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| Please check the examination details below before entering your candidate information | |
| Candidate surname | Other names |
| Centre Number | Candidate Number |
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| Pearson Edexcel Level 3 GCE | |
| Tuesday 16 May 2023 | |
| Morning (Time: 1 hour 30 minutes) | Paper reference 8CH0/01 |
| Chemistry | |
| Advanced Subsidiary | |
| PAPER 1: Core Inorganic and Physical Chemistry | |
| You must have: Scientific calculator, Data Booklet, ruler | Total Marks |

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- For the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions.

Some questions must be answered with a cross \boxtimes . If you change your mind about an answer, put a line through the box \boxtimes and then mark your new answer with a cross \boxtimes .

1 Atoms of silicon contain protons, neutrons and electrons.

(a) Which are the correct data for a proton and a neutron?

(1)

| | Proton | | Neutron | |
|-----------------------------------|-----------------|---------------|-----------------|---------------|
| | Relative charge | Relative mass | Relative charge | Relative mass |
| <input type="checkbox"/> A | +1 | 1 | -1 | 0.0005 |
| <input type="checkbox"/> B | +1 | 1 | 0 | 1 |
| <input type="checkbox"/> C | -1 | 0.0005 | 0 | 1 |
| <input type="checkbox"/> D | 0 | 1 | +1 | 1 |

(b) (i) State the shape of the 2s orbital of a silicon atom.

(1)

(ii) State the difference between the two subatomic particles in the 2s orbital.

(1)



- (c) Silicon has three stable isotopes.

A sample of silicon was found to have a relative atomic mass, A_r , of 28.11 due to the presence of only the three stable isotopes.

The abundance for two of the isotopes is given in the table.

| Isotope | Abundance / % |
|------------------|---------------|
| ^{28}Si | 92.2 |
| ^{30}Si | 3.1 |

Determine the relative isotopic mass of the third stable isotope.
You **must** show your working.

(2)

- (d) Give the symbol, including the mass number and atomic number, for an atom of element **X** that has four fewer protons and three fewer neutrons than an atom of $^{28}_{14}\text{Si}$.

(1)

(Total for Question 1 = 6 marks)



2 This question is about the double salt $K_2Mg(SO_4)_2 \cdot 6H_2O$.

A double salt is a salt containing more than one cation or more than one anion.

- (a) (i) Give the reason why the term relative formula mass is used, rather than relative molecular mass, when discussing $K_2Mg(SO_4)_2 \cdot 6H_2O$.

(1)

- (ii) Give the reason why relative formula mass has no mathematical units.

(1)

- (iii) What is the relative formula mass of $K_2Mg(SO_4)_2 \cdot 6H_2O$?

Use the Periodic Table as a source of data.

(1)

- ☐ **A** 206.0
- ☐ **B** 322.7
- ☐ **C** 402.7
- ☐ **D** 595.3

- (iv) Calculate the amount of substance, in mol, in 25.0 g of $K_2Mg(SO_4)_2 \cdot 6H_2O$.

(1)

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- (b) Cations may be identified using a flame test on a solid or by the addition of aqueous sodium hydroxide to an aqueous solution containing the cation.

Describe the expected results of performing these tests on $K_2Mg(SO_4)_2 \cdot 6H_2O$. Include the observation for each cation in each test.

(4)

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- (c) The test used to show the presence of the **anion** in $K_2Mg(SO_4)_2 \cdot 6H_2O$ gives a white precipitate as the positive result.

(i) What are the reagents used for this test?

(1)

- ☐ A dilute hydrochloric acid and aqueous silver nitrate
- ☐ B dilute sulfuric acid and aqueous silver nitrate
- ☐ C dilute hydrochloric acid and aqueous barium chloride
- ☐ D dilute sulfuric acid and aqueous barium chloride

(ii) Write an ionic equation, including state symbols, for the formation of the white precipitate in the test for the anion in the double salt.

(1)

(Total for Question 2 = 10 marks)



3 This question is about elements in Group 7.

(a) Group 7 elements react with many metals.

- (i) What happens to the atoms of a metal and the Group 7 element when they react together?

