CLASS 11

Physics & Chemistry — Complete Formula Handbook

Contents

PHYSICS

Units and Measurements

Dimensional formula	[Quantity] = [M^a L^b T^c]
Relative error	$\Delta a / a$
Percentage error	$(\Delta a / a) \times 100\%$
Error in sum/difference	$\Delta(a \pm b) = \Delta a + \Delta b$
Error in product/quotient	$\Delta z/z = \Delta a/a + \Delta b/b$

Motion in a Straight Line

Average velocity	$v_{avg} = \Delta x / \Delta t$
Instantaneous velocity	$v = dx/dt$
Instantaneous acceleration	$a = dv/dt$
1st equation of motion	$v = u + at$
2nd equation of motion	$s = ut + \frac{1}{2}at^2$
3rd equation of motion	$v^2 = u^2 + 2as$
Distance in nth second	$sn = u + a(2n - 1)/2$

Motion in a Plane

Resultant of two vectors	$R = \sqrt{(A^2 + B^2 + 2AB \cos \theta)}$
Direction of resultant	$\tan \alpha = B \sin \theta / (A + B \cos \theta)$
Horizontal range (projectile)	$R = u^2 \sin 2\theta / g$
Maximum height (projectile)	$H = u^2 \sin^2 \theta / 2g$
Time of flight (projectile)	$T = 2u \sin \theta / g$
Centripetal acceleration	$a = v^2 / r = \omega^2 r$
Angular velocity	$\omega = v / r = 2\pi / T$

Laws of Motion

Newton's second law	$F = dp/dt = ma$
Momentum	$p = mv$
Impulse	$J = F\Delta t = \Delta p$
Friction (limiting)	$f = \mu N$
Centripetal force	$F = mv^2/r$

Max speed on banked road	$v = \sqrt{(rg(\mu+\tan\theta)/(1-\mu\tan\theta))}$

Work, Energy and Power

Work done	$W = F \cdot s \cos\theta$
Kinetic energy	$KE = \frac{1}{2}mv^2$
Work–energy theorem	$W = \Delta KE$
Gravitational PE	$U = mgh$
Spring PE	$U = \frac{1}{2}kx^2$
Power	$P = W/t = F \cdot v$
Elastic collision (1D) velocities	$v1 = ((m1-m2)u1 + 2m2u2)/(m1+m2)$
Coefficient of restitution	$e = (v2-v1)/(u1-u2)$

System of Particles and Rotational Motion

Centre of mass	$X_{cm} = \Sigma mixi / \Sigma mi$
Torque	$\tau = r \times F = rF \sin\theta$
Angular momentum	$L = r \times p = I\omega$
Moment of inertia	$I = \Sigma miri^2$
Moment of inertia (rod, center)	$I = ML^2/12$
Moment of inertia (disc)	$I = MR^2/2$
Moment of inertia (sphere, solid)	$I = 2MR^2/5$
Torque–angular acceleration	$\tau = I\alpha$
Rotational KE	$KE = \frac{1}{2}I\omega^2$
Conservation of angular momentum	$I1\omega1 = I2\omega2$

Gravitation

Newton's law of gravitation	$F = Gm1m2/r^2$
Gravitational field/acceleration	$g = GM/R^2$
g at height h	$g_h = g(1 - 2h/R)$ [h << R]
g at depth d	$g_d = g(1 - d/R)$
Gravitational PE	$U = -GMm/r$
Escape velocity	$v_e = \sqrt{(2GM/R)}$

Orbital velocity	**$v_o = \sqrt{(GM/r)}$**
Kepler's third law	**$T^2 \propto r^3$**

Mechanical Properties of Solids

Stress	**Stress = Force / Area**
Strain	**Strain = $\Delta L / L$**
Young's modulus	**Y = Stress / Strain = $FL / (A\Delta L)$**
Bulk modulus	**$K = -\Delta P / (\Delta V/V)$**
Shear modulus (modulus of rigidity)	**η = Shear stress / Shear strain**

