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AS Level Chemistry B (Salters)

H033/02 Chemistry in depth

Friday 9 June 2017 – Afternoon

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry B (Salters) (sent with general stationery)

You may use:
- a scientific or graphical calculator

First name									
Last name									
Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*****).
- This document consists of **24** pages.

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Answer **all** the questions.

1 Hydrogen peroxide decomposes very slowly in aqueous solution.

The equation for this decomposition is shown below.

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

It is known that some solid transition metal oxides can act as heterogeneous catalysts for this reaction.

(a) Explain what is meant by the terms *heterogeneous* and *catalyst*.

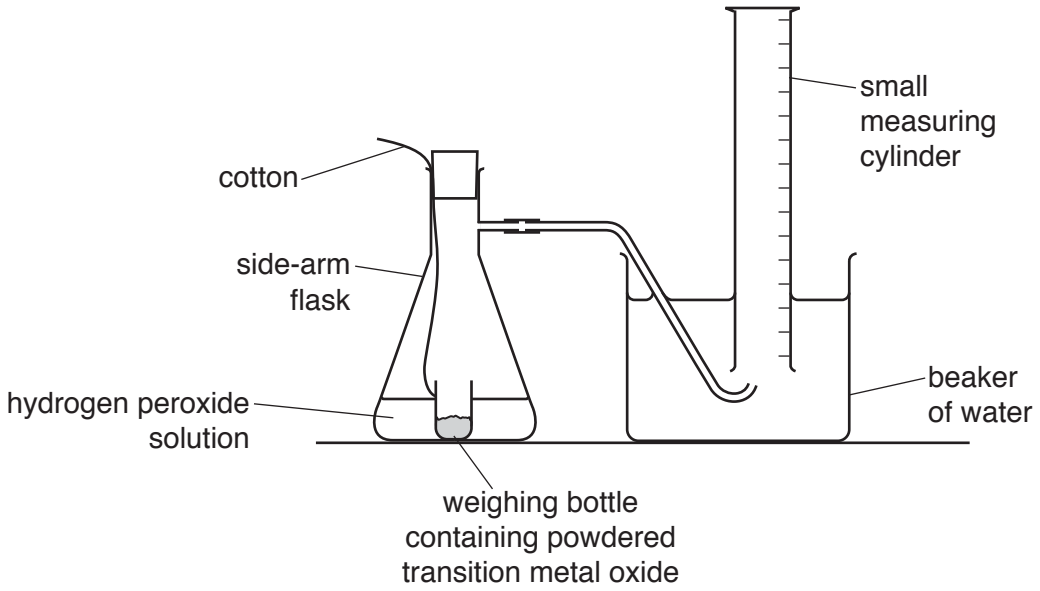
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..... **[2]**

(b) A student decides to investigate the catalytic effect of three different transition metal oxides: copper(II) oxide, zinc oxide and manganese(IV) oxide.

The student measures the volume of oxygen produced at regular intervals of time using the apparatus shown below.



(i) The student says that the same mass of each powdered transition metal oxide must be used in order to make valid comparisons.

State and explain whether or not the student is correct.

.....

.....

..... **[1]**

(ii) Identify **two** variables, apart from details of the transition metal oxide, that the student must control in this experiment.

1 .....

2 ..... **[1]**

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(c) The student displays the results of the investigation on a graph.

The results for copper(II) oxide and zinc oxide are plotted on the graph on page 5.

