

Chemical Thermodynamics: one-page cheat sheet

NEET Chemistry · Unit 4 · Physical Chemistry

1 • Systems & properties

Open	exchanges matter and energy
Closed	exchanges energy only
Isolated	exchanges neither
State function	p, V, T, U, H, S, G (path independent)
Path function	q and w
Extensive	mass, V, U, H, S, G, C
Intensive	T , density, C_m, E° ; a ratio of two extensive properties is intensive

Trap · q and w are path functions, but $q + w = \Delta U$ is a state function.

2 • First law, work & processes

$$\Delta U = q + w \quad w = -p_{\text{ext}}(V_f - V_i)$$

$$w_{\text{rev}} = -2.303 nRT \log \frac{V_f}{V_i} = -2.303 nRT \log \frac{p_i}{p_f}$$

Process	Condition	Result
Isothermal	$\Delta T = 0$	$\Delta U = 0$, so $q = -w$
Isochoric	$\Delta V = 0$	$w = 0$, $\Delta U = q_v$
Isobaric	$\Delta p = 0$	$\Delta H = q_p$
Adiabatic	$q = 0$	$\Delta U = w$

Free expansion $p_{\text{ext}} = 0$, so $w = 0$

Trap · Heat absorbed and work done **on** the system are positive (IUPAC). Reversible isothermal expansion gives **maximum** work.

3 • Enthalpy

$$\Delta H = \Delta U + \Delta n_g RT$$

$$\Delta n_g = 0 \quad \Delta H = \Delta U \quad (\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI})$$

$$\Delta n_g > 0 \quad \Delta H > \Delta U \quad (\text{PCl}_5 \rightarrow \text{PCl}_3 + \text{Cl}_2)$$

$$\Delta n_g < 0 \quad \Delta H < \Delta U \quad (\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3)$$

Δn_g counts gaseous products minus gaseous reactants only.

4 • Heat capacity

$$C_p - C_v = R \quad \gamma = \frac{C_p}{C_v}$$

Gas	C_v	C_p	γ
Monoatomic	$\frac{3}{2}R$	$\frac{5}{2}R$	1.67
Diatomic	$\frac{5}{2}R$	$\frac{7}{2}R$	1.40
Non-linear polyatomic	$3R$	$4R$	1.33

Ideal gas $\Delta U = nC_v\Delta T$, $\Delta H = nC_p\Delta T$ for any process

Six traps to remember

- q and w depend on path; ΔU , ΔH , ΔS do not.
- Reversible isothermal expansion gives **maximum** work; free expansion gives zero.
- $\Delta H = \Delta U + \Delta n_g RT$: count **gas** moles only.

5 • Thermochemistry

Hess's law $\Delta_r H = \Delta H_1 + \Delta H_2 + \dots$

Formation $\Delta_r H^\circ = \sum \Delta_f H^\circ(\text{products}) - \sum \Delta_f H^\circ(\text{reactants})$

Elements $\Delta_f H^\circ = 0$ in the standard state (graphite, O_2 , S rhombic)

Bond enthalpy $\Delta_r H^\circ = \sum \text{BE}(\text{reactants}) - \sum \text{BE}(\text{products})$, gas phase only

Born-Haber $\Delta_f H = \Delta_{\text{sub}} H + \Delta_i H + \frac{1}{2} \Delta_{\text{bond}} H + \Delta_{\text{eg}} H - \Delta_{\text{lattice}} H$

6 • Entropy

$$\Delta S = \frac{q_{\text{rev}}}{T}, \quad \Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} > 0$$

Surroundings $\Delta S_{\text{surr}} = -\Delta H/T$ at constant T, P

S rises solid $\rightarrow$ liquid $\rightarrow$ gas; heating; more moles of gas; dissociation

S falls cooling a crystal to 0 K; gas moles decrease

7 • Gibbs energy

$$\Delta G = \Delta H - T\Delta S, \quad \Delta G^\circ = -2.303 RT \log K$$

ΔH	ΔS	Spontaneous?
–	+	at all T
–	–	low T only
+	+	high T only
+	–	never

Equilibrium $\Delta G = 0$, so $T_{\text{eq}} = \Delta H^\circ / \Delta S^\circ$

8 • Types of enthalpy change

Combustion 1 mol burnt completely in O_2 ; always negative

Fusion, vapourisation $\Delta_{\text{sub}} H = \Delta_{\text{fus}} H + \Delta_{\text{vap}} H$

Neutralisation strong acid + strong base: about $-57.1 \text{ kJ mol}^{-1}$ of water formed

Lattice $\Delta_{\text{lattice}} H$ is positive as defined (crystal $\rightarrow$ gaseous ions)

Seen in NEET 2026

$2A(g) + B(g) \rightarrow 2D(g)$; $\Delta U^\ominus = -10 \text{ kJ}$, $\Delta S^\ominus = -44 \text{ J K}^{-1}$ at 298 K. Find $\Delta G^\ominus$.

$$\Delta n_g = -1 : \Delta H^\ominus = -10000 - 8.314 \times 298 = -12478 \text{ J}$$

$$\Delta G^\ominus = -12478 + 298 \times 44 \approx +634 \text{ J} \Rightarrow \text{non-spontaneous}$$

- Bond-enthalpy formula is reactants minus products; formation formula is the reverse.
- $\Delta S_{\text{surr}} = -\Delta H/T$; check the **total** entropy.
- ΔG sign depends on T only when ΔH and ΔS have the same sign.