

Kinetic Theory — Assignment 1

Class 11 Physics · Topic-wise question bank covering every concept of the chapter · Narayan Gurukul Academy

Instructions: (1) Attempt all questions. This worksheet walks through every concept of the chapter, topic by topic.
(2) The interactive MCQ version of these questions (with instant answer reveal) is available on the notes page.
(3) Universal values: $g = 10 \text{ m/s}^2$ unless stated. Give answers with correct SI units.

Ideal Gas and Its Assumptions

MCQ Questions (choose the correct option)

- In the kinetic theory model, collisions between gas molecules are —
 - perfectly elastic
 - perfectly inelastic
 - partly elastic
 - completely random in energy
- The ideal gas equation is —
 - $PV = nRT$
 - $PV = n/R T$
 - $P = nRTV$
 - $V = nRTP$
- Boyle's law states that at constant temperature, —
 - P is inversely proportional to V
 - P is proportional to V
 - V is proportional to T
 - P is proportional to T
- A real gas behaves most like an ideal gas at —
 - low pressure and high temperature
 - high pressure and low temperature
 - high pressure and high temperature
 - low pressure and low temperature

1 Mark Questions

- State the main assumptions of the kinetic theory of gases.
- Write the ideal gas equation and define each symbol.
- State Boyle's law.

2 Mark Questions

- What is an ideal gas? Under what conditions does a real gas approach ideal behaviour?
- State Boyle's law, Charles' law and Avogadro's law and show how they combine into the ideal gas equation.
- Find the number of moles in 44 g of CO_2 . (Molar mass = 44 g mol^{-1} .)

3 Mark Questions

- State the postulates of the kinetic theory of gases and explain why the ideal gas equation holds at low pressure and high temperature.

2. A gas occupies 2 m^3 at a pressure of 10^5 Pa and a temperature of 300 K . Find the number of moles and the number of molecules. ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$, $N_A = 6.02 \times 10^{23}$.)

Pressure Exerted by an Ideal Gas

MCQ Questions (choose the correct option)

- The pressure of an ideal gas is directly proportional to its —
(A) mean-square speed of the molecules
(B) mean speed of the molecules
(C) most probable speed
(D) average kinetic energy per molecule times N
- The pressure of a gas arises from —
(A) collisions of molecules with the container walls
(B) the weight of the gas
(C) molecular volume
(D) intermolecular forces at rest
- For an ideal gas, $P =$ —
(A) $(1/3)pv^2_{\text{avg}}$
(B) $(1/2)pv^2_{\text{avg}}$
(C) pv^2_{avg}
(D) $(1/3)pv_{\text{avg}}$
- If the mean-square speed of gas molecules is doubled at constant volume, the pressure —
(A) doubles
(B) becomes four times
(C) stays the same
(D) becomes half

1 Mark Questions

- Explain how pressure arises in the kinetic theory of gases.
- Write the expression $P = (1/3)pv^2_{\text{avg}}$ and identify the symbols.
- On which molecular quantity does gas pressure depend?

2 Mark Questions

- Derive the relation $P = (1/3)pv^2_{\text{avg}}$ from the kinetic theory model.
- The density of a gas is 1.5 kg m^{-3} and its molecules have a mean-square speed of $10^6 \text{ m}^2 \text{ s}^{-2}$. Find the pressure it exerts.
- Show that the pressure of a gas is directly proportional to its density at constant mean-square speed.

3 Mark Questions

- Use the kinetic theory to derive an expression for the pressure exerted by an ideal gas in terms of the mass, number density and mean-square speed of the molecules.
- A gas has a density of 2 kg m^{-3} and exerts a pressure of $2 \times 10^5 \text{ Pa}$. Find the root-mean-square speed of its molecules.

Kinetic Interpretation of Temperature

MCQ Questions (choose the correct option)

1. The average translational kinetic energy of a gas molecule is —
(A) $(3/2)k_B T$
(B) $(1/2)k_B T$
(C) $k_B T$
(D) $(3/2)RT$
2. Two different gases at the same temperature have —
(A) the same average translational KE per molecule
(B) the same average speed
(C) the same mass per molecule
(D) the same density
3. The temperature of a gas is a measure of the —
(A) average kinetic energy of its molecules
(B) total mass of the gas
(C) volume of the gas
(D) average speed of the fastest molecule
4. At a given temperature, which gas molecules move fastest on average? —
(A) the lightest molecules
(B) the heaviest molecules
(C) all move equally fast
(D) the densest gas

1 Mark Questions

1. State the kinetic interpretation of temperature.
2. Write the expression for the average kinetic energy of a gas molecule.
3. Two gases at the same temperature: what is equal for their molecules?

2 Mark Questions

1. Show that the average kinetic energy per molecule of a gas equals $(3/2)k_B T$.
2. Find the average translational kinetic energy of a molecule at 300 K. ($k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$)
3. Why is the average translational kinetic energy of all gases the same at a given temperature?

