2.19 Structures, Properties and Nanoparticles: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Nanoparticles are structures with dimensions much smaller than those we can see, but larger than individual atoms.

(a) State the approximate size range, in nanometres, of a nanoparticle. **(1)**

(b) Place the following in order of increasing size (smallest first): fine particle, atom, nanoparticle. **(1)**

(c) Give one everyday use of nanoparticles, and one possible risk associated with their use. **(2)**

(Total for Question 1 is 4 marks)

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2 Water can exist as a solid, a liquid or a gas, depending on its temperature.

(a) State the name of the change of state when a liquid turns into a gas. **(1)**

(b) Describe how the arrangement, movement and energy of the water particles change as the liquid evaporates to form a gas. **(3)**

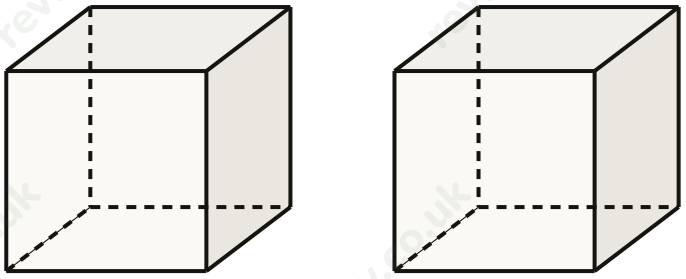
(c) A pure substance has one fixed melting point. Explain why melting point data can be used to help show whether a sample of a substance is pure. **(1)**

(Total for Question 2 is 5 marks)

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3 A manufacturer compares a cube-shaped silica nanoparticle with a side length of 20 nm to a bulk cube of the same silica with a side length of 2 cm.

Diagram NOT accurately drawn



(a) Calculate the surface area to volume ratio of the nanoparticle cube, in nm^{-1}. **(2)**

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(b) Calculate the surface area to volume ratio of the bulk cube, in cm^{-1}. **(2)**

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(c) Convert your answer to part (a) into cm^{-1}, and hence show that the nanoparticle's surface area to volume ratio is approximately 1×10^6 (one million) times greater than the bulk cube's ratio found in part (b). **(3)**

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(d) Explain why this large difference in surface area to volume ratio makes a nanoparticle catalyst more effective, per gram, than the same bulk material used as a catalyst. **(2)**

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(Total for Question 3 is 9 marks)

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4 Graphene, a single layer of graphite, was first isolated at the University of Manchester in 2004.

(a) State what is meant by the term 'graphene'. **(1)**

(b) Explain, in terms of its structure, why graphene is a good conductor of electricity. **(2)**

(c) Suggest one use of graphene in electronics, and state the property that makes it suitable for this use. **(1)**

(Total for Question 4 is 4 marks)

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5 Iodine exists as simple molecules with the formula I_2.

(a) State the type of bonding that joins the two iodine atoms together within an I_2 molecule. **(1)**

(b) Explain, in terms of the forces between particles, why iodine has a low melting point even though the covalent bond within each molecule is strong. **(2)**

(c) Explain why iodine does not conduct electricity in any state (solid, liquid or gas). **(2)**

(Total for Question 5 is 5 marks)

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Mark scheme · 2.19 Structures, Properties and Nanoparticles: 30-minute Pack

Question 1

(a) 1 nm to 100 nm (accept values within this range) cao **B1**

(a) Answer: 1 nm to 100 nm

(b) atom, nanoparticle, fine particle cao **B1**

(b) Answer: Atom, then nanoparticle, then fine particle

(c) a valid use, e.g. titanium dioxide/zinc oxide nanoparticles in sun cream, silver nanoparticles in antibacterial deodorants/dressings/food packaging, nanoparticle catalysts, or nanoparticles in electronics/sensors/sports equipment (any one) oe **B1**

(c) a valid risk, e.g. the effects of nanoparticles on human health and the environment are not yet fully known/understood, or nanoparticles may be able to pass through cell membranes/skin and enter the bloodstream more easily than larger particles (any one) oe **B1**

(c) Answer: For example: use, titanium dioxide nanoparticles in sun cream; risk, the long-term effects of nanoparticles on human health and the environment are not yet fully understood

Question 2

(a) evaporation (accept boiling if it occurs throughout the liquid at its boiling point) oe **B1**

(a) Answer: Evaporation

(b) the particles change from being close together in a random arrangement to being far apart in a random arrangement (oe) **B1**