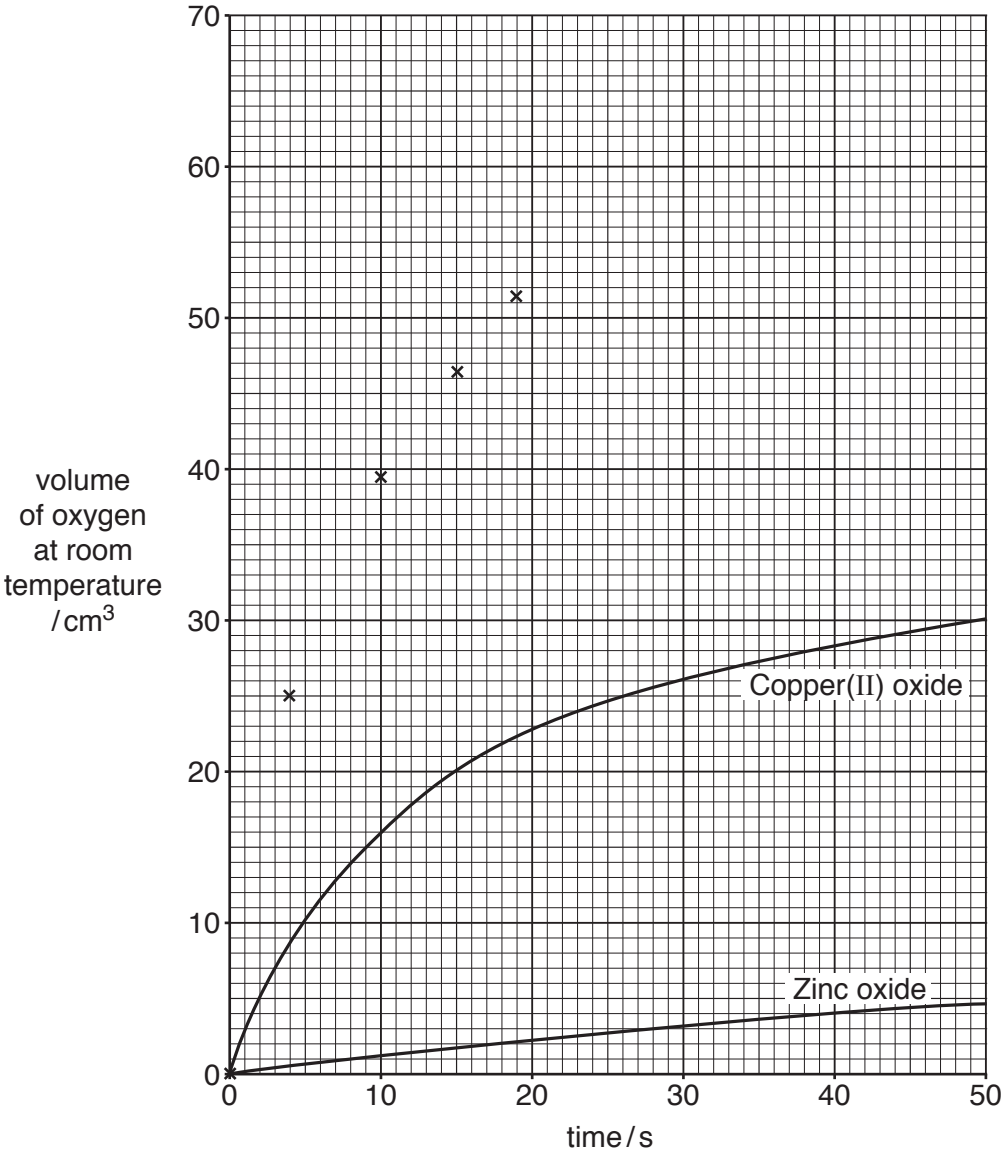
The student obtained the following results using manganese(IV) oxide.

Time / s	Volume of oxygen measured at room temperature / cm^3
0	0.0
4	25.0
10	39.5
15	46.5
19	51.5
25	55.0
30	60.5
36	62.5
40	63.0
45	63.0
49	63.0

(i) The first five results for manganese(IV) oxide have been plotted on page 5.

Plot the remaining results and draw the line of best fit. **[1]**

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(ii) Use the graph to explain which of the three catalysts is the most effective.

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..... **[1]**

(iii) The experiment is carried out at room temperature and pressure.

Use the graph to calculate the average rate of formation of oxygen over the first 15 s using copper(II) oxide. Give your answer in mol s^{-1}.

average rate = ... mol s^{-1} **[2]**

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(d) All three transition metal oxides used in the experiment are heterogeneous catalysts. Heterogeneous catalysts are used in a variety of reactions including cracking.

Write an equation for the cracking of decane, $C_{10}H_{22}$. Show the products as a branched alkene with four carbon atoms and one other branched product.

Use **skeletal** formulae.



[2]

(e) There are four main stages in a simple generalised model of heterogeneous catalysis.

(i) List these four stages in order.

Stage 1 .....

.....

Stage 2 .....

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Stage 3 .....

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Stage 4 .....

