CLASS 11 CHEMISTRY — FORMULA SHEET

Chapter 6 : Equilibrium (NCERT)

6.1 Equilibrium Constants (Kc & Kp)

Concept	Formula / Expression
For aA + bB ⇌ cC + dD	$K_c = [C]^c[D]^d \div [A]^a[B]^b$ (concentrations at equilibrium)
K_p (gaseous)	$K_p = (P_C^c \times P_D^d) \div (P_A^a \times P_B^b)$
Relation Kp ↔ Kc	$K_p = K_c (RT)^{\Delta n}$; Δn = (moles gaseous products − moles gaseous reactants)
When Δn = 0	$K_p = K_c$ (equal gas moles on both sides)
Units	K is dimensionless when Δn = 0; otherwise has units
Reaction reversed	K' = 1/K
Reaction × n	$K' = K^n$
Reactions added	$K = K_1 \times K_2$ (multiply individual constants)
Pure solids & liquids	Taken as 1 (excluded from K expression)

6.2 Reaction Quotient & Equilibrium Predictions

Concept	Rule
Reaction quotient (Q)	Same expression as K but with non-equilibrium concentrations
Q < K	Forward reaction proceeds (more products form)
Q > K	Reverse reaction proceeds (more reactants form)
Q = K	System is at equilibrium (no net change)
Magnitude of K	$K > 10^3$ → products dominate ; $K < 10^{-3}$ → reactants dominate ; in between → comparable
Link to Gibbs energy	$\Delta G^\circ = -RT \ln K = -2.303\ RT \log K$; $\Delta G^\circ < 0 \rightarrow K > 1$

6.3 Le Chatelier's Principle

Disturbance	Equilibrium Shift
Add reactant	Shifts FORWARD
Add product	Shifts BACKWARD
Increase pressure (↓ volume)	Shifts toward side with FEWER gas moles
Decrease pressure (↑ volume)	Shifts toward side with MORE gas moles
Increase temperature	Shifts in ENDOTHERMIC direction (K changes)
Decrease temperature	Shifts in EXOTHERMIC direction (K changes)
Add inert gas at constant V	NO shift (partial pressures unchanged)
Add inert gas at constant P	Shifts toward side with MORE gas moles
Add catalyst	NO shift; only reaches equilibrium FASTER (K unchanged)

6.4 Acids & Bases — Concepts

Concept	Definition
Arrhenius	Acid gives H^+ in water ; Base gives OH^- in water
Bronsted–Lowry	Acid = proton (H^+) donor ; Base = proton acceptor
Conjugate pair	Acid − H^+ → conjugate base ; differ by one proton (e.g. HCl/Cl^-)
Lewis	Acid = electron-pair acceptor ; Base = electron-pair donor
Strong vs weak	Strong acids/bases ionise completely; weak ones partially (have K_a/K_b)
Strong acids (memorise)	HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$

6.5 Ionisation of Water, pH Scale

Concept	Formula
Ionic product of water	$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 298 K
pH definition	pH = −log[H^+] ; pOH = −log[OH^-]
pH + pOH	pH + pOH = 14 (at 298 K only)
Neutral / acidic / basic	pH = 7 neutral ; pH < 7 acidic ; pH > 7 basic (at 298 K)
[H^+] from pH	$[H^+] = 10^{-pH}$
pKw	pK_w = pH + pOH = 14

6.6 Weak Acids/Bases — Ostwald's Dilution Law

Concept	Formula
Acid ionisation constant	$K_a = C\alpha^2/(1-\alpha) \approx C\alpha^2$ (when $\alpha << 1$)
Degree of dissociation	$\alpha = \sqrt{(K_a/C)}$
[H^+] of weak acid	$[H^+] = C\alpha = \sqrt{(K_a \times C)}$
[OH^-] of weak base	$[OH^-] = \sqrt{(K_b \times C)}$
pKa, pKb	$pK_a = -\log K_a$; $pK_b = -\log K_b$
Conjugate pair relation	$K_a \times K_b = K_w \rightarrow pK_a + pK_b = 14$
Stronger acid	Larger K_a / smaller pK_a

6.7 Buffers & Salt Hydrolysis

Type	Formula
Acidic buffer (Henderson)	$pH = pK_a + \log([Salt]/[Acid])$
Basic buffer (Henderson)	$pOH = pK_b + \log([Salt]/[Base])$
Salt of weak acid + strong base	Basic solution: $pH = 7 + \frac{1}{2}(pK_a + \log C)$

Type	Formula
Salt of strong acid + weak base	Acidic solution: pH = 7 − ½(pK_b + log C)
Salt of weak acid + weak base	pH = 7 + ½(pK_a − pK_b)
Salt of strong acid + strong base	Neutral (pH = 7), no hydrolysis (e.g. NaCl)

6.8 Solubility Product (Ksp)

Salt Type	Ksp Expression (S = molar solubility)
General A_xB_y	$K_{sp} = (xS)^x(yS)^y = x^x\, y^y\, S^{(x+y)}$
AB type (AgCl, $BaSO_4$)	$K_{sp} = S^2 \rightarrow S = \sqrt{K_{sp}}$
AB_2 or A_2B (CaF_2, Ag_2CrO_4)	$K_{sp} = 4S^3$
AB_3 or A_3B	$K_{sp} = 27S^4$
A_2B_3 (Bi_2S_3)	$K_{sp} = 108S^5$
Precipitation condition	Ionic product (Q) > K_{sp} → precipitate forms ; Q = K_{sp} → saturated ; Q < K_{sp} → unsaturated
Common ion effect	Adding a common ion DECREASES solubility (shifts equilibrium back)

★ QUICK MEMORY AIDS & TRICKS

6 strong acids	HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$ → 'Have Brought In Nice Sulphuric Perchloric'.
Kp = Kc when	Δn = 0 (equal gas moles both sides). Otherwise multiply by $(RT)^{\Delta n}$.
Q vs K	'Q Less → goes Forward, Q More → reverses.' (Q < K forward, Q > K backward)
Ka × Kb = Kw	→ pK_a + pK_b = 14. Stronger acid → weaker conjugate base.
Ksp shortcuts	AB → S^2 ; AB_2/A_2B → $4S^3$; AB_3 → $27S^4$; A_2B_3 → $108S^5$.
Le Chatelier inert gas	Constant V → no shift ; constant P → shifts to MORE moles side.
Salt pH rule	Weak acid salt → basic ; weak base salt → acidic ; both strong → neutral.
Buffer best when	pH = pK_a (equal salt & acid → max buffer capacity).