

Contents

1.1 Atomic Models — Scientist Timeline	2
1.2 Subatomic Particles, Electronic Configuration & Quantum Rules	3
1.3 Atomic Number, Mass Number & the Isotope Family	3
1.4 Radioactivity & Applications of Isotopes	4
2.1 States of Matter — Five States & Gas Laws	5
2.2 Mixtures — Solutions, Colloids & Suspensions	5
2.3 Separation Techniques	6
2.4 Phase Transitions & Latent Heat	6
2.5 Physical vs Chemical Changes	7
2.6 Types of Chemical Reactions	8
3.1 Periodic Table — Historical Development	9
3.2 Periodic Table — Blocks, Groups & Trends	9
3.3 Metals vs Non-metals vs Metalloids	10
3.4 Reactivity Series & Metal Reactions	10
3.5 Corrosion — Rusting, Tarnishing & Prevention	11
4.1 Ores & Minerals — Concepts + Master Ore Table	11
4.2 Metallurgy — Extraction Steps	12
4.3 Bihar/India Mineral Geography	13
4.4 Calcium Compounds — Family Table	13
4.5 Sodium Compounds & Water Hardness	14
4.6 Glass Types & Other Key Inorganic Compounds	14
5.1 Alloys — Master Table & Carat System	16
6.1 Non-metals — Allotropes of Carbon	16
6.2 Non-metals — Hydrogen and its Compounds	17
6.3 Non-metals — Sulphur and its Compounds	17
6.4 Non-metals — Nitrogen, Halogens & Inert Gases	18
6.5 Acid-Base-Salt — Theories of Acids and Bases	18
6.6 Common Acids & Natural/Chemical Indicators	19
6.7 Salts, Strong/Weak Acids & the pH Scale	19
7.1 Hydrocarbons — Saturated & Unsaturated	21
7.2 Aromatic Hydrocarbons — Benzene & its Reactions	21
7.3 Alcohols	22
7.4 Organic (Carboxylic) Acids	22
7.5 Explosive Substances	22
7.6 Polymers — Natural & Synthetic	23
7.6b Vulcanization & Thermoplastic vs Thermosetting	24
7.7 Fuels & Combustion — Calorific Values & Coal Types	24
7.8 LPG/CNG/Biogas & Fire Extinguishers	25
8.1 Drugs & Medicines — Classification	26

8.2 Named-Drug Trick Facts & Matching	26
8.3 Food Chemistry — Artificial Sweeteners	27
8.4 Food Preservatives, Antioxidants & Handling Chemicals	27
9.1 Soap — Composition & Saponification.....	27
9.2 Detergents — Composition & Advantage over Soap.....	28
10.1 Fertilizers — NPK Table, Haber Process & Biofertilizers.....	29
11.1 Miscellaneous — Air Pollutants.....	29
11.2 Miscellaneous — Greenhouse Effect & Ozone Layer.....	30
11.3 Miscellaneous — Acid Rain & Water Pollution	30
11.4 Miscellaneous — Smog Types.....	30
11.5 Miscellaneous — Applied Chemistry Grab-Bag.....	31

BPSC CHEMISTRY — FILE 1

Atomic Structure | Physical & Chemical Changes, Solution

Bold ORANGE numbers = high-yield facts. **RED traps** = common exam mistakes. Read subtopic-by-subtopic.

WHERE THESE QUESTIONS COME FROM

BPSC/UPPSC PYQs (39th-71st) via IAS Valley Notes compilation, cross-checked against a tagged Chemistry PYQ bank (Everyday/Applied, Acids-Bases-pH, Organic subtopics), the RO/APO 2026 Science paper, NCERT Class 6-12, and the 72nd BPSC General Science book.

1.1 Atomic Models — Scientist Timeline

In one line: Every major atomic model was built to fix a flaw in the one before it — know WHO, WHAT experiment, and WHAT limitation, in that order.

NUMBERS TO REMEMBER

Maharishi Kanad (~600 BCE, India): first to theorise 'Parmanu' — indivisible particles that combine into molecules.

Democritus (5th c. BCE, Greece): coined 'atomos' (uncuttable) — all matter = tiny indivisible particles.

Antoine Lavoisier (18th c., France): Father of Modern Chemistry; Law of Conservation of Mass; named C, H, O; disproved phlogiston theory.

John Dalton (1808, England): Atomic Theory — atoms indivisible; same element = identical atoms; compounds form in fixed ratios.

J.J. Thomson (1897/1904): discovered the electron (cathode ray tube); Plum Pudding Model — positive sphere + embedded electrons.

Ernest Rutherford (1911): Gold Foil/Alpha Scattering — atom is mostly empty space; dense positive nucleus at centre; discovered proton.

Niels Bohr (1913): electrons orbit in fixed energy levels/shells; absorb/emit energy only when jumping orbits; explains H spectrum only.

James Chadwick (1932): bombarded beryllium with alpha particles → discovered the neutron (neutral, mass slightly > proton).

Heisenberg & Schrödinger (1920s–30s): Quantum Model — electrons in probability orbitals, not fixed paths; Uncertainty Principle.

Model	Key Idea	Basis	Limitation
Thomson (1904)	Positive sphere + embedded e^-	Cathode ray tube	Could not explain gold foil results
Rutherford (1911)	Dense nucleus; mostly empty space	Alpha scattering	Couldn't explain why e^- don't fall into nucleus

Bohr (1913)	Fixed circular orbits (K,L,M,N)	H-atom spectrum	Fails for multi-electron atoms
Quantum Model	Electrons in probability orbitals (s,p,d,f)	Schrödinger wave mechanics	Mathematically complex, but most accurate

TRAPS — how the exam catches you

Uncertainty Principle applies ONLY to microscopic particles (electrons) — NOT macroscopic objects [real PYQ, BPSC APO paper].

Rutherford's experiment discovered the nucleus AND the proton — Chadwick discovered the neutron separately, 21 years later (1932). BUT note: many official BPSC answer keys credit E. Goldstein (1886, canal ray experiment) as the discoverer of the proton, with Rutherford providing later confirmation — both framings have appeared in real papers, so recognise either.

Bohr's model works well ONLY for hydrogen (single electron) — fails for multi-electron atoms; that gap is exactly what the Quantum Model fixes.

Modern atomic SYMBOLS (e.g. H, O, Na) are based on the method proposed by Berzelius — not Dalton (who used circular symbols) or Bohr/Thomson [real PYQ, BPSC CDPO 2022].

1.2 Subatomic Particles, Electronic Configuration & Quantum Rules

In one line: Electron/proton/neutron facts plus the three filling rules (Aufbau, Hund's, Pauli) are near-guaranteed 1-2 mark BPSC questions.

NUMBERS TO REMEMBER

Max electrons per shell = $2n^2$: K($n=1$)=2, L($n=2$)=8, M($n=3$)=18, N($n=4$)=32. Outermost shell cannot exceed 8 (Octet Rule).

Aufbau Principle: fill lowest-energy orbitals first ($1s \rightarrow 2s \rightarrow 2p \rightarrow 3s \rightarrow 3p \rightarrow 4s \rightarrow 3d \dots$).

Hund's Rule: electrons occupy orbitals singly before pairing (half-filled = more stable).

Pauli Exclusion Principle: max 2 electrons per orbital, with opposite spins — no two electrons share all 4 quantum numbers.

Quantum numbers: n =Principal (shell), l =Azimuthal (orbital shape: $s=0, p=1, d=2, f=3$), m =Magnetic (orientation), s =Spin ($\pm\frac{1}{2}$).

Sample configs: Na(11)=2,8,1; Cl(17)=2,8,7; Ca(20)=2,8,8,2; N(7)=2,5.

Bond order: CO=3 (triple), O₂=2 (double), N₂=3, H₂=1. Higher bond order = shorter & stronger bond.

Paramagnetic (unpaired e^- , attracted to field): O₂, Fe, Mn. Diamagnetic (all paired, weakly repelled): N₂, NaCl, H₂O. Ferromagnetic (strongly attracted, retains magnetism): Fe, Co, Ni.

Particle	Charge	Mass	Location	Discovered By
Electron (e^-)	-1	~0 amu (1/1840 of proton)	Outside nucleus	J.J. Thomson (1897)
Proton (p^+)	+1	~1 amu	Inside nucleus	Rutherford (1917)
Neutron (n^0)	0	~1 amu (slightly > proton)	Inside nucleus	Chadwick (1932)

TRAPS — how the exam catches you

Cathode rays travel straight, carry negative charge, and are IDENTICAL regardless of cathode material — this is what proves electrons are a universal constituent of all matter.

Valency = electrons in outermost shell, OR (8 – outermost electrons) if that count exceeds 4.

1.3 Atomic Number, Mass Number & the Isotope Family

In one line: Isotopes/Isobars/Isotones/Isoelectronic is a guaranteed match-the-definition question — anchor each to its ONE distinguishing variable.

NUMBERS TO REMEMBER

Atomic Number (Z) = protons = electrons (neutral atom). Defines the element's chemical identity.

Henry Moseley (1913): each element has a unique atomic number → basis of the Modern Periodic Table.

Mass Number (A) = protons + neutrons (nucleons). Neutrons (N) = A - Z.
 Protium (^1H): 1p, 0n. Deuterium ($^2\text{H/D}$): 1p, 1n. Tritium ($^3\text{H/T}$): 1p, 2n (radioactive). Hydrogen is the ONLY element with a common isotope having zero neutrons.

Type	Definition	Example
Isotopes	Same Z, different A (different neutrons)	^1H , ^2H , ^3H ; ^{235}U , ^{238}U
Isobars	Same A, different Z	^{14}C (Z=6) & ^{14}N (Z=7); ^{40}Ca & ^{40}Ar
Isotones	Same number of neutrons, different Z & A	^{14}C (N=8) & ^{15}N (N=8)
Isoelectronic	Same number of electrons	N_2 & CO (both $14e^-$); O^{2-} , F^- , Na^+ , Mg^{2+} , Al^{3+} (all $10e^-$)

TRAPS — how the exam catches you

Given $e^- = 18$, $n = 20 \rightarrow$ mass number $A = Z + N = 18 + 20 = 38$ (protons=electrons=18) — a real, repeatedly-asked BPSC calculation.

Isotopes have the SAME chemical properties (same Z) but DIFFERENT physical properties (different A/mass).

1.4 Radioactivity & Applications of Isotopes

In one line: Alpha/Beta/Gamma properties plus the isotope-to-application matching table are two of the highest-yield sub-topics in this chapter.

NUMBERS TO REMEMBER

Radioactivity discovered by Henri Becquerel (1896); term 'radioactivity' coined by Marie Curie, who also discovered Polonium and Radium.

Half-life = time for half the radioactive nuclei to decay; constant for each isotope, unaffected by temperature/pressure/chemical state.

Half-lives: C-14 = 5730 yr; U-238 = 4.5 billion yr; Ra-226 = 1600 yr.

Pitchblende = ore of Uranium; Marie Curie extracted Radium from pitchblende in trace amounts [39th BPSC 1994].

Atomic bomb = nuclear FISSION (splitting U-235/Pu-239). Hydrogen bomb = nuclear FUSION (uncontrolled) [67th BPSC 2022].

