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

CHEMISTRY **9701/11**

Paper 1 Multiple Choice **May/June 2011**

1 hour

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

5818048303

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 Which equation represents the second ionisation energy of an element X?

A $X(g) \rightarrow X^{2+}(g) + 2e$

B $X^{+}(g) \rightarrow X^{2+}(g) + e$

C $X(g) + 2e \rightarrow X^{2}(g)$

D $X(g) + e \rightarrow X^{2}(g)$

2 In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?

$$NO_3^-(aq) \xrightarrow{A} NO_2^-(aq) \xrightarrow{B} NO(g) \xrightarrow{C} N_2O(g) \xrightarrow{D} N_2(g)$$

3 In the extraction of aluminium by the electrolysis of molten aluminium oxide, why is cryolite added to the aluminium oxide?

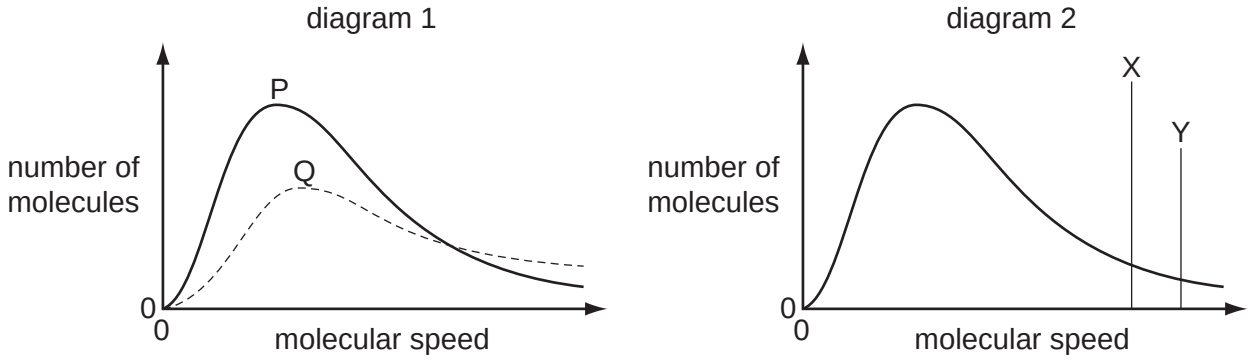
A to ensure the aluminium is not oxidised

B to ensure the anode is not oxidised

C to lower the melting point of the aluminium oxide

D to prevent corrosion of the cathode

4 Different Boltzmann distributions are shown in the diagrams.



In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.

In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.

Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

5 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?

A The nuclear charge of the elements increases.

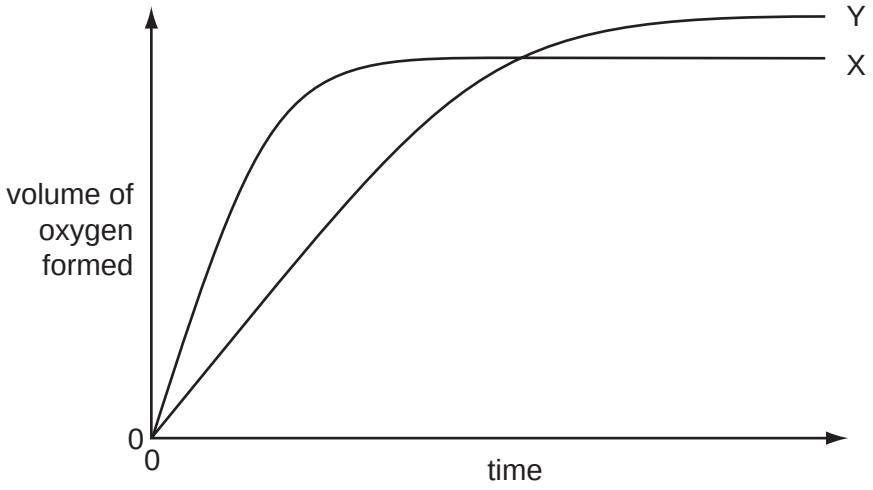
B The outer electron is in an ‘s’ subshell.

C The repulsion between spin-paired electrons increases.

D The shielding effect of the inner shells increases.

[Turn over

6 In the diagram, curve X was obtained by observing the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve Y?

A adding some 0.1 mol dm^{-3} hydrogen peroxide

B adding water

C lowering the temperature

D using less manganese(IV) oxide

7 In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at pressures below 100 atm.

What is the reason for this change?

A An iron catalyst is used.

B Maintaining the higher pressures is more expensive.

C The equilibrium yield of ammonia is increased at lower pressures.

D The rate of the reaction is increased at lower pressures.

8 The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.

$$2X(g) + 6H(g) \rightarrow X_2H_6(g) \qquad \Delta H = -2775\ kJ\ mol^{-1}$$

The bond energy of an X–H bond is 395 kJ mol^{-1}.

What is the bond energy of an X–X bond?

A –405.0 kJ mol^{-1}

B –202.5 kJ mol^{-1}

C +202.5 kJ mol^{-1}

D +405.0 kJ mol^{-1}

9 50 cm^3 of 2.50 mol dm^{-3} hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then 50 cm^3 of 2.50 mol dm^{-3} NaOH at the same temperature was quickly added, with stirring. The temperature rose by 17 °C.

The resulting solution may be considered to have a specific heat capacity of 4.2 J g^{-1} K^{-1}.

What is an approximate value for the molar enthalpy change of neutralisation of hydrochloric acid and sodium hydroxide from this experiment?

A $\frac{(50 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

B $\frac{(50 \times 4.2 \times 17)}{(0.10 \times 2.5)}$ J mol^{-1}

C $\frac{(100 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

D $\frac{(100 \times 4.2 \times 17)}{(50 \times 2.5)}$ J mol^{-1}

10 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp / °C	801	2852	3550
bp / °C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T?

	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO_2
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO_2

11 In which change would only van der Waals' forces have to be overcome?

A evaporation of ethanol $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$

B melting of ice $H_2O(s) \rightarrow H_2O(l)$

C melting of solid carbon dioxide $CO_2(s) \rightarrow CO_2(l)$

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

[Turn over

12 Hydrazine, N_2H_4, is widely used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta H = -534\,kJ\,mol^{-1}$$

Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.

Which statement explains why hydrazine does **not** burn spontaneously?

A Hydrazine is a liquid.

B The activation energy is too high.

C The N≡N bond is very strong.

D The reaction is exothermic.

13 0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.

What minimum volume of acid will be required for complete reaction?

A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 60 cm^3

14 Steam is passed over heated magnesium to give compound X and hydrogen.

What is **not** a property of compound X?

A It has an M_r of 40.3.

B It is basic.

C It is a white solid.

D It is very soluble in water.

15 X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2, Y_2 and Z_2 were separately added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row in the following table contains the ions X^-, Y^- and Z^- in order of their decreasing strength as reducing agents?

	strongest ⟶		weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

16 A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

17 Ammonium nitrate, NH_4NO_3, is manufactured in large quantities for use in fertiliser.

Which statement about ammonium nitrate fertiliser is **not** correct?

A It can cause environmental problems.

B It consists of 35 % nitrogen by mass.

C It is insoluble in water.

D Nitric acid is used in its manufacture.

[Turn over

18 Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

A $NO(g) + CO(g) \rightarrow NO_2(g) + C(s)$

B $NO(g) + CO_2(g) \rightarrow NO_2(g) + CO(g)$

C $2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$

D $2NO(g) + CO_2(g) \rightarrow 2NO_2(g) + C(s)$

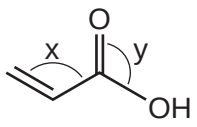
19 In the reaction pathway below, an alkane is converted into a carboxylic acid through several stages.

$$C_{10}H_{22} \xrightarrow{\text{stage 1}} C_2H_4 \xrightarrow[\text{catalytic hydration}]{\text{stage 2}} C_2H_5OH \xrightarrow{\text{stage 3}} CH_3CO_2H$$

Which processes occur at stage 1 and at stage 3?

	stage 1	stage 3
A	condensation	combustion
B	cracking	dehydration
C	cracking	oxidation
D	dehydration	combustion

20 Acrylic acid is produced from propene, a gaseous product of oil refineries.



acrylic acid

Which statement about acrylic acid is **not** correct?

A Both bond angles x and y are approximately 120°.

B It decolourises aqueous bromine.

C It gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

D It reacts with an alcohol to give an ester.

21 Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.

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

Which reagents could be used for this synthesis?

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

22 The formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons must be present for CH_3 to act in these different ways?

	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

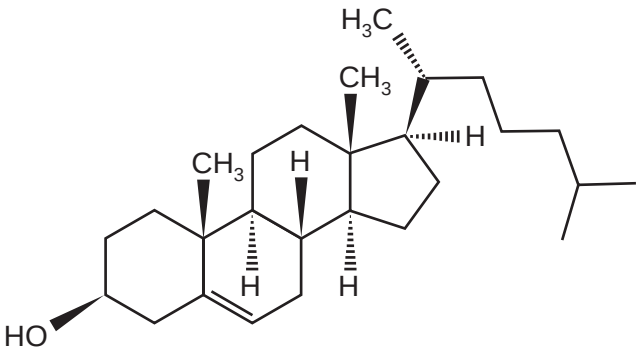
23 Pentanol, $C_5H_{11}OH$, has four structural isomers that are primary alcohols.

How many of these primary alcohols contain a chiral carbon atom?

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

[Turn over

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



cholesterol

Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y claimed that this molecule displays *cis-trans* isomerism at the C=C double bond.

Which of the students are correct?

A both X and Y

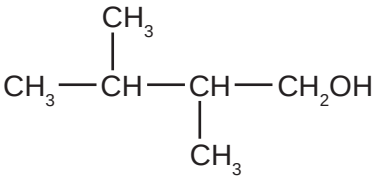
B neither X nor Y

C X only

D Y only

25 Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

A



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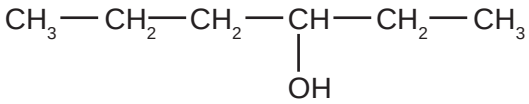

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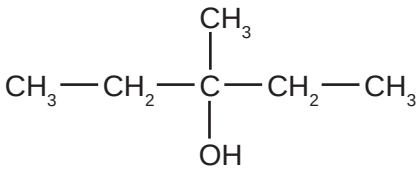

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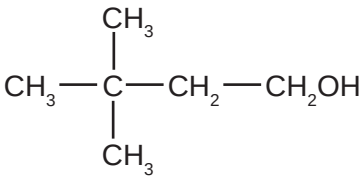


26 Compound X changes the colour of warm acidified sodium dichromate(VI) from orange to green. 1 mol of X reacts with 2 mol of HCN in the presence of KCN.

What could X be?

A $CH_3CH_2CH_2CHO$

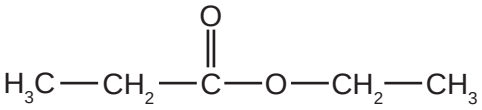
B $CH_3COCH_2COCH_3$

C $H_2C{=}CHCH_2CHO$

D $OHCCH_2CH_2CHO$

27 Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?

A



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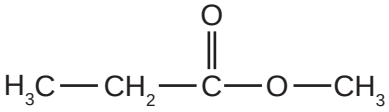

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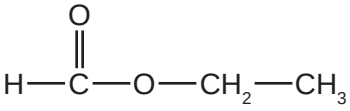

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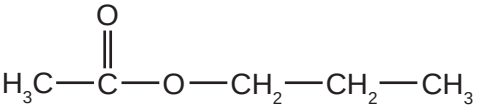

28 A compound Y is treated with warm acidified potassium dichromate(VI). The resulting organic product gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent but does not give a silver mirror with Tollens' reagent.

What is Y?

A butan-1-ol

B butan-2-ol

C butanal

D 2-methylpropan-2-ol

29 Aldehydes and ketones are carbonyl compounds.

Which of them react with $NaBH_4$ **and** react with Fehling's reagent?

A both aldehydes and ketones

B aldehydes only

C ketones only

D neither aldehydes nor ketones

[Turn over

30 The functional group in a primary alcohol is $-CH_2OH$.

Which reagent reacts with a primary alcohol, under suitable conditions, to give an organic product with the same number of oxygen atoms as the alcohol?

A Al_2O_3 **B** CH_3CO_2H **C** HBr **D** Na

Section B

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

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

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

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

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

31 Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?

1 Water can act as either an acid or a base.

2 Sulfuric acid, H_2SO_4, does not behave as an acid when dissolved in ethanol, C_2H_5OH.

3 The ammonium ion acts as a base when dissolved in liquid ammonia.

32 Which are features of the structure of metallic copper?

1 a lattice of ions

2 delocalised electrons

3 ionic bonds

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

Zinc reacts with hydrochloric acid according to the following equation.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Which statements are correct?

[All volumes are measured at room conditions.]

1 A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.

2 A 6.54 g sample of zinc reacts completely with exactly 100 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.

3 A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm^3 of hydrogen.

[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

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34 Which statements are correct?

1 Aluminium chloride dissolves in water to give an acidic solution.

2 Magnesium chloride dissolves in water to give a slightly acidic solution.

3 Sodium chloride dissolves in water to give an alkaline solution.

35 Which oxides react with water to give a solution of pH 10 or higher?

1 CaO

2 Na_2O

3 SrO

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

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

1 It forms diatomic molecules which dissociate more readily than chlorine molecules.

2 It reacts explosively with hydrogen.

3 It can oxidise iodide to iodine.

37 Which descriptions of the ammonium ion are correct?

1 It contains ten electrons.

2 It has a bond angle of 109.5°.

3 It has only three bonding pairs of electrons.

38 Which alkenes, on reaction with steam at 600 K and 6 x 10^6 Pa pressure in the presence of a phosphoric acid catalyst, could produce an alcohol containing a chiral carbon atom?

1 $(CH_3)_2C=CH_2$

2 $CH_3CH=CHCH_3$

3 $CH_3CH_2CH=CH_2$

39 Bromoethane undergoes all of the conversions shown.

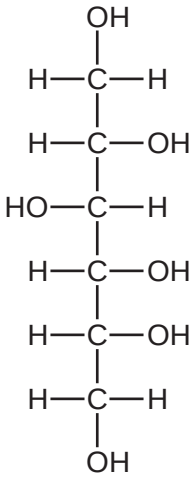
Which conversions are examples of nucleophilic substitution?

1 $C_2H_5Br \rightarrow C_2H_5CN$

2 $C_2H_5Br \rightarrow C_2H_5OH$

3 $C_2H_5Br \rightarrow C_2H_5NH_2$

40 Sorbitol is an artificial sweetener used to sweeten chocolate which is suitable for diabetics.



sorbitol

Which functional groups can be produced when this molecule is subjected to oxidation under suitable conditions?

1 aldehyde

2 carboxylic acid

3 ketone

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CHEMISTRY **9701/12**

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Section A

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

1 Helium, He, is the second element in the Periodic Table.

Tritium is the isotope of hydrogen ^{3}H.

What is the same in an atom of ^{4}He and an atom of ^{3}H?

A the number of electrons

B the number of neutrons

C the number of protons

D the relative atomic mass

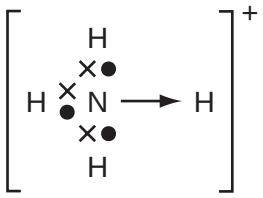
2 Which diagram correctly shows the bonding in the ammonium ion, NH_4^+?

key

● N electron

× H electron

A



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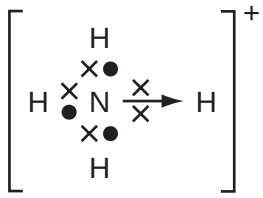

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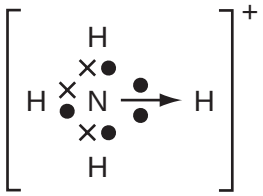

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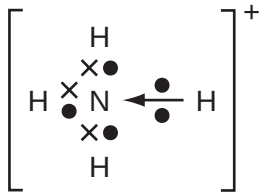


3 Aluminium is the most abundant metal in the Earth's crust. The extraction of aluminium is carried out by the electrolysis of aluminium oxide dissolved in molten cryolite.

Which material is used for each of the electrodes in this electrolysis?

	anode	cathode
A	aluminium	carbon
B	carbon	carbon
C	carbon	steel
D	steel	aluminium

4 The esterification reaction

$$\text{ethanol + ethanoic acid} \rightleftharpoons \text{ethyl ethanoate + water}$$

is an equilibrium. The forward reaction is exothermic.

How can the value of the equilibrium constant K_C be increased?

A by adding a little concentrated sulfuric acid as a catalyst

B by increasing the initial concentration of ethanol

C by lowering the temperature

D by raising the temperature

5 Ammonia is manufactured on a large scale by the Haber process.

In a particular plant, conditions of 400 °C and 250 atm in the presence of an iron catalyst are used.

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

What could contribute most to increasing the equilibrium yield of ammonia?

A adding more catalyst

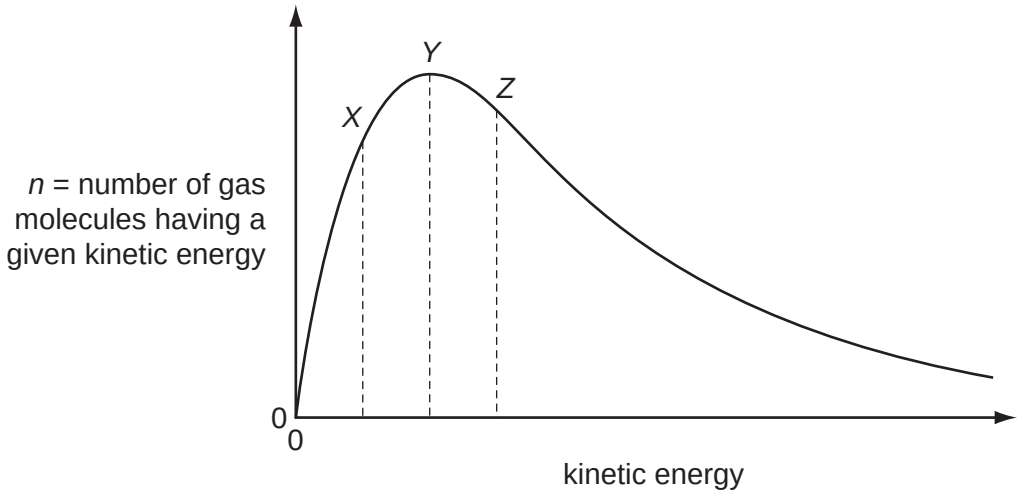
B increasing the pressure to 400 atm

C increasing the temperature to 1000 °C

D using air rather than nitrogen

[Turn over

6 The Boltzmann distribution for a gas at constant temperature is shown below.



If the temperature of the gas is **reduced** by 10 °C the graph changes shape.

What happens to the values of *n* for the points marked *X*, *Y* and *Z*?

	X	*Y*	*Z*
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

7 Titanium occurs naturally as the mineral rutile, TiO_2. One possible method of extraction of titanium is to reduce the rutile by heating with carbon.

$$TiO_2(s) + 2C(s) \rightarrow Ti(s) + 2CO(g)$$

The standard enthalpy changes of formation of $TiO_2(s)$ and $CO(g)$ are –940 kJ mol^{-1} and –110 kJ mol^{-1} respectively.

What is the standard enthalpy change of this reaction?

A –830 kJ mol^{-1}

B –720 kJ mol^{-1}

C +720 kJ mol^{-1}

D +830 kJ mol^{-1}

8 Which reaction has an enthalpy change equal to the standard enthalpy change of formation of propane?

A $3C(g) + 4H_2(g) \rightarrow C_3H_8(g)$

B $3C(g) + 8H(g) \rightarrow C_3H_8(g)$

C $3C(s) + 4H_2(g) \rightarrow C_3H_8(g)$

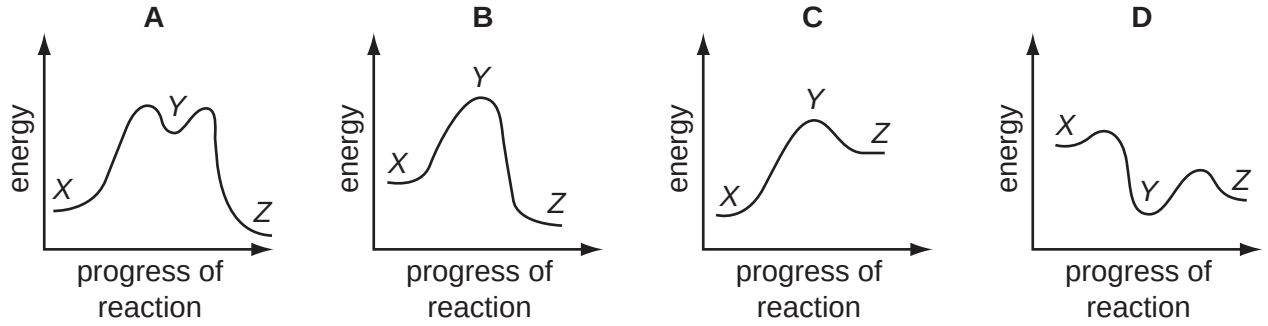
D $3C(s) + 4H_2(g) \rightarrow C_3H_8(l)$

9 In the conversion of compound *X* into compound *Z*, it was found that the reaction proceeded by way of compound *Y*, which could be isolated. The following steps were involved.

$X \rightarrow Y$; ΔH, positive

$Y \rightarrow Z$; ΔH, negative

Which reaction profile fits these data?



10 Tanzanite is used as a gemstone for jewellery. It is a hydrated calcium aluminium silicate mineral with a chemical formula $Ca_2Al_xSi_yO_{12}(OH).6½H_2O$. Tanzanite has M_r of 571.5.

Its chemical composition is 14.04 % calcium, 14.17 % aluminium, 14.75 % silicon, 54.59 % oxygen and 2.45 % hydrogen.

(A_r values: H = 1.0, O = 16.0, Al = 27.0, Si = 28.1, Ca = 40.1)

What are the values of x and y?

	x	y
A	1	1
B	2	3
C	3	3
D	6	1

[Turn over

11 0.144 g of an aluminium compound **X** react with an excess of water, to produce a gas. This gas burns completely in O_2 to form H_2O and 72 cm^3 of CO_2 only. The volume of CO_2 was measured at room temperature and pressure.

What could be the formula of **X**?
[C = 12.0, Al = 27.0; 1 mole of any gas occupies 24 dm^3 at room temperature and pressure]

A Al_2C_3 **B** Al_3C_4 **C** Al_4C_3 **D** Al_5C_3

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

Which element is likely to have an electronegativity similar to that of aluminium?

A barium

B beryllium

C magnesium

D strontium

13 In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic configuration.

$$[Rn]\ 5f^{14}6d^{10}7s^{2}7p^{6}$$

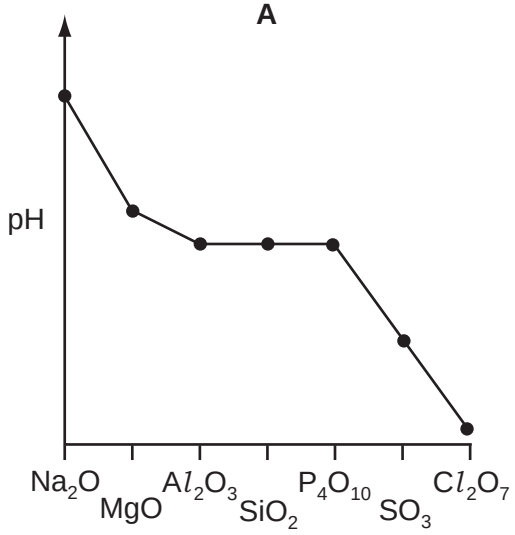
In which Group of the Periodic Table would you expect to find this element?

A II **B** IV **C** VI **D** 0

14 The highest oxides of the elements sodium to chlorine are separately added to water.

Which diagram best represents the pH of the resulting mixtures?

A



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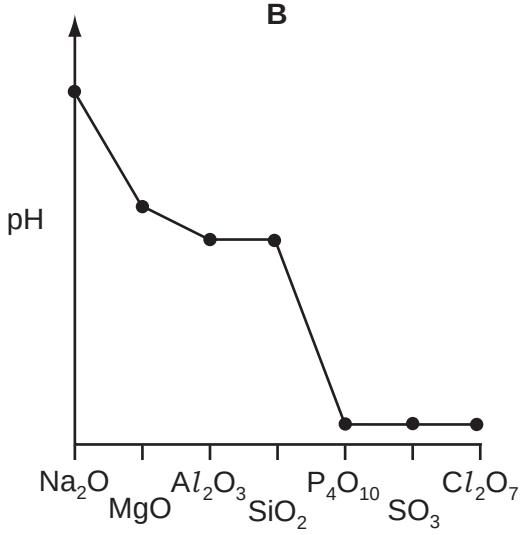

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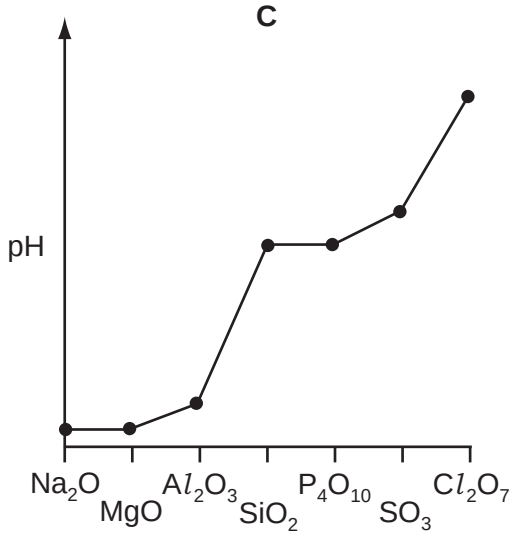
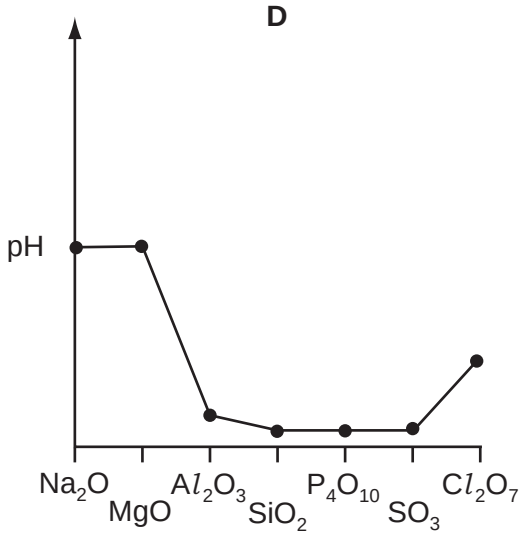
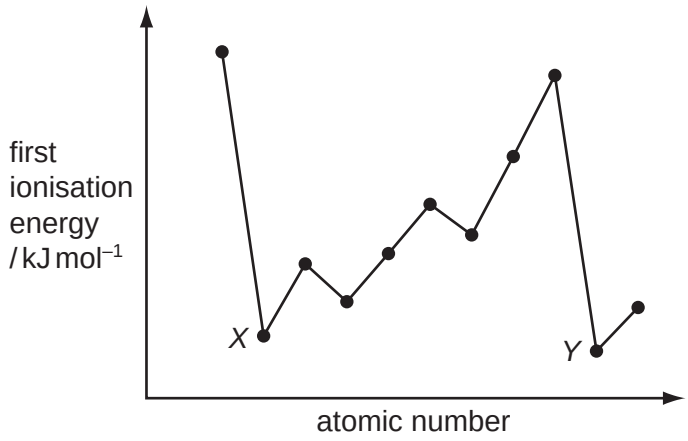


D



[Turn over

15 The diagram shows the first ionisation energies of 11 consecutive elements.



Which type of elements are labelled *X* and *Y*?

A Group I metals

B Group II metals

C halogens

D noble gases

16 Why does aluminium oxide dissolve in sodium hydroxide solution?

A Aluminium oxide can behave as a base.

B Aluminium oxide can behave as an acid.

C Aluminium oxide has a giant structure.

D The bonding in aluminium oxide is ionic.

17 Concentrated sulfuric acid can behave **both** as a strong acid **and** as an oxidising agent.

With which compound does concentrated sulfuric acid react in this way?

A ethanol

B magnesium carbonate

C propanenitrile

D sodium bromide

18 In the Contact process, what is the nature of the gaseous product and what is the identity of the catalyst?

	nature of gaseous product	catalyst
A	acidic	Fe
B	acidic	V_2O_5
C	basic	Fe
D	basic	V_2O_5

19 Which compound contains two different elements with identical oxidation states?

A HC*l*O **B** $Mg(OH)_2$ **C** Na_2SO_4 **D** NH_4Cl

20 Which reagent gives the same visible result with propanal and with propan-2-ol?

A 2,4-dinitrophenylhydrazine reagent

B acidified potassium dichromate(VI)

C sodium

D Tollens' reagent

21 Which halogenoalkane will undergo an S_N1 reaction and produce a yellow precipitate when $AgNO_3(aq)$ is added to it?

A 1-chlorobutane

B 1-iodobutane

C 2-chloro-2-methylpropane

D 2-iodo-2-methylpropane

22 Which reaction will give 2-chloropropane in the best yield?

A propane gas with chlorine gas in the presence of ultraviolet light

B propan-2-ol with dilute NaC*l*(aq)

C propan-2-ol with $SOCl_2$

D propene with dilute HC*l*(aq)

23 The products obtained by cracking an alkane, **X**, are methane, ethene and propene.

The mole fraction of ethene in the products is 0.5.

