2.2 Bonding, Structure and Properties of Matter: 1-hour Pack

Total Marks

AQA 8462 · Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Metals have a characteristic structure described as a sea of delocalised electrons.

(a) Give two typical physical properties of metals that arise from metallic bonding. Give one property in each box. **(2)**

(Total for Question 1 is 2 marks)

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2 A student is given masses to calculate percentage composition by mass. Calculate the percentage of oxygen in copper(II) oxide, CuO. Relative atomic masses: Cu = 64, O = 16.

(a) Calculate the relative formula mass, Mr, of CuO. **(2)**

.....

(b) Calculate the percentage by mass of oxygen in CuO. Give your answer to 1 decimal place. **(2)**

.....

(Total for Question 2 is 4 marks)

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3 Ionic compounds conduct electricity only when molten or in solution.

(a) Explain why solid sodium chloride does not conduct electricity but molten sodium chloride does. **(3)**

(Total for Question 3 is 3 marks)

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4 Graphene and fullerenes are other allotropes (forms) of carbon.

(a) State what graphene is. **(1)**

(b) Buckminsterfullerene (C_{60}) is a hollow, cage-like molecule that can be used to deliver drugs into the body. Suggest why this structure makes fullerenes suitable for this use. **(2)**

(c) Which property makes graphene especially useful in electronics? **(1)**

- ☐ A) It is a giant ionic lattice
- ☐ B) It is a good electrical insulator
- ☐ C) It conducts electricity and is extremely thin and strong
- ☐ D) It has a very low melting point

(Total for Question 4 is 4 marks)

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5 Poly(ethene) is an example of a polymer made from many small monomer units joined together.

(a) Describe the difference between the bonding within a polymer chain and the forces between separate, neighbouring polymer chains. **(3)**

(b) Use this to explain why many polymers are solid at room temperature. **(2)**

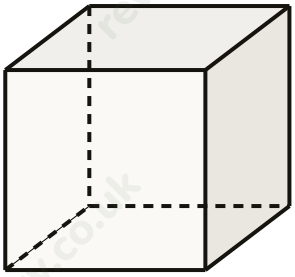
(Total for Question 5 is 5 marks)

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6 Nanoparticles are particles with dimensions between about 1 nm and 100 nm.

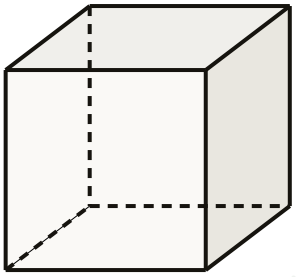
Diagram NOT accurately drawn

(a) - schematic, not to a common scale



5 nm

(b) - schematic, not to a common scale



2 cm

(a) A cube-shaped nanoparticle has sides of length 5 nm. Calculate the surface area to volume ratio of the nanoparticle. **(3)**

.....

(b) A larger, bulk sample of the same substance is cube-shaped with sides of length 2 cm. Calculate the surface area to volume ratio of this larger cube. **(3)**

.....

(c) Show that the surface area to volume ratio of the nanoparticle in part (a) is about 4×10^6 times greater than the surface area to volume ratio of the larger cube in part (b). ($1 \text{ cm} = 1 \times 10^7$ nm) **(2)**

(Total for Question 6 is 8 marks)

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7 Nanoparticles have a wide range of everyday and industrial uses.

(a) Give two uses of nanoparticles. **(2)**

(b) Evaluate the possible risks of using nanoparticles in everyday products. **(3)**

(Total for Question 7 is 5 marks)

8 Sodium chloride, carbon dioxide and diamond are three substances with very different structures. Compare the structure and bonding in these three substances, and use this to explain the differences in their melting points and ability to conduct electricity.

(Total for Question 8 is 6 marks)

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9 For each question, identify the correct answer.