3 Mark Questions

1. Derive the kinetic interpretation of temperature, starting from $P = (1/3)\rho v^2_{\text{avg}}$ and the ideal gas equation.
2. Compute the total translational kinetic energy of 2 moles of an ideal gas at 400 K. ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$)

Root-Mean-Square Speed**MCQ Questions (choose the correct option)**

1. The RMS speed of gas molecules is given by —
(A) $\sqrt{3k_B T/m}$
(B) $\sqrt{(kT/m)}$
(C) $\sqrt{(2kT/m)}$
(D) $\sqrt{(3mT/k_B)}$

2. The RMS speed of gas molecules is proportional to —
 - (A) $\sqrt{T}$
 - (B) T
 - (C) T^2
 - (D) $1/T$
3. At a given temperature, a lighter gas has —
 - (A) a higher RMS speed
 - (B) a lower RMS speed
 - (C) the same RMS speed
 - (D) zero RMS speed
4. For an ideal gas, the ordering of the three speeds is —
 - (A) $v_{rms} > v_{mean} > v_{mp}$
 - (B) $v_{mean} > v_{rms} > v_{mp}$
 - (C) $v_{mp} > v_{rms} > v_{mean}$
 - (D) $v_{rms} = v_{mean} = v_{mp}$

1 Mark Questions

1. Define the root-mean-square speed of gas molecules.
2. Write the expression for v_{rms} in terms of the molar mass M .
3. How does v_{rms} depend on temperature?

2 Mark Questions

1. Find the RMS speed of oxygen molecules at 300 K. ($M = 32 \times 10^{-3} \text{ kg mol}^{-1}$, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$.)
2. Compare the RMS speeds of hydrogen and oxygen at the same temperature.
3. If the temperature of a gas is raised from 300 K to 1200 K, by what factor does its RMS speed increase?

3 Mark Questions

1. Derive an expression for the root-mean-square speed of gas molecules in terms of T and molar mass.
2. At what temperature will the RMS speed of oxygen molecules equal that at which hydrogen has an RMS speed of 2000 m/s at 300 K? Derive your answer.

Degrees of Freedom and Specific Heats

MCQ Questions (choose the correct option)

1. The number of translational degrees of freedom of a monatomic gas is —
 - (A) 3
 - (B) 5
 - (C) 2
 - (D) 6
2. According to the equipartition theorem, energy per degree of freedom per molecule is —
 - (A) $(1/2)k_B T$
 - (B) $k_B T$
 - (C) $(3/2)k_B T$
 - (D) $2k_B T$
3. For a monatomic gas, C_V is —

- (A) $3R/2$
 - (B) $5R/2$
 - (C) R
 - (D) $7R/2$
4. For a diatomic gas excluding vibration, $\gamma = C_P/C_V$ is —
- (A) $7/5$
 - (B) $5/3$
 - (C) $3/2$
 - (D) $4/3$

1 Mark Questions

1. Define the degrees of freedom of a gas molecule.
2. State the law of equipartition of energy.
3. Write the value of C_V for a monatomic gas.

2 Mark Questions

1. Find the number of degrees of freedom of (a) monatomic and (b) diatomic gas molecules.
2. State the law of equipartition of energy and hence write C_V and C_P for a monatomic gas.
3. For a diatomic gas, using $f = 5$, find C_V , C_P and γ .

3 Mark Questions

1. State the law of equipartition of energy and use it to obtain the specific heats and γ for a monatomic and a diatomic gas.
2. Compute the internal energy of 3 moles of a monatomic gas at 400 K. ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$.)

The Maxwell Speed Distribution

MCQ Questions (choose the correct option)

1. The most probable speed of gas molecules is —
 - (A) $\sqrt{2k_B T/m}$
 - (B) $\sqrt{3k_B T/m}$
 - (C) $\sqrt{8k_B T/\pi m}$
 - (D) $\sqrt{k_B T/m}$
2. As the temperature of a gas rises, its Maxwell speed distribution —
 - (A) broadens and shifts to higher speeds
 - (B) narrows and shifts to lower speeds
 - (C) remains unchanged
 - (D) becomes a sharp single peak
3. For a gas, the correct order of the three speeds is —
 - (A) $v_{mp} < v_{mean} < v_{rms}$
 - (B) $v_{mp} > v_{rms} > v_{mean}$
 - (C) $v_{rms} < v_{mp} < v_{mean}$
 - (D) all equal
4. The Maxwell distribution describes —
 - (A) the distribution of molecular speeds in a gas

- (B) the pressure of a gas
- (C) the ideal gas equation
- (D) the diffusion of gases

1 Mark Questions

1. What is the Maxwell speed distribution?
2. Define the most probable speed.
3. Write the expressions for the three characteristic speeds of a gas.

2 Mark Questions

1. Find the most probable speed of nitrogen molecules at 300 K. ($M = 28 \times 10^{-3} \text{ kg mol}^{-1}$, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$.)
2. Explain why the Maxwell distribution broadens as the temperature increases.
3. State the ordering $v_{\text{mp}} < v_{\text{mean}} < v_{\text{rms}}$ and explain it briefly.

3 Mark Questions

1. Describe the Maxwell speed distribution and explain the physical meaning of the most probable, mean and RMS speeds.
2. Compute the most probable, mean and RMS speeds of argon atoms at 300 K. ($M = 40 \times 10^{-3} \text{ kg mol}^{-1}$, $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$.)