Exemplar Solutions for Class 11 Physics Chapter 12 – Kinetic Theory

Very Short Answers

14. Calculate the number of atoms in 39.4 g gold. Molar mass of gold is 197 g/mol.

Answer: Number of moles = 39.4 g ÷ 197 g/mol = 0.2 mol Number of atoms = 0.2 × 6.023 × 10^{23} = 1.20 × 10^{23} atoms

15. The volume of a given mass of a gas at 27°C, 1 atm is 100 cc. What will be its volume at 327°C?

Answer: T_1 = 27°C = 300 K, V_1 = 100 cm^3 T_2 = 327°C = 600 K Using Charles's law: $V_1/T_1 = V_2/T_2$ $V_2 = V_1 \times (T_2/T_1)$ = 100 × (600/300) = 200 cm^3

16. The molecules of a given mass of a gas have root mean square speeds of 100 m/s at 27°C and 1.00 atmospheric pressure. What will be the root mean square speeds of the molecules of the gas at 127°C and 2.0 atmospheric pressure?

Answer: T_1 = 300 K, T_2 = 400 K v_rms ∝ √T (pressure doesn't affect rms speed) v_rms2 = v_rms1 × $\sqrt{(T_2/T_1)}$ = 100 × √(400/300) = 100 × √(4/3) = 115.4 m/s

17. Two molecules of a gas have speeds of 9 × 10^6 m/s and 1 × 10^6 m/s respectively. What is the root mean square speed of these molecules?

Answer: v_rms = $\sqrt{[(v_1^2 + v_2^2)/2]}$ = $\sqrt{[(81\times10^{12} + 1\times10^{12})/2]}$ = $\sqrt{[41\times10^{12}]}$ = 6.4 × 10^6 m/s

18. A gas mixture consists of 2.0 moles of oxygen and 4.0 moles of neon at temperature T. Neglecting all vibrational modes, calculate the total internal energy of the system. (Oxygen has two rotational modes.)

Answer: O_2 (diatomic): degrees of freedom = 5, Internal energy = (5/2)nRT = (5/2) × 2 × RT = 5RT Ne (monatomic): degrees of freedom = 3, Internal energy = (3/2)nRT = (3/2) × 4 × RT = 6RT Total internal energy = 5RT + 6RT = 11RT

Short Answers

19. Calculate the ratio of the mean free paths of the molecules of two gases having molecular diameters 1 Å and 2 Å. The gases may be considered under identical conditions of temperature, pressure, and volume.

Answer: Mean free path λ ∝ 1/σ ∝ $1/d^2$ $\lambda_1/\lambda_2 = (d_2/d_1)^2 = (2/1)^2$ = 4:1

20. The container shown in figure has two chambers, separated by a partition, of volumes V_1 = 2.0 litre and V_2 = 3.0 litre. The chambers contain μ_1 = 4.0 and μ_2 = 5.0 moles of a gas at pressure p_1 = 1.00 atm and p_2 = 2.00 atm. Calculate the pressure after the partition is removed and the mixture attains equilibrium.

Answer: Initial state: $P_1V_1 = \mu_1RT$ and $P_2V_2 = \mu_2RT$ Total moles = $\mu_1 + \mu_2 = 4 + 5 = 9$ mol Total volume = $V_1 + V_2 = 2 + 3 = 5$ L From $P_1V_1 + P_2V_2 = P\_final(V_1 + V_2)$: P_final = (1×2 + 2×3)/(5) = 8/5 = 1.6 atm

21. A gas mixture consists of molecules of types A, B, and C with masses m_A > m_B > m_C. Rank the three types of molecules in decreasing order of a) average KE b) rms speeds

Answer: a) Average KE: At same temperature, average KE is same for all: KE_C = KE_B = KE_A b) RMS speeds: v_rms ∝ 1/√m, so (v_rms)_C > (v_rms)_B > (v_rms)_A

22. We have 0.5 g of hydrogen gas in a cubic chamber of size 3 cm kept at NTP. The gas in the chamber is compressed keeping the temperature constant till a final pressure of 100 atm. Is one justified in assuming the ideal gas law in the final state?

Answer: Volume of H_2 molecule ≈ $4\pi r^3/3 \approx 4.20 \times 10^{-30}$ m³ Number of moles = 0.5/2 = 0.25 mol Total molecular volume = $0.25 \times 6.023 \times 10^{23} \times 4.20 \times 10^{-30} \approx 6.3 \times 10^{-7}$ m³ Available volume at 100 atm ≈ $(3\times10^{-2})^3 \times (1/100) = 2.7 \times 10^{-8}$ m³ Since molecular volume is comparable to available volume, ideal gas assumption is not justified.

23. When air is pumped into a cycle tyre the volume and pressure of the air in the tyre both are increased. What about Boyle's law in this case?

Answer: Boyle's law (PV = constant) applies only when the amount of gas remains constant. When pumping air, we're adding more gas molecules, so the mass (and number of moles) increases. The correct relation is PV = nRT where n varies. Therefore, Boyle's law doesn't apply directly.

24. A balloon has 5.0 g mole of helium at 7°C. Calculate a) the number of atoms of helium in the balloon b) the total internal energy of the system

Answer: T = 7°C = 280 K a) Number of atoms = $5 \times 6.023 \times 10^{23} = 3.01 \times 10^{24}$ atoms b) For monatomic gas: Internal energy = (3/2)nRT = (3/2) × 5 × 8.314 × 280 = 1.74×10^4 J

25. Calculate the number of degrees of freedom of molecules of hydrogen in 1 cc of hydrogen gas at NTP.

Answer: At NTP, 22400 cc contains 1 mole Number of molecules in 1 cc = $(1/22400) \times 6.023 \times 10^{23} = 2.69 \times 10^{19}$ H_2 has 5 degrees of freedom Total degrees of freedom = $5 \times 2.69 \times 10^{19} = 1.34 \times 10^{20}$

26. An insulated container containing monoatomic gas of molar mass M is moving with a velocity v_0. If the container is suddenly stopped, find the change in temperature.

Answer: Initial kinetic energy = $\frac{1}{2}nMv_0^2$ This converts to internal energy: $\Delta U = nC_v\Delta T$ For monatomic gas: $C_v = (3/2)R$ $\frac{1}{2}nMv_0^2 = n(3/2)R\Delta T$ $\Delta T = Mv_0^2/(3R)$