3.9 Kinetic Theory of Gases and the Gas Laws: 30-minute Pack

Total Marks

EDEXCEL 4PH1 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 State what produces the pressure of a gas in a container, according to kinetic theory.

(Total for Question 1 is 1 mark)

2 State the meaning of absolute zero in the context of kinetic theory of gases.

(Total for Question 2 is 1 mark)

3 Convert a temperature of 25°C to kelvin for use in the pressure-temperature law at constant volume.

(Total for Question 3 is 2 marks)

4 Explain using kinetic theory why decreasing the volume of a gas at constant temperature increases its pressure.

(Total for Question 4 is 2 marks)

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5 Explain using the kinetic theory why increasing the temperature of a gas in a fixed-volume container increases its pressure.

(Total for Question 5 is 2 marks)

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6 A sealed 500 cm^3 container holds a gas at a pressure of 100 kPa. The gas is compressed to 200 cm^3 at the same temperature. Calculate the final pressure using Boyle's law, showing equation, substitution and final unit.

(Total for Question 6 is 3 marks)

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7 A helium balloon has volume 2.0 m^3 at pressure 101 kPa. It is taken down a mine where the pressure increases to 150 kPa at the same temperature. Calculate the balloon volume in the mine using Boyle's law. Show equation, substitution and unit.

(Total for Question 7 is 3 marks)

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8 A fixed-volume container holds a gas at pressure 120 kPa and temperature 300 K. The gas is heated at constant volume to 450 K. Calculate the new pressure using the pressure-temperature law $p1/T1 = p2/T2$. Show equation, substitution and unit.

(Total for Question 8 is 3 marks)

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9 A student measures pressure at constant volume and obtains p = 100 kPa at T = 273 K, and p = 200 kPa at T = 546 K. Use the pressure-temperature law to predict the pressure at T = 1092 K for the same volume. Show equation, substitution and unit.

(Total for Question 9 is 4 marks)

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10 Discuss the limitations of the kinetic theory model for real gases and explain under what conditions real gases deviate most from the ideal behaviour assumed by the model.

(Total for Question 10 is 6 marks)

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Mark scheme · 3.9 Kinetic Theory of Gases and the Gas Laws: 30-minute Pack

Question 1

collisions of particles with the container walls **B1**

Answer: Collisions of particles with the container walls produce the pressure

Question 2

the temperature at which particles have minimum possible kinetic energy (zero average kinetic energy) **B1**

Answer: Absolute zero is the temperature where particles have zero average kinetic energy

Question 3

states or uses conversion T(K) = T(°C) + 273 **M1**

298 K cao **A1**

Answer: 298 K

Question 4

reducing volume means particles have less space so they collide with the container walls more frequently **B1**

more frequent collisions per unit area increase the force per unit area, so pressure increases **B1**

Answer: Smaller volume reduces the distance between wall collisions so particles hit the walls more often; more collisions per unit time increase the force per unit area and so pressure rises

Question 5

higher temperature means particles have higher average kinetic energy / move faster **B1**

faster particles collide with walls more frequently and with greater force, increasing pressure **B1**

Answer: At higher temperature particles have higher average kinetic energy and move faster; they hit the walls more often and with greater force so pressure increases

Question 6

states Boyle's law p1V1 = p2V2 **M1**

substitutes values and rearranges, p2 = p1V1 / V2 = 100 kPa x 500 cm^3 / 200 cm^3 **M1**

final answer p2 = 250 kPa cao **A1**

Answer: 250 kPa

Question 7

states Boyle's law p1V1 = p2V2 **M1**

substitutes values and rearranges, V2 = p1V1 / p2 = 101 kPa x 2.0 m^3 / 150 kPa **M1**

final answer V2 = 1.35 m^3 cao (awrt) **A1**

Answer: 1.35 m^3

Question 8

states p1/T1 = p2/T2 **M1**

substitutes values and rearranges, p2 = p1 x T2 / T1 = 120 kPa x 450 K / 300 K **M1**

final answer p2 = 180 kPa cao **A1**

Answer: 180 kPa

Question 9

states p1/T1 = p2/T2 **M1**

substitutes values and rearranges, p2 = p1 x T2 / T1 = 100 kPa x 1092 K / 273 K **M1**

evaluates numeric ratio 1092 / 273 = 4 and multiplies to get 400 **M1**

final answer p2 = 400 kPa cao **A1**

Answer: 400 kPa

Question 10

Level 1 Limited statements about ideal gas assumptions or a simple identification of one limitation, with little or no linking to conditions where deviations occur. **1-2**

Level 2 Several correct points about limitations and some explanation of how attractive forces or particle volume cause deviations, with partial linkage to pressure and temperature conditions. **3-4**

Level 3 Well developed discussion that explains multiple limitations of the kinetic theory, why they arise, and clearly explains when and why real gases deviate from ideal behaviour under high pressure or low temperature conditions. **5-6**

Indicative content:

- Assumptions of the kinetic theory: point particles with no volume, no intermolecular forces, elastic collisions, rapid random motion
- Real gas particles have finite size and experience intermolecular attractions and repulsions, which the ideal model ignores
- At high pressure the finite volume of particles becomes significant compared with the container volume, reducing free space and causing pressure to differ from ideal predictions
- At low temperature intermolecular attractions become more important; particles slow and attract each other, reducing pressure compared with the ideal prediction at the same temperature
- Deviations are largest at high pressure and low temperature, and smallest at low pressure and high temperature where the ideal assumptions are more valid
- Reference to condensation as an extreme deviation where gas laws no longer apply because the gas liquefies
- How corrections are made in real gas equations such as van der Waals, qualitative mention only, not required

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