(a) Which type of bonding involves a 'sea' of delocalised electrons surrounding positive ions? **(1)**

- ☐ A) Ionic
- ☐ B) Covalent
- ☐ C) Metallic
- ☐ D) Hydrogen bonding

(b) Which property is typical of a simple covalent molecular substance? **(1)**

- ☐ A) High melting point
- ☐ B) Conducts electricity when solid
- ☐ C) Low melting and boiling point
- ☐ D) Extremely hard

(c) A solid conducts electricity, has a very high melting point, and is malleable rather than brittle. What type of structure/bonding does it most likely have? **(1)**

- ☐ A) Ionic compound
- ☐ B) Simple molecular substance
- ☐ C) Metallic
- ☐ D) Giant covalent (diamond-type)

(d) A white crystalline solid melts at 801°C, conducts electricity when molten or dissolved in water, but not when solid, and is brittle. What type of bonding does it have? **(1)**

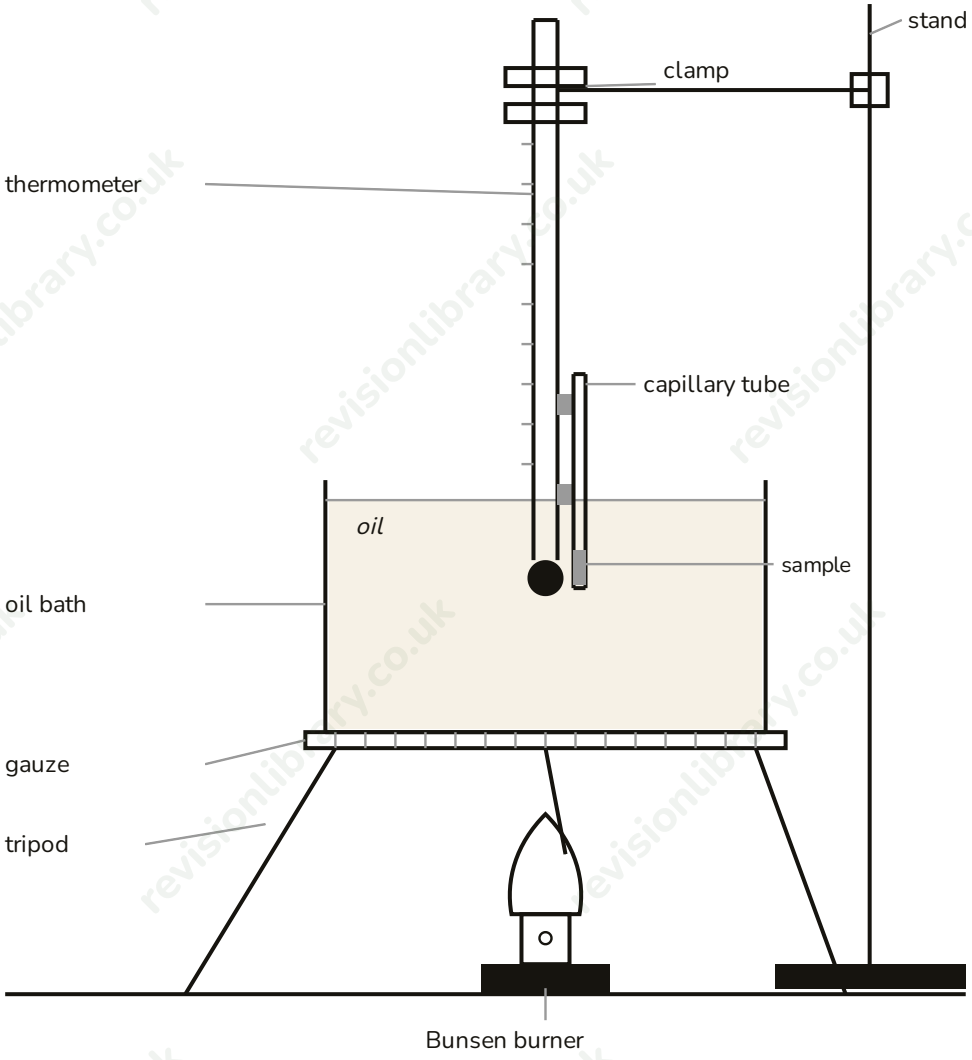
- ☐ A) Metallic
- ☐ B) Ionic
- ☐ C) Simple covalent (molecular)
- ☐ D) Giant covalent

(Total for Question 9 is 4 marks)

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10 A student investigates melting points. Figure 3 shows apparatus used for solids with melting points within the safe operating range of the oil bath and thermometer.

