3.21 Particle Motion, Gas Pressure and Temperature: 30-minute Pack

AQA 8464 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A rigid, sealed gas cylinder contains a fixed mass of gas at a fixed volume. The cylinder is placed near a heater and its temperature increases. Explain, using the particle model, why the pressure of the gas increases.

(Total for Question 1 is 4 marks)

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2 Priya investigates how the pressure of a fixed mass of gas depends on its temperature, at constant volume. She uses a rigid, round-bottomed flask containing trapped air, sealed with a bung fitted with a pressure sensor connected to a data logger. The flask is fully submerged in a water bath, which is heated using an electric heater and stirred continuously. A thermometer measures the temperature of the water.

(a) Identify the independent variable and the dependent variable in this investigation. **(2)**

(b) State one variable that Priya must control during this investigation, and explain why. **(2)**

(c) Priya stirs the water continuously throughout the experiment. Give one reason why. **(1)**

(d) Give one safety precaution, other than wearing eye protection, that Priya should take when carrying out this experiment. **(1)**

(e) Priya's results are shown in the table below. **(1)**
Temperature (°C): 20, 35, 50, 65, 80
Pressure (kPa): 105, 111, 116, 128, 127
Identify the anomalous result.

Temperature (°C)	Pressure (kPa)
20	105
35	111
50	116
65	128
80	127

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(f) Suggest one possible reason for this anomalous result. **(1)**

(g) Describe the pattern shown by the rest of Priya's results (ignoring the anomalous result), and use the particle model to explain this pattern. **(3)**

(Total for Question 2 is 11 marks)

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3 Higher tier. A gas syringe contains 45 cm^3 of air at a pressure of 1.2 x 10^5 Pa. Callum compresses the gas, at constant temperature, until its pressure is 3.0 x 10^5 Pa.

(a) Calculate the new volume of the gas. Use p1V1 = p2V2. **(3)**

(b) State one assumption you have made in this calculation. **(1)**

(Total for Question 3 is 4 marks)

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4 A fixed mass of gas is held in a cylinder fitted with a piston. Explain, using the particle model of matter, how each of the following changes increases the pressure of the gas: (i) increasing the temperature of the gas while the piston is held in a fixed position (constant volume); (ii) pushing the piston further into the cylinder at constant temperature (decreasing the volume).

(Total for Question 4 is 6 marks)

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Mark scheme · 3.21 Particle Motion, Gas Pressure and Temperature: 30-minute Pack

Question 1

as temperature increases, the average kinetic energy of the gas particles increases, so they move faster, oe **B1**

the particles collide with the walls of the cylinder more frequently, oe **B1**

the particles also collide with the walls with greater force (more energetic collisions), oe **B1**

since the volume (and wall area) is constant, this greater and more frequent force increases the force per unit area, so the pressure increases, oe **B1**

Answer: Heating increases the particles' average kinetic energy, so they move faster and collide with the walls more often and with more force; since the volume is constant, this increases the pressure.

Question 2

(a) independent variable: temperature of the water/gas **B1**

(a) dependent variable: pressure of the gas **B1**

(a) Answer: Independent variable: temperature of the gas/water. Dependent variable: pressure of the gas.

(b) the volume of the gas must be kept constant, e.g. by using a rigid, sealed flask, oe **B1**

(b) so that any change in pressure recorded is caused only by the change in temperature, making it a fair test, oe **B1**

(b) Answer: Volume must be kept constant (rigid, sealed flask), so any pressure change recorded is caused only by the change in temperature, making it a fair test.

(c) to ensure the temperature is the same (evenly distributed) throughout the water bath, so the thermometer reading represents the temperature of the gas, oe **B1**

(c) Answer: To keep the water at a uniform temperature, so the thermometer reading represents the gas temperature accurately.

(d) any sensible precaution, e.g. do not exceed the maximum working pressure/temperature rating of the flask and sensor, to prevent it cracking or the bung being forced out, oe **B1**

(d) Answer: For example: do not exceed the maximum pressure/temperature rating of the flask, to prevent it cracking or the bung being forced out.

(e) the result at 65°C (128 kPa) is anomalous **B1**

(e) Answer: The pressure of 128 kPa recorded at 65°C is anomalous.

(f) a pressure sensor error giving an unusually high reading, or an incorrectly recorded pressure, oe; do not accept thermal lag during heating, which would give a lower pressure **B1**

(f) Answer: For example: a pressure sensor error gave an unusually high reading, or the pressure was recorded incorrectly.

(g) as the temperature of the gas increases, the pressure increases (roughly steadily), oe **B1**

(g) increasing temperature increases the average kinetic energy (speed) of the gas particles, so they collide with the walls of the flask more frequently and with greater force, oe **B1**

(g) since the volume (and wall area) is constant, this greater and more frequent force increases the pressure, oe **B1**

(g) Answer: Pressure increases roughly steadily as temperature increases; higher temperature gives the particles more kinetic energy, so they hit the walls more often and harder, and since volume is fixed this raises the pressure.

Question 3

(a) correct rearrangement: V2 = p1V1 / p2, oe **M1**

(a) correct substitution: $(1.2 \times 10^5 * 45) / (3.0 \times 10^5)$, oe **M1**

(a) 18 cm^3 cao **A1**

(a) Answer: 18 cm^3

(b) the temperature (and mass/amount) of the gas stays constant during the compression, oe **B1**

(b) Answer: That the temperature of the gas stays constant during the compression.

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Question 4

Level 1 Basic, isolated statement(s) that pressure increases in one or both situations, with little or no reference to the particle model or reasoning linking cause to effect. **1-2**

Level 2 Some correct use of the particle model to explain the pressure increase in at least one of the two situations. Reasoning about the frequency and/or force of particle collisions is present but may be incomplete or only partly linked to pressure. **3-4**

Level 3 A clear, logically linked explanation of both situations using the particle model, correctly relating the increase in pressure to the frequency and/or force of particle collisions with the container walls in each case. **5-6**

Indicative content:

- Gas particles are in continuous, random motion and collide with the walls of the container.
- Pressure is caused by the total force from these many collisions acting on a given area of the walls.
- (i) Increasing temperature at constant volume: the average kinetic energy of the particles increases, so they move faster.
- (i) Faster particles collide with the walls of the cylinder more frequently.
- (i) Faster particles also collide with the walls with greater force (more energetic collisions).
- (i) Both the increased frequency and increased force of collisions increase the pressure.
- (ii) Decreasing volume at constant temperature: the average kinetic energy (and speed) of the particles is unchanged.
- (ii) In a smaller volume, particles travel a shorter distance between collisions with the walls, so they collide with the walls more frequently.
- (ii) The force of each individual collision is unchanged (temperature is constant), but the increased frequency of collisions increases the pressure.
- A strong answer distinguishes that in (i) both the frequency and force of collisions increase, whereas in (ii) only the frequency increases.

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