

Chemistry · Last-Hour Cram Sheet

CBSE Class 12 Chemistry (043) · 2026-27 ·

Theory 70 + Practical 30 · read this in the last hour, nothing else

A. The Paper at a Glance

MARKS BY UNIT — straight from the official course structure

Unit	Title	Marks	Branch
1	Solutions	7	Physical
2	Electrochemistry	9	Physical
3	Chemical Kinetics	7	Physical
4	d- and f-Block Elements	7	Inorganic
5	Coordination Compounds	7	Inorganic
6	Haloalkanes and Haloarenes	6	Organic
7	Alcohols, Phenols and Ethers	6	Organic
8	Aldehydes, Ketones and Carboxylic Acids	8	Organic
9	Amines	6	Organic
10	Biomolecules	7	Organic

Organic is 33 marks — nearly half the paper. Physical is 23, Inorganic 14. Electrochemistry (9) and

Aldehydes/Ketones/Acids (8) are the two biggest single chapters.

B. Every Formula in One Place

SOLUTIONS

$$M = n/V(L) \cdot m = n/\text{kg solvent} \cdot x_A = n_A/n_{\text{total}}$$

$$p = K_H x \cdot p = p^\circ x_A \cdot (p^\circ - p)/p^\circ = x_B$$

$$\Delta T_b = iK_b m \cdot \Delta T_f = iK_f m \cdot \pi = iCRT$$

$$K_b(\text{water}) = 0.52 \cdot K_f(\text{water}) = 1.86$$

ELECTROCHEMISTRY

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} \cdot \Delta G^\circ = -nFE^\circ \cdot F = 96500$$

$$E = E^\circ - (0.059/n) \log Q \cdot E^\circ = (0.059/n) \log K_c$$

$$\Lambda_m = \kappa \times 1000/M \cdot \alpha = \Lambda_m/\Lambda_m^\circ \cdot w = MIt/nF$$

KINETICS

$$\text{Zero: } [A] = [A]_0 - kt \cdot t_{1/2} = [A]_0/2k$$

$$\text{First: } k = (2.303/t) \log([A]_0/[A]) \cdot t_{1/2} = 0.693/k$$

$$\log(k_2/k_1) = (E_a/2.303R)(1/T_1 - 1/T_2)$$

INORGANIC

$$\mu = \sqrt{n(n+2)} \text{ BM} \cdot \Delta_t = (4/9)\Delta_o$$

Spectrochemical: $\text{I}^- < \text{Br}^- < \text{Cl}^- < \text{F}^- < \text{H}_2\text{O} < \text{NH}_3$
 $< \text{en} < \text{NO}_2^- < \text{CN}^- < \text{CO}$

C. Rules You Must Not Get Wrong

THE TWELVE THAT COST MOST MARKS

1. Molality is **temperature independent**; molarity is not.
2. Insert i for every electrolyte in colligative formulas.
3. In **both** cells, oxidation is at the anode — only the **signs** swap.
4. On dilution κ falls, Λ_m rises.
5. Only **first-order** half-life is independent of concentration.
6. A catalyst changes E_a **only** — never ΔH or K .
7. Zn, Cd, Hg are not transition elements; d^0 and d^{10} ions are colourless.
8. Tetrahedral complexes are always high spin.
9. Aqueous KOH $\rightarrow$ alcohol; alcoholic KOH $\rightarrow$ alkene.
10. α -H present $\rightarrow$ aldol. No α -H $\rightarrow$ Cannizzaro.
11. Fehling's fails for aromatic aldehydes; Tollens' does not.
12. Sucrose is non-reducing. Denaturation destroys 2° and 3° only.

D. Organic — the reagent decides the product

Reagent	Product / meaning
Aqueous KOH / alcoholic KOH	Alcohol / alkene
KCN / AgCN	Nitrile / isocyanide
Conc. H_2SO_4 443 K / 413 K	Alkene / ether
PCC	1° alcohol → aldehyde (stops)
$\text{H}_2/\text{Pd}-\text{BaSO}_4$	Rosenmund → aldehyde
Zn-Hg/HCl / $\text{NH}_2\text{NH}_2/\text{KOH}$	Clemmensen / Wolff-Kishner → CH_2
Br_2/KOH on amide	Hofmann → amine, one C less
NaNO_2/HCl, 273–278 K	Diazonium salt
CHCl_3 + alc. KOH	Carbylamine → 1° amine test
CO_2/NaOH on phenol	Kolbe → salicylic acid
$\text{CHCl}_3/\text{NaOH}$ on phenol	Reimer-Tiemann → salicylaldehyde
$\text{X}_2/\text{red P}$	HVZ → α -halo acid

E. The Distinguishing Tests

ONE TEST PER PAIR Aldehyde vs ketone →

Tollens' (silver mirror).

Aliphatic vs aromatic aldehyde → Fehling's (aromatic fails).

Carboxylic acid vs phenol $\rightarrow$ NaHCO_3 , brisk effervescence.

Phenol present $\rightarrow$ neutral FeCl_3 , violet colour.

1° , 2° , 3° alcohol $\rightarrow$ Lucas reagent (3° immediate, 2° 5 min, 1° on heating).

1° amine $\rightarrow$ carbylamine test, foul smell.

1° , 2° , 3° amine $\rightarrow$ Hinsberg's test.

$\text{CH}_3\text{CO}-$ group $\rightarrow$ iodoform, yellow precipitate.

F. How to Write for Marks

1. Equations, not sentences. In organic questions, a balanced equation with conditions above the arrow earns the mark; a description of it usually does not.

2. Conditions matter. Temperature, solvent, and catalyst are part of the answer — "alcoholic KOH ", "dry ether", " $273-278\text{ K}$ ".

3. In "why" questions, name the effect: resonance, $+I$, $-I$, steric hindrance, hydrogen bonding. Then say what it stabilises or destabilises.

4. Numericals: write the formula, then substitute, then the answer **with units**. Check **n** and **i** before starting.

5. Structures: draw them. A named product with no structure often loses half the mark in conversion questions.

6. Do not write the four formative-only topics in the board paper — they carry no marks there (see Ch 11).

Chapter 1 · Solutions

CBSE Class 12 Chemistry (043) · Physical Chemistry

Unit 1 = 7 marks · Ultimate Revision Sheet

60-SECOND RECALL

Molarity vs molality	M = mol solute / L of SOLUTION · m = mol solute / kg of SOLVENT . Only m is temperature-independent.
Henry's law	p = $K_H \times x$ · $K_H \uparrow$ with temperature $\Rightarrow$ solubility of gas $\downarrow$
Raoult's law	Volatile: p_{total} = $p^\circ_A x_A + p^\circ_B x_B$ · Non-volatile solute: p = $p^\circ_A x_A$
Four colligative properties	Relative lowering of VP · Elevation of b.p. · Depression of f.p. · Osmotic pressure
Water constants	K_b = 0.52 K kg mol ⁻¹ · K_f = 1.86 K kg mol ⁻¹
van't Hoff factor	i > 1 dissociation · i < 1 association · i = 1 neither
Best for molar mass	Osmotic pressure — measurable at room temperature, large values, works for macromolecules

1. Concentration — the five expressions

FORMULAS

$$\text{Mass \%} = (\text{mass of solute} / \text{mass of solution}) \times 100$$

$$\text{ppm} = (\text{mass of solute} / \text{mass of solution}) \times 10^6$$

Mole fraction $x_A = n_A / (n_A + n_B)$ $x_A + x_B = 1$

Molarity M = moles of solute / volume of SOLUTION in litres

Molality m = moles of solute / mass of SOLVENT in kg

THE TRAP EXAMINERS RELY ON Molarity

changes with temperature; molality does not. Volume expands on heating, mass does not. So any question about a property measured at different temperatures wants **molality**.

Molarity uses the **solution** volume, molality uses the **solvent** mass. Writing "per kg of solution" loses the mark.

2. Solubility and Henry's Law

WRITE THIS VERBATIM

Henry's law: the partial pressure of a gas in the vapour phase is **directly proportional to the mole fraction** of the gas in the solution. $p = K_H \times$

WHAT THE CONSTANT MEANS

Higher $K_H \Rightarrow$ **LOWER** solubility of that gas at the same

pressure.

K_H increases with temperature, so the solubility of a gas decreases as temperature rises — which is why aquatic life prefers cold water.

THE FOUR APPLICATIONS ASKED

1. Soft drinks are sealed under high CO_2 pressure to keep the gas dissolved.

2. Scuba divers (bends): at depth, more N_2 dissolves in blood; on rapid ascent it bubbles out and blocks capillaries. Divers' tanks use air diluted with helium.

3. Anoxia at high altitude: low partial pressure of $O_2 \rightarrow$ less O_2 in blood $\rightarrow$ weakness and poor thinking.

4. Deoxygenation in hot water — a consequence of K_H rising with temperature.

3. Vapour Pressure and Raoult's Law

FOR A SOLUTION OF TWO VOLATILE LIQUIDS

$$p_A = p_A^\circ x_A \quad \cdot \quad p_B = p_B^\circ x_B$$

$$p_{\text{total}} = p_A^\circ x_A + p_B^\circ x_B = p_B^\circ + (p_A^\circ - p_B^\circ) x_A$$

In the vapour phase: $y_A = p_A / p_{\text{total}}$

FOR A NON-VOLATILE SOLUTE — relative lowering

$$p_{\text{solution}} = p^{\circ}_A x_A$$

$$(p^{\circ}_A - p) / p^{\circ}_A = x_B \quad \text{relative lowering} = \text{mole fraction of solute}$$

$$(p^{\circ}_A - p) / p^{\circ}_A = (w_B/M_B) / (w_A/M_A + w_B/M_B)$$

4. Ideal and Non-Ideal Solutions

Basis	IDEAL	NON-IDEAL
Raoult's law	Obedied at all concentrations	Not obeyed
$\Delta_{\text{mix}}H$	Zero	Not zero
$\Delta_{\text{mix}}V$	Zero	Not zero
A–B forces	Same as A–A and B–B	Weaker (+ve) or stronger (–ve)
Examples	Benzene + toluene · n-hexane + n-heptane	See below

THE TWO DEVIATIONS — learn one example of each

	POSITIVE deviation	NEGATIVE deviation
A–B force	Weaker than A–A / B–B	Stronger than A–A / B–B
Vapour pressure	Higher than Raoult predicts	Lower than Raoult predicts
$\Delta_{\text{mix}}H$	Positive (endothermic)	Negative (exothermic)

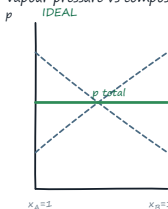
$\Delta_{\text{mix}} V$	Positive (expands)	Negative (contracts)
Example	Ethanol + acetone · carbon disulphide + acetone	Chloroform + acetone · nitric acid + water
Azeotrope formed	Minimum boiling — ethanol–water (95% ethanol)	Maximum boiling — nitric acid–water (68% HNO_3)

TRAP — why chloroform + acetone deviates negatively

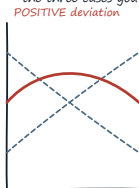
The two form a *hydrogen bond* between them, which is *stronger* than the forces in either pure liquid. Stronger attraction → molecules escape less readily → *lower* vapour pressure. Say the words "hydrogen bonding between the unlike molecules" — that is the mark.

Azeotropes cannot be separated by fractional distillation, because the liquid and vapour have the same composition at that point.

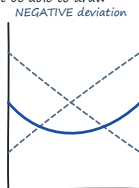
Vapour pressure vs composition — the three cases you must be able to draw



$\Delta H = 0$, $\Delta V = 0$
 A-B force = A-A, B-B
 e.g. benzene + toluene



p is **HIGHER** than Raoult predicts
 A-B force **WEAKER**, ΔH +ve
 ethanol + acetone, min-boiling



p **LOWER** than Raoult predicts
 A-B force **STRONGER**, ΔH -ve
 HNO_3 + water, max-boiling

Decide by the **A-B interaction**: weaker than the pure liquids $\rightarrow$ molecules escape more easily $\rightarrow$ pressure rises $\rightarrow$ **positive**. Stronger $\rightarrow$ **negative**. Everything else follows from that one line.