What is the identity of **X**?

A C_6H_{14} **B** C_8H_{18} **C** C_9H_{20} **D** $C_{11}H_{24}$

24 Which compound does **not** show cis-trans isomerism?

A 2-methylpent-2-ene

B 3-methylpent-2-ene

C 3,4-dimethylhex-3-ene

D pent-2-ene

25 Which formulae show propanone and propanal as different compounds?

A empirical, molecular, structural **and** displayed formulae

B molecular, structural and displayed formulae **only**

C structural and displayed formulae **only**

D displayed formulae **only**

26 How many isomers with the formula C_5H_{10} have structures that involve π bonding?

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

27 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.

$$CH_3CH_2CHCl_2 \xrightarrow{NaOH(aq)} CH_3CH_2CHO$$

Which term describes the first step of this reaction?

A electrophilic addition

B elimination

C nucleophilic substitution

D oxidation

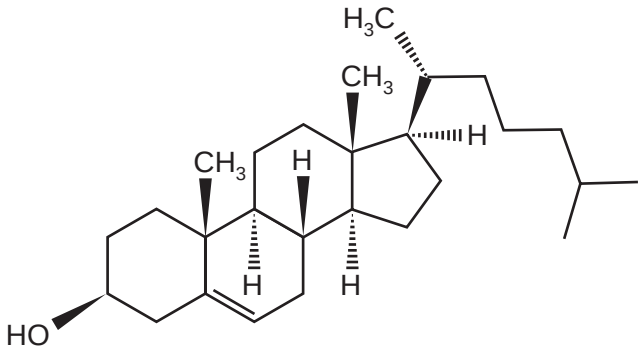
28 The ester $CH_3CH_2CH_2CO_2CH_3$ is responsible for the aroma of apples.

When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?

A CH_2O **B** CH_4O **C** C_2H_4O **D** $C_3H_6O_2$

29 This question should be answered by considering the reactions of $KMnO_4$ with different functional groups under the stated conditions.

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



cholesterol

Cholesterol is separately treated with

- cold, dilute acidified $KMnO_4$,
- hot, concentrated acidified $KMnO_4$.

What is the change in the **number** of chiral carbon atoms in the molecule during each reaction?

	cold, dilute acidified $KMnO_4$	hot, concentrated acidified $KMnO_4$
A	+1	0
B	+1	–1
C	+2	0
D	+2	–1

30 Which reaction would **not** give ethanoic acid as a product?

A heating ethanenitrile under reflux with dilute sodium hydroxide

B heating ethanenitrile under reflux with dilute sulfuric acid

C heating ethanal under reflux with acidified sodium dichromate(VI)

D heating ethanol under reflux with acidified sodium dichromate(VI)

[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 Solid calcium carbonate is added to 100 cm^3 of dilute hydrochloric acid and the rate of the reaction is measured. 100 cm^3 of distilled water is then added to a second 100 cm^3 portion of the acid, and the experiment repeated under the same conditions.

Why does the addition of water decrease the rate of the reaction?

1 Adding water reduces the frequency of collisions between reactant molecules.

2 Adding water reduces the proportion of effective collisions between reactant molecules.

3 Adding water reduces the proportion of reactant molecules possessing the activation energy.

32 When a sample of a gas is compressed at constant temperature from 1500 kPa to 6000 kPa, its volume changes from 76.0 cm^3 to 20.5 cm^3.

Which statements are possible explanations for this behaviour?

1 The gas behaves non-ideally.

2 The gas partially liquefies.

3 Gas is adsorbed on to the vessel walls.

33 Which equations apply to an ideal gas?
[p = pressure, V = volume, M = molar mass, ρ = density, c = concentration, R = gas constant, T = temperature]

1 $p = \frac{\rho RT}{M}$ **2** $pV = MRT$ **3** $pV = \frac{cRT}{M}$

34 What is involved when a hydrogen bond is formed between two molecules?

1 a hydrogen atom bonded to an atom less electronegative than itself

2 a lone pair of electrons

3 an electrostatic attraction between opposite charges

35 When the yellow liquid NCl_3 is stirred into aqueous sodium hydroxide, the reaction that occurs can be represented by the following equation.

$$2NCl_3(l) + 6NaOH(aq) \rightarrow N_2(g) + 3NaCl(aq) + 3NaOCl(aq) + 3H_2O(l)$$

What will be the result of this reaction?

1 The nitrogen undergoes a redox reaction.

2 A bleaching solution remains after the reaction.

3 The final solution gives a precipitate with acidified silver nitrate.

36 In a car engine pollutant oxide **Y**, which contains non-metallic element **X**, is formed.

Further oxidation of **Y** to **Z** occurs in the atmosphere. In this further oxidation, 1 mol of **Y** reacts with 0.5 mol of gaseous oxygen.

X could be either nitrogen or sulfur.

Which statements about **X**, **Y** and **Z** can be correct?

1 The oxidation number of **X** increases by two from **Y** to **Z**.

2 **Y** may have an unpaired electron in its molecule.

3 **Y** is a polar molecule.

37 Which compounds can be obtained from ethene in a **single** reaction?

1 CH_3CH_3

2 $-(-CH_2CH_2-)_n-$

3 $HOCH_2CH_2OH$

[Turn over

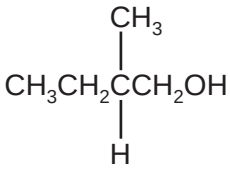
The responses **A** to **D** should be selected on the basis of

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

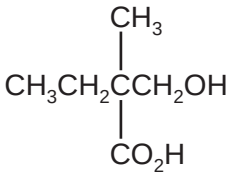
No other combination of statements is used as a correct response.

38 Which compounds when heated under reflux with an excess of hot acidified potassium dichromate(VI), give a product with a chiral centre?

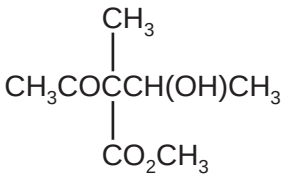
1



2



3



39 In the reaction between an aldehyde and HCN, catalysed by NaCN, which statements about the reaction mechanism are correct?

1 A new carbon-carbon bond is formed.

2 In the intermediate, the oxygen carries a negative charge.

3 The last stage involves the formation of a hydrogen-oxygen bond.

40 An organic compound, **X**, will react with an excess of calcium metal to produce a salt with the empirical formula $CaC_4H_6O_4$.

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

1 ethanoic acid

2 butanedioic acid

3 methylpropanedioic acid

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

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **May/June 2011**

1 hour

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

READ THESE INSTRUCTIONS FIRST

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

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

Read the instructions on the Answer Sheet very carefully.

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

This document consists of **14** printed pages and **2** blank pages.

Section A

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

1 Which equation represents the second ionisation energy of an element X?

A $X(g) \rightarrow X^{2+}(g) + 2e$

B $X^{+}(g) \rightarrow X^{2+}(g) + e$

C $X(g) + 2e \rightarrow X^{2}(g)$

D $X(g) + e \rightarrow X^{2}(g)$

2 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?

A The nuclear charge of the elements increases.

B The outer electron is in an 's' subshell.

C The repulsion between spin-paired electrons increases.

D The shielding effect of the inner shells increases.

3 In the extraction of aluminium by the electrolysis of molten aluminium oxide, why is cryolite added to the aluminium oxide?

A to ensure the aluminium is not oxidised

B to ensure the anode is not oxidised

C to lower the melting point of the aluminium oxide

D to prevent corrosion of the cathode

4 In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?

$$NO_3^-(aq) \xrightarrow{A} NO_2^-(aq) \xrightarrow{B} NO(g) \xrightarrow{C} N_2O(g) \xrightarrow{D} N_2(g)$$

5 In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at pressures below 100 atm.

What is the reason for this change?

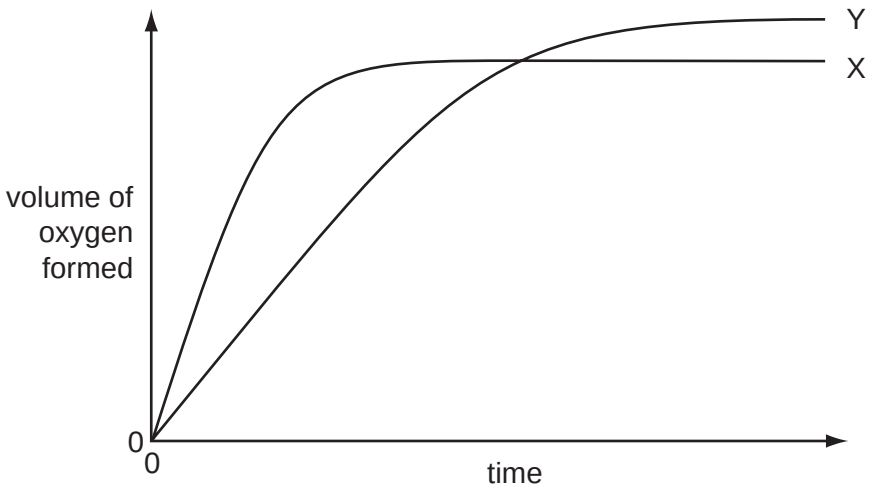
A An iron catalyst is used.

B Maintaining the higher pressures is more expensive.

C The equilibrium yield of ammonia is increased at lower pressures.

D The rate of the reaction is increased at lower pressures.

6 In the diagram, curve X was obtained by observing the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve Y?

A adding some 0.1 mol dm^{-3} hydrogen peroxide

B adding water

C lowering the temperature

D using less manganese(IV) oxide

[Turn over

7 Different Boltzmann distributions are shown in the diagrams.

diagram 1

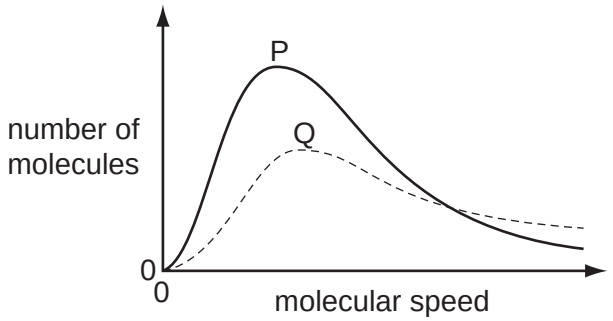
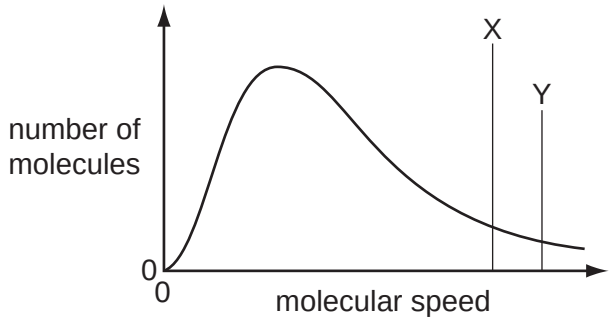


diagram 2



In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.

In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.

Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

8 50 cm^3 of 2.50 mol dm^{-3} hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then 50 cm^3 of 2.50 mol dm^{-3} NaOH at the same temperature was quickly added, with stirring. The temperature rose by 17 °C.

The resulting solution may be considered to have a specific heat capacity of 4.2 J g^{-1} K^{-1}.

What is an approximate value for the molar enthalpy change of neutralisation of hydrochloric acid and sodium hydroxide from this experiment?

A $\frac{(50 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

B $\frac{(50 \times 4.2 \times 17)}{(0.10 \times 2.5)}$ J mol^{-1}

C $\frac{(100 \times 4.2 \times 17)}{(0.050 \times 2.5)}$ J mol^{-1}

D $\frac{(100 \times 4.2 \times 17)}{(50 \times 2.5)}$ J mol^{-1}

9 The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.

$$2X(g) + 6H(g) \rightarrow X_2H_6(g) \qquad \Delta H = -2775\,kJ\,mol^{-1}$$

The bond energy of an X–H bond is 395 kJ mol^{-1}.

What is the bond energy of an X–X bond?

A –405.0 kJ mol^{-1}

B –202.5 kJ mol^{-1}

C +202.5 kJ mol^{-1}

D +405.0 kJ mol^{-1}

10 In which change would only van der Waals' forces have to be overcome?

A	evaporation of ethanol	$C_2H_5OH(l) \rightarrow C_2H_5OH(g)$
B	melting of ice	$H_2O(s) \rightarrow H_2O(l)$
C	melting of solid carbon dioxide	$CO_2(s) \rightarrow CO_2(l)$
D	solidification of butane	$C_4H_{10}(l) \rightarrow C_4H_{10}(s)$

11 Hydrazine, N_2H_4, is widely used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.

$$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g) \qquad \Delta H = -534\,kJ\,mol^{-1}$$

Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.

Which statement explains why hydrazine does **not** burn spontaneously?

A Hydrazine is a liquid.

B The activation energy is too high.

C The N≡N bond is very strong.

D The reaction is exothermic.

12 0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.

What minimum volume of acid will be required for complete reaction?

A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 60 cm^3

13 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp / °C	801	2852	3550
bp / °C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T?

	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO_2
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO_2

14 Steam is passed over heated magnesium to give compound X and hydrogen.

What is **not** a property of compound X?

A It has an M_r of 40.3.

B It is basic.

C It is a white solid.

D It is very soluble in water.

15 Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

A $NO(g) + CO(g) \rightarrow NO_2(g) + C(s)$

B $NO(g) + CO_2(g) \rightarrow NO_2(g) + CO(g)$

C $2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$

D $2NO(g) + CO_2(g) \rightarrow 2NO_2(g) + C(s)$

16 X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2, Y_2 and Z_2 were separately added to separate aqueous solutions containing X^-, Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row in the following table contains the ions X^-, Y^- and Z^- in order of their decreasing strength as reducing agents?

	strongest ⟶		weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

17 A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

A Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.

B Concentrated phosphoric acid is a stronger oxidising agent than iodine.

C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.

D Concentrated sulfuric acid is a stronger oxidising agent than iodine.

18 Ammonium nitrate, NH_4NO_3, is manufactured in large quantities for use in fertiliser.

Which statement about ammonium nitrate fertiliser is **not** correct?

A It can cause environmental problems.

B It consists of 35 % nitrogen by mass.

C It is insoluble in water.

D Nitric acid is used in its manufacture.

[Turn over

19 Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.

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

Which reagents could be used for this synthesis?

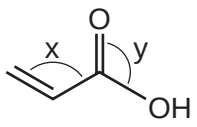
	step 1	step 2
A	HCN(g)	HC*l*(aq)
B	HCO_2Na(aq)	HC*l*(aq)
C	KCN(aq / alcoholic)	H_2SO_4(aq)
D	NaOH(aq)	$K_2Cr_2O_7$ / H_2SO_4(aq)

20 The formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons must be present for CH_3 to act in these different ways?

	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

21 Acrylic acid is produced from propene, a gaseous product of oil refineries.



acrylic acid

Which statement about acrylic acid is **not** correct?

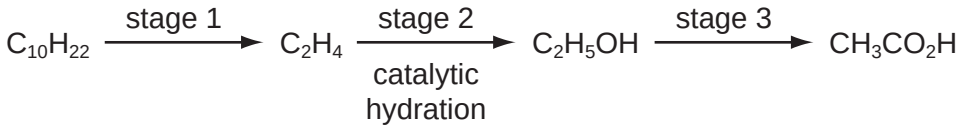
A Both bond angles x and y are approximately 120°.

B It decolourises aqueous bromine.

C It gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

D It reacts with an alcohol to give an ester.

22 In the reaction pathway below, an alkane is converted into a carboxylic acid through several stages.



Which processes occur at stage 1 and at stage 3?

	stage 1	stage 3
A	condensation	combustion
B	cracking	dehydration
C	cracking	oxidation
D	dehydration	combustion

23 A compound Y is treated with warm acidified potassium dichromate(VI). The resulting organic product gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent but does not give a silver mirror with Tollens' reagent.

What is Y?

A butan-1-ol

B butan-2-ol

C butanal

D 2-methylpropan-2-ol

24 Compound X changes the colour of warm acidified sodium dichromate(VI) from orange to green. 1 mol of X reacts with 2 mol of HCN in the presence of KCN.

What could X be?

A $CH_3CH_2CH_2CHO$

B $CH_3COCH_2COCH_3$

C $H_2C{=}CHCH_2CHO$

D $OHCCH_2CH_2CHO$

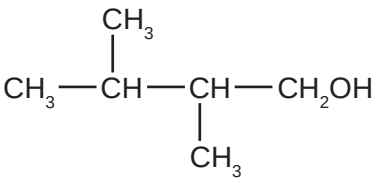
25 Pentanol, $C_5H_{11}OH$, has four structural isomers that are primary alcohols.

How many of these primary alcohols contain a chiral carbon atom?

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

26 Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

A



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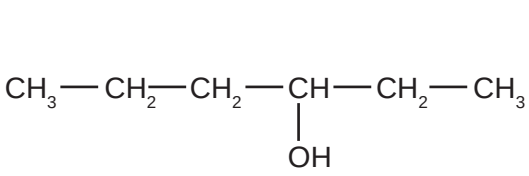

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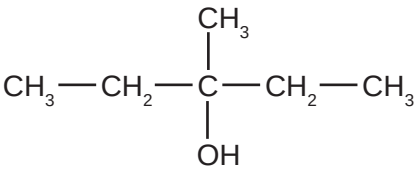
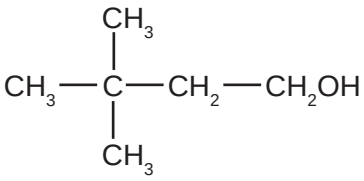
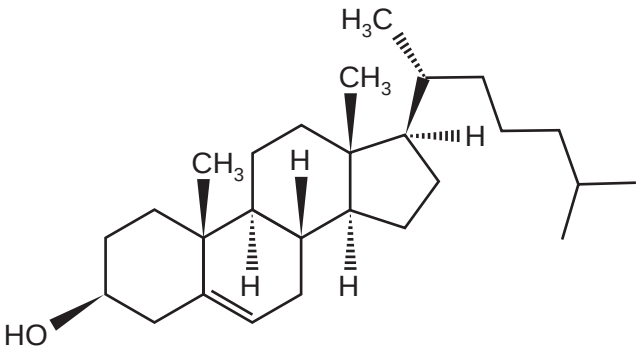


D



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



cholesterol

Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y claimed that this molecule displays *cis-trans* isomerism at the C=C double bond.

Which of the students are correct?

A both X and Y

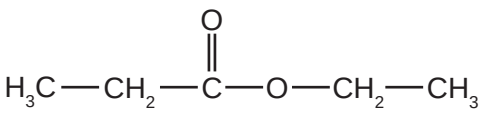
B neither X nor Y

C X only

D Y only

28 Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?

A



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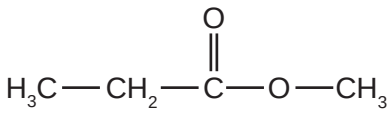

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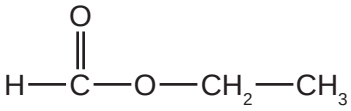

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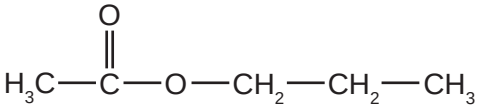


29 The functional group in a primary alcohol is $–CH_2OH$.

Which reagent reacts with a primary alcohol, under suitable conditions, to give an organic product with the same number of oxygen atoms as the alcohol?

A Al_2O_3 **B** CH_3CO_2H **C** HBr **D** Na

30 Aldehydes and ketones are carbonyl compounds.

Which of them react with $NaBH_4$ **and** react with Fehling's reagent?

A both aldehydes and ketones

B aldehydes only

C ketones only

D neither aldehydes nor ketones

[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 are features of the structure of metallic copper?

1 a lattice of ions

2 delocalised electrons

3 ionic bonds

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

Zinc reacts with hydrochloric acid according to the following equation.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Which statements are correct?

[All volumes are measured at room conditions.]

1 A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.

2 A 6.54 g sample of zinc reacts completely with exactly 100 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.

3 A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm^3 of hydrogen.

33 Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?

1 Water can act as either an acid or a base.

2 Sulfuric acid, H_2SO_4, does not behave as an acid when dissolved in ethanol, C_2H_5OH.

3 The ammonium ion acts as a base when dissolved in liquid ammonia.

34 Which descriptions of the ammonium ion are correct?

1 It contains ten electrons.

2 It has a bond angle of 109.5°.

3 It has only three bonding pairs of electrons.

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

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

1 It forms diatomic molecules which dissociate more readily than chlorine molecules.

2 It reacts explosively with hydrogen.

3 It can oxidise iodide to iodine.

36 Which statements are correct?

1 Aluminium chloride dissolves in water to give an acidic solution.

2 Magnesium chloride dissolves in water to give a slightly acidic solution.

3 Sodium chloride dissolves in water to give an alkaline solution.

37 Which alkenes, on reaction with steam at 600 K and 6 x 10^6 Pa pressure in the presence of a phosphoric acid catalyst, could produce an alcohol containing a chiral carbon atom?

1 $(CH_3)_2C=CH_2$

2 $CH_3CH=CHCH_3$

3 $CH_3CH_2CH=CH_2$

38 Which oxides react with water to give a solution of pH 10 or higher?

1 CaO

2 Na_2O

3 SrO

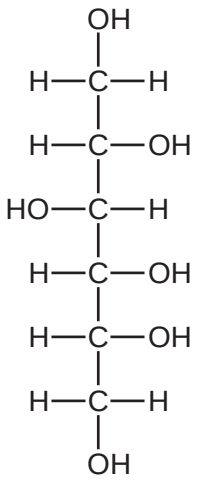
[Turn over

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.

39 Sorbitol is an artificial sweetener used to sweeten chocolate which is suitable for diabetics.



sorbitol

Which functional groups can be produced when this molecule is subjected to oxidation under suitable conditions?

1 aldehyde

2 carboxylic acid

3 ketone

40 Bromoethane undergoes all of the conversions shown.

Which conversions are examples of nucleophilic substitution?

1 $C_2H_5Br \rightarrow C_2H_5CN$

2 $C_2H_5Br \rightarrow C_2H_5OH$

3 $C_2H_5Br \rightarrow C_2H_5NH_2$

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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 **9701/21**

Paper 2 Structured Questions AS Core **May/June 2011**

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	
4	
5	
Total	

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

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

For Examiner's Use

1 Some intercontinental jet airliners use kerosene as fuel. The formula of kerosene may be taken as $C_{14}H_{30}$.

(a) To which homologous series of compounds does kerosene belong?

.....

[1]

(b) When kerosene burns in an excess of air, carbon dioxide and water form.
Balance the following equation for the complete combustion of kerosene.

$$.....C_{14}H_{30}(l) + ...O_2(g) \rightarrow .....CO_2(g) + ...H_2O(g)$$

[1]

(c) **In this section, give your answers to <u>one</u> decimal place.**

The flight path from Beijing to Paris is approximately 8195 km.
A typical intercontinental jet airliner burns 10.8 kg of kerosene for each kilometre covered.

(i) Calculate the mass, in tonnes, of $C_{14}H_{30}$ burnt on a flight from Beijing to Paris.
[1 tonne = 1 000 kg]

(ii) Use your equation in **(b)** to calculate the mass, in tonnes, of CO_2 produced during this flight.

[4]

Bicycles may be carried on commercial airliners. When carried on airliners, bicycles are placed in the luggage hold. This is a part of the aircraft which, in flight, will have different temperatures and air pressures from those at sea level.

For Examiner's Use

This question concerns the change in pressure in an inflated bicycle tyre from when it is at sea level to when it is in the hold of an airliner in flight.

(d) At sea level and a temperature of 20 °C an inflated bicycle tyre contains 710 cm^3 of air at an internal pressure of 6×10^5 Pa.

Use the general gas equation $PV = nRT$ to calculate the amount, in moles, of air in the tyre at sea level.

[2]

The same bicycle, with its tyres inflated at sea level as described in **(d)** above, is placed in the luggage hold of an airliner. At a height of 10 000 m, the temperature in the luggage hold is 5 °C and the air pressure is 2.8×10^4 Pa.

(e) Assuming the volume of the tyre does not change, use your answer to **(d)** to calculate the pressure inside the tyre at a height of 10 000 m.

[2]

[Total: 10]

[Turn over

2 Crude oil contains a mixture of hydrocarbons together with other organic compounds which may contain nitrogen, oxygen or sulfur in their molecules.

For Examiner's Use

At an oil refinery, after the fractional distillation of crude oil, a number of other processes may be used including 'cracking', 'isomerisation', and 'reforming'.

(a) (i) What is meant by the term '*cracking*' and why is it carried out?

.....

.....

.....

.....

(ii) Outline briefly how the cracking of hydrocarbons would be carried out.

.....

.....

(iii) Construct a balanced equation for the formation of heptane, C_7H_{16}, by cracking tetradecane, $C_{14}H_{30}$.

.....

[4]

One of the sulfur-containing compounds present in crude oil is ethanethiol, C_2H_5SH, the sulfur-containing equivalent of ethanol. Ethanethiol is toxic and is regarded as one of the smelliest compounds in existence.

(b) The boiling point of ethanol, C_2H_5OH, is higher than that of C_2H_5SH.
Suggest a reason for this difference.

.....

..... [1]

When ethanethiol is burned in an excess of air, three oxides of different elements are formed.

For Examiner's Use

(c) **(i)** Construct a balanced equation for this reaction.

.....

(ii) **Two** of the oxides formed cause serious environmental damage.

For **each** of these oxides, identify the type of pollution caused and describe one consequence of this pollution.

.....

.....

.....

.....

.....

[6]

(d) A small amount of ethanethiol is added to liquefied gases such as butane that are widely used in portable cooking stoves.

Suggest a reason for this.

.....[1]

Sulfur-containing compounds are removed from oil products at the refinery. The sulfur is recovered and converted into SO_2, which is then used in the Contact process.

(e) State the main operating details of the formation of SO_3 in the Contact process.

.....

.....

.....

.....

.....[3]

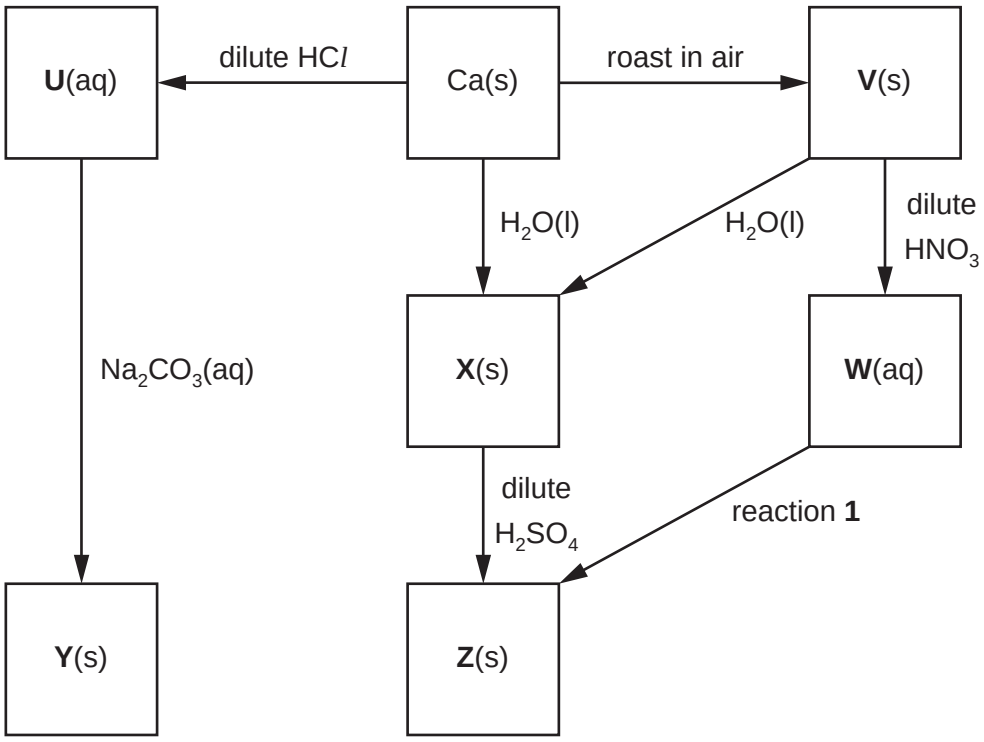
[Total: 15]

[Turn over

3 Calcium is the fifth most common element in the Earth's crust.
Calcium compounds occur in bones and teeth and also in many minerals.

