K6E Particles and their Behaviour: Depth and Practice

AQA AQA KS3 Science - Chemistry · Calculator allowed · about 75 minutes

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Under a microscope, smoke particles suspended in air appear to move in a constant, random, jerky (zig-zag) motion, even though there is no air current. What is the best explanation for this observation?

- ☐ A) The smoke particles are alive and moving by themselves
- ☐ B) The smoke particles are being hit unevenly by fast-moving, invisible air molecules
- ☐ C) The smoke particles are evaporating
- ☐ D) The smoke particles are attracting and repelling each other

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2 Required practical: a student sets up a smoke cell under a microscope. Smoke is trapped in a small glass cell and lit from the side, allowing tiny smoke particles to be seen as bright specks against a dark background. The student observes the smoke particles for several minutes.

(a) Describe what the student would observe about the movement of the smoke particles. **(2)**

(b) Explain this observation in terms of particle theory. **(3)**

(c) Suggest one reason why the smoke particles are observed, rather than trying to directly observe the air molecules themselves. **(1)**

3 Most changes of state go through a liquid stage, but some substances can change directly between a solid and a gas.

(a) Name the change of state in which a solid changes directly into a gas, without becoming a liquid first. **(1)**

(b) Give one real-life example of a substance that sublimes. **(1)**

(c) Name the change of state in which a gas changes directly into a solid, without becoming a liquid first. **(1)**

(d) Give one real-life example of this change. **(1)**

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4 Required practical: a student investigates how different conditions affect the rate of evaporation of water from wet cloth, representing washing hung out to dry. She hangs three identical, equally wet cloths in different locations and records the time for each to dry completely. Location 1: indoors, still air, cool room (18 degrees C) = 300 minutes. Location 2: outdoors, warm and breezy (24 degrees C, windy) = 70 minutes. Location 3: outdoors, warm and still (24 degrees C, no wind) = 150 minutes.

(a) Identify two factors that were varied between the three locations, other than temperature, that could affect the rate of evaporation. **(2)**

(b) Using locations 2 and 3, explain why moving air (wind) increases the rate at which water evaporates from the cloth. **(2)**

(c) Explain, in terms of particles, why warmer temperatures increase the rate of evaporation. **(2)**

5 The table below shows the densities of five materials. Material: cork, ice, aluminium, iron, lead. Density (g/cm^3): 0.24, 0.92, 2.7, 7.9, 11.3. A student finds an unlabelled metal block with a mass of 135 g and a volume of 50 cm^3.

(a) Calculate the density of the unlabelled block. **(2)**

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(b) Use the table to identify the material of the block. **(1)**

(c) State whether the block would float or sink in water (density of water = 1.0 g/cm^3), and explain your answer. **(2)**

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6 A simple liquid-in-glass thermometer contains coloured alcohol in a thin glass tube.

(a) Explain, in terms of particles, why the alcohol rises up the tube when the thermometer is warmed. **(2)**

(b) A bimetallic strip is made by joining a strip of copper to a strip of iron. Copper expands more than iron for the same rise in temperature. Explain, using this information, why the bimetallic strip bends when heated. **(3)**

7 A candle is made of solid wax. When lit, the flame melts some of the solid wax near the wick into a pool of liquid wax, and also burns some of the wax to produce heat and light.

(a) State whether melting the wax is a physical change or a chemical change, and explain your answer. **(2)**

(b) State whether burning the wax is a physical change or a chemical change, and explain your answer. **(2)**

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8 Most substances become denser as they cool and solidify. Water is unusual: ice has a density of about 0.92 g/cm^3, while liquid water has a density of about 1.00 g/cm^3 at 4 degrees C.

(a) Calculate the volume that 100 g of liquid water (at 4 degrees C) would occupy. **(2)**

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(b) Calculate the volume that the same 100 g of water would occupy once frozen into ice. **(2)**

....

(c) Use your answers to parts (a) and (b) to explain why ice floats on liquid water. **(1)**

9 Unlike most substances, water expands slightly as it freezes into ice, becoming less dense than liquid water (as shown in Question 8). Explain the consequences of this unusual property, both as a problem and as a benefit, giving real-world examples of each.

(6)

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10 For each statement, identify whether it is True or False. If a statement is false, give the correct version.

(a) All substances become denser when they freeze from a liquid into a solid. **(1)**

(b) Sublimation is the change of state directly from a solid to a gas, without passing through the liquid state. **(1)**

(c) Evaporation can only happen at a liquid's boiling point. **(1)**

(d) Brownian motion of smoke particles provides evidence that gas particles are moving randomly and constantly. **(1)**

11 A bottle of concentrated orange squash is diluted with water to make a drink. A student makes one glass using a small amount of squash with lots of water (dilute), and another glass using a large amount of squash with only a little water (concentrated).