5. Colligative Properties

DEFINITION

Properties that depend **only** on the **NUMBER** of solute particles, not on their nature.

ALL FOUR, WITH THEIR MOLAR-MASS FORMS

1. Relative lowering of vapour pressure: $(p^\circ - p)/p^\circ = x_B$

2. Elevation of boiling point: $\Delta T_b = K_b m \rightarrow M_B = (K_b \times w_B \times 1000) / (\Delta T_b \times w_A)$

3. Depression of freezing point: $\Delta T_f = K_f m \rightarrow M_B = (K_f \times w_B \times 1000) / (\Delta T_f \times w_A)$

4. Osmotic pressure: $\pi = CRT = (n/V)RT \rightarrow M_B = w_B RT / \pi V$

w_A = mass of solvent in grams, w_B = mass of solute in grams. The 1000 converts grams of solvent to kilograms.

OSMOSIS — the words that carry marks **Osmosis:**

flow of **solvent** through a semipermeable membrane from **lower** to **higher** concentration.

Osmotic pressure: the **excess pressure** that must be applied to just **stop** osmosis.

Isotonic: same osmotic pressure ·

Hypertonic: higher · **Hypotonic:** lower.

Reverse osmosis: pressure **greater than** the osmotic pressure pushes solvent the other way — used for **desalination of sea water**.

TRAP Osmotic pressure is preferred for finding the molar mass of **polymers and proteins** because it is measured at **room temperature** and gives **large, easily measured** values, while ΔT_f and ΔT_b would be too small to read.

0.1 M NaCl is NOT isotonic with 0.1 M glucose — NaCl gives twice the particles.

6. Abnormal Molar Mass and the van't Hoff Factor

FORMULAS

$$i = \text{normal molar mass} / \text{observed molar mass}$$

$$i = \text{observed colligative property} / \text{calculated colligative property}$$

$$i = \text{total particles after} / \text{total particles before}$$

Every colligative formula is multiplied by i :

$$\Delta T_b = iK_b m \cdot \Delta T_f = iK_f m \cdot \pi = iCRT$$

Behaviour	i	Observed molar mass	Example
Dissociation	> 1	Lower than normal	NaCl in water ($i \rightarrow 2$), K_2SO_4 ($i \rightarrow 3$)
Association	< 1	Higher than normal	Benzoic acid in benzene (dimer, $i \rightarrow 0.5$)
Neither	$= 1$	Normal	Glucose, urea in water

WORKED EXAMPLE — the standard depression question

1.8 g of glucose ($M = 180 \text{ g mol}^{-1}$) is dissolved in 100 g of water. $K_f = 1.86 \text{ K kg mol}^{-1}$. Find the freezing point.

Moles of glucose = $1.8 / 180 = 0.01 \text{ mol}$

Molality $m = 0.01 / 0.1 = 0.1 \text{ mol kg}^{-1}$

$\Delta T_f = K_f m = 1.86 \times 0.1 = 0.186 \text{ K}$

Freezing point = $273.15 - 0.186 = 272.96 \text{ K}$ (i.e. $-0.186 \text{ }^\circ\text{C}$)

If the solute were NaCl instead, $i = 2$ and ΔT_f would double to 0.372 K .

7. Question Triggers

which formula the wording wants

If the question says...	Use
"solubility of a gas", "pressure of the gas above the liquid"	Henry's law, $p = K_H x$
"vapour pressure of the solution", solute is non-volatile	$p = p^\circ x_A$
"both liquids are volatile", "composition of the vapour"	p_{total} , then $y_A = p_A / p_{\text{total}}$
"boils at..." / "freezes at..."	$\Delta T_b = i K_b m$ / $\Delta T_f = i K_f m$

"molar mass of a protein / polymer"	Osmotic pressure , $\pi = CRT$
"electrolyte" named (NaCl, K_2SO_4 , $CaCl_2$)	Insert i — never leave it out
"observed molar mass is double the expected"	Association , $i = 0.5$
"cannot be separated by fractional distillation"	Azeotrope

MOST-ASKED BOARD QUESTIONS

1. **[3M]** State Henry's law. Give **two** applications, and explain why K_H rises with temperature.
2. **[3M]** Define an ideal solution. How do positive and negative deviations from Raoult's law arise?
3. **[3M]** Calculate the freezing point / boiling point of a given solution.
4. **[2M]** Why is **osmotic pressure** preferred for determining the molar mass of macromolecules?
5. **[2M]** Define the van't Hoff factor. What values does it take for NaCl in water and benzoic acid in benzene?
6. **[1M]** Which colligative property is used in **desalination**? → **Reverse osmosis**

7. [1M] Why is molality preferred over molarity in colligative calculations? →
It does not change with temperature

THE HABIT THAT SCORES — Before touching a colligative numerical, write $i = ?$ at the top of your working. If the solute is an electrolyte and you forget i , every later line is wrong — and it is the single most common reason full-mark students lose a whole 3-marker in this chapter.

Chapter 2 · Electrochemistry

CBSE Class 12 Chemistry (043) · Physical · Unit 2

= 9 marks (the highest in the paper) · Ultimate Revision Sheet

60-SECOND RECALL

Galvanic cell	Chemical → electrical · anode -ve, cathode +ve · oxidation at anode
Electrolytic cell	Electrical → chemical · anode +ve, cathode -ve
Cell EMF	$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$
Nernst	$E = E^\circ - (0.059/n) \log Q$ at 298 K
At equilibrium	$E_{\text{cell}} = 0$ · $E^\circ = (0.059/n) \log K_c$
Thermodynamics	$\Delta G^\circ = -nFE^\circ$ · $F = 96500 \text{ C mol}^{-1}$
Molar conductivity	$\Lambda_m = \kappa \times 1000/M$ · rises on dilution for both types
Faraday	$w = ZIt$ · $w = (M/nF) \times It$

1. The Two Cells

THE COMPARISON — get the signs right

Basis	GALVANIC (voltaic)	ELECTROLYTIC
Conversion	Chemical → electrical	Electrical → chemical
Reaction	Spontaneous , ΔG negative	Non-spontaneous , driven by a battery
Anode	Negative , oxidation	Positive , oxidation

Cathode	Positive , reduction	Negative , reduction
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In **BOTH** cells oxidation always happens at the anode and reduction at the cathode.

Only the **signs** swap. That sentence answers the most common trap in this chapter.

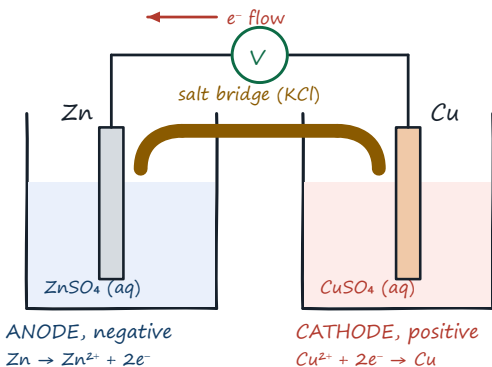
CELL REPRESENTATION



Anode on the **LEFT**, cathode on the right;
|| is the salt bridge.

Salt bridge: completes the circuit, and maintains electrical neutrality in the two half-cells by supplying ions. Without it the cell stops almost at once.

Daniell cell



READING THE CELL



$$E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = 0.34 - (-0.76) = 1.10 \text{ V}$$

Cell notation always puts the **ANODE** on the left. The salt bridge does two jobs: it keeps both solutions electrically neutral, and it completes the circuit.

Oxidation is at the anode in **BOTH** kinds of cell. What flips in an electrolytic cell is only the **sign** — there the anode is positive. That is the trap this diagram exists to kill.

$\Delta G^\circ = -nFE^\circ$, so a positive E° means a spontaneous cell.

2. Electrode Potential and EMF

FORMULAS

$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$ (both as **reduction** potentials)

$\Delta G^\circ = -nFE^\circ_{\text{cell}}$ E° positive $\Rightarrow \Delta G^\circ$ negative $\Rightarrow$ spontaneous

SHE (standard hydrogen electrode) is the reference, assigned $E^\circ = 0.00 \text{ V}$ exactly, at 1 bar H_2 , 1 M H^+ , 298 K.

More positive $E^\circ \rightarrow$ stronger oxidising agent, more easily reduced (F_2 is highest at +2.87 V).

More negative $E^\circ \rightarrow$ stronger reducing agent (Li is lowest at -3.05 V).

3. Nernst Equation

FORMULAS

$E = E^\circ - (RT/nF) \ln Q \rightarrow$ at 298 K: $E = E^\circ - (0.059/n) \log Q$

For $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$: $E = E^\circ - (0.059/2) \log([\text{Zn}^{2+}]/[\text{Cu}^{2+}])$

At equilibrium $E_{\text{cell}} = 0$ and $Q = K_c$, so $E^\circ = (0.059/n) \log K_c$

TRAP Solids and pure liquids never appear in Q — only ion concentrations and gas pressures do.

Increasing the concentration of the product ion lowers E ; increasing the reactant ion raises it.

When the cell is fully discharged, $E_{\text{cell}} = 0$, not E° .

4. Conductance

THE THREE QUANTITIES

Conductance $G = 1/R$ (siemens, S)

Conductivity $\kappa = G \times (l/A)$ $l/A = \text{cell constant, unit } m^{-1}$

Molar conductivity $\Lambda_m = \kappa \times 1000 / M$ (M in $mol L^{-1}$)

ON DILUTION — the graph question **Conductivity**

κ **DECREASES** on dilution — fewer ions per unit volume.

Molar conductivity Λ_m **INCREASES** on

dilution — the total volume containing one mole increases.

Strong electrolyte (KCl): Λ_m rises slowly and linearly; Λ°_m is found by

extrapolating the graph — Debye-Hückel-Onsager: $\Lambda_m = \Lambda^\circ_m - A\sqrt{c}$.

Weak electrolyte (CH_3COOH): Λ_m rises steeply near infinite dilution; the graph cannot be extrapolated, so Λ°_m must come from Kohlrausch's law.

KOHLRAUSCH'S LAW The limiting molar conductivity of an electrolyte is the sum of the individual contributions of its ions.

$$\Lambda^\circ_m(\text{CH}_3\text{COOH}) = \Lambda^\circ_m(\text{CH}_3\text{COONa}) + \Lambda^\circ_m(\text{HCl}) - \Lambda^\circ_m(\text{NaCl})$$

$$\text{Degree of dissociation } \alpha = \Lambda_m / \Lambda^\circ_m$$

5. Electrolysis and Faraday's Laws

FORMULAS

First law: $w \propto Q \rightarrow w = ZIt$ (Z = electrochemical equivalent)

Second law: $w_1/w_2 = E_1/E_2$ (same charge,

equivalent masses)

$w = (M \times I \times t) / (n \times 96500)$ — the form to actually use

1 faraday = 96500 C = charge on 1 mole of electrons.

6. Batteries, Fuel Cells and Corrosion

THE FOUR SYSTEMS

System	Key points
Dry cell (primary)	Anode Zn , cathode graphite in $\text{MnO}_2 + \text{NH}_4\text{Cl}$ paste. ~1.5 V . Cannot be recharged.
Lead storage battery (secondary)	Anode Pb , cathode PbO₂ , electrolyte H₂SO₄ . Rechargeable ; used in cars.
Fuel cell	H₂-O₂ cell with porous carbon electrodes and KOH. Efficiency ~70% . Product is only water , so it is pollution-free. Used in Apollo space programme .
Corrosion	An electrochemical process. Iron acts as anode (oxidised to Fe^{2+}), oxygen reduced at cathode; rust is hydrated ferric oxide, Fe₂O₃·xH₂O .