For Examiner's Use

Some reactions of calcium and its compounds are shown in the reaction scheme below.



(a) State the formula of **each** of the calcium compounds **U** to **Y**.

U .....

V .....

W .....

X .....

Y ..... [5]

(b) Compound **Y** may be converted into compound **V**.
Outline how this reaction would be carried out in a school or college laboratory using a small sample of **Y**.

.....

..... [1]

(c) **(i)** Construct balanced equations for the following reactions.

calcium to compound **U**

.....

compound **V** to compound **W**

.....

compound **U** to compound **Y**

.....

(ii) Construct a balanced equation for the effect of heat on solid compound **W**.

.....

[4]

(d) Suggest the formula of an aqueous reagent, other than an acid, for reaction **1**.

..... [1]

(e) What would be observed when **each** of the following reactions is carried out in a test-tube?

the formation of **X** from Ca(s)

.....

the formation of **X** from **V**

.....

[2]

[Total: 13]

[Turn over

4 Ketones are widely used as solvents and as intermediates in the chemical industry.

Ketones contain the reactive keto group,  .

For Examiner's Use

(a) Propanone, CH_3COCH_3, undergoes a reaction with hydrogen cyanide, HCN.

(i) What type of reaction is this?

.....

(ii) What reagents are used?

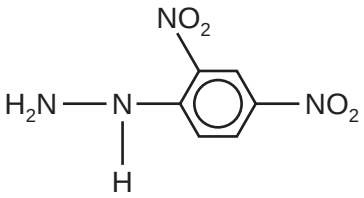
.....

(iii) Draw a diagram to show the dipole present in the propanone molecule.

[3]

(b) Propanone reacts with 2,4-dinitrophenylhydrazine reagent.

For Examiner's Use

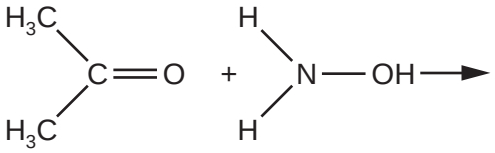


2,4-dinitrophenylhydrazine

(i) Construct a balanced equation for the reaction between propanone and 2,4-dinitrophenylhydrazine.

(ii) A similar type of reaction occurs between propanone and hydroxylamine, NH_2OH.

Draw the displayed formula of the organic product of this reaction.



[3]

[Total: 6]

5 The gas ethyne, C_2H_2, more commonly known as acetylene, is manufactured for use in the synthesis of organic compounds. It is also used, in combination with oxygen, in 'oxy-acetylene' torches for the cutting and welding of metals.

Industrially, ethyne is made from calcium carbide, CaC_2, or by cracking liquid hydrocarbons.

(a) When calcium carbide is reacted with water, ethyne and calcium hydroxide are formed.

Construct a balanced equation for this reaction.

.....[1]

Ethyne can also be obtained from ethene by using the following sequence of reactions.

$$CH_2CH_2 \xrightarrow{\text{step 1}} ClCH_2CH_2Cl \xrightarrow{\text{step 2}} HC{\equiv}CH$$

(b) **(i)** What types of reaction are step 1 and step 2?

step 1 .....

step 2 .....

(ii) Suggest what reagent and conditions would be used in a laboratory in step 2.

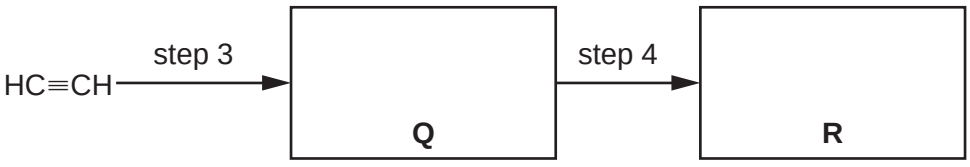
reagent .....

conditions ..... [5]

When ethyne is passed into water at 60 °C, in the presence of a little H_2SO_4 and Hg^{2+} ions, a pungent, colourless organic liquid, **Q**, with M_r of 44 is obtained. This is step 3.

When **Q** is warmed with Tollens' reagent in a test-tube, a silver mirror is formed.
On acidification, the solution remaining in the test-tube is found to contain the organic compound **R** which has M_r of 60. This is step 4.

(c) **(i)** Give the structural formulae of **Q** and **R**.



(ii) What type of reaction is step 3 and step 4?

step 3 .....

step 4 ..... [4]

(d) The standard enthalpy change of combustion of C_2H_2, $\Delta H_c^{\ominus}$, is $-1300\,kJ\,mol^{-1}$ at 298 K.

For Examiner's Use

Values of relevant standard enthalpy changes of formation, $\Delta H_f^{\ominus}$, measured at 298 K, are given in the table.

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

(i) Write balanced equations, with state symbols, that represent

the standard enthalpy change of combustion, $\Delta H_c^{\ominus}$, of C_2H_2, and

.....

the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of C_2H_2.

.....

(ii) Use the data above and your answer to **(i)** to calculate the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of C_2H_2.
Show clearly whether the standard enthalpy change of formation of C_2H_2 has a positive or negative value.

[6]

[Total: 16]

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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 **9701/22**

Paper 2 Structured Questions AS Core **May/June 2011**

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	
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3	
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Total	

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

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

For Examiner's Use

1 Ethanoic acid can be reacted with alcohols to form esters, an equilibrium mixture being formed.

$$CH_3CO_2H + ROH \rightleftharpoons CH_3CO_2R + H_2O$$

The reaction is usually carried out in the presence of an acid catalyst.

(a) Write an expression for the equilibrium constant, K_c, for this reaction, clearly stating the units.

K_c =

units ..... [2]

In an experiment to determine K_c a student placed together in a conical flask 0.10 mol of ethanoic acid, 0.10 mol of an alcohol ROH, and 0.005 mol of hydrogen chloride catalyst.
The flask was sealed and kept at 25 °C for seven days.
After this time, the student titrated all of the contents of the flask with 2.00 mol dm^{-3} NaOH using phenolphthalein indicator.
At the end-point, 22.5 cm^3 of NaOH had been used.

(b) **(i)** Calculate the amount, in moles, of NaOH used in the titration.

(ii) What amount, in moles, of this NaOH reacted with the hydrogen chloride?

(iii) Write a balanced equation for the reaction between ethanoic acid and NaOH.

(iv) Hence calculate the amount, in moles, of NaOH that reacted with the ethanoic acid.

[4]

(c) **(i)** Use your results from **(b)** to calculate the amount, in moles, of ethanoic acid present at equilibrium. Hence complete the table below.

For Examiner's Use

	CH_3CO_2H	ROH	CH_3CO_2R	H_2O
initial amount / mol	0.10	0.10	0	0
equilibrium amount / mol				

(ii) Use your results to calculate a value for K_c for this reaction.

[3]

(d) Esters are hydrolysed by sodium hydroxide. During the titration, sodium hydroxide reacts with ethanoic acid and the hydrogen chloride, but not with the ester.

Suggest a reason for this.

.....

..... [1]

(e) What would be the effect, if any, on the amount of ester present if all of the water were removed from the flask and the flask kept for a further week at 25 °C?

Explain your answer.

.....

.....

..... [2]

[Total: 12]

[Turn over

2 Halogenoalkanes have been widely used as aerosol propellants, refrigerants and solvents for many years.

For Examiner's Use

Fluoroethane, CH_3CH_2F, has been used as a refrigerant. It may be made by reacting ethene with hydrogen fluoride.

You are to calculate a value for the C–F bond energy in fluoroethane.

(a) Use relevant bond energies from the *Data Booklet*, and the equation below to calculate a value for the bond energy of the C–F bond.

$$CH_2 = CH_2(g) \quad + \quad HF(g) \quad \rightarrow \quad CH_3CH_2F(g) \qquad \Delta H^{\ominus} = -73\,kJ\,mol^{-1}$$

C–F bond energy = ... $kJ\,mol^{-1}$ [4]

(b) Another halogenoalkane which was used as a refrigerant, and also as an aerosol propellant, is dichlorodifluoromethane, CCl_2F_2.

State **two** reasons why compounds such as CH_3CH_2F and CCl_2F_2 have been used as aerosol propellants and refrigerants.

.....

..... [2]

CCl_2F_2 is one of many chlorofluorocarbon compounds responsible for damage to the ozone layer in the stratosphere.

For Examiner's Use

(c) By using relevant data from the *Data Booklet*, and your answer to **(a)** suggest why CCl_2F_2 is responsible for damage to the ozone layer in the stratosphere whereas CH_3CH_2F is not.

.....

.....

..... [2]

Both CH_3CH_2F and CCl_2F_2 are greenhouse gases.

The 'enhanced greenhouse effect' is of great concern to the international community.

(d) (i) What is meant by the term *enhanced greenhouse effect*?

.....

.....

.....

(ii) Water vapour is the most abundant greenhouse gas.

What is the second most abundant greenhouse gas?

..... [3]

A greenhouse gas which is present in very small amounts in the atmosphere is sulfur hexafluoride, SF_6, which is used in high voltage electrical switchgear.

(e) What shape is the SF_6 molecule?

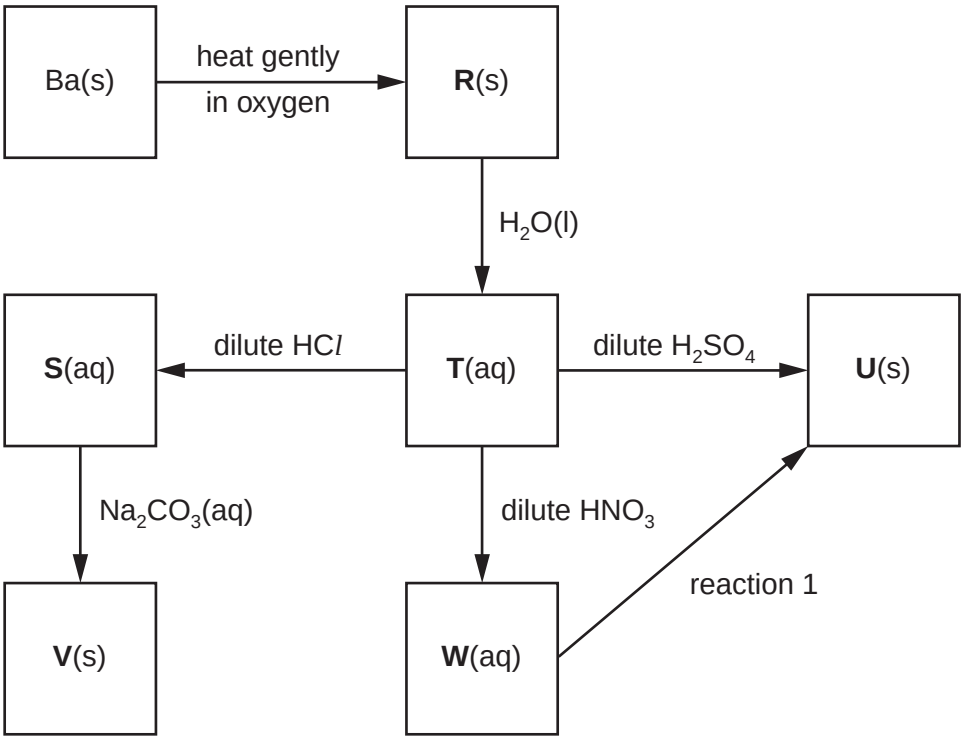
..... [1]

[Total: 12]

[Turn over

3 Barium, proton number 56, is a Group II element which occurs in nature as the carbonate or sulfate.
The element was first isolated by Sir Humphry Davy in 1808.
Some reactions of barium and its compounds are shown in the reaction scheme below.

For Examiner's Use



(a) State the formula of **each** of the barium compounds **R** to **W**.

R ..... **S** .....

T..... **U** .....

V ..... **W** ..... [6]

(b) **(i)** Write balanced equations for the following reactions.

compound **T** to compound **W**

.....

the roasting of **V** in air

.....

(ii) Suggest a gaseous reagent for the conversion of **T** into **V** and write a balanced equation for the reaction.

reagent .....

equation .....

[4]

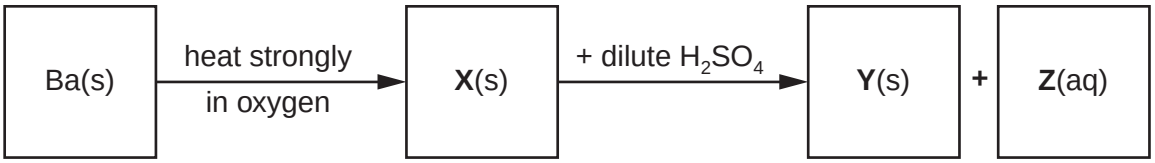
(c) Suggest the formula of an aqueous reagent, other than an acid, for reaction 1.

…….....

[1]

When barium is heated strongly in oxygen, an oxide **X** is formed.
The oxide **X** contains 18.9% of oxygen by mass.

The oxide **X** reacts with dilute sulfuric acid in a 1:1 ratio.
Two products, one insoluble and one soluble, are formed.



(d) **(i)** Calculate the empirical formula of **X**.

(ii) Suggest the identity of the solid **Y**.

.....

(iii) Use your answers to **(i)** and **(ii)** to construct an equation for the reaction of **X** with H_2SO_4.

..... [4]

[Total: 15]

[Turn over

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4 Chlorine is manufactured by electrolysis from brine, concentrated aqueous sodium chloride.

For Examiner's Use

(a) (i) Describe, with the aid of a fully labelled diagram, the industrial electrolysis of brine in a diaphragm cell. State what each electrode is made of and show clearly the inlet for the brine and the outlets for the products.

(ii) Write a half-equation, with state symbols, for the reaction at **each** electrode.

anode .....

cathode .....

(iii) Name the chemical that is produced in solution in this electrolytic process.

..... [7]

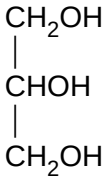
[Total: 7]

[Turn over

5 Although there are many different types of food eaten around the world, animal fats and/or vegetable oils are commonly used in cooking.

For Examiner's Use

Animal fats and vegetable oils are usually glyceryl esters, that is esters of glycerol, propane-1,2,3-triol.



Many animal fats contain esters of stearic acid, $CH_3(CH_2)_{16}CO_2H$.

Vegetable oils often contain esters of oleic acid, $CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$.

(a) Draw the structural formula of the glyceryl ester formed when one molecule of glycerol is completely esterified with stearic acid.

[1]

(b) What reagent(s) would you use, in a school or college laboratory, to obtain a small sample of oleic acid, $C_{17}H_{33}CO_2H$, from the glyceryl ester present in a vegetable oil?

.....

[1]

Oleic acid is the *cis* isomer and elaidic acid the *trans* isomer of

$$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H.$$

(c) By using this formula, draw the structural formula of elaidic acid, clearly showing the stereochemistry.

[1]

Oleic and elaidic acids are examples of mono-unsaturated acids.
Many vegetable oils contain esters of polyunsaturated fatty acids. Such oils are often hydrogenated to form esters containing saturated or mono-unsaturated fatty acids.

For Examiner's Use

(d) (i) Suggest the meaning of the term *polyunsaturated fatty acid*.

.....

.....

(ii) What reagent and condition(s) are used for the hydrogenation of an unsaturated fatty acid?

reagent .....

condition(s) ..... [3]

In cooking, unsaturated fats are often oxidised to give aldehydes or ketones.

(e) (i) Give the structural formulae of the two aldehydes formed by the partial oxidation of the unsaturated fat below.
In the structure, *X*, represents the rest of the fat molecule.

$$CH_3(CH_2)_7CH{=}CH(CH_2)_7X$$

(ii) Name the reagent you would use to show that the product contained **either** an aldehyde **or** a ketone. What change would be seen?

reagent .....

observation .....

(iii) What reagent would you use to **confirm** the presence of an aldehyde?
What change would be seen?

reagent .....

observation .....

[6]

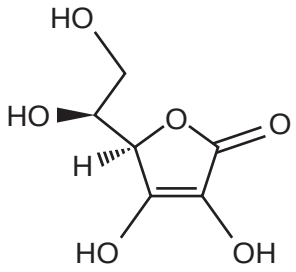
[Turn over

For Examiner's Use

Animal fats and vegetable oils can become rancid because of oxidation. The rancid fat or oil has an unpleasant smell and taste.

Antioxidants are used to prevent the spoilage of many foodstuffs by oxidation.

One antioxidant that is widely used is vitamin C, ascorbic acid.



ascorbic acid

(f) **(i)** How many chiral carbon atoms are present in one molecule of ascorbic acid? If none, write 'none'.

.....

(ii) The ascorbic acid molecule contains three functional groups.

Two of these are alcohol (primary and secondary) and alkene.

What is the name of the third functional group?

..... [2]

[Total: 14]

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 **May/June 2011**

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	
4	
5	
Total	

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

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

For Examiner's Use

1 Methanoic acid, HCO_2H, was formerly known as formic acid because it is present in the sting of ants and the Latin name for ant is *formica*. It was first isolated in 1671 by John Ray who collected a large number of dead ants and extracted the acid from them by distillation.

In this question, you should give all numerical answers to <u>two</u> significant figures.

At room temperature, pure methanoic acid is a liquid which is completely soluble in water.

When we are stung by a 'typical' ant a solution of methanoic acid, **A**, is injected into our skin.

Solution **A** contains 50% by volume of pure methanoic acid.

A 'typical' ant contains $7.5 \times 10^{-6}\,dm^3$ of solution **A**.

(a) (i) Calculate the volume, in cm^3, of solution **A** in one ant.

volume = ... cm^3

(ii) Use your answer to **(i)** to calculate the volume, in cm^3, of pure methanoic acid in one ant.

volume = ... cm^3

(iii) Use your answer to **(ii)** to calculate how many ants would have to be distilled to produce $1\,dm^3$ of pure methanoic acid.

number = ...
[3]

When we are stung by an ant, the amount of solution **A** injected is 80% of the total amount of solution **A** present in one ant.

For Examiner's Use

The density of pure methanoic acid is 1.2 g cm^{-3}.

(b) (i) Calculate the volume, in cm^3, of **pure** methanoic acid injected in one ant sting.

volume = ... cm^3

(ii) Use your answer to **(i)** to calculate the mass of methanoic acid present in one ant sting.

mass = ... g
[3]

Bees also sting us by using methanoic acid. One simple treatment for ant or bee stings is to use sodium hydrogencarbonate, $NaHCO_3$.

(c) (i) Construct a balanced equation for the reaction between methanoic acid and sodium hydrogencarbonate.

.....

(ii) In a typical bee sting, the mass of methanoic acid injected is 5.4×10^{-3} g. Calculate the mass of $NaHCO_3$ needed to neutralise one bee sting.

mass = ... g
[3]

[Total: 9]

[Turn over

2 The kinetic theory of gases is used to explain the large scale (macroscopic) properties of gases by considering how individual molecules behave.

(a) State **two** basic assumptions of the kinetic theory as applied to an ideal gas.

(i) .....

.....

(ii) .....

.....
[2]

(b) State **two** conditions under which the behaviour of a real gas approaches that of an ideal gas.

(i) .....

(ii) .....
[2]

(c) Place the following gases in decreasing order of ideal behaviour.

ammonia, neon, nitrogen

most ideal ..... **least ideal**

Explain your answer.

.....

.....
[3]

(d) By using the kinetic-molecular model, explain why a liquid eventually becomes a gas as the temperature is increased.

.....

.....

.....

.....[2]

(e) Ethane, CH_3CH_3, and fluoromethane, CH_3F are *iso*-electronic, that is they have the same total number of electrons in their molecules.

Calculate the **total** number of electrons in one molecule of CH_3F.

[1]

(f) The boiling points of these two compounds are given below.

compound	bp / K
CH_3CH_3	184.5
CH_3F	194.7

Suggest explanations for the following.

(i) the close similarity of the boiling points of the two compounds

.....

.....

(ii) the slightly higher boiling point of CH_3F

.....

.....

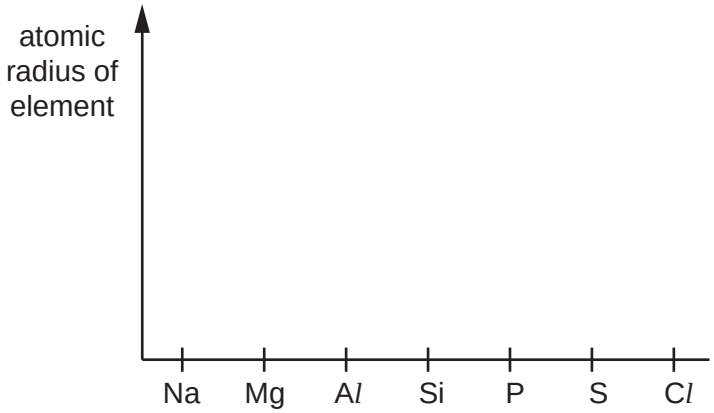
[2]

[Total: 12]

3 Elements in the same period of the Periodic Table show trends in physical and chemical properties. The grids on this page and on the opposite page refer to the elements of the third period, Na to C*l*.
On **each** of these grids, draw a clear sketch to show the variation of the stated property.
Below **each** grid, briefly explain the variation you have described in your sketch.
For each explanation you should refer to the important factors that cause the differences in the property you are describing.

For Examiner's Use

(a)



explanation .....

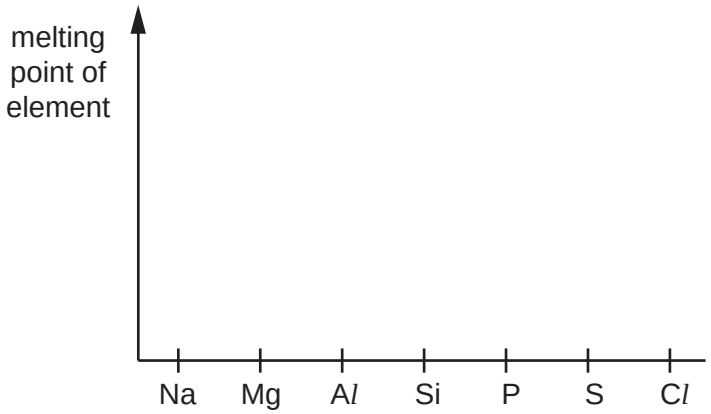
.....

.....

.....

[3]

(b)



explanation .....

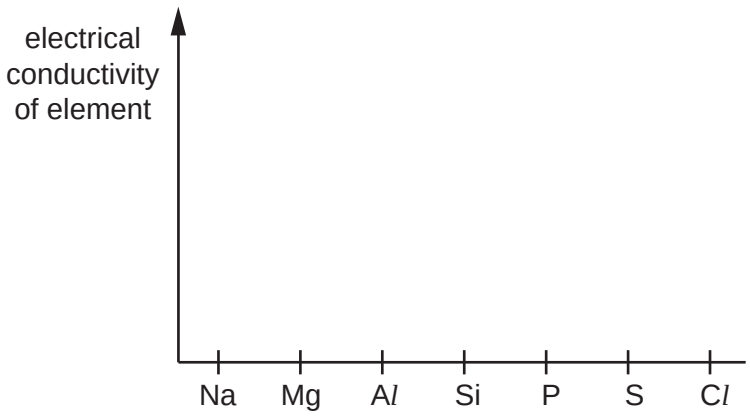
.....

.....

.....

[4]

(c)



explanation .....

.....

.....

.....

[4]

(d) The melting points of some of the oxides of the elements sodium to sulfur are given in the table below.

compound	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_6	SO_2
mp/K	1193	3173	2313	1883	297	198

(i) What type of bond is broken when **each** of the following compounds is melted?

Na_2O .....

SiO_2 .....

P_4O_6 .....

(ii) Identify **one** of these six oxides that has no reaction at all with water.

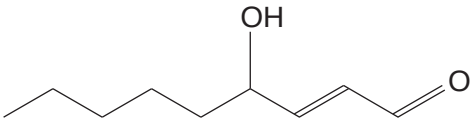
.....

[4]

[Total: 15]

4 The compound *trans*-4-hydroxy-2-nonenal (HNE) is thought to lead to infections of the lung when cigarettes are smoked.

For Examiner's Use



$CH_3(CH_2)_4CH(OH)CH=CHCHO$

***trans*-4-hydroxy-2-nonenal**

(a) What is the empirical formula of *trans*-4-hydroxy-2-nonenal?

..... [1]

(b) **(i)** HNE contains an alkene group. Name as fully as you can **two** other functional groups which are present in the HNE molecule.

.....

.....

(ii) How would you confirm the presence of the alkene group in HNE?
State the reagent used and the observation you would make.

reagent .....

observation .....
[5]

HNE is a reactive compound.

For Examiner's Use

(c) Give the structural formulae of all of the carbon-containing compounds formed in each case when HNE is reacted separately with the following reagents.

(i) hot concentrated manganate(VII) ions in acid solution

(ii) hot phosphorus trichloride, PCl_3

(iii) sodium tetrahydridoborate(III), $NaBH_4$

[4]

[Total: 10]

5 Fermentation of sugars by bacteria or moulds produces many different organic compounds.

For Examiner's Use

One compound present in fermented molasses is 2-ethyl-3-methylbutanoic acid which gives a distinctive aroma to rum.

$(CH_3)_2CHCH(C_2H_5)CO_2H$

2-ethyl-3-methylbutanoic acid

(a) (i) What is the molecular formula of 2-ethyl-3-methylbutanoic acid?

(ii) How many chiral carbon atoms are present in a molecule of 2-ethyl-3-methylbutanoic acid? If none write 'none'.

.....

[2]

A sample of 2-ethyl-3-methylbutanoic acid may be prepared in a school or college laboratory by the oxidation of 2-ethyl-3-methylbutan-1-ol, $(CH_3)_2CHCH(C_2H_5)CH_2OH$.

(b) (i) State the reagent(s) that would be used for this oxidation.
Describe what colour change would be seen.

reagent(s) .....

colour change from ..... to .....

This reaction is carried out by heating the reacting chemicals together.

(ii) What could be the main organic impurity present in the sample of the acid?

Explain your answer.

.....

.....

.....

(iii) State whether a distillation apparatus or a reflux apparatus should be used.

Explain your answer.

.....

.....

.....

[6]

(c) A structural isomer of 2-ethyl-3-methylbutan-1-ol is 2-ethyl-3-methylbutan-2-ol, $(CH_3)_2CHC(OH)(C_2H_5)CH_3$.

For Examiner's Use

What colour change would be seen if this were heated with the reagents you have given in **(b)(i)**?
Explain your answer as clearly as you can.

.....

.....

.....[3]

An isomer of 2-ethyl-3-methylbutanoic acid which is an ethyl ester is a very strong smelling compound which is found in some wines.

(d) This ethyl ester contains a branched hydrocarbon chain and is chiral.

Draw the displayed formula of this ethyl ester.

Identify the chiral carbon atom with an asterisk (*).

[3]

[Total: 14]

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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 **May/June 2011**

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 10 and 11.

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.

1 **FA 1** is sulfuric acid, H_2SO_4, of approximate concentration 0.7 mol dm^{-3}.
FA 2 is 0.150 mol dm^{-3} sodium hydroxide.
You are also provided with phenolphthalein (indicator).

For Examiner's Use

You will determine the exact concentration of **FA 1** by titration.

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

(a) Method

Dilution

- Pipette 25.0 cm^3 of **FA 1** into the 250 cm^3 graduated (volumetric) flask labelled **FA 3**.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution of **FA 3**.

Titration

- Rinse out the pipette with distilled water and then with **FA 3**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Add 5 drops of phenolphthalein indicator to the flask. The indicator should remain colourless.
- Fill the burette with **FA 2**.
- Titrate **FA 3** with **FA 2**, until a permanent pale 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 **FA 2** added in each accurate titration.
- Make sure that your 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 calculations.
Show clearly how you have obtained this value.

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

(c) Calculations

For Examiner's Use

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

(i) Calculate how many moles of NaOH were present in the volume of **FA 2** calculated in **(b)**.

..... mol of NaOH

(ii) Calculate how many moles of H_2SO_4 were present in 25.0 cm^3 of **FA 3**.

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

..... mol of H_2SO_4

(iii) Calculate how many moles of H_2SO_4 were present in 25.0 cm^3 of the undiluted solution **FA 1**.

..... mol of H_2SO_4

(iv) Calculate the concentration, in mol dm^{-3}, of H_2SO_4 in **FA 1**.

The concentration of H_2SO_4 in **FA 1** was ..... mol dm^{-3}. [4]

[Total: 12]

I	
II	
III	
IV	

2 You will determine, using Hess' Law, the enthalpy change, ΔH_1, for the reaction of magnesium with oxygen to form magnesium oxide.

