

Chemistry

Advanced Subsidiary

PAPER 1: Core Inorganic and Physical Chemistry

Time: 1 hour 30 minutes

In the boxes below, write your name, centre number and candidate number.

Surname					
Other names					
Centre Number					
Candidate Number					

YOU MUST HAVE

Scientific calculator, Data Booklet

YOU WILL BE GIVEN

Diagram Booklet, Periodic Table

INSTRUCTIONS

Answer ALL questions.

Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – 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 provided as a separate insert.

There may be spare copies of some diagrams.

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.

Answer ALL questions.

Some questions must be answered with a cross in a box \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 Which is the electronic configuration for the S^{2-} ion?

☐ A $1s^2 2s^2 2p^6 3s^2 3p^2$

☐ B $1s^2 2s^2 2p^6 3s^2 3p^4$

☐ C $1s^2 2s^2 2p^6 3p^6$

☐ D $1s^2 2s^2 2p^6 3s^2 3p^6$

(Total for Question 1 = 1 mark)

2 Which is the most likely sequence of values, in kJ mol^{-1} , for the first four ionisation energies of barium?

☐ A 1000 2251 3361 4564

☐ B 496 4563 6913 9544

☐ C 503 965 3458 4530

☐ D 578 1817 2745 11 578

(Total for Question 2 = 1 mark)

3 This question is about tests for ions.

- (a) A student wrote the following answer to a question about the processes that can give rise to a flame colour during a flame test of an inorganic compound.**

“When an inorganic compound is heated, energy is emitted as ions move up energy levels. Electrons return to lower energy levels and release energy as light which is always in the visible region of the electromagnetic spectrum.”

Identify THREE errors in this account. Include in your answers a correct word or phrase that should be used instead.

(3 marks)

First error

Correct word or phrase

3 continued.

Second error

Correct word or phrase

Third error

Correct word or phrase

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Turn over

3 continued.

(b) Which compound does NOT give a red colour in a flame test?

(1 mark)

- ☐ **A calcium chloride**
- ☐ **B lithium carbonate**
- ☐ **C sodium iodide**
- ☐ **D strontium bromide**

(c) A wire is used for a flame test.

Which material would be most suitable for a flame test wire?

(1 mark)

- ☐ **A copper**
- ☐ **B iron**
- ☐ **C magnesium**
- ☐ **D platinum**

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3 continued.

(d) An aqueous solution is suspected to be potassium bromide and is tested for the presence of the anion.

**(i) Write the NAME of the reagent used to test for the anion.
(1 mark)**

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3 continued.

- (ii) State the expected result of this test and the **FORMULA** of the product.
(2 marks)

Result of test

Formula of the product

(Total for Question 3 = 8 marks)

- 4 This question is about isotopes, mass spectra and hydrocarbons.

(a) Hydrogen has three isotopes, ^1H , ^2H and ^3H .

Which is the correct number of subatomic particles in ^3H ?

(1 mark)

Number of subatomic particles			
	Protons	Neutrons	Electrons
<input type="checkbox"/> A	2	1	2
<input type="checkbox"/> B	1	2	0
<input type="checkbox"/> C	1	2	1
<input type="checkbox"/> D	2	1	3

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4 continued.

- (b) Look at the diagram for Question 4(b) in the Diagram Booklet. It shows the mass spectrum of a sample of chlorine with one peak missing.**

Chlorine has two isotopes, ^{35}Cl and ^{37}Cl , and a relative atomic mass of 35.5

- (i) The relative abundance of the isotope ^{35}Cl is 75.5%.
The relative peak height of this isotope is 82.5 in the mass spectrum.**

**Calculate the relative peak height of the missing peak caused by the isotope ^{37}Cl .
(2 marks)**

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4 continued.

- (ii) Give a reason for the presence of the three peaks at 70, 72 and 74.
(1 mark)**

(continued on the next page)

4 continued.

- (iii) Explain, using calculations, why there is an approximate ratio of 9:6:1 for the peak heights corresponding to the m/z values of 70, 72 and 74.
(3 marks)**

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4 continued.