Preventing corrosion: barrier coating (paint, grease) · galvanisation (zinc coating) · cathodic protection with a sacrificial Mg or Zn block · alloying (stainless steel).

WORKED EXAMPLE

For the Daniell cell, $E^\circ_{\text{Cu}} = +0.34 \text{ V}$, $E^\circ_{\text{Zn}} = -0.76 \text{ V}$. Find E°_{cell} and ΔG° .

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = 0.34 - (-0.76) = +1.10 \text{ V}$$

$$n = 2 \text{ (Zn} \rightarrow \text{Zn}^{2+} + 2e^-)$$

$$\Delta G^\circ = -nFE^\circ = -2 \times 96500 \times 1.10 = -212,300 \text{ J} = -212.3 \text{ kJ mol}^{-1}$$

Negative, so the reaction is **spontaneous** — as it must be for a galvanic cell.

7. Question Triggers

which formula the wording wants

If the question says...	Use
"concentrations are not 1 M"	Nernst equation
"calculate the equilibrium constant of a cell reaction"	$E^\circ = (0.059/n) \log K_c$
"is the reaction spontaneous?"	$\Delta G^\circ = -nFE^\circ$; E° positive $\rightarrow$ yes
"mass deposited at an electrode"	$w = MIt/nF$
" Λ°_m of a weak electrolyte"	Kohlrausch's law — cannot extrapolate
"why does κ fall but Λ_m rise on dilution"	Ions per volume vs ions per mole

"cell has stopped working / is dead"

$E_{\text{cell}} = 0$, equilibrium reached

"rust formula"

$\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$

MOST-ASKED BOARD QUESTIONS

1. [3M] Write the **Nernst equation** and calculate E_{cell} for given concentrations.
2. [3M] Explain how κ and Λ_m vary with dilution for a strong and a weak electrolyte; sketch both graphs.
3. [3M] State **Kohlrausch's law** and use it to find Λ_m° of acetic acid and its degree of dissociation.
4. [2M] Relate ΔG° , E° and K_c .
5. [2M] Describe the $\text{H}_2\text{-O}_2$ fuel cell and give two advantages.
6. [2M] Explain **corrosion** as an electrochemical process and give two prevention methods.
7. [1M] What is the function of a **salt bridge**?

THE HABIT THAT SCORES — Before any Nernst calculation, write $n = ?$ and the balanced half-reactions.

Getting n wrong changes every subsequent digit, and it is the single most common error in the highest-weighted chapter of the paper.

Chapter 3 · Chemical Kinetics

CBSE Class 12 Chemistry (043) · Physical · Unit 3

= 7 marks · Ultimate Revision Sheet

60-SECOND RECALL

Rate law	Rate = $k[A]^x[B]^y$ — powers come from experiment , not the equation
Order	$x + y$ · can be 0, fractional or negative
Molecularity	Always a whole number, 1 2 or 3 , never zero
Zero order	$[A] = [A]_0 - kt$ · $t_{1/2} = [A]_0/2k$ · k unit $\text{mol L}^{-1} \text{s}^{-1}$
First order	$k = (2.303/t) \log([A]_0/[A])$ · $t_{1/2} = 0.693/k$ · k unit s^{-1}
Arrhenius	$k = Ae^{-E_a/RT}$ · $\log(k_2/k_1) = (E_a/2.303R)(1/T_1 - 1/T_2)$
Catalyst	Lowers E_a · does NOT change ΔH or K

1. Rate of Reaction

FORMULAS

$$\text{Average rate} = -\Delta[R]/\Delta t = +\Delta[P]/\Delta t$$

$$\text{For } aA + bB \rightarrow cC + dD: \text{rate} = -(1/a)d[A]/dt = + (1/c)d[C]/dt$$

The *minus sign* makes the rate positive for a disappearing reactant. Always divide by

the stoichiometric coefficient.

FACTORS AFFECTING RATE · Concentration ·

temperature (roughly doubles the rate for each 10 K) · catalyst · surface area · nature of reactants · radiation for photochemical reactions.

2. Order and Molecularity

THE DISTINCTION — asked almost every year

Basis	ORDER	MOLECULARITY
Meaning	Sum of the powers in the experimentally determined rate law	Number of species colliding in an elementary step
Determined by	Experiment	The balanced elementary equation
Possible values	0, fractional, even negative	Whole numbers only , 1, 2 or 3
Applies to	Elementary and complex reactions	Elementary steps only

For a multi-step reaction, the order is decided by the slowest (rate-determining) step.

3. Integrated Rate Equations

ZERO ORDER

$$[A] = [A]_0 - kt \cdot k = ([A]_0 - [A])/t \cdot t_{1/2} = [A]_0/2k$$

Plot $[A]$ against $t \rightarrow$ a straight line of slope $-k$. Rate is independent of concentration.

Examples: decomposition of HI on a gold surface; NH_3 on a hot platinum surface (surface-catalysed reactions).

FIRST ORDER

$$k = (2.303/t) \log([A]_0/[A])$$

$$t_{1/2} = 0.693/k \text{ — independent of initial concentration}$$

Plot $\log[A]$ against $t \rightarrow$ a straight line of slope $-k/2.303$.

Examples: all radioactive decay; decomposition of N_2O_5 ; hydrogenation of ethene.

TRAP Only the first-order half-life is independent of the starting concentration. For zero order $t_{1/2} \propto [A]_0$.

Units of k give away the order: zero order $\text{mol L}^{-1} \text{s}^{-1}$, first order s^{-1} , second order $\text{L mol}^{-1} \text{s}^{-1}$. General form: $\text{mol}^{1-n} \text{L}^{n-1} \text{s}^{-1}$.

A pseudo first order reaction is second order in principle but behaves as first order because one reactant is in **large excess** — e.g. hydrolysis of an ester or of cane sugar in water.

4. Temperature Dependence and Collision Theory

ARRHENIUS EQUATION

$k = A e^{-E_a/RT}$ A = frequency factor, E_a = activation energy

$\log k = \log A - E_a/2.303RT$ → plot $\log k$ vs $1/T$, slope $-E_a/2.303R$

$\log(k_2/k_1) = (E_a/2.303R)(1/T_1 - 1/T_2)$

COLLISION THEORY

A reaction occurs only when molecules collide with (1) **sufficient energy** — at least the activation energy — and (2) **the proper orientation**.

Rate = $P Z_{AB} e^{-E_a/RT}$ Z = collision frequency, P = steric (probability) factor

Why temperature matters so much: a modest rise in T greatly increases the **fraction of molecules with energy above E_a** — this is what doubles the rate, not the small rise in collision frequency.

CATALYST

A catalyst provides an **alternative path with lower activation energy**. It therefore speeds up the forward and the backward reaction equally. It does **NOT** change ΔH , the **equilibrium constant**, or the position of equilibrium — only the **time taken to reach it**.

WORKED EXAMPLE

A first-order reaction is 50% complete in 30 minutes. Find k and the time for 75% completion.

$$k = 0.693/t_{1/2} = 0.693/30 = 0.0231 \text{ min}^{-1}$$

For 75%: $[A]_0/[A] = 100/25 = 4$

$$t = (2.303/k) \log 4 = (2.303/0.0231) \times 0.602 = 60 \text{ minutes}$$

Shortcut: 75% complete = two half-lives = $2 \times 30 = 60 \text{ min}$ ✓

(a) The plot that gives a STRAIGHT line tells you the order

$[A]$



ZERO order

$$[A] = [A]_0 - kt$$

$$\text{slope} = -k$$

$$t_{1/2} = [A]_0/2k$$

$t_{1/2}$ **DEPENDS** on conc.

$\ln[A]$



FIRST order

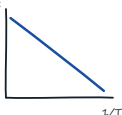
$$k = (2.303/t) \log([A]_0/[A])$$

$$\text{slope} = -k/2.303 \text{ (log plot)}$$

$$t_{1/2} = 0.693/k$$

$t_{1/2}$ is **INDEPENDENT** of conc.

$\ln k$



ARRHENIUS

$$k = Ae^{-E_a/RT}$$

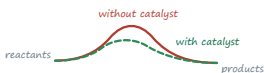
$$\text{slope} = -E_a/R$$

$$\text{intercept} = \ln A$$

Steeper line $\rightarrow$ larger E_a

(b) A catalyst lowers E_a **ONLY**

It cannot change ΔH , and it cannot change K — it speeds up both directions equally.



A fitted straight line is the proof of order — if the examiner gives you data, plot the one that comes out straight. **Only first-order $t_{1/2}$ is concentration-independent**, which is why radioactive decay is first order.

5. Question Triggers

which formula the wording wants

If the question says...	Use
"half-life does not depend on concentration"	First order
"rate is independent of concentration"	Zero order
"k has units s^{-1} "	First order
"one reactant is in large excess"	Pseudo first order
"rate constant at two temperatures"	Arrhenius, $\log(k_2/k_1)$
"catalyst added — effect on $\Delta H / K$ "	No change ; only E_a falls
"slope of $\log k$ vs $1/T$ "	$-E_a/2.303R$
"why does rate roughly double per 10 K"	More molecules exceed E_a

MOST-ASKED BOARD QUESTIONS

1. **[3M]** Derive the integrated rate equation for a first-order reaction and show $t_{1/2} = 0.693/k$.
2. **[3M]** Numerical using the Arrhenius equation to find E_a from k at two temperatures.
3. **[2M]** Distinguish between order and molecularity.

4. [2M] Explain *pseudo first order* with an example.
5. [2M] Determine the order and rate law from a table of initial rates.
6. [1M] How does a catalyst affect ΔH ? →
Not at all

THE HABIT THAT SCORES — When a numerical gives you the **units of k** , read the order straight off them before doing anything else. It tells you which integrated equation to use and takes two seconds.

Chapter 4 · d- and f-Block Elements

CBSE Class 12 Chemistry (043) · Inorganic · Unit 4

= 7 marks · Ultimate Revision Sheet

60-SECOND RECALL

Transition element	Has a partially filled d subshell in its ground state or in a common oxidation state
Not transition	Zn, Cd, Hg — d^{10} , completely filled
Exceptions	Cr = $3d^5 4s^1$ · Cu = $3d^{10} 4s^1$ (half/fully filled stability)
Highest O.S.	Mn = +7 · strongest reducing Sc , most stable +2 Mn
Colour	d-d transition — needs partially filled d
Magnetic moment	$\mu = \sqrt{n(n+2)}$ BM, n = unpaired electrons
Lanthanoid contraction	Poor shielding by 4f → steady size decrease

1. Position and Electronic Configuration

THE BASICS d-block: groups 3–12, general configuration $(n-1)d^{1-10} ns^{1-2}$.

Two exceptions to remember: **Cr** = $3d^5 4s^1$ and **Cu** = $3d^{10} 4s^1$, because half-filled and fully filled d subshells are extra stable

(symmetry + exchange energy).

Zn, Cd, Hg are NOT transition elements

— their *d* subshell is full in both the atom and all their common ions.

2. General Properties

THE PROPERTIES AND THEIR ONE-LINE REASONS

Property	Reason — this is the mark
High melting points	Strong metallic bonding from unpaired d electrons . Maximum in the middle of the series; Zn, Cd, Hg are low (no unpaired d electrons).
Variable oxidation states	(<i>n</i> - 1)d and <i>ns</i> have similar energies , so both can take part in bonding.
Coloured ions	d-d transition — an electron absorbs visible light and jumps between split d orbitals. Sc³⁺ (<i>d</i>⁰) and Zn²⁺ (<i>d</i>¹⁰) are colourless.
Paramagnetism	Due to unpaired electrons ; $\mu = \sqrt{[n(n+2)]}$ BM.
Catalytic activity	Variable oxidation states and the ability to form intermediates , plus large surface area. Eg V ₂ O ₅ , Fe, Ni.
Complex formation	Small size, high charge density, vacant d orbitals.
Alloy formation	Similar atomic radii , so one metal can replace another in the lattice.
Interstitial compounds	Small atoms (H, C, N) occupy interstitial sites → harder, higher melting, chemically inert.

