SUBJECT
Chemistry

MODULE
Organic Reactions, Inorganic Exceptions & Physical Formulas

WEIGHTAGE
180 Marks Matrix

CURRICULUM
NCERT Rationalized

NEET 2027 Chemistry Reaction & Formula Matrix

Prepared by NEETnova Academic Council & Kota Senior Faculty Panel * 100% Aligned with Official NTA & NMC Guidelines

1. EXECUTIVE OVERVIEW & STRATEGIC FOUNDATION

This master matrix connects all essential components of NEET Chemistry: named organic reactions, vital reagents, inorganic NCERT periodic exceptions, coordination compounds, and physical chemistry numerical formulas. Structured for rapid revision, it protects students from tricky distractors and calculation errors in the 45 chemistry questions.

2. NCERT LINE-BY-LINE COMPREHENSIVE STUDY MODULE

3.1 High-Yield Named Organic Reactions

Named reactions appear repeatedly in NEET. Aldol Condensation: requires alpha-hydrogen, forms beta-hydroxy aldehydes. Cannizzaro Reaction: aldehydes lacking alpha-hydrogen (HCHO, PhCHO) undergo disproportionation in conc. NaOH to alcohol + carboxylate salt. Reimer-Tiemann Reaction: Phenol + $CHCl_3$ + aq. NaOH yields Salicylaldehyde (ortho-formyl phenol). Kolbe Reaction: Sodium phenoxide + CO_2 (high pressure) + H^+ yields Salicylic acid (Aspirin precursor). Hofmann Bromamide Degradation: Primary amide + Br_2 + 4KOH yields 1° amine with ONE LESS carbon atom.

- Aldol: Requires α-H; Dilute NaOH catalyst; Forms β-hydroxy aldehyde/ketone, dehydrates to α,β-unsaturated carbonyl
- Cannizzaro: No α-H (HCHO, PhCHO); 50% conc. NaOH; Disproportionation redox giving Alcohol + Salt of acid
- Reimer-Tiemann: Phenol + $CHCl_3$ + aq. NaOH → Salicylaldehyde (Intermediate: Dichlorocarbene :CCl_2)
- Kolbe Reaction: Sodium phenoxide + CO_2 (4-7 atm, 400K) → Salicylic acid (o-hydroxybenzoic acid)
- Hofmann Bromamide: R-$CONH_2$ + Br_2 + 4KOH → R-NH_2 + K_2CO_3 + 2KBr + $2H_2O$ (Loss of 1 Carbon atom)

NCERT LINE HIGHLIGHT: Gabriel Phthalimide Synthesis specifically produces pure 1° aliphatic amines, NEVER aromatic amines (aryl halides do not undergo nucleophilic substitution).

3.2 Organic Reagents & Transformation Shortcuts

Selective oxidizing and reducing agents: PCC (Pyridinium Chlorochromate) mildly oxidizes 1° alcohols to aldehydes (stopping at aldehyde without over-oxidation to acid) and 2° alcohols to ketones. $LiAlH_4$ reduces acids, esters, and amides to alcohols/amines. $NaBH_4$ selectively reduces only aldehydes and ketones, NOT esters or carboxylic acids. Lucas Reagent (conc. HCl + anh. $ZnCl_2$): 3° alcohols give instant

turbidity, 2° alcohols give turbidity in 5 mins, 1° alcohols give no turbidity at room temperature.

- PCC: 1° Alcohol → Aldehyde (stops cleanly; does not oxidize further to carboxylic acid)
- Jones Reagent (CrO_3 / H_2SO_4): 1° Alcohol → Carboxylic acid; 2° Alcohol → Ketone
- $LiAlH_4$ (in dry ether): Strong reducing agent; reduces -COOH, -COOR, $-CONH_2$, -CHO, >C=O
- $NaBH_4$ (in ethanol): Mild reducing agent; reduces ONLY Aldehydes and Ketones (safe with esters/acids)
- Lucas Reagent (conc. HCl + anh. $ZnCl_2$): Distinguishes alcohols: 3° (instant), 2° (5 mins), 1° (heat required)

NCERT LINE HIGHLIGHT: Lucas test distinguishes 1°, 2°, and 3° alcohols based on carbocation stability (3° > 2° > 1°).

