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Most Important Chemistry Formulas for JEE Main

Most Important Physical Chemistry Formulas For JEE Main

Chapter – Some Basic Concepts in Chemistry

1. $$\text{Number of Moles} : n = \frac{w}{M}$$
2. $$\text{Molarity} : M = \frac{\text{moles of solute}}{\text{volume (L)}}$$
3. $$\text{Molality} : m = \frac{\text{moles of solute}}{\text{kg of solvent}}$$
4. $$\text{Mole fraction} : X_A = \frac{n_A}{n_A + n_B}$$
5. $$\text{Density relation} : \text{Density} = \frac{M}{V_m}$$
6. $$\text{Gas volume at STP} : 1 \text{ mol gas} = 22.4 \text{ L}$$

Chapter – Atomic Structure

1. Bohr's model of the hydrogen atom:

- Radius of nth orbit : $r_n = \frac{n^2h^2}{4\pi^2me^2} \cdot \frac{1}{Z} = \frac{n^2a_0}{Z}, a_0 = 0.529 \text{ \AA}$

- Velocity of electron in nth orbit: $v_n = 2.18 \times 10^6 \frac{Z}{n} \text{ m/s}$

- Energy of nth orbit (Hydrogen-like atom): $E_n = -\frac{13.6\, Z^2}{n^2} \text{ eV}$

- Energy difference between levels (photon emitted/observed): $\Delta E = E_i - E_f = h\nu$

2. Rydberg formula (spectral lines): $\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right), \quad n_2 > n_1 \; R_H = 1.097 \times 10^7 \text{ m}^{-1}$

3. De broglie wavelength: $\lambda = \frac{h}{mv}, \lambda = \frac{h}{\sqrt{2mE}}$

4. Heisenberg uncertainty principle: $\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$

5. Energy of electron in terms of wavenumber: $E = -\frac{R_H hc}{n^2}$

6. Effective nuclear charge (Slater's rule approximation): $Z_{\text{eff}} = Z - S$ S = shielding constant

7. Quantum numbers:

   - Principal (n): energy level
   - Azimuthal (l): $0 \rightarrow$ s, $1 \rightarrow$ p, $2 \rightarrow$ d, $3 \rightarrow$ f
   - Magnetic (m_l) : $m_l = -l$ to $+l$
   - Spin (m_s) : $m_s = +\frac{1}{2}, -\frac{1}{2}$

8. Ionisation energy (Hydrogen atom): $E_{\text{ion}} = 13.6 \text{ eV}$

9. Velocity of electron (Bohr's model): $v_n = \frac{2.18 \times 10^6 \, Z}{n} \text{ m s}^{-1}$

Chapter – Chemical Bonding and Molecular Structure

1. Bond Order (Molecular Orbital Theory) : Bond Order $= \frac{1}{2}$(Number of bonding electrons-

2. Dipole Moment: μ=d

where,

μ = dipole moment

q = charge

d = distance between charges, Unit: Debye (D)

3. $$\text{Percentage ionic character:\% Ionic Character} = \frac{\mu_{\text{observed}}}{\mu_{\text{theoretical}}} \times 100$$

4. $$\text{Formal Charge : Formal Charge (FC)} = V - N - \frac{B}{2}$$

where: V = valence electrons

N = non-bonded electrons

B = bonded electrons

(Used heavily in resonance & structure stability questions.)

5. $$\text{Lattice Enthalpy (Born–Landé Equation)} : U = \frac{N_A A Z^+ Z^- e^2}{4\pi\varepsilon_0 r_0}\left(1 - \frac{1}{n}\right)$$

where N_A = Avogadro's number , A = Madelung constant , $Z^{\pm}$ = ionic charges , r_0 = neare

6. Steric Number (Hybridisation Formula): Steric number = σ-bonds + lone pairs

Steric No.	Hybridisation	Shape
2	sp	Linear
3	sp^2	Trigonal planar
4	sp^3	Tetrahedral
5	sp^3d	Trigonal bipyramidal
6	sp^3d^2	Octahedral

7. Relation Between Bond Length and Bond Order : Higher Bond Order $\Longrightarrow$ Shorter bond le

(Higher BO $\rightarrow$ shorter and stronger bond)

8. Electronegativity Difference & Type of Bond :
$$\begin{aligned} &\Delta\chi < 0.4 \Rightarrow \text{Covalent} \\ 0.4 < &\Delta\chi < 1.7 \Rightarrow \text{Polar covalent} \\ &\Delta\chi > 1.7 \Rightarrow \text{Ionic} \end{aligned}$$

9. Radius relation in ionic solids : $r_+ + r_- = r_0$

(where r_0 is the interionic distance used in lattice energy formulas)

Used with Born–Landé equation.