THE FACTS MOST OFTEN ASKED

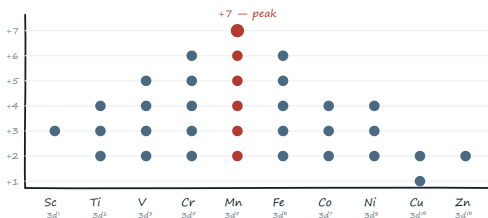
Mn shows the maximum oxidation state (+7) because it has the most unpaired electrons available ($3d^5 4s^2$).

Cu is the only 3d metal with a positive E° value — so it does not liberate H_2 from acids. The reason is its high sublimation and ionisation enthalpy not being compensated by hydration enthalpy.

Zn, Cd, Hg are not paramagnetic and their compounds are white/colourless.

Cr^{2+} is a strong reducing agent (changes to the stable d^3 Cr^{3+}), while Mn^{3+} is a strong oxidising agent (changes to the stable d^5 Mn^{2+}).

Oxidation states across the 3d series — why the maximum sits at manganese



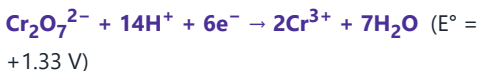
Mn has 5 unpaired 3d + 2 4s electrons = 7 available, so +7 is its maximum.
Zn ($3d^{10}$) shows only +2, so it is not a transition element at all.

States rise to Mn then fall, because after d^5 the 3d electrons pair up and are held too tightly to be lost. **Sc^{3+} (d^0) and Zn^{2+} (d^{10}) are colourless** for the same reason — no d-d transition is possible.

3. Important Compounds

POTASSIUM DICHROMATE $K_2Cr_2O_7$ Colour:

orange. Oxidation state of Cr: +6.



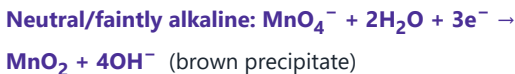
The equilibrium asked every year: in alkali, orange dichromate turns yellow chromate; on acidifying, the yellow turns back orange.



Structure: both ions are tetrahedral about each Cr; the dichromate has a Cr-O-Cr bridge.

POTASSIUM PERMANGANATE $KMnO_4$ Colour:

deep purple. Oxidation state of Mn: +7. It is diamagnetic and its colour is due to charge transfer, not d-d transition (Mn is d^0).



Structure: tetrahedral.

4. Lanthanoids and Actinoids

LANTHANOID CONTRACTION — guaranteed question

What: the steady decrease in atomic and ionic radii across the lanthanoid series.

Why: each added electron goes into the 4f subshell, which shields poorly, so the effective nuclear charge felt by the outer electrons rises steadily.

Consequences: (1) Zr and Hf have almost identical radii and are very hard to separate; (2) the second and third transition series have similar sizes and properties; (3) basicity of hydroxides decreases across the series.

LANTHANOIDS vs ACTINOIDS

Basis	LANTHANOIDS	ACTINOIDS
Filling	4f	5f
Common O.S.	Mainly +3	Wide range , +3 to +7
Radioactivity	Only promethium	All are radioactive
Complex formation	Less	Greater (smaller size, higher charge)

Uses: mischmetall (lanthanoid alloy) in lighter flints and tracer bullets; lanthanoid oxides as catalysts and in glass; uranium and plutonium as nuclear fuel.

5. Question Triggers

what the wording wants

If the question says...	The answer is...
"why is Zn not a transition element"	d¹⁰ in atom and ion — no partially filled d
"why are Zn ²⁺ and Sc ³⁺ colourless"	d¹⁰ and d⁰ — no d-d transition possible
"why does Cr have 3d ⁵ 4s ¹ "	Half-filled stability
"orange solution turns yellow on adding alkali"	Dichromate → chromate
"why is Cu ²⁺ coloured but Cu ⁺ colourless"	Cu ²⁺ is d⁹ , Cu ⁺ is d¹⁰
"Zr and Hf are difficult to separate"	Lanthanoid contraction
"calculate the magnetic moment"	$\mu = \sqrt{n(n+2)}$ BM
"why are transition metals good catalysts"	Variable oxidation states + intermediate formation

MOST-ASKED BOARD QUESTIONS

1. **[3M]** Explain variable oxidation states, colour and catalytic activity of transition elements.

2. [3M] Write the preparation / oxidising reactions of KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$, with the ionic equations.
3. [3M] What is lanthanoid contraction? Give its cause and two consequences.
4. [2M] Calculate the spin-only magnetic moment of a given ion.
5. [2M] Compare lanthanoids and actinoids.
6. [1M] Which 3d element has the highest oxidation state? $\rightarrow \text{Mn (+7)}$

THE HABIT THAT SCORES — Every "why" question in this chapter is answered by one of four things: number of unpaired electrons, half/fully filled stability, similar energy of $(n-1)d$ and ns , or poor shielding by f electrons. Name the reason explicitly — describing the observation again earns nothing.

Chapter 5 · Coordination Compounds

CBSE Class 12 Chemistry (043) · Inorganic · Unit 5

= 7 marks · Ultimate Revision Sheet

60-SECOND RECALL

Coordination number	Number of bonds from ligands to the central metal
Naming order	Ligands alphabetically, then metal ; anion complex → metal ends in -ate
CFT splitting	Octahedral: t_{2g} low, e_g high · Tetrahedral: reversed, $\Delta_t = 4/9 \Delta_o$
Strong field ligand	Large Δ_o → pairing → low spin , inner orbital (d^2sp^3)
Weak field ligand	Small Δ_o → no pairing → high spin , outer orbital (sp^3d^2)
Spectrochemical series	$I^- < Br^- < Cl^- < F^- < H_2O < NH_3 < en < NO_2^- < CN^- < CO$
Magnetic moment	$\mu = \sqrt{n(n+2)}$ BM

1. Werner's Theory and Basic Terms

WERNER'S POSTULATES

Metals show *two kinds of valency: primary (ionisable), satisfied by anions and written outside the square bracket, and secondary (non-*

ionisable), satisfied by ligands and equal to the **coordination number**.

The secondary valencies have **fixed spatial arrangement**, which is what gives the geometry.

THE TERMS **Ligand**: an ion or molecule that donates a **lone pair** to the metal.

Monodentate (NH_3 , Cl^- , CN^-) · **bidentate** (en , $\text{C}_2\text{O}_4^{2-}$) · **hexadentate** (EDTA^{4-}).

Ambidentate ligand: can attach through either of two atoms — NO_2^- (N or O), SCN^- (S or N).

Chelate: a ring formed by a polydentate ligand; chelates are **extra stable** (the chelate effect).

2. Nomenclature

THE RULES IN ORDER 1. Name the **cation first**, then the anion.

2. Within the complex, name **ligands alphabetically**, then the metal.

3. Anionic ligands end in **-o**: chlorido, cyanido, hydroxido, oxalato. Neutral ones

keep their name, except **aqua** (H_2O), **ammine** (NH_3), **carbonyl** (CO), **nitrosyl** (NO).

4. Use di, tri, tetra — but **bis**, **tris**, **tetrakis** for ligands that already contain a prefix (bis(ethylenediamine)).

5. Oxidation state of the metal in **Roman numerals** in brackets.

6. If the complex is an **anion**, the metal name ends in **-ate** (ferrate, cuprate, cobaltate, argentate, plumbate).

WORKED NAMES $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3 \rightarrow$

hexaamminecobalt(III) chloride

$\text{K}_4[\text{Fe}(\text{CN})_6] \rightarrow$ potassium

hexacyanidoferrate(II)

$[\text{Pt}(\text{NH}_3)_2\text{Cl}_2] \rightarrow$

diamminedichloridoplatinum(II)

$[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \rightarrow$

tetraaquadichloridochromium(III) chloride

3. Isomerism

STRUCTURAL ISOMERISM — four types

Type	Difference	Example
------	------------	---------

Ionisation	Exchange between inside and outside the sphere → different ions in solution	$[\text{Co}(\text{NH}_3)_5\text{SO}_4]\text{Br}$ and $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$
Hydrate	Water inside vs outside the sphere	$[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ and $[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$
Linkage	Ambidentate ligand bonded through a different atom	$[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]^{2+}$ and $[\text{Co}(\text{NH}_3)_5(\text{ONO})]^{2+}$
Coordination	Ligands swapped between two complex ions	$[\text{Co}(\text{NH}_3)_6][\text{Cr}(\text{CN})_6]$ and $[\text{Cr}(\text{NH}_3)_6][\text{Co}(\text{CN})_6]$

STEREISOMERISM

Geometrical (cis-trans): shown by square planar MA_2B_2 and octahedral MA_4B_2 / MA_3B_3 .

Tetrahedral complexes do NOT show geometrical isomerism — all four positions are adjacent.

Optical: shown by octahedral complexes with **bidentate** ligands, e.g. $[\text{Co}(\text{en})_3]^{3+}$

and **cis**- $[\text{Co}(\text{en})_2\text{Cl}_2]^+$. The **trans** form has a plane of symmetry and is **optically inactive**.

4. Bonding — VBT and Crystal Field Theory

VALENCE BOND THEORY

Hybridisation	Geometry	Type
d^2sp^3	Octahedral	Inner orbital, low spin (strong field)
sp^3d^2	Octahedral	Outer orbital, high spin (weak field)
dsp^2	Square planar	Usually d^8 , e.g. $[\text{Ni}(\text{CN})_4]^{2-}$
sp^3	Tetrahedral	e.g. $[\text{NiCl}_4]^{2-}$

The classic pair: $[\text{Ni}(\text{CN})_4]^{2-}$ is dsp^2 , square planar, diamagnetic; $[\text{NiCl}_4]^{2-}$ is sp^3 , tetrahedral, paramagnetic — because CN^- is a strong field ligand and Cl^- is weak.

CRYSTAL FIELD THEORY Ligands are treated as point charges that split the five degenerate d orbitals.

Octahedral: t_{2g} (3 orbitals) lowered by $0.4\Delta_o$, e_g (2 orbitals) raised by $0.6\Delta_o$.

Tetrahedral: the reverse order, and $\Delta_t = (4/9)\Delta_o$ — always too small to force

pairing, so tetrahedral complexes are always high spin.

If $\Delta_o > P$ (pairing energy) $\rightarrow$ electrons pair up $\rightarrow$ low spin. If $\Delta_o < P \rightarrow$ high spin.

Colour arises when an electron absorbs light to jump from t_{2g} to e_g ; the colour seen is the complement of the light absorbed.

TRAP $[\text{Ni}(\text{CO})_4]$ is tetrahedral and diamagnetic even though Ni normally is not — CO is so strong a ligand that it pairs the $3d^8$ electrons, giving sp^3 with all electrons paired.

In metal carbonyls the M–C bond has both a σ bond ($\text{C} \rightarrow \text{M}$) and a π back bond ($\text{M} \rightarrow \text{C}$); this synergic effect strengthens M–C and weakens C–O.

WORKED EXAMPLE

Predict the hybridisation, geometry and magnetic behaviour of $[\text{Fe}(\text{CN})_6]^{3-}$.

