CLASS 11 PHYSICS — FORMULA SHEET

Chapter 12 : Kinetic Theory (NCERT)

12.1 Ideal Gas Laws

Law	Formula
Boyle's law	PV = constant (T constant)
Charles's law	V/T = constant (P constant)
Gay-Lussac's law	P/T = constant (V constant)
Avogadro's law	Equal volumes have equal molecules (same T, P)
Ideal gas equation	PV = nRT = NkT
Gas constant	$R = 8.314\ J\ mol^{-1}\ K^{-1}$
Boltzmann constant	$k = R \div N_A = 1.38 \times 10^{-23}\ J/K$
Avogadro number	$N_A = 6.022 \times 10^{23}$ per mole

12.2 Kinetic Theory — Pressure & Energy

Concept	Formula
Pressure of gas	$P = (1/3)(mN/V)\ \bar{v}^2 = (1/3)\rho\ \bar{v}^2$
Pressure & KE	P = (2/3)(E/V) ; E = average KE per unit volume
Average KE per molecule	$(1/2)m\ \bar{v}^2 = (3/2)kT$
Average KE per mole	(3/2)RT
Internal energy (ideal gas)	U = (3/2)nRT (monatomic)
KE depends only on	Temperature (not on mass or type of gas)

12.3 Molecular Speeds

Speed	Formula
RMS speed	$v_{rms} = \sqrt{(3RT/M)} = \sqrt{(3kT/m)} = \sqrt{(3P/\rho)}$
Average speed	$v_{avg} = \sqrt{(8RT/\pi M)} = \sqrt{(8kT/\pi m)}$
Most probable speed	$v_{mp} = \sqrt{(2RT/M)} = \sqrt{(2kT/m)}$
Ratio of speeds	$v_{rms} : v_{avg} : v_{mp} = \sqrt{3} : \sqrt{(8/\pi)} : \sqrt{2} = 1.73 : 1.60 : 1.41$
Order	$v_{rms} > v_{avg} > v_{mp}$
Speed vs temperature	$v \propto \sqrt{T}$ (all speeds increase with $\sqrt{T}$)

12.4 Degrees of Freedom & Equipartition

Concept	Detail
Degrees of freedom (f)	Monatomic: 3 ; Diatomic: 5 ; Polyatomic (non-linear): 6
Equipartition theorem	Each degree of freedom has energy (1/2)kT per molecule

Concept	Detail
Energy per mole	$U = (f/2)RT$
Specific heats	$C_v = (f/2)R$; $C_p = (f/2 + 1)R$
Adiabatic exponent	$\gamma = C_p/C_v = 1 + 2/f$
Monatomic γ	$\gamma = 1.67$ ($f = 3$)
Diatomic γ	$\gamma = 1.40$ ($f = 5$)

12.5 Mean Free Path

Concept	Formula
Mean free path	$\lambda = 1 \div (\sqrt{2}\, \pi\, d^2\, n)$
In terms of P, T	$\lambda = kT \div (\sqrt{2}\, \pi\, d^2\, P)$
d = molecular diameter	n = number density (molecules per volume)
Mean free path vs P	$\lambda \propto 1/P$ (lower pressure → longer free path)
Mean free path vs T	$\lambda \propto T$ (at constant P)

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Ideal gas	PV = nRT = NkT. Use n (moles) with R, or N (molecules) with k.
Pressure formula	$P = (1/3)\rho\bar{v}^2$. Pressure comes from molecular collisions.
KE & temperature	Average KE = (3/2)kT — depends ONLY on temperature.
Speed order	$v_{rms} > v_{avg} > v_{mp}$ (1.73 : 1.60 : 1.41). All $\propto \sqrt{T}$.
RMS speed	$v_{rms} = \sqrt{(3RT/M)}$. Lighter gas → faster molecules.
Degrees of freedom	Mono 3, di 5, polyatomic 6. Energy = (f/2)kT per molecule.
Cv from f	Cv = (f/2)R, Cp = Cv + R, $\gamma = 1 + 2/f$.
Mean free path	$\lambda = kT/(\sqrt{2}\, \pi d^2 P)$. Lower pressure → longer free path.