CLASS 11 PHYSICS — FORMULA SHEET

Chapter 11 : Thermodynamics (NCERT)

11.1 Basic Terms & Zeroth Law

Concept	Detail
Thermodynamic system	A definite quantity of matter under study
State variables	P, V, T, internal energy U (describe the state)
Thermal equilibrium	No net heat flow between systems (same temperature)
Zeroth law	If A is in equilibrium with C, and B with C, then A and B are in equilibrium → defines temperature
Internal energy (U)	Total KE + PE of molecules ; a state function
For ideal gas	U depends only on temperature

11.2 First Law of Thermodynamics

Concept	Formula
First law	$\Delta Q = \Delta U + \Delta W$ (heat = internal energy change + work done)
Sign convention	Q +ve if absorbed ; W +ve if done BY the gas
Work done by gas	$\Delta W = P\,\Delta V$; $W = \int P\,dV$ (area under P–V curve)
Change in internal energy	$\Delta U = n\,C_v\,\Delta T$ (depends only on temperature)
State vs path	U is a state function ; Q and W are path functions

11.3 Thermodynamic Processes

Process	Condition & Key Results
Isothermal	T constant ; $\Delta U = 0$; $Q = W = nRT \ln(V_2/V_1)$
Adiabatic	$Q = 0$; $\Delta U = -W$; $PV^\gamma = \text{constant}$
Adiabatic relations	$TV^{(\gamma-1)} = \text{const}$; $P^{(1-\gamma)}T^\gamma = \text{const}$
Isobaric (P constant)	$W = P\,\Delta V = nR\,\Delta T$; $Q = n\,C_p\,\Delta T$
Isochoric (V constant)	$W = 0$; $Q = \Delta U = n\,C_v\,\Delta T$
Cyclic process	$\Delta U = 0$; $Q = W$ (net) ; area of P–V loop = work

11.4 Specific Heats of Gas

Concept	Formula
Molar heat (constant V)	$C_v = (f/2)R$ (f = degrees of freedom)
Molar heat (constant P)	$C_p = C_v + R$ (Mayer's relation)
Ratio of specific heats	$\gamma = C_p/C_v = 1 + 2/f$
Monatomic gas	$C_v = (3/2)R$, $C_p = (5/2)R$, $\gamma = 1.67$

Concept	Formula
Diatomic gas	$C_v = (5/2)R$, $C_p = (7/2)R$, $\gamma = 1.40$
Polyatomic gas	$C_v = 3R$, $C_p = 4R$, $\gamma = 1.33$

11.5 Second Law & Heat Engines

Concept	Formula / Statement
Second law (Kelvin–Planck)	No engine can convert all heat into work (some is rejected)
Second law (Clausius)	Heat cannot flow from cold to hot body on its own
Heat engine efficiency	$\eta = W \div Q_1 = 1 - Q_2/Q_1$
Carnot efficiency	$\eta = 1 - T_2/T_1$ (T in kelvin)
Carnot is the maximum	No engine between two temperatures can beat Carnot
Refrigerator COP	$\beta = Q_2 \div W = Q_2 \div (Q_1 - Q_2)$
Carnot refrigerator COP	$\beta = T_2 \div (T_1 - T_2)$
Relation	$\eta + \beta$(for same engine reversed) ; $\beta = (1-\eta)/\eta$

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First law	$\Delta Q = \Delta U + \Delta W$. Heat in = internal energy rise + work by gas.
Process map	Isothermal: $\Delta U=0$; Adiabatic: $Q=0$; Isochoric: $W=0$; Isobaric: $Q=nC_p\Delta T$.
Adiabatic	PV^γ = constant. No heat exchange — fast compression/expansion.
Cp − Cv = R	Mayer's relation (per mole). Cp always greater than Cv.
Gamma values	Monatomic 1.67, diatomic 1.40, polyatomic 1.33. $\gamma = 1 + 2/f$.
Carnot efficiency	$\eta = 1 - T_2/T_1$ (kelvin). Higher source temperature → better efficiency.
No 100% engine	Second law forbids converting all heat into work.
Fridge COP	$\beta = T_2/(T_1-T_2)$. Smaller temperature gap → better cooling efficiency.