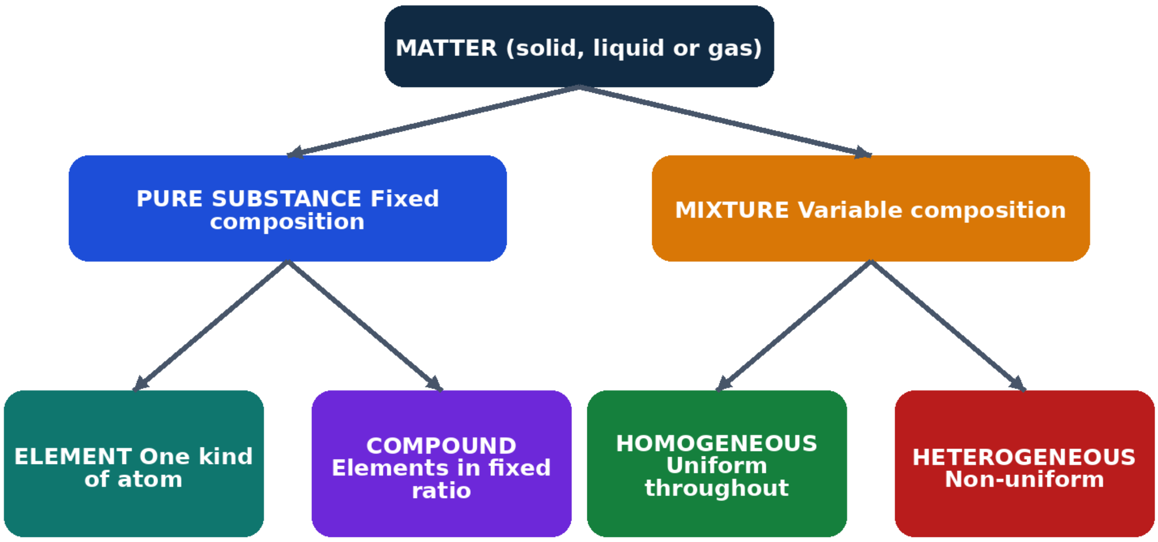
IS MATTER AROUND US PURE?

Complete Conceptual Notes for UPSC and WBCS

CLASSIFICATION OF MATTER



Examples: copper, oxygen | water, common salt | air, brass | soil, smoke

◆ **THE CENTRAL QUESTION** How do we distinguish a **pure substance**, a **mixture**, a **solution**, a **colloid** and a **suspension** - and how do we select the right separation method?

FOUNDATION SCIENCE • PRELIMINARY EXAMINATION • MAIN EXAMINATION ENRICHMENT

Prepared for JKH Institute Students

LEARNING MAP

How to Study This Chapter for Competitive Examinations

Move from definition to observation, then from observation to practical application.

In everyday language, "pure" often means **free from adulteration**. In science, a material is pure only when it contains **one kind of constituent particle** and has a **fixed composition** with characteristic properties.

◆ **CORE ISSUE** A packet marked "pure milk" can still be a **mixture** of water, fat, proteins, minerals and sugars. Scientific purity is about **composition**, not about marketing language.

A. Five Questions to Ask

1. Does the material have a **fixed composition** or can the proportion change?
2. Is the appearance **uniform throughout** or are different parts visible?
3. Do the particles **settle** when the material is left undisturbed?
4. Does the material **scatter light** and show the Tyndall effect?
5. Which physical property - size, density, solubility, volatility or boiling point - can be used for **separation**?