(a) Explain, in terms of particles, the difference between the dilute and concentrated drinks. **(2)**

(b) The student adds more water to the concentrated drink to dilute it further. Explain what happens to the concentration of squash particles as more water is added, assuming no squash is added or removed. **(2)**

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12 A short length of copper pipe has a mass of 178 g and a volume of 20 cm^3. Calculate its density.

(3)

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13 Which of these substances is well known for subliming (changing directly from solid to gas) at normal room pressure?

- ☐ A) Ice
- ☐ B) Solid carbon dioxide (dry ice)
- ☐ C) Table salt
- ☐ D) Copper

14 Match each description below to the correct state of matter: solid, liquid or gas.

(a) Has a fixed volume, but takes the shape of its container, flowing to fill the bottom of it. **(1)**

(b) Has both a fixed shape and a fixed volume. **(1)**

(c) Expands to completely fill any container it is placed in, however large. **(1)**

(d) Can be poured, but cannot usually be compressed (squashed) very much. **(1)**

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15 Solid carbon dioxide (dry ice) sublimes directly into carbon dioxide gas at normal atmospheric pressure and room temperature, rather than first melting into a liquid.

(a) Suggest what this tells you about the strength of the forces of attraction between carbon dioxide particles, compared with a typical solid like ice. **(2)**

(b) State one advantage of using solid carbon dioxide, rather than ice, to keep food cold during transport. **(2)**

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16 Evaporation and boiling are both changes from a liquid to a gas, but they are not the same process.

(a) State one difference between evaporation and boiling in terms of where in the liquid the change happens. **(1)**

(b) State one difference between evaporation and boiling in terms of temperature. **(2)**

17 A student pours 200 g of hot water into 200 g of cold water in an insulated container and stirs. After a while, the whole mixture reaches the same, constant temperature.

(a) Explain, in terms of particles, how energy is transferred from the hot water to the cold water when they mix. **(2)**

(b) State the term used to describe the water once it has reached a single, constant temperature throughout. **(1)**

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18 Water boils at 100 degrees C at normal atmospheric pressure (at sea level). On a high mountain, atmospheric pressure is much lower, and water has been observed to boil at only about 85 degrees C.

(a) State what this data suggests about the relationship between atmospheric pressure and the boiling point of water. **(1)**

(b) Suggest, in terms of particles, why a lower atmospheric pressure lowers the boiling point of a liquid. **(2)**

(c) Suggest one practical consequence of this effect for cooking food at high altitude. **(1)**

Mark scheme · K6E Particles and their Behaviour: Depth and Practice

Question 1

- **B1** B cao
- Answer: **B) The smoke particles are being hit unevenly by fast-moving, invisible air molecules**

Question 2

- (a) **B1** the smoke particles move constantly
- (a) **B1** in random, jerky (zig-zag), unpredictable directions, oe
- (a) Answer: **The smoke particles move constantly, in random, jerky, unpredictable directions.**
- (b) **M1** air molecules are far too small to see, but are moving very fast in random directions
- (b) **A1** these fast-moving air molecules collide with the much larger smoke particles from random directions
- (b) **A1** the collisions are not perfectly balanced on all sides at every instant, so the smoke particles are knocked in random, changing directions, oe
- (b) Answer: **Fast-moving, invisible air molecules collide unevenly with the larger smoke particles from random directions, knocking them about randomly.**
- (c) **B1** air molecules are far too small to be seen, even with a microscope; smoke particles are much larger and can be seen, giving indirect evidence of the moving air molecules around them, oe
- (c) Answer: **Air molecules are too small to see directly, but the larger, visible smoke particles show indirect evidence of their motion.**

Question 3

- (a) **B1** sublimation cao
- (a) Answer: **Sublimation**
- (b) **B1** any valid example, e.g. solid carbon dioxide (dry ice), or iodine, oe
- (b) Answer: **e.g. Solid carbon dioxide (dry ice).**
- (c) **B1** deposition cao
- (c) Answer: **Deposition**
- (d) **B1** any valid example, e.g. frost forming directly from water vapour in the air on a cold surface, oe
- (d) Answer: **e.g. Frost forming on a cold windscreen.**