(c) Look at the diagram for Question 4(c) in the Diagram Booklet. The mass spectrum of a hydrocarbon, **B, which has a molecular formula C_xH_y , is shown.**

- (i) Determine the relative molecular mass of compound **B**.
(1 mark)**

**Relative molecular mass
of compound **B** is _____**

- (ii) Deduce the molecular formula of hydrocarbon **B**.
(1 mark)**

4 continued.

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4 continued.

(d) 1.00 g of a DIFFERENT hydrocarbon, W, was burnt in oxygen.

Analysis of the combustion products showed that complete combustion produced 3.14 g of carbon dioxide and 1.29 g of water.

Water and carbon dioxide were the only products of combustion.

Calculate the EMPIRICAL formula of hydrocarbon W.

You MUST show your working.

(4 marks)

4 continued.

(Total for Question 4 = 13 marks)

Turn over

5 Intermolecular forces affect melting temperatures, boiling temperatures and solubility.

(a) The table gives the melting temperatures of some Group 7 hydrogen halides.

Compound	Melting temperature / K
HF	190
HCl	158
HBr	185

Predict the melting temperature, in K, of hydrogen iodide, HI, using the information in the table.

(1 mark)

Melting temperature of HI _____ K

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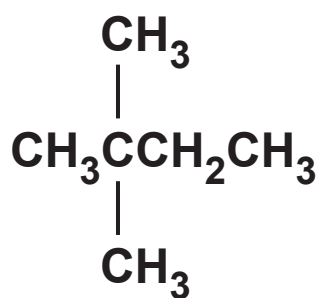
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(b) Look at the table for Question 5(b) in the Diagram Booklet. The compounds in the table are isomers.

Which is most likely to be the boiling temperature of another isomer, 2,2-dimethylbutane?

(1 mark)

The structure of 2,2-dimethylbutane is



☐ A 40 °C

☐ B 50 °C

☐ C 60 °C

☐ D 70 °C

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5 continued.

***(c) Methanol, CH_3OH , is miscible with water in all proportions.**

Sodium chloride is much less soluble in methanol than in water.

Explain these statements using your knowledge of the interactions between solutes and solvents.

You MUST use diagrams to illustrate your answers.

Answer space continues on the next 5 pages.

(6 marks)

5 continued.

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(Total for Question 5 = 8 marks)

6 Look at the table for Question 6(a) and 6(b) in the Diagram Booklet. It shows some information about the structure and bonding in four substances.

**(a) Complete the table.
(2 marks)**

**(b) Explain why the melting temperature of silicon(IV) oxide is much higher than that of iodine, even though the bonding in both is covalent.
(3 marks)**

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Turn over

6 continued.

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6 continued.

- (c) Iron and potassium chloride both conduct electricity when molten. However, only iron conducts electricity when solid.**

Explain these observations.

(3 marks)

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Turn over

6 continued.

(Total for Question 6 = 8 marks)

7 This question is about s-block elements and some of their compounds.

**(a) Which list contains only s-block elements?
(1 mark)**

- ☐ **A** Li, Na, Mg and Cl
- ☐ **B** K, Ca, Co and Rb
- ☐ **C** Mg, Al, Sr and Ba
- ☐ **D** Be, Rb, Ba and Ra

**(b) Which pair of statements describes the trends
DOWN Group 2?
(1 mark)**

	Solubility of sulfates	Solubility of hydroxides
<input type="checkbox"/> A	increases	increases
<input type="checkbox"/> B	decreases	increases
<input type="checkbox"/> C	decreases	decreases
<input type="checkbox"/> D	increases	decreases

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7 continued.

(c) The s-block nitrates undergo thermal decomposition.

(i) Look at the diagram for Question 7(c)(i) in the Diagram Booklet. Draw a dot-and-cross diagram for the nitrate(V) ion, NO_3^- , showing outer electrons only.
(1 mark)

(ii) Write an equation for the thermal decomposition of lithium nitrate.

State symbols are NOT required.
(1 mark)

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7 continued.

- (iii) The equation for the thermal decomposition of sodium nitrate is different from that for lithium nitrate.



The gas produced is collected in a gas syringe.

Calculate the theoretical volume of gas, in cm^3 , that could be collected at 298 K and 101 kPa by the decomposition of 0.500 g of pure sodium nitrate.

Give your answer to 2 significant figures.
(4 marks)

$$[pV = nRT, R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$$

7 continued.