Radiation	Nature	Charge	Penetrating Power
Alpha (α)	Helium nucleus ($2p+2n$)	+2	Least — stopped by paper
Beta (β)	Fast electron from nucleus	-1	Medium — stopped by Al sheet
Gamma (γ)	EM wave (photon)	0	Highest — needs lead/concrete

Isotope	Field	Use
Carbon-14	Archaeology	Carbon dating up to ~50,000 yrs; half-life 5730 yr
Uranium-235	Nuclear energy	Fission fuel — reactors & atomic bombs
Iodine-131	Medicine	Thyroid cancer & hyperthyroidism treatment
Cobalt-60	Medicine/Industry	Cancer radiotherapy; sterilising equipment; food irradiation
Sodium-24	Medicine	Tracing blood flow, detecting clots
Deuterium (D_2O)	Nuclear physics	Heavy water — moderator in reactors (slows neutrons, doesn't absorb them)
Phosphorus-32	Biology	Tracking DNA replication; plant phosphorus-uptake studies

TRAPS — how the exam catches you

Alpha rays are particles (He nucleus), NOT an electromagnetic wave — a real distractor in 'which is NOT an EM wave' questions.

D₂O (heavy water) = MODERATOR, not a fuel — it slows neutrons without absorbing them, sustaining a controllable chain reaction.

2.1 States of Matter — Five States & Gas Laws

In one line: Beyond solid/liquid/gas, know Plasma (4th, most abundant in the universe) and Bose-Einstein Condensate (5th, near absolute zero) plus the gas-law formulas.

NUMBERS TO REMEMBER

Plasma (4th state): ionised matter (free ions + electrons); most abundant visible matter in the universe — Sun, stars, lightning, neon signs, fluorescent tubes.

Bose-Einstein Condensate (5th state, BEC): near absolute zero (0K = -273.15°C); predicted by S.N. Bose & Einstein (1924-25); first created 1995 (Cornell, Wieman, Ketterle — Nobel 2001); all particles act as one quantum entity.

Temperature conversions: $K = ^\circ C + 273.15$; $^\circ C = (5/9)(^\circ F - 32)$.

1 mole of any gas at STP = 22.4 litres = 6.022×10^{23} molecules (Avogadro's number).

Property	Solid	Liquid	Gas
Shape/Volume	Both definite	Volume definite only	Neither definite
Particle arrangement	Rigid, close-packed	Close, mobile	Far apart, random
Compressibility	Negligible	Slight	High
Kinetic energy	Least	Intermediate	Highest

Law	Statement	Formula
Boyle's Law	Constant T: $V \propto 1/P$	$P_1 V_1 = P_2 V_2$
Charles's Law	Constant P: $V \propto T$	$V_1/T_1 = V_2/T_2$
Gay-Lussac's Law	Constant V: $P \propto T$	$P_1/T_1 = P_2/T_2$
Avogadro's Law	Equal V, T, P → equal molecules	1 mole gas = 22.4 L at STP
Ideal Gas Law	Combines all three	$PV = nRT$ ($R = 8.314 \text{ J/mol} \cdot \text{K}$)

TRAPS — how the exam catches you

Solids CANNOT flow easily — a 'which is not a solid characteristic' question tests exactly this [BPSC TRE-3 2024].

Pressure cooker: HIGH pressure → water boils ABOVE 100°C → food cooks faster. Mountains: LOW pressure → water boils BELOW 100°C → food takes longer.

2.2 Mixtures — Solutions, Colloids & Suspensions

In one line: Particle size is the deciding variable across all three; Tyndall Effect is present ONLY in colloids — the single most-tested distinguishing fact.

NUMBERS TO REMEMBER

Tyndall Effect = scattering of light by colloidal particles (named after John Tyndall). Milk & starch solution show it; salt water (a solution) does not.

Brownian motion (zig-zag movement) is seen in colloids AND suspensions — proves the particle nature of matter.

Feature	Solution	Colloid	Suspension
Particle size	<1 nm	1–1000 nm	>1000 nm

Tyndall Effect	Absent	PRESENT	Absent
Settling	Stable	Stable, no settling	Settles on standing
Examples	Salt/sugar water	Milk, fog, blood, jelly	Muddy water, chalk-water

Colloid Type	Dispersed Phase	Medium	Example
Aerosol (liquid)	Liquid	Gas	Fog, mist, hairspray
Aerosol (smoke)	Solid	Gas	Smoke, dust
Foam	Gas	Liquid	Shaving cream, soap lather
Emulsion	Liquid	Liquid	Milk, butter, mayonnaise
Sol	Solid	Liquid	Milk of magnesia, blood plasma, ink
Gel	Liquid	Solid	Jelly, boot polish, cheese

TRAPS — how the exam catches you

Colloids are NOT separated by ordinary filter paper — need a semipermeable membrane; suspensions ARE separated by ordinary filtration.

2.3 Separation Techniques

In one line: Match each technique to its underlying physical PRINCIPLE — that's how BPSC phrases these questions.

Technique	Principle	Example Use
Filtration	Particle size	Sand from water; water treatment
Evaporation	Boiling point (solid stays)	Salt from sea water
Distillation	Boiling point difference	Pure water from mixture
Fractional Distillation	Slightly different boiling points	Petroleum refining (petrol/kerosene/diesel/LPG)
Chromatography	Differential adsorption	Separating dyes in ink [BPSC CDPO 2022]
Centrifugation	Density difference, high speed	Cream from milk; washing machines [67th BPSC 2022]
Magnetic Separation	Magnetic property	Iron filings from sulfur
Sublimation	Solid→gas directly	Naphthalene, camphor, iodine, NH_4Cl , dry ice
Crystallization	Solubility varies with temperature	Purifying copper sulfate, alum
Solvent Extraction	Differential solubility, 2 solvents	Extracting iodine using CCl_4

- Simple physical separation methods (NCERT Class 6 level, still real PYQ material): Handpicking — removing large impurities (stones, husk) by hand. Threshing — beating stalks to separate grain seeds. Winnowing — using wind to blow away lighter chaff, leaving heavier grain. Sieving — passing through a mesh to separate by particle size. Sedimentation — heavier solid settles at the bottom when a liquid is added. Decantation — pouring off the clear liquid on top, leaving the settled solid behind.
- Desiccants (also called hygroscopic substances) absorb moisture from surroundings WITHOUT any chemical reaction — e.g. silica gel packets [real PYQ, BPSC CDPO 2022].

TRAPS — how the exam catches you

Working principle of a washing machine = Centrifugation (density-based), not filtration [67th BPSC Re-Exam 2022].

Fractional distillation $\neq$ plain distillation: fractional needs a fractionating column and works when boiling points are CLOSE together (e.g., petroleum fractions).

2.4 Phase Transitions & Latent Heat

In one line: All bond-BREAKING transitions absorb heat (endothermic); all bond-FORMING transitions release heat (exothermic) — one rule covers all six transitions.

NUMBERS TO REMEMBER

Latent heat = heat absorbed/released during phase change WITHOUT temperature change. Fusion (ice): 334 J/g. Vaporization (water): 2260 J/g — this is why STEAM BURNS are more severe than hot-water burns. Water's anomalous expansion: EXPANDS on freezing (ice less dense than water); maximum density at 4°C; ice floats and insulates aquatic life in winter — due to hydrogen bonding. Dry ice = solid CO₂; sublimates at -78.5°C at 1 atm; used in food preservation, fog effects, refrigerant, dry cleaning. Evaporation (surface only, any temperature, causes cooling) vs Boiling (throughout liquid, fixed boiling point, no cooling effect).

Transition	Direction	Heat Change
Melting (Fusion)	Solid → Liquid	Absorbed
Freezing	Liquid → Solid	Released
Vaporization (Boiling)	Liquid → Gas	Absorbed
Condensation	Gas → Liquid	Released
Sublimation	Solid → Gas directly	Absorbed
Deposition	Gas → Solid directly	Released

- Triple point of water = the exact temperature-pressure combination where solid, liquid and gas coexist in equilibrium: 273.16 K (0.01°C) and 611.657 Pa — used as a reference point for temperature calibration [real PYQ, 67th BPSC].
- Hygrometer = instrument used to measure humidity/moisture content in air [real PYQ, 64th BPSC].
- Viscosity = a fluid's resistance to flow; honey has the highest viscosity among common liquids [real PYQ, 66th BPSC].
- Dissolved solutes change water's boiling/freezing point: adding SALT raises the boiling point and lowers the freezing point; adding METHYL ALCOHOL (methanol) LOWERS the boiling point — both via weakened hydrogen bonding [real PYQ, 67th BPSC Re-Exam 2022].
- For an IDEAL solution (two liquids mixing with no molecular interaction), the enthalpy of mixing must be ZERO [real PYQ, 70th BPSC Re-Exam 2024].

TRAPS — how the exam catches you

Increasing pressure RAISES boiling point (pressure cooker); decreasing pressure LOWERS it (mountains) — commonly reversed by test-takers.

Liquefaction of a gas needs LOW temperature + HIGH pressure together — pick one condition wrong and the gas won't liquefy [real PYQ, 70th BPSC 2024].

2.5 Physical vs Chemical Changes

In one line: The test is simple — did a NEW substance form? If yes, chemical. A few 'tricky examples' below are BPSC's favourite way to test this.

NUMBERS TO REMEMBER

Law of Conservation of Mass (Lavoisier): total mass of reactants = total mass of products; atoms are rearranged, never created or destroyed.

Law of Definite (Constant) Proportions (Joseph Proust): in a given compound, elements are always present in a fixed mass ratio — e.g. water is always H:O = 1:8 by mass; ammonia is always N:H = 14:3 by mass.

Law of Multiple Proportions (Dalton, 1803): when two elements combine to form MORE THAN ONE compound, the masses of one element that combine with a fixed mass of the other are in a ratio of small whole numbers. Dalton's atomic theory successfully explains all three laws — conservation of mass, definite proportions, AND multiple proportions [real PYQ, 70th BPSC 2024] — but NOT the law of radioactivity, which doesn't exist as a law of chemical combination.

Feature	Physical Change	Chemical Change
New substance?	No	Yes
Reversibility	Generally reversible	Generally irreversible
Signs	State/shape/size change only	Colour change, gas, precipitate, heat/light

- Burning a candle = BOTH: melting wax (physical) + combustion of wax (chemical).
- Blackening of silverware = Chemical ($\text{Ag} + \text{H}_2\text{S} \rightarrow \text{Ag}_2\text{S}$).
- Boiling of water = Physical (still H_2O) — a real, repeated BPSC answer [65th BPSC Re-Exam 2020].
- Rusting of iron = Chemical (new compound $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ formed).
- Dissolving salt/sugar in water = Physical (recoverable by evaporation); dissolving CO_2 in water = Chemical (forms H_2CO_3).
- Electrolysis of water = Chemical/decomposition reaction ($\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2$) [BPSC BAO 2024].

2.6 Types of Chemical Reactions

In one line: Six named reaction types, one memory hook each — this table alone answers most 'identify the reaction type' questions.

NUMBERS TO REMEMBER

OIL RIG: Oxidation Is Loss (of e^-)/gain of O; Reduction Is Gain (of e^-)/loss of O. Oxidizing agent gets reduced; reducing agent gets oxidized.

Exothermic (heat released): combustion, neutralization, respiration, rusting, dissolving H_2SO_4 . Endothermic (heat absorbed): photosynthesis, thermal decomposition ($\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$), dissolving NH_4Cl .

Thermite reaction: $\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe} + \text{heat}$ — highly exothermic; used to weld railway tracks; Al is a stronger reducing agent than Fe.

Lime water test for CO_2 : $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3\downarrow$ (milky); excess $\text{CO}_2 \rightarrow \text{Ca}(\text{HCO}_3)_2$ (soluble, clears again).