Figure 3 - melting point apparatus



(a) Name one piece of apparatus, other than a thermometer, used to measure a melting point in this way. **(1)**

(b) State one variable that should be kept the same for each solid to make this a fair comparison. **(1)**

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(c) The student is given the following reference data for four unknown solids, A, B, C and D. These data were not measured using the apparatus in Figure 3. **(3)**

Solid	Melting point (°C)
A	1085
B	-78 (sublimes; does not have a true liquid melting point at normal pressure)
C	3550
D	1538

Using the melting points, suggest which solid, A, B, C or D, is most likely to be: (i) an ionic compound, (ii) a simple molecular substance, (iii) a giant covalent substance such as diamond.

(d) Explain why the student should repeat each melting point measurement and calculate a mean. **(2)**

(e) One repeat reading for a solid measured using the apparatus in Figure 3 is much lower than the other readings taken. Suggest how the student should treat this reading. **(1)**

(Total for Question 10 is 8 marks)

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Mark scheme · 2.2 Bonding, Structure and Properties of Matter: 1-hour Pack

Question 1

(a) good conductor of electricity, oe **B1**

(a) malleable or ductile or high melting point, oe **B1**

(a) Answer: Good conductor of electricity; malleable (or high melting point).

Question 2

(a) substitutes: Mr = 64 + 16 **M1**

(a) 80 cao **A1**

(a) Answer: 80

(b) calculates fraction: (16 / 80) x 100 **M1**

(b) 20.0% cao **A1**

(b) Answer: 20.0%

Question 3

(a) states ions are present in solid sodium chloride but are fixed in position (cannot move) **M1**

(a) states that when molten the ions are free to move **M1**

(a) conclusion: molten sodium chloride conducts because the mobile ions carry charge, whereas the solid does not cao **A1**

(a) Answer: In solid sodium chloride the ions are present but fixed in the lattice so they cannot move and cannot carry charge; when molten the lattice breaks down and ions are free to move so they can carry charge and the molten salt conducts.

Question 4

(a) a single layer of graphite, one atom thick (a sheet of carbon atoms arranged in hexagonal rings) oe **B1**

(a) Answer: A single layer of graphite, one carbon atom thick.

(b) the hollow cage/tube structure can trap/enclose (encapsulate) a drug molecule inside it **B1**

(b) so the drug can be carried/delivered to a specific (target) part of the body oe **B1**

(b) Answer: The hollow cage can encapsulate a drug molecule, allowing it to be carried and released at a specific site in the body.

(c) C cao **B1**

(c) Answer: C

Question 5

(a) atoms within a polymer chain are joined by strong covalent bonds **B1**

(a) there are only weak intermolecular forces between separate/neighbouring polymer chains **B1**

(a) the covalent bonds within a chain are much stronger than the forces between chains oe **B1**

(a) Answer: Strong covalent bonds join atoms within each chain, but only weak intermolecular forces act between separate chains.

(b) the (many) weak intermolecular forces between the long, tangled chains still require a reasonable amount of energy to overcome in total oe **B1**

(b) so the polymer does not melt easily and remains solid at room temperature oe **B1**

(b) Answer: The combined weak forces between the long, entangled chains take enough energy to overcome that the polymer stays solid at room temperature.

Question 6

(a) surface area = 6 x 5^2 = 150 (nm^2) **M1**

(a) volume = 5^3 = 125 (nm^3) **M1**

(a) ratio = 150 / 125 = 1.2 : 1 (or 1.2 nm^{-1}) cao **A1**

(a) Answer: 1.2 : 1 (1.2 nm^{-1})

(b) surface area = 6 x 2^2 = 24 (cm^2) **M1**

(b) volume = 2^3 = 8 (cm^3) **M1**

(b) ratio = 24 / 8 = 3 : 1 (or 3 cm^{-1}) cao **A1**

(b) Answer: 3 : 1 (3 cm^{-1})

(c) converts the larger cube's ratio into nm^{-1}: 3 cm^{-1} = 3 / (1 x 10^7) = 3 x 10^{-7} nm^{-1} **dM1**

(c) factor = 1.2 / (3 x 10^{-7}) = 4 x 10^6 cso **A1**

(c) Answer: About 4 x 10^6 times greater

Question 7

(a) e.g. sun creams/cosmetics (better UV protection/skin coverage) **B1**

(a) e.g. medicine/drug delivery; catalysts (larger surface area); antibacterial coatings (e.g. silver nanoparticle socks); electronics (any two distinct valid uses) **B1**

(a) Answer: Any two of: sun creams, medicine/drug delivery, catalysts, antibacterial coatings, electronics.