(1)

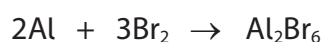
| | Metal | Group 7 element |
|-----------------------------------|--|--|
| <input type="checkbox"/> A | gains electrons to form a positive ion | loses electrons to form a negative ion |
| <input type="checkbox"/> B | increases in oxidation number | gains electrons to form a negative ion |
| <input type="checkbox"/> C | loses electrons to form a negative ion | decreases in oxidation number |
| <input type="checkbox"/> D | loses electrons to form a positive ion | increases in oxidation number |

- (ii) Which is **not** true when calcium reacts with bromine?

(1)

- ☐ **A** bromine reacts less vigorously than chlorine
- ☐ **B** during the reaction bromine oxidises the calcium
- ☐ **C** the percentage by mass of calcium in the product is 33 %
- ☐ **D** the product gives a brick-red flame test

- (iii) The equation for the reaction between aluminium and bromine is shown.

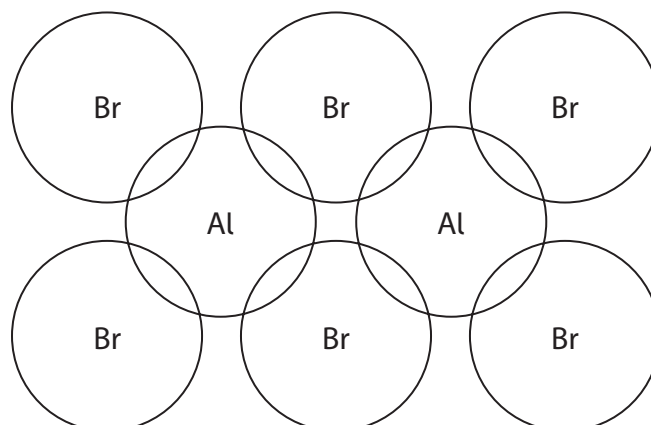


The compound is a dimer made up of two covalently bonded monomers joined by dative covalent bonds.

Complete the dot-and-cross diagram, showing outer shell electrons only, of this dimer.

Use • for bromine electrons and x for aluminium electrons.

(2)



- (iv) Platinum metal reacts with fluorine to give a compound of platinum with an oxidation number of +6.

Give the formula of this compound of platinum.

(1)

- (v) Chromium reacts with iodine.

The only product contains 12.0% chromium by mass.

Calculate the empirical formula of the chromium iodide formed.

You **must** show your working.

(2)

- (b) Chlorine, bromine and iodine are three of the Group 7 elements. The bond length and bond enthalpies in molecules of these elements are shown in the table.

| Bond | Bond length / nm | Bond enthalpy / kJ mol^{-1} |
|-------|------------------|--------------------------------------|
| Cl—Cl | 0.199 | 243.4 |
| Br—Br | 0.228 | 192.9 |
| I—I | 0.267 | 151.2 |

- (i) Explain how the trend in bond length relates to the trend in bond strength on **descending** the group.

(2)



- (ii) The relative reactivity of chlorine and iodine can be demonstrated using the reaction between one of these elements and the potassium salt of the other halogen.

Describe an experiment to show how this is deduced and give the expected observation for the reaction that occurs.

Include an ionic equation for this reaction.

State symbols are not required.

(3)

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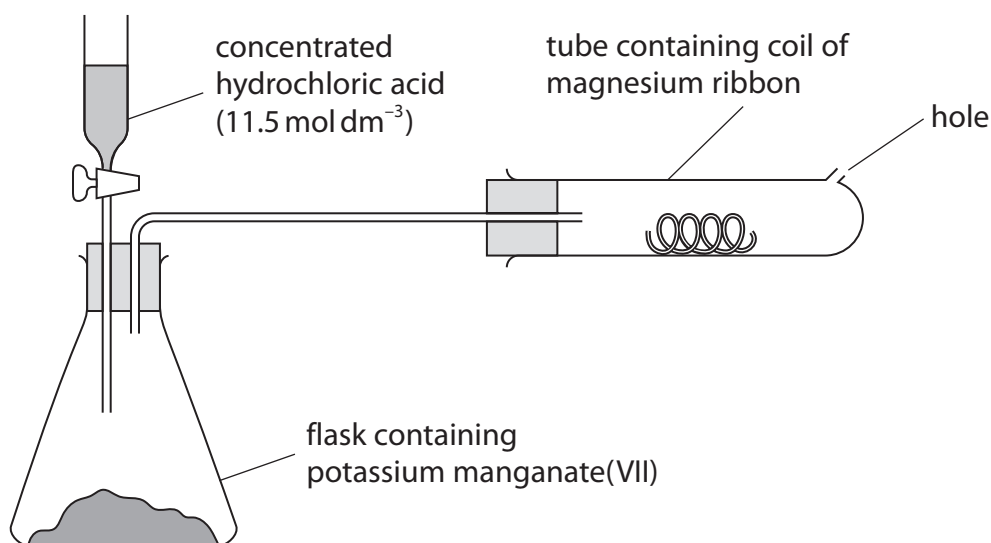
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(Total for Question 3 = 12 marks)