3.3 Inorganic NCERT Trend Exceptions & Anomalies

Frequent NTA exception traps: Ionization Enthalpy anomalies: B < Be (Be has stable filled $2s^2$ configuration), O < N (N has stable half-filled $2p^3$ configuration). Electron Gain Enthalpy: Cl > F (F has small size and high inter-electronic repulsion in 2p orbital), S > O. Inert Pair Effect: Stability of lower oxidation state increases down group 13, 14, 15 (Tl^+ > Tl^{3+}, Pb^{2+} > Pb^{4+}, Bi^{3+} > Bi^{5+}). Acidic strength of hydrides: HF < HCl < HBr < HI (bond dissociation enthalpy decreases down group).

- Ionization Enthalpy: Be > B ($2s^2$ vs $2p^1$ penetration); N > O (half-filled $2p^3$ extra exchange energy)
- Electron Gain Enthalpy: Cl (-349 kJ/mol) > F (-328 kJ/mol); S > O (inter-electronic repulsion in 2p subshell)
- Inert Pair Effect: Relativistic contraction of $6s^2$ electrons makes Tl^+, Pb^{2+}, Bi^{3+} more stable than higher states
- Reducing Nature of Oxoacids of Phosphorus: H_3PO_2 (one P-OH, two P-H bonds) is a stronger reducing agent than H_3PO_3

NCERT LINE HIGHLIGHT: Chlorine has a more negative electron gain enthalpy (-349 kJ/mol) than Fluorine (-328 kJ/mol) due to compact size of 2p subshell in Fluorine.

3.4 Coordination Compounds & Crystal Field Theory (CFT)

Spectrochemical series determines ligand field strength: I^- < Br^- < S^{2-} < SCN^- < Cl^- < F^- < OH^- < $C_2O_4^{2-}$ < H_2O < NCS^- < $EDTA^{4-}$ < NH_3 < en < CN^- < CO. Strong field ligands cause pairing (low spin, Δ_o > P); weak field ligands result in high spin (Δ_o < P). Spin-only magnetic moment formula: μ = √(n(n + 2)) Bohr Magnetons (BM), where n is the number of unpaired electrons.

- Spectrochemical Series: Halides < O-donors < N-donors < C-donors (CO and CN^- are strongest)
- Octahedral Splitting (Δ_o): d-orbitals split into lower t_2g (d_{xy}, d_{yz}, d_{zx}) and higher e_g ($d_{x^2-y^2}$, d_{z^2})
- Tetrahedral Splitting (Δ_t): Inverted splitting; Δ_t = (4/9) Δ_o; Pairing never occurs (always high spin)
- Magnetic Moment: μ = √[n(n + 2)] BM; n = 1 (1.73 BM), n = 2 (2.83 BM), n = 3 (3.87 BM), n = 4 (4.90 BM), n = 5 (5.92 BM)

NCERT LINE HIGHLIGHT: CO and CN^- are strong field ligands causing maximum d-orbital splitting (Δ_o), while halides are weak field ligands.

3.5 Physical Chemistry Quantitative Relationships

Core numerical formulas: Solutions: Raoult Law P = P_A + P_B. Colligative properties: ΔT_b = i * K_b * m, ΔT_f = i * K_f * m, π = i * C * R * T (van t Hoff factor i = 1 + (n - 1)α for dissociation). Electrochemistry: Nernst equation E_cell = E°_cell - (0.0591/n) log Q at 298K. Chemical Kinetics: First order rate law k = (2.303/t) log([A]$_0$/[A]), half life t_1/2 = 0.693/k. Equilibrium: pH of acidic buffer = pKa + log([Salt]/[Acid]).

