Question One (15 marks)

(a) Consider the molecule SO_2.

(i) Draw its Lewis structure (electron dot diagram), showing all lone pairs.

(ii) State the shape of the molecule and the approximate bond angle.

(iii) Explain whether the molecule is polar or non-polar.

[6 marks]

(b) The electronegativity of Mg is 1.31 and the electronegativity of O is 3.44.

Classify the bond between Mg and O as ionic, polar covalent or non-polar covalent, and explain how the electronegativity values lead to your answer, including the direction of any bond polarity.

[4 marks]

(c) Potassium forms an ionic compound with sulfur.

(i) Write the electron arrangement change for each atom as the compound forms, and write the formula of the compound.

(ii) Explain why the compound has a high melting point and why it only conducts electricity when molten or dissolved in water.

[5 marks]

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THE WORKED ANSWER TO THAT QUESTION

Question 1 (15 marks) [Bonding, shape and polarity]

(a) Consider the molecule SO_2. (i) Draw its Lewis structure (electron dot diagram), showing all lone pairs. (ii) State the shape of the molecule and the approximate bond angle. (iii) Explain whether the molecule is polar or non-polar.

(a) Answer: SO_2 is bent (V-shaped) with a bond angle of about 117°; it is polar

- Evidence level: Excellence (count valence electrons, place bonds and lone pairs, then decide shape and polarity from the symmetry).
- (i) Valence electrons: 6 (S) + 6 (O) + 6 (O) = 18. The central atom is S; it forms 2 bond(s) to O, O (with 2 multiple bond(s)).
- The central atom has 1 lone pair(s) and 3 region(s) of electron density.
- (ii) 3 regions of electron density with 1 lone pair(s): the shape is bent (V-shaped), with a bond angle of about 117°.
- Achievement: (iii) States whether the molecule is polar or non-polar.
- Merit: Gives a reason for the bond polarity: the bonds are polar because of the difference in electronegativity between S and the other atoms.
- Excellence: Full explanation: the bonds are polar and the bent (V-shaped) shape is not symmetrical, so the bond dipoles do not cancel and the molecule is polar.

> **KEY TAKEAWAY**
> Shape and polarity: count regions of electron density to get the shape; then ask whether the polar bonds are arranged symmetrically (dipoles cancel, so non-polar) or not (dipoles add, so polar).

(b) The electronegativity of Mg is 1.31 and the electronegativity of O is 3.44. Classify the bond between Mg and O as ionic, polar covalent or non-polar covalent, and explain how the electronegativity values lead to your answer, including the direction of any bond polarity.

(b) Answer: ionic bond

- Evidence level: Excellence (use the electronegativity difference to classify the bond and show the direction of polarity).
- Difference = |1.31 − 3.44| = 2.13.
- Achievement: States the bond type (ionic).
- Merit: Links to the difference: a difference of 2.13 is large (above about 1.7), so the bond is ionic.
- Excellence: Full explanation: the electrons are transferred (or almost completely pulled) to O, giving ions held by electrostatic attraction.

> **KEY TAKEAWAY**
> Bond type: |ΔEN| above about 1.7 is ionic, 0.4 to 1.7 polar covalent, and below 0.4 non-polar covalent; in a polar bond the more electronegative atom is δ−.

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(c) Potassium forms an ionic compound with sulfur. (i) Write the electron arrangement change for each atom as the compound forms, and write the formula of the compound. (ii) Explain why the compound has a high melting point and why it only conducts electricity when molten or dissolved in water.

(c) Answer: (i) K loses 1, S gains 2 electron(s); formula K_2S; (ii) strong electrostatic attractions between ions in the lattice give a high melting point; ions are free to move only when molten or dissolved

- Evidence level: Excellence (describe electron transfer, balance the charges, and explain properties from the lattice structure).
- (i) K loses 1 electron(s) to form K^+; S gains 2 electron(s) to form S^{2-}. The charges must balance: 2 × (1) = 1 × (−2), so the formula is K_2S (potassium sulfide).
- Achievement: (ii) States that the compound has a lattice of ions with strong attractions between them.
- Merit: Links to the properties: a lot of energy is needed to overcome the strong electrostatic attractions between oppositely charged ions, so the melting point is high; the ions cannot move in the solid.
- Excellence: Full explanation: the solid is a regular lattice of oppositely charged ions held together by strong electrostatic attractions in all directions, so a large amount of energy is required to melt it (high melting point). In the solid the ions are fixed in position, so there are no mobile charged particles and it does not conduct; when molten or dissolved the ions are free to move and carry charge, so it conducts.

KEY TAKEAWAY

Ionic compounds: metals lose electrons to form positive ions, non-metals gain them to form negative ions; the formula balances the charges; the lattice has strong attractions (high melting point) and conducts only when the ions can move.

LOS: Bonding, shape and polarity (91164)

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