_2(s) \rightarrow$ 1 mol $H_2O(g)$

Assume that 1 mol of any sample of the solid basic carbonate contains 1 mol H_2O.

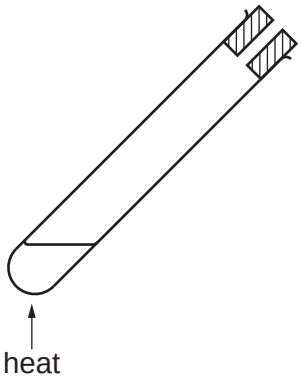
[M_r: CO_2, 44.0; H_2O, 18.0]

.....

.....

..... [1]

(d) Add to the diagram below additional standard laboratory apparatus that would enable you to collect and measure the volume of carbon dioxide evolved in the experiment. Ensure that your apparatus does not also collect and measure any of the water vapour evolved.



[2]

[Total: 10]

3 **FA 4**, **FA 5**, **FA 6** and **FA 7** are aqueous solutions each containing one of the ions Al^{3+}, Mg^{2+}, Pb^{2+}, Zn^{2+}.

For Examiner's Use

You will carry out the following tests on each of the solutions.

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

I	
II	
III	
IV	

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

(a) Carry out the following tests. Record your observations in the spaces provided in the table.

You should rinse and reuse test-tubes where possible.

test		*observations*			
		FA 4	**FA 5**	**FA 6**	**FA 7**
(i)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous sodium hydroxide. Swirl the tube, then				
	add a further 2 cm depth of aqueous sodium hydroxide.				
(ii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous ammonia. Swirl the tube, then				
	add a further 2 cm depth of aqueous ammonia.				
(iii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous potassium iodide.				

[4]

(b) Use the Qualitative Analysis Notes on page 11 to identify the cation present in each of the solutions.
Complete the table below to identify each ion and to give supporting evidence from your observations.

For Examiner's Use

solution	*cation*	*supporting evidence*
FA 4		
FA 5		
FA 6		
FA 7		

[4]

I	
II	
III	
IV	

Do not carry out the following test.

(c) Use the Qualitative Analysis Notes on pages 11 and 12 to select a further reagent that could be used to confirm the presence of Pb^{2+} in one of the solutions **FA 4**, **FA 5**, **FA 6** and **FA 7**.

The reagent is ..... . [1]

(d) **FA 8** contains aqueous copper(II) ions.
Carry out the following tests and make careful observations of all that happens in each experiment.

For Examiner's Use

	test	*observations*
(i)	To 2 cm depth of **FA 8** in a boiling-tube add 1 spatula measure of zinc metal powder. Leave to stand for 1 minute, then	
	add 2 cm depth of distilled water and leave to stand for a further 2 minutes.	
(ii)	To 1 cm depth of **FA 8** in a test-tube add 1 cm depth of concentrated hydrochloric acid. **(Care: corrosive)** Retain the mixture for use in **(iii)**.	
(iii)	Using a dropping pipette transfer 1 cm depth of the solution in **(ii)** into another test-tube. Add 1 cm depth of water and shake the tube.	

[5]

I	
II	
III	
IV	
V	

(e) From your observations in **(d)(i)** complete the equation below:

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

[1]

[Total: 15]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

[Turn over

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+(aq); gives yellow ppt. with Ba^{2+}(aq); gives bright yellow ppt. with Pb^{2+}(aq)
chloride, Cl^- (aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
bromide, Br^- (aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq)); gives yellow ppt. with Pb^{2+}(aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acid)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acid)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/33**

Advanced Practical Skills **October/November 2010**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
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.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 12.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **11** printed pages and **1** blank page.

There are three questions on this paper. Question 2 should not be the last question attempted.

For Examiner's Use

1 You are to determine the concentration of hydrochloric acid, which supplies the H^+ ions in the following reaction.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3H_2O(l) + 3I_2(aq)$$

In the presence of an excess of IO_3^- ions and an excess of I^- ions, the amount of I_2 liberated is directly proportional to the amount of H^+ ions present and can be determined by titration with sodium thiosulfate, $Na_2S_2O_3$.

You are provided with the following reactants.

FA 1 hydrochloric acid
FA 2 containing 15.0 g dm^{-3} sodium thiosulfate, $Na_2S_2O_3.5H_2O$
aqueous potassium iodate(V), KIO_3
aqueous potassium iodide, KI

(a) Method

- Fill a burette with **FA 2**.
- Pipette 25.0 cm^3 of **FA 1** into the conical flask.
- Use a 25 cm^3 measuring cylinder to add to the flask 10 cm^3 of aqueous potassium iodate(V) **and** 10 cm^3 of aqueous potassium iodide. There is an excess of each of these reagents.
- Place the flask on a white tile.
- Titrate the liberated iodine with **FA 2**.
- During the titration the colour of the iodine in the solution will fade from red-brown to orange to yellow. The end-point occurs when the solution just goes colourless with the addition of a single drop of **FA 2**.
- You should perform a **rough titration**.
  In the space below record your burette readings for this rough titration.

The rough titre is ..... cm^3

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record in a suitable form below all of your burette readings and the volume of **FA 2** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your titration results obtain a suitable value to be used in your calculation. Show clearly how you have obtained this value.

For Examiner's Use

25.0 cm^3 of **FA 1** require ..... cm^3 of **FA 2**. [1]

Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(c) **(i)** Calculate the concentration, in mol dm^{-3}, of the sodium thiosulfate in **FA 2**.
FA 2 contains 15.0 g dm^{-3} $Na_2S_2O_3.5H_2O$.
[A_r: H, 1.0; O, 16.0; Na, 23.0; S, 32.1]

The concentration of sodium thiosulfate in **FA 2** is ..... mol dm^{-3}.

(ii) Calculate how many moles of $Na_2S_2O_3$ are contained in the volume of **FA 2** recorded in **(b)**.

..... mol of $Na_2S_2O_3$

(iii) Calculate how many moles of iodine, I_2 reacted with the $Na_2S_2O_3$ in **(ii)**.

$$2Na_2S_2O_3(aq) + I_2(aq) \rightarrow Na_2S_4O_6(aq) + 2NaI(aq)$$

..... mol of iodine reacted with the sodium thiosulfate.

(iv) Calculate how many moles of hydrochloric acid, HC*l*, reacted with an excess of potassium iodate(V) and an excess of potassium iodide to produce the amount of iodine calculated in **(iii)**.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3H_2O(l) + 3I_2(aq)$$

..... mol of HC*l* produced the amount of iodine calculated in **(iii)**.

I	
II	
III	
IV	
V	

(v) Calculate the concentration, in mol dm^{-3}, of HCl in **FA 1**.

For Examiner's Use

The concentration of HCl in **FA 1** is ..... mol dm^{-3}.
[5]

(d)

Each reading with a burette has a maximum error of ±0.05 cm^3.
Grade B volumetric (bulb) pipettes are calibrated to ±0.06 cm^3.

(i) Calculate the maximum error in the volume run from the burette recorded in any titration.

The maximum error is ..... cm^3.

(ii) Express the maximum error calculated in **(i)** as a percentage error for the volume calculated in **(b)**.

The maximum error is ..... %.

(iii) Calculate the percentage error when 25.0 cm^3 of **FA 1** was pipetted into the conical flask.

The error was ..... %.
[2]

[Total: 15]

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2 **FA 3** is powdered basic copper(II) carbonate, a hydrated mixture of copper(II) carbonate and copper(II) hydroxide.
The approximate formula for the basic carbonate is $CuCO_3.Cu(OH)_2.H_2O$.

For Examiner's Use

When heated, basic copper(II) carbonate decomposes.

$$CuCO_3.Cu(OH)_2.H_2O(s) \longrightarrow 2CuO(s) + CO_2(g) + 2H_2O(g)$$

You are to determine the change in mass as the solid is heated and decomposed.

(a) Method – Read through the instructions before starting any practical work.

- Record all weighings in an appropriate form in the space below.
- Weigh and record the mass of an empty boiling-tube.
- Tip the contents of the tube labelled **FA 3** into the weighed boiling-tube. Reweigh and record the total mass of the boiling-tube and **FA 3**.
- Heat **FA 3** in the boiling-tube **very gently** until the vigorous decomposition of the copper carbonate has stopped; then heat more strongly for 1 to 2 minutes. **Take care not to lose any solid from the tube during the initial heating.**
- Warm the upper parts of the boiling-tube to evaporate any water that may have condensed while heating the carbonate.
- Place the hot tube on a heat-proof mat and leave to cool.
- **You are advised to continue with part (d) of this question or to start another question while the tube cools.**
- When cool, reweigh the boiling-tube and the residual copper(II) oxide.
- Reheat, cool and reweigh the tube until you are satisfied decomposition is complete.

Results

In an appropriate form, in the space below, record all of your balance readings, the mass of basic copper(II) carbonate and the mass of residual copper oxide.

I	
II	
III	
IV	
V	
VI	

[6]

Calculations

For Examiner's Use

(b) Calculate the loss in mass during the experiment as a percentage of the mass of solid heated.

[1]

(c) The theoretical loss in mass is 33.5%.

The proportions of $CuCO_3$ and $Cu(OH)_2$ in the basic carbonate can vary from the 1:1 ratio given in the formula.

Make use of the following information to account for the difference between the value you have calculated in **(b)** and the theoretical percentage loss in mass.

1 mol $CuCO_3(s) \rightarrow$ 1 mol $CO_2(g)$
1 mol $Cu(OH)_2(s) \rightarrow$ 1 mol $H_2O(g)$

Assume that 1 mol of any sample of the solid basic carbonate contains 1 mol H_2O.

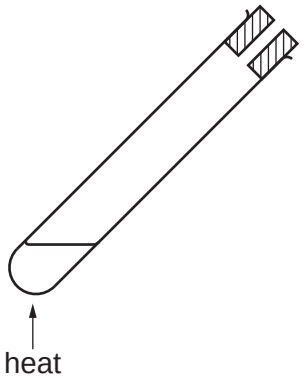
[M_r: CO_2, 44.0; H_2O, 18.0]

.....

.....

..... [1]

(d) Add to the diagram below additional standard laboratory apparatus that would enable you to collect and measure the volume of carbon dioxide evolved in the experiment. Ensure that your apparatus does not also collect and measure any of the water vapour evolved.



[2]

[Total: 10]

3 **FA 4**, **FA 5**, **FA 6** and **FA 7** are aqueous solutions each containing one of the ions Al^{3+}, Mg^{2+}, Pb^{2+}, Zn^{2+}.

For Examiner's Use

You will carry out the following tests on each of the solutions.

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

I	
II	
III	
IV	

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

(a) Carry out the following tests. Record your observations in the spaces provided in the table.

You should rinse and reuse test-tubes where possible.

test		*observations*			
		FA 4	**FA 5**	**FA 6**	**FA 7**
(i)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous sodium hydroxide. Swirl the tube, then				
	add a further 2 cm depth of aqueous sodium hydroxide.				
(ii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous ammonia. Swirl the tube, then				
	add a further 2 cm depth of aqueous ammonia.				
(iii)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous potassium iodide.				

[4]

(b) Use the Qualitative Analysis Notes on page 11 to identify the cation present in each of the solutions.
Complete the table below to identify each ion and to give supporting evidence from your observations.

For Examiner's Use

solution	*cation*	*supporting evidence*
FA 4		
FA 5		
FA 6		
FA 7		

[4]

I	
II	
III	
IV	

Do not carry out the following test.

(c) Use the Qualitative Analysis Notes on pages 11 and 12 to select a further reagent that could be used to confirm the presence of Pb^{2+} in one of the solutions **FA 4**, **FA 5**, **FA 6** and **FA 7**.

The reagent is ..... . [1]

(d) **FA 8** contains aqueous copper(II) ions.
Carry out the following tests and make careful observations of all that happens in each experiment.

For Examiner's Use

	test	*observations*
(i)	To 2 cm depth of **FA 8** in a boiling-tube add 1 spatula measure of zinc metal powder. Leave to stand for 1 minute, then	
	add 2 cm depth of distilled water and leave to stand for a further 2 minutes.	
(ii)	To 1 cm depth of **FA 8** in a test-tube add 1 cm depth of concentrated hydrochloric acid. **(Care: corrosive)** Retain the mixture for use in **(iii)**.	
(iii)	Using a dropping pipette transfer 1 cm depth of the solution in **(ii)** into another test-tube. Add 1 cm depth of water and shake the tube.	

[5]

I	
II	
III	
IV	
V	

(e) From your observations in **(d)(i)** complete the equation below:

$$Cu^{2+}(aq) + Zn(s) \rightarrow$$

[1]

[Total: 15]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

[Turn over

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+(aq); gives yellow ppt. with Ba^{2+}(aq); gives bright yellow ppt. with Pb^{2+}(aq)
chloride, Cl^- (aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
bromide, Br^- (aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq)); gives yellow ppt. with Pb^{2+}(aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acid)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acid)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/34**

Advanced Practical Skills **October/November 2010**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
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Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 13 and 14.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **12** printed pages and **4** blank pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

There are three questions on this paper. Question 2 should not be the last question attempted.

For Examiner's Use

1 **FB 1** is an aqueous solution containing 21.50 g dm^{-3} of a mixture of iron(II) sulfate, $FeSO_4$ and iron(III) sulfate, $Fe_2(SO_4)_3$.
FB 2 is an aqueous solution containing 2.00 g dm^{-3} potassium manganate(VII), $KMnO_4$.

In the presence of acid, the iron(II) sulfate is oxidised by potassium manganate(VII).

$$2KMnO_4(aq) + 8H_2SO_4(aq) + 10FeSO_4(aq) \rightarrow 5Fe_2(SO_4)_3(aq) + 2MnSO_4(aq) + K_2SO_4(aq) + 8H_2O(l)$$

(a) Method

- Fill a burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 1** into the conical flask.
- Use a 25 cm^3 measuring cylinder to add 10 cm^3 of dilute sulfuric acid to the flask.
- Place the flask on a white tile.
- Carefully titrate with **FB 2** until the first permanent pink colour is obtained.

You should perform a **rough titration**.
In the space below record your burette readings for this rough titration.

The rough titre is ..... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record in a suitable form below all of your burette readings and the volume of **FB 2** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results obtain a suitable value to be used in your calculation. Show clearly how you have obtained this value.

For Examiner's Use

25.0 cm^3 of **FB 1** required ..... cm^3 of **FB 2**. [1]

Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(c) **(i)** Calculate the concentration, in mol dm^{-3}, of the potassium manganate(VII) in **FB 2**.
FB 2 contains 2.00 g dm^{-3} $KMnO_4$.
[A_r: O, 16.0; K, 39.1; Mn, 54.9]

The concentration of potassium manganate(VII) in **FB 2** is ..... mol dm^{-3}.

(ii) Calculate how many moles of $KMnO_4$ were present in the volume calculated in **(b)**.

..... mol of $KMnO_4$.

(iii) Calculate how many moles of iron(II) sulfate, $FeSO_4$, reacted with the potassium manganate(VII) in **(ii)**.

$$2KMnO_4(aq) + 8H_2SO_4(aq) + 10FeSO_4(aq) \rightarrow 5Fe_2(SO_4)_3(aq) + 2MnSO_4(aq) + K_2SO_4(aq) + 8H_2O(l)$$

I	
II	
III	
IV	
V	

..... mol of $FeSO_4$ reacted with the potassium manganate(VII).

[Turn over

(iv) Calculate the concentration, in mol dm^{-3} of $FeSO_4$ in **FB 1**.

For Examiner's Use

The concentration of $FeSO_4$ in **FB 1** is ..... mol dm^{-3}.

(v) Calculate the concentration, in g dm^{-3}, of $FeSO_4$ in **FB 1**.
[A_r: O, 16.0; S, 32.1; Fe, 55.8]

FB 1 contains ..... g dm^{-3} of $FeSO_4$.

(vi) **FB 1** is an aqueous solution containing 21.50 g dm^{-3} of $FeSO_4$ and $Fe_2(SO_4)_3$.
Calculate the percentage, by mass, of $FeSO_4$ in this mixture.

The mixture contains ..... % $FeSO_4$.
[5]

[Total: 13]

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2 **FB 3** is a mixture containing anhydrous sodium carbonate, Na_2CO_3, and sodium hydrogencarbonate, $NaHCO_3$.

For Examiner's Use

When heated, sodium hydrogencarbonate decomposes.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Anhydrous sodium carbonate does not decompose when heated.

You are to determine if sodium hydrogencarbonate is the major component, by mass, of the mixture in **FB 3**.

(a) Method – Read through the instructions before starting any practical work.

- Weigh and record the mass of an empty boiling-tube.
- Tip the contents of the tube labelled **FB 3** into the weighed boiling-tube. Reweigh and record the mass of the boiling-tube and **FB 3**.
- Gently heat the **FB 3** in the boiling-tube for 2 minutes then heat strongly for a further 2 minutes.
  Take care not to lose any solid from the tube during heating.
- Warm the upper parts of the boiling-tube to evaporate any water that may have condensed while heating the solid.
- Place the hot tube on a heat-proof mat and leave to cool.
- **You are advised to continue with part (d) of this question or to start another question while the tube cools.**
- When cool, reweigh the boiling-tube and the residual sodium carbonate.
- Reheat, cool and reweigh the tube until you are satisfied decomposition is complete.

Results

In an appropriate form, in the space below, record all of your balance readings, the mass of **FB 3** heated, the mass of residual sodium carbonate and the mass loss on heating.

I	
II	
III	
IV	
V	
VI	

[6]

Calculations

For Examiner's Use

Do not use your experimental results in part (i)

(b) (i) Use the equation for the decomposition of $NaHCO_3$ on heating to calculate the **theoretical** ratio $\frac{\text{mass of } NaHCO_3}{\text{mass loss on heating}}$.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

[M_r: $NaHCO_3$, 84.0; CO_2, 44.0; H_2O, 18.0]

theoretical ratio = ...

(ii) Use the following expression to calculate the mass of $NaHCO_3$ in the sample of **FB 3** that was heated.

theoretical ratio from **b(i)** × experimental mass loss from **(a)**

mass of $NaHCO_3$ = ... g

(iii) Tick the appropriate box in the table below.

$NaHCO_3$ **is** the major component, by mass, in **FB 3**	
$NaHCO_3$ **is not** the major component, by mass, in **FB 3**	

Justify your answer with supporting evidence.

.....

.....

[2]

(c) Do not carry out your suggestions.

Suggest two ways in which you could show that sodium carbonate does not decompose on heating.

(i) .....

.....

(ii) .....

..... [2]

(d) A student is asked to weigh, with maximum precision, a solid.

The three balances available are:

balance A, reading to 1 decimal place,
balance B, reading to 2 decimal places,
balance C, reading to 3 decimal places.

The smallest division on a burette is 0.1 cm^3. The maximum error in a single burette reading is ±0.05 cm^3 Balance readings can be treated in the same way.

Complete the following table.

balance	maximum error for a single balance reading / g	maximum % error when weighing:
A	±	9.0 g of solid =
B	±	4.00 g of solid =
C	±	0.500 g of solid =

[2]

[Total: 12]

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3 **FB 4**, **FB 5**, **FB 6** and **FB 7** are aqueous solutions each containing one of the ions Al^{3+}, NH_4^+, Mg^{2+}, Mn^{2+}.