For Examiner's Use

$$Mg(s) + \tfrac{1}{2}O_2(g) \rightarrow MgO(s)$$

(a) Reaction of magnesium with sulfuric acid

Method

FA 4 is 0.64 mol dm^{-3} sulfuric acid.
FA 5 is magnesium turnings. This is supplied in two containers.

You will carry out the experiment **twice**.

- Support the plastic cup in a 250 cm^3 beaker.
- Using a measuring cylinder, transfer 25 cm^3 of **FA 4** into the plastic cup.
- Tilt the beaker so that the bulb of the thermometer is covered by the solution. Measure and record the initial temperature of the solution.
- **Carefully**, add all the **FA 5** from one of the containers into the plastic cup.
- Stir the mixture constantly with the thermometer.
- Record the highest temperature obtained.
- Empty and rinse the plastic cup and dry it with a paper towel.
- Repeat the experiment using the second portion of **FA 5**.

In the space below, record all your readings in an appropriate form.
Calculate the mean temperature rise.

I	
II	
III	
IV	
V	

mean temperature rise = ... °C [5]

Calculation

Show your working and express your answers to **three** significant figures.

(i) Using the mean temperature rise above, calculate the mean heat energy produced in the reaction.
(You may assume that 4.3 J are required to raise the temperature of 1.0 cm^3 of any solution by 1.0 °C.)

heat energy produced = ...
value *unit*

(ii) Calculate the enthalpy change, ΔH_2, in $kJ\,mol^{-1}$, for the following reaction.

For Examiner's Use

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

You should assume that the magnesium in your reaction is in excess.

ΔH_2 = ... $kJ\,mol^{-1}$ [2]
sign *value*

(b) Reaction of magnesium oxide with sulfuric acid

Method

FA 4 is $0.64\,mol\,dm^{-3}$ sulfuric acid.
FA 6 is magnesium oxide.

- Using a measuring cylinder, transfer $50\,cm^3$ of **FA 4** into a $250\,cm^3$ beaker.
- Place the beaker on a tripod and gauze, and heat gently until the temperature of the acid reaches 45 °C–60 °C.
- Support a plastic cup in a $250\,cm^3$ beaker.
- Transfer all the solution of hot **FA 4** into the plastic cup.
- Stir and record the temperature of hot **FA 4**.
- **Immediately** add all the **FA 6** to the **FA 4** in the plastic cup.
- Stir the mixture constantly with the thermometer.
- Record the highest temperature obtained.

In the space below, record all your readings in an appropriate form.

[3]

[Turn over

Calculation

For Examiner's Use

Show your working and express your answers to **three** significant figures.

(i) Calculate the heat energy produced in the reaction.
(You may assume that 4.3 J are required to raise the temperature of 1.0 cm^3 of any solution by 1.0 °C.)

heat energy produced = ...
value *unit*

(ii) Calculate the enthalpy change, ΔH_3, in $kJ\,mol^{-1}$, for the following reaction.

$$MgO(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2O(l)$$

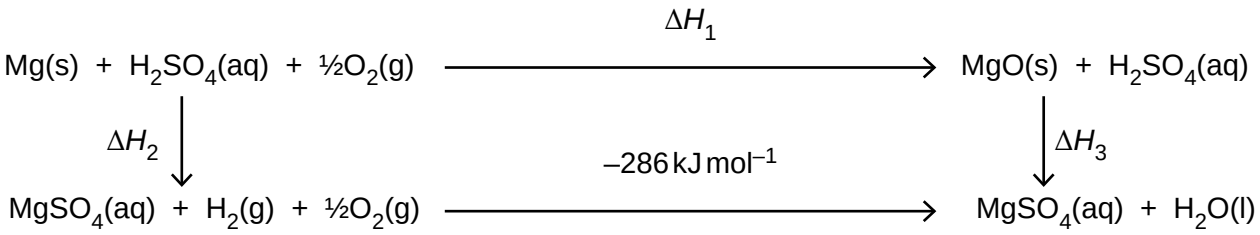
You should assume that the magnesium oxide in your reaction is in excess.

ΔH_3 = ... $kJ\,mol^{-1}$
sign *value*

(iii) The enthalpy change for the following reaction is $-286\,kJ\,mol^{-1}$.

$$H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow H_2O(l) \qquad \Delta H = -286\,kJ\,mol^{-1}$$

Use the Hess' Law cycle given below to calculate ΔH_1, the enthalpy change for the reaction of magnesium with oxygen.



ΔH_1 = ... $kJ\,mol^{-1}$ [3]
sign *value*

(c) Suggest **one** improvement to the method by which heat losses from your apparatus could have been reduced.

.....

..... [1]

[Total: 14]

3 Qualitative Analysis

For Examiner's Use

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

When 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 should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and re-use test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the full name or correct formula of the reagents must be given.

(a) **FA 7** contains one cation and one anion from those listed in the Qualitative Analysis Notes on pages 10 and 11.

Put two spatula measures of **FA 7** into a test-tube.
Add about two-thirds of a test-tube of distilled water and dissolve the solid.
For each test that you carry out, use 1 cm depth of the solution of **FA 7**.

(i) Carry out the following tests and complete the table below.

test	*observation(s)*
Add 5 drops of aqueous barium chloride (or barium nitrate) to your solution of **FA 7**.	
Add 5 drops of aqueous silver nitrate to your solution of **FA 7**.	

I	
II	
III	

[Turn over

(ii) Put a **very small** spatula measure of solid **FA 7** into a hard glass test-tube.
Hold the test-tube horizontally and heat it gently for a few seconds, then heat it strongly until no further change takes place.
Leave the test-tube to cool to room temperature.
*While cooling takes place, move on to **(iv)**.*
In the space below record the observations made at each stage in an appropriate form.

For Examiner's Use

(iii) State what deductions you can make about the identity of the anion in **FA 7** from the tests above.

.....

.....

(iv) Use the information in the Qualitative Analysis Notes on pages 10 and 11 to select a further test to confirm the identity of the anion in **FA 7**.

test .....

Carry out **this test** and, in the space below, record the observation(s) made in an appropriate form. State your conclusion.

IV	
V	
VI	
VII	
VIII	
IX	

(v) The cation in **FA 7** is aluminium ion, calcium ion or zinc ion.
Select **one reagent** to identify the cation in **FA 7**.

reagent .....

Use this reagent to carry out a test.
Record the observation(s) made and identify the cation.

.....

.....

.....

..... [9]

(b) **FA 8** contains one cation from those listed on page 10 and 11.

For Examiner's Use

Put all of the **FA 8** into a test-tube.
Half fill the test-tube with distilled water and dissolve the solid.

(i) To 1 cm depth of the solution of **FA 8** in a test-tube, add aqueous potassium iodide until the test-tube is half full. Allow the mixture to stand for two minutes.

Use a dropping pipette to transfer about 1 cm^3 of the mixture from the top of the test-tube to another test-tube. Add 5 drops of starch solution.
Record all of your observations.

I	
II	
III	
IV	
V	

(ii) State what **type** of chemical behaviour has been shown by potassium iodide in this reaction. Give an ionic equation to justify your answer.

.....

.....

.....

(iii) To another 1 cm depth of solution of **FA 8** in a test-tube, add aqueous sodium hydroxide.
Record the observation(s) made.
Give the **ionic** equation for the reaction taking place.

.....

.....

.....

.....[5]

[Total: 14]

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.]

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 acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

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 **9701/32**

Advanced Practical Skills **May/June 2011**

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

1 Many solid salts exist as hydrates. One example is washing soda – hydrated sodium carbonate, $Na_2CO_3.\mathbf{x}H_2O$.

For Examiner's Use

You are to determine the value of **x** in $Na_2CO_3.\mathbf{x}H_2O$ by titration with hydrochloric acid.

FB 1 is hydrated sodium carbonate, $Na_2CO_3.\mathbf{x}H_2O$.
FB 2 is 0.200 mol dm^{-3} hydrochloric acid, HCl.
methyl orange indicator

The equation for the reaction between hydrated sodium carbonate and hydrochloric acid is shown below.

$$Na_2CO_3.\mathbf{x}H_2O + 2HCl \longrightarrow 2NaCl + CO_2 + (\mathbf{x} + 1)\, H_2O$$

(a) Method

- Weigh the tube containing **FB 1**, the hydrated sodium carbonate. Record the mass in the space below.
- Add all the **FB 1** into a 250 cm^3 glass beaker. Reweigh the tube containing any residual **FB 1**. Record the mass in the space below.
- Calculate and record the mass of **FB 1** used.

mass of **FB 1** used = ... g

- Use the 50 cm^3 measuring cylinder to add, in total, about 100 cm^3 of distilled water to the beaker.
- Stir with a glass rod until all the solid has dissolved.
- Pour the solution from the beaker into the 250 cm^3 graduated (volumetric) flask.
- Wash out the beaker thoroughly with distilled water and add the washings to the graduated flask.
- Make up the contents of the graduated flask to the 250 cm^3 mark with distilled water.
- Shake the flask to mix the solution of **FB 1**.
- Pipette 25.0 cm^3 of your solution of **FB 1** into a conical flask.
- Add to the flask a few drops of methyl orange indicator and place the flask on a white tile.
- Fill the burette with hydrochloric acid, **FB 2**.
- Titrate the solution of **FB 1** with the acid until the end-point is reached.

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

For Examiner's Use

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

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

I	
II	
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VII	

[7]

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

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

[Turn over

(c) Calculations

For Examiner's Use

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

(i) Calculate how many moles of HCl were present in the volume of **FB 2** calculated in **(b)**.

..... mol of HCl

(ii) Calculate how many moles of $Na_2CO_3.\mathbf{x}H_2O$ were present in 25.0 cm^3 of the solution of **FB 1**.

$$Na_2CO_3.\mathbf{x}H_2O + 2HCl \longrightarrow 2NaCl + CO_2 + (\mathbf{x} + 1)\, H_2O$$

..... mol of $Na_2CO_3.\mathbf{x}H_2O$

(iii) Calculate how many moles of $Na_2CO_3.\mathbf{x}H_2O$ were present in 250 cm^3 of the solution of **FB 1**.

..... mol of $Na_2CO_3.\mathbf{x}H_2O$

(iv) Use the mass of **FB 1** that you weighed out to calculate the relative formula mass of $Na_2CO_3.\mathbf{x}H_2O$.

relative formula mass = ...

I	
II	
III	
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V	
VI	

(v) Calculate the value of **x** in $Na_2CO_3.\mathbf{x}H_2O$.
[A_r: H, 1.0; C, 12.0; O, 16.0; Na, 23.0]

For Examiner's Use

x = ... [6]

(d) The error in a single burette reading is $\pm 0.05\,cm^3$.

What is the percentage error in the titre volume calculated in **(b)**?

percentage error = ... % [1]

[Total: 15]

[Turn over

2 You are to determine the enthalpy change for the reaction of hydrated sodium carbonate, $Na_2CO_3.\mathbf{x}H_2O$, with hydrochloric acid, HC*l*(aq).

For Examiner's Use

The equation for this reaction is shown below.

$$Na_2CO_3.\mathbf{x}H_2O(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + CO_2(g) + (\mathbf{x} + 1)H_2O(l)$$

FB 3 is hydrated sodium carbonate, $Na_2CO_3.\mathbf{x}H_2O$.
FB 4 is 4.00 mol dm^{-3} hydrochloric acid, HC*l*.

Make sure that in this experiment you use the hydrochloric acid labelled FA 4.

(a) Method

- Support the plastic cup in a 250 cm^3 beaker.
- Use a measuring cylinder to transfer 25 cm^3 of **FB 4** into the plastic cup.
- Tilt the beaker so that the bulb of the thermometer is covered by the solution.
- Measure and record the temperature of the solution.
- Measure and record the mass of the tube containing **FB 3**.
- **Carefully** tip all the hydrated sodium carbonate from the weighed tube into the plastic cup.
- **There will be effervescence. Add the solid in small portions with constant stirring using the thermometer.**
- Record the lowest temperature obtained.
- Reweigh the tube containing any residual **FB 3**.

In the space below, record, in an appropriate form,

- both balance readings,
- both temperature measurements,
- the mass of **FB 3** used in the experiment,
- the fall in temperature.

I	
II	
III	
IV	
V	

[5]

(b) Calculation

Show your working and express your answers to **three** significant figures.

(i) Calculate the heat energy change involved in the reaction.
(You may assume that 4.3 J are required to change the temperature of 1.0 cm^3 of any solution by 1.0 °C.)

heat energy produced = ... J

(ii) Calculate the number of moles of $Na_2CO_3.\mathbf{x}H_2O$ you used in **2(a)**.
You will need to use the relative formula mass you calculated in **1(c)(v)**.
If you were unable to calculate the relative formula mass in **1(c),** assume it is 259 but note that this is **not** the correct value.

For Examiner's Use

..... mol of $Na_2CO_3.\mathbf{x}H_2O$

(iii) Calculate the enthalpy change, in $kJ\,mol^{-1}$, for the following reaction.

$$Na_2CO_3.\mathbf{x}H_2O(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + CO_2(g) + (\mathbf{x} + 1)H_2O(l)$$

I	
II	
III	
IV	

enthalpy change = ... $kJ\,mol^{-1}$

sign *value*

[4]

(c) In experiments carried out to determine enthalpy changes, heat transfer between the surroundings and the reactants is a significant source of error. This problem can be limited by improved insulation.

Apart from modifications made to minimise heat transfer, suggest **one** possible improvement you could make to the apparatus or procedure to make the determination of the enthalpy change more accurate.

.....

.....

..... [1]

[Total: 10]

[Turn over

3 Qualitative Analysis

For Examiner's Use

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.

Where reagents are selected for use in a test, the full name or correct formula of the reagents must be given.

(a) (i) You are provided with three solutions **FB 5**, **FB 6** and **FB 7**, each of which contains a single cation. One of these cations is aluminium, one is magnesium and the other is lead.

Use the information in the Qualitative Analysis Notes on page 11 to select reagents that would enable you to determine the cation in **FB 5**, **FB 6** and **FB 7**.

reagents .....

Carry out suitable tests and record the results of your experiments in an appropriate form in the space below.

[4]

I	
II	
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(ii) Complete the table below.

For Examiner's Use

	FB 5	FB 6	FB 7
cation			

What is the **minimum** evidence from your observations, that enables you to identify these cations?

The minimum evidence for the cation in **FB 5** is .....

.....

The minimum evidence for the cation in **FB 6** is .....

.....

The minimum evidence for the cation in **FB 7** is .....

.....

[4]

I	
II	
III	
IV	

(b) You are provided with solid **FB 8**.

Carry out the tests and complete the following table.

test	*observations*
(i) To a spatula measure of **FB 8**, in a test-tube, add about a 1 cm depth of distilled water to make a solution. To this solution add 4 pieces of magnesium ribbon.	
(ii) To a small spatula measure of **FB 8**, in a boiling tube, add 3 cm depth of aqueous sodium hydroxide. Warm gently and carefully.	
(iii) To a spatula measure of **FB 8**, in a test-tube, add about a 1 cm depth of distilled water to make a solution. To this solution add an equal volume of aqueous sodium hydroxide. ..... To this mixture add a small volume of hydrogen peroxide.	.....

Identify the metal ion present in **FB 8**.

metal ion = ...

State the change in oxidation number (state) of this metal ion that is occurring in test **(i)**.

oxidation number (state) changes from ..... to .....

State the change in oxidation number (state) of this metal ion that is occurring in test **(iii)**.

oxidation number (state) changes from ..... to .....

[7]

[Total: 15]

For Examiner's Use

I	
II	
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VI	
VII	

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 acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

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 **May/June 2011**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

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DO **NOT** WRITE IN ANY BARCODES.

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The number of marks is given in brackets [ ] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
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Total	

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UNIVERSITY of CAMBRIDGE International Examinations

1 **FA 1** is an iron salt in which all the iron is present as Fe^{2+} cations. You will work out the percentage of iron in this salt by titrating a solution of this salt with a standard solution aqueous potassium manganate(VII).

For Examiner's Use

FA 1 is an unknown iron(II) salt.
FA 2 is 1.00 mol dm^{-3} sulfuric acid.
FA 3 is 0.0100 mol dm^{-3} potassium manganate(VII).

(a) Method

Weighing out the salt

- Weigh the tube containing **FA 1**.
- Tip the contents of the tube into a 250 cm^3 beaker.
- Re-weigh the empty tube.
- Record all your readings in a suitable form in the space below.

Preparing the solution

- To the salt in the beaker use a measuring cylinder to add approximately 200 cm^3 of **FA 2** and stir until the salt has dissolved.
- Pour the contents of the beaker carefully into the 250 cm^3 graduated (volumetric) flask using the small funnel.
- Rinse the contents of the beaker twice with a little distilled water and add these washings to the graduated flask.
- Fill the graduated flask to the line with distilled water. Shake carefully to ensure adequate mixing.

Titration

- Fill the burette with **FA 3**.
- Pipette 25.0 cm^3 of the solution of **FA 1** from the graduated flask into a conical flask.
- Titrate the solution of **FA 1** in the flask with **FA 3** until the first appearance of a permanent pink colour.

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 are necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record in an appropriate form below all of your burette readings and the volume of **FA 3** added in each accurate titration.

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 calculations. Show clearly how you have obtained this value.

25.0 cm^3 of the solution of **FA 1** required ..... cm^3 of **FA 3**.
[2]

(c) Calculations

For Examiner's Use

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

(i) Calculate how many moles of $MnO_4^-(aq)$ were present in the volume of **FA 3** calculated in **(b)**.

moles of $MnO_4^-(aq)$ = ... mol

(ii) Use the following equation to calculate how many moles of $Fe^{2+}(aq)$ were present in the conical flask.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \longrightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 8H_2O(aq)$$

moles of $Fe^{2+}(aq)$ in the conical flask = ... mol

(iii) Calculate the number of moles of Fe^{2+} in your weighed sample of **FA 1**.

moles of Fe^{2+} in the weighed sample = ... mol

I	
II	
III	
IV	
V	

(iv) Calculate the percentage of iron in **FA 1**.
[A_r: Fe, 55.8]

For Examiner's Use

the percentage of iron in **FA 1** = ... %
[5]

(d) There are a number of sources of potential error in this experiment. One of these involves the readings taken using the balance.

(i) State the maximum individual error in any single balance reading.

maximum individual error = ... g

(ii) Calculate the maximum percentage error in the mass of **FA 1** used in your experiment.

maximum percentage error = ... % [2]

[Total: 16]

[Turn over

2 **FA 4** is an **impure** sample of hydrated magnesium sulfate, $MgSO_4.7H_2O$. When heated the water of crystallisation is driven off to leave anhydrous magnesium sulfate, $MgSO_4$. The impurity does not give off water when heated. By determining how much water is present in the impure sample, the percentage purity can be calculated.

For Examiner's Use

(a) Method

- Weigh a clean dry crucible.
- Empty all of the **FA 4** into the crucible.
- Reweigh the crucible and its contents.
- Support the crucible in the pipe-clay triangle on top of a tripod.
- Heat the crucible gently for about 1 minute and then more strongly for a further 4 minutes.
- Allow the crucible to cool. You should start question 3 while cooling is taking place.
- When the crucible is cool enough to handle, reweigh the crucible and its contents.
- Repeat the cycle of heating and weighing as many times as you think necessary.

In the space below, record, in an appropriate form, all your weighings and include the mass of **FA 4** used and the mass of water that was lost.

I	
II	
III	
IV	
V	

[5]

(b) Calculations

For Examiner's Use

Show your working and express your answers to **three** significant figures.

(i) Using the mass of water that was lost on heating, calculate the mass of $MgSO_4.7H_2O$ that was present in the initial sample of **FA 4**.
[A_r: H, 1.0; O, 16.0; Mg, 24.3; S, 32.1]

mass of $MgSO_4.7H_2O$ = ... g [1]

(ii) Calculate the percentage by mass of $MgSO_4.7H_2O$ in **FA 4**.

percentage by mass of $MgSO_4.7H_2O$ in **FA 4** = ... % [1]

(c) Suggest an improvement to the practical procedure that would give a more accurate value for the percentage by mass of $MgSO_4.7H_2O$ in **FA 4**.

.....

.....

..... [1]

[Total: 8]

[Turn over

Qualitative Analysis

For Examiner's Use

3 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.

Where reagents are selected for use in a test, the full name or correct formula of the reagents must be given.

FA 5 is a sodium salt.
FA 6 is a salt containing a single cation and a single anion from those listed in the Qualitative Analysis Notes on pages 11 and 12.
FA 7 is an aqueous solution of an unknown compound.

By carrying out specific tests you will identify some of the ions in these.

(a) Put a spatula measure of **FA 5** into a boiling tube. Heat it gently for a few minutes and then strongly until no further changes are seen.
Record your observations at each stage, in the space below.

[2]

Leave the boiling tube to cool. Do not discard the contents as they will be used later in the question.

(b) Put a spatula measure of **FA 6** into a test-tube. Half fill the test-tube with distilled water and dissolve the solid. You will use this solution to carry out the following tests.

- To a 1 cm depth of a solution of **FA 6** in a boiling tube, add 0.5 cm depth of aqueous sodium hydroxide using a teat pipette. Heat the mixture carefully.
- To a 1 cm depth of a solution of **FA 6** in a test-tube, add aqueous ammonia.
- To a 1 cm depth of a solution of **FA 6** in a test-tube, add aqueous barium chloride or barium nitrate.
- To a 1 cm depth of a solution of **FA 6** in a test-tube, add aqueous silver nitrate, followed by aqueous ammonia.

Record your observations for each of the tests in the space below.
Identify the ions present in **FA 6**.

For Examiner's Use

FA 6 contains ..... and ..... [6]

(c) Put a small spatula measure of **FA 6** into a boiling tube. Taking great care, add **5 drops** of concentrated sulfuric acid.
CARE: Concentrated sulfuric acid is very corrosive.

Once you have made your observations fill the boiling tube with water.
Record your observations in the space below.

What type of chemical reaction occurs between **FA 6** and sulfuric acid?
Justify your answer.

.....

..... [3]

[Turn over

(d) To the residue in the boiling tube from **(a)**, slowly and carefully add **FA 7** to a depth of about 5 cm.
Divide this solution equally into two test-tubes.
- To one test-tube add 5 drops of aqueous lead nitrate.
- To the other test-tube add 5 drops of aqueous silver nitrate.

Record your observations for each test in the space below.

For Examiner's Use

[2]

(e) Use the information in the Qualitative Analysis Notes on pages 11 and 12 to select one test to confirm the identity of the cation in **FA 7** and one test to confirm the identity of the anion in **FA 7**.
Carry out both tests and record your observations for each of the tests in the space below.
Identify the ions present in **FA 7**.

FA 7 contains ..... and ..... [3]

[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 acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

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 **May/June 2011**

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 and **1** insert.

1 You are to determine the concentration, in $mol\,dm^{-3}$, of the aqueous sodium thiosulfate. To do this you will first produce iodine solution by reacting aqueous potassium iodide with aqueous potassium manganate(VII). In this reaction iodide ions are oxidised to iodine by manganate(VII) ions in acidic solution.

For Examiner's Use

$$2MnO_4^-(aq) + 10I^-(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5I_2(aq) + 8H_2O(l)$$

You will then titrate the iodine with aqueous thiosulfate ions, in **FB 1**.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

You are provided with the following.

FB 1 is a solution of sodium thiosulfate, $Na_2S_2O_3$, of unknown concentration**.**
FB 3 is $0.0050\,mol\,dm^{-3}$ potassium manganate(VII), $KMnO_4$.
FB 4 is $0.10\,mol\,dm^{-3}$ potassium iodide, KI.
FB 5 is $1.0\,mol\,dm^{-3}$ sulfuric acid, H_2SO_4.
starch indicator

(a) Method

Dilution

- Fill the 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 2**.
- Make the solution up to the mark with distilled water.
- Shake the flask to mix the solution of **FB 2**.

In the space below record your burette readings and the volume of **FB 1** added to the graduated flask.

Titration

For Examiner's Use

- Fill a second burette with **FB 2**, the diluted sodium thiosulfate.
- Pipette 25.0 cm^3 of **FB 3** into a conical flask.
- Using a 25 cm^3 measuring cylinder, add about 10 cm^3 of **FB 4**.
- Using the same measuring cylinder, add about 10 cm^3 of **FB 5**.
- Titrate the mixture in the flask with **FB 2** until the colour is pale yellow.
- Add about 10 drops of starch indicator. A blue-black colour should be seen as the starch reacts with the remaining iodine.
- Continue to add **FB 2** until the blue-black colour just disappears leaving a colourless solution.

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.
- Make certain any recorded results show the precision of your practical work.
- Record in an appropriate form below all of your burette readings and the volume of **FB 2** added in each accurate titration.

I	
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[7]

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

The iodine produced by 25.0 cm^3 of **FB 3** required …… cm^3 of **FB 2**. [1]

[Turn over

(c) Calculations

For Examiner's Use

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

(i) Calculate how many moles of MnO_4^- were pipetted into the conical flask.

..... mol of MnO_4^-

(ii) Calculate how many moles of I_2 were produced from the number of moles of MnO_4^- calculated in **(i)**.

$$2MnO_4^-(aq) + 10I^-(aq) + 16H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5I_2(aq) + 8H_2O(l)$$

..... mol of I_2

(iii) Calculate how many moles of $S_2O_3^{2-}$ reacted with the I_2 in **(ii)**.

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

..... mol of $S_2O_3^{2-}$

(iv) Calculate how many moles of $S_2O_3^{2-}$ were present in the 250 cm^3 graduated (volumetric) flask.

..... mol of $S_2O_3^{2-}$

(v) Use your answer to **(iv)** and the volume of **FB 1** that was diluted to calculate the concentration, in mol dm^{-3}, of the original solution of sodium thiosulfate, **FB 1**.

The concentration of $Na_2S_2O_3$ in **FB 1** was ..... mol dm^{-3}.
[6]

I	
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VI	

(d) The maximum error for a 25 cm^3 pipette commonly used in schools is ±0.06 cm^3.
The maximum individual error in any single burette reading is ±0.05 cm^3.

For Examiner's Use

Calculate each of the following.

The maximum percentage error in the volume of **FB 3** pipetted into the conical flask

maximum percentage error in the pipetted volume of **FB 3** = ... %

The maximum percentage error in the titre calculated in **(b)**

maximum percentage error in the titre volume = ... %
[1]

[Total: 15]

[Turn over

2 You are to investigate how the rate of the following reaction varies with the concentration of sodium thiosulfate, $Na_2S_2O_3$.

For Examiner's Use

$$Na_2S_2O_3(aq) + H_2SO_4(aq) \rightarrow S(s) + Na_2SO_4(aq) + SO_2(g) + H_2O(l)$$

The rate can be found by measuring how long it takes for the solid sulfur formed to obscure the printing on the insert provided.

Care should be taken to avoid inhalation of $SO_2(g)$ that is given off during this reaction.

FB 5 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4.
FB 6 is 0.10 mol dm^{-3} sodium thiosulfate $Na_2S_2O_3$.

Read through the instructions carefully and prepare a table for your results on page 7 before starting any practical work.

(a) Method

- Using the 50 cm^3 measuring cylinder transfer 45 cm^3 of **FB 6** into a 100 cm^3 beaker.
- Using the 25 cm^3 measuring cylinder measure 10 cm^3 of **FB 5**.
- Tip the **FB 5** into the **FB 6** in the beaker and **immediately** start timing.
- Stir the mixture once with a glass rod and place it on top of the printed insert.
- View the printed insert from above so that it is seen through the mixture.
- Record the time, to the nearest second, when the printing on the insert **just** disappears.

- Empty and rinse the beaker. Shake out as much of the water as possible and dry the outside of the beaker.
- You will repeat the experiment to find out how the time for the printing on the insert to disappear changes when a different volume of **FB 6** is used.
- Using the 50 cm^3 measuring cylinder transfer 20 cm^3 of **FB 6** and 25 cm^3 of distilled water into the 100 cm^3 beaker.
- Using the 25 cm^3 measuring cylinder add 10 cm^3 of **FB 5** to the mixture and **immediately** start timing.
- Stir the mixture once with a glass rod and place it on top of the printed insert.
- View the printed insert from above so that it is seen through the mixture.
- Record the time, to the nearest second, when the printing on the insert **just** disappears.

- Select suitable volumes of **FB 6 and** distilled water for **two** further experiments to investigate the effect of volume of sodium thiosulfate on the time taken for the printing on the insert to **just** disappear.

Calculate the values of 1/time, where time is in seconds, to an appropriate number of significant figures.

In the space below, record, in an appropriate form, all measurements of volume, time, and your calculated values of 1/time.

For Examiner's Use

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II	
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V	

[5]

(b) Why was the **total** volume of solution kept constant in the experiments?

.....

..... [1]

(c) It may be assumed that the rate of reaction is proportional to 1/time.
Draw a conclusion from your results about the relationship between the concentration of sodium thiosulfate used and the rate of reaction.
Explain your answer.

.....

.....

..... [1]

(d) In the four experiments, which value of the time measured had the greatest error?
Explain your answer.