(b) nanoparticles have a very large surface area to volume ratio, which may make them more chemically reactive than the bulk material oe **B1**

(b) small nanoparticles could enter cells or pass into the bloodstream (e.g. through skin or if inhaled), potentially causing harm oe **B1**

(b) the long-term effects of nanoparticles on human health and the environment are not yet fully known/tested oe **B1**

(b) Answer: Risks include increased reactivity (due to high surface area to volume ratio), the possibility of nanoparticles entering cells or the bloodstream, and long-term health/environmental effects not yet being fully known.

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Question 8

Level 1 Basic, isolated statements about the structure or a property of one or two of the substances. Little or no linking of structure/bonding to melting point or conductivity. Answer is mostly descriptive rather than explanatory, with limited scientific detail. **1-2**

Level 2 A sound description of the structure and bonding of at least two of the three substances, with some explanation linking structure to melting point and/or electrical conductivity. Reasoning is mostly clear but may be incomplete or lack detail for all three substances. **3-4**

Level 3 A detailed and accurate comparison of the structure and bonding of all three substances. Clear, logical explanations of how the type and strength of bonding/structure accounts for the differences in melting point and electrical conductivity, using correct scientific terminology throughout. **5-6**

Indicative content:

- Sodium chloride is a giant ionic lattice held together by strong electrostatic forces of attraction between oppositely charged ions, acting in all directions
- A large amount of energy is needed to break these forces, giving NaCl a high melting point
- NaCl conducts electricity only when molten or dissolved, because the ions are then free to move and carry charge; in the solid the ions are fixed in the lattice and cannot move
- Carbon dioxide is a simple molecular substance; atoms within each CO_2 molecule are held together by strong covalent bonds
- Between CO_2 molecules there are only weak intermolecular forces
- Only a small amount of energy is needed to overcome these weak intermolecular forces (the covalent bonds are not broken), so CO_2 has a very low melting/boiling point
- CO_2 does not conduct electricity because the molecules have no overall electric charge and there are no free ions or delocalised electrons
- Diamond is a giant covalent structure in which each carbon atom forms four strong covalent bonds to other carbon atoms
- A very large amount of energy is needed to break these many strong covalent bonds, giving diamond an extremely high melting point
- Diamond does not conduct electricity because all four outer electrons of each carbon atom are held in covalent bonds, so there are no delocalised electrons or free ions to carry charge
- Overall, melting points increase in the order CO_2, then NaCl, then diamond, reflecting the increasing strength/number of bonds or forces that must be broken
- Of the three, only NaCl conducts electricity, and only when molten or dissolved; CO_2 and diamond never conduct because neither has free-moving charged particles

Question 9

(a) C cao **B1**

(a) Answer: C

(b) C cao **B1**

(b) Answer: C

(c) C cao **B1**

(c) Answer: C

(d) B cao **B1**

(d) Answer: B

Question 10

(a) capillary tube; OR oil bath; OR Bunsen burner/heat source (any one suitable item) **B1**

(a) Answer: Capillary tube (or oil bath, or Bunsen burner).

(b) the rate of heating (how quickly the temperature is increased); OR the amount/mass of solid used oe **B1**

(b) Answer: The rate of heating (or the amount of solid used).

(c) (i) A (or D) - high melting point consistent with a giant ionic lattice oe **B1**

(c) (ii) B - very low melting point/sublimes, consistent with weak intermolecular forces between simple molecules oe **B1**

(c) (iii) C - extremely high melting point, consistent with a giant covalent structure with many strong covalent bonds oe (ft from a consistent, justified pattern of reasoning) **B1**

(c) Answer: (i) A or D (ionic, high melting point); (ii) B (simple molecular, very low melting point); (iii) C (giant covalent, extremely high melting point).

(d) repeating reduces the effect of random errors (e.g. in reading the thermometer or judging exactly when melting starts) oe **B1**

(d) calculating a mean gives a more accurate/reliable estimate of the true melting point oe **B1**

(d) Answer: Repeating reduces random error in judging when melting occurs, and taking a mean gives a more accurate, reliable result.

(e) identify it as an anomalous result and exclude/ignore it when calculating the mean (and repeat the measurement if time allows) oe **B1**

(e) Answer: Treat it as an anomaly and exclude it from the mean calculation, repeating the measurement if possible.

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