B. Examination Relevance

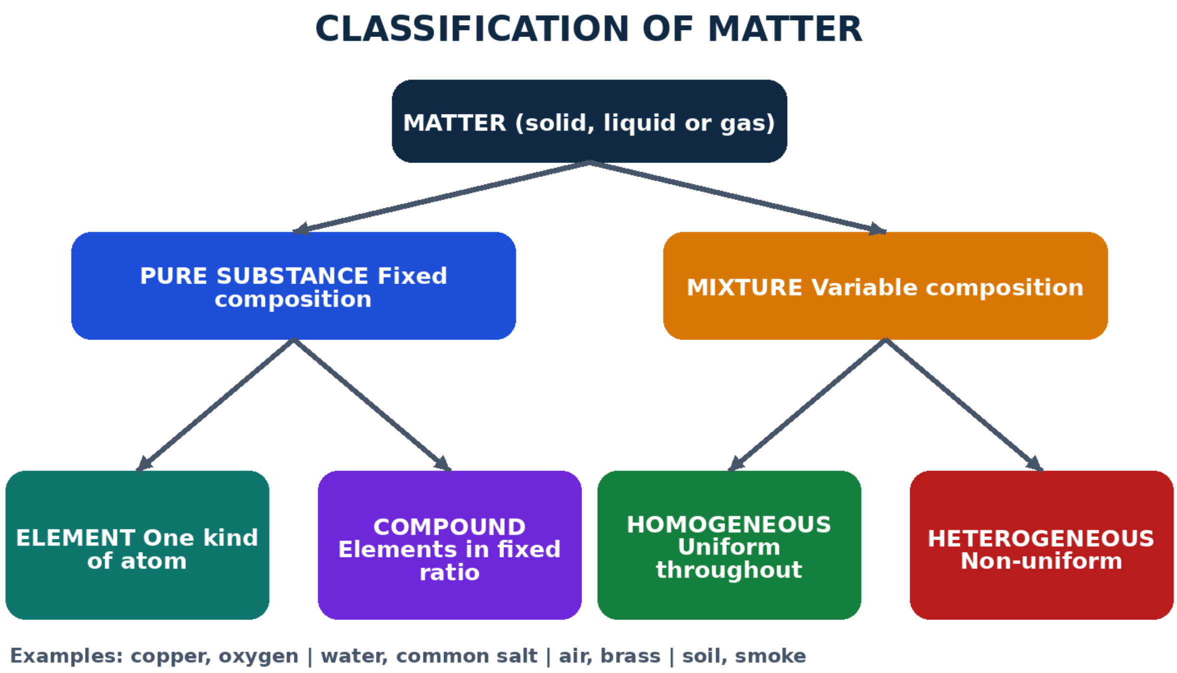
Area	What the examiner may test
Preliminary Examination	Definitions, examples, particle size, properties, apparatus and method selection.
Environment	Aerosols, smog, water pollution, sedimentation and filtration.
Public Health	Municipal water purification, diagnostic centrifugation and medicine purification.
Industry	Alloys, petroleum refining, gas separation, crystallisation and chromatography.
Main Examination	Science-based explanation of public services, pollution control and technological processes.

◆ **MEMORY FORMULA** **Composition** tells us what the material is; **particle behaviour** tells us whether it is a solution, colloid or suspension; **property difference** tells us how to separate it.

1

Matter: Pure Substances and Mixtures

The most important classification framework in this chapter.



A **pure substance** has a fixed composition and contains only one kind of chemical entity. It may be an **element** or a **compound**. A **mixture** contains two or more pure substances physically combined in any proportion.

Feature	Pure substance	Mixture
Composition	Fixed	Variable
Constituents	One element or one compound	Two or more substances
Properties	Definite characteristic properties	Depends on proportions and components
Separation	Chemical/electrochemical method for compounds	Usually physical methods

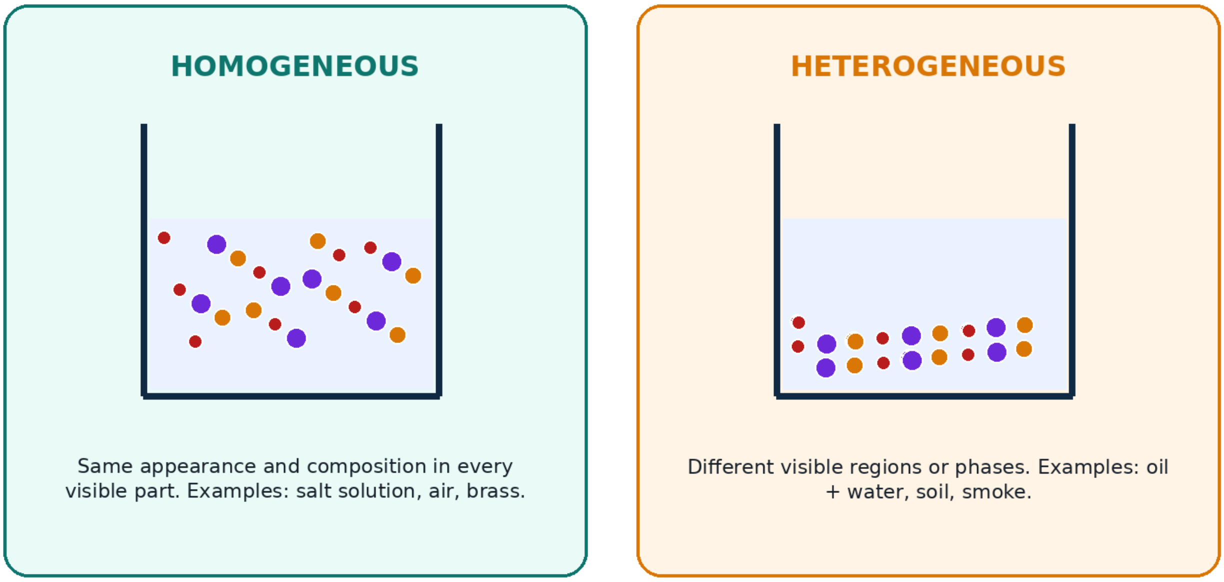
◆ **PRACTICAL USE** Quality control laboratories test whether medicines, food additives and industrial chemicals meet a specified **composition**. The same idea underlies standards set by scientific and regulatory bodies.