(b) the particles move faster and move freely/randomly in all directions, rather than moving around each other while staying close together (oe) **B1**

(b) the particles gain energy (the change is endothermic), which is used to overcome the forces of attraction between them (oe) **B1**

(b) Answer: The particles move from close together (random arrangement) to far apart (random arrangement); they move much faster and more freely in all directions; they gain energy, which is used to overcome the forces of attraction between them

(c) an impure sample melts over a range of temperatures and/or at a lower temperature than the pure substance, so if the sample melts sharply at the known melting point it is likely to be pure (oe) **B1**

(c) Answer: A pure substance melts sharply at one fixed temperature; an impure sample melts over a range of temperatures (often starting lower), so comparing the melting behaviour to the known value indicates purity

Question 3

(a) surface area = 6 x 20^2 = 2400 nm^2, volume = 20^3 = 8000 nm^3 (oe) **M1**

(a) 0.3 nm^{-1} (accept 3 : 10 or 0.3 : 1) cao **A1**

(a) Answer: 0.3 nm^{-1}

(b) surface area = 6 x 2^2 = 24 cm^2, volume = 2^3 = 8 cm^3 (oe) **M1**

(b) 3 cm^{-1} (accept 3 : 1) cao **A1**

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

(c) correct conversion factor used: 1 nm = 1 x 10^{-7} cm, so 1 nm^{-1} = 1 x 10^7 cm^{-1} (oe), ft from (a) **M1**

(c) 0.3 nm^{-1} = 0.3 x (1 x 10^7) = 3 x 10^6 cm^{-1}, ft from (a) **A1**

(c) comparison to (b): 3 x 10^6 / 3 = 1 x 10^6, so the nanoparticle's ratio is approximately one million (10^6) times greater than the bulk cube's ratio, ft from (a) and (b) **A1**

(c) Answer: 3 x 10^6 cm^{-1}, which is approximately 1 x 10^6 (one million) times greater than the bulk cube's ratio of 3 cm^{-1}

(d) a much greater proportion of the atoms/particles in a nanoparticle sample are on the surface, exposed and available to react with reactant particles, for a given mass (oe) **M1**

(d) so reactions can take place faster, or the same catalytic effect can be achieved using a much smaller mass of nanoparticle catalyst than bulk catalyst (oe) **A1**

(d) Answer: A much greater proportion of the particles in a nanoparticle sample are on the exposed surface for a given mass, so more collisions with reactant particles can happen; this means reactions are catalysed faster, or the same effect is achieved using far less material

Question 4

(a) a single layer of graphite, one carbon atom thick, with carbon atoms arranged in hexagons (oe) **B1**

(a) Answer: A single layer of graphite, one carbon atom thick, with the carbon atoms arranged in a hexagonal pattern

(b) each carbon atom in graphene forms three covalent bonds, so one outer electron per carbon atom is not used in bonding (oe) **M1**

(b) these electrons are delocalised and free to move across the sheet, allowing them to carry electrical charge, so graphene conducts electricity well (oe) **A1**

(b) Answer: Each carbon atom forms only three covalent bonds, leaving one electron per atom delocalised and free to move across the sheet; these delocalised electrons carry charge, making graphene an excellent conductor

(c) a valid use with a matching property, e.g. flexible touchscreens because graphene is thin, strong and conducts electricity, or as a very thin, lightweight electrical conductor in circuits (any one, use and property must match) oe **B1**

(c) Answer: For example: flexible touchscreens, because graphene is extremely thin, strong and conducts electricity well

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Question 5

(a) covalent bonding oe **B1**

(a) Answer: Covalent bonding

(b) melting iodine only requires overcoming the weak intermolecular forces (forces of attraction between molecules), not breaking the strong covalent bonds within the molecules (oe) **M1**

(b) these intermolecular forces are weak, so only a small amount of energy is needed to overcome them, giving a low melting point (oe) **A1**

(b) Answer: Melting iodine only overcomes the weak forces of attraction between I_2 molecules, not the strong covalent bonds within them; since these intermolecular forces are weak, little energy is needed, giving a low melting point

(c) iodine molecules have no overall electrical charge (oe) **M1**

(c) there are no ions and no free/delocalised electrons able to move and carry charge through the substance (oe) **A1**

(c) Answer: Iodine molecules are uncharged and there are no ions or delocalised electrons present to move and carry electrical charge, so iodine cannot conduct in any state

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