..... **[2]**

(ii) Use this model to explain the effect of a catalyst poison on the action of a heterogeneous catalyst.

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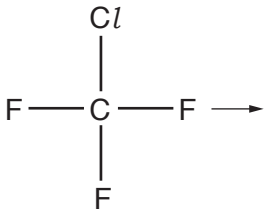
..... **[1]**

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(f) Chlorine radicals in the stratosphere are homogeneous catalysts for the breakdown of ozone. These radicals are produced by the breakdown of CFCs when they absorb ultraviolet radiation in the stratosphere.

(i) $CCl F_3$ is one such CFC.

Show the electron movements and give the products for the photodissociation of $CCl F_3$.



[1]

(ii) The bond enthalpy of the C–C*l* bond is +346 kJ mol^{-1}.

Calculate the maximum wavelength of radiation (in nm) needed to break a **single** C—C*l* bond.

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

(1 nm = 10^{-9} m)

maximum wavelength = ... nm **[3]**

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(g)* Both oxygen and chlorine atoms react with ozone in the stratosphere.

Describe and compare the roles of oxygen and chlorine atoms in the breakdown of ozone and their relative effects. Include equations where appropriate.

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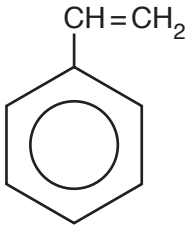
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2 Poly(phenylethene), commonly known as 'polystyrene', can be used to make packaging. The monomer phenylethene is shown below.

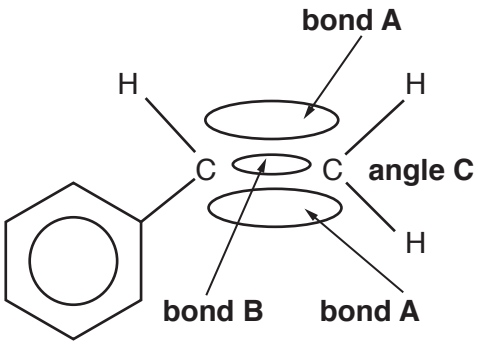


phenylethene

(a) Draw the structure of the repeating unit of poly(phenylethene).

[1]

(b) The bonding between the carbon atoms in phenylethene can be represented as shown below.



(i) Name the **types** of bond represented by **A** and **B**.

Bond **A** .....

Bond **B** ..... **[1]**

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(ii) State and explain the bond angle **C**.

Bond angle **C** = ...°

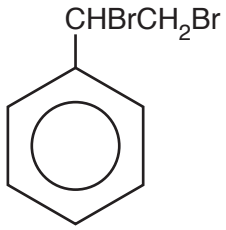
Explanation .....

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..... **[3]**

(c) Phenylethene is polymerised in the laboratory. Any unreacted phenylethene can be detected by adding aqueous bromine to the reaction mixture. Bromine reacts to produce **compound A**.



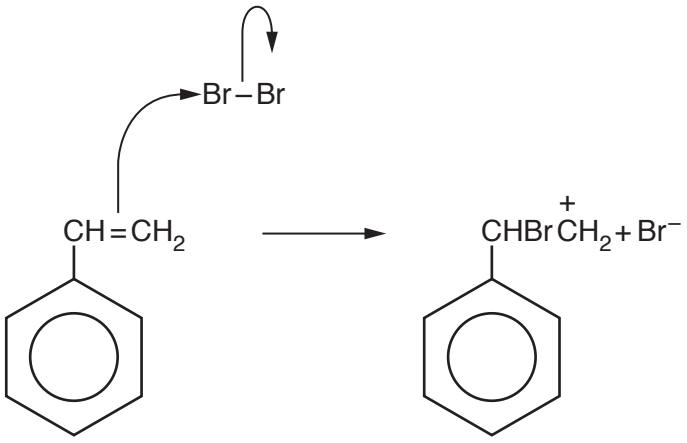
compound A

(i) What colour **change** would be observed when phenylethene reacts with aqueous bromine?

..... **[1]**

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(ii) The first step in the mechanism for the reaction of phenylethene with bromine is shown below.