- Solutions: ΔT_b = i K_b m; ΔT_f = i K_f m; π = i C R T; Relative lowering (P° - P)/P° = i X_solute
- van t Hoff Factor: i = 1 + (n - 1)α (dissociation); i = 1 - (1 - 1/n)β (association/dimerization)
- Electrochemistry: ΔG° = -n F E°_cell; E_cell = E°_cell - (0.0591/n) $\log_{10}$ Q at 298 K
- Kinetics: First order t_1/2 = 0.693/k (independent of initial $[A]_0$); t_99.9% = 10 × t_1/2
- Ionic Equilibrium: pH = pKa + log([Conjugate Base]/[Acid]); Buffer capacity is maximum when pH = pKa

NCERT LINE HIGHLIGHT: For a first order reaction, half life is completely independent of the initial reactant concentration.

TABLE 3.1: ORGANIC CHEMISTRY HIGH-YIELD NAMED REACTIONS MATRIX

Reaction Name	Starting Substrate	Reagent & Conditions	Major Product	Key Diagnostic Feature
Aldol Condensation	Aldehydes with α-H (e.g. CH_3CHO)	Dilute NaOH / Heat	α,β-Unsaturated aldehyde	Requires at least one α-hydrogen
Cannizzaro Reaction	Aldehydes with NO α-H (HCHO, PhCHO)	50% Conc. NaOH / KOH	Alcohol + Carboxylate salt	Disproportionation redox reaction

Reimer-Tiemann	Phenol	$CHCl_3$ + aq. NaOH at 340K	Salicylaldehyde (o-formyl)	Dichlorocarbene ($:CCl_2$) intermediate
Kolbe-Schmitt	Sodium Phenoxide	CO_2 (4-7 atm, 400K) + H^+	Salicylic acid	Electrophilic aromatic substitution
Hofmann Bromamide	Primary Acid Amide (R-$CONH_2$)	Br_2 + 4KOH / Heat	1° Amine (R-NH_2)	Product has one less Carbon atom
Clemmensen Reduction	Aldehyde / Ketone (>C=O)	Zn-Hg + Conc. HCl	Alkane (>CH_2)	Acid-sensitive substrates avoid this
Wolff-Kishner	Aldehyde / Ketone (>C=O)	NH_2-NH_2 + KOH / Glycol	Alkane (>CH_2)	Base-stable substrates suitable

TABLE 3.2: INORGANIC NCERT PERIODIC TREND EXCEPTIONS & ANOMALIES

Periodic Property	Expected General Trend	Actual Observed Anomaly	Physical Cause / NCERT Explanation
1st Ionization Enthalpy	Group 2 < Group 13	Be (899 kJ) > B (801 kJ)	Be has stable filled $2s^2$ orbital; $2p^1$ electron of B is shielded.
1st Ionization Enthalpy	Group 15 < Group 16	N (1402 kJ) > O (1314 kJ)	N has extra-stable half-filled $2p^3$ subshell with higher exchange energy.
Electron Gain Enthalpy	Fluorine > Chlorine	Cl (-349 kJ) > F (-328 kJ)	Compact 2p subshell in F causes high inter-electronic repulsion.
Electron Gain Enthalpy	Oxygen > Sulphur	S (-200 kJ) > O (-141 kJ)	Small size of Oxygen atom creates intense electron-electron repulsion.
Thermal Stability of Carbonates	Increases down Group 2	$BeCO_3$ < $MgCO_3$ < $CaCO_3$ < $BaCO_3$	Larger cation stabilizes larger polyatomic carbonate anion.
Inert Pair Effect Stability	Tl^{3+} > Tl^+, Pb^{4+} > Pb^{2+}	Tl^+ > Tl^{3+}, Pb^{2+} > Pb^{4+}, Bi^{3+} > Bi^{5+}	Relativistic contraction of 6s electrons prevents valence participation.