For Examiner's Use

You will carry out the following tests on each of the solutions.

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.
If any solution is warmed, a boiling-tube MUST be used.

(a) Carry out the following tests. Record your observations in the spaces provided in the table.

test		*observations*			
		FB 4	**FB 5**	**FB 6**	**FB 7**
(i)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous sodium hydroxide. Swirl the tube, then				
	add a further 2 cm depth of aqueous sodium hydroxide.				
In tests* (ii) *and* (iii) *put a cross in any boxes where the test is not carried out.					
(ii)	If a precipitate remains at the end of test **(i)** leave the test-tube and contents to stand for a few minutes.				
(iii)	If **no** precipitate formed at all in test **(i)** tip the contents of the tube into a boiling-tube and warm gently. **Care: heated solutions containing sodium hydroxide are liable to be ejected from the tube.**				

test		observations			
		FB 4	**FB 5**	**FB 6**	**FB 7**
(iv)	To 1 cm depth of solution in a test-tube add 1 cm depth of aqueous ammonia. Swirl the tube, then				
	add a further 2 cm depth of aqueous ammonia.				

[6]

For Examiner's Use

I	
II	
III	
IV	
V	
VI	

(b) Use the Qualitative Analysis Notes on page 13 to identify the cation present in each of the solutions.
Complete the table below to identify each ion and to give supporting evidence from your observations.

solution	*cation*	*supporting evidence*
FB 4		
FB 5		
FB 6		
FB 7		

[4]

I	
II	
III	
IV	

Rinse and re-use test-tubes where possible.

[Turn over

(c) Carry out the following tests on the solution you have identified as containing Al^{3+} ions and record your observations in the spaces provided.

		observation
(i)	Add aqueous sodium iodide	
(ii)	Add dilute sulfuric acid	

Explain how your results confirm the presence of Al^{3+} and eliminate any other ion.

.....

..... [1]

(d) What other cation listed in the Qualitative Analysis Notes on page 13 would give similar results to Al^{3+} in **(a)**?

..... [1]

(e) Carry out the following tests and make careful observations of all that happens in each experiment. Complete the table.

	test	*observations*
(i)	To 1 cm depth of aqueous silver nitrate in a test-tube add 1 cm depth of aqueous sodium chloride. Keep the tube for comparison with the observations in test **(ii)**.	
(ii)	Repeat test **(i)**. To 1 cm depth of aqueous silver nitrate in a test-tube add 1 cm depth of aqueous sodium chloride, then	*Do not repeat your observations from test* **(i)**
	add 1 cm depth of aqueous sodium iodide and shake the tube.	

[2]

(f) Suggest an explanation for your observations when aqueous sodium iodide is added in test **(e)(ii)**.

.....

.....

..... [1]

[Total: 15]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

[Turn over

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+(aq); gives yellow ppt. with Ba^{2+}(aq); gives bright yellow ppt. with Pb^{2+}(aq)
chloride, Cl^- (aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
bromide, Br^- (aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq)); gives yellow ppt. with Pb^{2+}(aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acid)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acid)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/35**

Advanced Practical Skills **October/November 2010**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
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.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 13 and 14.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **13** printed pages and **3** blank pages.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

1 **FA 1** is an aqueous solution of hydrochloric acid, HC*l*.
FA 2 is aqueous sodium hydroxide containing 10.00 g dm^{-3} NaOH.

For Examiner's Use

You are to determine the concentration, in mol dm^{-3}, of the hydrochloric acid in **FA 1**.

(a) Method

- Fill a burette with **FA 2**.
- Pipette 10.0 cm^3 of **FA 1** into a conical flask.
- Add to the flask a few drops of the acid-base indicator provided.
- Place the flask on a white tile.
- Titrate the acid in the flask with **FA 2**.

You should perform a **rough titration**.
In the space below record your burette readings for this rough titration.

The rough titre is ..... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record in a suitable form below all of your burette readings and the volume of **FA 2** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your titration results obtain a suitable value to be used in your calculation.
Show clearly how you have obtained this value.

10.0 cm^3 of **FA 1** required ..... cm^3 of **FA 2**.
[1]

Calculations

For Examiner's Use

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(c) **(i)** Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide in **FA 2**.
FA 2 contains 10.00 g dm^{-3} NaOH.
[A_r: H, 1.0; O, 16.0; Na, 23.0]

The concentration of sodium hydroxide in **FA 2** is ..... mol dm^{-3}.

(ii) Calculate how many moles of sodium hydroxide are contained in the volume recorded in **(b)**.

..... mol of NaOH.

(iii) Deduce how many moles of hydrochloric acid were pipetted into the conical flask and calculate the concentration, in mol dm^{-3}, of the hydrochloric acid in **FA 1**.

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

I	
II	

The concentration of the hydrochloric acid in **FA 1** is ..... mol dm^{-3}.
[2]

[Total: 10]

[Turn over

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2 **FA 3** is crushed impure calcium carbonate, $CaCO_3$.
FA 4 is 0.500 mol dm^{-3} hydrochloric acid
FA 5 is 0.280 mol dm^{-3} sodium hydroxide.

For Examiner's Use

You are to determine the percentage purity of calcium carbonate by dissolving a measured mass of **FA 3** in a known volume of hydrochloric acid, which is in excess.
The hydrochloric acid remaining after all the calcium carbonate has dissolved can be determined by titration with aqueous sodium hydroxide, **FA 4**.
You may assume that any impurity present in the calcium carbonate does **not** react with hydrochloric acid.

(a) Method – Read through the instructions before starting any practical work.

- Weigh and record the mass of an empty boiling-tube.
- Add to the boiling-tube between 2.60 g and 2.80 g of **FA 3**.
- Reweigh the tube and its contents.
- In part **(b)** of the method you will tip the **FA 3** into hydrochloric acid, then re-weigh the tube and any residual **FA 3**.

In the space below record, in an appropriate form, all of the balance readings and the mass of **FA 3** used in the experiment.

I	
II	

[2]

(b) Method – Read through the instructions before starting any practical work.

- Pour approximately 150 cm^3 of **FA 4** into a 250 cm^3 beaker.
- Add, a little at a time with constant stirring, the weighed **FA 3** to the acid in the beaker.
- After each small addition stir until the effervescence has ceased and all the solid has dissolved.
- Reweigh the tube and any residual **FA 3**. Record the mass in **(a)**.
- Transfer the solution in the beaker to the 250 cm^3 graduated (volumetric) flask labelled **FA 6**.
- Rinse the beaker several times with **a small amount of FA 4** and add the rinsings to the graduated flask.
- Make up the solution to the 250 cm^3 mark by **adding FA 4**, **not water**.
- Shake the flask to obtain a uniform solution.

[Turn over

Titration

For Examiner's Use

- Fill a burette with **FA 5**.
- Pipette 25.0 cm^3 of **FA 6** from the graduated flask into a conical flask.
- Add to the flask a few drops of the acid-base indicator provided.
- Place the flask on a white tile.
- Titrate the acid in the flask with **FA 5**.

You should perform a **rough titration**.
In the space below record your burette readings for this rough titration.

The rough titre is ..... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record in a suitable form below all of your burette readings and the volume of **FA 5** added in each titration.
- Make certain any recorded results show the precision of your practical work.

I	
II	

[2]

(c) From your titration results obtain a suitable value to be used in your calculation.
Show clearly how you have obtained this value.

25.0 cm^3 of **FA 6** required ..... cm^3 of **FA 5**.

(d) Calculations

For Examiner's Use

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

Remember – **FA 4** is 0.500 mol dm^{-3} hydrochloric acid
FA 5 is 0.280 mol dm^{-3} sodium hydroxide.

(i) Calculate how many moles of sodium hydroxide are contained in the volume recorded in **(c)**.

..... mol of NaOH

(ii) Deduce how many moles of hydrochloric acid reacted with the sodium hydroxide in **(i)** and calculate how many moles of hydrochloric acid were present in the 250 cm^3 graduated flask labelled **FA 6**.

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

..... mol of HCl were present in the graduated flask.

(iii) Calculate how many moles of hydrochloric acid were present in 250 cm^3 of **FA 4**.

250 cm^3 of **FA 4** contained ..... mol HCl.

(iv) Calculate the following.

(answer to **(d)(iii)** – answer to **(d)(ii)**)

This is the amount of hydrochloric acid that reacted with the calcium carbonate in the weighed sample of **FA 3**.

I	
II	

..... mol of HCl reacted with the calcium carbonate in ..... g **FA 3**.

[Turn over

(v) Use your answer to **(iv)** to calculate the mass of calcium carbonate that reacted with hydrochloric acid.
This is the mass of pure $CaCO_3$ in the weighed sample of **FA 3**.

For Examiner's Use

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

[A_r: Ca, 40.0; C, 12.0; O, 16.0]

The weighed sample of **FA 3** contains ..... g of $CaCO_3$.

(vi) Calculate the percentage of calcium carbonate, $CaCO_3$, in **FA 3** by evaluating the following expression.

$$\frac{\text{mass of } CaCO_3 \text{ from } \textbf{(d)(v)}}{\text{mass of } \textbf{FA 3} \text{ used, from } \textbf{(a)}} \times 100$$

Complete your evaluation even if your answer is greater than 100%

III	
IV	
V	

FA 3 contains ..... % calcium carbonate.
[5]

(e) 6.25 g of pure calcium carbonate are required to neutralise all the hydrochloric acid in 250 cm^3 of **FA 4**.

You were instructed to measure a mass between 2.60 g and 2.80 g of **FA 3** in this experiment.

What difficulties might you encounter if you used a mass of about 5.50 g of **FA 3** in this experiment?

.....

.....

.....
[1]

(f) **(i)** Complete the following table.

For Examiner's Use

The balance used in the experiment displays the mass to	.....	decimal places.
The maximum error in a single balance reading is	±	g.
The maximum error in measuring the mass of **FA 3** is	±	g.

(ii) Calculate the maximum percentage error in the mass of **FA 3** measured in **(a)**.

The maximum error in the mass of **FA 3** is ..... %.
[2]

(g) **(i)** The percentage of calcium carbonate in the weighed sample of **FA 3** can also be found by investigating the thermal decomposition of the compound into calcium oxide and carbon dioxide.
Write a balanced equation, including state symbols, for this thermal decomposition.

(ii) **Briefly outline** the key measurements to be made in order to find the percentage of calcium carbonate in **FA 3** by this method.

1. .....
2. .....
3. .....
4. .....
5. .....
6. .....

(You do not have to use all of the numbered steps in your answer)

[2]

[Total: 14]

[Turn over

For Examiner's Use

3 **FA 7**, **FA 8** and **FA 9** are aqueous solutions, each containing one cation and one anion from those listed on pages 13 and 14 in the Qualitative Analysis Notes.

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.
If any solution is warmed, a boiling-tube MUST be used.
Rinse and reuse test-tubes wherever possible.

(a) Use aqueous sodium hydroxide and aqueous ammonia, in separate tests, to identify the cation present in **FA 7**, **FA 8** and **FA 9**.

Present your results for each of the solutions in a suitable form below.

I	
II	
III	
IV	
V	
VI	

Conclusion

Complete the following table.

solution	*cation*	*supporting evidence*
FA 7		
FA 8		
FA 9		

[6]

(b) (i) **FA 7**, **FA 8** and **FA 9** each contain a single anion which may be C*l*$^-$, I$^-$ or SO_4^{2-}.

For Examiner's Use

Suggest a reagent that would enable you to identify any solutions containing SO_4^{2-}.

Reagent .....

Use this reagent to test each of the solutions. Record your observations in the table below. Indicate, with a tick in the final column, any solution containing SO_4^{2-}.

solution	*observation*	*SO_4^{2-} present*
FA 7		
FA 8		
FA 9		

(ii) Select a further reagent that will enable you to identify the halide ion present in any remaining solution(s).

Reagent ……..

Use this reagent to test the remaining solution(s).
Record your observations and the identity of the halide in a suitable form in the space below.

I	
II	
III	
IV	
V	

[5]

[Turn over

(c) **FA 10** is a white crystalline solid which turns into another white solid, **FA 11**, when heated strongly.
Carry out the tests on **FA 10** and **FA 11** in the table below.
Observe carefully at each stage and record all of your observations in the table.

For Examiner's Use

	test	*observations*
(i)	Place 1 spatula measure of **FA 10** in a hard glass test-tube. Heat the solid **very strongly** until no further change is seen.	
(ii)	Place 1 **<u>small</u>** spatula measure of **FA 11** in a test-tube and add 1 cm depth of dilute hydrochloric acid.	
	As soon as you have completed your observation in **(ii)**, fill the test-tube with water.	

I	
II	
III	
IV	
V	

[5]

[Total: 16]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

[Turn over

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-}(aq)	yellow solution turns orange with H^+(aq); gives yellow ppt. with Ba^{2+}(aq); gives bright yellow ppt. with Pb^{2+}(aq)
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq)); gives yellow ppt. with Pb^{2+}(aq)
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil, NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acid)
sulfite, SO_3^{2-}(aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acid)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/36**

Advanced Practical Skills **October/November 2010**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
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.

Answer **all** questions.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 12.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **12** printed pages.

UNIVERSITY of CAMBRIDGE International Examinations

You must prepare Flask A and Flask B in Question 2 before starting Question 1. Shake each flask periodically during the time you spend on Question 1.

For Examiner's Use

1 **FB 1** is 0.125 mol dm^{-3} sulfuric acid, H_2SO_4.
FB 2 is an aqueous solution of sodium hydroxide, NaOH.

You are to determine the concentration, in mol dm^{-3}, of the sodium hydroxide in **FB 2**.

(a) Method

- Fill a burette with **FB 1**.
- Run between 45.50 cm^3 and 46.50 cm^3 of **FB 1** from the burette into the 250 cm^3 graduated (volumetric) flask, labelled **FB 3**.
- Make up to the mark with distilled water.
- Shake the flask to mix the solution.

In the space below record your burette readings and the volume of **FB 1** added to the graduated flask.

You are reminded to shake Flask A and Flask B periodically.

Titration

- Fill a second burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 3**, the diluted acid, into a conical flask.
- Add to the flask a few drops of phenolphthalein indicator.
- Place the flask on a white tile.
- Titrate the acid in the flask with **FB 2**.
  At the end-point a "permanent" pink colour will remain in the solution.
- **Note**: The "permanent" pink colour will fade over several minutes as carbon dioxide is absorbed from the atmosphere.

You should perform a **rough titration**.
In the space below record your burette readings for this rough titration.

The rough titre is ..... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results
- Record in a suitable form on page 3 all of your burette readings and the volume of **FB 2** added in each accurate titration.
- Make certain any recorded results show the precision of your practical work.

You will require the burette containing FB 2 for Question 2.

For Examiner's Use

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results obtain a suitable value to be used in your calculation. Show clearly how you have obtained this value.

25.0 cm^3 of **FB 3** required ..... cm^3 of **FB 2**.
[1]

Calculations
Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(c) **(i)** Calculate how many moles of H_2SO_4 in **FB 1** were run from the burette into the 250 cm^3 graduated, (volumetric) flask.

..... mol of H_2SO_4 were run from the burette into the graduated flask.

(ii) Calculate how many moles of H_2SO_4 in **FB 3** were pipetted from the graduated flask into the conical flask in each titration.

I	
II	
III	
IV	
V	

..... mol of H_2SO_4 were pipetted into the conical flask.

(iii) Calculate how many moles of NaOH reacted with the H_2SO_4 in **(ii)**.

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

The H_2SO_4 in the titration flask reacted with ..... mol of NaOH.

[Turn over

(iv) Calculate the concentration, in mol dm^{-3}, of NaOH in **FB 2**.

For Examiner's Use

The concentration of NaOH in **FB 2** is …… mol dm^{-3}.
[5]

(d) The individual error in any burette reading is ±0.05 cm^3.
Two students, A and B, record identical burette readings.

final burette reading	25.60 cm^3
initial burette reading	1.35 cm^3
volume added	24.25 cm^3

Explain the following.

(i) The initial burette reading made by student A was 0.05 cm^3 greater than the true value but the volume added was exactly 24.25 cm^3.

.....

.....

(ii) The initial burette reading made by student B was 0.05 cm^3 less than the true value and the actual volume added was exactly 24.15 cm^3.

.....

.....
[2]

(e) In the instructions for the experiment you were told that the "permanent" pink colour at the end-point would fade over a few minutes as carbon dioxide is absorbed from the atmosphere.

(i) Explain why absorption of carbon dioxide at the end-point would reverse the indicator colour change seen in the titration.

.....

.....

(ii) Suggest a modification to the titration method, using the same indicator, that would overcome this problem.

.....

.....
[2]

[Total: 17]

2 **FB 4** is 0.050 mol dm^{-3} sodium hydroxide solution.
FB 5 is 0.200 mol dm^{-3} propanoic acid, $C_2H_5CO_2H$.
FB 6 is an organic liquid that does not mix with water.

For Examiner's Use

Propanoic acid dissolves both in water and in the organic layer, **FB 6**.
When an aqueous solution of the acid is shaken with **FB 6**, some of the acid transfers to the organic layer.
The amount of acid remaining in the aqueous layer can be determined by titration with aqueous sodium hydroxide.

Preparation of the mixture in Flask A and in Flask B.

Flask A

- Use a measuring cylinder to place 50 cm^3 of **FB 5** into the stoppered flask labelled **Flask A**.
- Use a second measuring cylinder to add to the flask 40 cm^3 of **FB 6**, the organic liquid.
- Replace the stopper in the flask.

Flask B

- Use the first measuring cylinder to place 50 cm^3 of **FB 5** into the stoppered flask labelled **Flask B**.
- Use the second measuring cylinder to add to the flask 60 cm^3 of **FB 6**, the organic liquid.
- Replace the stopper in the flask.

- Shake both flasks vigorously for about 1 minute.
- **Leave the flasks on the workbench and start Question 1.**
- Shake the flasks for a further minute at intervals during the course of your work on another question.

(a) Titrations

For each flask follow the same procedure.

- Empty the burette containing **FB 2**.
- Rinse the burette thoroughly with **FB 4**.
- Fill the burette with **FB 4**.
- Ensure the two layers have separated – this should take no longer than 1 minute after shaking the flask.
- Pipette 10.0 cm^3 of the **lower** (aqueous) layer into a conical flask. Attach the pipette filler to the pipette before inserting it into the mixture, in order to close the top of the pipette to prevent any of the top (organic) layer from entering the pipette.
- Replace the stopper in the flask.
- Titrate the acid in the conical flask with **FB 4**, using phenolphthalein indicator, as in Question 1.
- **One titration will be sufficient for each experiment but take care to ensure that no errors are made during the procedure**.

I	
II	
III	
IV	

[Turn over

Results

Record, in a single table below, the burette readings and volume of **FB 4** added, for each of **Flask A** and **Flask B**.

For Examiner's Use

[4]

(b) Calculations

In these calculations make use of the following.

- The concentration of NaOH in **FB 4** is 0.050 mol dm^{-3}.
- 50 cm^3 of 0.200 mol dm^{-3} propanoic acid, the volume of acid added to each flask, contains 0.010 mol $C_2H_5CO_2H$.
- 1 mol $C_2H_5CO_2H$ reacts with 1 mol NaOH.

