2.2 Bonding and Structure: 30-minute Pack

AQA 7405 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question tests key definitions used throughout the bonding and structure topic.

(a) Define electronegativity. **(1)**

(b) Define a coordinate (dative covalent) bond. **(1)**

(c) State what is meant by a permanent dipole. **(1)**

(d) State what is meant by van der Waals (London/dispersion) forces. **(1)**

(Total for Question 1 is 4 marks)

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2 This question uses ionic radii to compare the strength of ionic bonding in sodium chloride, NaCl, and magnesium oxide, MgO. Ionic radii: Na^+ = 102 pm, Cl^- = 181 pm, Mg^{2+} = 72 pm, O^{2-} = 140 pm. The electrostatic force of attraction between two ions is proportional to (Q1 x Q2) / r^2, where Q1 and Q2 are the sizes of the ionic charges and r is the distance between the ion centres (the sum of their ionic radii).

(a) State two factors that affect the strength of ionic bonding (the magnitude of lattice enthalpy). **(2)**

(b) Show that the value of (Q1 x Q2) / r for MgO is more than five times greater than the value for NaCl, where r is the sum of the two ionic radii (in pm). **(4)**

(c) Explain how the calculation in part (b) accounts for the fact that magnesium oxide has a higher melting point than sodium chloride. **(2)**

(d) Going down Group 2, from MgO to CaO to SrO to BaO, explain how you would expect the lattice enthalpy and melting point of the Group 2 oxide to change, and why. **(2)**

(Total for Question 2 is 10 marks)

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3 This question is about metallic bonding and the properties of metals and alloys.

(a) Describe the structure and bonding present in a typical metal. **(2)**

(b) Explain why metals are good conductors of electricity in both the solid and molten states. **(3)**

(c) Explain why metals are malleable. **(2)**

(d) Explain, in terms of structure, why alloys are generally harder than the pure metals from which they are made. **(3)**

(Total for Question 3 is 10 marks)

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Mark scheme · 2.2 Bonding and Structure: 30-minute Pack

Question 1

(a) the power (ability) of an atom in a covalent bond to attract the bonding (shared) pair of electrons towards itself, oe **B1**

(a) Answer: The power of an atom in a covalent bond to attract the bonding pair of electrons towards itself.

(b) a covalent bond in which both of the shared electrons in the bonded pair are provided by the same atom, oe **B1**

(b) Answer: A covalent bond in which both shared electrons come from the same atom.

(c) a small, permanent charge separation across a bond caused by a difference in electronegativity between the two bonded atoms, giving one atom a partial positive charge (delta+) and the other a partial negative charge (delta-), oe **B1**

(c) Answer: A permanent small charge separation across a bond, delta+ on one atom and delta- on the other, caused by unequal electronegativities.

(d) weak intermolecular forces caused by instantaneous (temporary) dipoles inducing dipoles in neighbouring molecules or atoms, oe **B1**

(d) Answer: Weak intermolecular forces caused by instantaneous dipoles inducing dipoles in neighbouring particles.

Question 2

(a) the size of the ionic charge (a greater charge gives stronger electrostatic attraction) oe **B1**

(a) the ionic radius (a smaller radius means ions are closer together, giving stronger attraction) oe **B1**

(a) Answer: Ionic charge and ionic radius.

(b) sum of ionic radii: NaCl, r = 102 + 181 = 283 pm; MgO, r = 72 + 140 = 212 pm **M1**

(b) charge product: NaCl, Q1 x Q2 = 1 x 1 = 1; MgO, Q1 x Q2 = 2 x 2 = 4 **M1**

(b) value for NaCl = 1/283 = 3.53 x 10^{-3} (pm^{-1}); value for MgO = 4/212 = 1.887 x 10^{-2} (pm^{-1}) (allow awrt) **M1**

(b) ratio = 1.887x10^{-2} / 3.53x10^{-3} = 5.3 (accept 5.3-5.4), confirming the value for MgO is more than five times greater than for NaCl, cso **A1**

(b) Answer: Ratio approx 5.3: the MgO value is about 5.3 times greater than the NaCl value, confirming the statement.

(c) the larger calculated value for MgO (ft from (b)) shows a stronger electrostatic force of attraction between its ions, meaning MgO has a greater (more exothermic) lattice enthalpy oe **M1**

(c) more energy is required to overcome these stronger ionic bonds, so a higher temperature is needed to melt MgO than NaCl oe **A1**

(c) Answer: The larger value for MgO shows stronger ionic attraction (greater lattice enthalpy), so more energy (a higher temperature) is needed to melt MgO, giving it a higher melting point than NaCl.

(d) the ionic radius of the Group 2 cation increases down the group, while its charge stays the same (2+) oe **B1**

(d) the ions become further apart, so electrostatic attraction weakens: lattice enthalpy becomes less negative (decreases in magnitude) and melting point decreases down the group oe **B1**

(d) Answer: Lattice enthalpy (in magnitude) and melting point both decrease going down Group 2, because increasing cation radius (same charge) weakens the electrostatic attraction between ions.

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Question 3

(a) a giant metallic lattice of positive metal ions arranged in a regular, close-packed structure oe **B1**

(a) surrounded by a "sea" of delocalised electrons that are free to move throughout the whole structure oe **B1**

(a) Answer: A giant lattice of positive metal ions in a regular arrangement, surrounded by a sea of delocalised electrons.

(b) the delocalised electrons are free to move throughout the metallic structure and can carry charge oe **B1**

(b) metallic bonding (and the delocalised electrons) is present in both the solid and molten states, since only the regular arrangement of ions is lost on melting, not the bonding itself oe **B1**

(b) so mobile charge carriers (delocalised electrons) are available to conduct electricity in both states oe **B1**

(b) Answer: Delocalised electrons are free to move and carry charge in both solid and molten metal, since metallic bonding persists on melting.

(c) the layers of positive metal ions can slide over one another when a force is applied oe **B1**

(c) because metallic bonding is non-directional, the delocalised electrons continue to attract and hold the ions together as the layers move, so the metal bends/changes shape without breaking oe **B1**

(c) Answer: Layers of metal ions can slide over each other under force, while the non-directional sea of delocalised electrons keeps holding the structure together, so metals bend rather than shatter.

(d) an alloy contains atoms of one or more other elements, which are usually a different size from the atoms of the pure metal oe **M1**

(d) this distorts the regular arrangement of layers of ions in the lattice oe **M1**

(d) the layers can no longer slide over each other as easily, making the alloy harder/stronger than the pure metal oe **A1**

(d) Answer: Alloys contain atoms of different sizes, which distort the regular layered structure and prevent layers sliding easily, making alloys harder than pure metals.

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