

Q1. What is the formula of calcium nitrate(V)?

A  $\text{CaNO}_3$

B  $\text{Ca}(\text{NO}_3)_2$

C  $\text{Ca}_2\text{NO}_2$

D  $\text{Ca}(\text{NO}_2)_2$

(Total 1 mark)

Q2. Some airbags in cars contain sodium azide ( $\text{NaN}_3$ ).

- (a) Sodium azide is made by reacting dinitrogen monoxide gas with sodium amide ( $\text{NaNH}_2$ ) as shown by the equation.

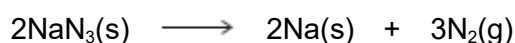


Calculate the mass of sodium amide needed to obtain 550 g of sodium azide, assuming there is a 95.0% yield of sodium azide. Give your answer to 3 significant figures.

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(5)

- (b) If a car is involved in a serious collision, the sodium azide decomposes to form sodium and nitrogen as shown in the equation.



The nitrogen produced then inflates the airbag to a volume of  $7.50 \times 10^{-2} \text{ m}^3$  at a

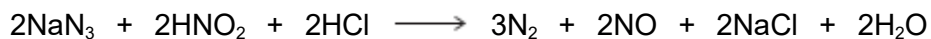
pressure of 150 kPa and temperature of 35 °C.

Calculate the minimum mass of sodium azide that must decompose.  
(The gas constant  $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$ )

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(6)

- (c) Sodium azide is toxic. It can be destroyed by reaction with an acidified solution of nitrous acid ( $\text{HNO}_2$ ) as shown in the equation.



- (i) A 500 cm<sup>3</sup> volume of the nitrous acid solution was used to destroy completely 150 g of the sodium azide.

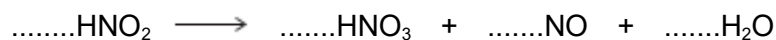
Calculate the concentration, in mol dm<sup>-3</sup>, of the nitrous acid used.

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(3)

- (ii) Nitrous acid decomposes on heating.

Balance the following equation for this reaction.



(1)

- (d) Sodium azide has a high melting point.

Predict the type of bonding in a crystal of sodium azide.  
Suggest why its melting point is high.

Type of bonding .....

Reason for high melting point .....

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(3)

- (e) The azide ion has the formula  $\text{N}_3^-$

- (i) The azide ion can be represented as  $\text{N} \equiv \text{N} - \text{N}^-$   
One of these bonds is a co-ordinate bond.

On the following diagram, draw an arrowhead on one of the bonds to represent the direction of donation of the lone pair in the co-ordinate bond.



(1)

- (ii) Give the formula of a molecule that has the same number of electrons as the azide ion.

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(1)

- (iii) Which is the correct formula of magnesium azide?

Tick (✓) **one** box.

$\text{Mg}_3\text{N}$

$\text{MgN}$

MgN<sub>6</sub>

Mg<sub>3</sub>N<sub>2</sub>

(1)  
(Total 21 marks)

**Q3.** Zinc forms many different salts including zinc sulfate, zinc chloride and zinc fluoride.

- (a) People who have a zinc deficiency can take hydrated zinc sulfate (ZnSO<sub>4</sub>.xH<sub>2</sub>O) as a dietary supplement.

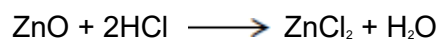
A student heated 4.38 g of hydrated zinc sulfate and obtained 2.46 g of anhydrous zinc sulfate.

Use these data to calculate the value of the integer x in ZnSO<sub>4</sub>.xH<sub>2</sub>O  
Show your working.

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(3)

- (b) Zinc chloride can be prepared in the laboratory by the reaction between zinc oxide and hydrochloric acid.  
The equation for the reaction is



A 0.0830 mol sample of pure zinc oxide was added to 100 cm<sup>3</sup> of 1.20 mol dm<sup>-3</sup> hydrochloric acid.

Calculate the maximum mass of anhydrous zinc chloride that could be obtained from the products of this reaction.

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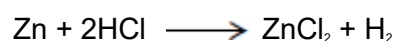
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(4)

- (c) Zinc chloride can also be prepared in the laboratory by the reaction between zinc and hydrogen chloride gas.



An impure sample of zinc powder with a mass of 5.68 g was reacted with hydrogen chloride gas until the reaction was complete. The zinc chloride produced had a mass of 10.7 g.

Calculate the percentage purity of the zinc metal.  
Give your answer to 3 significant figures.

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- (d) Predict the type of crystal structure in solid zinc fluoride and explain why its melting point is high.

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(3)  
 (Total 14 marks)

**Q4.** The table below shows the boiling points of some hydrogen compounds formed by Group 6 elements.

	H <sub>2</sub> O	H <sub>2</sub> S	H <sub>2</sub> Se	H <sub>2</sub> Te
Boiling point / K	373	212	232	271

(a) State the strongest type of intermolecular force in water and in hydrogen sulfide (H<sub>2</sub>S).

Water .....

Hydrogen sulfide .....

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(2)

(b) Draw a diagram to show how two molecules of water are attracted to each other by the type of intermolecular force you stated in part (a). Include partial charges and all lone pairs of electrons in your diagram.

(3)

(c) Explain why the boiling point of water is much higher than the boiling point of

hydrogen sulfide.

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(1)

(d) Explain why the boiling points increase from H<sub>2</sub>S to H<sub>2</sub>Te

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(2)

(e) When H<sup>+</sup> ions react with H<sub>2</sub>O molecules, H<sub>3</sub>O<sup>+</sup> ions are formed.

Name the type of bond formed when H<sup>+</sup> ions react with H<sub>2</sub>O molecules.  
Explain how this type of bond is formed in the H<sub>3</sub>O<sup>+</sup> ion.

Type of bond .....

Explanation .....

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(2)

(f) Sodium sulfide (Na<sub>2</sub>S) has a melting point of 1223 K.  
Predict the type of bonding in sodium sulfide and explain why its melting point is high.

Type of bonding .....

Explanation .....

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(3)

(Total 13 marks)