3.3 Particle Model of Matter: Test Pack

AQA 8463 · Calculator allowed · about 65 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The particle model describes solids, liquids and gases in terms of how their particles are arranged and how they move.

(a) Describe the arrangement of particles in a solid. **(1)**

(b) Describe the movement of particles in a liquid. **(1)**

(c) Describe the arrangement and movement of particles in a gas. **(2)**

(Total for Question 1 is 4 marks)

2 Changes of state have specific names.

(a) Name the change of state when a solid becomes a liquid. **(1)**

(b) Name the change of state when a liquid becomes a gas below its boiling point, at the surface of the liquid only. **(1)**

(c) Name the change of state when a gas becomes a liquid. **(1)**

(d) Name the change of state when a liquid becomes a solid. **(1)**

(Total for Question 2 is 4 marks)

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3 A student measures the mass and volume of a small piece of aluminium to calculate its density.

(a) The mass is 13.5 g and the volume is 5.00 cm^3. Convert the mass into kilograms. **(1)**

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(b) Calculate the density of the aluminium in kg/m3. (1 cm^3 = 1e-6 m^3) **(2)**

.....

(Total for Question 3 is 3 marks)

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4 Required practical: a student investigates the specific heat capacity of a metal block using an electrical heater inserted into a hole in the block, together with a thermometer. The block is wrapped in an insulating jacket.

(a) Name one piece of apparatus, other than a thermometer, needed to measure the energy transferred to the block by the heater, and state what quantity it measures. **(2)**

(b) State one way the experiment could be improved to reduce energy losses to the surroundings. **(1)**

(c) The student records: mass of block = 1.0 kg, initial temperature = 18°C, final temperature = 32°C, energy supplied by the heater = 13300 J. Calculate the specific heat capacity of the metal. Use: change in thermal energy = mass x specific heat capacity x change in temperature **(3)**

.....

(d) The accepted value of specific heat capacity for this metal is 900 J/(kg °C). Suggest why the student's calculated value in part (c) is higher than the accepted value. **(2)**

.....

.....

(e) The student varies how long the heater is switched on, keeping its power constant, and records the temperature rise. State the independent variable in this investigation. **(1)**

(Total for Question 4 is 9 marks)

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5 Two identical, sealed, rigid containers, A and B, each hold the same volume and the same mass of gas. Container A is kept at 20°C. Container B is kept at 80°C. Compare, using the particle model, the pressure of the gas in the two containers, and explain any difference.

(Total for Question 5 is 6 marks)

6 A 0.50 kg block of copper at 95°C is placed into 0.30 kg of water at 15°C, in a perfectly insulated container. Specific heat capacity of copper = 385 J/(kg °C). Specific heat capacity of water = 4200 J/(kg °C). Assume no energy is transferred to the surroundings, and that the copper and water reach the same final temperature.

(a) State the term for the common temperature reached by the copper and the water once no further net energy transfer occurs between them. **(1)**

(b) Show that the energy transferred by the copper as it cools from 95°C to a final temperature, θ_f, is given by: $E = 0.5 \times 385 \times (95 - \theta_f)$ **(1)**

(c) Using the principle that the energy transferred by the copper as it cools equals the energy transferred to the water as it warms, form an equation and calculate the final temperature, θ_f, of the copper and water. **(4)**

(Total for Question 6 is 6 marks)

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7 A solid substance is heated and its temperature changes.

(a) Convert 15°C to kelvin. Use: temperature in kelvin (K) = temperature in °C + 273 **(1)**

(b) The solid is heated further until it starts to melt. Explain, in terms of the particle model, why the temperature of the substance does not increase while it is melting, even though energy is still being transferred to it. **(3)**

(Total for Question 7 is 4 marks)

8 Specific latent heat is the energy needed to change the state of 1 kg of a substance, without changing its temperature. Use the equation: energy for a change of state = mass x specific latent heat (E = m x L).

(a) State the two types of specific latent heat, and the change of state that each one applies to. **(2)**

(b) The specific latent heat of fusion of ice is 334000 J/kg. Calculate the energy needed to completely melt 0.20 kg of ice at 0°C. **(2)**

(Total for Question 8 is 4 marks)

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9 The specific latent heat of fusion of ice is 334000 J/kg. Use: thermal energy for a change of state = mass x specific latent heat

(a) Calculate the energy required to melt 0.25 kg of ice at 0°C. **(2)**

.....

(b) State why this energy transfer does not cause a change in temperature. **(1)**

(c) State what is meant by the specific latent heat of fusion of a substance. **(2)**

(Total for Question 9 is 5 marks)

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10 An experiment measures the specific heat capacity of a liquid. A mass of 0.750 kg of the liquid is heated from 18.0°C to 38.0°C using an electrical heater supplying 900 W. The heater is switched on for 240 s. Neglect heat losses to the surroundings for the calculation.

(a) Calculate the specific heat capacity c of the liquid using E = m c deltaT, where E is the energy supplied by the heater. **(4)**

.....

(Total for Question 10 is 4 marks)

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Mark scheme · 3.3 Particle Model of Matter: Test Pack

Question 1

(a) particles are held in fixed positions, close together, in a regular arrangement, oe **B1**

(a) Answer: The particles are held in fixed positions, close together, in a regular arrangement.

(b) particles are close together but can move around/slide past each other, oe **B1**

(b) Answer: The particles are close together but can move around and slide past each other.