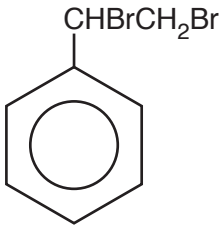


intermediate 1

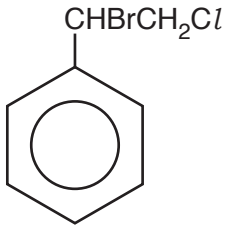
What name is given to the **type** of organic intermediate, such as **intermediate 1**, formed in the reaction?

..... **[1]**

(iii) If an aqueous mixture of bromine and potassium chloride is added to phenylethene, some of **compound B** is produced, as well as **compound A**.



compound A



compound B

Use the mechanism shown in **(c)(ii)** to explain why both **compound A** and **compound B** are formed.

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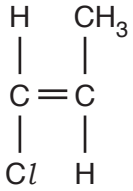
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..... **[1]**

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(d) Another substituted alkene is 1-chloroprop-1-ene, shown below



1-chloroprop-1-ene

Unlike phenylethene, 1-chloroprop-1-ene shows *E/Z* stereoisomerism.

Describe how this *E/Z* isomerism arises.

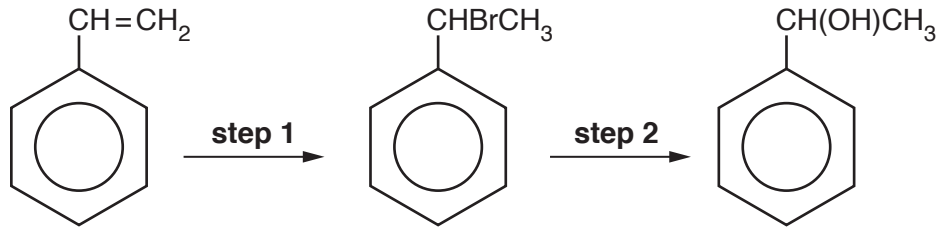
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..... **[2]**

(e) 1-phenylethanol is a compound that is used when making perfumes.
1-phenylethanol can be prepared in the laboratory from phenylethene in two steps.

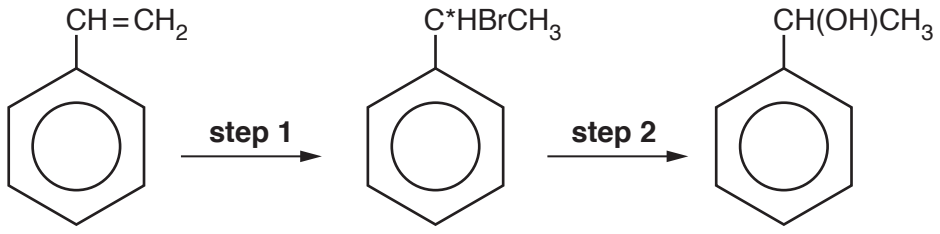


phenylethene **1-phenyl-1-bromoethane** **1-phenylethanol**

(i) Give the reagent that you would use for **step 1**.

..... **[1]**

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phenylethene **1-phenyl-1-bromoethane** **1-phenylethanol**

(ii) Draw a diagram to show the three-dimensional arrangement of the atoms around the carbon atom C* in 1-phenyl-1-bromoethane.

[1]

(iii) 1-phenylethanol is an example of a secondary alcohol.

Explain why the alcohol is classified as *secondary*.

.....

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..... **[1]**

(iv) 1-phenylethanol is reacted with potassium dichromate(VI) in sulfuric acid.

Draw the structural formula of the product of this reaction.

[1]

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3 Brine is a concentrated aqueous sodium chloride solution. Chlorine is made by the electrolysis of brine. Sodium hydroxide and hydrogen are co-products.

The equation representing the overall reaction that occurs during this electrolysis is shown below.

$$2Cl^-(aq) + 2H_2O(l) \longrightarrow Cl_2(g) + 2OH^-(aq) + H_2(g)$$

(a) (i) Calculate the amount (in moles) of NaOH in 0.50 tonne of sodium hydroxide.

amount of NaOH = ... mol **[1]**

(ii) Calculate the mass of chlorine (in tonnes) produced at the same time as 0.50 tonne of sodium hydroxide.

mass = ... tonnes **[1]**

(iii) Calculate the volume (in m^3) that this chlorine would occupy at RTP.

volume = ... m^3 **[1]**

(b) Molten sodium chloride is electrolysed instead of an aqueous solution.