2

Homogeneous and Heterogeneous Mixtures

Uniformity is judged at the scale of observation.

HOMOGENEOUS AND HETEROGENEOUS MIXTURES



A **homogeneous mixture** has the same composition and properties in every visible portion. A **heterogeneous mixture** has physically distinct regions, phases or non-uniform composition.

A. Examples of homogeneous mixtures: **air**, salt solution, sugar solution, vinegar and many alloys.

B. Examples of heterogeneous mixtures: **soil**, smoke, oil-water mixture, sand in water and granite.

C. Homogeneous does not mean “fixed composition.” A copper sulphate solution can be pale or dark because the amount of solute can change.

D. A colloid often appears homogeneous to the naked eye but is scientifically **heterogeneous** because it has a dispersed phase and a dispersion medium.

◆ **EXAM TRAP** **Brass** is normally treated as a homogeneous mixture, although its composition can vary. **Milk** appears uniform but is a colloidal heterogeneous mixture.

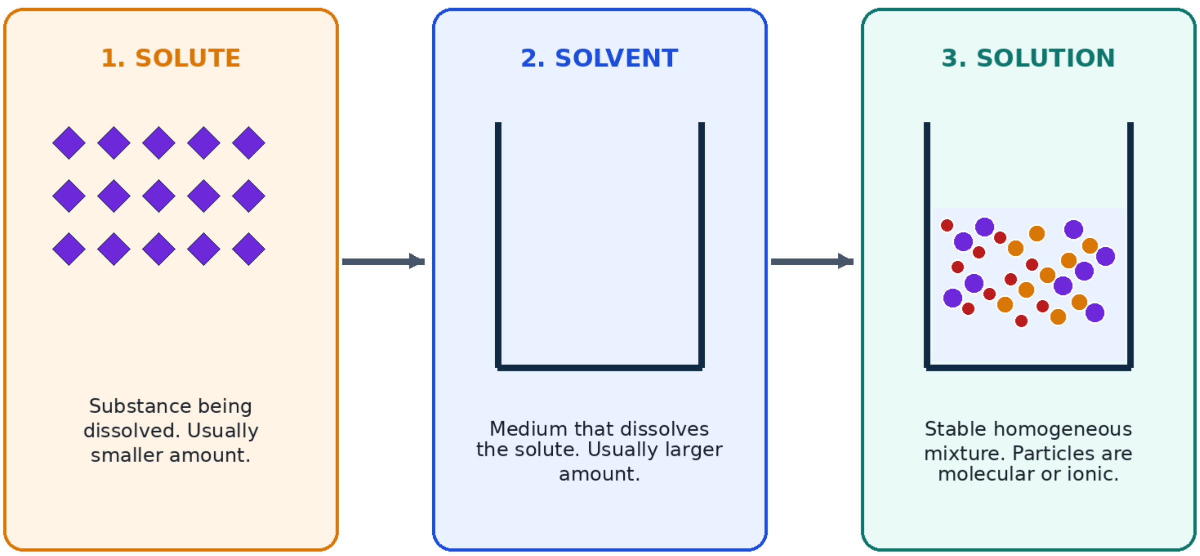
◆ **REAL-LIFE LINK** Uniform pharmaceutical syrups require controlled mixing. Non-uniform suspensions must be shaken because particles may settle during storage.

3

Solution: Solute, Solvent and Uniform Distribution

A solution is a homogeneous mixture of two or more substances.

HOW A SOLUTION FORMS



The component that dissolves another component is the **solvent**, usually present in the larger amount. The component dissolved in it is the **solute**, usually present in the smaller amount.

1. Sugar in water: sugar is the **solute** and water is the **solvent**.
2. Tincture of iodine: iodine is the solute and alcohol is the solvent.
3. Soda water: carbon dioxide is the solute and water is the solvent.
4. Air: nitrogen is treated as the principal solvent-like component; oxygen and minor gases are solute-like components.

◆ **PROPERTIES OF A TRUE SOLUTION** Particles are smaller than about **1 nanometre**, cannot be seen with the naked eye, do not settle, pass through ordinary filter paper and normally do not show the Tyndall effect.

◆ **PRACTICAL USE** Solutions are central to intravenous fluids, oral rehydration solution, fertilizers, metal plating, laboratory reagents and drug formulation.

4

Solutions Are Not Always Liquid

The physical state of the final solution depends mainly on the solvent.

SOLUTIONS CAN EXIST IN ALL THREE STATES

GAS IN GAS
Air: oxygen and other gases in nitrogen

GAS IN LIQUID
Soda water: carbon dioxide in water

LIQUID IN LIQUID
Alcohol in water; vinegar

SOLID IN LIQUID
Salt or sugar in water

SOLID IN SOLID
Alloys: brass, bronze, steel

LIQUID IN SOLID
Dental amalgam and some gels

Key idea: "solution" describes uniform mixing, not merely a liquid state.