(i) Calculate the volume of **FB 4** that contains 0.010 mol NaOH.
This is the volume of **FB 4** that would have reacted with the propanoic acid in the 50 cm^3 of the aqueous layer, **before** shaking with the organic liquid.

Volume of **FB 4** = ... cm^3

(ii) For each flask, use your titration result in **(a)** to calculate the volume of **FB 4** needed to react with the acid remaining in **50 cm^3** of the aqueous layer, **after** shaking with the organic liquid.

Flask A	Flask B
volume of **FB 4** = ... cm^3	volume of **FB 4** = ... cm^3

(iii) The amount of propanoic acid transferred to the organic layer can be represented by the following.

(answer **(i)** – answer to **(ii)**)

For each flask evaluate this expression.

Flask A (answer to **(i)** – answer to **(ii)**) = ... cm^3

Flask B (answer to **(i)** – answer to **(ii)**) = ... cm^3

[2]

(c) In which flask was most propanoic acid transferred to the organic layer?

For Examiner's Use

Justify your answer.

.....

.....

.....

[1]

(d) It is suggested that shaking the mixture leads to the following equilibrium being established.

$$C_2H_5CO_2H(aq) \rightleftharpoons C_2H_5CO_2H(org)$$

Determine the equilibrium constant by evaluating the expressions in the following table.

(i) Determine the equilibrium constant by evaluating the expressions in the following table. **Ignore units**.

Flask A	**Flask B**
$K_c = \frac{\text{answer } \mathbf{(b)(iii)}}{\text{answer } \mathbf{(b)(ii)}} \times 1.25$	$K_c = \frac{\text{answer } \mathbf{(b)(iii)}}{\text{answer } \mathbf{(b)(ii)}} \times 0.83$
K_c = ...	K_c = ...

(ii) Explain whether or not your results support the idea that equilibrium has been established in each flask.

.....

.....

.....

[1]

[Total: 8]

[Turn over

For Examiner's Use

3 **FB 7**, **FB 8** and **FB 9** are aqueous solutions, each containing cations and anions from those listed on pages 11 and 12 in the Qualitative Analysis Notes.

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.
If any solution is warmed, a boiling-tube MUST be used.
Rinse and reuse test-tubes and boiling-tubes where possible.

(a) **(i)** One or more of the solutions **FB 7**, **FB 8** and **FB 9** are believed to contain the ammonium ion, NH_4^+.

Suggest a reagent that would enable you to identify the presence of NH_4^+ and describe how you would use the reagent in an appropriate test.

reagent .....

test .....

.....

Use this reagent to test each of the solutions. Record your observations in the table below.

solution	*observation*
FB 7	
FB 8	
FB 9	

I	
II	

(ii) One or more of the solutions contains the sulfate ion, SO_4^{2-}.
Select reagents that would enable you to identify the presence of SO_4^{2-}.
Show clearly, by describing how the reagents will be used, how you would distinguish SO_4^{2-} from the sulfite ion, SO_3^{2-}.

For Examiner's Use

reagents .....

test .....

Use these reagents to test each of the solutions. Record your observations in the table below.

solution	*observation*
FB 7	
FB 8	
FB 9	

III	
IV	
V	

(iii) Conclusions

The ammonium ion, NH_4^+, is present in .....

The sulfate ion, SO_4^{2-}, is present in .....

[5]

(b) Use aqueous sodium hydroxide and aqueous ammonia in separate tests to identify any cation (apart from NH_4^+) present in **FB 7**, **FB 8** and **FB 9**.

Present your results for each of the solutions in a suitable form below.

I	
II	
III	
IV	

[4]

[Turn over

(c) Conclusion

For Examiner's Use

Complete the following table.
Place a cross in any box where no cation has been identified.

solution	*cation*	*supporting evidence*
FB 7		
FB 8		
FB 9		

[1]

(d) Carry out the following tests on **FB 10**.
Observe carefully at each stage and record all of your observations in the table.

test		*observations*
(i)	Place 2 spatula measures of **FB 10** in a dry, hard glass boiling-tube. Heat the solid gently at first, then strongly until no further change is seen. Retain the solid for use in **(ii)**.	
(ii)	Tip the contents of the tube in **(i)** into a second boiling-tube. Add 2 cm depth of dilute hydrochloric acid **a little at a time**. Warm the tube and leave to stand.	

I	
II	
III	
IV	
V	

[5]

[Total: 15]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), Pb^{2+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

[Turn over

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+(aq); gives yellow ppt. with Ba^{2+}(aq); gives bright yellow ppt. with Pb^{2+}(aq)
chloride, Cl^- (aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
bromide, Br^- (aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+(aq) (insoluble In NH_3(aq)); gives yellow ppt. with Pb^{2+}(aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil, NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acid)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acid)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1643609853

CHEMISTRY **9701/41**

Paper 4 Structured Questions **October/November 2010**

1 hour 45 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.

Section B
Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

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	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	

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

UNIVERSITY of CAMBRIDGE International Examinations

BLANK PAGE

Section A

For Examiner's Use

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

1 **(a)** Write a balanced equation for the reaction of each of the following chlorides with water.

phosphorus(V) chloride .....

silicon(IV) chloride .....

[2]

(b) When sulfur is heated under pressure with chlorine, the major product is SCl_2 (Cl-S-Cl).

$$S_8(g) + 8Cl_2(g) \rightarrow 8SCl_2(g)$$

Use data from the *Data Booklet* to calculate the enthalpy change, ΔH, for this reaction. The eight sulfur atoms in the S_8 molecule are all joined in a single ring by single bonds.

ΔH = ...kJ mol^{-1}

[2]

(c) Under suitable conditions, SCl_2 reacts with water to produce a yellow precipitate of sulfur and a solution **A**. Solution **A** contains a mixture of SO_2(aq) and compound **B**.

(i) What is the oxidation number of sulfur in SCl_2? .....

(ii) Work out how the oxidation number of sulfur changes during the reaction of SCl_2 with water.

.....

.....

(iii) Suggest the identity of compound **B**. .....

(iv) Construct an equation for the reaction between SCl_2 and water.

.....

(v) What would you observe when each of the following reagents is added to separate samples of solution **A**?

$AgNO_3$(aq) .....

$K_2Cr_2O_7$(aq) .....

[7]

[Total: 11]

2 **(a)** **(i)** What is meant by the term *ligand* in the context of transition element chemistry?

For Examiner's Use

.....

.....

(ii) Decide which of the following species could be a ligand, and which could not be. Place a tick (✓) in the appropriate column.

species	can be a ligand	cannot be a ligand
OH^-		
NH_4^+		
CH_3OH		
CH_3NH_2		

[3]

(b) Read the following description of some reactions of copper(II) sulfate, and answer the questions that follow.

When 0.1 mol of white anhydrous $CuSO_4$ is dissolved in liquid ammonia at –33 °C, a deep blue solution **C** results.
When 0.2 mol of solid NaOH is added to solution **C**, and the ammonia solvent allowed to evaporate, a solid residue is obtained.
Heating this residue to 200 °C produces a dark coloured mixture of two solids.
When water is added to this mixture, a black solid **D** and a colourless solution **E** are formed. Neither **D** nor **E** contains nitrogen.
Adding aCl_2(aq) to solution **E** produces a white precipitate **F**.
Solid **D** dissolves in HNO_3(aq) on warming, without evolution of gas, to give a pale blue solution containing $Cu(NO_3)_2$(aq).

(i) Suggest the formula of the compound contained in each of the following.

solution **C** .....

solid **D** .....

solution **E** .....

white precipitate **F** .....

(ii) Name the type of reaction that is occurring when **D** reacts with HNO_3(aq).

.....

[5]

(c) **(i)** Describe what you would observe when a solid sample of anhydrous $Cu(NO_3)_2$ is strongly heated.

For Examiner's Use

.....

.....

(ii) Write an equation for this reaction.

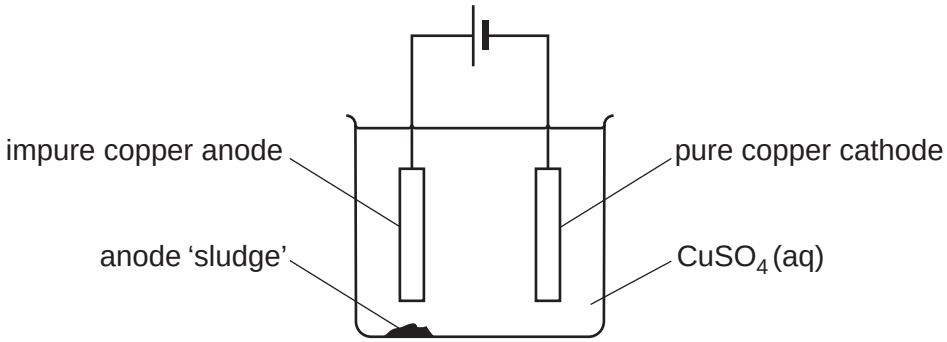
.....

[2]

[Total: 10]

3 The electrolytic purification of copper can be carried out in an apparatus similar to the one shown below.

For Examiner's Use



The impure copper anode contains small quantities of metallic nickel, zinc and silver, together with inert oxides and carbon resulting from the initial reduction of the copper ore with coke. The copper goes into solution at the anode, but the silver remains as the metal and falls to the bottom as part of the anode 'sludge'. The zinc also dissolves.

(a) (i) Write a half equation including state symbols for the reaction of copper at the anode.

.....

(ii) Use data from the *Data Booklet* to explain why silver remains as the metal.

.....

(iii) Use data from the *Data Booklet* to predict what happens to the nickel at the anode.

.....

.....

(iv) Write a half equation including state symbols for the main reaction at the cathode.

.....

(v) Use data from the *Data Booklet* to explain why zinc is not deposited on the cathode.

.....

.....

(vi) Suggest why the blue colour of the electrolyte slowly fades as the electrolysis proceeds.

.....

.....

[7]

For Examiner's Use

(b) Most of the current passed through the cell is used to dissolve the copper at the anode and precipitate pure copper onto the cathode. However, a small proportion of it is 'wasted' in dissolving the impurities at the anode which then remain in solution.
When a current of 20.0 A was passed through the cell for 10.0 hours, it was found that 225 g of pure copper was deposited on the cathode.

(i) Calculate the following, using appropriate data from the *Data Booklet*.

- number of moles of copper produced at the cathode

- number of moles of electrons needed to produce this copper

- number of moles of electrons that passed through the cell

(ii) Hence calculate the percentage of the current through the cell that has been 'wasted' in dissolving the impurities at the anode.

[4]

(c) Nickel often occurs in ores along with iron. After the initial reduction of the ore with coke, a nickel-iron alloy is formed.
Use data from the *Data Booklet* to explain why nickel can be purified by a similar electrolysis technique to that used for copper, using an impure nickel anode, a pure nickel cathode, and nickel sulfate as the electrolyte. Explain what would happen to the iron during this process.

.....

.....

.....

.....[2]

[Total: 13]

4 The most typical oxides of tin and lead are SnO, SnO_2, PbO and PbO_2.

For Examiner's Use

The following two generalisations can be made about the oxides of the elements in Group IV.

- As the metallic character of the elements increases down the Group, the oxides become more basic.
- The oxides of the elements in their higher oxidation states are more acidic than the oxides of the elements in their lower oxidation states.

(a) Use these generalisations to suggest which of the above oxides of tin or lead is **most likely** to react with each of the following reagents. In each case write a balanced equation for the reaction.

(i) with NaOH(aq)

formula of oxide .....

equation .....

(ii) with HC*l*(aq)

formula of oxide .....

equation .....

[4]

(b) 'Red lead' is used as a pigment, and as a metal primer paint to prevent the corrosion of steel. It is an oxide of lead that contains 9.30% oxygen by mass.

Calculate to **3 significant figures** the number of moles of oxygen and lead contained in a 100.0 g sample of red lead. Hence calculate its empirical formula.

empirical formula: ..... [2]

(c) Lead(II) chloride is slightly soluble in water.

For Examiner's Use

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq) \qquad K_{sp} = 2.0 \times 10^{-5}$$

(i) Write an expression for the solubility product, K_{sp} for lead(II) chloride and state its units.

K_{sp} = ... units .....

(ii) Calculate $[Pb^{2+}(aq)]$ in a saturated solution of $PbCl_2$.

.....

.....

An excess of $PbCl_2(s)$ is stirred with $0.50\,mol\,dm^{-3}$ $NaCl$ until equilibrium has been established. The excess $PbCl_2(s)$ is then filtered off.

(iii) Assuming $[Cl^-]$ remains at $0.50\,mol\,dm^{-3}$ throughout, calculate the $[Pb^{2+}(aq)]$ in the remaining solution.

.....

.....

(iv) Suggest an explanation for the difference between this value and the value that you calculated in **(ii)**.

.....

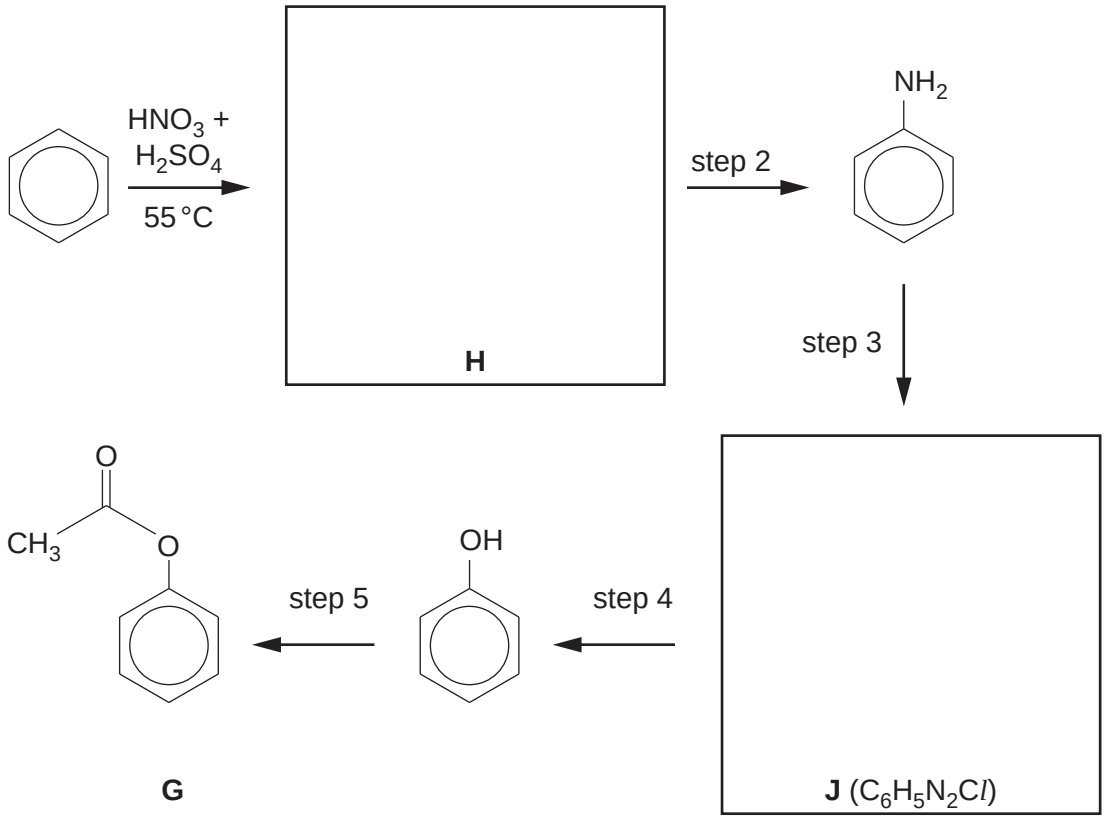
[4]

[Total: 10]

[Turn over

5 **(a)** Compound **G** can be synthesised from benzene by the route shown below.

For Examiner's Use



(i) **Name** the functional group formed in step 5.

.....

(ii) Draw the structures of the intermediates **H** and **J** in the boxes above.

(iii) Suggest reagents and conditions for the following.

step 2 .....

step 3 .....

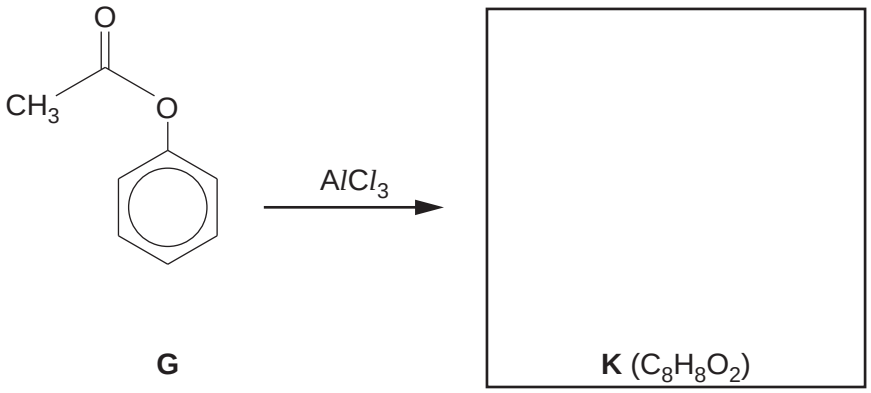
step 4 .....

step 5 .....

[7]

(b) In a reaction discovered just over 100 years ago by the German chemist Karl Fries, compound **G** is converted into compound **K** when it is heated with $AlCl_3$. Compound **K** is a structural isomer of **G**.

For Examiner's Use



Compound **K** is a 1,4-disubstituted benzene derivative. It is insoluble in water, but dissolves in NaOH(aq). It gives a white precipitate with Br_2(aq), and a yellow precipitate with alkaline aqueous iodine.

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

.....

.....

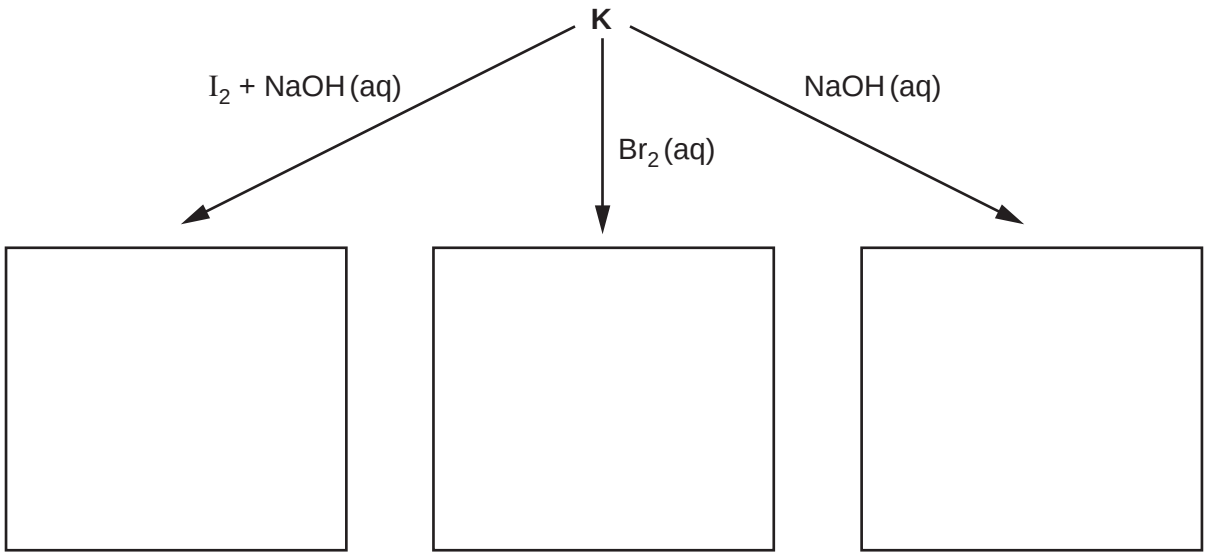
(ii) Use the information given above to **name** two functional groups in compound **K**.