Question 4

- (a) **B1** amount of air movement (wind/breeze)
- (a) **B1** whether the cloth is indoors or outdoors (oe, e.g. humidity of the surrounding air)
- (a) Answer: **Amount of air movement (wind), and whether the location is indoors or outdoors.**
- (b) **M1** moving air continually replaces the humid air just above the wet cloth with drier air
- (b) **A1** this keeps the concentration gradient of water particles high, so more water particles can escape (evaporate) from the cloth's surface per second, oe
- (b) Answer: **Wind replaces the humid air near the cloth with drier air, keeping the concentration gradient high so evaporation continues quickly.**
- (c) **M1** at a higher temperature, water particles have more kinetic energy on average
- (c) **A1** so more particles at the surface have enough energy to escape into the air as vapour in a given time, oe
- (c) Answer: **Warmer water particles have more kinetic energy on average, so more of them have enough energy to escape from the surface as vapour each second.**

Question 5

- (a) **M1** 135 / 50
- (a) **A1** 2.7 g/cm^3 cao
- (a) Answer: **2.7 g/cm^3**
- (b) **B1** aluminium (ft from a)
- (b) Answer: **Aluminium**
- (c) **M1** the block would sink (ft from a/b)
- (c) **A1** because its density (2.7 g/cm^3) is greater than the density of water (1.0 g/cm^3), oe
- (c) Answer: **It would sink, because its density (2.7 g/cm^3) is greater than the density of water (1.0 g/cm^3).**

Question 6

- (a) **M1** the alcohol particles gain kinetic energy and move/vibrate more, taking up slightly more space (the average spacing between them increases)
- (a) **A1** so the same mass of alcohol expands and is pushed up the narrow tube, giving a higher reading, oe
- (a) Answer: **Heating gives the alcohol particles more energy and they take up more space, so the alcohol expands and rises up the narrow tube.**
- (b) **M1** when heated, both metals expand, but the copper expands more than the iron for the same temperature rise
- (b) **A1** because the two metals are joined together, the copper side becomes longer than the iron side
- (b) **A1** this difference in expansion forces the strip to bend, curving toward the iron side (the side that expanded less), oe
- (b) Answer: **Copper expands more than iron for the same heating; since they are joined, the copper side becomes longer, forcing the strip to curve toward the iron side.**

Question 7

- (a) **M1** physical change
- (a) **A1** no new substance is formed; the wax is still wax, just in a different state, and it would re-form solid wax if it cooled again (the change is reversible), oe
- (a) Answer: **A physical change - the wax is still the same substance, just in a different state, and the change is reversible.**
- (b) **M1** chemical change
- (b) **A1** new substances are formed (e.g. carbon dioxide and water vapour), and the change cannot simply be reversed by cooling, oe
- (b) Answer: **A chemical change - new substances are formed and the change cannot be reversed by cooling.**

Question 8

- (a) **M1** volume = 100 / 1.00
- (a) **A1** 100 cm^3 cao
- (a) Answer: **100 cm^3**
- (b) **M1** volume = 100 / 0.92
- (b) **A1** awrt 108.7 cm^3 cao
- (b) Answer: **awrt 108.7 cm^3**
- (c) **B1** the same mass of ice takes up a greater volume than liquid water (it is less dense), so ice floats on the denser liquid water beneath it, ft oe
- (c) Answer: **The same mass of ice takes up more volume (108.7 cm^3) than the liquid water it formed from (100 cm^3), so ice is less dense and floats.**

Question 9

- **Level 1** (1-2): Basic, isolated statements are made about ice floating or water expanding, with little or no reference to real-world consequences or to why the property is unusual.
- **Level 2** (3-4): A description of at least one consequence (as a problem or a benefit) with a relevant real-world example, but the answer may cover only one side (problem or benefit) or lack detail on why it happens.
- **Level 3** (5-6): A clear, well-linked explanation of both a problem and a benefit caused by water's unusual expansion on freezing, each supported by a correct real-world example, with reference to the reduced density of ice compared with liquid water.
- **Indicative content:**
  - Because ice is less dense than liquid water, it floats rather than sinking.
  - Problem: water in pipes, drains or in cracks in rocks expands as it freezes; the expanding ice can crack or burst pipes, or break up rock (freeze-thaw weathering), because the ice takes up more space than the water that formed it.
  - Benefit: a layer of ice forming on the surface of a pond or lake floats, insulating the liquid water underneath and helping to keep it from freezing solid, so fish and other aquatic organisms can survive the winter beneath the ice.
  - If ice were denser than water, as happens with most substances on freezing, it would sink to the bottom, and ponds or lakes could freeze from the bottom up, which would be far more likely to kill aquatic life.
  - Both consequences follow directly from the fact that a given mass of ice has a larger volume (lower density) than the same mass of liquid water, as calculated in Question 8.