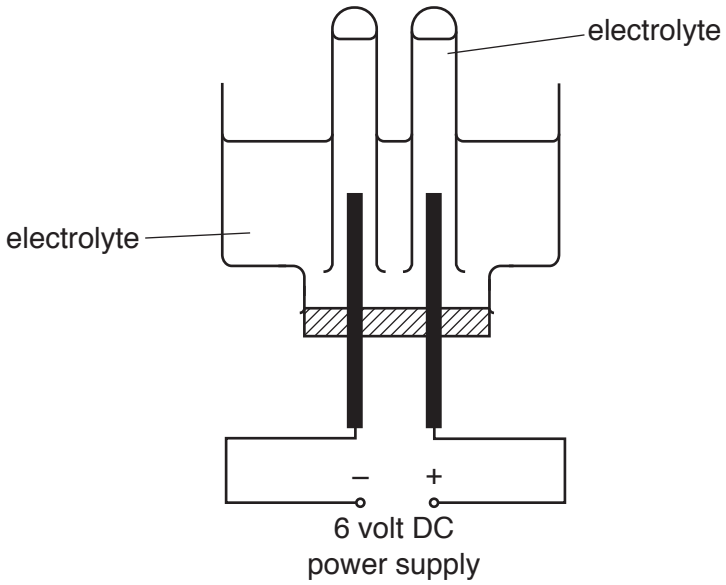
What would be the similarity and the difference in the products at the two electrodes?

Similarity .....

Difference ..... **[1]**

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(c) A student investigates the electrolysis of aqueous solutions of sodium halides in the laboratory using the apparatus shown below.



Describe what would be **observed** at each electrode when the electrolyte is aqueous sodium **iodide**.

(i) at the anode (positive electrode)

.....

(ii) at the cathode (negative electrode)

..... **[1]**

(d) Write the half-equations involved in the electrolysis of sodium **bromide** solution.

(i) at the anode (+)

[1]

(ii) at the cathode (–)

[1]

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(e) A student investigates the reactions of aqueous halogen solutions with aqueous solutions of sodium halides.

The student adds 1 cm depth of bromine solution to an equal volume of a sodium halide solution in a test-tube.

A 1 cm depth of cyclohexane is then added, the mixture is shaken and the immiscible liquids allowed to separate. The upper layer is purple.

(i) What is the colour of the lower layer?

..... **[1]**

(ii) Write the **ionic** equation for the reaction between the aqueous solutions of bromine and the sodium halide.

[1]

(f) In a separate test-tube reaction, aqueous solutions of chlorine and sodium iodide are mixed. The equation for the reaction is shown below.

$$Cl_2(aq) + 2NaI(aq) \longrightarrow I_2(aq) + 2NaCl(aq) \qquad \textbf{equation 3.1}$$

(i) Write the ionic half-equation for the oxidation reaction.

[1]

(ii) Identify the oxidising agent in the reaction in **equation 3.1**.

..... **[1]**

(g) The oxidising strength of the halogens decreases going down the Group.
Explain this trend.

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..... **[3]**

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4 A student investigates the relative reactivities of calcium and barium with water and observes that barium is more vigorous than calcium.

(a) (i) The teacher asks the student to explain this observation using the following data.

Element	First ionisation enthalpy / kJ mol^{-1}
Calcium	+590
Barium	+502

The student makes three statements:

1. The first ionisation enthalpies are the $\Delta_r H$ values for the following reactions.

   $Ba(s) \longrightarrow Ba^+(aq) + e^-$

   $Ca(s) \longrightarrow Ca^+(aq) + e^-$

2. Less energy is needed to remove an electron from the outer shell of a barium atom than from the outer shell of a calcium atom. Therefore barium is more reactive.

3. A barium atom is bigger than a calcium atom, so the electrons are more spread out. This explains why less energy is needed to remove an electron from the outer shell of a barium atom.

Discuss the student's three statements and correct any incorrect chemistry where necessary.

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..... **[4]**

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(ii) The student reacts 1.26 g of calcium with excess water.

Calculate the volume of hydrogen (in cm^3) produced at RTP.

$$Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$$

Give your answer to an **appropriate** number of significant figures.

volume of hydrogen = ... cm^3 **[2]**

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(b)* The student then wishes to compare the thermal stabilities of calcium carbonate and strontium carbonate.