Rancidity = oxidation of fats/oils; prevented by antioxidants (BHA, BHT, Vit C/E), N_2 gas packaging (chips packets), refrigeration, air-tight/vacuum packaging.

Type	Pattern	Example
Combination	$\text{A} + \text{B} \rightarrow \text{AB}$	$2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$
Decomposition	$\text{AB} \rightarrow \text{A} + \text{B}$	$2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$ (electrolysis)
Single Displacement	More reactive replaces less reactive	$\text{Fe} + \text{CuSO}_4 \rightarrow \text{FeSO}_4 + \text{Cu}$
Double Displacement	Ion exchange, often precipitate	$\text{AgNO}_3 + \text{NaCl} \rightarrow \text{AgCl}\downarrow + \text{NaNO}_3$
Combustion	$\text{Fuel} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{energy}$	$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
Neutralization	$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$ (exothermic)	$\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

TRAPS — how the exam catches you

ALWAYS add acid to water, NEVER water to acid — diluting H_2SO_4 is highly exothermic and can cause dangerous spattering [NCERT Class 10].

In a soda-acid fire extinguisher: dilute H_2SO_4 + sodium bicarbonate (NaHCO_3) [70th BPSC Pre 2024] — a repeatedly tested composition fact.

Faraday constant is a UNIVERSAL constant (~96,485 coulombs per mole) — it does NOT depend on the electrolyte, the current passed, or the solvent volume [real PYQ, 66th BPSC 2020]. It equals the total charge carried by one mole of electrons.

Reduction (gain of electrons/hydrogen or loss of oxygen) happens in photosynthesis too: CO_2 is REDUCED to carbohydrates using energy from sunlight — a real, counter-intuitive PYQ pairing [BPSC Teacher exam].

— END —

BPSC CHEMISTRY — FILE 2

Inorganic Chemistry | Metals, Minerals, Ores

Bold ORANGE numbers = high-yield facts. RED traps = common exam mistakes. Read subtopic-by-subtopic.

WHERE THESE QUESTIONS COME FROM

BPSC/UPPSC PYQs (39th-71st) via IAS Valley Notes compilation, cross-checked against a tagged Chemistry PYQ bank, the RO/APO 2026 Science paper, NCERT Class 6-12, and the 72nd BPSC General Science book.

3.1 Periodic Table — Historical Development

In one line: Four names, four attempts — each fixed a flaw in the last. Mendeleev arranged by MASS; Moseley (Modern table) by ATOMIC NUMBER — the single most-tested contrast here.

NUMBERS TO REMEMBER

Modern Periodic Table: 18 groups, 7 periods, 118 elements. Longest period = 6th (32 elements). Shortest = 1st (2 elements: H, He).

Mendeleev's predictions: Eka-boron = Scandium, Eka-aluminium = Gallium, Eka-silicon = Germanium.

Scientist	Year	Contribution / Limitation
Dobereiner	1817	Law of Triads — 3rd element's properties between first two (Li-Na-K). Couldn't classify all elements.
John Newlands	1866	Law of Octaves — every 8th element similar (musical octaves). Worked only for first 17 elements.
Dmitri Mendeleev	1869	Arranged 63 elements by increasing ATOMIC MASS; predicted undiscovered elements (Eka-boron=Sc, Eka-silicon=Ge); left gaps.
Henry Moseley	1913	Modern Periodic Law — properties are a periodic function of ATOMIC NUMBER, not mass. Basis of today's table.

TRAPS — how the exam catches you

Mendeleev's table could not explain the position of isotopes and placed Hydrogen awkwardly with the halogens — this exact gap is what atomic-number-based Moseley table fixed.

3.2 Periodic Table — Blocks, Groups & Trends

In one line: Memorise the AIEM trend rule once — it answers every 'across period vs down group' question in one shot.

NUMBERS TO REMEMBER

AIEM memory hook: Atomic radius, Ionization energy, Electronegativity, Metallic character — across a period: radius↓ IE↑ EN↑ metallic↓; down a group, all reverse.

Fluorine (F) = most electronegative element (4.0, Pauling scale). Noble gases = highest ionization energy in each period.

Smallest atom = Hydrogen; largest naturally occurring = Francium. Most abundant metal in crust = Aluminium (8.1%). Most abundant element in crust = Oxygen (46.6%), then Silicon (27.7%).

Most abundant gas in atmosphere = Nitrogen (78%). Radon = rarest noble gas, NOT normally present in air (unlike He, Ne, Ar, Kr, Xe).

Block	Groups	Key Elements
s-block	1, 2	H, He, Li, Na, K, Be, Mg, Ca — alkali & alkaline earth metals

p-block	13–18	B, C, N, O, F, Cl, noble gases
d-block	3–12	Transition metals: Sc→Zn etc.
f-block	bottom rows	Lanthanides (Ce–Lu) & Actinides (Th–Lr) — all actinides radioactive

Group	Name	Key Property
1	Alkali Metals	1 valence e ⁻ ; soft; stored in kerosene (Na, K)
2	Alkaline Earth Metals	2 valence e ⁻ ; Ca in bones/teeth
17	Halogens	7 valence e ⁻ ; most reactive non-metals; F = most electronegative
18	Noble Gases	Complete outer shell; chemically inert

Property	Across Period (L→R)	Down Group (Top→Bottom)
Atomic Radius	Decreases	Increases
Ionization Energy	Increases	Decreases
Electronegativity	Increases	Decreases
Metallic Character	Decreases	Increases

TRAPS — how the exam catches you

Mercury (Hg) = only liquid METAL at room temperature. Bromine (Br) = only liquid NON-metal at room temperature — a classic pairing trap.

Iodine is the only non-metal with metallic lustre — don't confuse with Bromine (liquid, not lustrous).

3.3 Metals vs Non-metals vs Metalloids

In one line: Metalloids (semiconductors) sit between the two extremes — B, Si, Ge, As, Sb, Te, Po is the full list BPSC expects you to know cold.

NUMBERS TO REMEMBER

Metalloids/semimetals: Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium, Polonium. Silicon & Germanium = most important semiconductors (transistors, chips, solar cells).

Property	Metals	Non-metals	Metalloids
Lustre	Shiny (except non-lustrous few)	None (except Iodine)	Semi-metallic
Malleability	Malleable, ductile	Brittle	Brittle
Conduction	Good (Ag best)	Poor (except graphite)	Semiconductors
Oxide nature	Basic	Acidic	Amphoteric
Electron tendency	Lose e ⁻ (electropositive)	Gain e ⁻ (electronegative)	Either

3.4 Reactivity Series & Metal Reactions

In one line: One ordered list explains almost every metal-reaction question — memorise it once, apply it everywhere.

NUMBERS TO REMEMBER

Reactivity series (most → least reactive): K > Na > Ca > Mg > Al > Zn > Fe > Pb > (H) > Cu > Hg > Ag > Pt > Au. Most reactive metal = Potassium (K); least reactive = Gold (Au). Metals above hydrogen displace it from dilute acids.

K, Na, Ca: react violently with COLD water. Mg: reacts with HOT water. Al, Zn, Fe: react only with STEAM. Cu, Pb: no reaction with water/dilute acid. Au, Ag, Pt: noble metals — unreactive even with hot conc. acids; only Aqua Regia dissolves Au/Pt.

Aqua Regia = 1 part conc. HNO_3 + 3 parts conc. HCl (by volume) — the only mixture that dissolves gold and platinum.

Metal	With Air/ O_2	With Water	With Dilute Acid
K, Na	Catch fire; kept in kerosene	Violent — $\text{MOH} + \text{H}_2$	Violent
Mg	Burns, dazzling white flame	Only hot water/steam	Readily: $\text{MgCl}_2 + \text{H}_2$
Al, Zn, Fe	Oxide layer on heating	Only steam	Readily
Cu	Blackens (CuO)	No reaction	No reaction
Au, Ag, Pt	No reaction	No reaction	No reaction (only Aqua Regia dissolves Au/Pt)

TRAPS — how the exam catches you

Al and Zn are AMPHOTERIC metals — they react with BOTH acids and bases, releasing H_2 gas in either case. Purest form of iron = Wrought iron (lowest carbon content) — not cast iron (most brittle) or steel (most used) [BPSC CDPO 2018].

Food cans are coated with TIN, not zinc, because zinc is MORE reactive than tin (the opposite of the intuitive guess) [real PYQ, BPSC Teacher & TRE-3 2024].

Noble metals (Au, Ag, Pt) are found in PURE/native form in nature — Uranium and Lead are NOT noble metals, a real distractor pairing [BPSC Re-Exam 2022].

The MORE NEGATIVE a metal's standard electrode potential, the STRONGER its reducing power — a real PYQ ranked three metals purely by their electrode-potential values using this rule [70th BPSC Re-Exam 2024].

When iron rusts, its weight actually INCREASES (oxygen is added to form $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$) — per BPSC's own official answer key, this is the accepted answer even though flaking rust can reduce weight over a very long time [real PYQ, 67th BPSC Re-Exam 2022].

3.5 Corrosion — Rusting, Tarnishing & Prevention

In one line: Rusting/tarnishing are slow oxidation (chemical change) — the prevention methods table is the exam-relevant half of this topic.

Method	How it Works	Example
Galvanization	Zn coating; Zn = sacrificial anode	Pipes, buckets, roofing sheets
Electroplating	Protective metal layer via electrolysis	Cr on steel, Sn on cans
Alloying	Corrosion-resistant elements added	Cr in stainless steel (self-healing Cr_2O_3)
Anodization	Thickens natural oxide layer	Aluminium cookware, aircraft parts

- Rusting of iron: $\text{Fe} + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ (hydrated iron oxide, red-brown).
- Green patina on copper: $\text{Cu} + \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ (basic copper carbonate).
- Tarnishing of silver: $\text{Ag} + \text{H}_2\text{S} \rightarrow \text{Ag}_2\text{S}$ (silver sulfide, black) — real PYQ: silver ornaments blacken due to atmospheric H_2S , NOT oxygen [BPSC APO paper].

TRAPS — how the exam catches you

Galvanized (zinc-coated) pots are UNSUITABLE for storing oil/fatty/acidic food — the zinc coating reacts with free fatty acids/moisture to form toxic zinc salts, both spoiling the food and corroding the pot [real PYQ, 71st BPSC].

4.1 Ores & Minerals — Concepts + Master Ore Table

In one line: Ore = mineral that's PROFITABLE to extract metal from — all ores are minerals, not all minerals are ores. The metal↔ore table is pure recall; learn it as pairs.

NUMBERS TO REMEMBER

Gangue = impurities in ore (sand, rock, clay) removed during extraction.

Crust abundance order: Oxygen(46.6%) > Silicon(27.7%) > Aluminium(8.1%) > Iron(5.0%) > Calcium(3.6%) > Sodium(2.8%) > Potassium(2.6%) > Magnesium(2.1%).

Main ingredient in cement manufacture = Limestone [real PYQ, 67th BPSC 2022].

Other major iron ores beyond Haematite/Magnetite: Limonite ($\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$) and Siderite (FeCO_3) [real PYQ, 42nd BPSC].