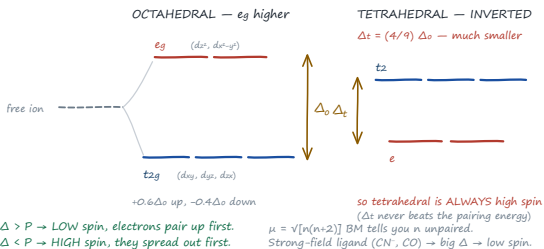
Charge on Fe: $x + 6(-1) = -3 \Rightarrow x = +3 \rightarrow \text{Fe}^{3+}$ is $3d^5$

CN^- is a **strong field ligand** $\rightarrow$ electrons pair up $\rightarrow t_{2g}^5 e_g^0$, leaving **1 unpaired electron**

Hybridisation d^2sp^3 , geometry **octahedral**, **low spin**

$\mu = \sqrt{1(1+2)} = \sqrt{3} = 1.73 \text{ BM} \rightarrow$ **paramagnetic**

Crystal field splitting — octahedral vs tetrahedral



Spectrochemical order: $\text{I}^- < \text{Br}^- < \text{Cl}^- < \text{F}^- < \text{H}_2\text{O} < \text{NH}_3 < \text{en} < \text{NO}_2^- < \text{CN}^- < \text{CO}$. Learn the two ends and you can place the rest.

5. Question Triggers

what the wording wants

If the question says...	The answer is...
" CN^- , CO or NO_2^- as ligand"	Strong field $\rightarrow$ low spin, inner orbital
" Cl^- , F^- , H_2O as ligand"	Weak field $\rightarrow$ high spin, outer orbital
"tetrahedral complex, is it low spin?"	Never — Δ_t is too small
"shows optical isomerism"	Octahedral with bidentate ligands, cis form
"same formula, different ions in solution"	Ionisation isomerism
" NO_2^- bonded through N or O"	Linkage isomerism (ambidentate)
"why is $[\text{Ni}(\text{CO})_4]$ diamagnetic"	CO pairs all electrons; sp^3
"why are complexes coloured"	d-d transition across Δ_o

MOST-ASKED BOARD QUESTIONS

1. [3M] For a given complex, state the **oxidation state, hybridisation, geometry and magnetic moment**.
2. [3M] Explain **crystal field splitting** in octahedral and tetrahedral complexes, with diagrams.
3. [3M] Write IUPAC names / formulas for given coordination compounds.

4. [2M] Draw all the **isomers** of a given complex and identify the optically active one.
5. [2M] Explain why $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic but $[\text{NiCl}_4]^{2-}$ is paramagnetic.
6. [2M] What is the **synergic effect** in metal carbonyls?
7. [1M] Give an example of an **ambidentate ligand**. $\rightarrow \text{NO}_2^-$ or SCN^-

THE HABIT THAT SCORES — Work every bonding question in the same four steps: **oxidation state** $\rightarrow$ **d-electron count** $\rightarrow$ **strong or weak field** $\rightarrow$ **pair or don't pair**. Hybridisation, geometry and magnetic moment all follow automatically, and you never have to memorise individual complexes.

Chapter 6 · Haloalkanes and Haloarenes

CBSE Class 12 Chemistry (043) · Organic · Unit 6 =

6 marks · Ultimate Revision Sheet

60-SECOND RECALL

Reactivity order	R-I > R-Br > R-Cl > R-F (C-X bond strength decides)
S_N1	3° > 2° > 1° · carbocation intermediate · racemisation · polar protic solvent
S_N2	1° > 2° > 3° · one step · inversion (Walden) · polar aprotic solvent
Haloarenes	Much less reactive — resonance + sp ² carbon
Saytzeff rule	Elimination gives the more substituted alkene
Finkelstein	R-Cl + NaI → R-I (dry acetone)
Swarts	R-X + AgF → R-F

1. Nature of the C-X Bond

THE BASICS The C-X bond is **polar** because the halogen is more electronegative: carbon carries δ⁺ and is open to attack by nucleophiles.

Bond length increases C-F < C-Cl < C-Br < C-I, so bond strength decreases in the

same order.

This is why **iodides are the most reactive** and fluorides the least — the weakest bond breaks most easily.

2. Preparation

THE ROUTES ASKED

From alcohols: $R-OH + HX \rightarrow R-X$ (with $ZnCl_2$ for $1^\circ/2^\circ$); better reagents are **PCl_5 , PCl_3 or $SOCl_2$** .

$SOCl_2$ is preferred because the by-products SO_2 and HCl are **gases that escape**, leaving a pure product. (Darzen's procedure.)

From alkenes: addition of HX follows **Markovnikov's rule**; with **peroxide**, HBr adds **anti-Markovnikov** (Kharasch effect) — **only HBr** , not HCl or HI .

Finkelstein: $R-Cl + NaI \rightarrow R-I + NaCl$, in **dry acetone** ($NaCl$ precipitates, driving it forward).

Swarts: $R-X + AgF / Hg_2F_2 \rightarrow R-F$.

Haloarenes: electrophilic substitution with X_2 and a Lewis acid ($Fe/FeCl_3$), or from a diazonium salt by **Sandmeyer's reaction**.

3. Substitution — S_N1 vs S_N2

THE COMPARISON THAT CARRIES THE MARKS

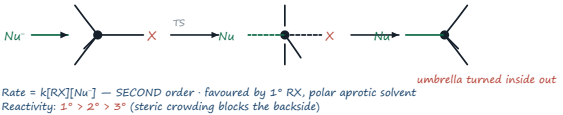
Basis	S_N1	S_N2
Steps	Two ; slow ionisation first	One , concerted
Intermediate	Carbocation	Transition state only
Kinetics	First order — rate = $k[RX]$	Second order — rate = $k[RX][Nu]$
Reactivity	$3^\circ > 2^\circ > 1^\circ > CH_3X$	$CH_3X > 1^\circ > 2^\circ > 3^\circ$
Stereochemistry	Racemisation (flat carbocation, attack from both sides)	Inversion of configuration (Walden inversion)
Solvent	Polar protic (water, alcohol)	Polar aprotic (acetone, DMSO)

Why 3° favours S_N1 : the carbocation is stabilised by +I and hyperconjugation.

Why 1° favours S_N2 : least steric hindrance to backside attack.

S_N2 — one step, backside attack, INVERSION

Nu^- comes in as X^- leaves, through a 5-bonded transition state.



S_N1 — two steps, via a PLANAR carbocation, RACEMISATION



The reactivity orders are **opposite**, and both follow from one idea: S_N2 is blocked by bulk, S_N1 is helped by it. Optically pure substrate + inversion $\rightarrow S_N2$; + racemic product $\rightarrow S_N1$.

4. Elimination and Other Reactions

ELIMINATION

With **alcoholic KOH**, a haloalkane gives an **alkene**

(dehydrohalogenation). With **aqueous KOH** it gives an **alcohol** instead — that single word decides the product.

Saytzeff's rule: the major alkene is the **more substituted** (more stable) one.

THE NAMED REACTIONS

Wurtz: $2R-X + 2Na$ (dry ether) $\rightarrow R-R$ — makes a **symmetrical alkane** with double the carbons.

Fittig: two aryl halides + $Na \rightarrow$ biphenyl.

Wurtz-Fittig: aryl halide + alkyl halide +

Na $\rightarrow$ alkylarene.

Grignard reagent: $R-X + Mg$ (dry ether) $\rightarrow RMgX$. Must be prepared in **completely dry** conditions, because even traces of water decompose it to an alkane.

With $AgCN \rightarrow$ isocyanide (ambident nucleophile, N-attack); with $KCN \rightarrow$ nitrile (C-attack). Same logic: $AgNO_2 \rightarrow$ nitroalkane, $KNO_2 \rightarrow$ alkyl nitrite.

WHY HALOARENES ARE SO UNREACTIVE — the standard 2-marker

1. **Resonance:** the lone pair on the halogen delocalises into the ring, giving the **C-X bond partial double-bond character**, so it is shorter and stronger.

2. **sp^2 carbon:** the carbon bearing X is **sp^2** (more electronegative, holds the bond more tightly) rather than **sp^3** .

3. The ring's π electrons **repel the approaching nucleophile**.

4. The **phenyl cation** formed on ionisation is very unstable.

Substitution does occur under **drastic conditions**, and is much easier if **$-NO_2$ groups are present at ortho and para positions**.

POLYHALOGEN COMPOUNDS — quick facts **$CHCl_3$**

(**chloroform**): on standing in air and light it slowly oxidises to poisonous **phosgene** (**$COCl_2$**), so it is stored in **dark coloured bottles filled to the brim** with 1% ethanol.

CCl_4 : used as a solvent; depletes the ozone layer. **DDT**: first major synthetic

insecticide, now restricted due to persistence. **Freons**: refrigerants, **damage the ozone layer**. **Iodoform CHI_3** : antiseptic.

5. Question Triggers what the reagent tells you

Reagent / clue	Product
Aqueous KOH	Alcohol (substitution)
Alcoholic KOH	Alkene (elimination)
KCN vs AgCN	Nitrile vs isocyanide
KNO_2 vs AgNO_2	Alkyl nitrite vs nitroalkane
Na / dry ether	Wurtz — symmetrical alkane
Mg / dry ether	Grignard reagent
NaI / dry acetone	Finkelstein → alkyl iodide
"optically active product is racemised"	$\text{S}_{\text{N}}1$, via carbocation
"configuration is inverted"	$\text{S}_{\text{N}}2$, Walden inversion

MOST-ASKED BOARD QUESTIONS

1. [3M] Distinguish $\text{S}_{\text{N}}1$ and $\text{S}_{\text{N}}2$ with mechanism, order of reactivity and stereochemistry.
2. [3M] Why are haloarenes less reactive than haloalkanes towards nucleophilic substitution?

3. [2M] Convert: alcohol $\rightarrow$ haloalkane $\rightarrow$ alkene $\rightarrow$ alkane (conversion chains).
4. [2M] Explain Markovnikov and the peroxide effect.
5. [2M] Why is chloroform stored in dark bottles?
6. [1M] Which haloalkane is most reactive in S_N1 ? $\rightarrow$ Tertiary

THE HABIT THAT SCORES — In organic chapters the reagent is the question. Build the habit of reading the reagent first — aqueous or alcoholic, K or Ag salt, with or without peroxide — because each pair differs by one word and changes the entire product.

Chapter 7 · Alcohols, Phenols and Ethers

CBSE Class 12 Chemistry (043) · Organic · Unit 7 =

6 marks · Ultimate Revision Sheet

60-SECOND RECALL

Acidity order	Phenol > water > alcohol · among alcohols 1° > 2° > 3°
Why phenol is acidic	Phenoxide ion is resonance stabilised
Lucas test	3° immediate turbidity · 2° in 5 min · 1° on heating
Victor Meyer	1° red · 2° blue · 3° colourless
Phenol test	Neutral FeCl₃ → violet colour
Williamson	R-X + R'ONa → ether — use primary halide
Kolbe	Phenol + CO ₂ /NaOH → salicylic acid
Reimer–Tiemann	Phenol + CHCl ₃ /NaOH → salicylaldehyde

1. Preparation

ALCOHOLS From alkenes: acid-catalysed hydration (Markovnikov); hydroboration-oxidation with B₂H₆/H₂O₂, OH⁻ gives the anti-Markovnikov alcohol.

From carbonyls: reduction with NaBH₄ or

LiAlH_4 — aldehyde $\rightarrow 1^\circ$ alcohol, ketone $\rightarrow 2^\circ$ alcohol.

From Grignard reagents: $\text{HCHO} \rightarrow 1^\circ$, any other aldehyde $\rightarrow 2^\circ$, ketone $\rightarrow 3^\circ$ alcohol. This pattern is asked constantly.

PHENOLS From cumene (the industrial route): cumene + $\text{O}_2 \rightarrow$ cumene

hydroperoxide $\rightarrow$ with dilute acid gives phenol + acetone.