.....

.....

..... [1]

(e) How could the procedure be adapted to find the effect of changing the concentration of acid on the rate of reaction?

.....

.....

..... [1]

[Total: 9]

[Turn over

3 Qualitative Analysis

For Examiner's Use

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.

Where reagents are selected for use in a test the full name or correct formula of the reagents must be given.

There are two parts to this question. In the first part you will analyse three metal salts, **FB 7**, **FB 8** and **FB 9**, to identify the cation in each. In the second part you will carry out a series of tests on a different salt, **FB 10**, to identify the anion.

(a) **FB 7**, **FB 8** and **FB 9** each contain one of aluminium ions, lead ions or zinc ions.
By reference to the Qualitative Analysis Notes on pages 11 and 12, select **two** appropriate reagents to perform tests to identify the cations present.

reagent .....

Record the tests performed and the results of those tests in an appropriate form in the space below.

I	
II	
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V	

[5]

(b) From your observations, identify the cations present in **FB 7**, **FB 8** and **FB 9**. State the **minimum** evidence to support each of your choices.

FB 7 contains …… cations.

evidence .....

.....

FB 8 contains …… cations.

evidence .....

.....

FB 9 contains …… cations.

evidence .....

.....

[3]

For Examiner's Use

(c) You are provided with a solid sample of **FB 10** which is a metal salt. Use this sample to perform the experiments described below.
Record all your observations in the table.

	test	*observations*
(i)	Place a spatula measure of solid **FB 10** into a dry hard-glass tube. Hold the test-tube in a holder. Heat the test-tube gently at first	
	and then **very strongly** for several minutes.	
	Allow the test-tube to cool, and then half fill it with distilled water. Dissolve the solid residue. This is **FB 11**. Retain this for tests **(iv)** and **(v)**. **While you are waiting for the test-tube to cool, continue with experiment (c)(ii) and (iii).**	
(ii)	Pour a 2 cm depth of aqueous copper(II) sulfate in a test-tube. Add a spatula measure of solid **FB 10**.	
(iii)	Pour a 2 cm depth of aqueous aluminium sulfate into a test-tube. Add a spatula measure of solid **FB 10**.	

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II	
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V	

[Turn over

test	*observations*
(iv) Pour a 2 cm depth of solution **FB 11** into a test-tube. Add the same volume of aqueous barium chloride.	
Then, using a dropping pipette, add dilute hydrochloric acid until no further change is seen.	
(v) Pour 1 cm depth of **FB 11** into a test-tube and add an equal depth of aqueous copper(II) sulfate.	
Transfer the contents of the test-tube into an evaporating dish and place it over a Bunsen burner on a tripod and gauze. Heat strongly until all the water has been driven off and no further change is seen.	

For Examiner's Use

[5]

(d) Consider your observations in **(c)** and answer the following questions. In each case, provide evidence from your observations to support your conclusions.

(i) Identify the anion present in **FB 11** and state evidence to support your choice.

FB 11 contains the …… anion.

evidence .....

.....

(ii) Suggest what type of reaction occurs as **FB 10** is converted into **FB 11**.

.....

.....

(iii) Suggest an explanation for what you observed in **(c)(iii)**.

.....

.....

[3]

[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 acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

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 **9701/35**

Advanced Practical Skills **May/June 2011**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

READ THESE INSTRUCTIONS FIRST

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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 14 and 15.

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 **15** printed pages and **1** blank page.

You are to determine the percentage by mass of water in the borax crystals.

For Examiner's Use

Borax reacts with hydrochloric acid according to the equation.

$$Na_2B_4O_7(aq) + 2HCl(aq) + 5H_2O(l) \rightarrow 2NaCl(aq) + 4H_3BO_3(aq)$$

1 **FA 1** is an aqueous solution containing 38.10 g dm^{-3} of **borax** crystals. **Borax** has the formula, $Na_2B_4O_7.\mathbf{x}H_2O$.
FA 2 is 1.00 mol dm^{-3} hydrochloric acid, HCl.

You are also provided with an indicator suitable for the titration of a strong acid and a weak base.

The indicator provided is .....

(a) Method

Dilution

- Fill the burette with **FA 2**.
- Run between 44.50 cm^3 and 45.50 cm^3 of **FA 2** from the burette into the 250 cm^3 graduated (volumetric) flask, labelled **FA 3**.
- Make the solution up to the mark with distilled water.
- Shake the flask to mix the solution of **FA 3**.

In the space below record your burette readings and the volume of **FA 2** added to the graduated flask.

Titration

- Fill a second burette with **FA 3**, the diluted hydrochloric acid.
- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Add to the flask a few drops of the indicator provided.
- Titrate the borax in the flask with **FA 3** until the appropriate colour change is observed for the end-point.

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.
- Make certain any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FA 3** added in each accurate titration.

For Examiner's Use

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[7]

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

25.0 cm^3 of **FA 1** required …….. cm^3 of **FA 3**.
[1]

(c) Calculations

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

(i) Calculate the concentration of hydrochloric acid, in mol dm^{-3}, in the diluted solution, **FA 3**.

The concentration of HCl in **FA 3** was …….. mol dm^{-3}.

(ii) Calculate how many moles of HCl were present in the volume of **FA 3** calculated in **(b)**.

…….. mol of HCl

(iii) Calculate how many moles of $Na_2B_4O_7$ reacted with the HC*l* in **(ii)**.

$$Na_2B_4O_7(aq) + 2HCl(aq) + 5H_2O(l) \rightarrow 2NaCl(aq) + 4H_3BO_3(aq)$$

The HC*l* run from the burette reacted with …….. mol of $Na_2B_4O_7$.

(iv) Calculate the concentration, in g dm^{-3}, of $Na_2B_4O_7$ in **FA 1**.
[A_r: B, 10.8; O, 16.0; Na, 23.0]

The concentration of $Na_2B_4O_7$ in **FA 1** is …….. g dm^{-3}.

(v) Use your answer to **(iv)** and the information at the start of question 1 to calculate the percentage by mass of water in the borax crystals, $Na_2B_4O_7.\mathbf{x}H_2O$.
[A_r: H, 1.0; B, 10.8; O, 16.0; Na, 23.0]

Borax crystals contain …….. % water.
[6]

(d) The maximum error for a 25 cm^3 pipette commonly used in schools is ±0.06 cm^3.
The maximum error in any single burette reading is ±0.05 cm^3.

Calculate the maximum percentage error in each of the following.

(i) The volume of **FA 1** pipetted into the conical flask.

maximum percentage error in the pipetted volume = …….. %.

(ii) The titre volume calculated in **(b)**.

maximum percentage error in titre volume = …….. %.
[1]

[Total: 15]

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For Examiner's Use

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2 Read through the question carefully before starting any practical work.

For Examiner's Use

Sodium carbonate, Na_2CO_3,
- reacts exothermically with hydrochloric acid,
- does not decompose when heated,
- reacts with acids.
  $CO_3^{2-}(s) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

Sodium hydrogencarbonate, $NaHCO_3$,
- reacts endothermically with hydrochloric acid,
- decomposes when heated,
  $2HCO_3^-(s) \rightarrow H_2O(g) + CO_2(g) + CO_3^{2-}(s)$
- reacts with acids.
  $HCO_3^-(s) + H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

You are to measure the temperature changes when samples of
(i) sodium carbonate,
(ii) sodium hydrogencarbonate,
(iii) a mixture of sodium carbonate and sodium hydrogencarbonate,
react with an excess of hydrochloric acid.

FA 4 is sodium carbonate, Na_2CO_3.
FA 5 is sodium hydrogencarbonate, $NaHCO_3$.
FA 6 is a mixture of sodium carbonate and sodium hydrogencarbonate.
FA 7 is 3.0 mol dm^{-3} hydrochloric acid, HCl.

Method

(a) sodium carbonate

- Support the plastic cup in a 250 cm^3 beaker.
- Use a measuring cylinder to transfer 50 cm^3 of **FA 7** into the plastic cup.
- Measure and record the temperature of the acid in the cup.
- Measure and record the mass of the container labelled **FA 4**, containing Na_2CO_3.
- **Carefully** tip the sodium carbonate from the weighed container **FA 4** into the hydrochloric acid in the plastic cup.
  Note: There will be vigorous effervescence. Do not breathe the vapour. Add the solid in small portions with constant stirring using the thermometer.
- Record the highest temperature obtained.
- Reweigh the container **FA 4** with any residual sodium carbonate. Record the mass.
- Empty and rinse the plastic cup and dry it using a paper towel.

In the space at the top of the next page, record, in an appropriate form,

- both balance readings and both temperature measurements,
- the mass of sodium carbonate, $\mathbf{m_1}$, used in the experiment,
- the temperature rise, $\Delta\mathbf{T_1}$.

For Examiner's Use

I	
II	
III	
IV	

[4]

Calculate the rise in temperature for each gram of sodium carbonate used in the experiment.

$\frac{\Delta T_1}{m_1}$ = [+] ..... °C g^{-1}

sign *value*

(b) sodium hydrogencarbonate

- Support the plastic cup in a 250 cm^3 beaker.
- Use a measuring cylinder to transfer 50 cm^3 of **FA 7** into the plastic cup.
- Measure and record the temperature of the acid in the cup.
- Measure and record the mass of the container labelled **FA 5**, containing $NaHCO_3$.
- **Carefully** tip the sodium hydrogencarbonate from the weighed container **FA 5** into the hydrochloric acid in the plastic cup.
  Note: There will be vigorous effervescence. Add the solid in small portions with constant stirring using the thermometer.
- Record the lowest temperature obtained.
- Reweigh the container **FA 5** with any residual sodium hydrogencarbonate. Record the mass.
- Empty and rinse the plastic cup and dry it using a paper towel.

In the space below, record, in an appropriate form,

- both balance readings and both temperature measurements,
- the mass of sodium hydrogencarbonate, $\mathbf{m_2}$, used in the experiment,
- the temperature fall, $\Delta\mathbf{T_2}$.

I	
II	

[2]

Calculate the fall in temperature for each gram of sodium hydrogencarbonate used in the experiment.

$\frac{\Delta T_2}{m_2}$ = [–] ..... °C g^{-1}

sign *value*

[Turn over

(c) mixture of sodium carbonate and sodium hydrogencarbonate

For Examiner's Use

- Support the plastic cup in a 250 cm^3 beaker.
- Use a measuring cylinder to transfer 50 cm^3 of **FA 7** into the plastic cup.
- Measure and record the temperature of the acid in the cup.
- Measure and record the mass of a clean, dry, weighing-bottle or tube.
- Add to the tube between **8.5 g and 9.5 g** of the mixture **FA 6**.
- Record the mass of the weighing-bottle or tube + **FA 6**.
- **Carefully** tip the weighed mixture into the hydrochloric acid in the plastic cup.
- **Note: There will be vigorous effervescence. Add the solid in small portions with constant stirring using the thermometer.**
- Record the highest or lowest temperature obtained.
- Reweigh the weighing-bottle or tube with any residual mixture. Record the mass.

In the space below, record, in an appropriate form,

- all balance readings and temperature measurements,
- the mass of the mixture, $\mathbf{m_3}$, used in the experiment,
- the temperature change, $\Delta\mathbf{T_3}$.

Make certain that your recorded temperature change carries an appropriate sign.

I	
II	

[2]

(d) Transfer the following data from parts **(a)**, **(b)** and **(c)**.

(a) $\frac{\Delta T_1}{m_1}$ = **+** ..... °C g^{-1}

(b) $\frac{\Delta T_2}{m_2}$ = **—** ..... °C g^{-1}

(c) $\mathbf{m_3}$ = ... g $\mathbf{\Delta T_3}$ = [ ] ..... °C

sign

For Examiner's Use

The masses of sodium carbonate and sodium hydrogencarbonate in the weighed sample of the mixture used in experiment **(c)** can be represented as follows.

mass of sodium carbonate / g = **W**

mass of sodium hydrogencarbonate / g = ($\mathbf{m_3}$ – **W**)

Evaluate the following equation to determine a value for **W**.

$$[\ \mathbf{W} \times \frac{\Delta \mathbf{T_1}}{\mathbf{m_1}}\ ] + [(\mathbf{m_3} - \mathbf{W}) \times \frac{\Delta \mathbf{T_2}}{\mathbf{m_2}}\ ] = \Delta \mathbf{T_3}$$

The mass of sodium carbonate was …… g.
[1]

(e) Use the information at the beginning of question 2 to outline an alternative method that could be used in a school laboratory to find the mass of sodium carbonate and the mass of sodium hydrogencarbonate in the mixture **FA 6**.

.....

.....

.....

.....
[1]

[Total: 10]

3 Qualitative Analysis

For Examiner's Use

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.

Where reagents are selected for use in a test, the full name or correct formula of the reagents must be given.

FA 8, **FA 9** and **FA 10** are aqueous solutions each containing a sodium cation and a single anion which could be a nitrite, a nitrate or a halide.

(a) By reference to the Qualitative Analysis Notes on page 15, select a single reagent that would enable you to identify any solution containing the nitrite ion, NO_2^-.

reagent .....

Use **this reagent** to test each of the solutions. Record your observations in the table below. State clearly where no reaction has been observed.

solution	*observation*
FA 8	
FA 9	
FA 10	

[2]

(b) By reference to the Qualitative Analysis Notes on page 15, select **one** reagent that would show that a halide ion is present.

reagent .....

Use **this reagent** to test each of the solutions.
Record your observations in an appropriate form in the space below.

For Examiner's Use

Select **another** reagent to **identify or confirm** which halide ions are present in the solutions.

reagent .....

Tick the appropriate statement about the use of this reagent.

It is added to the tube already containing the first reagent.	
It is added to a fresh sample of solution.	

Use **this reagent** to identify or confirm which halide ions are present in the solutions and record your observations in an appropriate form in the space below.

[3]

I	
II	
III	

(c) From the results in **(a)** and **(b)** state which anions have been identified in the solutions.

Complete the following table.
Place a cross in any box if no anion has been identified.

solution	**FA 8**	**FA 9**	**FA 10**
anion present			

[1]

[Turn over

FA 11 and **FA 12** are aqueous solutions each containing one cation from those listed in the Qualitative Analysis Notes printed on page 14.

For Examiner's Use

(d) Use aqueous sodium hydroxide and aqueous ammonia in separate tests to identify the cation present in each of the solutions.
You will also require some of the solution, **FA 11**, for tests in **(f)**.

Record the results of your experiments with sodium hydroxide and ammonia in an appropriate form in the space below.

I	
II	
III	

[3]

(e) Identification of the cations in FA 11 and FA 12

Complete the table below.

solution	**FA 11**	**FA 12**
cation present		

What is the evidence **from your observations in (d)** that enables you to identify the cation present in each of the solutions?

The evidence supporting the conclusion for the cation in **FA 11** is

I	
II	

.....

.....

The evidence supporting the conclusion for the cation in **FA 12** is

.....

.....

[2]

(f) Complete the following table.

For Examiner's Use

	test	*observations*
(i)	Pour 1 cm depth of **FA 11** into a test-tube. Add 1 cm depth of aqueous potassium iodide. Divide this mixture into two parts for use in **(ii)** and **(iii)**	
(ii)	To the first part of the mixture from **(i)** add a few drops of starch solution.	
(iii)	To the second part of the mixture from **(i)** add aqueous sodium thiosulfate, a drop at a time, until no further change is observed.	

In part **(i)** and in part **(iii)** redox reactions have taken place.

Complete the table below to show the ion or molecule which has been oxidised and the ion or molecule which has been reduced in each of these reactions.

reaction	*the ion or molecule which has been*	
	oxidised	*reduced*
(i)		
(iii)		

[4]

I	
II	
III	
IV	

[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.]

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 acids)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

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 Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/41**

Paper 4 Structured Questions **May/June 2011**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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 pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

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 **18** printed pages and **2** blank pages.

Section A

For Examiner's Use

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

1 Taken together, nitrogen and oxygen make up 99% of the air. Oxygen is by far the more reactive of the two gases, and most of the substances that react with air combine with the oxygen rather than with the nitrogen.

(a) State **one** reason why the molecule of nitrogen, N_2, is so unreactive.

.....[1]

Despite the apparent lack of reactivity of N_2, nitrogen atoms have been found to form bonds with almost all of the elements in the Periodic Table. Lithium metal reacts with nitrogen gas at room temperature to give lithium nitride, Li_3N. Magnesium produces magnesium nitride, Mg_3N_2, as well as magnesium oxide, when heated in air.

(b) Calculate the lattice energy of magnesium nitride using the following data, in addition to relevant data from the *Data Booklet*.

enthalpy change	value/kJ mol^{-1}
atomisation of Mg(s)	+148
total of electron affinities for the change $N(g) \rightarrow N^{3-}(g)$	+2148
enthalpy of formation of $Mg_3N_2(s)$	–461

lattice energy = ...kJ mol^{-1} [3]

(c) Lithium reacts readily with nitrogen, and because of this Li_3N has been considered as a possible intermediate in the 'fixing' of nitrogen to make ammonia-based fertilisers.

For Examiner's Use

$$N_2(g) \xrightarrow{+\ Li} Li_3N \xrightarrow{+\ H_2O} NH_3 \ +\ \mathbf{A}$$

(i) Construct an equation for the reaction between Li_3N and H_2O, and hence identify compound **A**.

.....

(ii) Using your knowledge of the Haber process, consider **one** advantage and **one** disadvantage of using lithium as a means of fixing nitrogen, rather than the Haber process.

advantage of the lithium method

.....

disadvantage of the lithium method

.....

[3]

(d) Another possible advantage of Li_3N is that it contains a large percentage by mass of nitrogen. Another fertiliser that contains a large percentage by mass of nitrogen is urea, NH_2CONH_2.

(i) Calculate and compare the percentages by mass of nitrogen in Li_3N and NH_2CONH_2.

.....

.....

.....

(ii) What *class* of organic compound is urea?

.....

(iii) Write an equation for the production of ammonia by the reaction between urea and water.

.....

(iv) Urea can be applied directly to the soil either before or during the growing of crops.
What would be a major **disadvantage** of using lithium nitride in this way?

.....

.....

[5]

[Total: 12]

[Turn over

For Examiner's Use

2 **(a)** State briefly what is meant by the following terms.

(i) reversible reaction

.....

(ii) dynamic equilibrium

.....

.....

[2]

(b) Water ionises to a small extent as follows.

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq) \qquad \Delta H = +58\,kJ\,mol^{-1}$$

(i) Write an expression for K_c for this reaction.

.....

(ii) Write down the expression for K_w, the ionic product of water, and explain how this can be derived from your K_c expression in **(i)**.

.....

.....

(iii) State and explain how the value of K_w for hot water will differ from its value for cold water.

.....

.....

[3]

(c) K_w can be used to calculate the pH of solutions of strong and weak bases.

(i) Use the value of K_w in the *Data Booklet* to calculate the pH of $0.050\,mol\,dm^{-3}$ NaOH.

pH = ...

Ammonia ionises slightly in water as follows.

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

The following expression applies to this equilibrium.

$$[H_2O] \times K_c = [NH_4^+][OH^-]/[NH_3] = 1.8 \times 10^{-5}\,mol\,dm^{-3}$$

(ii) Calculate $[OH^-(aq)]$ in a $0.050\,mol\,dm^{-3}$ solution of NH_3. You may assume that only a small fraction of the NH_3 ionises, so that $[NH_3]$ at equilibrium remains at $0.050\,mol\,dm^{-3}$.

For Examiner's Use

$[OH^-(aq)]$ = ...

(iii) Use the value of K_w in the *Data Booklet*, and your answer in **(ii)**, to calculate $[H^+(aq)]$ in $0.050\,mol\,dm^{-3}$ $NH_3(aq)$.

$[H^+(aq)]$ = ...

(iv) Calculate the pH of this solution.

pH = ...

[6]

[Total: 11]

[Turn over

For Examiner's Use

3 **(a)** State and explain the variation in the oxidation numbers of the chlorides of the elements Na, Mg, A*l* and Si.

.....

.....

.....

.....[2]

(b) Describe the reaction of phosphorus(V) chloride with water, and write an equation for the reaction.

.....

.....[2]

(c) When microwave radiation is passed through phosphorus(III) chloride, PCl_3, at low pressure, a new chloride of phosphorus, **B**, is formed.
B contains 69.6% by mass of chlorine and 30.4% by mass of phosphorus, and its M_r is approximately 200.

(i) Calculate the empirical and molecular formulae of **B**.

.....

(ii) Assuming phosphorus and chlorine show their typical valencies, draw the displayed formula of **B**, showing all bonds and lone pairs.

.....

(iii) Calculate the oxidation number of phosphorus in **B**.

.....

(iv) One mole of **B** reacts with four moles of water.
Suggest the structure of the phosphorus-containing product of this reaction.

.....
[6]

[Total: 10]

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For Examiner's Use

4 The combustion of fuels in motor vehicles, trains, aeroplanes and power stations produces the pollutant gas NO_2.

(a) Write an equation to show how NO_2 is formed in these situations.

.....[1]

(b) **(i)** How is the NO_2 removed from the exhaust gases of motor vehicles?

.....

(ii) Write an equation for this process.

.....
[2]

(c) Suggest whether the production of the pollutant NO_2 would be reduced if fossil fuels were replaced by hydrogen as a fuel for combustion. Explain your answer.

.....

.....[1]

(d) In the atmosphere, NO_2 acts as a catalyst for the oxidation of SO_2 to SO_3.

$$SO_2(g) + \tfrac{1}{2}\,O_2(g) \xrightarrow{NO_2} SO_3(g)$$

(i) What is the environmental significance of this reaction?

.....

The oxidation takes place in two steps. The initial reaction is that between NO_2 and SO_2.

reaction 1 $NO_2(g) + SO_2(g) \rightleftharpoons NO(g) + SO_3(g)$ $\quad \Delta H = -168\,kJ\,mol^{-1}$

(ii) Write an equation to show how the NO_2 is regenerated in the second step of the oxidation.

.....

(iii) Write an expression for the equilibrium constant, K_p for *reaction 1*, stating its units.

K_p =

units .....

(iv) If equal amounts of $NO_2(g)$ and $SO_2(g)$ are allowed to react at room temperature, it is found that 99.8% of the gases have been converted into products at equilibrium. Calculate a value for K_p.

K_p = ...

(v) The temperature of the atmosphere decreases with height. How will this affect the position of the equilibrium in *reaction 1*? Explain your answer.

For Examiner's Use

.....

.....

[7]

[Total: 11]

5 **(a)** There are several ways of introducing chlorine atoms into organic molecules. State the reagents and conditions necessary to carry out the following transformations.

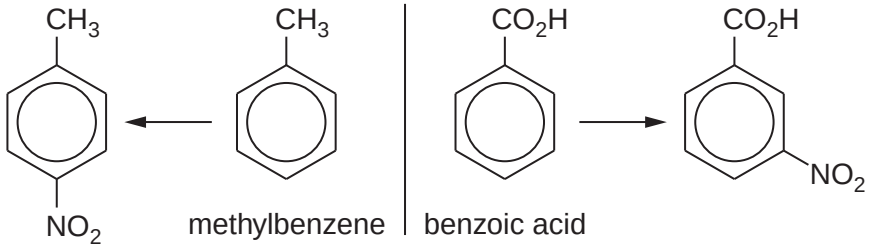
For Examiner's Use

transformation	reagents + conditions
$C_2H_4 \longrightarrow C_2H_5Cl$	
$C_2H_5OH \longrightarrow C_2H_5Cl$	
$C_2H_6 \longrightarrow C_2H_5Cl$	
$C_2H_4 \longrightarrow C_2H_4Cl_2$	
$CH_3CO_2H \longrightarrow CH_3COCl$	
	
	

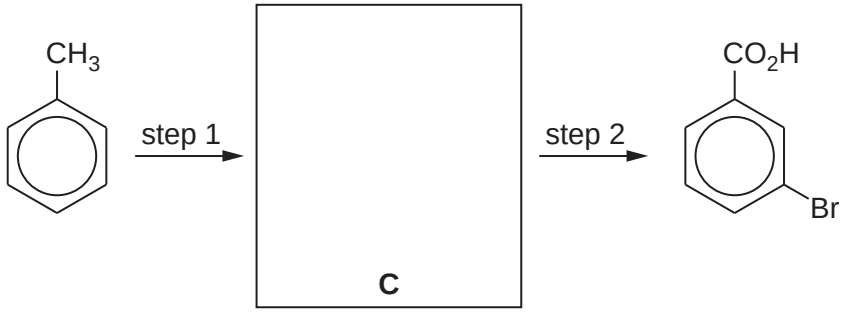
[6]

(b) **(i)** When treated with concentrated HNO_3 + H_2SO_4 at 55 °C, benzene produces nitrobenzene.
Outline the mechanism of this reaction. You should include all charges, and use curly arrows to represent the movement of electron pairs.

In aromatic substitution of monosubstituted benzenes, the orientation of an incoming group depends on the nature of the group already attached to the ring.
For example, using the same reagents and conditions as in **(i)**, methylbenzene and benzoic acid produce the following nitro compounds.



(ii) Using this information as an aid, suggest a structure for compound **C** in the following synthesis of 3-bromobenzoic acid.



(iii) Suggest reagents and conditions for steps 1 and 2.

step 1	step 2

[6]

[Total: 12]

[Turn over

6 **(a)** The reaction producing tri-iodomethane (iodoform) can be used as a test for the presence of certain groups within a molecule.

(i) State the reagents and conditions used for this reaction.

.....

(ii) Write the structural formula of **one** functional group that would give a positive result with this iodoform reaction.

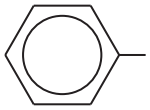
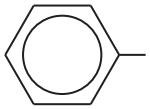
.....

(iii) What do you observe in a positive test?

.....

.....

(iv) In the following table place a tick (✓) in the column against each compound that would give a positive result with this test, and a cross (✗) against each compound that would give a negative result.

compound	result
CH_3OH	
CH_3CH_2OH	
CH_3CHO	
CH_3CO_2H	
	
	

[6]

(b) The iodoform test can be used, along with other reactions, to work out the structures of unknown compounds.
Use the information in the table below to deduce the structures of the compounds in the following scheme, and draw these structures in the boxes provided.

$$\underset{\textbf{D}}{C_7H_{12}O} \xrightarrow{\text{hot concentrated acidified } KMnO_4} \underset{\textbf{E}}{C_3H_6O} + \underset{\textbf{F}}{C_4H_6O_3}$$

Results of tests (✓ indicates a positive result; ✗ indicates a negative result)

test	results of tests with each compound		
	D	**E**	**F**
iodoform	✗	✓	✓
Fehling's solution	✓	✗	✗
2,4-dinitrophenyl-hydrazine reagent	✓	✓	✓
Na_2CO_3(aq)	✗	✗	✓

structures

D($C_7H_{12}O$)	**E**(C_3H_6O)	**F**($C_4H_6O_3$)

[3]

(c) Treatment of compound **F** with $NaBH_4$ gives compound **G**, $C_4H_8O_3$. Heating **G** with Al_2O_3 gives a mixture of three isomeric unsaturated carboxylic acids **H**, **J** and **K**, $C_4H_6O_2$, two of which are stereoisomers of each other.
Suggest structures for **G**, **H**, **J**, and **K**, and name the type of stereoisomerism shown.

G	$\xrightarrow{Al_2O_3}$	**H**	+	**J**	+	**K**

type of stereoisomerism ..... [5]

[Total: 14]

[Turn over

Section B

For Examiner's Use

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

7 Enzymes are a special group of protein molecules present in large amounts in living organisms. Enzymes behave as catalysts but, unlike inorganic catalysts, they generally catalyse only one particular reaction.

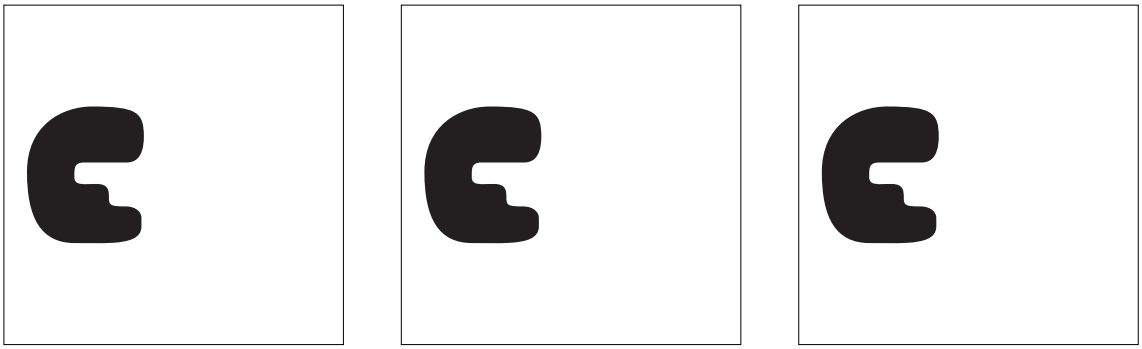
(a) Inorganic catalysts often work better on heating, but enzymes rarely work at temperatures much above 45°C. Explain why this is the case.