(c) particles are far apart (spread out), oe **B1**

(c) particles move quickly, in random directions, oe **B1**

(c) Answer: The particles are far apart (spread out) and move quickly in random directions.

Question 2

(a) melting **B1**

(a) Answer: Melting

(b) evaporation **B1**

(b) Answer: Evaporation

(c) condensation **B1**

(c) Answer: Condensation

(d) freezing (solidification) oe **B1**

(d) Answer: Freezing

Question 3

(a) conversion: 13.5 g = 0.0135 kg **B1**

(a) Answer: 0.0135 kg

(b) substitutes mass and volume into density = mass / volume with volume converted to m3 **M1**

(b) density = 2700 kg/m3 cao **A1**

(b) Answer: 2700 kg/m3

Question 4

(a) a joulemeter (or an ammeter, voltmeter and stopwatch/timer) **B1**

(a) measures the energy transferred, in joules (or the current, potential difference and time, used to calculate energy transferred) **B1**

(a) Answer: Joulemeter; measures energy transferred in joules.

(b) add further insulation to the block / cover exposed holes in the block oe **B1**

(b) Answer: Add further insulation to the block or cover exposed holes.

(c) rearranges to c = change in thermal energy / (mass x change in temperature) **M1**

(c) 13300 / (1.0 x 14) substituted **M1**

(c) 950 J/(kg °C) cao **A1**

(c) Answer: 950 J/(kg °C)

(d) not all the energy supplied by the heater was transferred to the block; some energy was transferred to the surroundings (heating the air, insulation or thermometer) instead **B1**

(d) so the actual energy that raised the temperature of the block was less than the measured energy supplied, giving a calculated specific heat capacity that is too high **B1**

(d) Answer: Some energy was lost to the surroundings rather than heating the block, making the calculated value too high.

(e) time the heater is switched on for oe **B1**

(e) Answer: Time the heater is switched on.

Question 5

Level 1 A simple statement is made, for example that container B has a higher pressure, with little or no reference to the particle model. **1-2**

Level 2 A partial explanation is given, linking temperature to particle kinetic energy or particle speed, but the chain of reasoning to pressure is incomplete. **3-4**

Level 3 A complete, logical chain of reasoning is given, linking temperature to particle kinetic energy, particle speed, and the frequency and force of collisions with the container walls, leading to a correct comparison of pressures. **5-6**

Indicative content:

- the gas in container B has a higher pressure than the gas in container A
- gas particles in B have a greater average kinetic energy than particles in A, because B is at a higher temperature
- particles in B move at a greater average speed than particles in A
- particles in B collide with the walls of the container more frequently than particles in A
- particles in B collide with the walls with greater force than in A, because each collision transfers more momentum
- since the volume (and therefore wall area) of both containers is the same, the greater frequency and force of collisions in B produces a greater pressure in B

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Question 6

(a) equilibrium temperature **B1**

(a) Answer: Equilibrium temperature

(b) correct substitution of mass, specific heat capacity and temperature change (95 - θ_f) into change in thermal energy = mass x specific heat capacity x change in temperature, matching the given expression (answer given) cso **B1**

(b) Answer: E = 0.5 x 385 x (95 - θ_f) (given)

(c) correct equation formed: 0.5 x 385 x (95 - θ_f) = 0.30 x 4200 x (θ_f - 15) **M1**

(c) both sides expanded correctly: 18287.5 - 192.5 θ_f = 1260 θ_f - 18900 **M1**

(c) terms correctly collected and rearranged for θ_f: θ_f = 37187.5 / 1452.5 **dM1**

(c) awrt 25.6°C cao **A1**

(c) Answer: 25.6°C (awrt)

Question 7

(a) 288 K cao **A1**

(a) Answer: 288 K

(b) the energy transferred is used to weaken or break the bonds (forces of attraction) between particles **B1**

(b) this increases the potential energy of the particles, not their kinetic energy **B1**

(b) temperature depends on the average kinetic energy of the particles, so the temperature stays constant during melting **B1**

(b) Answer: Energy breaks bonds between particles (increasing potential energy) rather than increasing kinetic energy, so temperature stays constant.

Question 8

(a) specific latent heat of fusion, for melting/freezing, oe **B1**

(a) specific latent heat of vaporisation, for boiling/condensing, oe **B1**

(a) Answer: Specific latent heat of fusion applies to melting (or freezing); specific latent heat of vaporisation applies to boiling (or condensing).

(b) quotes E = m x L and substitutes: E = 0.20 x 334000 **M1**

(b) 66800 J cao **A1**

(b) Answer: 66800 J

Question 9

(a) 0.25 x 334000 substituted **M1**

(a) 83500 J (8.35 x 10^4 J) cao **A1**

(a) Answer: 83500 J

(b) the energy is used to break the bonds (forces of attraction) between particles, increasing potential energy rather than kinetic energy **B1**

(b) Answer: Energy increases potential energy (breaking bonds), not kinetic energy.

(c) the energy required to change the state of **B1**

(c) 1 kg of the substance from solid to liquid, at constant temperature **B1**

(c) Answer: The energy needed to change 1 kg of a substance from solid to liquid without a change in temperature.

Question 10

(a) calculates energy supplied E = power x time = 900 x 240 = 216000 J **M1**

(a) substitutes into c = E / (m deltaT) with deltaT = 20.0°C **M1**

(a) evaluates c = 216000 / (0.750 x 20.0) = 14400 J/kg °C cao **A1**

(a) states units J/kg °C cao **B1**

(a) Answer: 14400 J/kg °C

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