10. Resonance Energy Concept (Indirect Formula Use) : Resonance Energy $= E_{\text{actual}} - E_{\text{most st}}$

(Used in conceptual stability comparison.)

11. VSEPR Lone Pair–Bond Pair Repulsion Order: LP–LP $>$ LP–BP $>$ BP–BP

(Used for shape prediction & bond angle distortion.)

12. Relation Between Dipole Moment & Geometry : $\vec{\mu}_{\text{net}} = \sum_i \vec{\mu}_i$

Chapter – Chemical Thermodynamics

1. First Law of thermodynamics : $\Delta U = q + w$
2. Enthalpy Change : $\Delta H = \Delta U + \Delta n_g RT$
3. Gibbs Free Energy : $\Delta G = \Delta H - T\Delta S$
4. Gibbs Free Energy at equilibrium : $\Delta G^\circ = -RT \ln K$
5. Heat at constant pressure : $q_p = nC_p\Delta T$
6. Relation between C_p and C_v : $C_p - C_v = R$

Chapter – Solutions

1. Raoult's Law : $P_A = X_A P_A^0$
2. Elevation in boiling point : $\Delta T_b = K_b m$
3. Depression in freezing point : $\Delta T_f = K_f m$
4. Van't Hoff factor : $i = \dfrac{\text{observed value}}{\text{calculated value}}$
5. Osmotic Pressure : $\pi = CRT$

Chapter – Chemical Equilibrium

1. Law of Mass Action : $K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$
2. Relation between K_p and K_c : $K_p = K_c(RT)^{\Delta n}$
3. Degree of dissociation : $\alpha = \frac{\text{moles dissociated}}{\text{initial moles}}$
4. Relation with equilibrium constant (weak electrolyte) : $K = \frac{\alpha^2 C}{1-\alpha}$

Chapter – Ionic Equilibrium

1. pH definition: $pH = -\log[H^+]$
2. pOH: $pOH = -\log[OH^-]$
3. Relationship between pH and pOH: $pH + pOH = 14$
4. Ionic Product of Water: $K_w = [H^+][OH^-]$
5. Henderson–Hasselbalch Equation: $pH = pK_a + \log\frac{\text{salt}}{\text{acid}}$

Chapter – Redox Reactions and Electrochemistry

1. Nernst equation: $E = E^\circ - \frac{0.0591}{n}\log Q$
2. Faraday's first law of electrolysis: $m = ZIt$
3. Faraday's second of electrolysis: $\frac{m_1}{m_2} = \frac{E_1}{E_2}$
4. Gibb's free energy relation: $\Delta G = -nFE$
5. Kohlrausch law of independent migration of ions: $\Lambda_m^\circ = \nu_+\lambda_+^\circ + \nu_-\lambda_-^\circ$

Chapter – Chemical Kinetics

1. $$\text{Rate Law: Rate} = k[A]^n$$

2. $$\text{First Order Rate Constant: } k = \frac{2.303}{t}\log\frac{[A]_0}{[A]}$$

3. $$\text{Half-life for First Order Reaction: } t_{1/2} = \frac{0.693}{k}$$

4. $$\text{Arrhenius Equation: } k = Ae^{-\frac{E_a}{RT}}$$

5. $$\text{Log form of Arrhenius: } \log k = \log A - \frac{E_a}{2.303RT}$$

Most Important Organic Chemistry Formulas For JEE Main

Chapter – Purification and Characterisation of Organic Compounds

- $$\text{Percentage of Element: } \%\,\text{Element} = \frac{\text{Mass of element}}{\text{Molar mass}} \times 100$$
- $$\text{Empirical formula: Empirical Mass} = \sum(\text{atomic masses})$$
- $$\text{Molecular mass: Molecular Mass} = \text{n} \times \text{Empirical Mass}$$
- $$\text{Vapour density relation: M} = 2 \times \text{V.D.}$$

Key Reactions / Tests

Lassaigne's Test (Detection):

Element	Reagent	Observation
N	$FeSO_4$ + HCl	Prussian Blue
S	Lead Acetate	Black ppt
Halogen	$AgNO_3$	White/Yellow ppt

Chapter – Some Basic Principles of Organic Chemistry (GOC)

- Inductive Effect: $+I, -I+I, -I+I, -I : Order : -NO2 > -CN > -COOH > -F > -$
- Hyperconjugation: Stability $\propto$ No. of α-Hydrogens
- Index of Hydrogen Deficiency (IHD): IHD $= \frac{2C+2+N-H-X}{2}$

Key Reactions:

- Heterolytic bond fission:

Definition: A covalent bond breaks unequally, then ions form.

Reaction: $CH3 - Cl- > CH3^{+} + Cl^{-}$

Use: SN1, E1 reactions

- Homolytic bond fission:

Definition: Covalent bond breaks equally $\rightarrow$ free radicals form.