.....

.....

.....[2]

(b) Using the shape below to represent an enzyme, sketch how an enzyme is specific to the breakdown of a particular substrate molecule



enzyme + substrate enzyme-substrate complex enzyme + products

[3]

(c) Describe the effects of a competitive, and of a non-competitive inhibitor on the interaction between enzyme and substrate.

For Examiner's Use

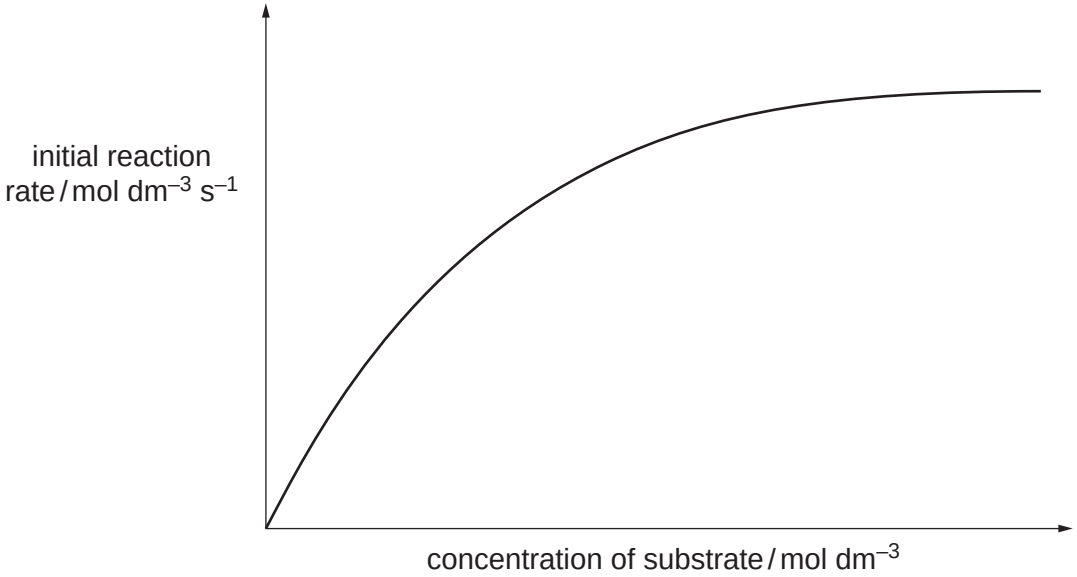
.....

.....

.....

.....[2]

(d) **(i)** The diagram shown illustrates an enzyme-catalysed reaction. On the diagram sketch the graph that would be obtained if the same reaction was carried out in the presence of a **non-competitive** inhibitor.



(ii) Explain why a **non-competitive** inhibitor has this effect on the reaction.

.....

.....
[3]

[Total: 10]

For Examiner's Use

8 Chromatography is an important analytical technique in chemistry. There is a number of techniques under the general heading of chromatography.

(a) Paper and gas chromatography rely on partition to separate the components in a mixture, whereas thin-layer chromatography uses adsorption.

Explain what is meant by **(i)** *partition* and **(ii)** *adsorption*, in the context of chromatography.

(i) partition .....

.....

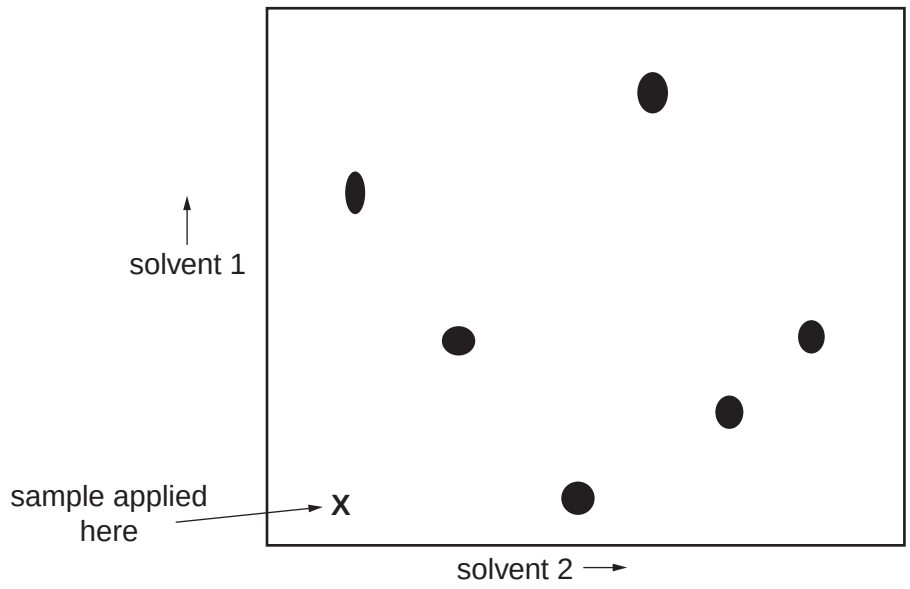
.....

(ii) adsorption .....

.....

.....[2]

(b) In paper or thin-layer chromatography, better separation may be achieved by running the chromatogram in one solvent, then turning the paper at right angles and running it in a second solvent. The chromatogram below was produced in this way.



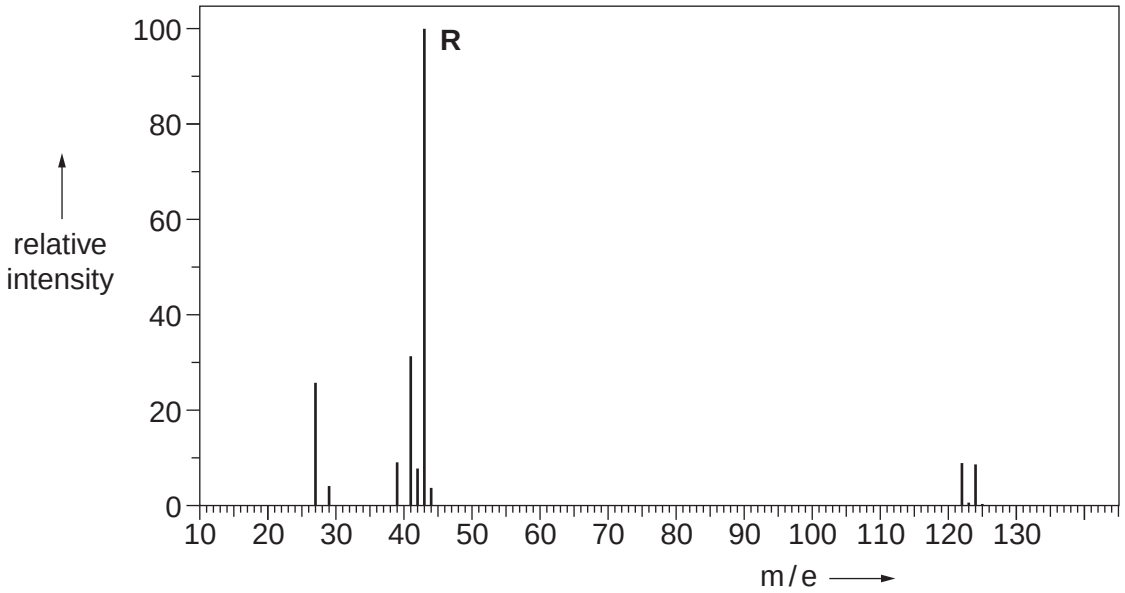
(i) Ring the spot which was insoluble in solvent 1.

(ii) Label as **A** and **B** the spots which were **not** resolved using solvent 1.

[2]

(c) The mass spectrum shown was obtained from a compound of formula C_pH_qX, where X represents a halogen atom.

For Examiner's Use



(i) Deduce the identity of X, giving a reason.

X is .....

.....

(ii) If the relative heights of the M and M+1 peaks are 9 and 0.3 respectively, calculate the value of p. Use this value and the m / e value of the molecular ion to calculate the value of q, and hence the molecular formula of the compound. Show your working.

(iii) Suggest a formula for the ion responsible for the peak labelled **R**.

..... [4]

(d) In the fragmentation of alcohols which occurs in a mass spectrometer, small stable, neutral molecules are sometimes produced. Suggest the identity of **two** such molecules, each with an M_r less than 30.

(i) ..... **(ii)** ..... [2]

[Total: 10]

9 In today's world, many traditional materials have been replaced by different sorts of polymers. This includes rigid polymers such as those used in car bodies to replace steel and flexible polymers like those used in textiles to replace cotton or wool.

For Examiner's Use

(a) **(i)** To form a polymer, what is the **minimum** number of functional groups that the monomer must possess?

.....

(ii) Illustrate your answer to **(i)** with the structure of a possible monomer.

[2]

(b) State **two** differences between addition and condensation polymerisation.

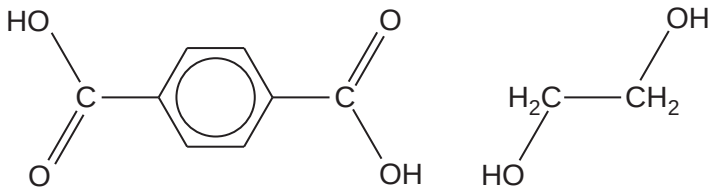
(i) .....

.....

(ii) .....

.....[2]

(c) The polymer formed from the co-polymerisation of the two monomers shown is known as *Terylene.*



benzene-1, 4-dicarboxylic acid **ethane-1-2-diol**

(i) The two monomers react by condensation polymerisation. What other molecule is formed in this reaction?

.....

(ii) Draw the structure of **one** repeat unit of *Terylene.*

For Examiner's Use

(iii) What is the name given to polymers containing the same functional group as *Terylene*?

..... [4]

(d) The monomers ethene and but-1-ene can also co-polymerise to form a polyalkene, but this does not produce a regular alternating structure like *Terylene.* Explain why this is the case, drawing diagrams if you wish.

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.....

[2]

[Total: 10]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/42**

Paper 4 Structured Questions **May/June 2011**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

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 pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

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	
Total	

This document consists of **16** printed pages and **4** blank pages.

Section A

For Examiner's Use

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

1 **(a)** Hydrogen fluoride, HF, behaves as a weak acid in water, with $K_a = 5.6 \times 10^{-4}\,\text{mol dm}^{-3}$.

Calculate the pH of a $0.050\,\text{mol dm}^{-3}$ solution of HF.

pH = ...[2]

(b) Gaseous ammonia and hydrogen fluoride react together to give solid ionic ammonium fluoride.

$$NH_3(g) + HF(g) \rightleftharpoons NH_4F(s) \qquad \Delta H = -147\,\text{kJ mol}^{-1}$$

(i) What *type of reaction* is this?

.....

(ii) Draw dot-and-cross diagrams (outer shells only) describing the bonding in the three compounds involved in this reaction.

NH_3	HF	NH_4F

(iii) There are **three** types of bonding in NH_4F.
Give the names of each of the three types, and state where in the compound each type occurs.

.....

.....

.....

(iv) The reaction between NH_3 and HF is reversible. What conditions of temperature and pressure would favour the **reverse** reaction, i.e. the dissociation of NH_4F? Explain your answer.

.....

.....

.....

[9]

(c) Many commercial copper and brass polishes contain ammonia. The tarnish that forms on the surface of copper is often copper sulfide, CuS. In the presence of O_2 from the air, NH_3 can combine with this copper sulfide to produce the soluble cuprammonium sulfate, $[Cu(NH_3)_4]SO_4$.

(i) Construct an equation for this reaction.

.....

(ii) State the colour of cuprammonium sulfate solution.

.....

(iii) Describe what you would see if a solution of cuprammonium sulfate was diluted with water. Explain your answer.

.....

.....

[3]

(d) When sulfuric acid is added to $Cu^{2+}(aq)$, no colour change occurs, but when concentrated hydrochloric acid is added to $Cu^{2+}(aq)$, the solution turns yellow-green. The solution reverts to its original colour when it is diluted with water.

Suggest the type of reaction occurring with $HCl(aq)$, suggest what is formed during the reaction, and write an equation for the change.

.....

.....

.....

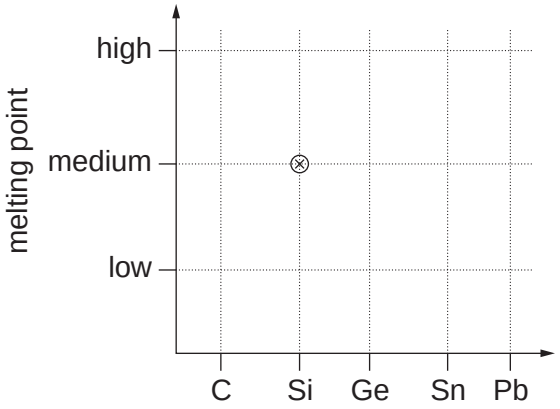
.....[3]

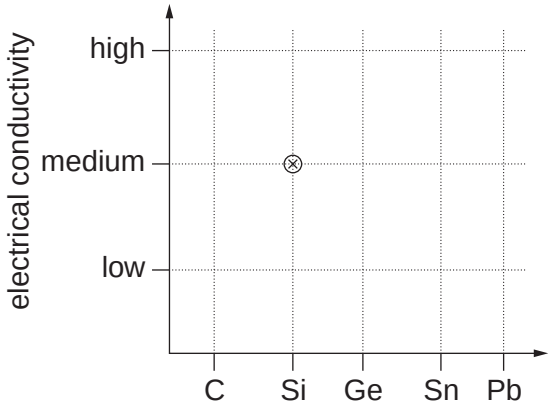
[Total: 17]

[Turn over

2 **(a)** **(i)** On the following grids, plot points showing the variation in the named property of the Group IV elements. Your points should show for each element, whether the melting point/electrical conductivity is 'high', 'medium' or 'low'. The point for silicon has already been plotted in each case.

For Examiner's Use





(ii) Suggest explanations of these trends in terms of the structure and bonding of the Group IV elements.

melting point

.....

.....

electrical conductivity

.....

.....

[6]

(b) Choose **one** reaction to illustrate **each** of the following statements. Write an equation for each of your chosen reactions, and describe what you would see as the reaction is carried out.

(i) PbO is more stable than PbO_2.

.....

.....

(ii) CO is easily oxidised to CO_2.

.....

.....

(iii) Aqueous $SnCl_2$ is a useful reducing agent.

.....

.....

[4]

[Total: 10]

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3 **(a)** State the relationship between the Faraday constant, *F*, the charge on the electron, *e*, and the Avogadro number, *L*.

For Examiner's Use

.....[1]

(b) If the charge on the electron, the A_r and the valency of copper are known, the value of the Avogadro number can be determined experimentally. This is done by passing a known current for a known time through a copper electrolysis cell, and weighing the mass of copper deposited onto the cathode.

(i) Draw a diagram of suitable apparatus for carrying out this experiment.
Label the following: power supply (with + and – terminals); anode; cathode; and ammeter.
State the composition of the electrolyte.

The following are the results obtained from one such experiment.

current passed through the cell	=	0.500 A
time current was passed through cell	=	30.0 min
initial mass of copper cathode	=	52.243 g
final mass of copper cathode	=	52.542 g

(ii) Use these data and relevant information from the *Data Booklet* to calculate a value of *L* to **3 significant figures**.

L = ...
[9]

(c) Use relevant information from the *Data Booklet* to identify the substances formed at the anode and at the cathode when aqueous solutions of the following compounds are electrolysed.

For Examiner's Use

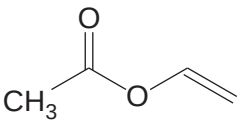
compound	product at anode	product at cathode
AgF		
$FeSO_4$		
$MgBr_2$		

[5]

[Total: 15]

For Examiner's Use

4 **(a)** Polyvinyl acetate, PVA, is a useful adhesive for gluing together articles made from wood, paper or cardboard. The monomer of PVA is ethenyl ethanoate, **B**.

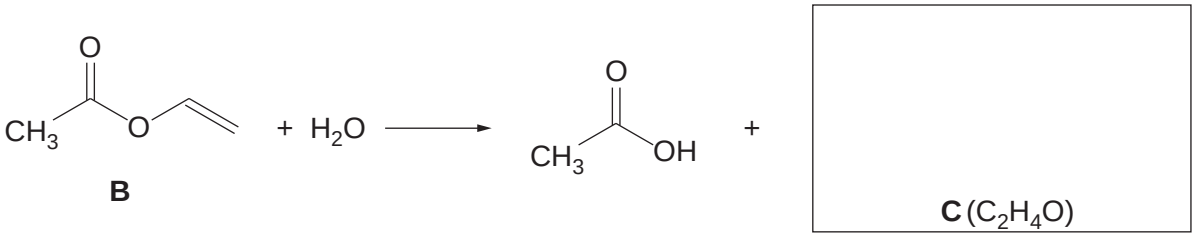


B

PVA is formed from **B** by the process of addition polymerisation.

(i) Draw a section of the PVA molecule containing at least 2 monomer molecules, and identify clearly the repeat unit.

The ester **B** can be hydrolysed in the usual way, according to the following equation.



(ii) Use this information to suggest a possible structure for **C** and draw it in the box above.

When substance **C** is extracted from the product mixture, it is found that it does **not** decolourise $Br_2(aq)$, but it **does** form a pale yellow precipitate with alkaline aqueous iodine.

(iii) Suggest a structure for **C** that fits this new information.

(iv) Suggest a confirmatory test for the functional group in the structure you have drawn in **(iii)**. Your answer should include the reagent you would use and the observation you would make.

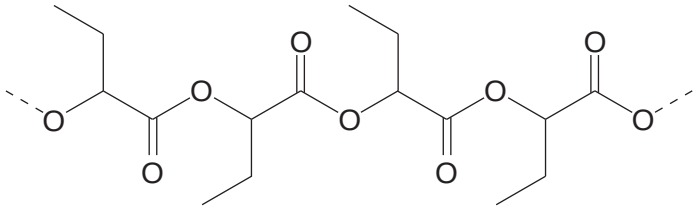
.....

.....

[6]

(b) The following diagram represents a section of another polymer.

For Examiner's Use



D

(i) On the above formula draw brackets, [ ], around the atoms that make up the repeat unit of this polymer.

(ii) Name the functional group in polymer **D**.

.....

(iii) Suggest and draw the structure of the monomer, **E**, that could form this polymer.

(iv) What *type of polymerisation* is involved in making polymer **D** from its monomer?

.....

(v) What is the relationship between the repeat unit of polymer **D** and the repeat unit of PVA?

.....

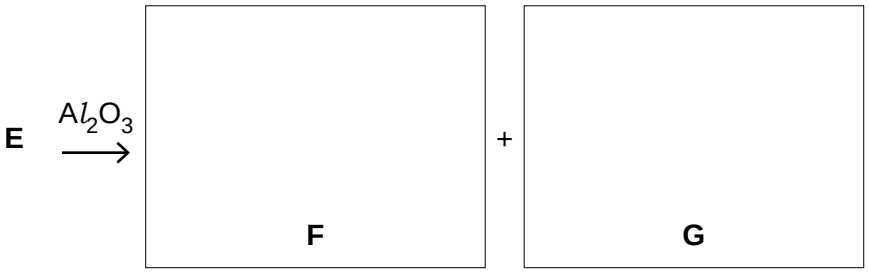
[5]

(c) Monomer **E** exists as two stereoisomers. Heating either isomer with Al_2O_3 gives a mixture of two unsaturated carboxylic acids **F** and **G**, which are stereoisomers of each other.

(i) Name the *type of stereoisomerism* shown by compound **E**.

.....

(ii) Suggest structures for **F** and **G**, and name the type of stereoisomerism they show.



type of isomerism .....

[4]

[Total: 15]

[Turn over

5 **(a)** Describe and explain how the acidities of ethanol and phenol compare to that of water.

For Examiner's Use

.....

.....

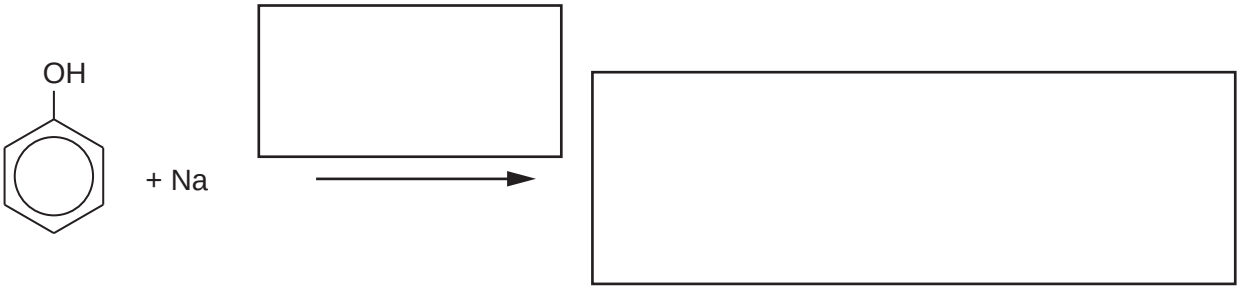
.....

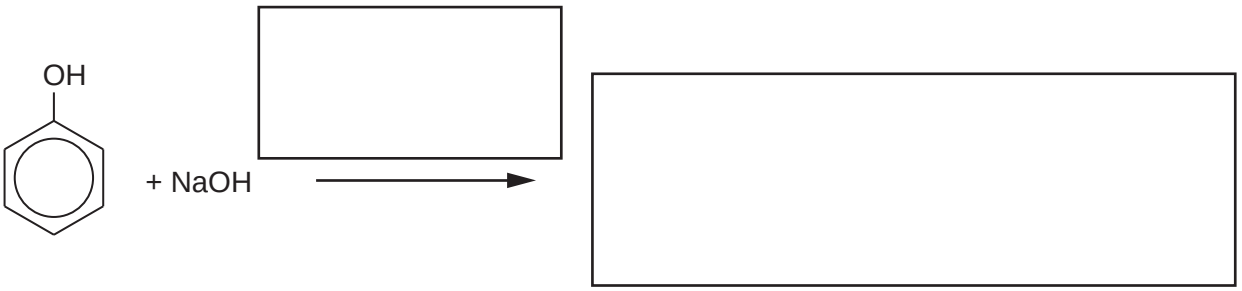
.....

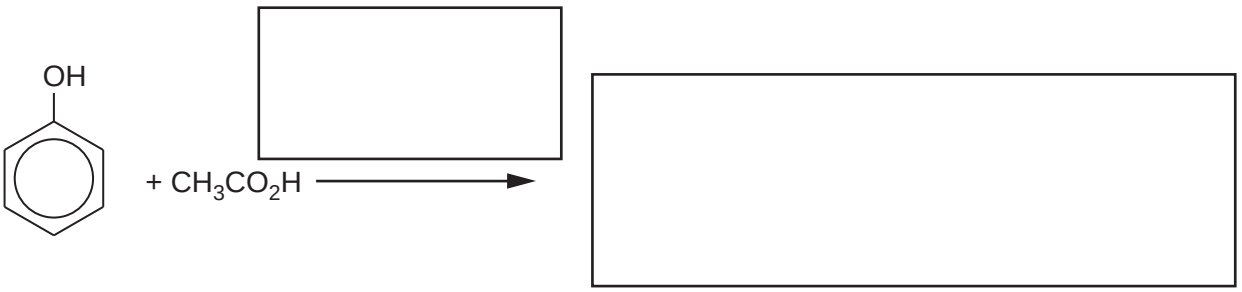
.....

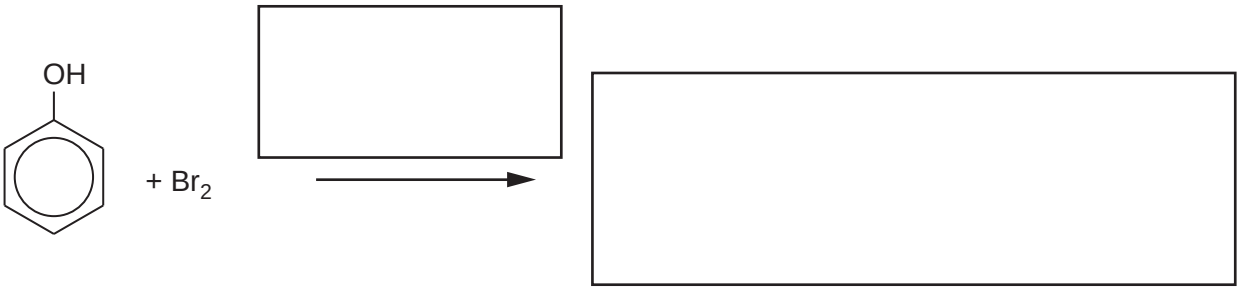
.....[4]

(b) Complete the following equations showing **all** the products of each of these reactions of phenol. Include reaction conditions where appropriate in the boxes over the arrows. If no reaction occurs write ***no reaction*** in the products box.





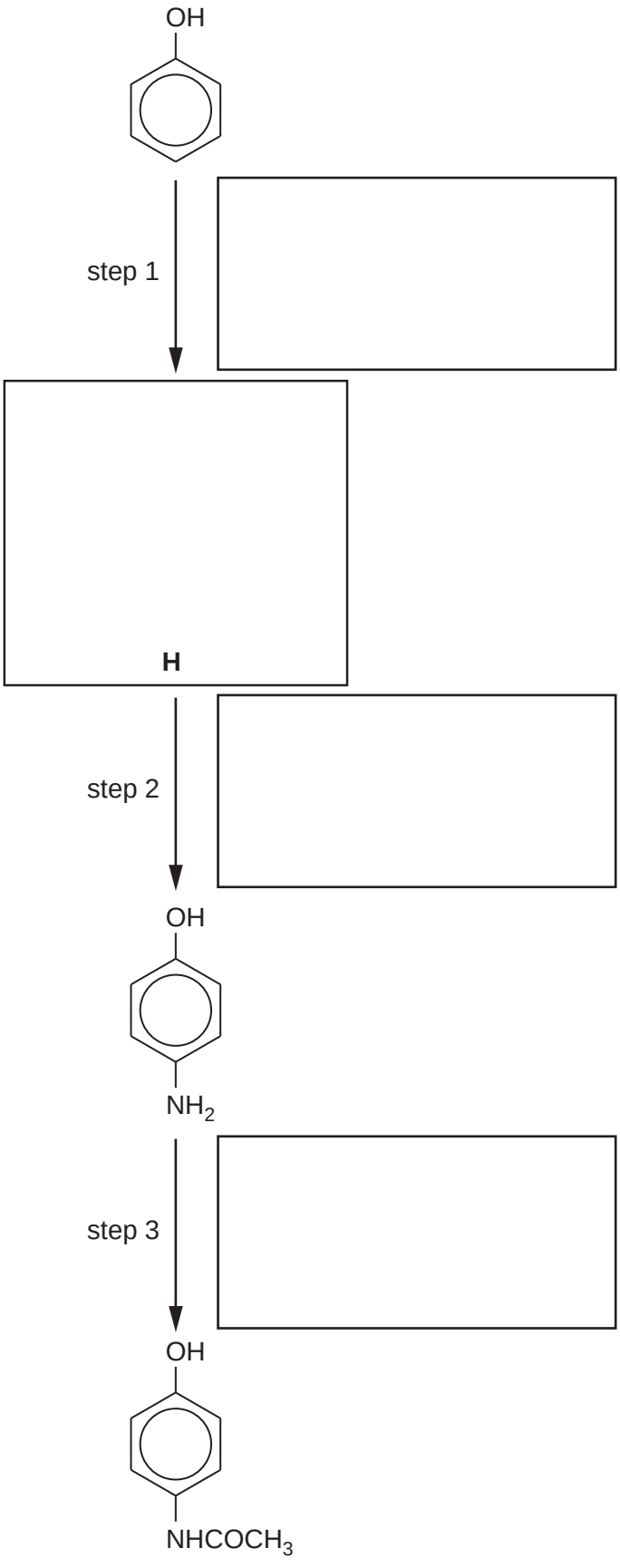




[5]

(c) The analgesic drug paracetamol can be synthesised from phenol by the following route. Suggest reagents and conditions for the each of three steps, and suggest the structure of the intermediate **H**. Write your answers in the boxes provided.

For Examiner's Use



paracetamol

[4]

[Total: 13]

[Turn over

Section B

For Examiner's Use

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

6 Enzymes are protein molecules that are highly efficient in catalysing specific chemical reactions in living organisms.

(a) To work in tissues, enzyme molecules generally need to be water-soluble. What does this tell you about the nature of the side-chains on the exterior of the molecules?

.....

..... [1]

(b) Enzymes function by a substrate molecule interacting with a particular part of the enzyme known as the 'active site'. The substrate is converted into products that are then released, to be replaced by another substrate molecule.

(i) Describe briefly the primary, secondary and tertiary structures of an enzyme.

.....

.....

.....

.....

.....

.....

(ii) The activity of an enzyme depends upon the tertiary structure of the protein molecule. Explain how the tertiary structure produces an effective active site.