From haloarenes: chlorobenzene + NaOH at 623 K, 300 atm (Dow's process).

From diazonium salts: warm with water.

From benzene sulphonic acid: fuse with NaOH .

2. Acidity — the central idea of the chapter

WHY PHENOL IS MORE ACIDIC THAN AN ALCOHOL

On losing H^+ , phenol gives the phenoxide ion, whose negative charge is delocalised over the ring by resonance — so it is stable.

An alkoxide ion has no such delocalisation, and the +I effect of the alkyl group

actually **intensifies** the negative charge, destabilising it.

Among alcohols, acidity falls $1^\circ > 2^\circ > 3^\circ$, because more alkyl groups mean more +I effect.

SUBSTITUENT EFFECT ON PHENOL

Electron-withdrawing groups ($-\text{NO}_2$, $-\text{X}$)

INCREASE acidity — they spread the negative charge further. Order: picric acid (2,4,6-trinitrophenol) > nitrophenol > phenol.

Electron-donating groups ($-\text{CH}_3$, $-\text{OCH}_3$)

DECREASE acidity — cresol is a weaker acid than phenol.

3. Reactions of Alcohols

THE KEY REACTIONS

With Na: gives alkoxide + H_2 — shows the acidic hydrogen.

Esterification: alcohol + carboxylic acid / acid chloride / anhydride $\rightarrow$ **ester**. The reaction with an acid chloride is faster and is called **acetylation**.

Dehydration with conc. H_2SO_4 : at 443 K $\rightarrow$ alkene; at 413 K $\rightarrow$ ether. The

temperature is the whole question. Ease of dehydration: $3^\circ > 2^\circ > 1^\circ$.

Oxidation: $1^\circ \rightarrow$ aldehyde $\rightarrow$ carboxylic acid; **PCC stops at the aldehyde.** $2^\circ \rightarrow$ ketone. 3° resists oxidation (no α -H on the carbinol carbon).

THE THREE DISTINGUISHING TESTS

Test	1°	2°	3°
Lucas (conc. HCl + ZnCl ₂)	Turbidity only on heating	Turbidity in ~5 min	Immediate turbidity
Victor Meyer	Red	Blue	Colourless
Oxidation	Aldehyde then acid	Ketone	No reaction

4. Reactions of Phenol

THE NAMED REACTIONS

Kolbe's reaction:

sodium phenoxide + CO₂ (400 K, 4–7 atm), then H⁺ $\rightarrow$ **salicylic acid** (2-hydroxybenzoic acid) — the precursor of aspirin.

Reimer–Tiemann: phenol + CHCl₃ +

NaOH, then H⁺ $\rightarrow$ **salicylaldehyde** (2-hydroxybenzaldehyde). The attacking species is **dichlorocarbene**, :CCl₂.

Bromination: with bromine water phenol gives an immediate white precipitate of 2,4,6-tribromophenol; in CS_2 at low temperature it gives mainly the para monobromo product.

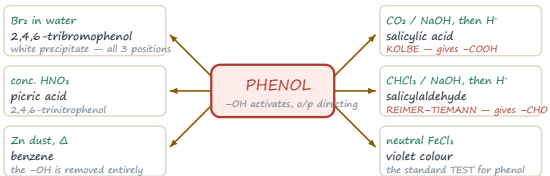
With neutral $FeCl_3$: a violet colour — the standard test for phenol.

Nitration: dilute HNO_3 gives o- and p-nitrophenol; conc. HNO_3 gives picric acid.

TRAP The $-OH$ group is strongly activating and ortho/para directing, which is why phenol reacts with bromine water without any catalyst while benzene needs a Lewis acid.

Phenol does not undergo the Friedel-Crafts reaction well with $AlCl_3$, because the Lewis acid bonds to the $-OH$ oxygen.

Phenol — the six reactions worth memorising as a map



Acidity: **picric acid** > **nitrophenol** > **phenol** > **ethanol** — phenol beats alcohol because the phenoxide ion is resonance stabilised; -NO₂ groups stabilise it further, -CH₃ groups do the opposite. But phenol does NOT react with NaHCO₃ — a carboxylic acid does. That is how you tell them apart.

Kolbe gives **-COOH**, Reimer-Tiemann gives **-CHO**. Both attach at the ortho position, and mixing up which reagent gives which is the usual lost mark.

5. Ethers

PREPARATION AND REACTIONS Williamson

synthesis: $R-X + R'O^-Na^+ \rightarrow \text{ether}$. It is an S_N2 reaction, so the halide **must be primary** — a tertiary halide gives the alkene by elimination instead. This is a favourite trap.

Cleavage by HX: the halide attacks the smaller alkyl group (S_N2), giving an alkyl halide plus an alcohol. If one group is tertiary, it goes by S_N1 and the tertiary halide forms.

Anisole (methoxybenzene) with HI gives **phenol + methyl iodide**, never

iodobenzene, because the C–O bond to the ring has partial double bond character.

6. Question Triggers what the reagent tells you

Reagent / clue	Product or answer
Conc. H_2SO_4 , 443 K	Alkene
Conc. H_2SO_4 , 413 K	Ether
PCC	1° alcohol → aldehyde (stops there)
$\text{CHCl}_3 + \text{NaOH}$ on phenol	Salicylaldehyde (Reimer–Tiemann)
$\text{CO}_2 + \text{NaOH}$ on phenol	Salicylic acid (Kolbe)
Neutral $\text{FeCl}_3 \rightarrow$ violet	Phenol present
Bromine water $\rightarrow$ white ppt	2,4,6-tribromophenol
B_2H_6 then $\text{H}_2\text{O}_2/\text{OH}^-$	Anti-Markovnikov alcohol
"distinguish 1°, 2°, 3° alcohol"	Lucas or Victor Meyer test

MOST-ASKED BOARD QUESTIONS

1. [3M] Why is phenol more acidic than ethanol? Explain using resonance, and order substituted phenols by acidity.
2. [3M] Write the Kolbe and Reimer–Tiemann reactions with equations.

3. [2M] Explain the **Williamson synthesis** and why a tertiary halide fails.
4. [2M] How will you distinguish between **1°, 2° and 3°** alcohols?
5. [2M] Conversion chains: propene → propan-2-ol, phenol → aspirin, etc.
6. [1M] What does phenol give with **neutral FeCl_3** ? → **Violet colour**

THE HABIT THAT SCORES — Nearly every "explain the order" question in this chapter is answered by **resonance stabilisation of the anion** or the **+I / -I effect**. Name the effect, then say whether it stabilises or destabilises the conjugate base — that two-step sentence is the full mark.

Chapter 8 · Aldehydes, Ketones and Carboxylic Acids

CBSE Class 12 Chemistry (043) · Organic · Unit 8

= 8 marks (highest in organic) · Ultimate Revision Sheet

60-SECOND RECALL

Reactivity to Nu	HCHO > CH₃CHO > ketone — steric + electronic
Tollens	Silver mirror — aldehyde only
Fehling	Red-brown Cu₂O — aliphatic aldehyde only (not aromatic)
Iodoform	Needs CH₃CO- or CH₃CH(OH)- → yellow CHI ₃
Aldol	Needs α-hydrogen
Cannizzaro	Needs NO α-hydrogen (HCHO, C ₆ H ₅ CHO)
Acidity	Carboxylic acid > phenol > alcohol
HVZ	X ₂ /red P → α-halo acid (needs α-H)

1. The Carbonyl Group

STRUCTURE AND REACTIVITY

The carbonyl carbon is sp^2 , planar, and carries δ^+ — so it is attacked by **nucleophiles** (unlike alkenes, which attract electrophiles).

Order of reactivity towards nucleophilic addition:



Two reasons, always give both: (1) +I effect of alkyl groups reduces the δ^+ on carbon; (2) **steric hindrance** blocks the nucleophile. Aryl groups also deactivate by **resonance**.

2. Preparation

THE ROUTES ASKED Aldehydes: oxidation of

1° alcohol with **PCC**; **Rosenmund reduction** (acid chloride + $\text{H}_2/\text{Pd}-\text{BaSO}_4$);

Stephen reaction (nitrile + SnCl_2/HCl);

DIBAL-H on nitriles or esters.

Ketones: oxidation of 2° alcohol; acid chloride + **dialkylcadmium**; **Friedel-Crafts acylation** for aryl ketones.

From alkynes: hydration of ethyne gives acetaldehyde; any other alkyne gives a ketone.

Carboxylic acids: oxidation of 1° alcohol or

aldehyde; hydrolysis of nitriles; Grignard + CO_2 then H^+ (adds one carbon).

3. Reactions of Aldehydes and Ketones

NUCLEOPHILIC ADDITION $\text{HCN} \rightarrow$ cyanohydrin

· $\text{NaHSO}_3 \rightarrow$ bisulphite adduct (used to purify carbonyls) · alcohol $\rightarrow$ hemiacetal then acetal · Grignard $\rightarrow$ alcohol.

Addition-elimination with ammonia derivatives: with 2,4-DNP $\rightarrow$ orange-yellow precipitate (the standard test for a carbonyl group); with $\text{NH}_2\text{OH} \rightarrow$ oxime; with $\text{NH}_2\text{NH}_2 \rightarrow$ hydrazone.

THE TWO REACTIONS DECIDED BY α -HYDROGEN

Aldol condensation — requires at least one α -H. Two molecules combine in dilute alkali to give a β -hydroxy aldehyde or ketone, which on heating loses water to give an α,β -unsaturated product.

Cannizzaro reaction — requires NO α -H. With concentrated alkali the aldehyde disproportionates into an alcohol and a salt of the acid. Classic examples: HCHO and benzaldehyde.

Check the α -hydrogen first and the question answers itself.

OXIDATION AND REDUCTION Aldehydes oxidise easily to acids; ketones resist oxidation and need drastic conditions (C-C cleavage, Popoff's rule).

Reduction: $\text{NaBH}_4/\text{LiAlH}_4 \rightarrow$ alcohol. To go all the way to the hydrocarbon: Clemmensen ($\text{Zn-Hg}/\text{HCl}$, acidic) or Wolff-Kishner ($\text{NH}_2\text{NH}_2/\text{KOH}$, basic). Pick by whether the molecule tolerates acid or base.

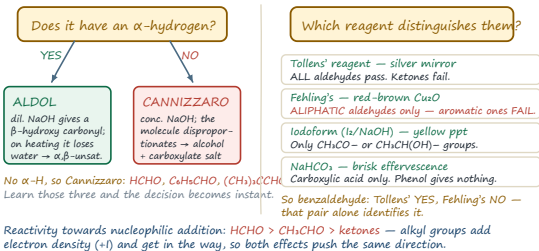
THE DISTINGUISHING TESTS — know exactly what each detects

Test	Positive result	Detects
Tollens' (ammoniacal AgNO_3)	Silver mirror	All aldehydes ; ketones do not respond
Fehling's	Red-brown ppt of Cu_2O	Aliphatic aldehydes only — aromatic ones fail
Iodoform (I_2/NaOH)	Yellow CHI_3	$\text{CH}_3\text{CO-}$ or $\text{CH}_3\text{CH(OH)-}$ group
2,4-DNP	Orange-yellow ppt	Any aldehyde or ketone

The classic exam pair: benzaldehyde gives Tollens' but **not** Fehling's. Acetone gives

iodoform but **not** Tollens'.

Two decisions settle almost every carbonyl question



If a question gives you conc. NaOH and an aldehyde with no α -H, it is Cannizzaro every time. If it gives dil. NaOH and an α -H is present, it is aldol.

4. Carboxylic Acids

ACIDITY — the reasoning asked The carboxylate

ion is resonance stabilised over two equivalent oxygens, which makes the acid far stronger than phenol (where the charge is spread over carbon atoms) or an alcohol.

