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HIGHER

C2H Bonding, Structure and Properties of Matter: Higher Tier Practice

AQA 8462 · Calculator allowed · about 100 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Describe the type of bonding and the particle arrangement in sodium chloride (table salt).

(a) Name the type of bonding in sodium chloride. **(1)**

(b) State the arrangement of the ions in the solid (type of structure). **(1)**

(Total for Question 1 is 2 marks)

2 A sample of magnesium oxide contains magnesium ions Mg2+ and oxide ions O2-. Explain, using charges, why the formula is MgO.

(a) State the charges on magnesium and oxide ions. **(1)**

(b) Explain how these charges lead to the formula MgO, using the idea of overall charge balance. **(2)**

(Total for Question 2 is 3 marks)

3 Calcium carbonate, $CaCO_3$, decomposes on heating to give calcium oxide and carbon dioxide. A student heated 2.50 g of pure $CaCO_3$ and collected 0.55 g of CO_2.

(a) Calculate the number of moles of carbon dioxide collected. Mr of CO_2 = 44.0. **(2)**

....

(b) Using stoichiometry ($CaCO_3 \rightarrow CaO + CO_2$), calculate the percentage yield of CO_2 from the 2.50 g of $CaCO_3$. Mr of $CaCO_3$ = 100.1. **(2)**

....

(Total for Question 3 is 4 marks)

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4 A student compares melting points of sodium chloride (NaCl), magnesium oxide (MgO) and silicon dioxide (SiO_2). Explain why MgO has a much higher melting point than NaCl, and why SiO_2 has a very high melting point despite having covalent bonds.

(a) Explain why MgO has a higher melting point than NaCl. **(2)**

(b) Explain why SiO_2 has a very high melting point even though it is covalently bonded. **(2)**

(Total for Question 4 is 4 marks)

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5 Draw a simple dot-and-cross style diagram showing the bonding in a hydrogen chloride molecule, HCl, and state the type of bond.

(a) Show the electrons for H and Cl and indicate the shared pair. **(2)**

(b) State the type of bond in HCl. **(1)**

(Total for Question 5 is 3 marks)

6 Explain why solid sodium chloride does not conduct electricity but molten sodium chloride does.

(a) Explain why solid NaCl does not conduct. **(1)**

(b) Explain why molten NaCl conducts. **(1)**

(Total for Question 6 is 2 marks)

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7 Compare metallic bonding with simple molecular covalent bonding in terms of electrical conductivity and malleability. Give one reason for each property.

(a) State whether metals conduct electricity and give the reason. **(1)**

(b) State whether simple molecular substances conduct electricity and give the reason. **(1)**

(c) Explain why metals are generally malleable whereas simple molecular substances are brittle or soft. **(1)**

(Total for Question 7 is 3 marks)

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8 Silicon can form the giant covalent structure found in sand and also form discrete molecules in other compounds. Consider diamond (a form of carbon) and a molecule of silicon tetrachloride, SiCl4.

(a) State whether diamond is a giant covalent structure or a simple molecular substance. **(1)**

(b) State whether SiCl4 is a giant covalent structure or a simple molecular substance. **(1)**

(c) Give one reason why diamond is hard while SiCl4 is a liquid at room temperature. **(1)**

(Total for Question 8 is 3 marks)

9 A student analyses a compound and finds it contains 2.40 g of carbon and 0.40 g of hydrogen. Calculate the empirical formula of the compound. Relative atomic masses: C = 12.0, H = 1.0.

(a) Calculate the number of moles of C and of H in the sample. Show your working. **(3)**

....

(b) Find the simplest whole number ratio of C to H and state the empirical formula. **(2)**

....

(Total for Question 9 is 5 marks)

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10 Explain how electrical conductivity differs between metals, ionic compounds and covalent molecular substances. In your answer compare the particles that carry charge in each type of substance and why their mobility differs. Use examples to support your explanation.

(Total for Question 10 is 6 marks)

Mark scheme · C2H Bonding, Structure and Properties of Matter: Higher Tier Practice

Question 1

- (a) **B1** ionic bonding cao
- **(a) Answer: Ionic bonding**
- (b) **B1** giant ionic lattice (regular arrangement of alternating Na^+ and Cl^- ions) cao
- **(b) Answer: Giant ionic lattice (regular arrangement of Na^+ and Cl^- ions)**

Question 2

- (a) **B1** Mg^{2+} and O^{2-} cao
- **(a) Answer: Mg^{2+} and O^{2-}**
- (b) **M1** states that total positive charge must balance total negative charge in an ionic compound
- (b) **A1** shows 1 x Mg^{2+} (+2) balances 1 x O^{2-} (-2) so formula is MgO cao
- **(b) Answer: One Mg^{2+} balances one O^{2-} so the formula is MgO**

Question 3

- (a) **M1** substitutes: moles = mass / Mr = 0.55 / 44.0
- (a) **A1** 0.0125 mol cao
- **(a) Answer: 0.0125 mol**
- (b) **M1** calculates moles of $CaCO_3$: 2.50 / 100.1 = 0.024975... and uses 1:1 stoichiometry so theoretical moles CO_2 = 0.024975...
- (b) **A1** percentage yield = (0.0125 / 0.024975...) x 100 = 50.0% (to three significant figures) cao
- **(b) Answer: 50.0%**