- 4 The reaction between magnesium and chlorine can be carried out using the apparatus shown.



The coil of magnesium ribbon is first heated strongly until it just melts. Chlorine gas is then produced by a chemical reaction in the conical flask.

The chlorine gas is passed over the heated magnesium, resulting in the formation of magnesium chloride.

- (a) In order to melt the magnesium, it must be heated strongly.

Explain why the structure of magnesium gives it a high melting temperature.

(2)

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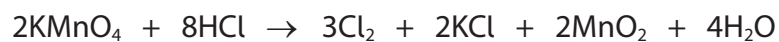
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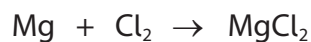


(b) The equation for the reaction to produce chlorine is shown.



The concentration of the hydrochloric acid is 11.5 mol dm^{-3} .

The equation for the reaction between the chlorine and the magnesium is shown.



Calculate the minimum volume of concentrated hydrochloric acid, in cm^3 , required to produce 4.00 g of magnesium chloride, MgCl_2 .

Give your answer to an appropriate number of significant figures.

(4)



- (c) Bottles of potassium manganate(VII), KMnO_4 , have three hazard warning labels. One of these is shown.



This hazard symbol means that potassium manganate(VII) is liable to

(1)

- ☐ **A** burn easily in the presence of oxygen
- ☐ **B** explode
- ☐ **C** react dangerously with oxygen
- ☐ **D** react vigorously with reducing agents

(Total for Question 4 = 7 marks)

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- (d) The table gives data for chlorine and chlorine compounds of some Period 3 elements. The data show evidence that the type of bonding in compounds is a continuum across Period 3.

| | Empirical formula | Melting temperature / °C | Electrical conductivity |
|--------------------------|-------------------|--------------------------|-------------------------|
| Sodium chloride | NaCl | 801 | Yes, when molten |
| Magnesium chloride | MgCl ₂ | 714 | Yes, when molten |
| Aluminium chloride | AlCl ₃ | 180 (sublimes) | No |
| Silicon tetrachloride | SiCl ₄ | -70 | No |
| Phosphorus(III) chloride | PCl ₃ | -112 | No |
| Chlorine | Cl ₂ | -102 | No |

Discuss the extent to which the data in the table demonstrate a continuum of bonding type.

Include reference to the data of **three** of the substances in the table with different types of bonding.

(3)

(Total for Question 5 = 9 marks)



- 6 Redox reactions can be understood in terms of electron transfer **or** in terms of changes of oxidation number.

(a) The equation for a redox reaction is shown.



- (i) State, in terms of electron transfer, what you understand by the terms oxidation and reduction.

(1)

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- (ii) Explain, in terms of electron transfer, which of the species is the oxidising agent and which is the reducing agent.

(2)

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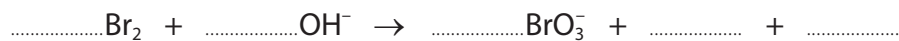


- (b) Bromine reacts with sodium hydroxide solution in a disproportionation reaction to form BrO_3^- .

Complete the equation for this disproportionation.

Justify the balancing of the equation in terms of the changes in oxidation number.

(4)



(Total for Question 6 = 7 marks)

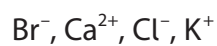


7 This question is about ions.

- (a) Draw a dot-and-cross diagram of the ionic compound potassium chloride.
Show outer shell electrons only.

(1)

- (b) Deduce the order of increasing size of the ions:



Justify your answer.