.....

.....

(iii) Give **two** conditions that can **reduce** the activity of an enzyme, explaining the reason in each case.

I .....

.....

.....

II .....

.....

.....

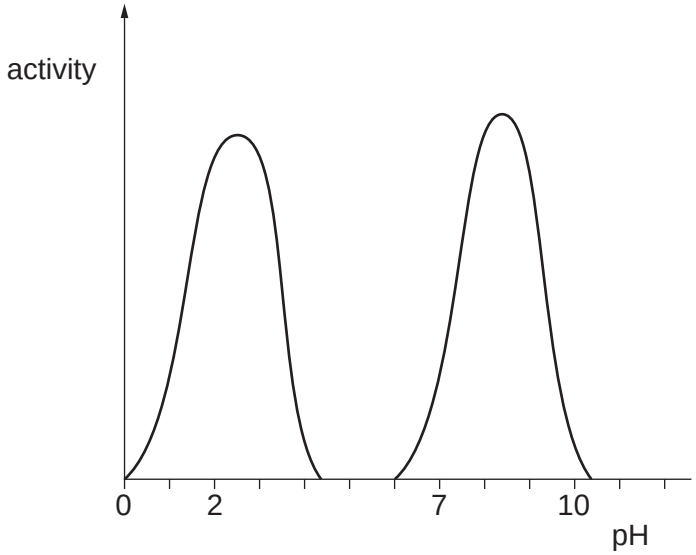
[6]

(c) An individual enzyme operates best at a specific pH. Different enzymes operate best under conditions of different pH. Three enzymes involved in the digestion of food are amylase, pepsin and trypsin.

For Examiner's Use

- Amylase, found in saliva, hydrolyses starch to a mixture of glucose and maltose under approximately neutral conditions.
- Pepsin hydrolyses proteins to peptides in the acid conditions of the stomach.
- Trypsin continues the hydrolysis of peptides to amino acids in the mildly alkaline conditions of the small intestine.

The graph below shows the activity of two of the three enzymes mentioned above.



(i) Label each peak shown with the name of the enzyme responsible, either amylase, pepsin or trypsin.

(ii) On the axes above, sketch the graph that the third enzyme would produce, and label it with the name of that enzyme.

[3]

[Total: 10]

7 The technique of DNA fingerprinting has been one of the most important developments in biochemical analysis in recent times. It has enabled enormous advances to be made in forensic science, medicine and archaeology.

(a) The table shows different stages in the production of a genetic fingerprint. Use the numbers 1 to 6 to put the stages in the correct sequence in the blank column.

stages	process	correct sequence (numbers)
A	place samples on agarose gel	
B	use polymerase chain reaction	
C	label with radioactive isotope	
D	extract DNA	
E	use restriction enzyme	
F	carry out electrophoresis	

[3]

(b) One of the stages above uses a radioactive isotope.

(i) What isotope is used? .....

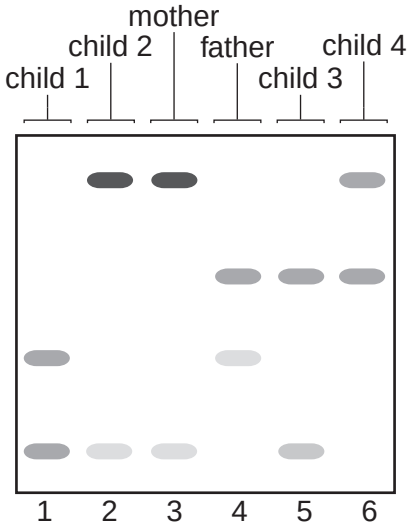
(ii) Why is this isotope chosen?

.....

.....

[2]

(c) The following DNA fingerprints were taken from a family of mother, father and four children.



(i) Are all of the children related to the mother? State the evidence for your answer.

.....

.....

(ii) Which child is unlikely to be related to the father? State the evidence for your answer.

.....

.....

[2]

(d) DNA fingerprinting has been successfully used in archaeological investigations.

(i) Ancient writings were often made on goatskins. Over the centuries these have often become broken into fragments, making reconstruction of the writings almost impossible.

Suggest how the use of DNA fingerprinting might be able to identify which fragments came from a particular skin.

.....

.....

.....

.....

(ii) Apart from the examples of human remains and goatskins, state one other material that could be investigated using this technique.

.....

.....

[3]

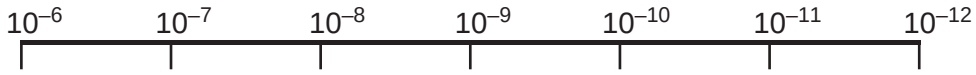
[Total: 10]

[Turn over

For Examiner's Use

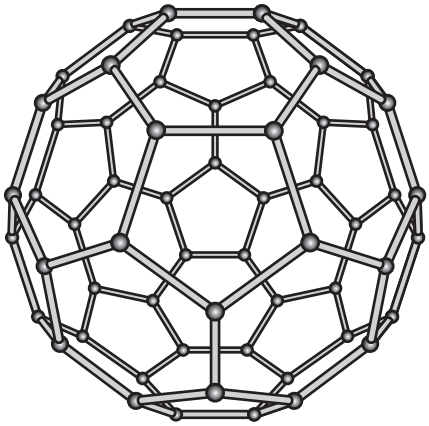
8 Nanotechnology is a fast-developing area of science based on the ability to manipulate materials of very small dimensions.

(a) On the scale shown in metres, mark the upper and lower limits of the range of sizes for nanoparticles.



[2]

(b) One of the most commonly recognised nanoparticles is the 'buckyball', a spherical form of carbon containing 60 carbon atoms. It has been referred to as the third allotrope of carbon.



Diamond and graphite are two other allotropes of carbon. Suggest what is meant by the term *allotrope*.

.....

.....

.....[2]

(c) Nanoparticles are used to deliver drugs within cells. Suggest what property of nanoparticles enables them to be used in this way. Explain your answer.

.....

.....

.....[2]

For Examiner's Use

(d) Copper is an important metal that has been used for thousands of years. The problem today is that most of the ores rich in copper compounds have been used up. A century ago ores containing >2% of copper by mass would have been worked; today's mines have to operate at much lower percentages, down to 0.5% of copper by mass.

(i) By what *type of reaction* is the copper present in the ore converted to copper metal?

.....

One of the main ores of copper contains the mineral *chalcopyrite*, $CuFeS_2$.

(ii) Calculate the percentage of copper by mass in *chalcopyrite*.

(iii) If the ore contains 2% of *chalcopyrite* by mass, calculate the mass of copper which can be produced from each tonne of ore.

(iv) Certain bacteria are able to extract copper from the 'spoil' heaps of previously mined copper ore. These bacteria are sprayed onto the spoil heaps in an aqueous solution and the resulting solution containing iron(II) sulfate and copper(II) sulfate is collected in tanks.

Suggest how the copper could be recovered as metal.

.....

.....

.....

[4]

[Total: 10]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8731910747

CHEMISTRY **9701/43**

Paper 4 Structured Questions **May/June 2011**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

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Section B
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You may lose marks if you do not show your working or if you do not use appropriate units.
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The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
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4	
5	
6	
7	
8	
Total	

This document consists of **16** printed pages and **4** blank pages.

Section A

For Examiner's Use

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

1 **(a)** Hydrogen fluoride, HF, behaves as a weak acid in water, with $K_a = 5.6 \times 10^{-4}\,\text{mol dm}^{-3}$.

Calculate the pH of a $0.050\,\text{mol dm}^{-3}$ solution of HF.

pH = ...[2]

(b) Gaseous ammonia and hydrogen fluoride react together to give solid ionic ammonium fluoride.

$$NH_3(g) + HF(g) \rightleftharpoons NH_4F(s) \qquad \Delta H = -147\,\text{kJ mol}^{-1}$$

(i) What *type of reaction* is this?

.....

(ii) Draw dot-and-cross diagrams (outer shells only) describing the bonding in the three compounds involved in this reaction.

NH_3	HF	NH_4F

(iii) There are **three** types of bonding in NH_4F.
Give the names of each of the three types, and state where in the compound each type occurs.

.....

.....

.....

(iv) The reaction between NH_3 and HF is reversible. What conditions of temperature and pressure would favour the **reverse** reaction, i.e. the dissociation of NH_4F? Explain your answer.

.....

.....

.....

[9]

(c) Many commercial copper and brass polishes contain ammonia. The tarnish that forms on the surface of copper is often copper sulfide, CuS. In the presence of O_2 from the air, NH_3 can combine with this copper sulfide to produce the soluble cuprammonium sulfate, $[Cu(NH_3)_4]SO_4$.

(i) Construct an equation for this reaction.

.....

(ii) State the colour of cuprammonium sulfate solution.

.....

(iii) Describe what you would see if a solution of cuprammonium sulfate was diluted with water. Explain your answer.

.....

.....

[3]

(d) When sulfuric acid is added to $Cu^{2+}(aq)$, no colour change occurs, but when concentrated hydrochloric acid is added to $Cu^{2+}(aq)$, the solution turns yellow-green. The solution reverts to its original colour when it is diluted with water.

Suggest the type of reaction occurring with HC*l*(aq), suggest what is formed during the reaction, and write an equation for the change.

.....

.....

.....

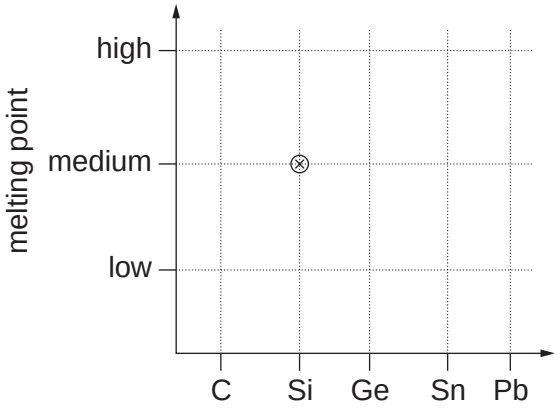
.....[3]

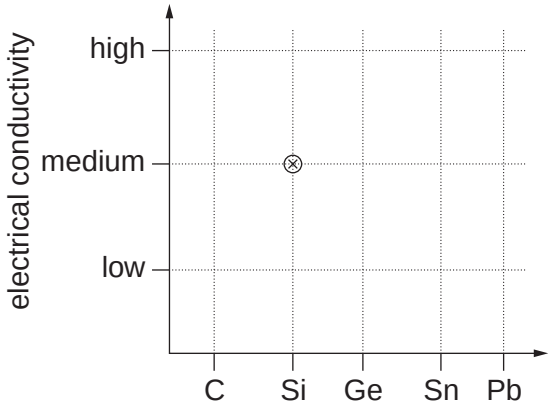
[Total: 17]

[Turn over

For Examiner's Use

2 **(a)** **(i)** On the following grids, plot points showing the variation in the named property of the Group IV elements. Your points should show for each element, whether the melting point/electrical conductivity is 'high', 'medium' or 'low'. The point for silicon has already been plotted in each case.





(ii) Suggest explanations of these trends in terms of the structure and bonding of the Group IV elements.

melting point

.....

.....

electrical conductivity

.....

.....

[6]

(b) Choose **one** reaction to illustrate **each** of the following statements. Write an equation for each of your chosen reactions, and describe what you would see as the reaction is carried out.

(i) PbO is more stable than PbO_2.

.....

.....

(ii) CO is easily oxidised to CO_2.

.....

.....

(iii) Aqueous $SnCl_2$ is a useful reducing agent.

.....

.....

[4]

[Total: 10]

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3 **(a)** State the relationship between the Faraday constant, *F*, the charge on the electron, *e*, and the Avogadro number, *L*.

For Examiner's Use

.....[1]

(b) If the charge on the electron, the A_r and the valency of copper are known, the value of the Avogadro number can be determined experimentally. This is done by passing a known current for a known time through a copper electrolysis cell, and weighing the mass of copper deposited onto the cathode.

(i) Draw a diagram of suitable apparatus for carrying out this experiment.
Label the following: power supply (with + and – terminals); anode; cathode; and ammeter.
State the composition of the electrolyte.

The following are the results obtained from one such experiment.

current passed through the cell	=	0.500 A
time current was passed through cell	=	30.0 min
initial mass of copper cathode	=	52.243 g
final mass of copper cathode	=	52.542 g

(ii) Use these data and relevant information from the *Data Booklet* to calculate a value of *L* to **3 significant figures**.

L = ...
[9]

(c) Use relevant information from the *Data Booklet* to identify the substances formed at the anode and at the cathode when aqueous solutions of the following compounds are electrolysed.

For Examiner's Use

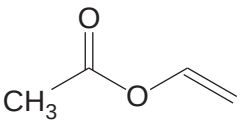
compound	product at anode	product at cathode
AgF		
$FeSO_4$		
$MgBr_2$		

[5]

[Total: 15]

For Examiner's Use

4 **(a)** Polyvinyl acetate, PVA, is a useful adhesive for gluing together articles made from wood, paper or cardboard. The monomer of PVA is ethenyl ethanoate, **B**.

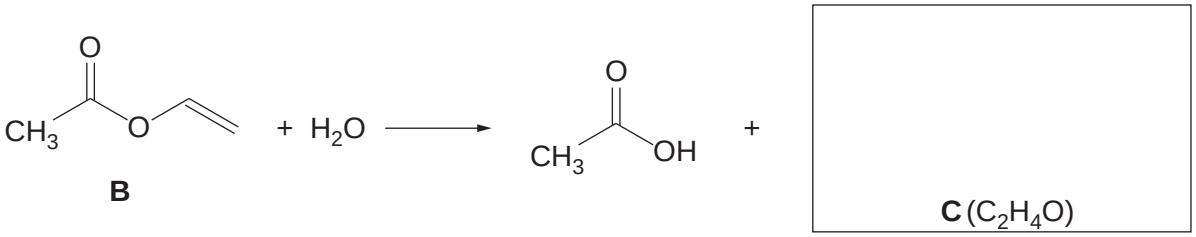


B

PVA is formed from **B** by the process of addition polymerisation.

(i) Draw a section of the PVA molecule containing at least 2 monomer molecules, and identify clearly the repeat unit.

The ester **B** can be hydrolysed in the usual way, according to the following equation.



(ii) Use this information to suggest a possible structure for **C** and draw it in the box above.

When substance **C** is extracted from the product mixture, it is found that it does **not** decolourise $Br_2(aq)$, but it **does** form a pale yellow precipitate with alkaline aqueous iodine.

(iii) Suggest a structure for **C** that fits this new information.

(iv) Suggest a confirmatory test for the functional group in the structure you have drawn in **(iii)**. Your answer should include the reagent you would use and the observation you would make.

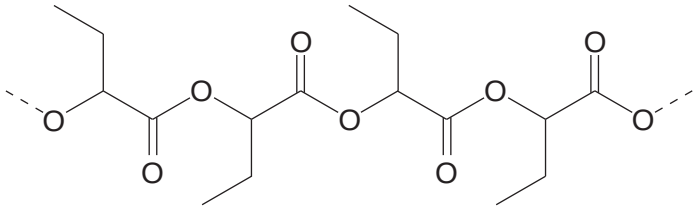
.....

.....

[6]

(b) The following diagram represents a section of another polymer.

For Examiner's Use



D

(i) On the above formula draw brackets, [ ], around the atoms that make up the repeat unit of this polymer.

(ii) Name the functional group in polymer **D**.

.....

(iii) Suggest and draw the structure of the monomer, **E**, that could form this polymer.

(iv) What *type of polymerisation* is involved in making polymer **D** from its monomer?

.....

(v) What is the relationship between the repeat unit of polymer **D** and the repeat unit of PVA?

.....

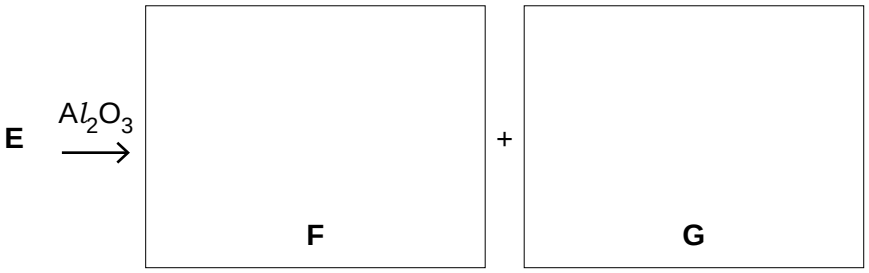
[5]

(c) Monomer **E** exists as two stereoisomers. Heating either isomer with Al_2O_3 gives a mixture of two unsaturated carboxylic acids **F** and **G**, which are stereoisomers of each other.

(i) Name the *type of stereoisomerism* shown by compound **E**.

.....

(ii) Suggest structures for **F** and **G**, and name the type of stereoisomerism they show.



type of isomerism .....

[4]

[Total: 15]

5 **(a)** Describe and explain how the acidities of ethanol and phenol compare to that of water.

For Examiner's Use

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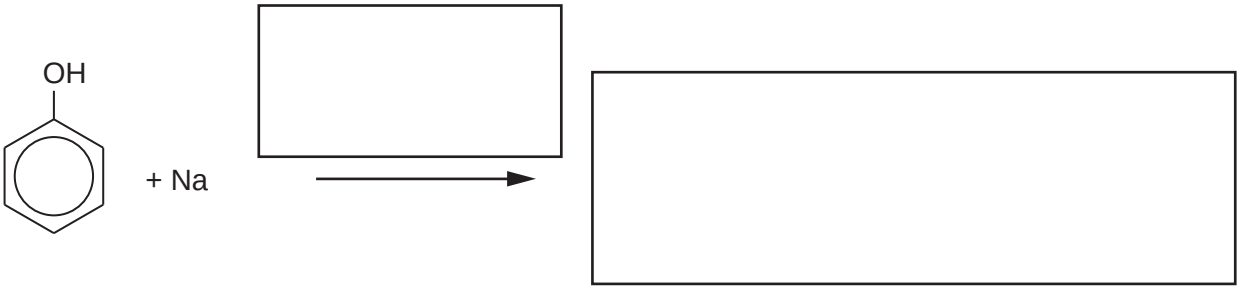
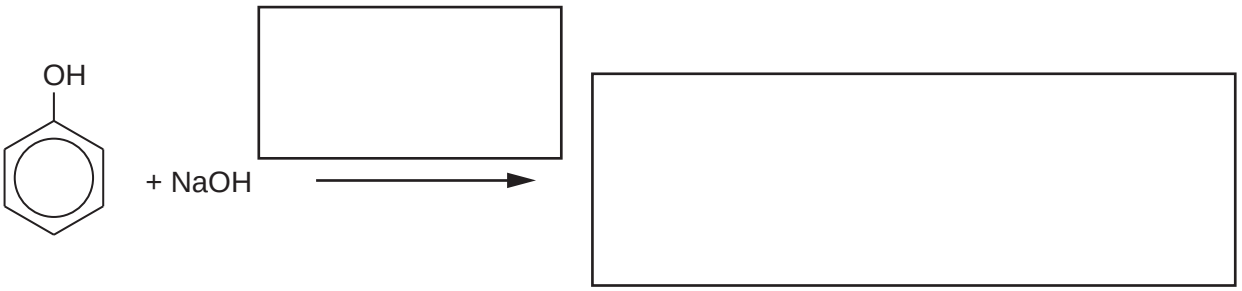
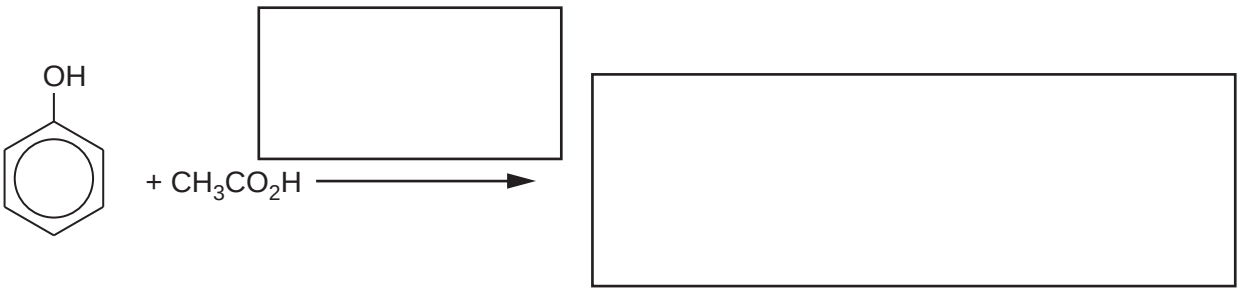
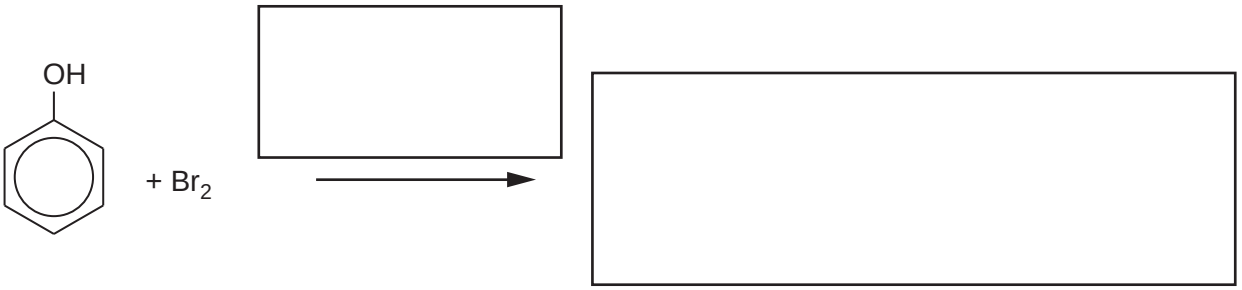
.....[4]

(b) Complete the following equations showing **all** the products of each of these reactions of phenol. Include reaction conditions where appropriate in the boxes over the arrows. If no reaction occurs write ***no reaction*** in the products box.





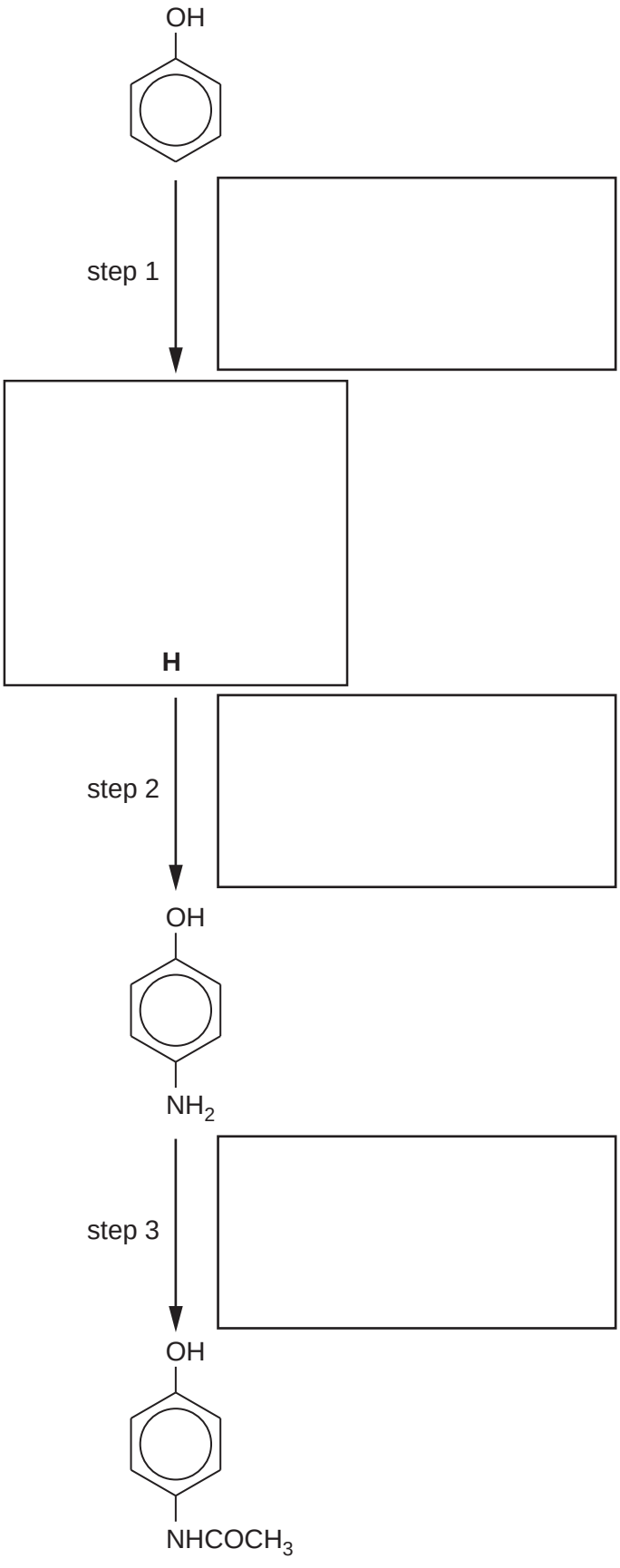




[5]

(c) The analgesic drug paracetamol can be synthesised from phenol by the following route. Suggest reagents and conditions for the each of three steps, and suggest the structure of the intermediate **H**. Write your answers in the boxes provided.

For Examiner's Use



paracetamol

[4]

[Total: 13]

[Turn over

Section B

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

For Examiner's Use

6 Enzymes are protein molecules that are highly efficient in catalysing specific chemical reactions in living organisms.

(a) To work in tissues, enzyme molecules generally need to be water-soluble. What does this tell you about the nature of the side-chains on the exterior of the molecules?

.....

..... [1]

(b) Enzymes function by a substrate molecule interacting with a particular part of the enzyme known as the 'active site'. The substrate is converted into products that are then released, to be replaced by another substrate molecule.

(i) Describe briefly the primary, secondary and tertiary structures of an enzyme.

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(ii) The activity of an enzyme depends upon the tertiary structure of the protein molecule. Explain how the tertiary structure produces an effective active site.

.....

.....

(iii) Give **two** conditions that can **reduce** the activity of an enzyme, explaining the reason in each case.

I .....

.....

.....

II .....

.....

.....

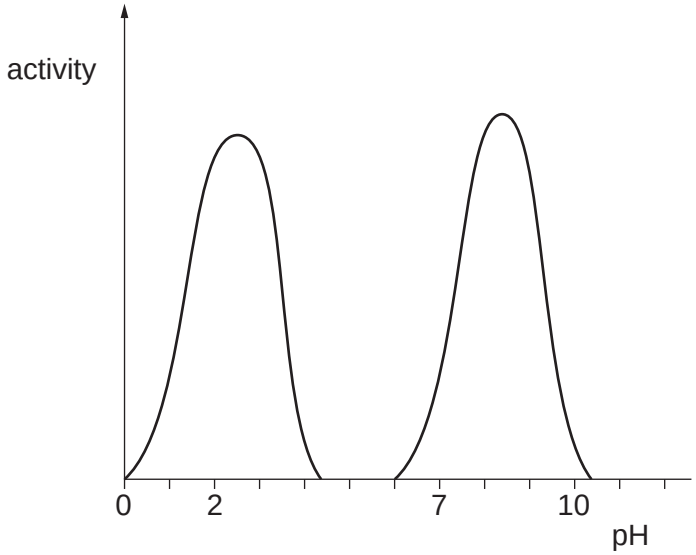
[6]

(c) An individual enzyme operates best at a specific pH. Different enzymes operate best under conditions of different pH. Three enzymes involved in the digestion of food are amylase, pepsin and trypsin.

For Examiner's Use

- Amylase, found in saliva, hydrolyses starch to a mixture of glucose and maltose under approximately neutral conditions.
- Pepsin hydrolyses proteins to peptides in the acid conditions of the stomach.
- Trypsin continues the hydrolysis of peptides to amino acids in the mildly alkaline conditions of the small intestine.

The graph below shows the activity of two of the three enzymes mentioned above.



(i) Label each peak shown with the name of the enzyme responsible, either amylase, pepsin or trypsin.

(ii) On the axes above, sketch the graph that the third enzyme would produce, and label it with the name of that enzyme.

[3]

[Total: 10]

7 The technique of DNA fingerprinting has been one of the most important developments in biochemical analysis in recent times. It has enabled enormous advances to be made in forensic science, medicine and archaeology.

(a) The table shows different stages in the production of a genetic fingerprint. Use the numbers 1 to 6 to put the stages in the correct sequence in the blank column.

stages	process	correct sequence (numbers)
A	place samples on agarose gel	
B	use polymerase chain reaction	
C	label with radioactive isotope	
D	extract DNA	
E	use restriction enzyme	
F	carry out electrophoresis	

[3]

(b) One of the stages above uses a radioactive isotope.

(i) What isotope is used? .....