Mechanical Properties of Fluids

Pressure	**$P = F/A$**
Pressure due to fluid column	**$P = h\rho g$**
Pascal's law	**Pressure applied is transmitted equally in all directions**
Archimedes' principle	**Buoyant force = $\rho_{fluid} \times V_{displaced} \times g$**
Equation of continuity	**$A1v1 = A2v2$**
Bernoulli's equation	**$P + \frac{1}{2}\rho v^2 + \rho gh$ = constant**
Stokes' law	**$F = 6\pi\eta rv$**
Terminal velocity	**$v_t = 2r^2(\rho - \sigma)g / 9\eta$**
Surface tension	**$T = F / L$**

Thermal Properties of Matter

Temperature scale conversion	**$C/5 = (F-32)/9 = (K-273)/5$**
Linear expansion	**$L = L0(1 + \alpha\Delta T)$**
Area expansion	**$A = A0(1 + \beta\Delta T)$, $\beta = 2\alpha$**
Volume expansion	**$V = V0(1 + \gamma\Delta T)$, $\gamma = 3\alpha$**
Heat and specific heat	**$Q = mc\Delta T$**
Latent heat	**$Q = mL$**
Stefan–Boltzmann law	**$E = \sigma T$■**
Wien's displacement law	**λmT = constant**
Newton's law of cooling	**$-dT/dt = k(T - T0)$**

Thermodynamics

First law of thermodynamics	$\Delta Q = \Delta U + \Delta W$
Work done by gas	$W = \int P\, dV$
Work (isobaric)	$W = P\Delta V$
Efficiency of heat engine	$\eta = 1 - Q2/Q1 = W/Q1$
Carnot engine efficiency	$\eta = 1 - T2/T1$
Coefficient of performance (refrigerator)	$COP = Q2 / W$

Kinetic Theory of Gases

Ideal gas equation	$PV = nRT$
Pressure of gas (kinetic theory)	$P = (1/3)\rho \blacksquare v^2 \blacksquare$
RMS speed	$v\_rms = \sqrt{(3RT/M)} = \sqrt{(3kT/m)}$
Average KE per molecule	$KE = (3/2)kT$
Degrees of freedom & energy	Energy per DOF = (1/2)kT

Oscillations

SHM displacement	$x = A \sin(\omega t + \phi)$
Angular frequency	$\omega = 2\pi/T = 2\pi f$
SHM velocity	$v = \omega\sqrt{(A^2 - x^2)}$
SHM acceleration	$a = -\omega^2 x$
Time period (spring–mass)	$T = 2\pi\sqrt{(m/k)}$
Time period (simple pendulum)	$T = 2\pi\sqrt{(L/g)}$
Total energy in SHM	$E = \frac{1}{2}m\omega^2A^2$

Waves

Wave speed	$v = f\lambda$
Speed of transverse wave on string	$v = \sqrt{(T/\mu)}$
Speed of sound in a medium	$v = \sqrt{(E/\rho)}$
Beat frequency	$f\_beat = \|f1 - f2\|$
Doppler effect (general)	$f' = f\ (v \pm vo)/(v \blacksquare vs)$
Fundamental frequency (string, both ends fixed)	$f = v/2L$

Fundamental frequency (closed pipe)	**f = v/4L**
Fundamental frequency (open pipe)	**f = v/2L**

CHEMISTRY

Some Basic Concepts of Chemistry

Mole concept	n = Given mass / Molar mass
Avogadro's number	$N_A = 6.022 \times 10^{23}$ /mol
Molarity	M = moles of solute / Volume of solution (L)
Molality	m = moles of solute / mass of solvent (kg)
Mole fraction	$x_A = n_A / (n_A + n_B)$
Mass percentage	% = (mass of solute / mass of solution) × 100
Percentage yield	% yield = (actual yield / theoretical yield) × 100
Empirical formula mass relation	Molecular formula = n × Empirical formula (n = M/Empirical formula mass)
Normality	N = M × n-factor