The word **solution** refers to a uniform mixture, not merely to a liquid. A solution may be gaseous, liquid or solid. **Alloys** are important solid solutions used in engineering and public infrastructure.

System	Example	Competitive-exam note
Gas in gas	Air	Composition is uniform on a macroscopic scale.
Gas in liquid	Carbonated water	Gas solubility generally increases with pressure.
Liquid in liquid	Alcohol-water	Miscible liquids form one phase.
Solid in liquid	Salt-water	Most familiar laboratory solution.
Solid in solid	Brass, steel	Alloys retain mixture character and may have variable composition.

◆ **GOVERNANCE LINK** Choice of alloy affects bridges, railways, electrical networks, coins and medical devices. Material composition therefore has consequences for **safety**, **cost** and **durability**.

5

Concentration of a Solution

Concentration expresses how much solute is present in a given amount of solution.

THREE SCHOOL-LEVEL EXPRESSIONS OF CONCENTRATION

MASS BY MASS %	MASS BY VOLUME %	VOLUME BY VOLUME %
$\frac{\text{mass of solute}}{\text{mass of solution}} \times 100$	$\frac{\text{mass of solute}}{\text{volume of solution}} \times 100$	$\frac{\text{volume of solute}}{\text{volume of solution}} \times 100$

Example: 40 g salt + 320 g water = 360 g solution. Mass by mass percentage = (40/360) × 100 = 11.1%.

Solved Example

A solution contains **40 g salt** in **320 g water**. Mass of solution = 40 + 320 = **360 g**. Therefore, mass by mass percentage = (40/360) × 100 = **11.1%**.

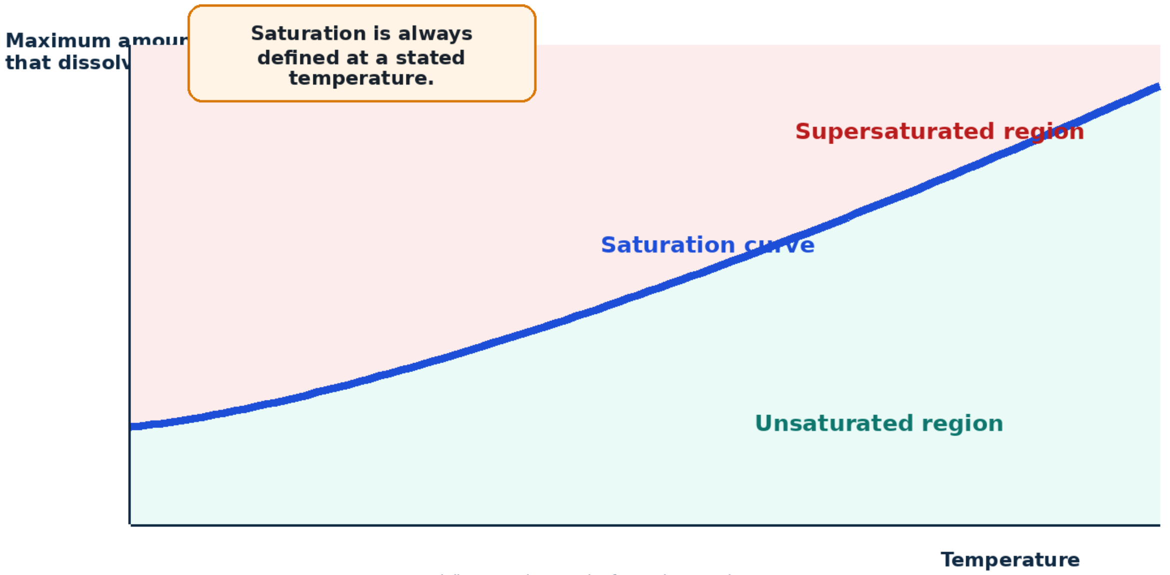
- **FORMULA DISCIPLINE** Read the denominator carefully. “Mass by mass” uses **mass of solution**; “mass by volume” uses **volume of solution**; “volume by volume” uses **volume of solution**.
- **PRACTICAL USE** Concentration determines medicine dose, disinfectant strength, salinity, fertilizer preparation and laboratory accuracy. A small calculation error may create a major public-health or industrial problem.

6

Saturated, Unsaturated and Supersaturated Solutions

Saturation is meaningful only at a specified temperature.

SATURATION AND SOLUBILITY: A CONCEPTUAL VIEW



Conceptual diagram - shape varies from solute to solute.

A. An **unsaturated solution** can dissolve more solute at the stated temperature.

B. A **saturated solution** has dissolved the maximum amount possible at that temperature.

C. A **supersaturated solution** temporarily contains more dissolved solute than the normal saturation limit and is unstable.

D. Solubility is the maximum amount of solute that dissolves in a given amount of solvent at a specified temperature.

◆ **FACTORS AFFECTING SOLUBILITY** For many solids, solubility increases with **temperature**. For gases, solubility generally increases with **pressure** and decreases with higher temperature.