Metal	Principal Ore(s)	Formula
Aluminium	Bauxite	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
Iron	Haematite / Magnetite	Fe_2O_3 / Fe_3O_4
Copper	Copper pyrites (Chalcopyrite)	CuFeS_2
Zinc	Zinc blende (Sphalerite)	ZnS
Lead	Galena	PbS
Mercury	Cinnabar	HgS
Tin	Cassiterite	SnO_2
Titanium	Ilmenite / Rutile	FeTiO_3 / TiO_2
Thorium	Monazite	mixed phosphates
Uranium	Pitchblende / Carnotite	UO_2
Silver	Argentite	Ag_2S
Gold	Native gold	Au (free state)

- Blue vitriol = Copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) — white when anhydrous, blue when hydrated; dissolves in water, insoluble in alcohol [real PYQ, 63rd BPSC 2017].
- Technetium (Tc, atomic number 43) is the first artificially prepared element — isolated in 1937 by Carlo Perrier and Emilio Segrè [real PYQ, 70th BPSC 2024].
- Sapphire and Ruby share the chemical formula Al_2O_3 (crystalline aluminium oxide, corundum) — colour differences come from trace impurities [real PYQ, 66th BPSC Re-Exam 2020].
- Electrical conductivity order among common metals (highest to lowest): Silver > Copper > Gold > Aluminium > Beryllium > Calcium [real PYQ, 65th BPSC Re-Exam 2020].
- By DENSITY, Platinum ($\sim 21.45 \text{ g/cm}^3$) is the 'heaviest' common metal — denser than Gold (19.32), Mercury (13.54) and Silver (10.5). A separate real PYQ instead asked for the heaviest metal by comparing Uranium, Copper, Aluminium and Silver, and accepted Uranium (atomic mass 238) — recognise BOTH framings ('heaviest' can mean density OR atomic mass depending on the options given).

TRAPS — how the exam catches you

Galena (PbS) is the ore of LEAD, not aluminium — a real PYQ distractor asking 'which is NOT an ore of aluminium' [ScienceMCQ bank]. Aluminium's real ores/minerals: Bauxite (main), Corundum, Feldspar, Kaolinite (China clay).

$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ is the formula of China clay (Kaolinite), not bauxite [BPSC School Teacher 2023].

Zinc blende (ZnS) is a good conductor of heat and electricity — an often-missed exception.

Four real aluminium ores with formulas, all fair game: Bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), Cryolite (Na_3AlF_6), Corundum (Al_2O_3), Diaspore ($\text{AlO}(\text{OH})$) [real PYQ, 70th BPSC 2024 — corundum AND cryolite both confirmed as aluminium ores].

Non-ferrous metallic minerals contain NO iron (e.g. cobalt, tin, copper, zinc). Ferrous metallic minerals DO contain iron — but note manganese, nickel and chromium are also classed as ferrous-associated/alloying minerals in BPSC's own answer key framing [real PYQ, 65th BPSC Re-Exam 2020].

4.2 Metallurgy — Extraction Steps

In one line: Four steps in fixed order: Concentration → Oxide conversion → Reduction → Refining. Match reduction METHOD to metal REACTIVITY.

NUMBERS TO REMEMBER

Step 1 (Concentration/Ore Dressing): crushing/grinding, magnetic separation, froth flotation (sulphide ores), gravity separation, leaching.

Step 2 (Conversion to oxide): Roasting = heating sulphide ore in EXCESS air ($\text{ZnS} + \text{O}_2 \rightarrow \text{ZnO} + \text{SO}_2$). Calcination = heating carbonate ore in LIMITED air ($\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$).

Step 3 (Reduction) — Smelting is specifically defined as the process where a metal is obtained in a FUSED/molten state via high-temperature reduction of the ore [real PYQ, 67th BPSC Re-Exam 2022].

Step 4 (Refining): Electrolytic refining (impure=anode, pure=cathode) for Cu/Ag/Au. Distillation for volatile metals (Zn, Hg). Zone refining for ultra-pure semiconductors (Si, Ge).

Electroplating a vessel with zinc: the VESSEL is made the negative pole (cathode) and PURE ZINC is made the positive pole (anode) — zinc loses electrons to become a cation and deposits onto the vessel [real PYQ, 46th BPSC].

Reactivity	Reduction Method	Example
Less reactive (Hg, Ag)	Heat alone	$2\text{HgO} \rightarrow 2\text{Hg} + \text{O}_2$
Medium (Zn, Fe, Cu, Pb)	Carbon/CO reduction (smelting)	$\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
Fe (special case)	Thermite/Displacement	$\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe}$
Highly reactive (Na, Ca, Mg, Al)	Electrolytic reduction	Molten NaCl $\rightarrow$ Na; molten Al_2O_3 (in cryolite) $\rightarrow$ Al

4.3 Bihar/India Mineral Geography

In one line: A recurring 'state + mineral' question set — Jaduguda (India's only uranium mine) and Monazite (Kerala coast) are the two highest-value facts here.

- Iron ore: Jharkhand (Singbhum). Coal: Jharia, Bokaro (Jharkhand). Mica: Jharkhand/Bihar.
- Uranium: Jaduguda, Jharkhand — India's ONLY uranium mine.
- Monazite (thorium ore): Kerala coast — a nuclear-fuel-relevant sand deposit.
- Iron ore belts elsewhere: Bababudan Hills (Karnataka), Dhalli-Rajhara Range (Chhattisgarh), Noamundi (Jharkhand) [real RO Prelims 2026 PYQ — Kemmangundi is in Karnataka, NOT Odisha, a common trap].

4.4 Calcium Compounds — Family Table

In one line: One reaction chain — limestone $\rightarrow$ quicklime $\rightarrow$ slaked lime $\rightarrow$ lime water/POP/bleaching powder — connects this entire family; learn the chain, not isolated facts.

NUMBERS TO REMEMBER

Lime water CO_2 test: $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 \downarrow$ (milky); excess $\text{CO}_2 \rightarrow \text{Ca}(\text{HCO}_3)_2$ (clear again).

POP sets by REHYDRATING: $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O} + 1\frac{1}{2}\text{H}_2\text{O} \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ (gypsum) — and EXPANDS slightly on setting, which is exactly why it's used for dental moulds/fracture casts.

Compound	Formula	Prep / Key Use
Limestone (Calcite)	CaCO_3	Cement, glass, steel flux
Quicklime	CaO	$\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ (calcination)
Slaked lime	$\text{Ca}(\text{OH})_2$	$\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2$ (exothermic); bleaching powder, whitewashing
Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	Raw material for Plaster of Paris
Plaster of Paris	$\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$	Gypsum heated at $120\text{--}130^\circ\text{C}$; fracture casts
Bleaching Powder	CaOCl_2	$\text{Ca}(\text{OH})_2 + \text{Cl}_2 \rightarrow \text{CaOCl}_2 + \text{H}_2\text{O}$; disinfectant

TRAPS — how the exam catches you

Plaster of Paris is NOT slaked lime — a very common trick question. POP = $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$; slaked lime = $\text{Ca}(\text{OH})_2$.

Bleaching powder is poorly SOLUBLE in water — a 'which is NOT true' PYQ tests exactly this [39th BPSC 1994]. It releases Cl_2 gas on reaction with dilute acid.

4.5 Sodium Compounds & Water Hardness

In one line: Baking soda vs baking powder vs washing soda is a guaranteed compare-and-contrast question — know what each ADDITIONALLY contains and why.

NUMBERS TO REMEMBER

Chlor-alkali process: $\text{NaCl(aq)} \xrightarrow{\text{electrolysis}} \text{NaOH} + \text{Cl}_2 + \text{H}_2$. Products: NaOH (caustic soda), Cl_2 (bleaching powder/PVC/antiseptics), H_2 (fuel/margarine) [NCERT Class 10].

Baking Powder = NaHCO_3 + tartaric acid + starch — the acid neutralises the bitter Na_2CO_3 taste that baking soda alone would leave behind.

Compound	Formula	Common Name
Sodium chloride	NaCl	Table/Rock salt
Sodium hydroxide	NaOH	Caustic soda
Sodium carbonate	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$	Washing soda
Sodium bicarbonate	NaHCO_3	Baking soda
Sodium sulphate	$\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$	Glauber's salt
Sodium thiosulphate	$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$	Hypo (photography fixer)
Borax	$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	Tincar

Hardness Type	Cause	Removal
Temporary	$\text{Ca}(\text{HCO}_3)_2$, $\text{Mg}(\text{HCO}_3)_2$	Boiling; Clark's method [$\text{Ca}(\text{OH})_2$]
Permanent	CaSO_4 , MgSO_4 , CaCl_2 , MgCl_2	Washing soda (Na_2CO_3); ion exchange/zeolite; distillation

4.6 Glass Types & Other Key Inorganic Compounds

In one line: Glass composition determines its use — swap one oxide (Pb for Ca, or add B_2O_3) and you get an entirely different glass.

Glass Type	Composition	Use
Soda glass	$\text{Na}_2\text{O} + \text{CaO} + \text{SiO}_2$	Windows, bottles
Pyrex (borosilicate)	$\text{SiO}_2 + \text{B}_2\text{O}_3 + \text{Al}_2\text{O}_3 + \text{Na}_2\text{O}$	Lab glassware — low thermal expansion
Optical (flint) glass	$\text{SiO}_2 + \text{PbO} + \text{K}_2\text{O}$	Lenses, prisms — high refractive index (Pb)
Safety glass	2 glass sheets + plastic layer	Car windshields

Compound	Formula	Key Fact
Sulphuric acid	H_2SO_4	'King of Chemicals'; most-produced industrial chemical; never add water to it — always acid to water
Ammonia	NH_3	Haber process: $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ (Fe catalyst, 450°C , 200 atm)
Hydrogen peroxide	H_2O_2	Bleaching agent; 3% solution = antiseptic; oxidising agent
Nitrous oxide	N_2O	'Laughing gas'; medical anaesthetic; whipped-cream propellant

- White lead (commercial name 'Safeda') = basic/alkaline lead carbonate, formula $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$ [real PYQ, BPSC 11th-12th 2023].
- CaO (quicklime) is SOLUBLE in water (reacts to form $\text{Ca}(\text{OH})_2$) — but FeO and ZnO are NOT soluble in water [real PYQ, BPSC TRE-3 2024].
- Zinc Oxide (ZnO) is used across rubber, plastic, ceramics, glass, cement, paints, ointments, food products, batteries, and even secondarily in solvents and explosives — a much broader use-list than most students expect [real PYQ, BPSC TRE-3 2024].

- Manganese is used in match manufacturing, leather processing, photography-related materials, and dry battery production — India's top manganese-ore states are Madhya Pradesh, Maharashtra, Odisha, Karnataka and Andhra Pradesh [real PYQ, BPSC TRE-3 2024].
- In lab-grown diamonds (LGD), Graphite is used as the diamond 'seed' (via the HPHT or Chemical Vapour Deposition method) — Moissanite/White Sapphire/Cubic Zirconia are themselves diamond SIMULANTS, not the seed material used to grow real lab diamonds [real PYQ, 70th BPSC Re-Exam 2024].

— **END** —

BPSC CHEMISTRY — FILE 3

Alloys | Non-metals (Carbon, Hydrogen, S/N/Halogens/Inert Gases, Acid-Base-Salt)

Bold ORANGE numbers = high-yield facts. RED traps = common exam mistakes. Read subtopic-by-subtopic.

WHERE THESE QUESTIONS COME FROM

BPSC/UPPSC PYQs (39th-71st) via IAS Valley Notes compilation, cross-checked against a tagged Chemistry PYQ bank, the RO/APO 2026 Science paper, NCERT Class 6-12, and the 72nd BPSC General Science book.