.....

.....

(iii) Suggest the structural formula of **K**, and draw it in the box above.

(iv) Suggest structures for the aromatic products of the following reactions.

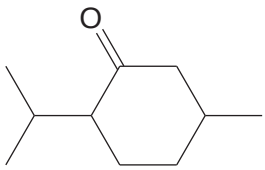


[7]

[Total: 14]

6 Menthone, $C_{10}H_{18}O$, is a cyclic ketone that occurs in oil of peppermint.

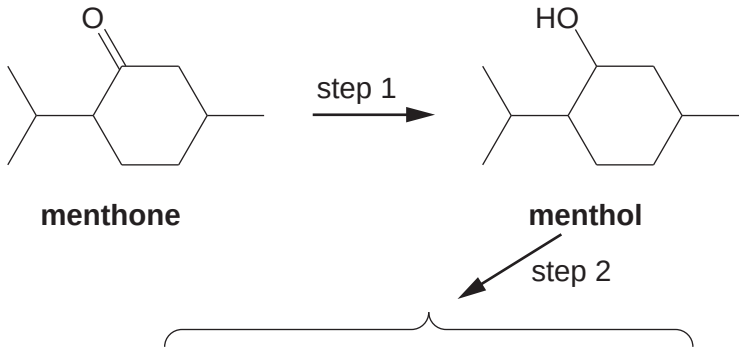
For Examiner's Use



menthone

(a) Use asterisks (*) on the formula above to identify any chiral centres in the molecule of menthone. [2]

(b) Menthone can be reduced to menthol, which can be dehydrated to a mixture of two alkenes, **L** and **M**.



(i) Suggest reagents for

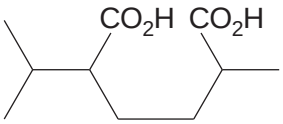
step 1, ...

step 2. .....

(ii) Suggest structures for **L** and **M** and draw them in the boxes above. [4]

(c) When heated with concentrated, acidified $KMnO_4(aq)$, one of the two alkenes **L** or **M** produces the dicarboxylic acid **N**.

For Examiner's Use



N

(i) Give the letter of the alkene that produced **N** by this reaction.

.....

(ii) Suggest the structure of the product, **P**, of the reaction between the other alkene you have drawn and hot concentrated acidified $KMnO_4$.

P

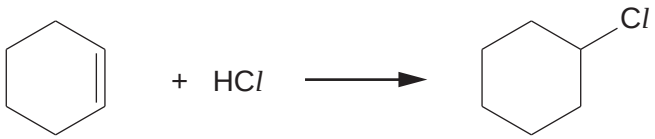
(iii) Suggest **one** chemical test that would enable you to distinguish between **N** and **P**.

reagent(s).....

observation.....

[3]

(d) Chlorocyclohexane can be prepared by bubbling HCl(g) through a solution of cyclohexene.



Suggest the mechanism of this 2-stage reaction by means of a diagram. Include all whole or partial charges, and represent the movements of electron pairs by curly arrows.

[3]

[Total: 12]

Section B

For Examiner's Use

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

7 Whilst small amounts of some metal ions are vital in the human body, others can be highly toxic.

(a) Hg^{2+} ions are toxic for a number of reasons. Hg^{2+} ions can react with the R–S–S–R group, which is found in proteins.

$$R–S–S–R + 2Hg^{2+} + H_2 \rightarrow 2\ R–S–Hg^{+} + 2H^{+} \qquad \text{reaction 1}$$

(i) What is the name of the R–S–S–R group in proteins?

.....

(ii) Which level of protein structure will be affected by reaction 1?

.....

.....

(iii) Why will this affect the activity of an enzyme?

.....

.....

[3]

(b) Ag^{+} ions can combine with free –COOH groups in the side chains of the amino acid residues in proteins to form partially covalent silver carboxylates.

$$RCOOH + Ag^{+} \rightarrow RCOOAg + H^{+} \qquad \text{reaction 2}$$

(i) What type of behaviour is the –COOH group showing in reaction 2?

.....

.....

(ii) What types of R group interactions will be affected by reaction 2? Explain your answer.

.....

.....

.....

.....

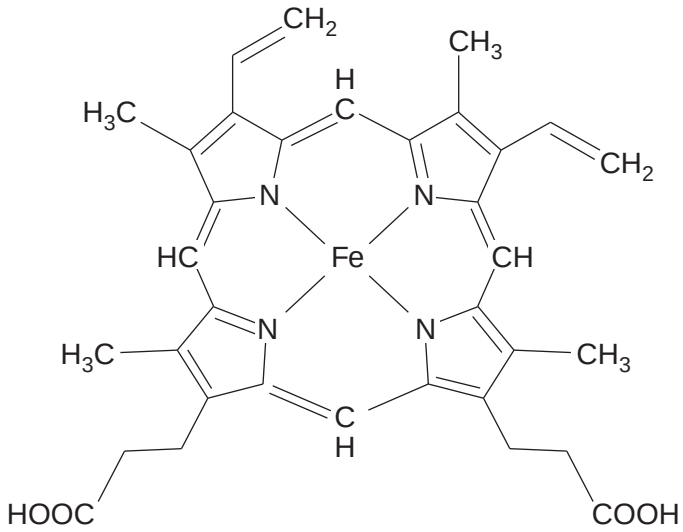
.....

[4]

(c) By contrast, iron is an extremely important metal used in haemoglobin to transport oxygen molecules from the lungs to muscle cells and to carry carbon dioxide in the reverse direction.

For Examiner's Use

One haemoglobin molecule contains four haem groups, each of which contains one iron atom. In the haem group four nitrogen atoms are in the same plane as the iron atom. The oxygen molecule is attached above this plane, and the iron atom is joined to a protein chain below this plane.



haem

(i) How many oxygen **atoms** could one haemoglobin molecule transport?

.....

(ii) By what type of bonding is the oxygen molecule likely to be held to the iron atom in haem?

.....

(iii) What is the geometry of bonding around the iron atom?

.....

[3]

[Total: 10]

8 **(a)** NMR spectroscopy and X-ray crystallography are two techniques that use electromagnetic radiation to look at the structures of large molecules.

For each technique state the sub-atomic particle involved, and explain how this particle interacts with the radiation.

NMR.....

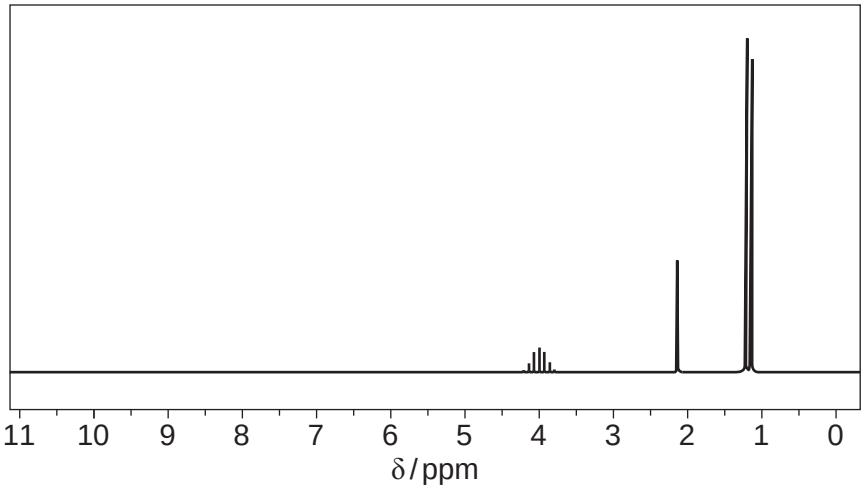
.....

X-ray .....

.....

[4]

(b) The two NMR spectra **1** and **2** were obtained before and after an alcohol, **Y**, was oxidised to give compound **Z**. The numbers of hydrogen atoms responsible for each peak have **not** been shown. All the peaks have been shown.



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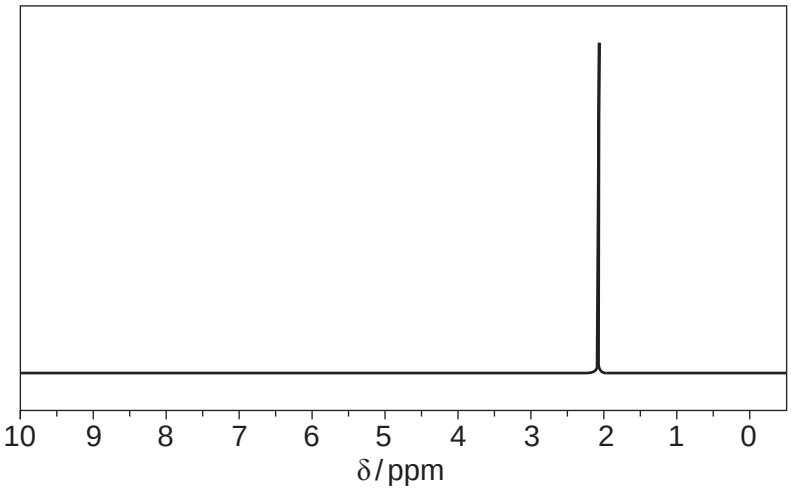

2

For Examiner's Use

(i) State which spectrum, **1** or **2**, was produced by the alcohol, giving a reason for your answer.

spectrum .....

reason .....

.....

(ii) The mass spectrum of **Y** showed an M : M + 1 peak ratio of 17.6:0.6.
Use this and other information in the question to suggest the identities of both **Y** and **Z**.

(iii) Draw a displayed formula for **Y** in the box provided

Y is

(iv) Explain why the NMR spectrum of **Z** only shows one peak.

.....

.....

[7]

[Total: 11]

For Examiner's Use

9 A possible source of energy for the road vehicles of the future is hydrogen. One of the problems still to be solved is the storage of the hydrogen in the vehicle. A conventional tank holding liquid hydrogen would have to be pressurised and refrigerated. In a crash, this type of tank could break resulting in the rapid release of hydrogen and an explosion.

One alternative is to use a fuel tank packed with carbon nanotubes. The hydrogen in the tank would be adsorbed onto the surface of the nanotubes at a pressure of no more than a few atmospheres.

(a) (i) What is the approximate width of a carbon nanotube?

.....

(ii) In what structural form is the carbon in a nanotube?

.....

(iii) What forces could be responsible for holding the hydrogen on the surface of the nanotubes? Explain your answer.

.....

.....

.....

[4]

(b) The hydrogen atoms in a fuel tank packed with nanotubes are closer together than in liquid hydrogen. Suggest **one** advantage of this.

.....

.....[1]

(c) When a nanotube-packed fuel tank is full of hydrogen there is a steady pressure of hydrogen in the tank. While hydrogen gas is being removed from the fuel tank to power the car, the pressure in the fuel tank drops very little for some time. State Le Chatelier's principle, and suggest how it explains this observation.

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.....

.....

.....

.....[4]

[Total: 9]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3430056738

CHEMISTRY **9701/42**

Paper 4 Structured Questions **October/November 2010**

1 hour 45 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.

Section B
Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

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

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Section A

For Examiner's Use

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

1 **(a)** Write a balanced equation for the reaction of each of the following chlorides with water.

phosphorus(V) chloride .....

silicon(IV) chloride .....

[2]

(b) When sulfur is heated under pressure with chlorine, the major product is SCl_2 (Cl-S-Cl).

$$S_8(g) + 8Cl_2(g) \rightarrow 8SCl_2(g)$$

Use data from the *Data Booklet* to calculate the enthalpy change, ΔH, for this reaction. The eight sulfur atoms in the S_8 molecule are all joined in a single ring by single bonds.

ΔH = ...kJ mol^{-1}

[2]

(c) Under suitable conditions, SCl_2 reacts with water to produce a yellow precipitate of sulfur and a solution **A**. Solution **A** contains a mixture of SO_2(aq) and compound **B**.

(i) What is the oxidation number of sulfur in SCl_2? .....

(ii) Work out how the oxidation number of sulfur changes during the reaction of SCl_2 with water.

.....

.....

(iii) Suggest the identity of compound **B**. .....

(iv) Construct an equation for the reaction between SCl_2 and water.

.....

(v) What would you observe when each of the following reagents is added to separate samples of solution **A**?

$AgNO_3$(aq) .....

$K_2Cr_2O_7$(aq) .....

[7]

[Total: 11]

2 **(a)** **(i)** What is meant by the term *ligand* in the context of transition element chemistry?

For Examiner's Use

.....

.....

(ii) Decide which of the following species could be a ligand, and which could not be. Place a tick (✓) in the appropriate column.

species	can be a ligand	cannot be a ligand
OH^-		
NH_4^+		
CH_3OH		
CH_3NH_2		

[3]

(b) Read the following description of some reactions of copper(II) sulfate, and answer the questions that follow.

When 0.1 mol of white anhydrous $CuSO_4$ is dissolved in liquid ammonia at –33 °C, a deep blue solution **C** results.
When 0.2 mol of solid NaOH is added to solution **C**, and the ammonia solvent allowed to evaporate, a solid residue is obtained.
Heating this residue to 200 °C produces a dark coloured mixture of two solids.
When water is added to this mixture, a black solid **D** and a colourless solution **E** are formed. Neither **D** nor **E** contains nitrogen.
Adding aCl_2(aq) to solution **E** produces a white precipitate **F**.
Solid **D** dissolves in HNO_3(aq) on warming, without evolution of gas, to give a pale blue solution containing $Cu(NO_3)_2$(aq).

(i) Suggest the formula of the compound contained in each of the following.

solution **C** .....

solid **D** .....

solution **E** .....

white precipitate **F** .....

(ii) Name the type of reaction that is occurring when **D** reacts with HNO_3(aq).

.....

[5]

(c) **(i)** Describe what you would observe when a solid sample of anhydrous $Cu(NO_3)_2$ is strongly heated.

For Examiner's Use

.....

.....

(ii) Write an equation for this reaction.

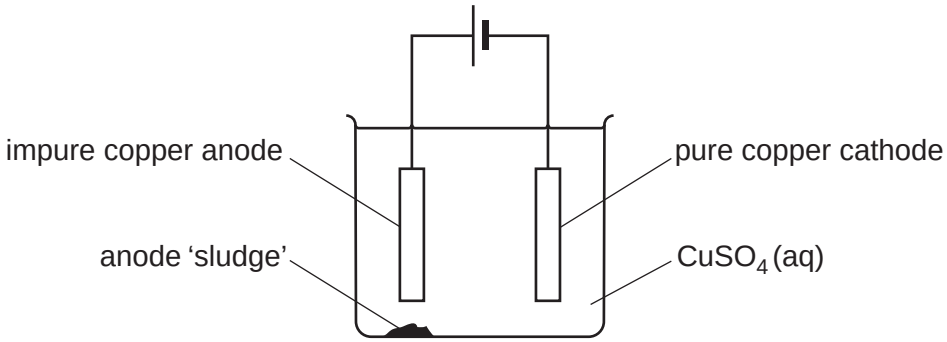
.....

[2]

[Total: 10]

3 The electrolytic purification of copper can be carried out in an apparatus similar to the one shown below.

For Examiner's Use



The impure copper anode contains small quantities of metallic nickel, zinc and silver, together with inert oxides and carbon resulting from the initial reduction of the copper ore with coke. The copper goes into solution at the anode, but the silver remains as the metal and falls to the bottom as part of the anode 'sludge'. The zinc also dissolves.

(a) (i) Write a half equation including state symbols for the reaction of copper at the anode.

.....

(ii) Use data from the *Data Booklet* to explain why silver remains as the metal.

.....

(iii) Use data from the *Data Booklet* to predict what happens to the nickel at the anode.

.....

.....

(iv) Write a half equation including state symbols for the main reaction at the cathode.

.....

(v) Use data from the *Data Booklet* to explain why zinc is not deposited on the cathode.

.....

.....

(vi) Suggest why the blue colour of the electrolyte slowly fades as the electrolysis proceeds.

.....

.....

[7]

For Examiner's Use

(b) Most of the current passed through the cell is used to dissolve the copper at the anode and precipitate pure copper onto the cathode. However, a small proportion of it is 'wasted' in dissolving the impurities at the anode which then remain in solution.
When a current of 20.0 A was passed through the cell for 10.0 hours, it was found that 225 g of pure copper was deposited on the cathode.

(i) Calculate the following, using appropriate data from the *Data Booklet*.

- number of moles of copper produced at the cathode

- number of moles of electrons needed to produce this copper

- number of moles of electrons that passed through the cell

(ii) Hence calculate the percentage of the current through the cell that has been 'wasted' in dissolving the impurities at the anode.

[4]

(c) Nickel often occurs in ores along with iron. After the initial reduction of the ore with coke, a nickel-iron alloy is formed.
Use data from the *Data Booklet* to explain why nickel can be purified by a similar electrolysis technique to that used for copper, using an impure nickel anode, a pure nickel cathode, and nickel sulfate as the electrolyte. Explain what would happen to the iron during this process.

.....

.....

.....

.....[2]

[Total: 13]

4 The most typical oxides of tin and lead are SnO, SnO_2, PbO and PbO_2.

For Examiner's Use

The following two generalisations can be made about the oxides of the elements in Group IV.

- As the metallic character of the elements increases down the Group, the oxides become more basic.
- The oxides of the elements in their higher oxidation states are more acidic than the oxides of the elements in their lower oxidation states.

(a) Use these generalisations to suggest which of the above oxides of tin or lead is **most likely** to react with each of the following reagents. In each case write a balanced equation for the reaction.

(i) with NaOH(aq)

formula of oxide .....

equation .....

(ii) with HC*l*(aq)

formula of oxide .....

equation .....

[4]

(b) 'Red lead' is used as a pigment, and as a metal primer paint to prevent the corrosion of steel. It is an oxide of lead that contains 9.30% oxygen by mass.

Calculate to **3 significant figures** the number of moles of oxygen and lead contained in a 100.0 g sample of red lead. Hence calculate its empirical formula.

empirical formula: ..... [2]

(c) Lead(II) chloride is slightly soluble in water.

For Examiner's Use

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq) \qquad K_{sp} = 2.0 \times 10^{-5}$$

(i) Write an expression for the solubility product, K_{sp} for lead(II) chloride and state its units.

K_{sp} = ... units .....

(ii) Calculate $[Pb^{2+}(aq)]$ in a saturated solution of $PbCl_2$.

.....

.....