◆ **REAL-LIFE LINK** Cold soft drinks retain more dissolved carbon dioxide. Crystallisation uses temperature-dependent solubility to recover purified solids.

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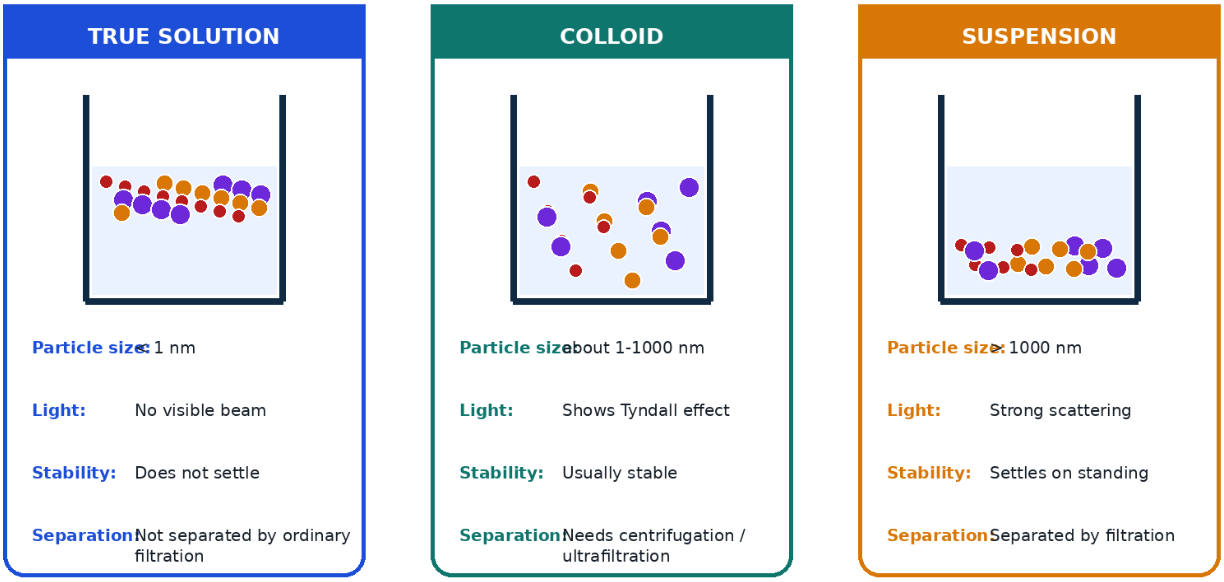
True Solution, Colloid and Suspension

Particle size controls visibility, stability, light scattering and separability.

TRUE SOLUTION vs COLLOID vs SUSPENSION



Property	True solution	Colloid	Suspension
Nature	Homogeneous	Heterogeneous but appears uniform	Heterogeneous
Particle size	Below about 1 nm	About 1-1000 nm	Above about 1000 nm
Visibility	Not visible	Not individually visible	Often visible
Tyndall effect	Absent	Present	Strong scattering
Settling	No	Generally no	Yes
Ordinary filtration	Not separated	Not separated	Separated

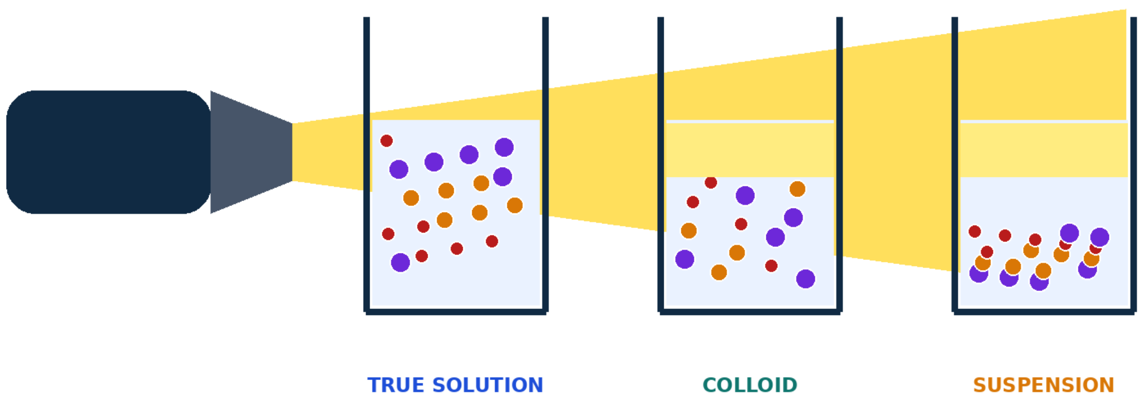
◆ **EXAM TRAP** A colloid is not a true solution. It is a **heterogeneous system** whose particles are too small to be seen individually but large enough to scatter light.

8

Tyndall Effect and the Behaviour of Colloids

Light scattering makes the path of a beam visible.