5.1 Alloys — Master Table & Carat System

In one line: Alloys = homogeneous mixtures of metals made harder, more corrosion-resistant, or lower-melting than the pure metal — German Silver is the single most-repeated trick fact in this topic.

NUMBERS TO REMEMBER

24 carat = pure gold (100%, too soft for jewellery). 22 carat = 91.7% gold. 18 carat = 75% gold. 14 carat = 58.3% gold.

Alloy	Components	Use
Brass	Cu + Zn	Utensils, musical instruments, cartridges
Bronze	Cu + Sn	Statues, coins, bells, medals
Steel	Fe + C (<2%)	Buildings, bridges, vehicles
Stainless Steel	Fe+Cr+Ni+Mn	Cutlery, surgical tools; Cr = corrosion-resistant
Duralumin	Al+Cu+Mn+Mg	Aircraft bodies — light yet strong
Solder	Sn 60% + Pb 40%	Joining electrical wires; low melting point
Fuse wire	Sn 63% + Pb 37%	Electrical fuses; melts on overload
German Silver	Cu+Zn+Ni (NO silver)	Ornaments, cutlery
Gun Metal	Cu+Zn+Sn	Guns, valves, gears
Nichrome	Ni 80% + Cr 20%	Heater coils, electric irons — high resistivity
Amalgam	Hg + any metal	Dental fillings (Ag-Sn-Hg)
Magnalium	Mg + Al	Aircraft frames — very light

TRAPS — how the exam catches you

German Silver contains NO silver at all — it's Cu+Zn+Ni. Extremely common BPSC/UPPSC trick question. Fuse wire and Solder have the SAME two components (Sn+Pb) but DIFFERENT proportions — don't confuse them.

'White metal' is itself an alloy — usually Lead + Tin (sometimes with cadmium, bismuth, zinc) [real PYQ, 67th BPSC Re-Exam 2022].

Gold and Platinum do NOT corrode at all [real PYQ, BPSC BAO 2024] — the two 'noble' metals immune to atmospheric attack.

6.1 Non-metals — Allotropes of Carbon

In one line: Diamond and graphite are BOTH pure carbon — the only difference is atomic arrangement, and that arrangement alone explains every property difference.

NUMBERS TO REMEMBER

Graphite conducts electricity because each carbon has ONE delocalized (free-moving) π electron. Diamond does NOT conduct — all 4 electrons are locked in bonds, none free.

Graphite is also used as a MODERATOR in nuclear reactors, just like heavy water (D_2O) — both slow down neutrons.

The purest form of amorphous carbon is Lamp black — NOT wood/sugar/bone charcoal (which are all impure amorphous carbon forms) [real PYQ, BPSC CDPO 2022].

Allotrope	Structure	Key Property
Diamond	3D tetrahedral (sp^3), each C bonded to 4 others	Hardest natural substance; poor conductor
Graphite	Layered hexagonal (sp^2), weak inter-layer bonds	Soft, slippery; GOOD conductor of electricity
Fullerene (C_{60})	Soccer-ball structure, 60 C atoms	Molecular solid; used in nanotechnology, drug delivery
Graphene	Single layer of graphite (2D)	Strongest known material; excellent conductor
Coal/Coke	Amorphous, no regular structure	Fuel; coke used in steel manufacturing

6.2 Non-metals — Hydrogen and its Compounds

In one line: Hydrogen is unique — one electron, one proton, placed in Group 1 but chemically resembling both alkali metals and halogens.

NUMBERS TO REMEMBER

Most abundant element in the universe (mostly combined, as water/hydrocarbons on Earth).

Lab preparation: $Zn + \text{dilute } H_2SO_4 \rightarrow ZnSO_4 + H_2\uparrow$. Industrial: electrolysis of water; steam reforming of natural gas.

Properties: colourless, odourless, lightest gas known, highly flammable, burns with a pale blue flame; $2H_2 + O_2 \rightarrow 2H_2O$.

Isotopes: Protium (1H , 1p 0n), Deuterium ($^2H/D$, 1p 1n), Tritium ($^3H/T$, 1p 2n, radioactive) — hydrogen is the ONLY element whose common isotope (protium) has zero neutrons.

Uses: hydrogenation of vegetable oils (making vanaspati/margarine — Ni catalyst), ammonia manufacture (Haber process), rocket fuel, fuel cells, oxy-hydrogen welding.

Hydrogen has the highest calorific value of any fuel (~1,50,000 kJ/kg) and zero carbon emission — central to the emerging 'Hydrogen Economy'.

Hydrogen storage methods: physically by high-pressure compression (gas cylinders), or chemically by absorption into metal hydrides (Pd, Pt readily absorb/occlude hydrogen gas).

'Colours' of hydrogen (by production method): Green H_2 = electrolysis using renewable power (zero emission).

Grey H_2 = steam methane reforming of natural gas (the MOST common industrial method today, but releases CO_2 — NOT green despite hydrogen itself being clean-burning). Blue H_2 = grey process + carbon capture.

TRAPS — how the exam catches you

Helium, not hydrogen, is used to fill weather/party balloons DESPITE hydrogen being lighter — because hydrogen forms an explosive mixture with air, while helium is inert [real BPSC APO PYQ].

D_2O (heavy water, made from deuterium) is used as a nuclear reactor MODERATOR — not as a fuel.

Hydrofluoric acid (HF) is NEVER stored in glass bottles — it reacts with and etches the SiO_2 in glass. Stored in wax/plastic/polyethylene containers instead.

Oxy-acetylene (not oxy-hydrogen) is the gas combination most commonly used for welding/cutting metal in real BPSC PYQs — oxy-hydrogen welding exists but is asked far less often.

6.3 Non-metals — Sulphur and its Compounds

In one line: The Contact Process (making H_2SO_4 from sulphur) is the highest-yield fact here — know the 3-step chain, not just the final product.

NUMBERS TO REMEMBER

Allotropes: Rhombic sulphur (α -sulphur) — yellow, stable at room temperature. Monoclinic sulphur (β -sulphur) — stable only above $96^\circ C$.

Occurrence: native sulphur deposits (e.g., Sicily); sulphide ores — iron pyrites (FeS_2), galena (PbS), zinc blende (ZnS), copper pyrites ($CuFeS_2$); gypsum ($CaSO_4 \cdot 2H_2O$).

Contact Process (industrial H_2SO_4 manufacture): $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$; $2\text{SO}_2 + \text{O}_2 \xrightarrow{(\text{V}_2\text{O}_5 \text{ catalyst, } \sim 450^\circ\text{C})} 2\text{SO}_3$; $\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{Oleum}$; $\text{Oleum} + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$.
 H_2SO_4 = 'King of Chemicals' — highest-volume industrial chemical produced worldwide; used in fertilizers, batteries, detergents, dyes.
 SO_2 : colourless, pungent gas; used as a bleaching agent (in presence of moisture) and as a food preservative (sulphiting); also the MAIN cause of acid rain when it oxidises to H_2SO_4 in the atmosphere.

TRAPS — how the exam catches you

NEVER add water to concentrated H_2SO_4 — always add acid to water. Dilution is highly exothermic and can cause dangerous spattering.

6.4 Non-metals — Nitrogen, Halogens & Inert Gases

In one line: Nitrogen is inert due to its $\text{N}\equiv\text{N}$ triple bond; halogens get LESS reactive down the group; noble gases are inert because their outer shell is already full — three different reasons for three different kinds of 'unreactive'.

NUMBERS TO REMEMBER

Nitrogen (N_2) = 78% of atmosphere; the $\text{N}\equiv\text{N}$ triple bond makes it chemically very stable/inert at room temperature. Fixed naturally by lightning and by Rhizobium bacteria (legume root nodules); industrially by the Haber process.

Halogen reactivity DECREASES down the group: $\text{F} > \text{Cl} > \text{Br} > \text{I}$ (opposite of the metal reactivity trend, since halogens gain electrons rather than lose them).

Noble gas uses: Helium — balloons/airships (safe, non-flammable), deep-sea diving gas mixtures, MRI/cryogenics. Neon — glowing signs (red-orange). Argon — inert atmosphere for welding; fills incandescent bulbs to stop filament oxidation. Krypton/Xenon — flash lamps, high-intensity headlights. Radon — radioactive; a health hazard when it accumulates in enclosed spaces (basements).

Element	Colour/State	Key Use
Fluorine (F_2)	Pale yellow gas	Toothpaste fluoridation; Teflon; most electronegative element
Chlorine (Cl_2)	Greenish-yellow gas	Water disinfection; bleaching powder; PVC manufacture
Bromine (Br_2)	Reddish-brown LIQUID	Photography (AgBr); flame retardants; only liquid non-metal at room temp
Iodine (I_2)	Violet/purple solid, metallic lustre	Antiseptic (tincture); iodised salt (prevents goiter)

6.5 Acid-Base-Salt — Theories of Acids and Bases

In one line: Three theories, each BROADER than the last — Arrhenius (aqueous only) → Brønsted-Lowry (proton transfer) → Lewis (electron pairs, covers everything).

NUMBERS TO REMEMBER

Water is amphoteric — acts as a BASE with HCl (accepts H^+) and as an ACID with NH_3 (donates H^+).

$\text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$; $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$.

Amphoteric OXIDES react with BOTH acids and bases: Al_2O_3 (aluminium oxide) and ZnO (zinc oxide) are the two classic examples. CuO , by contrast, is purely BASIC — a common mix-up in PYQs.

Theory	Acid	Base	Scope
Arrhenius (1884)	Gives H^+ in water	Gives OH^- in water	Aqueous solutions only
Brønsted-Lowry (1923)	Proton (H^+) DONOR	Proton (H^+) ACCEPTOR	Non-aqueous media too
Lewis (1923)	Electron-pair ACCEPTOR	Electron-pair DONOR	Broadest — all coordination chemistry

TRAPS — how the exam catches you

Dry HCl gas does NOT turn dry litmus paper red — acidic behaviour needs H_3O^+ ions, which form only when HCl dissolves in WATER. Moist/aqueous HCl does change litmus; the dry gas alone does not.

6.6 Common Acids & Natural/Chemical Indicators

In one line: 'Ants Sting Forcefully' — Ant=Formic, Vinegar=Acetic, Lemon=Citric, Curd=Lactic. These four source→acid pairs are asked almost every year.

Acid	Formula	Natural Source
Hydrochloric acid	HCl	Gastric juice (stomach)
Sulphuric acid	H_2SO_4	'King of Chemicals'; car batteries
Nitric acid	HNO_3	Explosives (TNT/RDX), fertilizers, aqua regia
Acetic acid	CH_3COOH	Vinegar
Citric acid	$\text{C}_6\text{H}_8\text{O}_7$	Citrus fruits (lemon, orange)
Lactic acid	$\text{CH}_3\text{CHOHCOOH}$	Sour milk/curd; muscles during exercise
Formic acid	HCOOH	Ant/bee sting, nettle leaves
Oxalic acid	$(\text{COOH})_2$	Tomatoes, spinach
Tartaric acid	$\text{C}_4\text{H}_6\text{O}_6$	Grapes, tamarind

Indicator	Source	In Acid	In Base
Litmus	Lichen	Red	Blue
Turmeric	Curcuma longa	Yellow	Red/Brown
Phenolphthalein	Synthetic	Colourless	Pink
China Rose extract	Hibiscus	Dark Pink	Green
Methyl orange	Synthetic	Red/Pink	Yellow/Orange

TRAPS — how the exam catches you

Onion and clove oil are OLFACTORY indicators — their smell disappears in basic solutions [NCERT Class 10].