An excess of $PbCl_2(s)$ is stirred with $0.50\,mol\,dm^{-3}$ $NaCl$ until equilibrium has been established. The excess $PbCl_2(s)$ is then filtered off.

(iii) Assuming $[Cl^-]$ remains at $0.50\,mol\,dm^{-3}$ throughout, calculate the $[Pb^{2+}(aq)]$ in the remaining solution.

.....

.....

(iv) Suggest an explanation for the difference between this value and the value that you calculated in **(ii)**.

.....

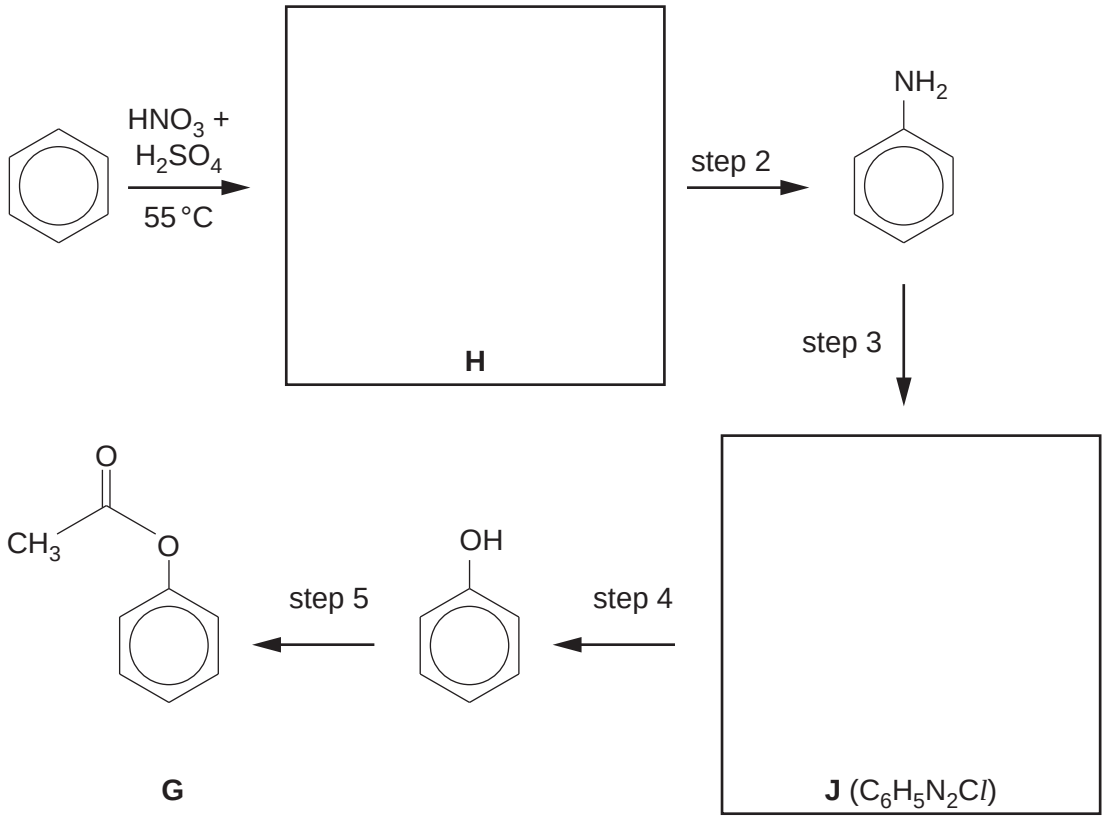
[4]

[Total: 10]

[Turn over

5 **(a)** Compound **G** can be synthesised from benzene by the route shown below.

For Examiner's Use



(i) **Name** the functional group formed in step 5.

.....

(ii) Draw the structures of the intermediates **H** and **J** in the boxes above.

(iii) Suggest reagents and conditions for the following.

step 2 .....

step 3 .....

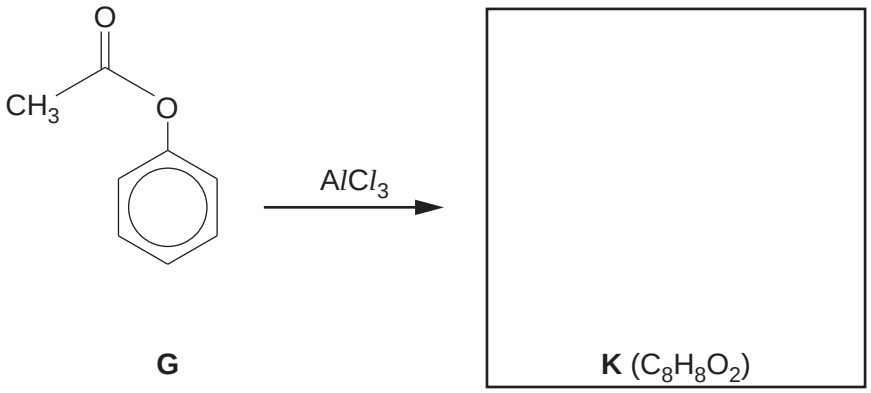
step 4 .....

step 5 .....

[7]

(b) In a reaction discovered just over 100 years ago by the German chemist Karl Fries, compound **G** is converted into compound **K** when it is heated with $AlCl_3$. Compound **K** is a structural isomer of **G**.

For Examiner's Use



Compound **K** is a 1,4-disubstituted benzene derivative. It is insoluble in water, but dissolves in NaOH(aq). It gives a white precipitate with Br_2(aq), and a yellow precipitate with alkaline aqueous iodine.

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

.....

.....

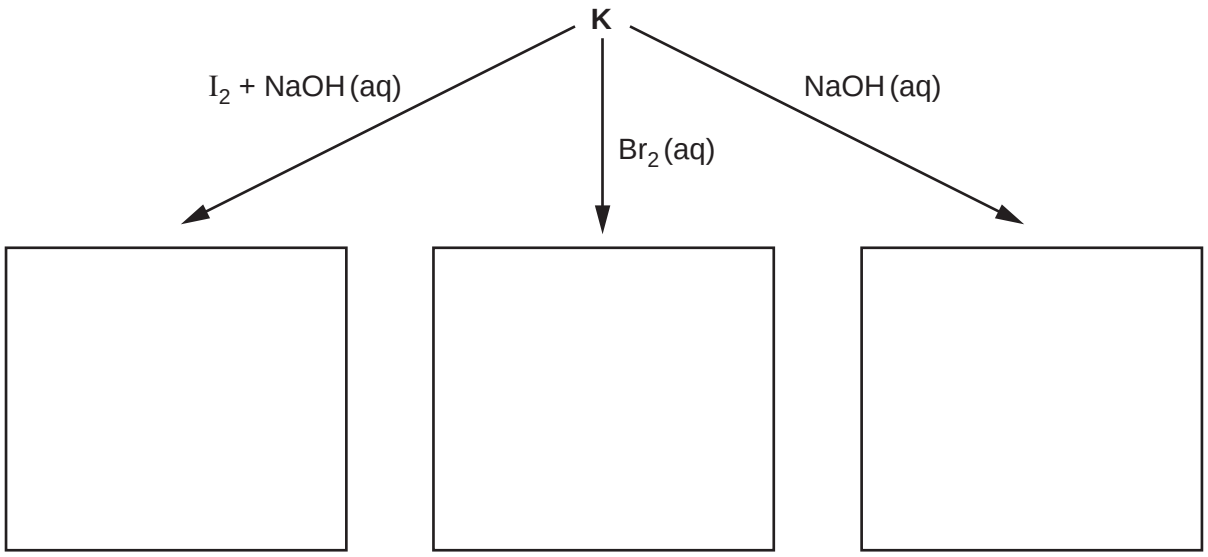
(ii) Use the information given above to **name** two functional groups in compound **K**.

.....

.....

(iii) Suggest the structural formula of **K**, and draw it in the box above.

(iv) Suggest structures for the aromatic products of the following reactions.

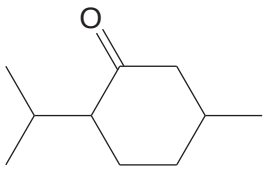


[7]

[Total: 14]

6 Menthone, $C_{10}H_{18}O$, is a cyclic ketone that occurs in oil of peppermint.

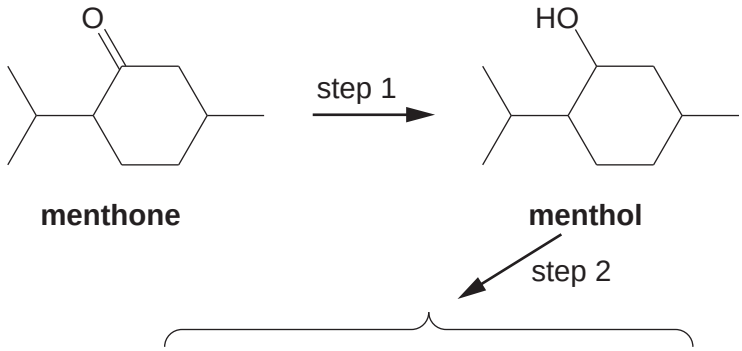
For Examiner's Use



menthone

(a) Use asterisks (*) on the formula above to identify any chiral centres in the molecule of menthone. [2]

(b) Menthone can be reduced to menthol, which can be dehydrated to a mixture of two alkenes, **L** and **M**.



(i) Suggest reagents for

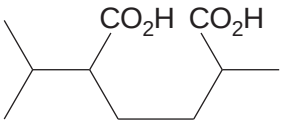
step 1, ...

step 2. .....

(ii) Suggest structures for **L** and **M** and draw them in the boxes above. [4]

(c) When heated with concentrated, acidified $KMnO_4(aq)$, one of the two alkenes **L** or **M** produces the dicarboxylic acid **N**.

For Examiner's Use



N

(i) Give the letter of the alkene that produced **N** by this reaction.

.....

(ii) Suggest the structure of the product, **P**, of the reaction between the other alkene you have drawn and hot concentrated acidified $KMnO_4$.

P

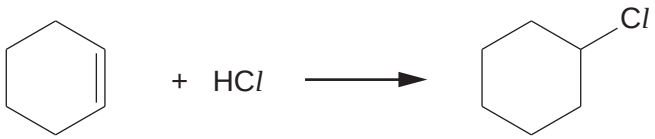
(iii) Suggest **one** chemical test that would enable you to distinguish between **N** and **P**.

reagent(s).....

observation.....

[3]

(d) Chlorocyclohexane can be prepared by bubbling HCl(g) through a solution of cyclohexene.



Suggest the mechanism of this 2-stage reaction by means of a diagram. Include all whole or partial charges, and represent the movements of electron pairs by curly arrows.

[3]

[Total: 12]

Section B

For Examiner's Use

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

7 Whilst small amounts of some metal ions are vital in the human body, others can be highly toxic.

(a) Hg^{2+} ions are toxic for a number of reasons. Hg^{2+} ions can react with the R–S–S–R group, which is found in proteins.

$$R–S–S–R + 2Hg^{2+} + H_2 \rightarrow 2\ R–S–Hg^{+} + 2H^{+} \qquad \text{reaction 1}$$

(i) What is the name of the R–S–S–R group in proteins?

.....

(ii) Which level of protein structure will be affected by reaction 1?

.....

.....

(iii) Why will this affect the activity of an enzyme?

.....

.....

[3]

(b) Ag^{+} ions can combine with free –COOH groups in the side chains of the amino acid residues in proteins to form partially covalent silver carboxylates.

$$RCOOH + Ag^{+} \rightarrow RCOOAg + H^{+} \qquad \text{reaction 2}$$

(i) What type of behaviour is the –COOH group showing in reaction 2?

.....

.....

(ii) What types of R group interactions will be affected by reaction 2? Explain your answer.

.....

.....

.....

.....

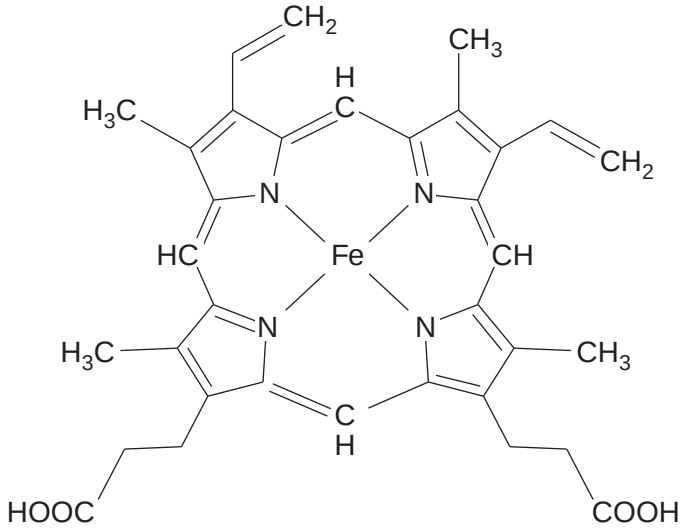
.....

[4]

(c) By contrast, iron is an extremely important metal used in haemoglobin to transport oxygen molecules from the lungs to muscle cells and to carry carbon dioxide in the reverse direction.

For Examiner's Use

One haemoglobin molecule contains four haem groups, each of which contains one iron atom. In the haem group four nitrogen atoms are in the same plane as the iron atom. The oxygen molecule is attached above this plane, and the iron atom is joined to a protein chain below this plane.



haem

(i) How many oxygen **atoms** could one haemoglobin molecule transport?

.....

(ii) By what type of bonding is the oxygen molecule likely to be held to the iron atom in haem?

.....

(iii) What is the geometry of bonding around the iron atom?

.....

[3]

[Total: 10]

8 **(a)** NMR spectroscopy and X-ray crystallography are two techniques that use electromagnetic radiation to look at the structures of large molecules.

For each technique state the sub-atomic particle involved, and explain how this particle interacts with the radiation.

NMR.....

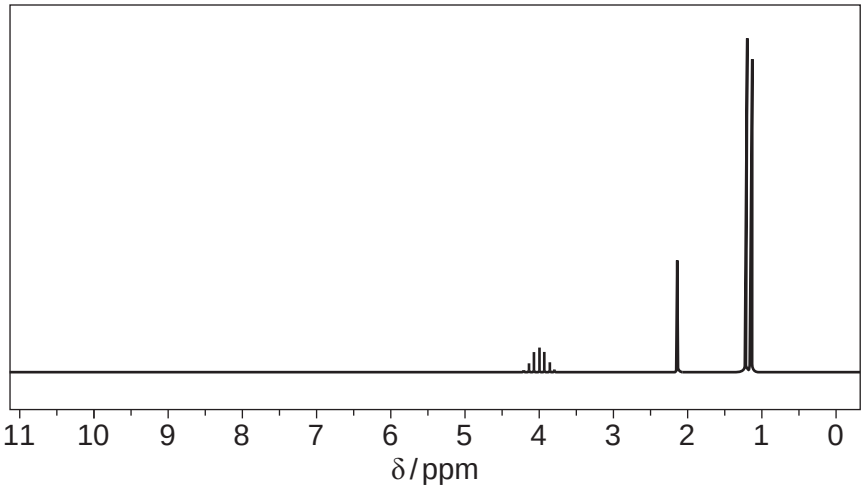
.....

X-ray .....

.....

[4]

(b) The two NMR spectra **1** and **2** were obtained before and after an alcohol, **Y**, was oxidised to give compound **Z**. The numbers of hydrogen atoms responsible for each peak have **not** been shown. All the peaks have been shown.



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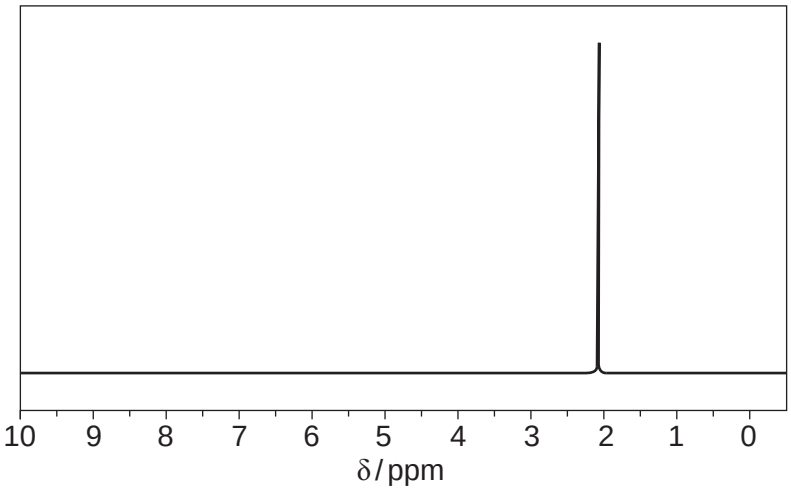

2

For Examiner's Use

(i) State which spectrum, **1** or **2**, was produced by the alcohol, giving a reason for your answer.

spectrum .....

reason .....

.....

(ii) The mass spectrum of **Y** showed an M : M + 1 peak ratio of 17.6:0.6.
Use this and other information in the question to suggest the identities of both **Y** and **Z**.

(iii) Draw a displayed formula for **Y** in the box provided

Y is

(iv) Explain why the NMR spectrum of **Z** only shows one peak.

.....

.....

[7]

[Total: 11]

For Examiner's Use

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One alternative is to use a fuel tank packed with carbon nanotubes. The hydrogen in the tank would be adsorbed onto the surface of the nanotubes at a pressure of no more than a few atmospheres.

(a) (i) What is the approximate width of a carbon nanotube?

.....

(ii) In what structural form is the carbon in a nanotube?

.....

(iii) What forces could be responsible for holding the hydrogen on the surface of the nanotubes? Explain your answer.

.....

.....

.....

[4]

(b) The hydrogen atoms in a fuel tank packed with nanotubes are closer together than in liquid hydrogen. Suggest **one** advantage of this.

.....

.....[1]

(c) When a nanotube-packed fuel tank is full of hydrogen there is a steady pressure of hydrogen in the tank. While hydrogen gas is being removed from the fuel tank to power the car, the pressure in the fuel tank drops very little for some time. State Le Chatelier's principle, and suggest how it explains this observation.

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.....[4]

[Total: 9]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9452358243

CHEMISTRY **9701/43**

Paper 4 Structured Questions **October/November 2010**

1 hour 45 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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For Examiner's Use	
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This document consists of **19** printed pages and **1** blank page.

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

Section A

For Examiner's Use

Answer **all** the questions in the space provided.

1 (a) (i) Write equations to illustrate the reactions of the following oxides with water.

phosphorus(V) oxide .....

sulfur(IV) oxide .....

(ii) When NO_2 reacts with water, nitrogen undergoes a disproportionation reaction in which one nitrogen atom decreases its oxidation number by 1 and another nitrogen atom increases its oxidation number by 1. A mixture of two acids results.
Suggest an equation for the reaction between NO_2 and water.

.....

(iii) In a similar disproportionation reaction, ClO_2 reacts with aqueous NaOH to produce a solution containing two chlorine-containing sodium salts.
Suggest an equation for the reaction between ClO_2 and aqueous NaOH.