TYNDALL EFFECT: WHY A LIGHT BEAM BECOMES VISIBLE



Scattering occurs when dispersed particles are large enough to redirect visible light.

The **Tyndall effect** is the scattering of light by colloidal particles. The beam becomes visible because light is redirected toward the observer. Dust, mist and smoke in air can produce the same effect.

1. A fine sunbeam entering a dusty room becomes visible because air contains suspended or colloidal particles.
2. Fog reduces visibility because tiny water droplets scatter light.
3. The blue appearance of diluted milk under a beam is linked with scattering by fat and protein particles.
4. True solutions do not normally show a visible beam because their particles are too small.

◆ **ENVIRONMENT LINK** Smog and aerosols affect visibility, radiation balance and respiratory health. The same basic particle-scattering concept appears in environmental science and air-quality discussions.

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Types and Everyday Importance of Colloids

Colloids are everywhere in food, atmosphere, medicine and industry.

COMMON TYPES OF COLLOIDS

Dispersed phase	Medium	Type	Examples
Liquid	Gas	Aerosol	Fog, cloud, mist
Solid	Gas	Aerosol	Smoke, dust
Gas	Liquid	Foam	Shaving cream
Liquid	Liquid	Emulsion	Milk, face cream
Solid	Liquid	Sol	Paint, mud, milk of magnesia
Gas	Solid	Solid foam	Foam rubber, pumice
Liquid	Solid	Gel	Jelly, cheese, butter
Solid	Solid	Solid sol	Coloured glass, gemstones

The solute-like component is the **dispersed phase**, while the continuous component is the **dispersion medium**. Classification depends on the physical states of these two components.

◆ **PRACTICAL USE** Paints, cosmetics, medicines, food products, rubber, foams and aerosols are designed by controlling colloidal stability. Wastewater treatment also uses coagulation to destabilise fine particles.

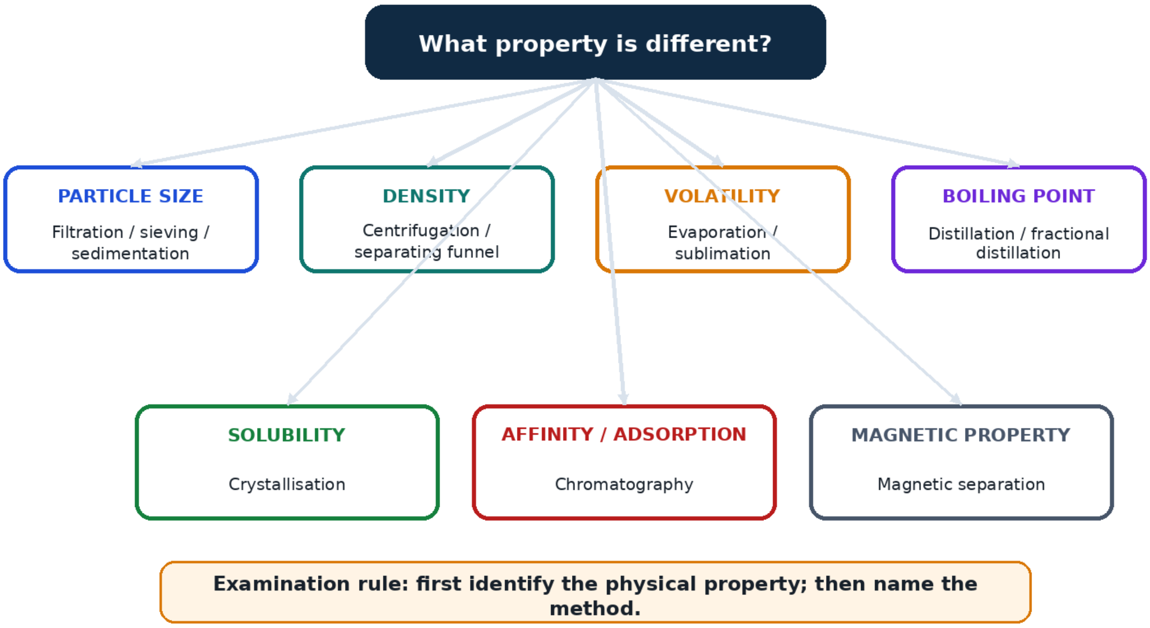
◆ **ADVANCED LINK** Colloidal particles show **Brownian movement**, a random zig-zag motion caused by molecular collisions. This motion helps resist settling and contributes to stability.

10

Separation of Mixtures: The Master Decision Rule

A separation method exploits a difference in physical property.

CHOOSING THE CORRECT SEPARATION METHOD



Never memorise a method in isolation. First identify the relevant difference: **particle size**, **density**, **solubility**, **volatility**, **boiling point**, **magnetism** or **affinity** for a surface and solvent.

> ◆ **MODEL ANSWER LINE** Components of a mixture retain their individual identity; therefore, they can often be separated by exploiting differences in their physical properties without forming a new substance.