Question 4

- (a) **M1** states that melting point depends on strength of electrostatic attraction between ions
- (a) **A1** Mg^{2+} and O^{2-} have higher charges than Na^+ and Cl^- so stronger electrostatic attraction and more energy is needed to overcome the lattice cao
- **(a) Answer: MgO has Mg^{2+} and O^{2-} so stronger electrostatic attraction than Na^+ and Cl^-, therefore a higher melting point.**
- (b) **M1** states that SiO_2 forms a giant covalent (network) structure
- (b) **A1** many strong covalent bonds throughout the network must be broken so a lot of energy is required cao
- **(b) Answer: SiO_2 is a giant covalent network with many strong covalent bonds, so a large amount of energy is required to melt it.**

Question 5

- (a) **M1** diagram shows H with 1 electron and Cl with 7 electrons and a shared pair between them (dot and cross or equivalent)
- (a) **A1** shared pair shown so Cl has 8 electrons and H has 2, cao
- **(a) Answer: H has 1 electron, Cl has 7; they share one pair so H has 2 and Cl has 8 electrons (dot and cross).**
- (b) **B1** polar covalent bond or covalent bond with polarity cao
- **(b) Answer: Polar covalent bond**

Question 6

- (a) **B1** no mobile charged particles in the solid state (ions fixed in the lattice)
- **(a) Answer: In solid NaCl the ions are fixed in the lattice so there are no mobile charged particles to carry current.**
- (b) **B1** ions are free to move when molten so mobile charged particles conduct electricity
- **(b) Answer: When molten the ions are free to move and so mobile charged particles can conduct electricity.**

Question 7

- (a) **B1** metals conduct because of mobile delocalised electrons
- **(a) Answer: Metals conduct electricity due to mobile delocalised electrons.**
- (b) **B1** simple molecular substances do not conduct because they have no mobile charged particles
- **(b) Answer: Simple molecular substances do not conduct because they have no mobile charged particles.**
- (c) **B1** metal atoms can slide over each other without breaking bonding because delocalised electrons maintain bonding; molecular solids break intermolecular forces when stressed so are brittle or soft
- **(c) Answer: Metals are malleable because layers of atoms can slide with delocalised electrons maintaining attraction; simple molecular solids are brittle or soft because applied stress breaks intermolecular forces between molecules.**

Question 8

- (a) **B1** giant covalent structure cao
- **(a) Answer: Giant covalent structure**
- (b) **B1** simple molecular substance (discrete $SiCl_4$ molecules) cao
- **(b) Answer: Simple molecular substance (discrete $SiCl_4$ molecules)**
- (c) **B1** diamond has strong covalent bonds in a giant network requiring much energy to break; $SiCl_4$ has weak intermolecular forces between discrete molecules so it is liquid at room temperature
- **(c) Answer: Diamond is hard because of the strong covalent bonds in its giant network; $SiCl_4$ is liquid because only weak intermolecular forces act between its discrete molecules.**

Question 9

- (a) **M1** calculates moles C = 2.40 / 12.0 and moles H = 0.40 / 1.0
- (a) **A1** moles C = 0.200 mol cao
- (a) **A1** moles H = 0.400 mol cao
- **(a) Answer: Moles: C = 0.200 mol, H = 0.400 mol**
- (b) **M1** divides by smallest number of moles: 0.200 to get ratio C:H = 1 : 2
- (b) **A1** empirical formula CH_2 cao
- **(b) Answer: CH_2**

Question 10

- **Level 3** (5-6): Detailed explanation that compares all three types of substance, correctly identifies the charged particles that conduct in each case, explains why those particles are mobile or immobile in different states, and gives appropriate examples. The answer is coherent and logically structured.
- **Level 2** (3-4): A partial comparison that correctly describes two types of substance with explanation of charge carriers and some reason for mobility or lack of mobility. Examples may be present but explanation lacks full clarity or completeness.
- **Level 1** (1-2): Basic statements about conductivity with limited or no explanation of the particles involved. May list properties or examples without linking to causes.
- **Indicative content:**
  - Metals: conduct because of delocalised electrons that are free to move through the metal lattice; example copper or iron; explanation that electrons are mobile in solid metal so conduct in solid state.
  - Ionic compounds: do not conduct as solids because ions are fixed in place in a lattice; conduct when molten or dissolved because ions become free to move and carry charge; example molten NaCl or aqueous NaCl.
  - Covalent molecular substances: do not conduct in solid or liquid state because there are no free ions or delocalised electrons; example iodine or silicon tetrachloride.
  - Compare mobility: delocalised electrons in metals are mobile even in solid state, whereas ionic charge carriers require melting or dissolving to move; molecular substances lack mobile charged particles altogether.
  - A concluding comparative sentence linking types to typical applications or properties, for example metals used as electrical wiring because of conductivity in solid state.