.....
[4]

(b) The major source of sulfur for the manufacture of sulfuric acid by the Contact process is the de-sulfurisation of 'sour' natural gas. Many natural gas wells produce a mixture of volatile hydrocarbons (mainly CH_4 and C_2H_6) together with up to 25% hydrogen sulfide, H_2S.

(i) Complete and balance the following equation showing the complete combustion of a gaseous mixture consisting of 2 mol of CH_4, 1 mol of C_2H_6 and 1 mol of H_2S.

$$2CH_4 + C_2H_6 + H_2S + \_\_\_\_\_ \rightarrow SO_2 + \_\_\_\_\_ + \_\_\_\_\_$$

(ii) Explain why it is important to remove the H_2S before burning the natural gas industrially.

.....

.....

The H_2S is removed by passing the 'sour' natural gas through a solvent containing ethanolamine. The following reaction takes place.

$$HOCH_2CH_2NH_2 + H_2S(g) \rightarrow HOCH_2CH_2NH_3^+ + SH^-$$

(iii) If a sample of natural gas contains 5% by volume of H_2S, calculate the mass of ethanolamine required to remove all the H_2S from a 1000 dm^3 sample of gas, measured under room conditions.

.....

.....

.....

.....

The H_2S can be recovered by warming the solution to 120 °C, when the above reaction is reversed. The ethanolamine can then be recycled.

For Examiner's Use

(iv) What *type* of reaction is occurring here?

.....

The recovered H_2S is converted to sulfur by the following two reactions.

I Part of the H_2S is burned in air.

$$H_2S + 1.5O_2 \longrightarrow SO_2 + H_2O$$

II The gas stream resulting from reaction **I** is then blended with the remaining H_2S and fed into an iron oxide catalyst bed, where sulfur and water are produced according to the following equation.

$$2H_2S(g) + SO_2(g) \longrightarrow 3S(g) + 2H_2O(g)$$

(v) Use the following data to calculate $\Delta H^{\ominus}$ for the reaction between H_2S and SO_2.

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$H_2S(g)$	–21
$SO_2(g)$	–297
$H_2O(g)$	–242
S(g)	+11

$\Delta H^{\ominus}$ = ... kJ mol^{-1}

[8]

[Total: 12]

2 **(a)** Explain why complexes of transition elements are often coloured.

.....

.....

.....

.....

.....[3]

(b) When water is added to white anhydrous $CuSO_4$, the solid dissolves to give a blue solution. The solution changes to a yellow-green colour when concentrated NH_4Cl(aq) is added to it. Concentrating the solution produces green crystals of an ammonium salt with the empirical formula $CuN_2H_8Cl_4$.
Explain these observations, showing your reasoning.

.....

.....

.....

.....

.....[3]

(c) Copper can be recovered from low-grade ores by 'leaching' the ore with dilute H_2SO_4, which converts the copper compounds in the ore into $CuSO_4$(aq). The concentration of copper in the leach solution can be estimated by adding an excess of aqueous potassium iodide, and titrating the iodine produced with standard $Na_2S_2O_3$(aq).

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$
$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

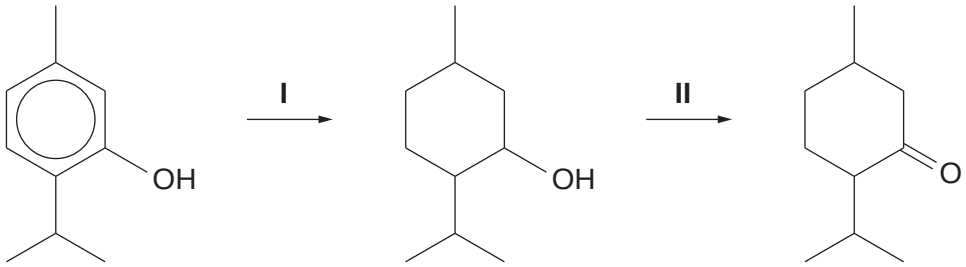
When an excess of KI(aq) was added to a 50.0 cm^3 sample of leach solution, and the resulting mixture titrated, 19.5 cm^3 of 0.0200 mol dm^{-3} $Na_2S_2O_3$(aq) were required to discharge the iodine colour.
Calculate the $[Cu^{2+}(aq)]$, and hence the percentage by mass of copper, in the leach solution.

percentage of copper = ...% [3]

[Total: 9]

3 Menthol and menthone, the main constituents of oil of peppermint, can be made synthetically from thymol by the following route.

For Examiner's Use



thymol menthol menthone

(a) State the *type of reaction* of

- reaction **I**, ...
- reaction **II**. .....

[2]

(b) Suggest **one** test for **each** of the three compounds that would give a positive result with the stated compound but a negative result with **both** the other two compounds.

thymol

test .....

observation .....

menthol

test .....

observation .....

menthone

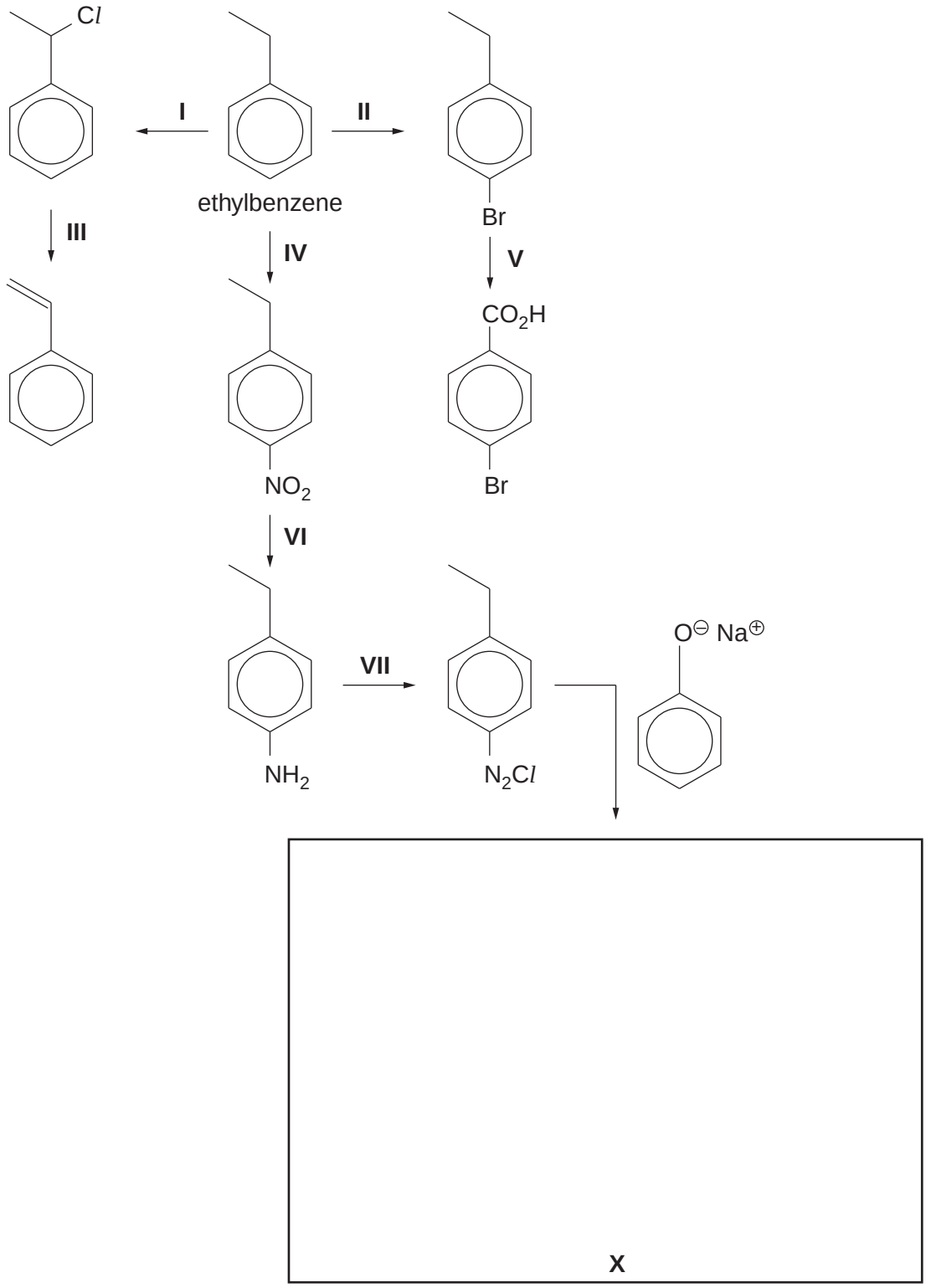
test .....

observation .....[6]

[Total: 8]

4 The following chart shows some reactions of ethylbenzene and compounds produced from it.

For Examiner's Use



(i) Draw the structure of compound **X** in the box provided in the chart above.

(ii) Suggest reagents and conditions for each of the reactions, writing them in the spaces below.

For Examiner's Use

reaction I .....

reaction II .....

reaction III .....

reaction IV .....

reaction V .....

reaction VI .....

reaction VII .....

[Total: 8]

5 Chlorine is manufactured by the electrolysis of brine, NaC*l*(aq). At the cathode, $H_2(g)$ and $OH^-(aq)$ are produced, but the product at the anode depends on the [NaC*l*(aq)] in the solution. Either $O_2(g)$ or $Cl_2(g)$ is produced.

For Examiner's Use

(a) The equation for the cathode reaction is $2H_2O(l) + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$.

Starting from **neutral** NaC*l*(aq), write equations for the production at the anode of

(i) $O_2(g)$, ...

(ii) $Cl_2(g)$. .....
[2]

(b) For electrolysis to occur, the voltage applied to the cell must be at least as large as the $E^{\ominus}_{cell}$, as calculated from standard electrode potentials.
Use the *Data Booklet* to calculate $E^{\ominus}_{cell}$ for the production at the anode of

(i) $O_2(g)$, ...

(ii) $Cl_2(g)$. .....
[2]

(c) **(i)** By using **one** of the phrases *more positive*, *less positive* or *no change*, use the equations you wrote in **(a)** to deduce the effect of increasing [$Cl^-(aq)$] on

- the E_{anode} for the production of $O_2(g)$, ...
- the E_{anode} for the production of $Cl_2(g)$. .....

(ii) Hence explain why the $Cl_2(g) : O_2(g)$ ratio increases as [NaC*l*(aq)] increases.

.....

.....[3]

(d) Sodium chlorate(V) is prepared commercially by electrolysing NaC*l*(aq) in a cell which allows the cathode and anode electrolytes to mix.
The cathode reaction is the same as that described in **(a)**.
The equation for the anode reaction is

$$Cl^-(aq) + 6OH^-(aq) - 6e^- \longrightarrow ClO_3^-(aq) + 3H_2O(l)$$

(i) Construct an ionic equation for the overall reaction.

.....

(ii) Calculate the mass of $NaClO_3$ that is produced when a current of 250 A is passed through the cell for 60 minutes.

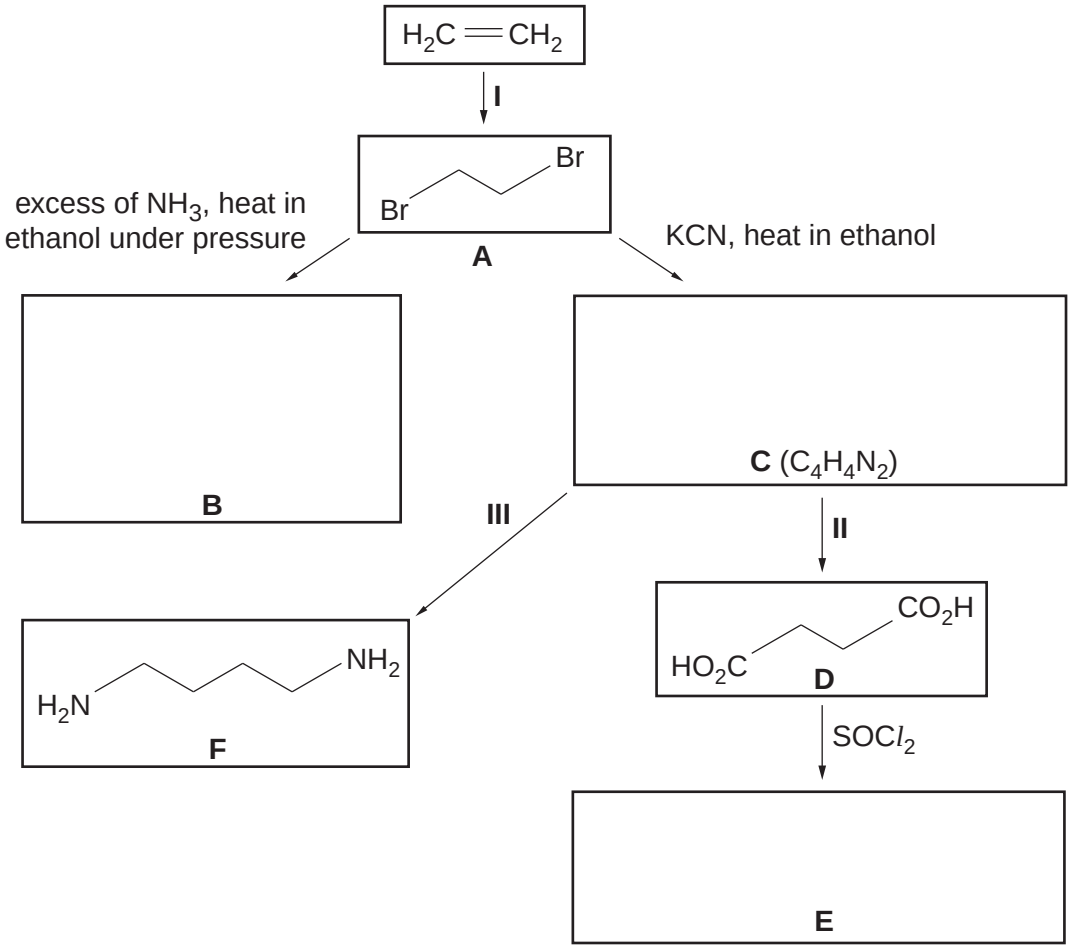
For Examiner's Use

mass of $NaClO_3$ = ... g [4]

[Total: 11]

6 The following scheme outlines the production of some compounds from ethene.

For Examiner's Use



(a) (i) Suggest the reagent and conditions for reaction **I**.

.....

(ii) Describe the mechanism of reaction **I** by means of a diagram. Include all whole, partial and induced charges, and represent the movements of electron pairs by curly arrows.

[3]

(b) Suggest the identities of compounds **B**, **C** and **E**, and draw their structures in the boxes opposite. [3]

For Examiner's Use

(c) Suggest reagents and conditions for

reaction **II**,

.....

reaction **III**.

.....[2]

(d) During reaction **II** the nitrogen atoms are lost from the organic molecule. Suggest the identity of the nitrogen-containing ion produced during this reaction.

.....[1]

(e) Compounds **E** and **F** react together to give a polymer and an inorganic product.

(i) Draw **one** repeat unit of this polymer.

(ii) Identify the inorganic product.

.....[2]

(f) A 0.100 mol dm^{-3} solution of compound **D** has a pH of 2.60.

(i) Calculate the $[H^+]$ in this solution.

.....

.....

(ii) Hence calculate the value of K_a of compound **D**.

.....

.....
[2]

[Total: 13]

[Turn over

For Examiner's Use

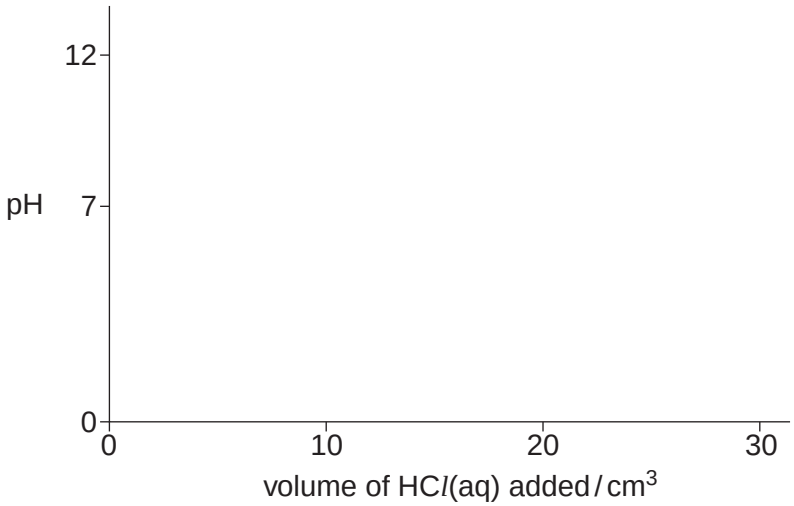
7 When an aqueous solution of compound **G**, $NH_2CH_2CH_2CH_2NH_2$, is titrated with HC*l*(aq), two successive acid-base reactions take place.

(a) Write equations for these two acid-base reactions.

.....

..... [2]

(b) A 0.10 mol dm^{-3} solution of **G** has a pH of 11.3. When 30 cm^3 of 0.10 mol dm^{-3} HC*l* is added to 10 cm^3 of a 0.10 mol dm^{-3} solution of **G**, the final pH is 1.6.
Using the following axes, sketch the pH changes that occur during this addition of HC*l*(aq).



[2]

[Total: 4]

For Examiner's Use

8 **(a)** **(i)** By means of a clear, labelled diagram, describe the shape of the tin(IV) chloride molecule.

(ii) Explain the shape of the tin(IV) chloride molecule in terms of its bonding.

.....

.....

[2]

(b) **(i)** What would you expect to observe when tin(IV) chloride reacts with water? Suggest an explanation for your answer.

.....

.....

.....

(ii) Write an equation for the reaction between tin(IV) chloride and water.

.....

[3]

[Total: 5]

Section B

For Examiner's Use

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

9 DNA is an extremely important chemical in human cells. It has been described as the 'blueprint of life'.

(a) What **three** types of compound are linked together in DNA?

.....[1]

(b) DNA consists of two strands linked together. Draw a **block diagram** to illustrate this and showing **two** repeat units in the backbones, labelling the components and showing and labelling the bonds between the strands.

