CLASS 12

Physics & Chemistry — Complete Formula Handbook

Contents

PHYSICS

Electric Charges and Fields

Coulomb's law	$F = kq_1q_2/r^2$, $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/q = kQ/r^2$
Electric field (dipole, axial)	$E = 2kp/r^3$
Electric field (dipole, equatorial)	$E = kp/r^3$
Torque on dipole	$\tau = p \times E = pE \sin\theta$
Gauss's law	$\blacksquare E \cdot dA = Q_{enclosed} / \varepsilon_0$
Field due to infinite sheet	$E = \sigma / 2\varepsilon_0$
Field due to conducting sphere (outside)	$E = kQ/r^2$

Electrostatic Potential and Capacitance

Electric potential	$V = kQ/r$
Potential energy of two charges	$U = kq_1q_2/r$
Relation between E and V	$E = -dV/dr$
Capacitance	$C = Q/V$
Parallel plate capacitor	$C = \varepsilon_0 A/d$
Capacitor with dielectric	$C = K\varepsilon_0 A/d$
Capacitors in series	$1/C = 1/C_1 + 1/C_2 + ...$
Capacitors in parallel	$C = C_1 + C_2 + ...$
Energy stored in capacitor	$U = \frac{1}{2}CV^2 = \frac{1}{2}QV = Q^2/2C$

Current Electricity

Current	$I = Q/t = neAv_d$
Ohm's law	$V = IR$
Resistivity	$R = \rho L/A$
Resistance & temperature	$R_t = R_0(1 + \alpha\Delta T)$
Resistors in series	$R = R_1 + R_2 + ...$
Resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
EMF and terminal voltage	$V = E - Ir$

Electrical power	$P = VI = I^2R = V^2/R$
Kirchhoff's current law	$\Sigma I_{in} = \Sigma I_{out}$
Kirchhoff's voltage law	$\Sigma V = 0$ (around a closed loop)
Wheatstone bridge balance	$P/Q = R/S$
Potentiometer principle	$V \propto l$ (balancing length)

Moving Charges and Magnetism

Force on moving charge	$F = qvB \sin\theta$
Force on current-carrying wire	$F = BIL \sin\theta$
Biot–Savart law	$dB = (\mu_0/4\pi) \times Idl \sin\theta / r^2$
Magnetic field due to straight wire	$B = \mu_0 I / 2\pi r$
Magnetic field at centre of loop	$B = \mu_0 I / 2R$
Magnetic field inside solenoid	$B = \mu_0 nI$
Ampere's circuital law	$\blacksquare B \cdot dl = \mu_0 I_{enclosed}$
Force between two parallel wires	$F/L = \mu_0 I_1 I_2 / 2\pi d$
Torque on current loop	$\tau = NIAB \sin\theta$
Radius of circular path in B field	$r = mv / qB$

Magnetism and Matter

Magnetic dipole moment (bar magnet)	$m = q_m \times 2l$
Magnetic field on axial line	$B = \mu_0 2m / 4\pi r^3$
Magnetic field on equatorial line	$B = \mu_0 m / 4\pi r^3$
Magnetic susceptibility	$\chi = I/H$
Relative permeability	$\mu_r = 1 + \chi$

Electromagnetic Induction

Faraday's law	$e = -d\Phi/dt$
Motional EMF	$e = Blv$
Self-inductance	$e = -L(dI/dt)$
Mutual inductance	$e_2 = -M(dI_1/dt)$

Energy stored in inductor	$U = \frac{1}{2}LI^2$
Lenz's law	Induced current opposes the change in flux that produced it

Alternating Current

RMS value	$I_{rms} = I_0/\sqrt{2}$, $V_{rms} = V_0/\sqrt{2}$
Inductive reactance	$X_L = \omega L = 2\pi fL$
Capacitive reactance	$X_C = 1/\omega C = 1/2\pi fC$
Impedance (RLC series)	$Z = \sqrt{R^2 + (X_L - X_C)^2}$
Resonant frequency	$f_0 = 1 / (2\pi\sqrt{LC})$
Power in AC circuit	$P = V_{rms} I_{rms} \cos\phi$
Quality factor	$Q = \omega_0 L / R$
Transformer equation	$V_s/V_p = N_s/N_p = I_p/I_s$

Electromagnetic Waves

Speed of EM wave	$c = 1/\sqrt{\mu_0\varepsilon_0} = 3 \times 10^8$ m/s
Relation between E0 and B0	$E_0 = cB_0$

Ray Optics and Optical Instruments

Mirror formula	$1/v + 1/u = 1/f$
Lens formula	$1/v - 1/u = 1/f$
Lens maker's formula	$1/f = (n-1)(1/R_1 - 1/R_2)$
Magnification (mirror/lens)	$m = -v/u = h'/h$
Power of lens	$P = 1/f$ (metres); Unit: Dioptre
Power of lens combination	$P = P_1 + P_2 + \ldots$
Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
Critical angle	$\sin C = 1/n$
Prism formula	$n = \sin((A+\delta m)/2) / \sin(A/2)$
Simple microscope magnification	$m = 1 + D/f$
Compound microscope magnification	$m = (L/f_0) \times (D/f_e)$
Astronomical telescope magnification	$m = f_0/f_e$

Wave Optics

Young's double slit — fringe width	**$\beta = \lambda D/d$**
Path difference (constructive)	**$\Delta = n\lambda$**
Path difference (destructive)	**$\Delta = (n + ½)\lambda$**
Resolving power of microscope	**RP = 2n sin θ / λ**
Brewster's law	**tan θB = n**