Quick Selection Examples

A. Sand + water -> filtration because particle size is different.

B. Oil + water -> separating funnel because the liquids are immiscible and have different densities.

C. Salt + water -> evaporation or crystallisation because the solvent is volatile and the salt is non-volatile.

D. Acetone + water -> distillation because the liquids are miscible but have different boiling points.

E. Dyes in ink -> chromatography because components differ in solubility and adsorption.

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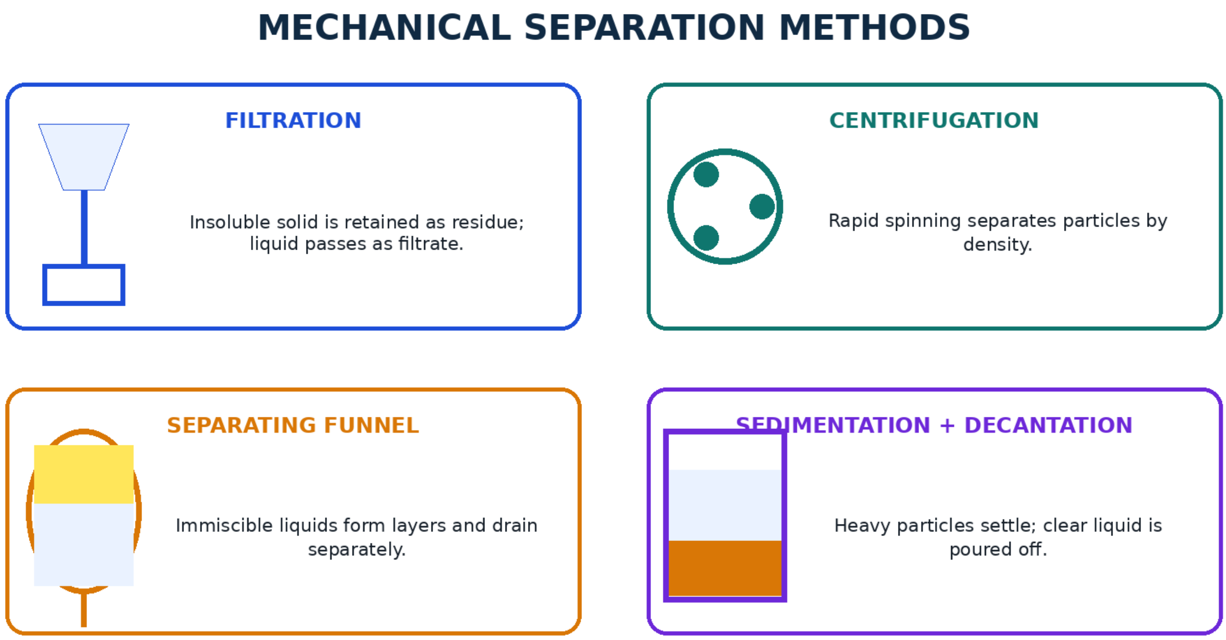
Mechanical Methods of Separation

These methods mainly use particle size or density differences.



Method	Principle	Common use
Filtration	Insoluble particles are larger than filter pores.	Tea leaves, laboratory precipitate, water treatment.
Sedimentation	Heavier particles settle under gravity.	Muddy water, treatment tanks.
Decantation	Clear upper liquid is poured off.	Water from settled sand.
Loading / coagulation	Fine particles combine into heavier flocs.	Alum in water treatment.
Centrifugation	Rapid rotation enhances density separation.	Cream from milk, blood components, washing machine.
Separating funnel	Immiscible liquids form layers by density.	Kerosene-water, oil-water.

◆ **PUBLIC HEALTH LINK** Diagnostic laboratories centrifuge blood to separate plasma, cells and other components. The principle is simple, but speed, time and tube balance must be carefully controlled.

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Thermal and Affinity-Based Methods

Volatility, boiling point, solubility and adsorption guide the method.

THERMAL AND AFFINITY-BASED METHODS

EVAPORATION

Recover a non-volatile solid from a volatile solvent.

Example: Ink dye, salt from solution

SUBLIMATION

One solid changes directly into vapour.

Example: Camphor + salt; ammonium chloride

CHROMATOGRAPHY

Components move at different rates due to different affinities.

Example: Dyes, pigments, drugs

DISTILLATION

Vaporise and condense a liquid component.

Example: Acetone-water; pure water

FRACTIONAL DISTILLATION

Repeated vaporisation-condensation for close boiling points.

Example: Petroleum fractions; liquid air

CRYSTALLISATION

Form pure crystals from a concentrated solution.

Example: Copper sulphate; alum; sea salt

A method is selected because components differ in a measurable physical property.

A. Evaporation removes a volatile solvent and leaves a non-volatile solute. It is useful when the solvent need not be recovered.

B. Sublimation separates a sublimable solid such as camphor or ammonium chloride from a non-sublimable impurity.

C. Chromatography separates dissolved substances because they move at different rates between a stationary phase and a mobile phase.