[4]

(c) DNA is used to encode for the production of a particular protein. Put the following biochemical structures in the correct sequence from the use of DNA as a template to the formation of the protein by writing their names in the relevant box below.

tRNA

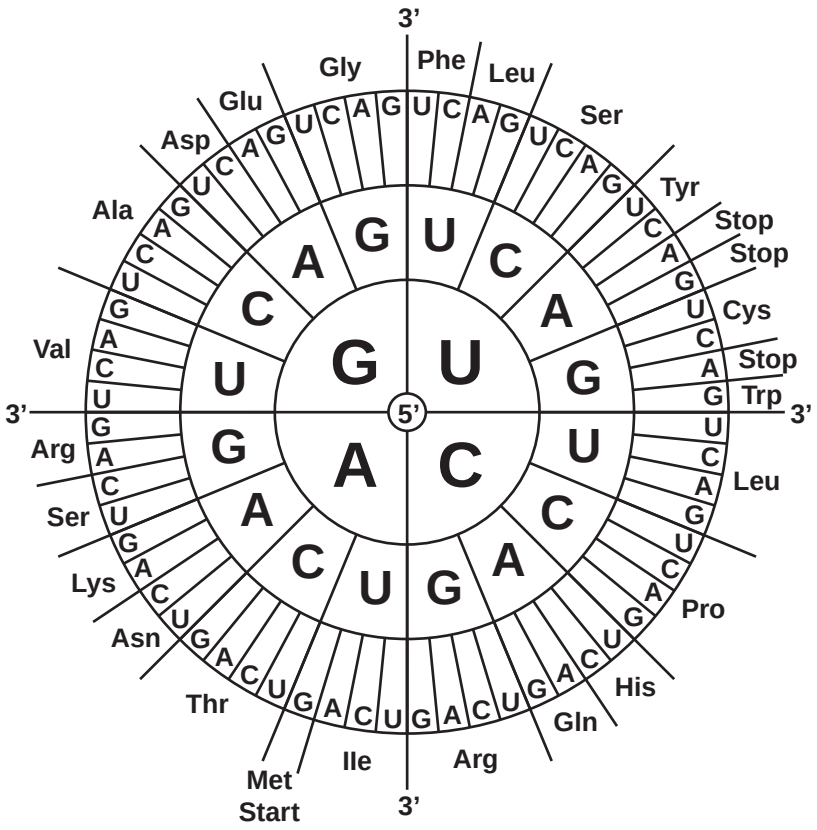
mRNA

ribosomes

DNA ➡ [ ] ➡ [ ] ➡ [ ] ➡ protein [2]

(d) In order to produce proteins, the information stored in the DNA molecules has to be translated to produce an mRNA strand. A sequence of three bases, called a triplet, on the mRNA describes a particular amino acid. These amino acids are then combined together to form proteins. The amino acid specified by each triplet is shown below.

For Examiner's Use



The sequence of three bases in a triplet is read from the middle outwards e.g. UGG specifies Trp.

(i) There are four different bases present in mRNA. How many different triplets are possible using these four bases.

.....

(ii) What peptide fragment would the following sequence code for when read from left to right? (Use 3-letter abbreviations for amino acids.)

5' – A U G A G C C G A C U U G A C G U G – 3'

……..

(iii) What would be the effect of changing the 11th base from U to C?

.....

[4]

[Total: 11]

10 Instrumental methods of analysis have become increasingly important in recent years. The use of chromatography to separate substances, and NMR spectroscopy to identify them, has become routine in many laboratories.

For Examiner's Use

(a) Chromatography relies on either partition or adsorption to help separate substances.

(i) Briefly explain how each method brings about separation.

partition .....

.....

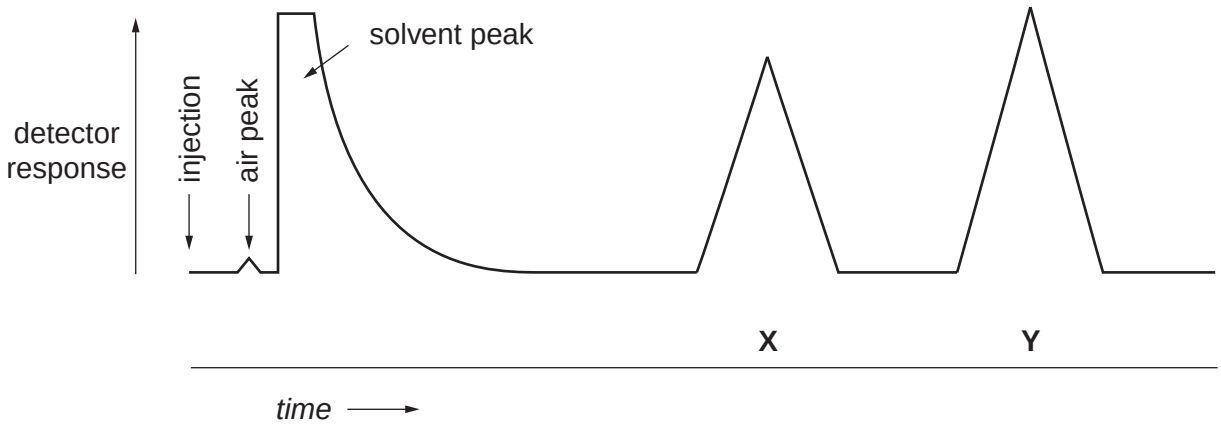
adsorption .....

.....

(ii) The table shows three different techniques of chromatography. Identify which separation method, *partition or adsorption*, applies to each.

technique	separation method
paper chromatography	
thin-layer chromatography	
gas/liquid chromatography	

(iii) The diagram represents the output from gas/liquid chromatography carried out on a mixture.



Determine the percentage of each of the two components **X** and **Y** in the mixture.

[5]

(b) NMR spectroscopy is a very important analytical technique for use with organic compounds.

For Examiner's Use

(i) Why is NMR spectroscopy particularly useful for organic compounds?

.....

.....

(ii) Two molecules, propanal and propanone, have the same molecular formula, C_3H_6O. Draw the displayed formula of each compound and explain briefly how NMR spectroscopy can distinguish between the two structures.

.....

.....

.....

.....

[4]

[Total: 9]

11 One of the greatest challenges facing scientists today is the development of effective drugs to treat different forms of cancer.

For Examiner's Use

(a) Drugs can be introduced into the body by injection or by mouth. Taking drugs by injection avoids the drug being broken down in the digestive system.
State **two** other advantages of giving drugs by injection.

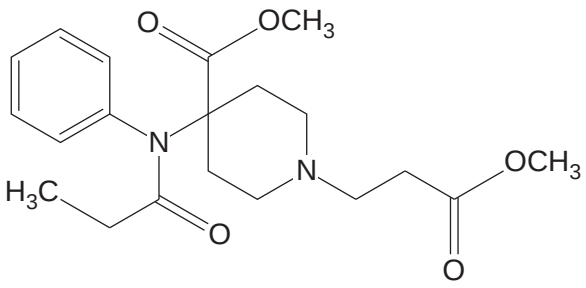
.....

.....

.....

..... [2]

(b) The drug *Ultiva* has been developed to treat ovarian cancer, and is usually given by injection.



Ultiva

Study the structure of *Ultiva* and draw a **circle** around **two different** functional groups that could be broken down in the digestive system. [2]

(c) One way of avoiding the breakdown of drugs in the body is to use a specially designed nanoparticle which encloses the drug. If the nanoparticles are made of a particular sort of polymer, they absorb water at the slightly acidic pH inside some cells, increasing their diameter from around 100 nm to around 1000 nm. This spreads out the polymer chains allowing release of the drug.

(i) Other than absorbing water, suggest a property this polymer would need to possess for its use in drug delivery.

.....

.....

(ii) Why would this method of release **not** work if the nanoparticles were taken by mouth?

.....
[2]

(d) Polymers may be formed by two different types of chemical reaction.
Name the two types of reaction and write an equation to illustrate each reaction type.

For Examiner's Use

name .....

equation .....

name .....

equation .....
[3]

(e) The breakdown of polymers, such as carbohydrates and proteins in the body is important for digestion. What type of reaction is generally involved?

.....[1]

[Total: 10]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

9860454644

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2010**

1 hour 15 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.

Answer **all** questions.
You are advised to show all working in calculations.
Use of Data Booklet is unnecessary.

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	
1	
2	
Total	

This document consists of **9** printed pages and **3** blank pages.

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1 When aqueous sodium chloride, NaC*l*, is added to aqueous lead nitrate, $Pb(NO_3)_2$, a white precipitate of lead chloride, $PbCl_2$, is produced. A suggested stoichiometric equation is

For Examiner's Use

$$Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$$

In separate experiments, different volumes of 0.20 mol dm^{-3} aqueous sodium chloride are added to a fixed volume of 0.10 mol dm^{-3} aqueous lead nitrate. In each case, the precipitate is filtered, washed with distilled water and thoroughly dried. The mass of the precipitate is recorded.

You are to plan an experiment to investigate this reaction in order to confirm or reject the stoichiometry of the equation.

(a) By considering the suggested stoichiometric equation, predict and explain how the number of moles of the precipitate, $PbCl_2$, will change as the number of moles of NaC*l* added increases.

Prediction .....

.....

.....

Explanation .....

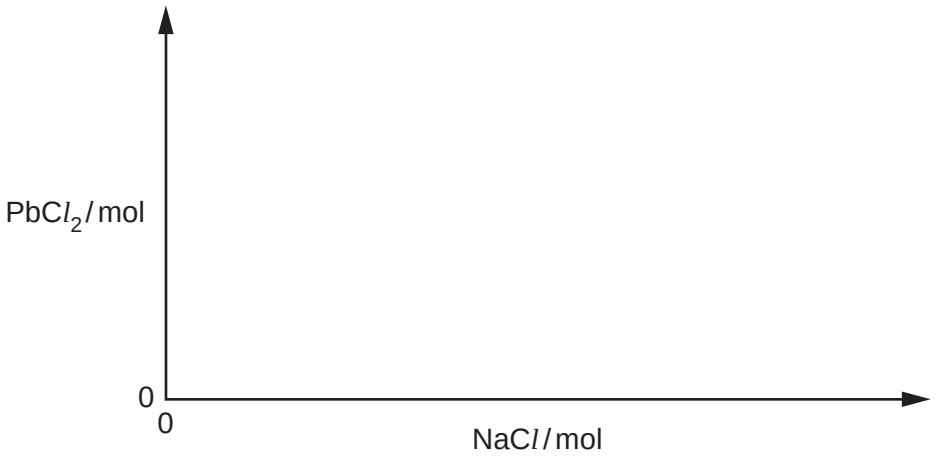
.....

..... [2]

(b) State a limiting factor that must be taken into account when increasing the volume of the aqueous sodium chloride added.

.....

Sketch the graph which would result if, after some of the experiments, the NaC*l* is in excess. Start your graph with no NaC*l* added.



[3]

For Examiner's Use

(c) In the experiment you are about to plan, identify the following.

(i) the independent variable .....

(ii) the dependent variable .....

(iii) another variable to be controlled .....

[2]

(d) Design a laboratory experiment to test your prediction in **(a)**.

You are provided with 250 cm^3 of 0.20 mol dm^{-3} aqueous sodium chloride.

(i) Outline how you would prepare 250 cm^3 of 0.10 mol dm^{-3} aqueous lead nitrate.

[A_r: N, 14; O, 16; Pb, 207]

(ii) Give a step by step description of how you would carry out **one** experiment.
You should state
- the volumes of each solution to be used,
- how the volumes will be measured,
- how you would dry the precipitate.

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For Examiner's Use

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.....[6]

(e) In the table below

- enter appropriate headings to show additional data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in **(a)**. The headings should include the appropriate units,
- enter the volumes from your plan in **(d)**,
- enter suitable volumes for four further experiments.

[2]

(f) How would you ensure that at the end of each experiment the precipitate was thoroughly dried?

.....

..... [1]

[Total: 16]

[Turn over

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2 The melting point of solid water is 0 °C. This is the same as the freezing point of water. This freezing point can be lowered (depressed) by the addition of a solute, such as glucose. The extent of the freezing point depression depends on the **number of particles of solute dissolved** in the solution.

For Examiner's Use

The freezing point depression, ΔT_f, is proportional to the molal concentration, c_m, of the solution.

$$\Delta T_f = K_f c_m$$

where K_f is the freezing point depression constant.

The molal concentration (molality) of a solution is defined as the number of moles of a solute dissolved in one kilogram of water e.g. a one molal solution has one mole of solute dissolved in one kilogram of water.

An experiment was carried out to investigate the relationship between ΔT_f and c_m.

- A weighed sample of distilled water was placed in a boiling tube.
- A weighed sample of glucose was added.
- The mixture was stirred until a solution was obtained.
- The tube was placed in a freezing apparatus to lower the temperature.
- The freezing point of the solution was measured precisely and the freezing point depression calculated.

[Turn over

(a) Calculate the M_r of glucose $C_6H_{12}O_6$.

[A_r: H, 1.0; C, 12.0; O, 16.0] [1]

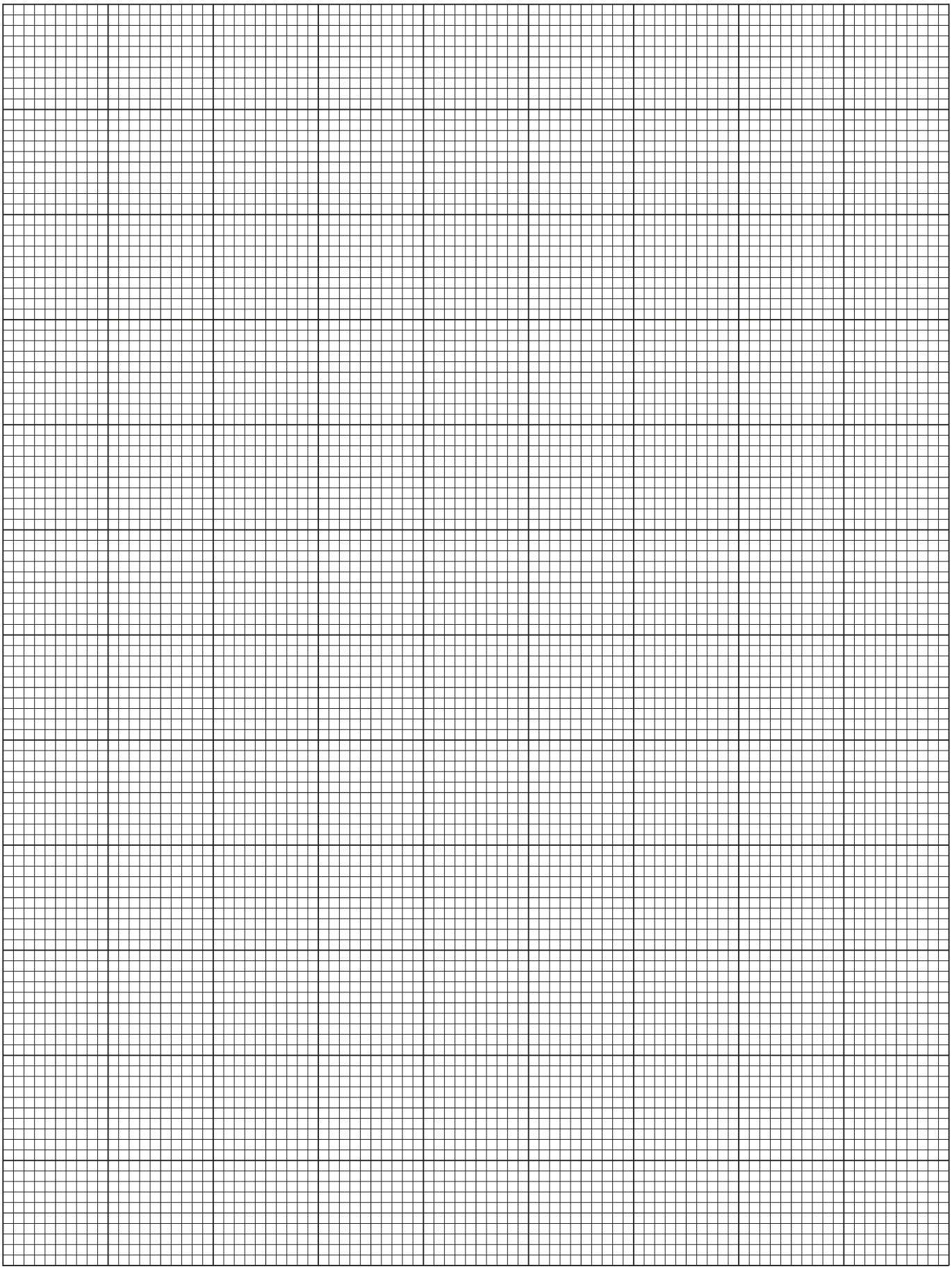
For Examiner's Use

(b) The results of the experiment are recorded below.

A	B	C	D	E	F
mass of water / g	mass of glucose / g	freezing point depression ΔT_f / °C			
100	10.0	1.03			
100	12.2	1.26			
100	18.0	2.09			
100	23.3	2.40			
100	27.7	2.86			
100	30.9	3.22			
100	33.1	3.31			
100	38.6	3.98			
100	42.3	4.37			

Process the results in the table to calculate the molality of the glucose solution. This will enable you to plot a graph to show how the freezing point depression, ΔT_f, varies with the molality of the solution.
Record these values to **three significant figures** in the additional columns of the table. You may use some or all of the columns.
Label the columns you use.
For each column you use include units where appropriate and an expression to show how your values are calculated. You may use the column headings A to F for this purpose. [2]

(c) Present the data calculated in **(b)** in graphical form. Draw the line of best fit.



[3]

(d) Circle on the graph any point(s) you consider to be anomalous.
For any point circled on the graph suggest an error in the conduct of the experiment that might have led to this anomalous result.

For Examiner's Use

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.....

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.....

.....

..... [3]

(e) **(i)** Determine the value of $\Delta T_f / c_m$ from your graph. This is the freezing point depression constant K_f. Mark clearly on the graph any construction lines and show clearly in your calculation how the intercepts were used in the calculation of the slope.

(ii) By considering the data you have processed and the graph you have drawn, decide if the experimental procedure described is suitable for the determination of the freezing point depression constant K_f. Explain your reasoning.

[3]

(f) When the experiment was repeated using sodium chloride instead of glucose as the solute, the freezing point depressions were found to be twice the value obtained in the glucose experiment for each molality.
Using the information given at the start of the question suggest a reason for this.

.....

.....

..... [1]

(g) Using your suggestion from **(f)** predict the effect on the freezing point depression if a weak acid such as ethanoic acid was used instead of glucose or sodium chloride as the solute.

.....

..... [1]

[Total: 14]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0061419187

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2010**

1 hour 15 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.

Answer **all** questions.
You are advised to show all working in calculations.
Use of Data Booklet is unnecessary.

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	
1	
2	
Total	

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UNIVERSITY of CAMBRIDGE International Examinations

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For Examiner's Use

$$Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$$

In separate experiments, different volumes of 0.20 mol dm^{-3} aqueous sodium chloride are added to a fixed volume of 0.10 mol dm^{-3} aqueous lead nitrate. In each case, the precipitate is filtered, washed with distilled water and thoroughly dried. The mass of the precipitate is recorded.

You are to plan an experiment to investigate this reaction in order to confirm or reject the stoichiometry of the equation.

(a) By considering the suggested stoichiometric equation, predict and explain how the number of moles of the precipitate, $PbCl_2$, will change as the number of moles of NaC*l* added increases.

Prediction .....

.....

.....

Explanation .....