Electron-withdrawing groups increase acidity: $\text{FCH}_2\text{COOH} > \text{ClCH}_2\text{COOH} >$

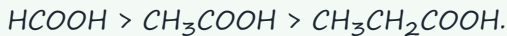
BrCH_2COOH , and $\text{Cl}_3\text{CCOOH} >$

$\text{Cl}_2\text{CHCOOH} > \text{ClCH}_2\text{COOH}$.

The effect falls off with distance: 2-chlorobutanoic acid is stronger than 3-

chloro, which is stronger than 4-chloro.

Electron-donating groups decrease acidity:



REACTIONS With $\text{NaHCO}_3 \rightarrow$ brisk

effervescence of CO_2 — this distinguishes a carboxylic acid from a phenol, which does **not** react.

Esterification with alcohol/ H^+ · $\text{SOCl}_2 \rightarrow$ acid chloride · NH_3 then heat $\rightarrow$ amide · $\text{LiAlH}_4 \rightarrow 1^\circ$ alcohol (NaBH_4 will not reduce an acid).

Decarboxylation: sodium salt + soda lime $\rightarrow$ alkane with **one carbon less**.

HVZ reaction: $\text{X}_2/\text{red P}$ gives the α -halo acid — requires an α -hydrogen, so HCOOH does not undergo it.

WORKED EXAMPLE — a typical identification question

An organic compound gives a *silver mirror with Tollens'*, *no colour with Fehling's*, and *undergoes Cannizzaro with conc. NaOH*. Identify it.

Tollens' positive $\rightarrow$ it is an *aldehyde*
Fehling's negative $\rightarrow$ it is *aromatic*
Cannizzaro $\rightarrow$ it has *no α -hydrogen*
 $\Rightarrow$ the compound is *benzaldehyde*, C_6H_5CHO .

5. Question Triggers what the reagent tells you

Reagent / observation	Conclusion
Tollens' positive, Fehling's negative	Aromatic aldehyde
Iodoform positive	Has CH_3CO- or $CH_3CH(OH)-$
Effervescence with $NaHCO_3$	Carboxylic acid (phenol gives none)
Conc. NaOH, no α-H	Cannizzaro
Dilute NaOH, has α-H	Aldol
Zn-Hg / HCl	Clemmensen $\rightarrow C=O$ to CH_2
NH_2NH_2 / KOH, glycol	Wolff-Kishner $\rightarrow C=O$ to CH_2
$H_2/Pd-BaSO_4$	Rosenmund $\rightarrow$ aldehyde
X_2 / red P	HVZ $\rightarrow \alpha$ -halo acid

MOST-ASKED BOARD QUESTIONS

1. [3M] Distinguish between the given pairs of compounds using chemical tests.
2. [3M] Explain the **aldol** and **Cannizzaro** reactions with mechanisms and examples.
3. [3M] Arrange given acids in order of **acidity** and justify.
4. [2M] Why are aldehydes **more reactive than ketones** towards nucleophilic addition?
5. [2M] Conversion chains, e.g. ethanol $\rightarrow$ ethanoic acid $\rightarrow$ ethanoyl chloride $\rightarrow$ ethanamide.
6. [1M] Which reagent distinguishes a carboxylic acid from a phenol? $\rightarrow$ **NaHCO_3**

THE HABIT THAT SCORES — For any aldehyde/ketone question, ask two things in order: **does it have an α -hydrogen?** and **is it aromatic?** Those two answers decide aldol vs Cannizzaro and Fehling's vs Tollens' — which between them account for most of the marks in this unit.

Chapter 9 · Amines

CBSE Class 12 Chemistry (043) · Organic · Unit 9 =

6 marks · Ultimate Revision Sheet

60-SECOND RECALL

Basicity in water	$2^\circ > 1^\circ > 3^\circ > \text{NH}_3$ (for ethyl; the order is a balance of three effects)
Aromatic vs aliphatic	Aniline is much WEAKER — lone pair delocalised into the ring
Carbylamine test	1° amine only → foul-smelling isocyanide
Hinsberg	Distinguishes 1°, 2°, 3°
Gabriel	Gives pure 1° amine — fails for aromatic amines
Hofmann bromamide	Amide → amine with ONE carbon less
Diazotisation	$\text{NaNO}_2 + \text{HCl}$, 273–278 K
Coupling	Diazonium + phenol/aniline → azo dye (orange/yellow)

1. Structure and Classification

THE BASICS

Amines are derivatives of ammonia with one, two or three H atoms replaced — 1°, 2°, 3°. Nitrogen is sp^3 and the shape is **pyramidal** with a lone pair.

Boiling points: $1^\circ > 2^\circ > 3^\circ$, because 3° amines have no N-H bond and therefore no intermolecular hydrogen bonding.

2. Preparation

THE FOUR METHODS

1. Reduction of nitro compounds: H_2/Pd , or Sn/HCl — nitrobenzene $\rightarrow$ aniline.

2. Ammonolysis of alkyl halides: gives a mixture of 1° , 2° , 3° and quaternary salt. Using a large excess of ammonia favours the 1° amine.

3. Gabriel phthalimide synthesis: gives a pure primary amine. It cannot be used for aromatic amines, because aryl halides do not undergo the required nucleophilic substitution with the phthalimide anion.

4. Hofmann bromamide degradation: amide + $\text{Br}_2/\text{KOH} \rightarrow$ primary amine with one carbon fewer. Watch for questions that need a carbon removed — this is the reaction.

Also: reduction of nitriles (LiAlH_4) gives an amine with the **same** number of carbons.

3. Basicity — the heart of the chapter

THE THREE COMPETING EFFECTS 1. +I effect:

alkyl groups push electron density onto N
→ more basic.

2. Steric hindrance: too many bulky groups block the proton → less basic.

3. Solvation: the more N-H bonds the cation has, the better it is stabilised by hydrogen bonding with water → more basic.

Net result in water: $2^\circ > 1^\circ > 3^\circ > \text{NH}_3$
for ethylamines. In the gas phase, where solvation is absent, it is simply $3^\circ > 2^\circ > 1^\circ$.

WHY ANILINE IS A WEAK BASE — guaranteed question

In aniline, the lone pair on nitrogen is delocalised into the benzene ring by resonance, so it is less available for donation to a proton. The anilinium ion formed has no such stabilisation.

Order: aliphatic amine > ammonia > aniline.

Substituents: electron-donating groups ($-\text{CH}_3$, $-\text{OCH}_3$) increase basicity; electron-

withdrawing groups ($-\text{NO}_2$) decrease it sharply. So p -toluidine $>$ aniline $>$ p -nitroaniline.

4. Reactions

THE IDENTIFICATION TESTS Carbylamine

(isocyanide) test: amine + CHCl_3 + alcoholic $\text{KOH} \rightarrow$ foul-smelling isocyanide. Given only by 1° amines, aliphatic or aromatic.

Hinsberg's test with benzenesulphonyl chloride: 1° gives a product soluble in alkali (it still has an acidic N-H); 2° gives one insoluble in alkali; 3° does not react.

With HNO_2 : 1° aliphatic $\rightarrow$ alcohol + N_2 gas; 1° aromatic $\rightarrow$ diazonium salt; $2^\circ \rightarrow$ nitrosamine (yellow oily); $3^\circ \rightarrow$ salt.

ACYLATION AND RING SUBSTITUTION

Acetylation of aniline with acetic anhydride gives acetanilide. This is used to protect the $-\text{NH}_2$ group before nitration or bromination, because the free amino group is so strongly activating that it would give the trisubstituted product.

Aniline + bromine water $\rightarrow$ 2,4,6-tribromoaniline (white precipitate) — the activating $-\text{NH}_2$ makes control impossible without protection.

Aniline does not undergo Friedel-Crafts, because AlCl_3 bonds to the lone pair on nitrogen, making it a deactivating group.

5. Diazonium Salts

PREPARATION AND THE REACTION MAP

Diazotisation: aniline + $\text{NaNO}_2 + \text{HCl}$ at $273\text{--}278\text{ K}$ $\rightarrow$ benzenediazonium chloride. The low temperature is essential — the salt decomposes above about 278 K .

Reagent	Product
CuCl/HCl or CuBr/HBr (Sandmeyer)	Chlorobenzene / bromobenzene
Cu powder + HX (Gattermann)	Chloro / bromobenzene
KI	Iodobenzene
HBF_4, then heat	Fluorobenzene
H_2O, warm	Phenol
H_3PO_2 or ethanol	Benzene (removes the group entirely)

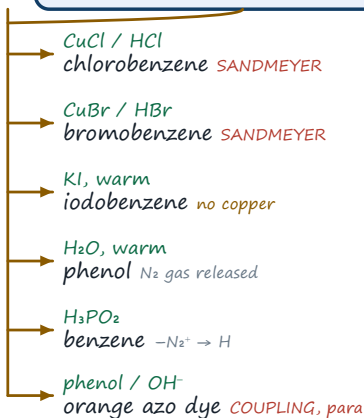
Phenol / aniline in
mild alkali

Azo dye — coupling reaction

Coupling occurs at the *para* position and produces intensely coloured *azo compounds* used as dyes.

TRAP The diazonium route is the *only* practical way to put $-I$ or $-F$ on a benzene ring, and the only way to make phenol or benzene *from aniline*. Any question asking for an aryl iodide almost certainly wants diazotisation.

Diazonium salt — the junction box



WHAT THE MAP IS FOR Temperature is part of the answer. The salt is made at 273–278 K; above 278 K it decomposes to phenol on its own.

This route is the **only practical way to put $-\text{I}$ or $-\text{F}$ on a benzene ring**, and the only way to make phenol or benzene from aniline. Any question asking for an aryl iodide almost certainly wants diazotisation.

Basicity in water: $2^\circ > 1^\circ > 3^\circ > \text{NH}_3$ for aliphatic amines — 3° drops because it is

too crowded to hydrate. **Aromatic amines** are far weaker: the lone pair is delocalised into the ring.

Carbylamine test ($\text{CHCl}_3 + \text{alc. KOH}$, foul smell) is given by **1° amines only**;
Hinsberg's test separates all three.

6. Question Triggers what the reagent tells you

Reagent / observation	Conclusion
$\text{CHCl}_3 + \text{alc. KOH}$, foul smell	1° amine (carbylamine test)
Br_2/KOH on an amide	Hofmann → amine, one carbon less
Phthalimide route	Gabriel → pure 1° aliphatic amine
$\text{NaNO}_2 + \text{HCl}$ at 273–278 K	Diazonium salt
Orange dye formed	Coupling reaction
CuCl / HCl	Sandmeyer
"why is aniline a weaker base"	Lone pair delocalised into the ring
"why acetylate before nitration"	To control the strongly activating $-\text{NH}_2$

MOST-ASKED BOARD QUESTIONS

1. [3M] Arrange amines in order of **basic strength** and justify, in water and in the gas phase.

2. [3M] Write the **Gabriel** and **Hofmann bromamide** reactions; why does Gabriel fail for aromatic amines?
3. [3M] Give the reactions of **benzenediazonium chloride** with any three reagents.
4. [2M] How do you distinguish 1° , 2° and 3° amines?
5. [2M] Why is **aniline acetylated** before nitration?
6. [1M] Which test is given only by primary amines? $\rightarrow$ **Carbylamine**

THE HABIT THAT SCORES — Draw the diazonium reaction map as a wheel with the salt at the centre.

Almost every aromatic conversion question in the paper

- aniline to phenol, to iodobenzene, to benzene, to a dye
- is one spoke of that wheel.