Structure of Atom

Energy of photon	$E = h\nu = hc/\lambda$
Bohr's radius	$r_n = 0.529 \times n^2/Z$ Å
Bohr's energy	$E_n = -13.6\ Z^2/n^2$ eV
Rydberg equation	$1/\lambda = RZ^2(1/n1^2 - 1/n2^2)$
de Broglie wavelength	$\lambda = h/mv = h/p$
Heisenberg uncertainty principle	$\Delta x \cdot \Delta p \geq h/4\pi$
Number of subshells / orbitals	Subshells = n; Orbitals in subshell = 2l+1
Max electrons in shell	$2n^2$
Aufbau/Pauli/Hund's rules	Filling order by (n+l); no 2 e■ same 4 quantum numbers; max multiplicity in degenerate orbitals

Classification of Elements and Periodicity

Effective nuclear charge trend	Increases across a period
Atomic radius trend	Decreases across period, increases down group
Ionization enthalpy trend	Increases across period, decreases down group
Electron gain enthalpy trend	Generally becomes more negative across a period

Chemical Bonding and Molecular Structure

Octet rule	Atoms tend to have 8 electrons in valence shell for stability
Formal charge	FC = (Valence e■) – (Non-bonding e■) – ½(Bonding e■)
Dipole moment	μ = q × d
Bond order (MOT)	Bond order = ½(Nb – Na)
VSEPR shapes	AB2: linear, AB3: trigonal planar, AB4: tetrahedral, AB5: trigonal bipyramidal, AB6: octahedral
Hybridisation types	sp (linear), sp^2 (trigonal planar), sp^3 (tetrahedral), sp^3d, sp^3d^2

States of Matter (Gases and Liquids)

Boyle's law	PV = constant (at const T)
Charles's law	V/T = constant (at const P)
Gay-Lussac's law	P/T = constant (at const V)
Ideal gas equation	PV = nRT
Combined gas law	P1V1/T1 = P2V2/T2
Dalton's law of partial pressure	P_total = P1 + P2 + P3 + ...
Graham's law of diffusion	r1/r2 = √(M2/M1)
Van der Waals equation	$(P + an^2/V^2)(V – nb) = nRT$
RMS speed of gas	u_rms = √(3RT/M)

Thermodynamics

First law of thermodynamics	ΔU = q + w
Enthalpy	H = U + PV
Enthalpy change (const. pressure)	ΔH = ΔU + ΔnRT
Hess's law	ΔH(reaction) = ΣΔH(products) – ΣΔH(reactants)
Gibbs free energy	ΔG = ΔH – TΔS
Spontaneity condition	ΔG < 0 (spontaneous)
Entropy change	ΔS = q_rev / T

Equilibrium

Law of mass action / Kc	Kc = [C]^c[D]^d / [A]^a[B]^b
Relation between Kp and Kc	Kp = Kc(RT)^Δn
Ionic product of water	Kw = [H+][OH–] = 10^{-14} (at 25°C)

pH	pH = –log[H+]
pOH	pOH = –log[OH–]
pH + pOH	pH + pOH = 14
Henderson–Hasselbalch equation	pH = pKa + log([salt]/[acid])
Ka and pKa	pKa = –log Ka
Solubility product	Ksp = [A+]^m[B–]^n

Redox Reactions

Oxidation number rules	Free element = 0; monoatomic ion = its charge; O = –2 (usually), H = +1 (usually)
Oxidation	Loss of electrons / increase in oxidation number
Reduction	Gain of electrons / decrease in oxidation number

Organic Chemistry — Basic Principles

General formula (alkanes)	CnH2n+2
General formula (alkenes)	CnH2n
General formula (alkynes)	CnH2n–2
Degree of unsaturation	DoU = (2C + 2 + N – H)/2
Inductive/resonance/hyperconjugation	Electronic effects influencing molecule stability and reactivity

Hydrocarbons

Combustion of alkane	CnH2n+2 + O2 → CO2 + H2O
Markovnikov's rule	H adds to carbon with more H atoms in HX addition to alkenes
Wurtz reaction	2R–X + 2Na --(dry ether)--> R–R + 2NaX