JEE Main 2026 Thermodynamics & Kinetic Theory Question PDF

Q1. A diatomic gas ($\gamma = 1.4$) expands adiabatically from 4 L to 8 L at an initial pressure 2×10^5 Pa. Find the work done.

Solution

$W = (P_1V_1 - P_2V_2)/(\gamma - 1)$
Using $P_1V_1^\gamma = P_2V_2^\gamma \Rightarrow P_2 = P_1(V_1/V_2)^\gamma$
$P_2 = 2\times10^5(0.5)^{1.4} = 2\times10^5 \times 0.378 = 7.56\times10^4$ Pa
$W = (2\times10^5\times4\times10^{-3} - 7.56\times10^4\times8\times10^{-3})/0.4 = (800 - 604.8)/0.4 = 487$ J

Answer: 487 J

Q2. A gas expands isothermally from 2 L to 8 L at 300 K. The initial pressure is 4×10^5 Pa. Find the work done.

Solution

For an isothermal process,
$W = nRT \ln(V_2/V_1) = P_1V_1 \ln(V_2/V_1)$
$W = (4\times10^5)(2\times10^{-3}) \ln(8/2) = 800 \ln(4) = 800 \times 1.386 = 1109$ J

Answer: 1109 J

Q3. At what temperature will the RMS speed of oxygen molecules be twice its value at 300 K?

Solution

$v_{rms} \propto \sqrt{T} \Rightarrow v_2/v_1 = \sqrt{(T_2/T_1)}$
$2 = \sqrt{(T_2/300)} \Rightarrow T_2 = 4\times300 = 1200$ K

Answer: 1200 K

Q4. If the mean free path at 27°C and 1 atm is 6.6×10^{-8} m, find it at 54°C and 0.5 atm.

Solution

$\lambda \propto T / P$
$\lambda_2/\lambda_1 = (T_2/T_1) \times (P_1/P_2)$
$\lambda_2 = 6.6\times10^{-8} \times (327/300) \times (1/0.5) = 6.6\times10^{-8} \times 2.18 = 1.44\times10^{-7}$ m

Answer: 1.44×10^{-7} m

Q5. Find the pressure of 1 mole of nitrogen gas in a 10 L container if RMS speed = 500 m/s.

Solution

$P = (1/3) \times (m/V) \times v_{rms}^2 \times N_A$
$M = 28$ g/mol $= 28\times10^{-3}$ kg/mol
$P = (1/3)(1\times28\times10^{-3}/10^{-2})(500^2) = (1/3)(2.8)(2.5\times10^5) = 2.33\times10^5$ Pa

Answer: 2.33×10^5 Pa

Q6. Find the average kinetic energy per molecule of a monatomic gas at 300 K.

Solution

$E = (3/2)kT = (3/2)(1.38\times10^{-23})(300) = 6.21\times10^{-21}$ J

Answer: 6.21×10^{-21} J

Q7. A gas expands from 2 L to 6 L at a constant pressure of 1×10^5 Pa. Find work done.

Solution

$W = P\Delta V = 1\times10^5 \times (6-2)\times10^{-3} = 400$ J

Answer: 400 J

Q8. For a monatomic gas, if temperature increases by 40 K for 2 mols, find ΔU.

Solution

$\Delta U = nC_V\Delta T = n(3/2\ R)\Delta T = 2\times1.5\times8.314\times40 = 998$ J

Answer: 998 J

Q9. If temperature of gas increases by factor 2 during adiabatic compression, find pressure ratio (γ = 1.4).

Solution

$T_2/T_1 = (P_2/P_1)^{(\gamma-1)/\gamma}$
$2 = (P_2/P_1)^{(0.4/1.4)}$
$(P_2/P_1) = 2^{(3.5)} = 11.3$

Answer: 11.3

Q10. For O_2 at 300 K, find v_mp and v_rms.

Solution

$M = 32\times10^{-3}$ kg/mol
$v_{mp} = \sqrt{(2RT/M)} = \sqrt{(2\times8.314\times300/0.032)} = 395$ m/s
$v_{rms} = \sqrt{(3RT/M)} = \sqrt{(3\times8.314\times300/0.032)} = 484$ m/s

Answer: v_mp = 395 m/s and v_rms = 484 m/s

Q11. Find v_avg : v_mp : v_rms for a gas.

Solution

$v_{mp} = \sqrt{(2RT/M)}$, $v_{avg} = \sqrt{(8RT/\pi M)}$, $v_{rms} = \sqrt{(3RT/M)}$
Ratio = 1.128 : 1 : 1.225 ≈ 1.13 : 1 : 1.22

Answer: 1.13 : 1 : 1.22

Q12. If a Carnot engine absorbs 600 J of heat from the source at 500 K and rejects heat to sink at 300 K, find Q_2.

Solution

$Q_2/Q_1 = T_2/T_1 \Rightarrow Q_2 = 600\times(300/500) = 360$ J

Answer: 360 J

Q13. A monatomic gas ($\gamma = 5/3$) is compressed adiabatically to half its volume. Find T_2/T_1.

Solution

$T_2/T_1 = (V_1/V_2)^{(\gamma-1)} = (2)^{(2/3)} = 1.59$

Answer: 1.59

Q14. Find internal energy of 3 mols of monatomic gas at 300 K.

Solution

$U = (3/2)nRT = 1.5 \times 3 \times 8.314 \times 300 = 11224$ J

Answer: 11224 J

Q15. For an isochoric process, pressure of a gas doubles. Find the ratio of final to initial temperature.

Solution

$P \propto T \Rightarrow T_2/T_1 = P_2/P_1 = 2$

Answer: 2