Question 10

- (a) **B1** False; most substances become denser on freezing, but water is unusual and becomes less dense (expands) on freezing, oe
- (a) Answer: **False - water is an exception and becomes less dense (expands) on freezing.**
- (b) **B1** True cao
- (b) Answer: **True**
- (c) **B1** False; evaporation can happen at any temperature (from the surface of a liquid), not only at the boiling point, oe
- (c) Answer: **False - evaporation happens at any temperature, from the surface of a liquid.**
- (d) **B1** True cao
- (d) Answer: **True**

Question 11

- (a) **M1** the concentrated drink has a greater number of squash (solute) particles in the same volume of solution than the dilute drink
- (a) **A1** so there are fewer water particles relative to squash particles in the concentrated drink than in the dilute drink, oe
- (a) Answer: **The concentrated drink has more squash particles per unit volume than the dilute drink, which has relatively more water particles.**
- (b) **M1** the same number of squash particles becomes spread through a larger volume of liquid as water is added
- (b) **A1** so the concentration (number of squash particles per unit volume) decreases, oe
- (b) Answer: **The same number of squash particles is spread through more liquid, so the concentration decreases.**

Question 12

- **M1** density = mass / volume
- **M1** 178 / 20
- **A1** 8.9 g/cm^3 cao
- Answer: **8.9 g/cm^3**

Question 13

- **B1** B cao
- Answer: **B) Solid carbon dioxide (dry ice)**

Question 14

- (a) **B1** liquid cao
- (a) Answer: **Liquid**
- (b) **B1** solid cao
- (b) Answer: **Solid**
- (c) **B1** gas cao
- (c) Answer: **Gas**
- (d) **B1** liquid cao
- (d) Answer: **Liquid**

Question 15

- (a) **M1** the forces of attraction between carbon dioxide particles must be relatively weak
- (a) **A1** so at normal atmospheric pressure, warming the solid gives the particles enough energy to overcome these weak forces completely and escape straight into the gas state, rather than only partly overcoming them to form a liquid, oe
- (a) Answer: **The forces between carbon dioxide particles are relatively weak, so warming gives particles enough energy to escape straight into a gas rather than forming a liquid first.**
- (b) **M1** it does not leave any liquid behind as it changes state (it sublimes straight to a gas), unlike ice, which melts into liquid water
- (b) **A1** so it keeps the food cold without making it wet, oe
- (b) Answer: **Dry ice sublimes straight to gas, leaving no liquid behind, so it keeps food cold without making it wet.**

Question 16

- (a) **B1** evaporation happens only at the surface of a liquid; boiling happens throughout the whole liquid (bubbles form within it), oe
- (a) Answer: **Evaporation happens only at the surface; boiling happens throughout the whole liquid.**
- (b) **B1** evaporation can happen at any temperature below the boiling point
- (b) **B1** boiling only happens at one specific temperature (the boiling point) for a given substance at a given pressure, oe
- (b) Answer: **Evaporation can happen at any temperature below the boiling point; boiling happens only at the boiling point.**

Question 17

- (a) **M1** faster-moving (higher energy) particles from the hot water collide with slower-moving particles from the cold water
- (a) **A1** energy is transferred from the faster particles to the slower particles during these collisions, until the average particle energy (and so the temperature) is the same throughout, oe
- (a) Answer: **Faster hot-water particles collide with slower cold-water particles, transferring energy until the average particle energy (temperature) is the same throughout.**
- (b) **B1** thermal equilibrium cao
- (b) Answer: **Thermal equilibrium.**

Question 18

- (a) **B1** as atmospheric pressure decreases, the boiling point of water also decreases, oe
- (a) Answer: **As atmospheric pressure decreases, the boiling point of water decreases.**
- (b) **M1** at a lower atmospheric pressure, there are fewer air particles pressing down on/colliding with the liquid's surface
- (b) **A1** so liquid particles need less kinetic energy (a lower temperature) to overcome this smaller pressure and escape into the gas state, oe
- (b) Answer: **Lower atmospheric pressure means fewer air particles pressing on the liquid's surface, so particles need less energy (a lower temperature) to escape as gas.**
- (c) **B1** food that is boiled takes longer to cook, because the boiling water is at a lower temperature than at sea level, oe
- (c) Answer: **Boiled food takes longer to cook, because the water boils at a lower temperature.**