# IG.C1 States of Matter and Changes of State

EDEXCEL 4CH1 · Calculator allowed · about 40 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

**1** In the simple particle model for solids, describe the arrangement of the particles and how tightly they are packed. Context: states of matter topic.

**(Total for Question 1 is 1 mark)**

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**2** State how the motion of particles in a liquid compares with that in a solid. Context: particle movement in different states of matter.

**(Total for Question 2 is 1 mark)**

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**3** Describe two differences in particle spacing and movement between liquids and gases, as used in the particle model. Context: comparison of liquid and gas particles.

**(Total for Question 3 is 2 marks)**

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**4** State the relative average kinetic energy of particles in the three states solid, liquid and gas. Context: particle energy and temperature in states of matter.

**(Total for Question 4 is 2 marks)**

**5** Describe what happens to particle movement and spacing when a solid is heated to become a liquid. Context: melting and particle behaviour.

**(Total for Question 5 is 2 marks)**

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**6** Describe the diffusion demonstration using bromine gas in a glass tube and explain what the observation shows about particle movement. Context: diffusion as evidence for moving particles.

**(Total for Question 6 is 3 marks)**

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**7** Describe what happens to particles and to the state of a liquid when it is heated until it boils, naming the change of state. Context: boiling and particle behaviour.

**(Total for Question 7 is 3 marks)**

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**8** State what is observed and explain particle behaviour when water vapour is cooled and condenses on a cold surface. Context: condensation as a change of state.

**(Total for Question 8 is 2 marks)**

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**9** Describe sublimation using a named example (for example solid iodine or dry ice), and state what the particle model says happens during sublimation. Context: sublimation as solid to gas change.

**(Total for Question 9 is 2 marks)**

**10** A student shows diffusion of ammonia and hydrogen chloride by placing concentrated aqueous NH3 at one end of a glass tube and concentrated HCl at the other end so that white ammonium chloride forms where the gases meet. State where the white ring forms relative to the two ends if ammonia molecules are lighter and explain why using particle ideas. Context: practical diffusion demonstration.

**(Total for Question 10 is 2 marks)**

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**11** Explain, in terms of particles, why gases are much easier to compress than liquids. Context: compressibility and particle spacing.

**(Total for Question 11 is 2 marks)**

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**12** Complete the diagram: a simple labelled sketch is required showing particle arrangement for a solid, liquid and gas in separate boxes. Describe one label for each box that explains particle movement. Context: diagram labelling of particle models.

**(Total for Question 12 is 2 marks)**

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**13** Suggest two realistic improvements a student could make to a diffusion practical in which they time how long it takes a coloured gas to spread along a tube, to make the results more reliable. Context: practical method improvements and control.

**(Total for Question 13 is 2 marks)**

**14** Explain why gases are generally easier to compress and why diffusion in gases is faster than in liquids, using particle model ideas. In your answer consider particle spacing, energy and collisions. Context: extended explanation comparing gas and liquid particle behaviour.

**(Total for Question 14 is 6 marks)**

# Mark scheme · IG.C1 States of Matter and Changes of State

## Question 1

- **B1** particles closely packed in a regular fixed arrangement
- **Answer: Particles are closely packed in a regular fixed arrangement.**

## Question 2

- **B1** particles move past each other and can flow
- **Answer: Particles move past each other and can flow; they have more motion than in a solid.**

## Question 3

- **B1** liquid: particles close together with little space between them
- **B1** gas: particles far apart, widely spaced and moving rapidly in all directions
- **Answer: Liquids have particles close together with little space; gases have particles far apart and moving rapidly in all directions.**

## Question 4

- **B1** order given as solid < liquid < gas
- **B1** or statement that gas particles have the highest and solids the lowest average kinetic energy
- **Answer: Solid < Liquid < Gas, gases have the highest average kinetic energy and solids the lowest.**

## Question 5

- **B1** particles gain energy and move faster
- **B1** particles break fixed positions, move past each other and spacing increases slightly
- **Answer: Particles gain energy and move faster; they break fixed positions and can move past each other so spacing increases slightly.**