6.7 Salts, Strong/Weak Acids & the pH Scale

In one line: A salt's acid/basic/neutral nature depends ENTIRELY on the strength of the acid and base that formed it — one rule explains NaCl, CH_3COONa , and NH_4Cl .

NUMBERS TO REMEMBER

NaCl (strong acid HCl + strong base NaOH) → NEUTRAL salt, pH=7. CH_3COONa (weak acid + strong base) → BASIC salt. NH_4Cl (strong acid + weak base) → ACIDIC salt [53rd-55th BPSC 2011].

$\text{pH} = -\log_{10}[\text{H}^+]$ (Soren Sorensen, 1909); range 0-14; each unit = $10\times$ change in H^+ concentration. pH<7 acidic, pH=7 neutral, pH>7 basic. $\text{pOH} = -\log[\text{OH}^-]$; pH+pOH=14 at 25°C.

For 0.1 N HCl: $[\text{H}^+]=0.1=10^{-1}$, so pH = 1 [real PYQ, 71st BPSC].

Substance	Approx. pH
Battery acid	0–1
Gastric juice	1.5–3.5
Lemon juice	2–2.5
Acid rain	<5.6
Pure water	7 (neutral)
Human blood	7.35–7.45
Milk of magnesia	10–10.5

TRAPS — how the exam catches you

Tooth enamel dissolves below pH 5.5 — that's the tooth-decay threshold, distinct from the acid-rain threshold of pH 5.6 [NCERT Class 10].

Bee sting is ACIDIC (formic acid) → treat with baking soda (alkaline). Wasp sting is ALKALINE → treat with vinegar (acidic). These are opposite — a classic reversal trap.

— *END* —

BPSC CHEMISTRY — FILE 4

Organic Chemistry — Hydrocarbons, Alcohol, Polymer, Organic Acid, Explosives, Fuel

Bold ORANGE numbers = high-yield facts. RED traps = common exam mistakes. Read subtopic-by-subtopic.

WHERE THESE QUESTIONS COME FROM

BPSC/UPPSC PYQs (39th-71st) via IAS Valley Notes compilation, a tagged Chemistry PYQ bank (Organic Chemistry & Materials Science subtopic), the RO/APO 2026 Science paper, and NCERT Class 10-12 organic chemistry chapters.

7.1 Hydrocarbons — Saturated & Unsaturated

In one line: Alkanes (single bonds, saturated) vs Alkenes/Alkynes (double/triple bonds, unsaturated) — the bond type alone decides the suffix, the reactivity, and the flame quality.

NUMBERS TO REMEMBER

Homologous series: a family of compounds with the same functional group, differing by a $-\text{CH}_2-$ unit each step, showing similar chemical properties and a gradual change in physical properties.

Functional groups (examples): $-\text{OH}$ (alcohol), $-\text{CHO}$ (aldehyde), $-\text{COOH}$ (carboxylic acid), $-\text{X}$ (haloalkane, $\text{X}=\text{halogen}$).

Saturated hydrocarbons burn with a CLEAN flame; unsaturated hydrocarbons burn with a more SOOTY/smoky flame (incomplete combustion due to higher carbon content).

Unsaturated hydrocarbons ADD hydrogen in the presence of a catalyst (Ni) to become saturated — this is hydrogenation, used industrially to convert vegetable oils into vanaspati ghee.

Saturated hydrocarbons (alkanes) are comparatively unreactive/inert; substitution reactions (not addition) are typical for them.

Class	Bond Type	Suffix	General Formula	Example
Alkanes	Single bonds only (saturated)	-ane	$\text{C}_n\text{H}_{2n+2}$	Methane CH_4 , Ethane C_2H_6
Alkenes	≥ 1 double bond (unsaturated)	-ene	C_nH_{2n}	Ethene C_2H_4
Alkynes	≥ 1 triple bond (unsaturated)	-yne	$\text{C}_n\text{H}_{2n-2}$	Ethyne (Acetylene) C_2H_2

7.2 Aromatic Hydrocarbons — Benzene & its Reactions

In one line: Benzene's ring reacts by ELECTROPHILIC SUBSTITUTION, not addition — sulfonation, nitration, and halogenation all follow the same 'catalyst generates an electrophile' pattern.

NUMBERS TO REMEMBER

Benzene (C_6H_6) treated with fuming sulfuric acid (oleum, excess SO_3) $\rightarrow$ benzenesulfonic acid ($\text{C}_6\text{H}_5\text{SO}_3\text{H}$) via electrophilic aromatic sulfonation [real PYQ].

The 'big four' electrophilic aromatic substitutions of benzene: Nitration ($\rightarrow$ nitrobenzene), Halogenation ($\rightarrow$ halobenzenes), Friedel-Crafts alkylation/acylation, and Sulfonation.

In benzene + Cl_2 (with FeCl_3 catalyst): FeCl_3 is a Lewis acid catalyst that polarises the $\text{Cl}-\text{Cl}$ bond, generating the electrophilic Cl^+ species that attacks the electron-rich ring — FeCl_3 itself is NOT consumed/oxidised/reduced, its role is purely to GENERATE the electrophile [real PYQ].

CO_2 is a linear, symmetric molecule ($\text{O}=\text{C}=\text{O}$) — its two $\text{C}=\text{O}$ bond dipoles point in exactly opposite directions and cancel out, giving CO_2 a net ZERO dipole moment (non-polar), unlike bent/pyramidal molecules like H_2O and NH_3 [real PYQ].

Benzene (C_6H_6) bonding count: 12 sigma (σ) bonds (6 $\text{C}-\text{C}$ + 6 $\text{C}-\text{H}$) + 3 pi (π) bonds (from the 3 alternating double bonds/delocalized ring system) — a frequently tested bond-counting fact.

TRAPS — how the exam catches you

SN1 and SN2 are nucleophilic SUBSTITUTION mechanisms; E2 (elimination) is NOT a substitution reaction — a real 'which is NOT' PYQ tests exactly this distinction.

Acidity order: Carboxylic acids > phenols with electron-withdrawing groups (e.g., p-Nitrophenol) > plain Phenol > Alcohols. So Benzoic acid > p-Nitrophenol > Phenol [real PYQ] — carboxylate resonance stabilization beats phenoxide stabilization.

7.3 Alcohols

In one line: Ethanol is BPSC's favourite alcohol question — know the difference between absolute, denatured, and rectified spirit.

NUMBERS TO REMEMBER

Ethanol (C_2H_5OH) is a liquid at room temperature; produced industrially by fermentation of sugars (yeast) or from ethylene (petrochemical route).

Absolute alcohol = 100% pure ethanol (no water) [real PYQ, BPSC BAO 2024].

Denatured alcohol = ethanol deliberately mixed with poisonous substances (e.g., methanol, pyridine) to make it unfit for drinking, while remaining usable industrially — this AVOIDS liquor tax on industrial ethanol.

Ethanol uses: pharmaceuticals — antiseptic, antipyretic (fever-reducing), and anti-allergic medicine production; antiseptics (70% ethanol solution kills germs better than 100% — some water is needed to denature microbial proteins), fuel (ethanol-blended petrol, India's E20 programme), solvent for polymers/cosmetics.

Fermentation biochemistry (sugarcane/molasses → ethanol): the enzyme Invertase converts sucrose (cane sugar) into glucose + fructose; the enzyme Zymase then converts glucose/fructose into ethanol + CO_2 — two distinct enzyme steps, a favourite NCERT-level detail.

Fructose is the sweetest naturally occurring sugar — sweeter than sucrose or glucose; a common comparison point against synthetic sweeteners (saccharin, aspartame).

Alcohols are oxidised to carboxylic acids (e.g., ethanol → acetic acid) — this is the ONLY route covered here; oxidation is the defining alcohol→acid conversion (e.g., using acidified $KMnO_4/K_2Cr_2O_7$, or aerobically by Acetobacter bacteria to make vinegar).

7.4 Organic (Carboxylic) Acids

In one line: Every 'natural acid + food source' pairing in this file traces back to a carboxylic acid — memorise the memory hook once, apply it to every question.

NUMBERS TO REMEMBER

Memory hook: 'Ants Sting Forcefully' → Ant sting = Formic acid. Vinegar = Acetic acid. Lemon = Citric acid. Curd = Lactic acid — the four most-asked source-acid pairs.

Carboxylic acids are MORE acidic than phenols/alcohols because their conjugate base (carboxylate ion) is resonance-stabilised across TWO equivalent oxygen atoms — a stronger stabilisation than phenoxide's single-ring resonance.

Acid	Formula	Source
Acetic (Ethanoic)	CH_3COOH	Vinegar
Citric	$C_6H_8O_7$	Citrus fruits
Lactic	$CH_3CHOHCOOH$	Curd/sour milk; exercising muscles
Formic (Methanoic)	$HCOOH$	Ant/bee sting — MOST reactive carboxylic acid
Oxalic	$(COOH)_2$	Tomatoes, spinach — removes rust/ink stains
Tartaric	$C_4H_6O_6$	Grapes, tamarind — used with baking soda in baking powder

7.5 Explosive Substances

In one line: Nitric acid (HNO_3) is the common thread — almost every major explosive is made by nitrating an organic compound with concentrated HNO_3/H_2SO_4 .

NUMBERS TO REMEMBER

Nitric acid (HNO_3) is the essential reagent for making nitro-explosives (TNT, RDX, nitroglycerin, gun cotton) via nitration reactions — this links Ch10's ' HNO_3 used in explosives' fact directly to this topic.

Nitroglycerin is chemically classed as an ESTER (glyceryl trinitrate = ester of glycerol and nitric acid) — not an amine or amide, a common classification trap.

Historic atomic bombs (fissile material, not chemical explosives but a related PYQ pairing): Hiroshima bomb 'Little Boy' used Uranium-235; Nagasaki bomb 'Fat Man' used Plutonium-239.

Firecracker/fireworks colours come from metal salts: Strontium salts → bright RED, Barium → green, Copper → blue, Sodium → yellow, Magnesium/Aluminium → white/silver sparks.

Explosive	Full Name/Composition	Key Fact
TNT	Trinitrotoluene	Made by nitrating toluene; relatively stable, standard military explosive
RDX	Cyclotrimethylenetrinitramine (Research Department Explosive)	More powerful than TNT; used in military & demolition
Nitroglycerin	Glyceryl trinitrate	Extremely shock-sensitive liquid explosive; also used medically (angina — vasodilator)
Dynamite	Nitroglycerin absorbed in kieselguhr (diatomaceous earth)	Invented by Alfred Nobel — made nitroglycerin safe to handle/transport
Gun Cotton	Nitrocellulose (cellulose nitrate)	Made by nitrating cellulose; propellant explosive
Gunpowder	Charcoal + Sulphur + Potassium nitrate (KNO_3)	Oldest known explosive/propellant
HMX (Octogen)	High Melting Explosive, $\text{C}_4\text{H}_8\text{N}_8\text{O}_8$	High explosive; rocket fuels, military use

7.6 Polymers — Natural & Synthetic

In one line: Addition polymerization (double-bond monomers simply join) vs Condensation polymerization (monomers join WITH loss of a small molecule like H_2O) — that one distinction sorts every polymer in the table below.