TABLE 3.3: COORDINATION COMPLEXES: LIGAND FIELD & MAGNETIC MOMENTS

Complex Ion	Central Metal	Ligand Field	Hybridization	Geometry	Unpaired e^-	Magnetic
$[Fe(CN)_6]^{4-}$	Fe^{2+} ($3d^6$)	Strong (CN^-)	d^2sp^3 (Inner)	Octahedral	0 (Diamagnetic)	0.00 BM
$[Fe(H_2O)_6]^{2+}$	Fe^{2+} ($3d^6$)	Weak (H_2O)	sp^3d^2 (Outer)	Octahedral	4 (Paramagnetic)	4.90 BM
$[Co(NH_3)_6]^{3+}$	Co^{3+} ($3d^6$)	Strong (NH_3)	d^2sp^3 (Inner)	Octahedral	0 (Diamagnetic)	0.00 BM
$[CoF_6]^{3-}$	Co^{3+} ($3d^6$)	Weak (F^-)	sp^3d^2 (Outer)	Octahedral	4 (Paramagnetic)	4.90 BM
$[Ni(CN)_4]^{2-}$	Ni^{2+} ($3d^8$)	Strong (CN^-)	dsp^2	Square Planar	0 (Diamagnetic)	0.00 BM
$[NiCl_4]^{2-}$	Ni^{2+} ($3d^8$)	Weak (Cl^-)	sp^3	Tetrahedral	2 (Paramagnetic)	2.83 BM

4. FORMULA VAULT, KEY EQUATIONS & SHORTCUTS

Nernst Equation at 298 K

$$E_{cell} = E^\circ_{cell} - (0.0591 / n) * \log_{10}(Q)$$

n: electrons transferred, Q: reaction quotient

First Order Kinetics Rate Law

$$k = (2.303 / t) * \log_{10}([A]_0 / [A]),\ t_{1/2} = 0.693 / k$$

$[A]_0$: initial conc, [A]: conc at time t

Elevation in Boiling Point

$$\Delta T_b = i * K_b * m$$

i: van t Hoff factor, K_b: ebullioscopic constant

Depression in Freezing Point

$$\Delta T_f = i * K_f * m$$

K_f: cryoscopic constant, m: molality

van t Hoff Factor (Dissociation)

$$i = 1 + (n - 1) * \alpha$$

n: ions produced per molecule, α: degree of dissociation

Acidic Buffer (Henderson-Hasselbalch)

$$pH = pKa + \log_{10}([Salt] / [Acid])$$

Valid when buffer capacity is optimal (pH = pKa ± 1)

Basic Buffer Equation

$$pOH = pKb + \log_{10}([Salt] / [Base])$$

pH = 14 - pOH at 298 K

Spin-Only Magnetic Moment

$$\mu = \text{sqrt}(n * (n + 2))\ BM$$

n: number of unpaired electrons in d-orbitals

Arrhenius Rate Equation

$$\log_{10}(k_2 / k_1) = (E_a / (2.303*R)) * [(T_2 - T_1) / (T_1*T_2)]$$

E_a: activation energy, $R = 8.314\ J\ K^{-1}\ mol^{-1}$

Osmotic Pressure Equation

$$\pi = i * C * R * T = i * (n/V) * R * T$$

Used for molar mass determination of polymers

5. STEP-BY-STEP SOLVED NUMERICALS & ILLUSTRATIONS

Illustration 01: Nernst Equation & Cell Potential Calculation

Problem: Calculate the EMF of the cell at 298 K: Zn(s) | Zn^{2+}(0.1 M) || Cu^{2+}(0.01 M) | Cu(s). Given $E^\circ(Zn^{2+}/Zn) = -0.76$ V, $E^\circ(Cu^{2+}/Cu) = +0.34$ V.