Reaction: $Cl2- > [h\nu]2Cl\cdot$

Use: Free radical substitution.

- Formation of carbocation: $\mathrm{HC \equiv CH + OH^{-} \longrightarrow HC \equiv C^{-} + H_2O}$
- Carbanion stability: Stability: $CH_3^{-} > 1^{\circ} > 2^{\circ} > 3^{\circ}$
- Formation of free radical: $CH_3 - CH_3 \overset{h\nu}{\longrightarrow} CH_3 \cdot + CH_3 \cdot$
- Free radical stability: Stability: $3^{\circ} > 2^{\circ} > 1^{\circ}$

Must-Know Stability Orders:

- Carbocation: $3^{\circ} > 2^{\circ} > 1^{\circ} > CH_3^{+}$
- Carbanion: $CH_3^{-} > 1^{\circ} > 2^{\circ} > 3^{\circ}$
- Free Radical: $3^{\circ} > 2^{\circ} > 1^{\circ}$

Chapter – Hydrocarbons

Most Important Reactions-

- Wurtz Reaction (Alkane Formation): $2R\text{–}X + 2Na \xrightarrow{\text{dry ether}} R\text{–}R + 2NaX$ (Mechanism:
- $R\text{–}CH = CHR' \xrightarrow{O_3} RCHO + R'CHO$ (Via ozonide formatio… and
- Friedel–Crafts Alkylation & Acylation: $C_6H_6 + RCl \xrightarrow{AlCl_3} C_6H_5R + HCl$ (Mechanism: E
- Baeyer's Test: Alkene $+ KMnO_4 \longrightarrow$ Vicinal Diol

Chapter – Organic Compounds Containing Halogens

- Finkelstein Reaction: $R\text{–}Cl + NaI \xrightarrow{\text{acetone}} R\text{–}I + NaCl$ (Mechanism: S_N2)
- Swarts Reaction: $R\text{–}Cl + AgF \longrightarrow R\text{–}F + AgCl$
- Dow's Process – Mechanism: Nucleophilic Aromatic Substitution: $C_6H_5Cl \xrightarrow[623\ K]{NaOH} C_6H_5OH$

  (Mechanism: Nucleophilic Aromatic Substitution)
- Sandmeyer Reaction: $ArN_2^+Cl^- + CuCl \longrightarrow ArCl + N_2$

Chapter – Organic Compounds Containing Oxygen

- Lucas Test : $R\text{–}OH + HCl \xrightarrow{ZnCl_2} R\text{–}Cl$
- Williamson Ether Synthesis (SN2): $R\text{–}O^-Na^+ + R'X \longrightarrow R\text{–}O\text{–}R' + NaX$ (Mechanism
- Aldol Condensation: $2CH_3CHO \xrightarrow{NaOH} CH_3CH(OH)CH_2CHO$
- Cannizzaro Reaction: $2HCHO + NaOH \longrightarrow HCOONa + CH_3OH$
- Clemmensen Reduction: $RCOR' \xrightarrow{Zn/Hg,\ HCl} RCH_2R'$
- Wolff–Kishner Reduction: $RCOR' \xrightarrow{NH_2NH_2,\ KOH} RCH_2R'$
- HVZ Reaction: $RCH_2COOH + Br_2 + P \longrightarrow RCHBrCOOH$
- Esterification: $RCOOH + ROH \xrightarrow{H_2SO_4} RCOOR + H_2O$

Chapter – Organic Compounds Containing Nitrogen

- Hoffmann Bromamide Reaction: $RCONH_2 + Br_2 + 4KOH \longrightarrow RNH_2 + K_2CO_3 + 2KB$
- Carbylamine Test: $RNH_2 + CHCl_3 + 3KOH \longrightarrow RNC + 3KCl + 3H_2O$
- Diazotization: $\text{Aniline} + NaNO_2 + HCl \longrightarrow ArN_2^+Cl^- + 2H_2O$
- Coupling Reaction: $ArN_2^+ + \text{Phenol} \longrightarrow \text{Azo Dye}$

Chapter – Biomolecules

- Peptide Bond Formation: $\text{Amino Acid} + \text{Amino Acid} \longrightarrow \text{Dipeptide} + H_2O$
- Glucose Open Chain: $CHO\text{–}(CHOH)_4\text{–}CH_2OH$
- Sucrose Hydrolysis: $\text{Sucrose} + H_2O \longrightarrow \text{Glucose} + \text{Fructose}$

Chapter – Principles Related to Practical Chemistry

Test	Observation
Tollens	Silver mirror
Fehling	Brick-red ppt
Lucas	Cloudiness
Bromine water	Decolourization
Baeyer	Purple – colourless
Carbylamine	Foul smell