(4)

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- (c) A saturated aqueous calcium hydroxide solution contains 17.3 g in 10.0 dm³ of solution.

Under these conditions the calcium hydroxide is fully dissociated into ions.

What is the concentration of the calcium ions in this solution, in mol dm⁻³?

(1)

- ☐ **A** 0.0233
- ☐ **B** 0.0303
- ☐ **C** 0.0431
- ☐ **D** 0.0597

(Total for Question 7 = 6 marks)

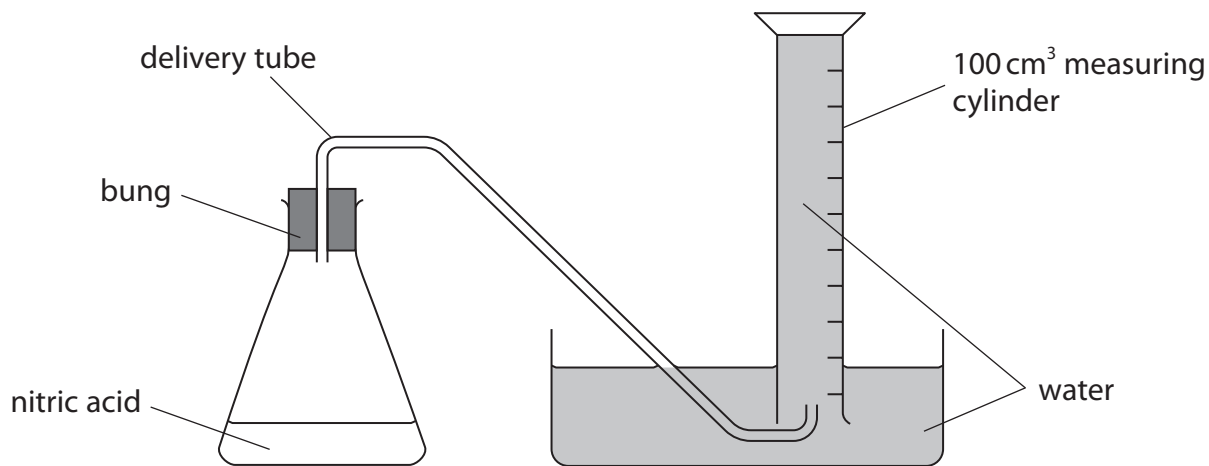


8 Reactions between calcium carbonate and acids produce carbon dioxide gas.

This reaction can be used in an experiment to determine the molar volume of carbon dioxide.

Procedure

- Step 1** Place 50 cm³ of 1 mol dm⁻³ nitric acid in a conical flask.
- Step 2** Set up the apparatus as shown in the diagram.
- Step 3** Place approximately 0.4 g of calcium carbonate in a test tube and weigh the test tube and its contents accurately.
- Step 4** Remove the bung from the conical flask.
- Step 5** Tip the calcium carbonate into the conical flask.
- Step 6** Replace the bung in the conical flask.
- Step 7** Once all the calcium carbonate has reacted, measure the volume of gas collected in the measuring cylinder.
- Step 8** Reweigh the test tube that had contained the calcium carbonate.
- Step 9** Repeat the experiment decreasing the mass of calcium carbonate added each time.



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(a) A major source of inaccuracy in this experiment occurs between Steps **5** and **6** when carbon dioxide gas is lost before the bung is replaced.

- (i) Identify a change to the acid in Step **1** that would reduce the volume of gas lost between Steps **5** and **6**. Justify your answer.

(2)

- (ii) Identify a change to the procedure in Steps **5** and **6** that would prevent loss of gas.

(2)

(b) A second source of inaccuracy results from the significant solubility in water of carbon dioxide.

