EngineeringRise

Degrees of freedom, equipartition, specific heats and mean free path

Formulas and units, JEE Main. Status: Reviewed on 2026-11-20.

Result	Formula	Units or note
Degrees of freedom (rigid)	monatomic 3; diatomic 5; linear triatomic 5; non-linear polyatomic 6; each active vibration adds 2 Valid when: rigid molecules at ordinary temperature; vibration counts only when active	dimensionless
Equipartition	(1/2) k T per quadratic term; U = (f/2) n R T Valid when: classical equipartition, ideal gas in thermal equilibrium	J
Molar heat capacities	Cv = (f/2) R; Cp = (f/2 + 1) R; Cp - Cv = R Valid when: ideal gas with f active degrees of freedom; Cp - Cv = R for any ideal gas	J/(mol K)
Ratio of specific heats	gamma = 1 + 2/f: 1.67 (f=3), 1.40 (f=5), 1.33 (f=6) Valid when: ideal gas with f active degrees of freedom	dimensionless
Heat at constant V and constant P	Q = n Cv dT; Q = n Cp dT; W = n R dT Valid when: ideal gas, constant Cv and Cp; Cv for constant volume, Cp for constant pressure	J
Mixture	Cv = sum(n Cv)/sum(n); gamma = (Cv + R)/Cv Valid when: non-reacting ideal gases mixed, constant heat capacities	J/(mol K) (dimensionless)
Final temperature on mixing (rigid, insulated)	T = (sum n Cv T)/(sum n Cv) Valid when: non-reacting ideal gases mixed in insulated rigid container, no work or heat exchange	K
Mean free path	lambda = k T / (sqrt(2) pi d^2 P) = 1/(sqrt(2) pi d^2 n_v) Valid when: ideal gas of hard spheres, d is molecular diameter	m
Collision frequency	nu = v_mean / lambda; v_mean = sqrt(8 k T/(pi m)) Valid when: ideal gas of hard spheres at temperature T; mean speed from Maxwell distribution	per s

Full lesson with worked examples:
https://www.engineeringrise.in/learn/learn/jee-main/physics/kinetic-theory-of-gases/degrees-of-freedom-equipartition-specific-heats-

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