Polymer	Monomer	Type
Polyethylene	Ethylene	Addition; Thermoplastic
PVC	Vinyl chloride	Addition; Thermoplastic
Teflon (PTFE)	Tetrafluoroethylene	Addition; Thermoplastic — non-stick, chemically inert
Nylon-6,6	Hexamethylenediamine + Adipic acid	Condensation; Thermoplastic
Polyester (Dacron)	Ethylene glycol + Terephthalic acid	Condensation; Thermoplastic
Bakelite	Phenol + Formaldehyde	Condensation; Thermosetting — world's FIRST synthetic polymer (1907, Baekeland)
Melamine-formaldehyde	Melamine + Formaldehyde	Condensation; Thermosetting
Buna-S (SBR)	Butadiene + Styrene	Addition; most widely used synthetic rubber
Kevlar	Diamine + diacid chloride	Condensation — bulletproof vests
PHBV	3-hydroxybutanoic + 3-hydroxyvaleric acid	Condensation; BIODEGRADABLE bioplastic [71st BPSC 2025 PYQ]
Superglue	Cyanoacrylate	Rapid moisture-triggered polymerization [real PYQ]

Natural Polymer	Monomer	Source
Starch	Glucose (α)	Rice, wheat, potato — plant energy storage
Cellulose	Glucose (β)	Plant cell walls — cotton, paper, wood
Natural Rubber	Isoprene	Latex from <i>Hevea brasiliensis</i>

Proteins	Amino acids	Hair, muscle, enzymes
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TRAPS — how the exam catches you

PHBV is a biodegradable polymer/bioplastic (produced naturally by bacteria) — NOT a synthetic non-biodegradable plastic [real PYQ, ScienceMCQ bank].

Superglue is a polymer of Cyanoacrylate, not Vinyl chloride (that's PVC's monomer) — a common distractor pairing [real PYQ].

Acrylic is called 'artificial wool'; Rayon is called 'artificial silk' — these two are frequently swapped in trick questions, so fix the pairing firmly: Acrylic→wool, Rayon→silk.

7.6b Vulcanization & Thermoplastic vs Thermosetting

In one line: Vulcanization (Goodyear, 1839) is what turns weak, sticky natural rubber into the tyres you actually use — sulfur cross-links the polymer chains.

NUMBERS TO REMEMBER

Vulcanization: heating natural rubber with sulfur at ~150°C creates cross-links between polymer chains → harder, stronger, more elastic, water-resistant. Discovered by Charles Goodyear (1839).

Natural rubber = polymer of Isoprene (2-methylbuta-1,3-diene); without vulcanization it's soft, sticky, and has poor mechanical properties.

Feature	Thermoplastic	Thermosetting
On heating	Softens, can be remoulded	Hardens PERMANENTLY
Recycling	CAN be recycled	CANNOT be recycled
Examples	PVC, polyethylene, nylon, Teflon	Bakelite, melamine-formaldehyde

7.7 Fuels & Combustion — Calorific Values & Coal Types

In one line: Hydrogen has the HIGHEST calorific value of any fuel — a fact that surprises most students but is asked repeatedly.

NUMBERS TO REMEMBER

Fire triangle: Fuel + Heat + Oxygen — remove any ONE to extinguish a fire.

Octane number = anti-knock quality of petrol (iso-octane=100, n-heptane=0). Cetane number = ignition quality of diesel.

Types of combustion: Rapid (wood, LPG), Spontaneous (white phosphorus, no external heat needed), Explosive (dynamite, gunpowder), Slow (rusting, respiration — no flame).

Fuel	Calorific Value (kJ/kg)	Note
Hydrogen	~1,50,000	HIGHEST of any fuel; zero carbon emission
LPG	~55,000	Propane+Butane; ethyl mercaptan added for smell
CNG	~55,000	Mainly CH ₄ ; cleanest vehicular fuel
Petrol	~47,000	Quality = OCTANE number
Diesel	~45,000	Quality = CETANE number
Coal (Anthracite)	~32,000	Best-quality coal
Biogas	~20,000	CH ₄ 50-75% + CO ₂ ; from manure/organic waste

Coal Type	Carbon %	Quality
Peat	~50%	Lowest — first stage of coal formation; plant traces still recognisable [real PYQ]

Lignite	60–70%	Brown coal
Bituminous	70–85%	Most abundant; power generation, coking coal
Anthracite	90–95%	Best/cleanest-burning

TRAPS — how the exam catches you

Peat, the EARLIEST stage of coal formation, is the variety that still shows visible plant-material traces — as coalification progresses toward anthracite, those traces are lost [real PYQ].

7.8 LPG/CNG/Biogas & Fire Extinguishers

In one line: LPG and CNG have DIFFERENT compositions despite both being 'cooking gas'-adjacent — Propane+Butane vs mostly Methane.

NUMBERS TO REMEMBER

Ethyl mercaptan is added to LPG/CNG (both naturally odourless) to give a detectable rotten-egg smell for leak detection.

Water gas = $\text{CO} + \text{H}_2$ (steam over hot coke). Producer gas = $\text{CO} + \text{N}_2$ (limited air over hot coke). Fuel cell: $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O} + \text{electricity}$ — zero emissions.

LPG cylinders don't carry a pressure gauge because the pressure inside stays roughly CONSTANT (governed by the liquid-vapour equilibrium) regardless of how much gas remains — pressure alone can't indicate the remaining quantity, unlike a CNG cylinder.

Feature	LPG	CNG	Biogas
Composition	Propane+Butane	Mainly CH_4 (80-90%)	CH_4 50-75% + CO_2
Storage	Liquid under pressure	Compressed gas, 200 bar	Gas, used/stored directly
Use	Domestic cooking	Vehicles	Cooking, heating

Extinguisher Type	Mechanism	Best For
Water	Cools below ignition temp	Class A (wood/paper) only
CO_2	Removes O_2 , cools	Electrical fires, flammable liquids
Dry Powder (ABC)	Smothers + interrupts chain reaction	All fire classes
Soda-Acid	$\text{NaHCO}_3 + \text{dil. H}_2\text{SO}_4 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$	Small/domestic fires [70th BPSC 2024 PYQ]

— END —

BPSC CHEMISTRY — FILE 5

Food Preservation, Nutrition, Medicine | Detergents and Soap

Bold ORANGE numbers = high-yield facts. RED traps = common exam mistakes. Read subtopic-by-subtopic.

WHERE THESE QUESTIONS COME FROM

BPSC/UPPSC PYQs (39th-71st) via IAS Valley Notes compilation, a tagged Chemistry PYQ bank (Everyday & Applied Chemistry subtopic), the RO/APO 2026 Science paper, and NCERT Class 10-12.

8.1 Drugs & Medicines — Classification

In one line: One drug can wear multiple hats (Aspirin = analgesic + antipyretic + anti-inflammatory + anticoagulant) — BPSC tests whether you know ALL of a drug's roles, not just one.

NUMBERS TO REMEMBER

Aspirin = Acetylsalicylic acid — simultaneously analgesic + antipyretic + anti-inflammatory + anticoagulant (blood thinner). Most commonly asked drug in BPSC.

Penicillin = first antibiotic, discovered by Alexander Fleming (1928).

Cisplatin, carboplatin, oxaliplatin (platinum-based compounds) are chemotherapy drugs — they bind cancer-cell DNA and interfere with replication [real PYQ].

Category	Function	Examples
Analgesics	Relieve pain	Aspirin, Paracetamol, Ibuprofen, Morphine
Antipyretics	Reduce fever	Aspirin, Paracetamol
Antibiotics	Kill/inhibit BACTERIA (not viruses)	Penicillin, Streptomycin, Tetracycline
Antiseptics	On LIVING tissue (wounds, skin)	Dettol, Savlon, 70% Ethanol, Iodine tincture
Disinfectants	On NON-living surfaces only	Phenol, Chlorine, Bleaching powder
Antacids	Neutralise excess stomach HCl	$Mg(OH)_2$, $Al(OH)_3$, $NaHCO_3$
Antihistamines	Block histamine — treat allergies	Cetirizine, Chlorpheniramine
Antimalarial	Treat malaria	Quinine (from Cinchona bark), Chloroquine
Sedatives/Tranquillisers	Reduce anxiety, induce sleep	Diazepam, Chlordiazepoxide
Chemotherapy drugs	Kill rapidly-dividing cancer cells	Cisplatin, Carboplatin (platinum compounds)

TRAPS — how the exam catches you

Antiseptics go on LIVING tissue; Disinfectants go on NON-living surfaces — never the reverse. Chloramine-T, for instance, is a strong oxidiser too harsh for living tissue, so it's used only as a non-living-surface disinfectant [real PYQ].

Quinine and Chloroquine are BOTH antimalarial — neither is an antibiotic, a frequent distractor pairing.

Oxytocin is a HORMONE (from hypothalamus, secreted by pituitary) — NOT an antibiotic [real PYQ, BPSC CDPO 2018].

8.2 Named-Drug Trick Facts & Matching

In one line: BPSC loves match-the-drug-to-its-class questions — this is a compressed answer key for the most commonly recycled options.

Drug	Class
Norethisterone	Antifertility/contraceptive hormone (progestin)
Levonorgestrel	Antifertility/contraceptive hormone (progestin) — emergency contraceptive pill [real PYQ, 71st BPSC 2025]
Venlafaxine	Antidepressant (SNRI)

Cetirizine	Antihistamine
Chlordiazepoxide	Tranquilliser (first benzodiazepine, brand Librium)
Arsphenamine (Salvarsan)	Early antisyphilitic chemotherapeutic agent
Tetraethyl lead	Historical anti-knock/octane-boosting fuel additive (now banned — toxic)

TRAPS — how the exam catches you

Norethisterone (norethindrone) is the antifertility/contraceptive-pill hormone — a real PYQ distractor list includes antidepressants and antihistamines to test if you know the specific class [71st BPSC].

India completely phased out LEADED petrol by 2000; tetraethyl lead has been replaced by ethanol blending (India's E20 programme) and MTBE.

8.3 Food Chemistry — Artificial Sweeteners

In one line: Sweetness is always measured RELATIVE to sugar — know the multiplier, not just the name.

Sweetener	Relative Sweetness	Note
Saccharin	300–500× sugar	FIRST artificial sweetener; slight bitter aftertaste
Aspartame	~200× sugar	Most widely used; breaks down at high cooking temp
Sucralose (Splenda)	~600× sugar	Stable at high temp; used in baking
Stevia	200–300× sugar	Natural — from Stevia rebaudiana plant
Neotame	~8000× sugar	Aspartame derivative, heat-stable

TRAPS — how the exam catches you

Aspartame is an artificial SWEETENER — not a synthetic rubber; a real PYQ tests this exact mix-up between chapter topics.

8.4 Food Preservatives, Antioxidants & Handling Chemicals

In one line: Different preservation methods work by different mechanisms — osmosis (salt/sugar), acidity (vinegar), or oxidation-blocking (antioxidants, N₂ gas) — know WHICH mechanism, not just the chemical name.

NUMBERS TO REMEMBER

Salt/Sugar: high concentration → plasmolysis (bacteria lose water by osmosis).

Vinegar (acetic acid): acidic environment inhibits bacteria — pickles, ketchup.

Sodium benzoate (C₆H₅COONa): the most common chemical preservative — cold drinks, jams, pickles.

Potassium metabisulphite: wine, dried fruits, fruit juices.

Antioxidants (BHA, BHT, Vitamin C/E): prevent RANCIDITY (oxidation of fats/oils).

Nitrogen gas filled in chips packets: prevents oxidation of oils — a physical (inert-atmosphere), not chemical, preservation method.

Iodised salt is fortified with Potassium Iodide (KI), NOT free/elemental iodine — a common misconception; KI is stable and safely provides dietary iodine to prevent goiter.