## Question 6

- **B1** description: brown bromine vapour introduced at one end spreads along the tube towards the other end over time
- **B1** observation: bromine colour gradually appears throughout the tube as the gas mixes with air
- **B1** conclusion: shows gas particles move and mix by random motion, providing evidence for diffusion
- **Answer: Brown bromine vapour spreads from the end where it is introduced until the colour is seen throughout the tube; this shows gas particles move and mix by random motion, demonstrating diffusion.**

## Question 7

- **B1** particles gain more energy and move much faster
- **B1** particles overcome forces between them and move far apart
- **B1** the liquid changes to a gas, this change of state is boiling (or vaporisation)
- **Answer: Particles gain energy and move much faster, overcoming attractions and moving far apart so the liquid becomes a gas; this change of state is boiling.**

## Question 8

- **B1** observation: droplets form on the cold surface
- **B1** explanation: gas particles lose energy, slow down and come closer together to form liquid
- **Answer: Droplets form on the cold surface; gas particles lose energy, slow down and come closer together to form liquid.**

## Question 9

- **B1** gives a named example, e.g. solid iodine or dry ice (solid $CO_2$) that sublimes
- **B1** explains that particles gain enough energy to go directly from the fixed solid positions to widely spaced gas particles, without passing through liquid
- **Answer: Example: solid iodine or dry ice sublimes; particles gain enough energy to leave the solid and become gas particles directly, skipping the liquid state.**

### Question 10

- **B1** the white ring forms nearer to the HCl end (the heavier gas travels less far)
- **B1** explanation: lighter NH3 molecules diffuse faster and travel further before meeting HCl, so the reaction location is nearer the heavier gas
- **Answer: The white ring forms nearer to the HCl end; lighter ammonia diffuses faster and travels further so the meeting point is closer to the heavier HCl.**

### Question 11

- **B1** gas particles are far apart with large spaces between them
- **B1** these large spaces can be reduced when compressed, whereas liquid particles are already close together so they cannot be compressed much
- **Answer: Gas particles are far apart with large gaps that can be pushed closer together when compressed; liquids have particles already close so there is little space to reduce.**

### Question 12

- **B1** solid box: particles very close together in fixed positions, labelled with 'vibrate in fixed positions' or equivalent
- **B1** liquid box: particles close but not fixed, labelled with 'move/slide past each other' or equivalent
- **Answer: Solid: very close, fixed, vibrate; Liquid: close, move/slide past each other; Gas: far apart, free rapid motion.**

### Question 13

- **B1** repeat the experiment several times and take a mean
- **B1** control variables such as temperature and initial concentration or use the same length/volume of gas each time
- **Answer: Repeat trials and average results; keep temperature and concentrations constant (and use same tube length) to control variables.**

### Question 14

- **Level 1** (1-2): Simple statements about one or two relevant facts, such as noting that gas particles are far apart or that particles move and collide.
- **Level 2** (3-4): Clear explanation covering particle spacing and movement for both gas and liquid, with some linking to compressibility or diffusion, but missing one supporting point or lacking depth in collision or energy discussion.
- **Level 3** (5-6): Detailed explanation comparing gases and liquids, referring to particle spacing, higher particle energy in gases, frequency of collisions and how these factors lead to easier compression and faster diffusion, with logical reasoning and examples.
- **Indicative content:**
  - Gases have particles that are widely spaced compared with liquids, so there is much empty space that can be reduced when compressed
  - Liquids have particles close together with little free space, so they are much less compressible
  - Gas particles have, on average, higher kinetic energy at the same temperature compared with how confined they behave in liquids, leading to faster motion
  - Faster motion and large free paths between particles make collisions that move particles into new regions more effective in gases, increasing diffusion rate
  - Diffusion is the net movement from high to low concentration; because gas particles move faster and have more space, the net mixing is quicker than in liquids
  - Examples or links: a bicycle pump compresses air easily because the large gaps between molecules are reduced; dye spreads more slowly in water than a gas spreads in a container