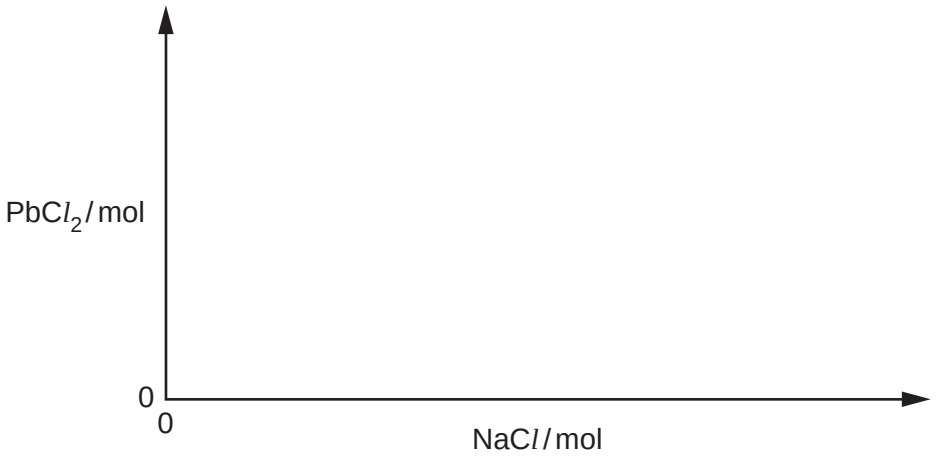
.....

..... [2]

(b) State a limiting factor that must be taken into account when increasing the volume of the aqueous sodium chloride added.

.....

Sketch the graph which would result if, after some of the experiments, the NaC*l* is in excess. Start your graph with no NaC*l* added.



[3]

(c) In the experiment you are about to plan, identify the following.

For Examiner's Use

(i) the independent variable .....

(ii) the dependent variable .....

(iii) another variable to be controlled .....

[2]

(d) Design a laboratory experiment to test your prediction in **(a)**.

You are provided with 250 cm^3 of 0.20 mol dm^{-3} aqueous sodium chloride.

(i) Outline how you would prepare 250 cm^3 of 0.10 mol dm^{-3} aqueous lead nitrate.

[A_r: N, 14; O, 16; Pb, 207]

(ii) Give a step by step description of how you would carry out **one** experiment.
You should state
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- how you would dry the precipitate.

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For Examiner's Use

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.....[6]

(e) In the table below

- enter appropriate headings to show additional data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in **(a)**. The headings should include the appropriate units,
- enter the volumes from your plan in **(d)**,
- enter suitable volumes for four further experiments.

[2]

(f) How would you ensure that at the end of each experiment the precipitate was thoroughly dried?

.....

..... [1]

[Total: 16]

[Turn over

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2 The melting point of solid water is 0 °C. This is the same as the freezing point of water. This freezing point can be lowered (depressed) by the addition of a solute, such as glucose. The extent of the freezing point depression depends on the **number of particles of solute dissolved** in the solution.

For Examiner's Use

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where K_f is the freezing point depression constant.

The molal concentration (molality) of a solution is defined as the number of moles of a solute dissolved in one kilogram of water e.g. a one molal solution has one mole of solute dissolved in one kilogram of water.

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- A weighed sample of glucose was added.
- The mixture was stirred until a solution was obtained.
- The tube was placed in a freezing apparatus to lower the temperature.
- The freezing point of the solution was measured precisely and the freezing point depression calculated.

[Turn over

(a) Calculate the M_r of glucose $C_6H_{12}O_6$.

[A_r: H, 1.0; C, 12.0; O, 16.0] [1]

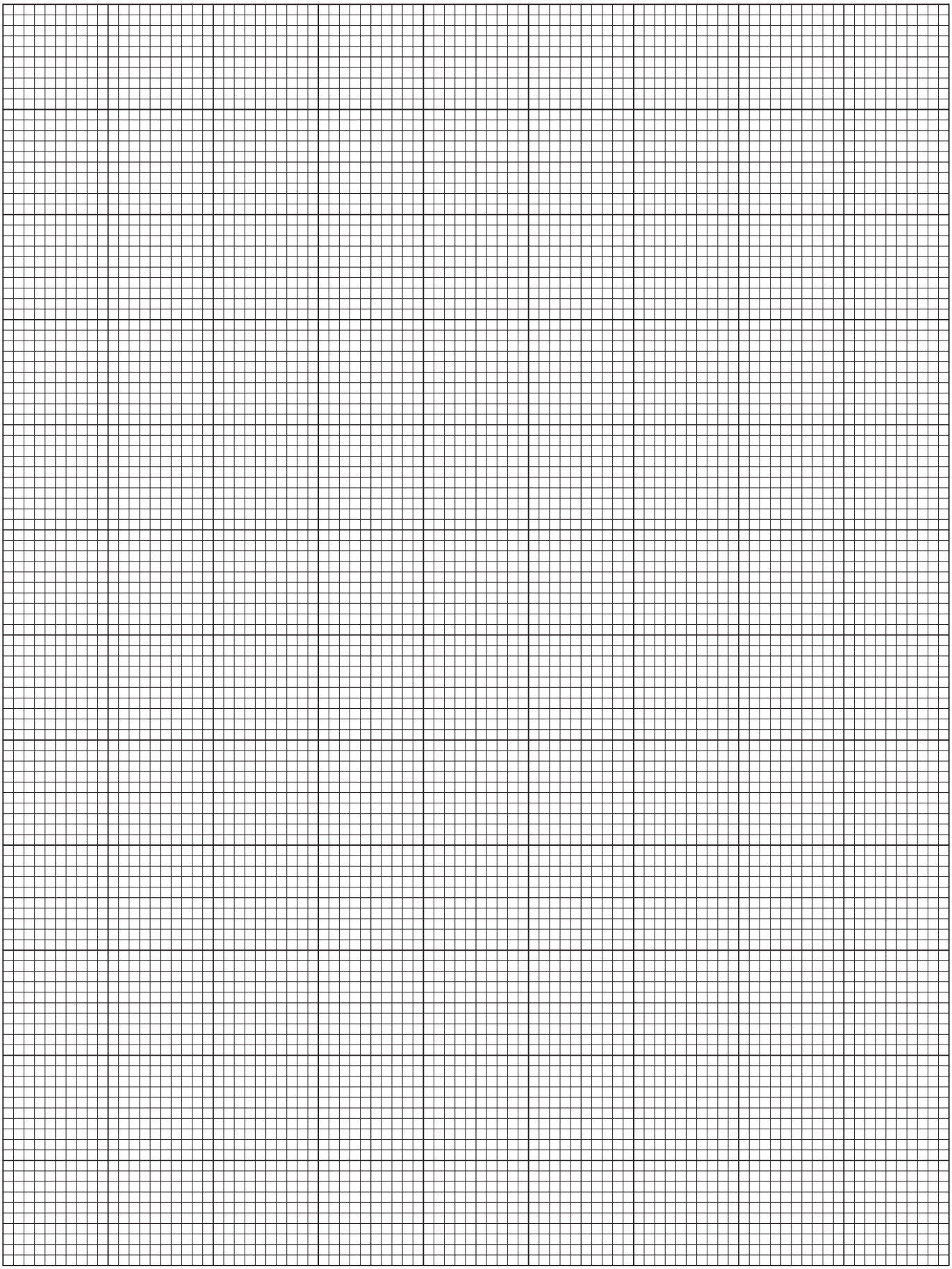
For Examiner's Use

(b) The results of the experiment are recorded below.

A	B	C	D	E	F
mass of water / g	mass of glucose / g	freezing point depression ΔT_f / °C			
100	10.0	1.03			
100	12.2	1.26			
100	18.0	2.09			
100	23.3	2.40			
100	27.7	2.86			
100	30.9	3.22			
100	33.1	3.31			
100	38.6	3.98			
100	42.3	4.37			

Process the results in the table to calculate the molality of the glucose solution. This will enable you to plot a graph to show how the freezing point depression, ΔT_f, varies with the molality of the solution.
Record these values to **three significant figures** in the additional columns of the table. You may use some or all of the columns.
Label the columns you use.
For each column you use include units where appropriate and an expression to show how your values are calculated. You may use the column headings A to F for this purpose. [2]

(c) Present the data calculated in **(b)** in graphical form. Draw the line of best fit.



[3]

(d) Circle on the graph any point(s) you consider to be anomalous.
For any point circled on the graph suggest an error in the conduct of the experiment that might have led to this anomalous result.

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(e) **(i)** Determine the value of $\Delta T_f / c_m$ from your graph. This is the freezing point depression constant K_f. Mark clearly on the graph any construction lines and show clearly in your calculation how the intercepts were used in the calculation of the slope.

(ii) By considering the data you have processed and the graph you have drawn, decide if the experimental procedure described is suitable for the determination of the freezing point depression constant K_f. Explain your reasoning.

[3]

(f) When the experiment was repeated using sodium chloride instead of glucose as the solute, the freezing point depressions were found to be twice the value obtained in the glucose experiment for each molality.
Using the information given at the start of the question suggest a reason for this.

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(g) Using your suggestion from **(f)** predict the effect on the freezing point depression if a weak acid such as ethanoic acid was used instead of glucose or sodium chloride as the solute.

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[Total: 14]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

5505312165

CHEMISTRY **9701/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2010**

1 hour 15 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.

Answer **all** questions.
You are advised to show all working in calculations.
Use of a Data Booklet is unnecessary.

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.

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1	
2	
Total	

This document consists of **9** printed pages and **3** blank pages.

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1 Aqueous hydrogen peroxide decomposes into oxygen gas and water. The reaction is normally very slow but is catalysed by solid manganese(IV) oxide.

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

You are to plan an experiment to investigate how the rate of the catalysed decomposition of aqueous hydrogen peroxide depends on its concentration.

(a) The rate of decomposition depends on the number of hydrogen peroxide molecules present in a given volume of solution.

(i) Use this information to predict and explain how the rate of decomposition of the hydrogen peroxide depends on the concentration.

Prediction .....

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Explanation .....

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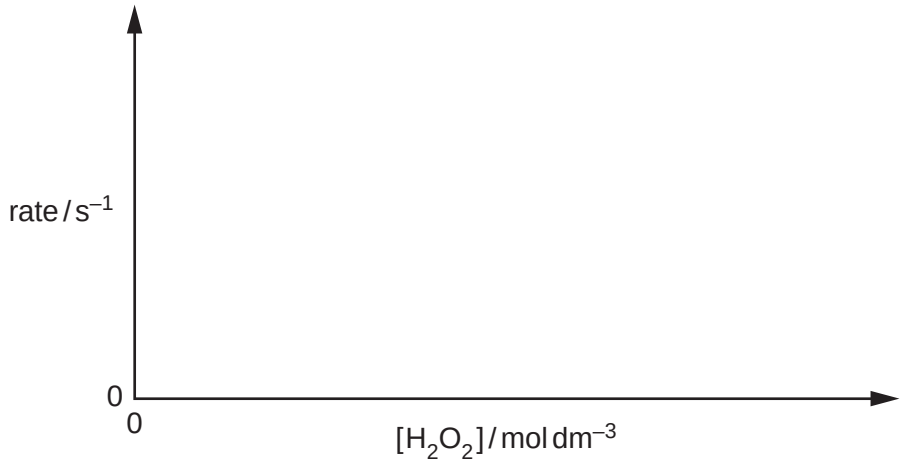
(ii) Display your prediction in the form of a sketch graph below.



[3]

[Turn over

(b) An approximate method for the determination of the rate of decomposition of the hydrogen peroxide is to measure the time taken to collect a fixed volume of oxygen. The volume is kept the same throughout a series of experiments. The rate of the reaction can be represented by the reciprocal of the time taken.

$$\text{Rate of reaction} \propto 1/\text{time taken}$$

In the experiment you are about to plan identify the following.

(i) the independent variable .....

(ii) the dependent variable ..... [2]

(c) Draw a diagram of the apparatus you would use in the experiment. Your apparatus should use only standard items found in a school or college laboratory and show clearly the following

(i) how the volume of the oxygen will be collected and measured,

(ii) how you will make sure that none of the oxygen is lost.

Label each piece of apparatus used, indicating its size or capacity.

[3]

(d) Using the apparatus shown in **(c)** design a laboratory experiment to test your prediction in **(a)**.

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In addition to the standard apparatus present in a laboratory you are provided with the following materials.

- 2.00 mol dm^{-3} aqueous hydrogen peroxide
- a supply of manganese(IV) oxide

(i) Complete the table below to show how you would prepare five solutions of aqueous hydrogen peroxide. Make sure that the correct units are recorded.

expt. No.	volume of H_2O_2	volume of H_2O	concentration of H_2O_2
1			
2			
3			
4			
5			

(ii) Give a step-by-step description of how you would use your apparatus shown in **(c)** to carry out **one** complete experiment.

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[Turn over

(e) State a problem which might be experienced by someone having to carry out these experiments alone.

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..... [1]

(f) Draw a table with appropriate headings to show the data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in **(a)**. The headings should include appropriate units.

[2]

[Total: 15]

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2 When a solute is added to two solvents, A and B, which do not mix, some of the solute dissolves in each of the solvents and an equilibrium is set up between the two solvents. At equilibrium the ratio of the two concentrations is a constant known as the **Partition Coefficient**, *K*.

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$$\frac{\text{concentration in solvent A}}{\text{concentration in solvent B}} = K$$

An experiment was carried out to determine *K* for succinic acid, $HO_2CCH_2CH_2CO_2H$, between water (boiling point 100 °C) and diethyl ether, $(C_2H_5)_2O$, (boiling point 35 °C).

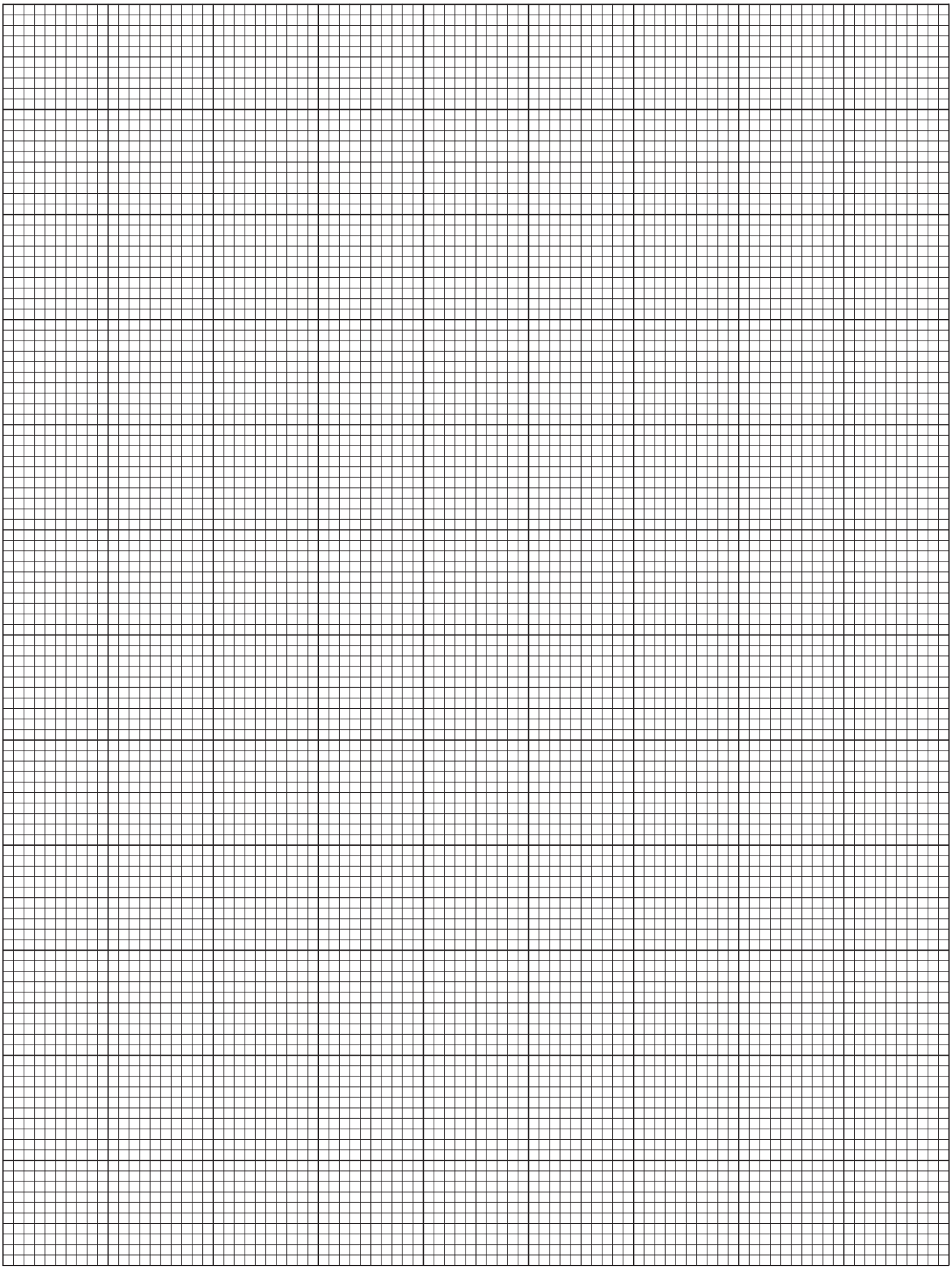
- 100 cm^3 of distilled water and 100 cm^3 of diethyl ether were transferred to a conical flask.
- A sample of succinic acid was added, the flask was stoppered and the mixture thoroughly shaken until all of the solid had dissolved.
- A 10.0 cm^3 sample of the water layer was removed and titrated with 0.10 mol dm^{-3} aqueous sodium hydroxide using phenolphthalein as an indicator.
- A 25.0 cm^3 sample of the diethyl ether layer was removed and a small amount of water added. This was then titrated with 0.020 mol dm^{-3} aqueous sodium hydroxide using phenolphthalein as an indicator.
- The experiment was repeated using the same volumes of water and diethyl ether but decreasing masses of succinic acid.

(a) The results of the series of titrations are recorded below.

A	B	C	D	E
expt. No.	volume of 0.10 mol dm^{-3} NaOH reacting with 10.0 cm^3 of the water layer / cm^3	volume of 0.020 mol dm^{-3} NaOH reacting with 25.0 cm^3 of the ether layer / cm^3		
1	24.3	18.6		
2	22.5	17.3		
3	20.3	15.6		
4	18.8	13.1		
5	16.3	12.5		
6	13.8	10.6		
7	10.3	7.9		
8	6.8	6.9		
9	5.0	3.8		
10	2.5	1.9		

Process the results in the table to calculate the concentration of the succinic acid in each layer.
Record these values to **three significant figures** in the additional columns of the table.
Label each column, including units and an expression to show how your values are calculated.
You may use the column headings A to E in your expression. [3]

(b) Present the concentration of the succinic acid in each layer in graphical form. Draw the line of best fit.



[3]

(c) Circle on the graph any point(s) you consider to be anomalous.
For any point circled on the graph suggest an error in the conduct of the experiment that might have led to this anomalous result.

For Examiner's Use

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(d) **(i)** Determine the value of *K* from your graph. Mark clearly on the graph any construction lines and show clearly in your calculation how the intercepts were used in the calculation of the slope.

(ii) By considering the data you have processed and the graph you have drawn, decide if the experimental procedure described is suitable for the determination of the Partition Coefficient, *K*. Explain your reasoning.

[3]

(e) In the experimental procedure a small volume of water was added to the diethyl ether prior to the titration with aqueous sodium hydroxide. The flask was constantly shaken during the titrations. What was the purpose of this technique?

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(f) Using a burette, the error associated with a titration depends on the value of the titre. Comment on the magnitude of the titres recorded in the table in **(a)** and indicate, with reasons, which have the highest error.

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[Total: 15]

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