Chapter 10 · Biomolecules

CBSE Class 12 Chemistry (043) · Organic · Unit 10

= 7 marks · Ultimate Revision Sheet

60-SECOND RECALL

Reducing sugars	All monosaccharides + maltose, lactose · sucrose is NOT
Sucrose	Glucose + fructose, α-1,2 glycosidic · invert sugar on hydrolysis
Starch	Amylose (linear) + amylopectin (branched)
Protein bond	Peptide bond, $-\text{CO}-\text{NH}-$
Essential amino acids	Cannot be synthesised by the body
Denaturation	2° and 3° structure destroyed; 1° stays intact
Vitamin C, B	Water soluble · A, D, E, K fat soluble
DNA vs RNA	DNA: deoxyribose, T , double helix · RNA: ribose, U , single strand

1. Carbohydrates

CLASSIFICATION **Monosaccharides** (glucose, fructose) cannot be hydrolysed further. **Disaccharides** (sucrose, maltose, lactose) give two units. **Polysaccharides** (starch, cellulose, glycogen) give many. **Reducing sugars** reduce Tollens' and

Fehling's: all monosaccharides, plus maltose and lactose. Sucrose is non-reducing, because both anomeric carbons are locked in the glycosidic link.

GLUCOSE — structure evidence asked directly Open chain: $\text{CHO}-(\text{CHOH})_4-\text{CH}_2\text{OH}$, an aldohexose, D-(+)-glucose.

Reaction	What it proves
HI, long heating $\rightarrow$ n-hexane	Straight chain of six carbons
Tollens'/Fehling's positive; HCN $\rightarrow$ cyanohydrin	Contains a -CHO group
Acetic anhydride $\rightarrow$ penta-acetate	Five -OH groups
Br_2 water $\rightarrow$ gluconic acid	-CHO oxidises to -COOH
$\text{HNO}_3 \rightarrow$ saccharic acid	Primary -OH also oxidises

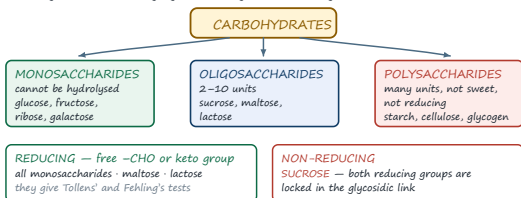
Two facts the open chain could NOT explain: glucose does not give the 2,4-DNP / NaHSO_3 tests properly, and it shows mutarotation — which is why the cyclic pyranose structure with α and β anomers was proposed.

THE POLYSACCHARIDES Starch = amylose (linear, α -1,4) + amylopectin (branched, α -1,4 and α -1,6). Storage form in plants.

Cellulose = linear chains of β -D-glucose joined β -1,4. Humans lack the enzyme for β links, which is why we cannot digest it.

Glycogen = "animal starch", more highly branched than amylopectin; stored in liver and muscle.

Carbohydrates — classify by how many units, then by whether it reduces



Sucrose $\rightarrow$ glucose + fructose on hydrolysis. The rotation flips from $+66^\circ$ to -20° , which is why it is called **INVERT SUGAR** — and both products **ARE** reducing, even though sucrose is not.

Protein traps: denaturation destroys 2° and 3° structure only, the primary sequence survives.

Starch and cellulose differ in **one bond**: starch is α -glycosidic (we digest it), cellulose is β -glycosidic (we cannot). That single letter is the whole answer.

2. Proteins

AMINO ACIDS Contain both $-NH_2$ and $-COOH$. In solution they exist as the **zwitterion** $^+H_3N-CHR-COO^-$, which is why they have **high melting points** and behave like ionic solids.

At the **isoelectric point** the amino acid has no net charge and does not migrate in an electric field.

Essential amino acids must come from the diet (valine, leucine, lysine...); **non-essential** ones the body makes itself.

THE FOUR LEVELS OF STRUCTURE

Primary: the sequence of amino acids joined by **peptide bonds**.

Secondary: local folding into an α -helix or β -pleated sheet, held by **hydrogen bonds**.

Tertiary: overall three-dimensional folding, held by disulphide bridges, hydrogen bonds, and hydrophobic interactions.

Quaternary: how two or more polypeptide chains pack together (e.g. haemoglobin).

DENATURATION — asked every year

Heat, acid or heavy metals destroy the **secondary** and **tertiary** structure, so the protein loses its biological activity. The **primary** structure remains intact.

Everyday examples: boiling an egg (albumin coagulates), curdling of milk.

ENZYMES

Enzymes are **biological catalysts**, almost all **globular proteins**. They are

highly specific — one enzyme, one reaction — and work by *lowering the activation energy*. Names usually end in -ase (maltase, urease).

3. Vitamins and Nucleic Acids

VITAMINS — the deficiency table

Vitamin	Solubility	Deficiency disease
A	Fat	Xerophthalmia, night blindness
B₁	Water	Beri beri
B₆	Water	Convulsions
B₁₂	Water	Pernicious anaemia
C	Water	Scurvy
D	Fat	Rickets and osteomalacia
E	Fat	Sterility, muscular weakness
K	Fat	Increased blood clotting time

Water soluble: B and C — must be supplied regularly since they are excreted.

Fat soluble: A, D, E, K — stored in liver and fatty tissue.

NUCLEIC ACIDS A *nucleoside* = sugar + base.

A *nucleotide* = sugar + base + *phosphate*.

Nucleotides join through *phosphodiester linkages*.

Basis	DNA	RNA
Sugar	2-deoxy-D-ribose	D-ribose
Bases	A, G, C, T	A, G, C, U
Strands	Double helix	Usually single
Function	Stores genetic information; replication	Protein synthesis

Base pairing: A–T (two H bonds) and G–C (three H bonds) — the two strands are complementary, which is the basis of replication.

4. Question Triggers what the wording wants

If the question says...	The answer is...
"does not reduce Fehling's solution"	Sucrose — non-reducing
"glucose gives penta-acetate"	It has five –OH groups
"why cyclic structure was proposed"	Mutarotation ; fails some –CHO tests
"boiling an egg / curdling milk"	Denaturation
"which structure survives denaturation"	Primary
"deficiency causes scurvy / rickets"	Vitamin C / Vitamin D
"base present in RNA but not DNA"	Uracil
"linkage in cellulose"	β-1,4 glycosidic

MOST-ASKED BOARD QUESTIONS

1. [3M] Describe the **structure of glucose** and the reactions that establish it.
2. [3M] Explain the **four levels of protein structure** and what denaturation destroys.
3. [3M] Compare **DNA and RNA** on sugar, bases, structure and function.
4. [2M] What are **essential and non-essential** amino acids? Give one example of each.
5. [2M] Why is sucrose called **invert sugar** and why is it non-reducing?
6. [1M] Name the vitamin whose deficiency causes **increased blood clotting time**. → Vitamin K

THE HABIT THAT SCORES — This chapter is almost pure recall, so it is the cheapest 7 marks in the paper. Learn the four small tables — reducing sugars, protein structure levels, vitamin deficiencies, DNA vs RNA — and you have nearly the whole unit.

Chapter 11 · The Four Formative-Only Topics

CBSE Class 12 Chemistry (043) · NOT in the 70-mark board paper · kept because schools still test them

READ THIS FIRST — WHY THIS CHAPTER EXISTS

The official 2026-27 syllabus lists these four topics and then says, in its own words, that they "will be assessed only formatively to reinforce understanding without adding to summative assessments."

So they are NOT part of the 70-mark board examination and carry no unit marks. They are also not in the 10-unit marks table.

They are kept here, at a summary level only, because school unit tests and internal assessments still ask them, and because dropping prescribed content silently is worse than flagging it. **Revise the ten real units first** — come here only if you have time left.

1. Surface Chemistry

ADSORPTION

Adsorption is the accumulation of a substance at a **surface**; **absorption** is uniform distribution throughout the bulk. **Sorption** is when both occur.

Basis	PHYSISORPTION	CHEMISORPTION
Forces	Weak van der Waals	Chemical bond
Enthalpy	Low, 20–40 kJ mol ⁻¹	High, 80–240 kJ mol ⁻¹
Specificity	Not specific	Highly specific
Reversibility	Reversible	Irreversible
Temperature	Decreases with rise	First increases, then decreases
Layers	Multilayer	Monolayer

Factors affecting adsorption of gases on solids: nature of the gas (easily liquefiable gases adsorb more), **surface area** (more area → more adsorption), **pressure** (increases adsorption), and **temperature** (generally decreases physisorption).

COLLOIDS

Basis	True solution	Colloid	Suspension
Particle size	< 1 nm	1–1000 nm	> 1000 nm

Tyndall effect	No	Yes	Yes
Filterability	Passes all filters	Passes filter paper, not ultrafilter	Retained

Lyophilic sols are solvent-loving, **reversible and stable** (starch, gum). **Lyophobic** sols are solvent-hating, **irreversible and need a stabiliser** (metal sols).

Coagulation is the precipitation of a colloid by adding an electrolyte. **Hardy-Schulze rule**: the greater the **charge on the coagulating ion**, the greater its power — $Al^{3+} > Ba^{2+} > Na^{+}$ for a negative sol.

Emulsions: **oil in water** (milk) and **water in oil** (butter), stabilised by an **emulsifier**.

2. Isolation of Elements

THE THREE STAGES

1. Concentration of the ore: **hydraulic washing** (density), **magnetic separation**, **froth flotation** (sulphide ores), **leaching** (chemical, e.g. bauxite with NaOH).

2. Reduction to the crude metal: **calcination** (heating in limited air, for carbonates) and **roasting** (heating in excess air, for sulphides), followed by reduction with **carbon**, or by **electrolysis** for very

reactive metals such as Al, Na and Mg.

3. Refining: electrolytic refining (Cu), **zone refining** (Si, Ge — uses different solubility of impurities in solid and molten states), **vapour phase refining** (Mond process for Ni, van Arkel for Ti and Zr), and **chromatography**.

Ellingham diagram: plots ΔG° against temperature and shows **which reducing agent works at which temperature** — a reduction is feasible when ΔG° becomes negative.

3. Polymers

CLASSIFICATION AND EXAMPLES

Homopolymer: one monomer (polythene, PVC).

Copolymer: two or more (Buna-S from butadiene + styrene; nylon-6,6).

Addition polymerisation: monomers with double bonds add on with **no by-product** — polythene, PVC, polystyrene, Teflon.

Condensation polymerisation: repeated condensation with **loss of a small molecule** (usually water) — **nylon-6,6** (adipic acid + hexamethylenediamine), **terylene/dacron** (ethylene glycol + terephthalic acid),

bakelite.

Natural rubber is *cis*-polyisoprene; vulcanisation with sulphur makes it harder and more elastic by forming cross-links.

Biodegradable polymers: PHBV and nylon-2-nylon-6.

4. Chemistry in Everyday Life

MEDICINES BY FUNCTION

Class	Does what	Examples
Analgesic	Relieves pain	Aspirin, paracetamol, morphine (narcotic)
Tranquiliser	Treats stress, anxiety	Equanil, valium, barbiturates
Antiseptic	Applied to living tissue	Dettol, savlon, 0.2% phenol
Disinfectant	Applied to non-living objects	1% phenol , chlorine in water
Antibiotic	Kills or inhibits microbes	Penicillin, chloramphenicol
Antacid	Reduces stomach acid	Ranitidine, omeprazole, $\text{Mg}(\text{OH})_2$
Antihistamine	Treats allergy	Cetirizine, brompheniramine
Antifertility	Birth control	Norethindrone, ethynylestradiol

Phenol is the classic trap: 0.2% is an antiseptic, 1% is a disinfectant — the

same substance, different concentration.

Food chemicals: preservatives (sodium benzoate), **artificial sweeteners** (aspartame — unstable when cooked; saccharin; sucralose — stable at cooking temperature), **antioxidants** (BHA, BHT).

HOW TO USE THIS CHAPTER — Treat it as insurance for school tests, not board preparation. If your revision time is limited, the **ten examinable units are always the better investment** — every mark in the board paper comes from those. Confirm with your teacher whether your school is testing these four topics this year.