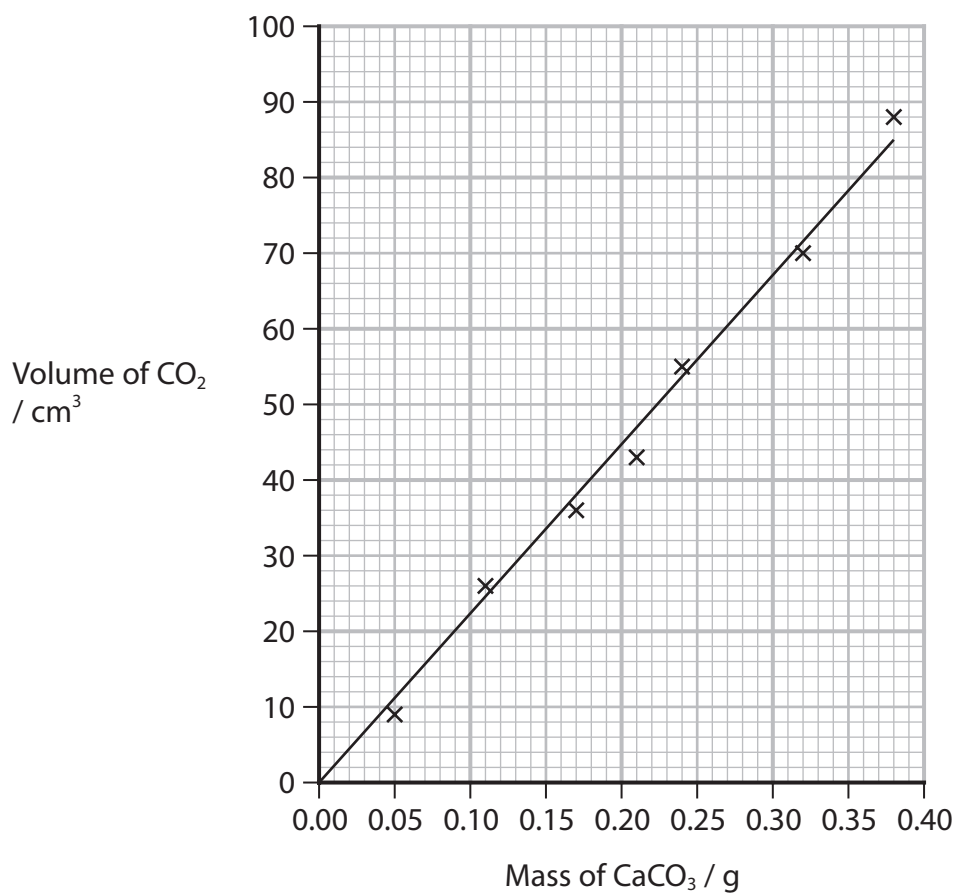
Give **two** improvements which together prevent this problem.

(2)



P 7 1 9 2 6 A 0 1 9 2 8

- (c) After appropriate improvements, the procedure was carried out and the results were plotted on a graph. A line of best fit was drawn.



- (i) Use the graph to find the molar volume of carbon dioxide, in dm^3 .
You must show your working on the graph.

[Assume molar mass of $\text{CaCO}_3 = 100 \text{ g mol}^{-1}$]

(3)



- (ii) The procedure was carried out at a temperature of 22°C and a pressure of $1.01 \times 10^5 \text{ Pa}$.

Calculate the theoretical molar volume, giving units with your answer.

[The ideal gas equation is $pV = nRT$. Gas constant (R) = $8.31 \text{ J mol}^{-1} \text{ K}^{-1}$]

(3)

(Total for Question 8 = 12 marks)



9 This question is about ionisation energy.

(a) The first four ionisation energies, in kJ mol^{-1} , of four elements are shown.

Which element is in Group 3?

(1)

- ☐ **A** 738 1451 7753 10541
- ☐ **B** 578 1817 2745 11578
- ☐ **C** 789 1577 3232 4356
- ☐ **D** 1012 1903 2912 4957

(b) The second ionisation energy of beryllium is more endothermic than the first ionisation energy.

- (i) Write an equation for the second ionisation of beryllium.
Include state symbols.

(2)

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*(ii) Explain how the nuclear structure and the electronic structure of the Group 2 elements affect ionisation energies.

Include:

- an explanation of the trend of the first ionisation energies down the group
- a comparison of the first two ionisation energies for an element.

(6)

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- (iii) The value of the sum of the first and second ionisation energies changes on descending Group 2.

Explain how this changing value might contribute to the relative reactivity of the elements with chlorine.

(2)

(Total for Question 9 = 11 marks)

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

[illegible]

* Lanthanide series

* Actinide series

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