Describe the experiment the student could carry out, giving reasons for the steps you describe. Suggest the expected results.

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..... **[6]**

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(c) Another student determines the concentration of calcium hydroxide in a solution by titrating 25.0 cm^3 of the solution against 0.0500 mol dm^{-3} hydrochloric acid.

The student obtains the following titres (in cm^3).

21.55 20.80 20.90

(i) Explain why the appropriate mean titre for this titration is 20.85 cm^3.

.....

.....

..... **[1]**

(ii) The student uses a burette that can be read to the nearest 0.05 cm^3.

Calculate the percentage uncertainty in the titre of 20.80 cm^3.

percentage uncertainty = ... % **[1]**

(iii) The equation for the reaction between calcium hydroxide and hydrochloric acid is shown below.

$$Ca(OH)_2(aq) + 2HCl(aq) \longrightarrow CaCl_2(aq) + 2H_2O(l)$$

Calculate the concentration (**in g dm^{-3}**) of the calcium hydroxide in the student's solution.

concentration of calcium hydroxide = ... g dm^{-3} **[3]**

(d) The elements in a modern Periodic Table are arranged by atomic number.

Explain the meaning of the term *atomic number*.

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..... **[1]**

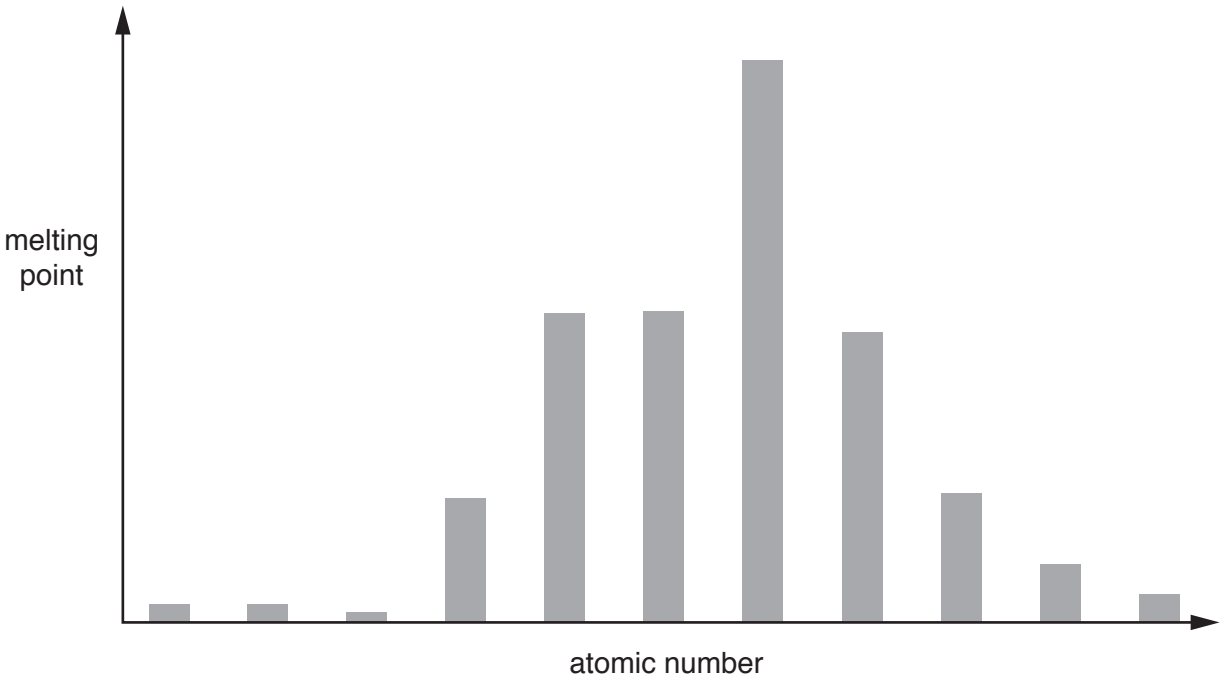
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(e) The bar chart below shows the pattern of melting points in a series of elements.

The elements are arranged in order of increasing atomic number with no gaps.

The elements sodium to chlorine form **part** of this series.

Write the symbol **Na** above a bar to label the position of **sodium** on the chart.



[1]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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