- Calcium carbide is used to artificially HASTEN fruit ripening (releases acetylene gas, mimics ethylene) — though banned in India for food use due to arsenic/phosphorus impurity risks.
- Potassium permanganate (KMnO₄) is used to PRESERVE fruit (as a wash, controls fungal growth).
- Silver iodide (AgI) is used for cloud seeding to induce ARTIFICIAL RAIN — not a food chemical, but a commonly paired distractor in the same PYQ set [real RO Prelims 2026 match-the-following].

9.1 Soap — Composition & Saponification

In one line: Soap cleans via MICELLE formation — hydrophobic tail traps grease, hydrophilic head faces water — this single mechanism explains everything soap can and can't do.

NUMBERS TO REMEMBER

Soap = sodium/potassium salt of a long-chain fatty acid; formula RCOONa or RCOOK .

Preparation — Saponification: $\text{fat/oil} + \text{NaOH(aq)} \rightarrow \text{soap} + \text{glycerol}$.

Soap molecule structure: hydrophilic head ($-\text{COO}^-\text{Na}^+$, water-loving) + hydrophobic tail (long hydrocarbon chain, grease-loving).

Micelle formation: soap molecules surround grease/dirt with hydrophobic tails pointing IN (toward grease) and hydrophilic heads pointing OUT (toward water) — this emulsifies grease so it washes away [real PYQ: soap removes grease by emulsification].

TRAPS — how the exam catches you

Soap does NOT work well in hard water — $\text{Ca}^{2+}/\text{Mg}^{2+}$ ions react with soap to form an insoluble scum: $2\text{RCOONa} + \text{CaCl}_2 \rightarrow (\text{RCOO})_2\text{Ca}\downarrow + 2\text{NaCl}$.

9.2 Detergents — Composition & Advantage over Soap

In one line: Detergents exist because soap has exactly one weakness (hard water) — everything about detergent chemistry follows from fixing that one weakness.

NUMBERS TO REMEMBER

Detergents = sodium alkyl sulphonates or sodium alkyl benzene sulphonates ($\text{R-SO}_3\text{Na}$) [real PYQ, 63rd BPSC 2017].

Advantage over soap: WORK IN HARD WATER — the $\text{Ca}^{2+}/\text{Mg}^{2+}$ salts of sulphonates remain SOLUBLE (unlike soap's insoluble scum).

Disadvantage: older/non-biodegradable detergents cause water pollution (persistent froth in rivers); modern detergents use straight-chain sulphonates that ARE biodegradable.

— END —

BPSC CHEMISTRY — FILE 6

Fertilizers | Miscellaneous (Environmental Chemistry & Applied Facts)

Bold ORANGE numbers = high-yield facts. RED traps = common exam mistakes. Read subtopic-by-subtopic.

WHERE THESE QUESTIONS COME FROM

BPSC/UPPSC PYQs (39th-71st) via IAS Valley Notes compilation, a tagged Chemistry PYQ bank, the RO/APO 2026 Science paper, and NCERT Class 6-12.

10.1 Fertilizers — NPK Table, Haber Process & Biofertilizers

In one line: Urea's 46% nitrogen content is the single most-asked fertilizer fact — everything else in this topic builds around the N-P-K framework.

NUMBERS TO REMEMBER

N-P-K roles: Nitrogen (N) for leaf/vegetative growth, Phosphorus (P) for roots/fruits, Potassium (K) for overall plant health/disease resistance.

Urea elements: C, H, N, O (carbamide) — a direct 'which elements are present' PYQ [66th BPSC 2020].

Nitrogen fertilizers manufactured via the Haber Process: $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ (Fe catalyst, 450°C, 200 atm) [NCERT Class 11].

Biofertilizers: Rhizobium (legume root nodules — nitrogen fixation), Azospirillum, Mycorrhiza, Blue-green algae.

Fertilizer	Formula	Nutrient
Urea	$\text{CO}(\text{NH}_2)_2$	46% N — highest of any N fertilizer; most widely used
DAP	$(\text{NH}_4)_2\text{HPO}_4$	N=18%, P_2O_5 =46%
Ammonium sulphate	$(\text{NH}_4)_2\text{SO}_4$	N=21%; oldest N fertilizer; also adds sulphur
Ammonium nitrate	NH_4NO_3	N=34%; fast-acting; explosive when concentrated
Potash (MOP)	KCl	Provides K — root development, disease resistance

TRAPS — how the exam catches you

Overuse of chemical fertilizers → eutrophication and nitrate contamination of groundwater — this links fertilizer overuse directly to the water-pollution topic below.

11.1 Miscellaneous — Air Pollutants

In one line: Each pollutant has ONE signature mechanism — CO binds haemoglobin, SO_2 causes acid rain, CFCs destroy ozone. Learn the mechanism, not just the source.

NUMBERS TO REMEMBER

CO is colourless, odourless, and binds haemoglobin 200× faster than O_2 , forming carboxyhaemoglobin — a repeatedly tested exact multiplier [real PYQ].

Pollutant	Main Source	Key Effect
CO	Incomplete combustion	Binds Hb 200× faster than O_2 → carboxyhaemoglobin → suffocation
SO_2	Burning coal/oil, ore smelting	MAIN cause of acid rain; respiratory disease
NO_x	Vehicle exhaust, power plants	Acid rain (HNO_3); photochemical smog
Ozone (tropospheric)	Photochemical smog	Eye/lung irritant — 'bad' ozone, unlike protective stratospheric ozone

Lead compounds	Leaded petrol (banned), battery recycling	Neurotoxin — affects children's brain development
CFCs (Freons)	Fridges, ACs, aerosol sprays	Destroy stratospheric ozone layer

11.2 Miscellaneous — Greenhouse Effect & Ozone Layer

In one line: One Chlorine atom destroys ~100,000 ozone molecules — the chain-reaction scale is exactly why CFCs are so damaging despite being used in tiny quantities.

NUMBERS TO REMEMBER

Greenhouse gases: CO₂ (main), CH₄, N₂O, O₃, H₂O vapour, CFCs. Global Warming Potential: CH₄ = 25× CO₂; N₂O = 298× CO₂; CFCs = thousands× CO₂.

CO₂ has risen from ~280 ppm (pre-industrial) to ~420 ppm today — mainly from fossil fuel combustion; deforestation reduces CO₂ absorption capacity.

Stratospheric ozone (15-35 km) is BENEFICIAL — absorbs UV-B/UV-C. Formation: O₂+UV→2O; O+O₂→O₃.

CFC depletion chain: CF₂Cl₂ --UV--> Cl + CF₂Cl; Cl+O₃→ClO+O₂; ClO+O→Cl+O₂ — the chain regenerates Cl, so one Cl atom can destroy ~100,000 O₃ molecules.

Montreal Protocol (1987): international treaty phasing out CFCs/HFCs — widely regarded as the most successful environmental treaty. Ozone hole is largest over Antarctica (polar vortex effect).

International climate agreements: Kyoto Protocol (1997), Paris Agreement (2015).

11.3 Miscellaneous — Acid Rain & Water Pollution

In one line: Minamata=Mercury, Itai-Itai=Cadmium — this Japan-disease pairing is asked almost every cycle; keep the two straight by remembering 'Itai-Itai' (ouch-ouch, from bone pain) = bone-damaging Cadmium.

NUMBERS TO REMEMBER

Acid rain: pH < 5.6 (normal rain is pH ~5.6 due to dissolved CO₂). Caused by SO₂→H₂SO₄ and NO_x→HNO₃ in rainwater.

Taj Mahal marble damage: CaCO₃ + H₂SO₄ → CaSO₄ + H₂O + CO₂ — the CaSO₄ (gypsum) forms a white powdery crust, a favourite illustrative BPSC example.

North Bihar: groundwater ARSENIC contamination (Ganga plains — Bhagalpur, Patna districts, natural geological deposits) plus fluorosis in several districts — both are major Bihar-specific BPSC topics.

Concept	Explanation
BOD	O ₂ consumed by microbes decomposing organic matter; high BOD = polluted water
COD	Total O ₂ to chemically oxidise ALL pollutants; COD ≥ BOD always
Eutrophication	Fertiliser runoff → algal bloom → blocks sunlight → O ₂ depletion → fish death
Minamata Disease	Mercury (Hg) poisoning via fish — Minamata Bay, Japan, 1956
Itai-Itai Disease	Cadmium (Cd) poisoning — Japan; severe bone/kidney damage
Fluorosis	Excess fluoride in drinking water — teeth/bone damage; endemic in Bihar, Rajasthan, Andhra Pradesh

11.4 Miscellaneous — Smog Types

In one line: Classical smog needs COLD + moisture; photochemical smog needs HOT + sunlight — opposite weather conditions produce two entirely different pollution chemistries.

Type	Classical (London) Smog	Photochemical (LA) Smog
Formation	Coal burning + fog; SO ₂ +smoke+moisture	NO _x +VOCs+sunlight → O ₃ , PAN
Weather	Cold, humid	Hot, sunny, low humidity
Main components	SO ₂ , soot (reducing smog)	O ₃ , PAN, NO ₂ (oxidising smog)

Effect	Respiratory problems	Eye irritation; PAN is most toxic component
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11.5 Miscellaneous — Applied Chemistry Grab-Bag

In one line: A cluster of standalone applied-chemistry facts BPSC has actually asked — each is a complete, self-contained fact worth memorising individually.

- A catalyst works by lowering the potential energy of the TRANSITION STATE (activation energy) — it does NOT change the energy of reactants or products [real RO Prelims 2026 PYQ].
- 'Night-glowing' phosphorescent pigment = Europium-doped strontium aluminate ($\text{SrAl}_2\text{O}_4\text{:Eu}$) — modern glow-in-the-dark material, replacing the older, shorter-glowing zinc sulphide doped with copper (ZnS:Cd).
- 'Smart film'/smart-glass (electrochromic) applications use Indium Tin Oxide (ITO) — a transparent conducting oxide, also standard in touchscreens and thin-film solar cells.
- Photostat (photocopier) machine drums are coated with Selenium [real PYQ, BPSC APO paper].
- Ammoniacal nitrogen in wastewater = the SUM of free ammonia (NH_3) AND ammonium ion (NH_4^+) together, not just one of the two [real PYQ].
- Fischer-Tropsch process: $\text{CO} + \text{H}_2 \xrightarrow{\text{iron catalyst}}$ hydrocarbons + oxygenated hydrocarbons — used to synthesise fuels from syngas [real PYQ].
- Agar-agar, alginic acid, and the jelly from Gracilaria algae are chemically Phyco-colloids [real PYQ].
- Lipids are insoluble in water because they are hydrophobic [real PYQ].
- Green Chemistry = designing chemical products/processes that reduce or eliminate the use and generation of hazardous substances — focuses on prevention at the source, not clean-up afterward.
- Cadmium is NOT radioactive (unlike Uranium, Radium, Thorium, which ARE) — a common trap since Cadmium 'sounds' radioactive. It's a toxic heavy metal, used in Ni-Cd rechargeable batteries, and causes Itai-Itai disease.
- Breathalyzer chemistry: the test cartridge contains potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) + dilute sulphuric acid, which is orange-red; it turns GREEN when it oxidises ethanol in the breath — the colour change (orange→green) indicates alcohol presence.
- The 'X' in X-ray stands for 'unknown' — Wilhelm Röntgen named it X-ray in 1895 because the nature of the radiation was unknown at the time of discovery.

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