Most Important Inorganic Chemistry Formulas For JEE Main

Chapter – Classification Of Elements And Periodicity In Properties

- Effective nuclear charge (Z_eff):

Where Z = atomic number, S = shielding constant

- Ionisation Energy (IE) Relation:

Higher $Z_{eff} \rightarrow$ higher ionisation energy

- Electronegativity (Pauling scale approximate relation) : $\Delta\chi = 0.208\sqrt{E_{AB} - \frac{E_{AA} + E_{BB}}{2}}$

Where:

$$\Delta\chi = |\chi_A - \chi_B|$$

E_{AB} = bond energy of A–B

E_{AA}, E_{BB} = bond energies of A–A and B–B

Important Concepts / Reactions:

- Alkali metals reacting with water: $2M + 2H_2O \longrightarrow 2MOH + H_2 \uparrow$
- (M = Li, Na, K, Rb, Cs)
- Halogen displacement reactions: $X_2 + 2Y^- \longrightarrow 2X^- + Y_2$
- (More reactive halogen displaces less reactive halogen)

Chapter – p-Block Elements

Group 13 (Boron Family):

- Bond energy trend: B–B > B–Al > Al–Al
- Lewis acidity of BX_3 : $BF_3 < BCl_3 < BBr_3 < BI_3$
- Hydrolysis of Boron halides: $BCl_3 + 3H_2O \longrightarrow B(OH)_3 + 3HCl$

Group 14 (Carbon Family):

- Oxidation states: +2 and +4, the stability of +2 increases down the group
- Important reaction: $CO + H_2 \rightarrow CH_4$ (Fischer-Tropsch reaction)

Group 15 (Nitrogen Family)

- Oxidation states: -3 to +5
- Important reactions: % Formation of Ammonium Chloride

$$NH_3 + HCl \longrightarrow NH_4Cl$$

% Haber Process for Ammonia Synthesis

$$N_2 + 3H_2 \xrightarrow[500\ ^\circ C]{\text{Fe catalyst}} 2NH_3$$

Group 16 (Oxygen Family)

- Oxidation states: $-2 to +6$
- Ozone formation: % Ozone Formation $3O_2 \xrightarrow{UV} 2O_3$
- Oxidation reactions: $H_2S + Cl_2 \longrightarrow S + 2HCl$

Group 17 (Halogens)

- Displacement reactions: $X_2 + Y^- \rightarrow Y_2 + X^-$
- Interhalogen formation: ClF_3, BrF_5

Group 18 (Noble Gases)

- Oxidation reaction: $Xe + F_2 \rightarrow XeF_2$
- Important compounds: XeF_2, XeF_4, XeF_6

Chapter – d- Block Elements

Key Formulas & Concepts:

1. Electronic configuration: $(n-1)d^{1-10}\ ns^{1-2}$
2. Coordination number & geometry:
   - $CN = 4 \rightarrow$ tetrahedral/square planar
   - $CN = 6 \rightarrow$ octahedral

Important Reactions:

- Formation of complexes: $[Fe(H_2O)_6]^{3+} + SCN^- \longrightarrow [Fe(H_2O)_5(SCN)]^{2+} + H_2O$
- Redox reactions: $Fe^{2+} \longrightarrow Fe^{3+} + e^-$
- Ligand substitution: $[Cu(NH_3)_4]^{2+} + 4Cl^- \longrightarrow [CuCl_4]^{2-} + 4NH_3$

Stability of complexes (CFSE concept):

- Δ_oct= crystal field splitting energy in octahedral complexes
- High-spin vs low-spin determination

Chapter – f- Block Elements

Important Concepts:

- Lanthanide contraction → affects ionic radius, density, and chemistry of subsequent elemer
- Oxidation state: +3 mostly
- Actinides → show +3, +4, +5, +6 depending on element

Key Reactions:

- Reduction of Lathanides: $\mathrm{Ln}^{3+} + e^- \longrightarrow \mathrm{Ln}^{2+}$ (for some Ln)
- Complex formation with water: $\mathrm{Ln}^{3+} + 6H_2O \longrightarrow [\mathrm{Ln}(H_2O)_6]^{3+}$

Chapter – Coordination Compounds

- Oxidation number of metal: Ox. no. of M-charge on complex−charge on ligands
- Substitution reaction: $[Co(NH_3)_6]^{3+} + Cl^- \longrightarrow [Co(NH_3)_5Cl]^{2+} + NH_3$
- Chelation with EDTA: $[Ni(H_2O)_6]^{2+} + EDTA^{4-} \longrightarrow [Ni(EDTA)]^{2-} + 6H_2O$
- Formation constant: $K_f = \dfrac{[ML_n]}{[M][L]^n}$
- Crystal field splitting (Octahedral): Δ_{oct} (Determines color and magnetic properties of th