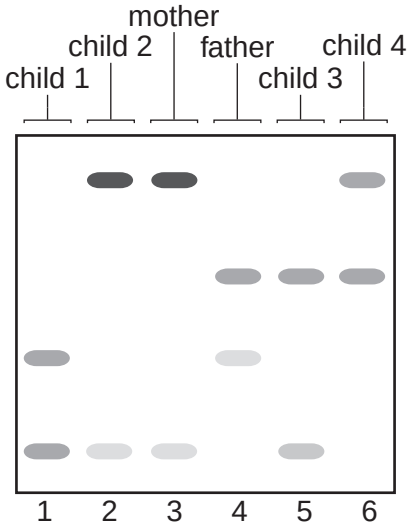
(ii) Why is this isotope chosen?

.....

.....

[2]

(c) The following DNA fingerprints were taken from a family of mother, father and four children.



(i) Are all of the children related to the mother? State the evidence for your answer.

.....

.....

(ii) Which child is unlikely to be related to the father? State the evidence for your answer.

.....

.....

[2]

(d) DNA fingerprinting has been successfully used in archaeological investigations.

(i) Ancient writings were often made on goatskins. Over the centuries these have often become broken into fragments, making reconstruction of the writings almost impossible.

Suggest how the use of DNA fingerprinting might be able to identify which fragments came from a particular skin.

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(ii) Apart from the examples of human remains and goatskins, state one other material that could be investigated using this technique.

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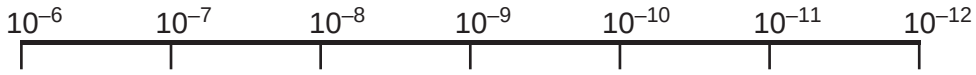
[3]

[Total: 10]

[Turn over

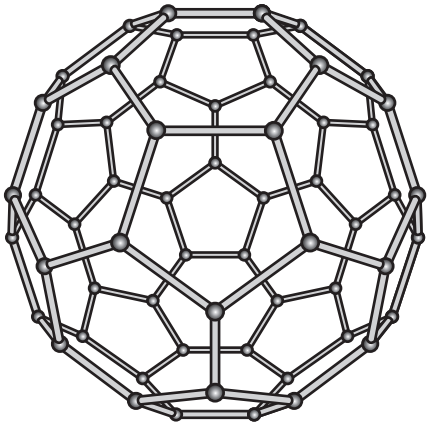
8 Nanotechnology is a fast-developing area of science based on the ability to manipulate materials of very small dimensions.

(a) On the scale shown in metres, mark the upper and lower limits of the range of sizes for nanoparticles.



[2]

(b) One of the most commonly recognised nanoparticles is the 'buckyball', a spherical form of carbon containing 60 carbon atoms. It has been referred to as the third allotrope of carbon.



Diamond and graphite are two other allotropes of carbon. Suggest what is meant by the term *allotrope*.

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.....[2]

(c) Nanoparticles are used to deliver drugs within cells. Suggest what property of nanoparticles enables them to be used in this way. Explain your answer.

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.....[2]

For Examiner's Use

(d) Copper is an important metal that has been used for thousands of years. The problem today is that most of the ores rich in copper compounds have been used up. A century ago ores containing >2% of copper by mass would have been worked; today's mines have to operate at much lower percentages, down to 0.5% of copper by mass.

(i) By what *type of reaction* is the copper present in the ore converted to copper metal?

.....

One of the main ores of copper contains the mineral *chalcopyrite*, $CuFeS_2$.

(ii) Calculate the percentage of copper by mass in *chalcopyrite*.

(iii) If the ore contains 2% of *chalcopyrite* by mass, calculate the mass of copper which can be produced from each tonne of ore.

(iv) Certain bacteria are able to extract copper from the 'spoil' heaps of previously mined copper ore. These bacteria are sprayed onto the spoil heaps in an aqueous solution and the resulting solution containing iron(II) sulfate and copper(II) sulfate is collected in tanks.

Suggest how the copper could be recovered as metal.

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[4]

[Total: 10]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6810082153

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

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 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.

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 **8** printed pages.

1 The carbonates of group II in the periodic table decompose on heating forming an oxide and carbon dioxide.
X is any group II cation (e.g. Mg^{2+})

For Examiner's Use

$$XCO_3 \rightarrow XO + CO_2$$

This decomposition occurs because the positively charged cations polarise (distort) the C—O bond in the carbonate ion causing the ion to break up. The charge density of the group II cations decreases down the group. This affects the decomposition rate.

> You are to plan an experiment to investigate how the rate of decomposition of a group II carbonate varies as the group is descended. The rate can be conveniently measured by finding the time taken to produce the same volume of carbon dioxide from each carbonate.

(a) (i) Predict how the rate of decomposition of the group II carbonates will change as the group is descended.

Explain this prediction in terms of the charge density of the cation as the group is descended.

prediction .....

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explanation .....

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.....

(ii) Display your prediction in the form of a sketch graph, clearly labelling the axes.

[3]

(b) In the experiment you are about to plan, identify the following.

For Examiner's Use

(i) the independent variable .....

(ii) the dependent variable .....

[2]

(c) Draw a diagram of the apparatus and experimental set up you would use to carry out this experiment. Your apparatus should use only standard items found in a school or college laboratory and show clearly the following.

(i) the apparatus used to heat the carbonate

(ii) how the carbon dioxide will be collected

Label each piece of apparatus used, indicating its size or capacity.

[2]

[Turn over

(d) Using the apparatus shown in **(c)** design a laboratory experiment to test your prediction in **(a)**.

For Examiner's Use

In addition to the standard apparatus present in a laboratory you are provided with the following materials,

samples of the carbonates of magnesium, calcium, strontium and barium,
a stop-watch/clock with second hand.

Give a step-by-step description of how you would carry out the experiment by stating

(i) the gas volume you would collect from each carbonate,

(ii) how you would calculate the mass of each carbonate to ensure that this volume of carbon dioxide is produced,

(iii) how you would control the factors in the heating so that different carbonates can be compared.

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.....[4]

(e) State a hazard that must be considered when planning the experiment and describe precautions that should be taken to keep risks to a minimum.

For Examiner's Use

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.....[2]

(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 **must** include the appropriate units.

[2]

(g) This simple experiment is likely to produce only approximate results.
Suggest an improvement to your apparatus or an alternative apparatus that may improve the reliability of the results.

[1]

[Total: 16]

[Turn over

2 When sodium nitrate, $NaNO_3$, is heated, it decomposes into sodium nitrite, $NaNO_2$, and oxygen.
A suggested equation is:-

For Examiner's Use

$$2NaNO_3 \rightarrow 2NaNO_2 + O_2$$

An experiment was carried out to attempt to confirm this.

- An empty boiling tube was weighed and the mass recorded.
- A sample of sodium nitrate was added to the boiling tube and the new mass recorded.
- The boiling tube and sodium nitrate was heated strongly for five minutes and then allowed to cool back to room temperature.
- The boiling tube and contents was then reweighed and the mass recorded.

(a) Calculate the relative molecular masses (M_r) of $NaNO_3$ and $NaNO_2$.
[A_r: N, 14.0; O, 16.0; Na, 23.0]

[1]

(b) The results of several such experiments are recorded below.

A	B	C	D	E	F	G
mass of boiling tube / g	mass of boiling tube + $NaNO_3$ / g	mass of boiling tube + $NaNO_2$ / g				
9.90	13.10	12.50				
10.05	14.73	13.91				
10.25	14.20	13.46				
9.80	12.67	12.65				
9.60	14.56	13.63				
10.30	15.80	14.76				
11.05	17.18	15.50				
10.00	17.00	15.68				
9.75	17.65	16.16				
10.15	18.48	16.84				

Process the results in the table to calculate the number of moles of sodium nitrate and the number of moles of sodium nitrite.

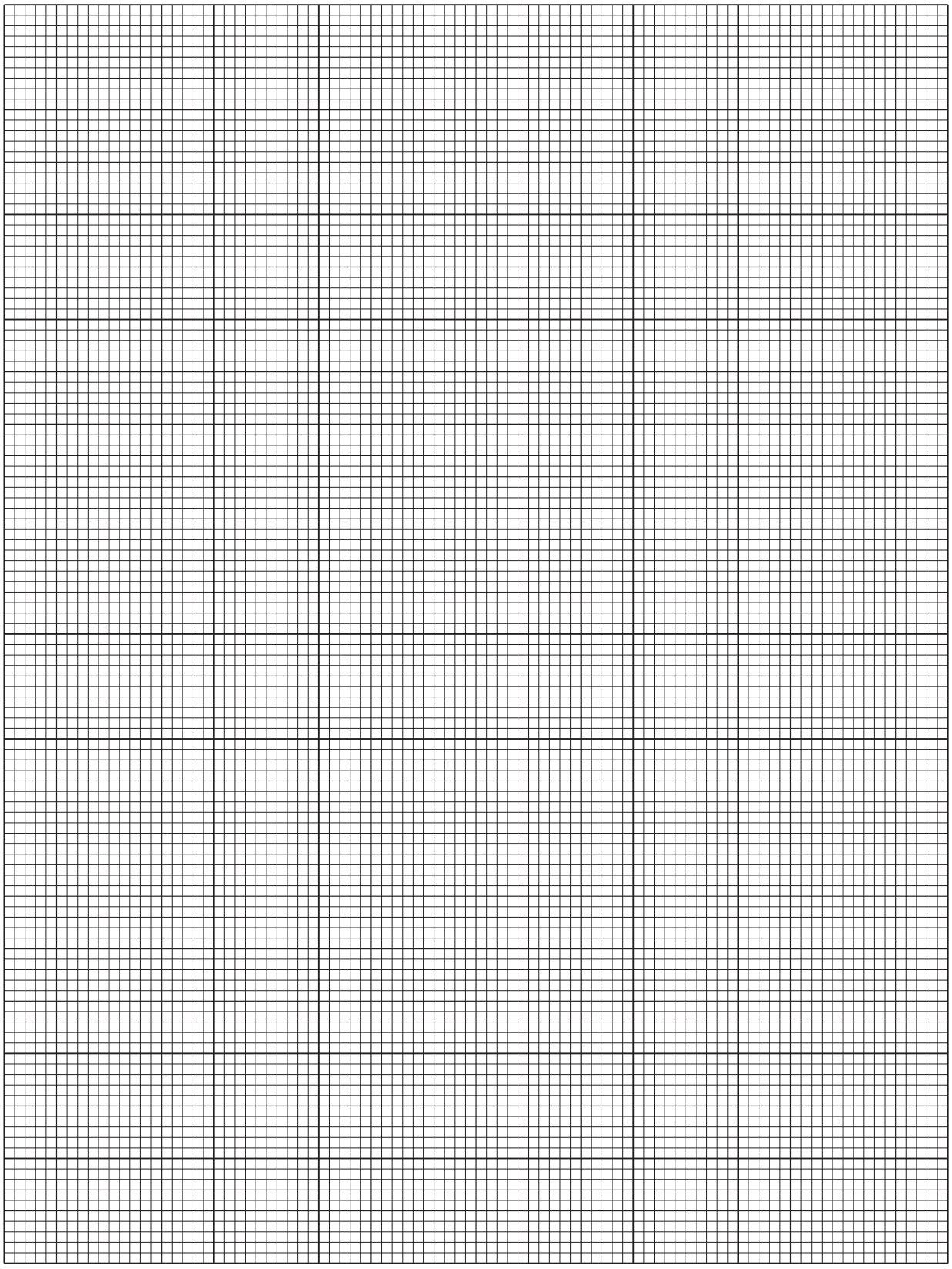
Record these values in the additional columns of the table. You may use some or all of the columns.

Masses should be recorded to **two decimal places**. Numbers of moles should be recorded to **two significant figures**.

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 G for these expressions (e.g. A–B). [2]

(c) Plot a graph to show the relationship between the number of moles of sodium nitrate and the number of moles of sodium nitrite.
Draw the line of best fit.

For Examiner's Use



[3]

(d) Circle and label on the graph any point(s) you consider to be anomalous.
For each anomalous point give a different reason why it is anomalous clearly indicating which point you are describing.

For Examiner's Use

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.....[3]

(e) Determine the slope of the 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.

[3]

(f) **(i)** Does the value of the slope of your graph calculated in **(e)** confirm the equation given in **(a)** or not?

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(ii) Explain your answer in **(f)(i)** above.

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[2]

[Total: 14]

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

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.
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For Examiner's Use	
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2	
Total	

This document consists of **9** printed pages and **3** blank pages.

1 Reactions involving two aqueous solutions are dependent on collisions occurring between the particles of the two reagents.

For Examiner's Use

As the temperature of the system is raised, the average kinetic energy of the particles increases.

You are to plan an experiment to investigate how the rate of the reaction between hydrochloric acid and sodium thiosulfate, $Na_2S_2O_3$, depends on the temperature of the reaction. When these two reagents react, after a short period they slowly produce a white or yellow precipitate of sulfur. As more sulfur is produced, the reaction mixture becomes more cloudy until it cannot be seen through (i.e. it is opaque). The time taken for the mixture to become opaque can be dependent on the relative concentrations of the reagents or the temperature of the reaction mixture.

(a) (i) Predict how the rate of reaction will change if the temperature of the reagents is **increased**. Using the idea of how the kinetic energy of the particles changes as the temperature of the reagents **increases**, explain your prediction in terms of particle collisions.

prediction.....

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.....

explanation.....

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.....

(ii) Display your prediction in the form of a sketch graph, clearly labelling the axes.

[3]

(b) 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 and experimental set up you would use to carry out this experiment. Your apparatus should use only standard items found in a school or college laboratory and show clearly the following.

(i) the apparatus used as the reaction vessel and how the thermometer will be positioned in order to measure the temperature of the solution as accurately as possible

(ii) how the solution will be heated

Label each piece of apparatus used, indicating its size or capacity and the temperature range that the thermometer should cover.

[2]

[Turn over

(d) Using the apparatus shown in **(c)** design a laboratory experiment to test your prediction in **(a)**.

For Examiner's Use

In addition to the standard apparatus present in a laboratory you are provided with the following materials,

0.100 mol dm^{-3} aqueous sodium thiosulfate,
1.00 mol dm^{-3} hydrochloric acid,
A stop-watch/clock with second hand.

Give a step-by-step description of how you would carry out the experiment by stating

(i) the number of experiments you would do, and their temperature range (minimum and maximum temperatures),

(ii) what you would keep constant in all the experiments,

(iii) what temperature measurements you would make,

(iv) how you would use the cloudiness (opacity) of the reaction mixture to measure the time taken for each reaction.

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..... [5]

(e) State a hazard that must be considered when planning the experiment and describe precautions that should be taken to keep risks to a minimum.

For Examiner's Use

.....

..... [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 section **(a)**. The headings **must** include the appropriate units.

[2]

[Total: 15]

[Turn over

2 The solubility of potassium chlorate(V) in water increases with temperature. The units of solubility are grams per one hundred grams of water (g / 100g water).

For Examiner's Use

An experiment is carried out to investigate this solubility.

- An empty boiling tube was weighed and the mass recorded.
- Some distilled water was added to the boiling tube and the new mass recorded.
- A small sample of potassium chlorate(V) was added and this new mass recorded.
- The boiling tube was carefully heated with stirring until all the solid had dissolved.
- The apparatus was allowed to cool slowly while constantly stirring and the temperature recorded when the first crystals appeared in the tube.

(a) The results of several such experiments are recorded below.

A	B	C	D	E	F	G
crystallising temperature / °C	mass of boiling tube /g	mass of boiling tube and water /g	mass of boiling tube, water and solid /g			
20.0	10.10	35.10	36.85			
25.0	10.20	35.20	37.45			
30.0	9.80	29.20	31.20			
40.0	9.95	32.95	36.55			
45.0	10.35	30.35	33.45			
50.0	9.90	34.90	39.40			
60.0	9.70	30.70	35.53			
65.0	9.95	33.95	40.07			
70.0	10.45	30.45	36.15			
75.0	10.35	35.35	42.75			
80.0	10.05	35.05	44.05			
90.0	10.10	40.10	53.90			

Process the results in the table to calculate the solubility in g / 100 g of the potassium chlorate(V) for each of the temperatures listed.

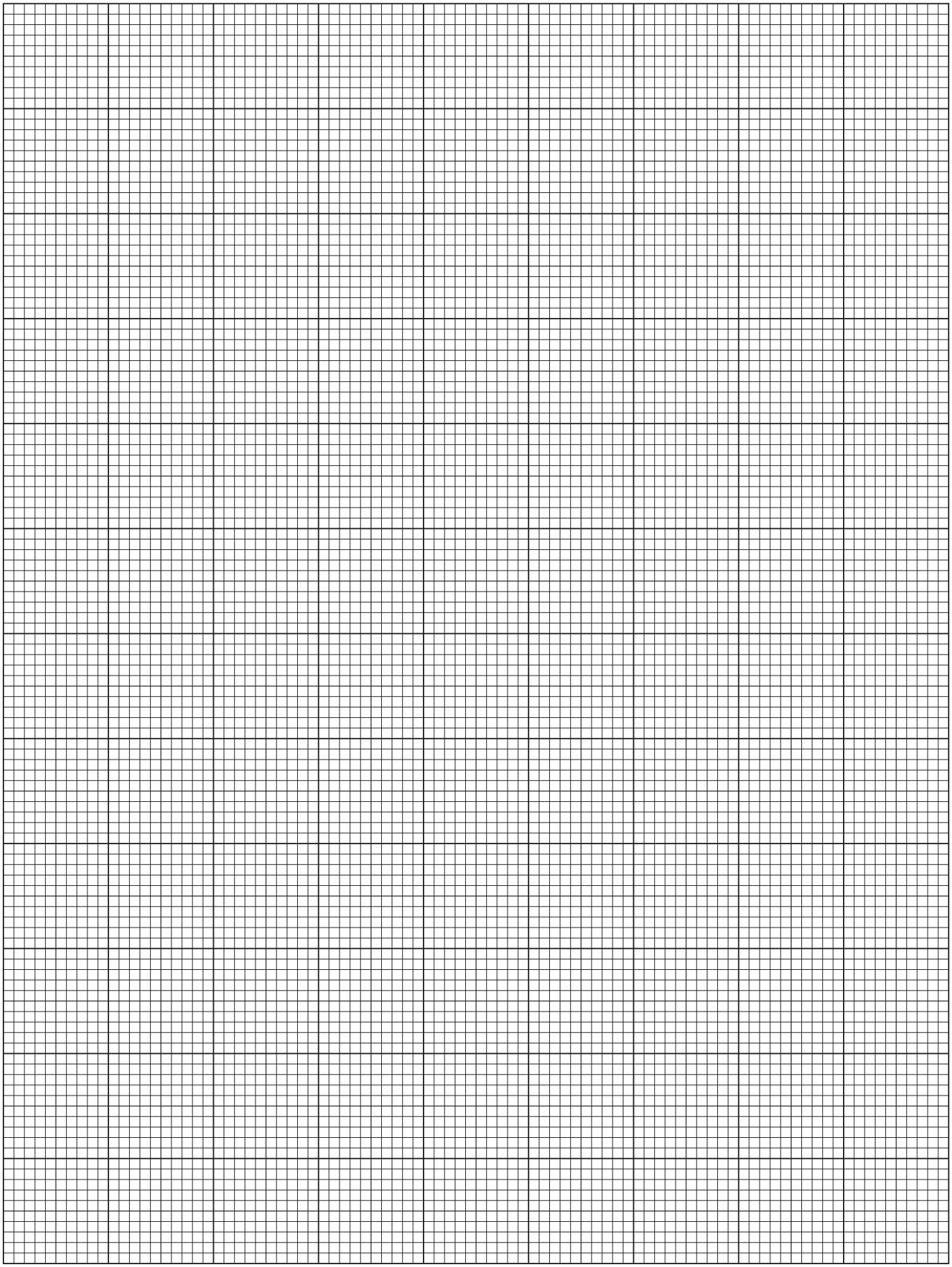
Record these values to **two decimal places** in the additional columns of the table. You may use some or all of the columns.

Label the columns you use.

For each column you use include units where appropriate and an expression to show how your values are calculated.

Use the column headings A to G for these expressions (e.g. A–B). [3]

(b) Plot a graph to show the variation of solubility with temperature.
Draw the line of best fit.



[4]

(c) Circle and label on the graph any point(s) you consider anomalous.
For each anomalous point give a different reason why it is anomalous clearly indicating which point you are describing.

For Examiner's Use

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..... [4]

(d) A solution of potassium chlorate(V) is made up using 50 g of water. This is found to be saturated at 85 °C. The solution is then cooled to 35 °C. Using your graph calculate the mass of solid deposited as a result of this temperature change.

[2]

(e) From the pattern of solubility demonstrated by your graph predict and explain whether the dissolving of potassium chlorate(V) in water is an exothermic or an endothermic reaction.

For Examiner's Use

prediction

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explanation

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..... [2]

[Total: 15]

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5752601311

CHEMISTRY **9701/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2011**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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For Examiner's Use	
1	
2	
Total	

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1 Reactions involving two aqueous solutions are dependent on collisions occurring between the particles of the two reagents.

For Examiner's Use

As the temperature of the system is raised, the average kinetic energy of the particles increases.

You are to plan an experiment to investigate how the rate of the reaction between hydrochloric acid and sodium thiosulfate, $Na_2S_2O_3$, depends on the temperature of the reaction. When these two reagents react, after a short period they slowly produce a white or yellow precipitate of sulfur. As more sulfur is produced, the reaction mixture becomes more cloudy until it cannot be seen through (i.e. it is opaque). The time taken for the mixture to become opaque can be dependent on the relative concentrations of the reagents or the temperature of the reaction mixture.

(a) (i) Predict how the rate of reaction will change if the temperature of the reagents is **increased**. Using the idea of how the kinetic energy of the particles changes as the temperature of the reagents **increases**, explain your prediction in terms of particle collisions.

prediction.....

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explanation.....

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(ii) Display your prediction in the form of a sketch graph, clearly labelling the axes.

[3]

(b) 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 and experimental set up you would use to carry out this experiment. Your apparatus should use only standard items found in a school or college laboratory and show clearly the following.

(i) the apparatus used as the reaction vessel and how the thermometer will be positioned in order to measure the temperature of the solution as accurately as possible

(ii) how the solution will be heated

Label each piece of apparatus used, indicating its size or capacity and the temperature range that the thermometer should cover.

[2]

[Turn over

(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,

0.100 mol dm^{-3} aqueous sodium thiosulfate,
1.00 mol dm^{-3} hydrochloric acid,
A stop-watch/clock with second hand.

Give a step-by-step description of how you would carry out the experiment by stating

(i) the number of experiments you would do, and their temperature range (minimum and maximum temperatures),

(ii) what you would keep constant in all the experiments,

(iii) what temperature measurements you would make,

(iv) how you would use the cloudiness (opacity) of the reaction mixture to measure the time taken for each reaction.

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(e) State a hazard that must be considered when planning the experiment and describe precautions that should be taken to keep risks to a minimum.

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(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 section **(a)**. The headings **must** include the appropriate units.

[2]

[Total: 15]

[Turn over

2 The solubility of potassium chlorate(V) in water increases with temperature. The units of solubility are grams per one hundred grams of water (g / 100g water).

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An experiment is carried out to investigate this solubility.

- An empty boiling tube was weighed and the mass recorded.
- Some distilled water was added to the boiling tube and the new mass recorded.
- A small sample of potassium chlorate(V) was added and this new mass recorded.
- The boiling tube was carefully heated with stirring until all the solid had dissolved.
- The apparatus was allowed to cool slowly while constantly stirring and the temperature recorded when the first crystals appeared in the tube.

(a) The results of several such experiments are recorded below.

A	B	C	D	E	F	G
crystallising temperature / °C	mass of boiling tube /g	mass of boiling tube and water /g	mass of boiling tube, water and solid /g			
20.0	10.10	35.10	36.85			
25.0	10.20	35.20	37.45			
30.0	9.80	29.20	31.20			
40.0	9.95	32.95	36.55			
45.0	10.35	30.35	33.45			
50.0	9.90	34.90	39.40			
60.0	9.70	30.70	35.53			
65.0	9.95	33.95	40.07			
70.0	10.45	30.45	36.15			
75.0	10.35	35.35	42.75			
80.0	10.05	35.05	44.05			
90.0	10.10	40.10	53.90			

Process the results in the table to calculate the solubility in g / 100 g of the potassium chlorate(V) for each of the temperatures listed.

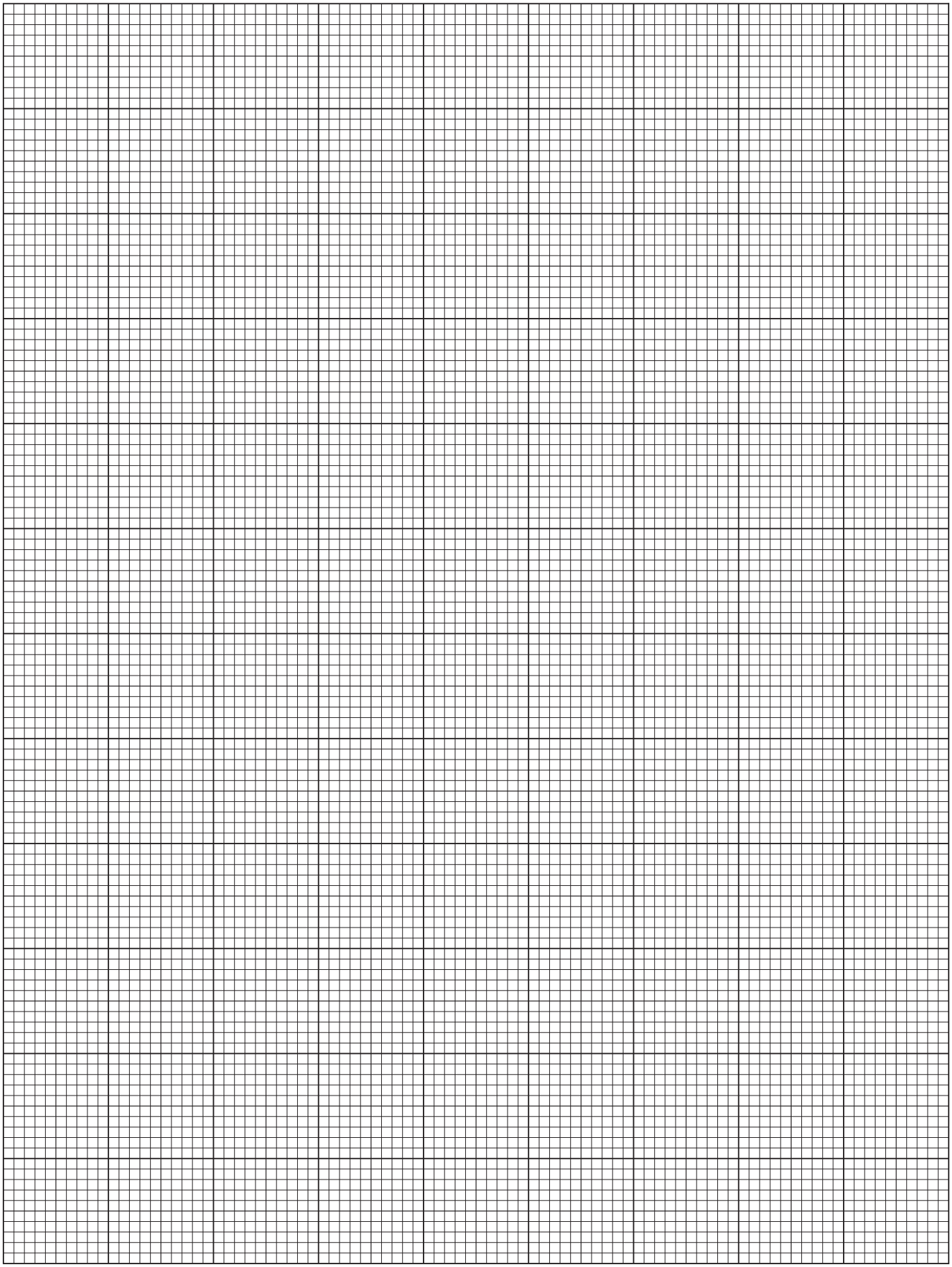
Record these values to **two decimal places** in the additional columns of the table. You may use some or all of the columns.

Label the columns you use.

For each column you use include units where appropriate and an expression to show how your values are calculated.

Use the column headings A to G for these expressions (e.g. A–B). [3]

(b) Plot a graph to show the variation of solubility with temperature.
Draw the line of best fit.



[4]

(c) Circle and label on the graph any point(s) you consider anomalous.
For each anomalous point give a different reason why it is anomalous clearly indicating which point you are describing.

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(d) A solution of potassium chlorate(V) is made up using 50 g of water. This is found to be saturated at 85 °C. The solution is then cooled to 35 °C. Using your graph calculate the mass of solid deposited as a result of this temperature change.

[2]

(e) From the pattern of solubility demonstrated by your graph predict and explain whether the dissolving of potassium chlorate(V) in water is an exothermic or an endothermic reaction.

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prediction

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explanation

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[Total: 15]

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