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7 continued.

(iv) State one reason why the experimental gas volume may differ from the calculated theoretical volume.

Assume that no gas escapes and measurements have been made accurately.

(1 mark)

(continued on the next page)

7 continued.

- (d) A textbook states, 'The thermal stability of Group 1 carbonates is generally higher than the thermal stability of Group 2 carbonates in the same period'.**

**Explain why Group 1 carbonates are more thermally stable than Group 2 carbonates.
(3 marks)**

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Turn over

7 continued.

(Total for Question 7 = 12 marks)

8 This question is about some reactions of chlorine and hydrogen chloride.

- (a) When hydrogen gas and chlorine gas are mixed and passed over a hot platinum catalyst, hydrogen chloride gas is formed.

The equation for this reaction is



In an experiment, 20 cm^3 of dry hydrogen gas was reacted with 20 cm^3 of dry chlorine gas.

All gas volumes were measured at room temperature and pressure (r.t.p.).

Calculate the number of gas molecules in the product at r.t.p.

(2 marks)

[Molar volume of a gas at r.t.p. = $24\,000\text{ cm}^3\text{ mol}^{-1}$

Avogadro constant (L) = $6.02 \times 10^{23}\text{ mol}^{-1}$]

8 continued.

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Turn over

8 continued.

(b) Hydrogen chloride gas dissolves in water to form hydrochloric acid.

- (i) Hydrogen chloride gas does not conduct electricity.
Hydrochloric acid is a good conductor of electricity.**

**Give a reason for this change in conductivity.
(1 mark)**

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8 continued.

- (ii) When concentrated hydrochloric acid on a glass rod is held above a concentrated ammonia solution, a white smoke is observed.**

**Write an equation, including state symbols, for the reaction that produces the white smoke.
(2 marks)**

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8 continued.

(iii) Hydrochloric acid is added to a test tube containing a sample of solid sodium carbonate.

**Give TWO observations.
(2 marks)**

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8 continued.

- (iv) Describe an experiment to enable you to accurately determine the concentration of an approximately 1 mol dm^{-3} solution of hydrochloric acid, using a solution of sodium hydroxide of concentration 1.00 mol dm^{-3} . Details of the calculation are not required. (5 marks)

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8 continued.

- (c) Chlorine can be produced by reacting concentrated hydrochloric acid with manganese(IV) oxide.

The equation for this reaction is



- (i) Deduce the half-equation for the formation of chlorine.
(1 mark)

(continued on the next page)

8 continued.

- (ii) A student reacted 5.0 cm^3 of 5.0 mol dm^{-3} hydrochloric acid with an excess of manganese(IV) oxide. 70 cm^3 of chlorine gas was produced.

The teacher said the expected percentage yield of the experiment is 75%.

Determine whether the student achieved the expected percentage yield.
(4 marks)

[Molar volume of a gas at
r.t.p. = $24\,000 \text{ cm}^3 \text{ mol}^{-1}$]

8 continued.

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8 continued.

- (d) Chlorine reacts with hot concentrated aqueous sodium hydroxide to produce sodium chlorate(V) as one of the products.

The equation for this reaction is



- (i) Explain, using oxidation numbers, why this is a disproportionation reaction.
(2 marks)

8 continued.

- (ii) Calculate the atom economy, by mass, of sodium chlorate(V) in this reaction.
(3 marks)**

(Total for Question 8 = 22 marks)

Turn over

9 Water gas is a fuel gas consisting of a mixture of carbon monoxide and hydrogen.

(a) Water gas is produced by passing steam over white hot coke.

The equation for the reaction is shown.



Calculate the total mass of products when 1000 kg of steam reacts completely.

(2 marks)

9 continued.

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Turn over

9 continued.

- (b) Look at the diagram for Question 9(b) in the Diagram Booklet. The complete combustion of water gas produces carbon dioxide and water. A student drew a diagram of the apparatus to attempt to identify the combustion products.**

**Evaluate whether the student's apparatus is suitable for identifying both of the combustion products. Include any improvements needed.
(5 marks)**

(continued on the next page)

Turn over

9 continued.

(Total for Question 9 = 7 marks)

TOTAL FOR PAPER = 80 MARKS
END OF PAPER