Strategic Framework: First compute standard cell potential $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode}$, write the overall cell reaction, find n (number of electrons), and apply the Nernst equation at 298 K.

1. Step 1: $E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{anode} = +0.34 - (-0.76) = +1.10$ V.
2. Step 2: Cell reaction: $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$. Here n = 2 electrons transferred.
3. Step 3: Reaction quotient $Q = [Zn^{2+}] / [Cu^{2+}] = 0.1 / 0.01 = 10$.
4. Step 4: Nernst equation: $E_{cell} = E^\circ_{cell} - (0.0591 / n) * \log_{10}(Q)$.
5. Step 5: $E_{cell} = 1.10 - (0.0591 / 2) * \log_{10}(10) = 1.10 - 0.02955 * (1) = 1.07045$ V ≈ 1.07 V.

FINAL ANSWER: $E_{cell} = 1.07$ V

Illustration 02: First-Order Kinetics Half-Life & Decay Time

Problem: A first order reaction has a rate constant $k = 2.303 \times 10^{-3}\ s^{-1}$. Find the time required for 90% completion of the reaction.

Strategic Framework: Use the integrated first-order rate law equation: $t = (2.303 / k) * \log([A]_0 / [A])$.

1. Step 1: Let initial concentration $[A]_0 = 100$.
2. Step 2: At 90% completion, remaining concentration [A] = 100 - 90 = 10.
3. Step 3: Concentration ratio $[A]_0 / [A] = 100 / 10 = 10$. $\log_{10}(10) = 1$.
4. Step 4: Time $t = (2.303 / (2.303 \times 10^{-3})) * \log_{10}(10) = 10^3 * 1 = 1{,}000$ seconds.

FINAL ANSWER: Time required = 1,000 seconds (~16.67 minutes)

6. HIGH-YIELD NCERT POINTERS & RAPID FIRE CHECKLIST

- ☐ Fluorine exhibits only -1 oxidation state in all its compounds due to highest electronegativity and lack of d-orbitals.
- ☐ Cannizzaro reaction is NOT shown by acetaldehyde (CH_3CHO) because it possesses three alpha-hydrogens, undergoing Aldol instead.
- ☐ $KMnO_4$ acts as an oxidizing agent in acidic (n=5), neutral/faintly alkaline (n=3), and strongly alkaline (n=1) media.
- ☐ Colligative properties depend SOLELY on the number of solute particles, not on their chemical identity.
- ☐ In a zero-order reaction, rate of reaction is constant and independent of reactant concentration ($t_{1/2} = [A]_0 / 2k$).

☐ The bond angle in H_2O (104.5°) is smaller than in NH_3 (107°) due to greater lone pair-lone pair repulsion in water.

7. NTA EXAM TRAPS & NEGATIVE MARKING ALERTS

Trap: Forgetting the van t Hoff factor i in colligative properties. For NaCl (i≈2), $CaCl_2$ (i≈3), Glucose (i=1). Omitting i leads to wrong answers.

Trap: Temperature in Kelvin vs Celsius in physical chemistry equations. Arrhenius and Nernst equations require absolute temperature in Kelvin (T = °C + 273.15).

Trap: Confusing Aldol and Cannizzaro reagents. Both use base (NaOH/KOH), but Aldol requires alpha-H, while Cannizzaro requires NO alpha-H.

Trap: Oxidation potential vs Reduction potential signs. IUPAC standard strictly uses Standard REDUCTION Potentials. If oxidation potential is given, reverse the sign.

8. MEMORY HACKS & MNEMONICS FOR RAPID RETENTION

Inorganic Oxidation Trend: "OIL RIG" -> Oxidation Is Loss of electrons, Reduction Is Gain of electrons.

Spectrochemical Series Ligand Strength: "Halides < Oxygen Donors < Nitrogen Donors < Carbon Donors" -> Halides are weakest (high spin), CO/CN^- are strongest (low spin).