Dual Nature of Radiation and Matter

Photon energy	**$E = h\nu = hc/\lambda$**
Einstein's photoelectric equation	**$KEmax = h\nu - \phi 0$**
Work function	**$\phi 0 = h\nu 0$**
Stopping potential	**eV0 = KEmax**
de Broglie wavelength	**$\lambda = h/p = h/mv$**

Atoms

Bohr's radius	**$rn = n^2h^2\varepsilon 0 / \pi mZe^2$ (= 0.529 n^2/Z Å)**
Energy of electron (Bohr model)	**$En = -13.6\ Z^2/n^2$ eV**
Rydberg formula	**$1/\lambda = R(1/n1^2 - 1/n2^2)$**

Nuclei

Nuclear radius	**R = R0A^(1/3)**
Mass–energy equivalence	**$E = mc^2$**
Binding energy	**$BE = \Delta m \times c^2$**
Radioactive decay law	**$N = N0e^{(-\lambda t)}$**
Half life	**$T½ = 0.693/\lambda$**
Mean life	**$\tau = 1/\lambda$**
Activity	**$A = \lambda N$**

Semiconductor Electronics

Diode current equation	**I = I0(e^(eV/kT) – 1)**
Transistor current relation	**IE = IB + IC**
Current gain (common emitter)	**β = IC/IB**

Current gain (common base)	α **= IC/IE**
Relation between α **and** β	$\beta = \alpha/(1-\alpha)$

CHEMISTRY

Solutions

Molarity	M = moles of solute / Volume of solution (L)
Molality	m = moles of solute / mass of solvent (kg)
Mole fraction	x_A = n_A/(n_A+n_B)
Raoult's law	P = P0 × x_solvent
Relative lowering of vapour pressure	(P0–P)/P0 = x_solute
Elevation in boiling point	ΔTb = Kb × m
Depression in freezing point	ΔTf = Kf × m
Osmotic pressure	π = CRT
Van't Hoff factor	i = (normal molar mass)/(observed molar mass)
Modified colligative property (with i)	ΔTb = i·Kb·m, π = iCRT

Electrochemistry

Nernst equation	E = E° – (RT/nF) ln Q
Nernst equation (25°C, log form)	E = E° – (0.0591/n) log Q
Relation between ΔG° and E°	ΔG° = –nFE°
Equilibrium constant from E°	log K = nE°/0.0591
Faraday's first law	m = ZIt
Molar conductivity	Λm = κ × 1000 / C
Kohlrausch's law	Λm° = λ°(cation) + λ°(anion)

Chemical Kinetics

Rate of reaction	Rate = –Δ[R]/Δt = Δ[P]/Δt
Rate law	Rate = k[A]^m[B]^n
Zero order integrated rate law	[A] = [A]0 – kt
First order integrated rate law	k = (2.303/t) log([A]0/[A])
Half-life (first order)	t1/2 = 0.693/k
Half-life (zero order)	t1/2 = [A]0 / 2k
Arrhenius equation	k = A e^(–Ea/RT)

Arrhenius equation (log form)	log(k2/k1) = Ea/2.303R × (1/T1 − 1/T2)

Surface Chemistry

Freundlich adsorption isotherm	x/m = kP^(1/n)

p-Block Elements

Oxidation states (Group 15)	−3, +3, +5 (common)
Oxidation states (Group 16)	−2, +2, +4, +6
Oxidation states (Group 17, halogens)	−1, +1, +3, +5, +7
Interhalogen general formula	XX'n (n = 1, 3, 5, 7)

d and f Block Elements

General electronic configuration (d-block)	(n−1)d^1–10 ns^0–2
General electronic configuration (f-block)	(n−2)f^1–14 (n−1)d^0–1 ns²
Magnetic moment (spin only)	μ = √(n(n+2)) BM

Coordination Compounds

Werner's coordination number	Number of ligand donor atoms bonded directly to central metal
EAN (Effective Atomic Number)	EAN = Z − (oxidation state) + 2 × (coordination number)
Crystal field splitting (octahedral)	Δo splits d-orbitals into t2g (lower) and eg (higher)

Haloalkanes and Haloarenes

SN1 reaction	Two-step mechanism via carbocation intermediate; rate = k[R–X]
SN2 reaction	One-step, backside attack, inversion of configuration; rate = k[R–X][Nu−]

Alcohols, Phenols and Ethers

Lucas test order of reactivity	3° alcohol > 2° alcohol > 1° alcohol
Williamson ether synthesis	R–X + R'ONa → R–O–R' + NaX

Aldehydes, Ketones and Carboxylic Acids

Aldol condensation	**2 CH3CHO --(dil. NaOH)--> CH3CH(OH)CH2CHO**
Cannizzaro reaction	**2 HCHO --(conc. NaOH)--> CH3OH + HCOONa**
Haloform reaction (iodoform test)	**CH3COR + I2/NaOH → CHI3 (yellow ppt) + RCOONa**

Amines

Basicity order (gas phase vs aqueous)	**In aqueous solution (alkyl amines): 2° > 1° > 3° (for methyl amines, varies by solvation)**
Diazotisation reaction	**ArNH2 + NaNO2 + 2HCl --(0–5°C)--> ArN2+Cl– + NaCl + 2H2O**

Biomolecules

Peptide bond formation	**Amino acid + Amino acid --(–H2O)--> Dipeptide (peptide bond: –CO–NH–)**
Glycosidic bond	**Bond linking two monosaccharide units (e.g., in sucrose, starch)**