D. Distillation recovers a volatile liquid through vaporisation followed by condensation.

E. Fractional distillation improves separation when boiling points are close by providing repeated condensation and vaporisation.

F. Crystallisation forms pure crystals from a concentrated solution and often gives better purity than complete evaporation.

◆ **EXAM NUANCE** The school-level “25 K difference” is a useful guideline for choosing simple or fractional distillation, not a rigid universal law.

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Chromatography: Separation by Differential Movement

A powerful method from classroom ink to forensic laboratories.

Principle

In paper chromatography, the paper acts as the **stationary phase** and the solvent acts as the **mobile phase**. Components move at different speeds because their **solubility in the solvent** and **attraction to the paper** are different.

Stage	What happens
1. Spotting	A small concentrated sample is placed above the solvent level.
2. Development	The solvent rises by capillary action.
3. Separation	Components travel different distances.
4. Visualisation	Separate spots reveal the presence of different components.

◆ **APPLICATIONS** Separation of colours in dyes, plant pigments, drug components, food colours, inks, forensic samples and blood or urine constituents.

◆ **EXAM EXTENSION** The retention factor, **Rf = distance travelled by solute / distance travelled by solvent front**, helps compare components under the same experimental conditions.

◆ **FORENSIC LINK** Chromatography does not by itself prove guilt. It provides analytical evidence that must be interpreted with controls, chain of custody and other evidence.

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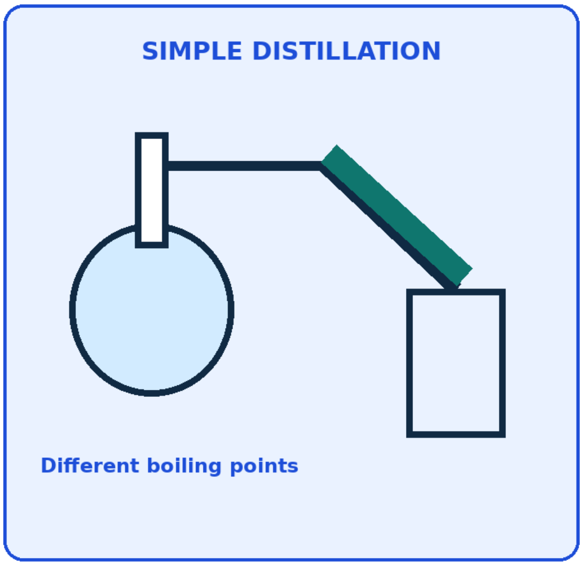
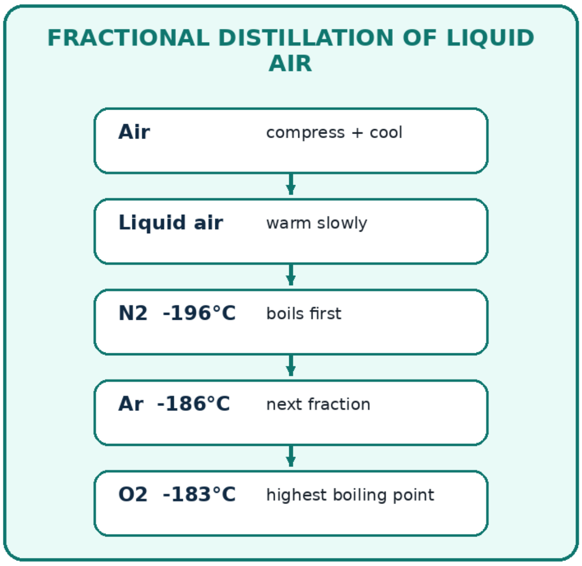
Distillation, Fractional Distillation and Liquid Air

Boiling-point differences become a separation tool.

DISTILLATION AND SEPARATION OF GASES FROM AIR





In **simple distillation**, the more volatile component vaporises first, travels into a condenser and returns to liquid form. **Fractional distillation** uses a fractionating column to create repeated vaporisation-condensation cycles and improve separation.

Gas	Approximate boiling point	Order on warming liquid air
Nitrogen	-196°C	Boils off first
Argon	-186°C	Intermediate
Oxygen	-183°C	Boils later / liquefies first on cooling

◆ **INDUSTRIAL USE** Fractional distillation separates petroleum into useful fractions and supplies oxygen, nitrogen and argon for hospitals, steelmaking, food packaging, welding and scientific work.

◆ **EXAM TRAP** On **cooling**, the gas with the higher boiling point liquefies first. On **warming liquid air**, the gas with the lower boiling point vaporises first.

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Crystallisation: Purification of Solids

Pure crystals form when a hot concentrated solution cools under controlled conditions.

1. Dissolve the impure solid in the **minimum amount of hot solvent**.
2. Filter to remove **insoluble impurities**.
3. Concentrate the solution until it is nearly saturated.
4. Cool slowly so that **pure crystals** form.
5. Separate and dry the crystals; soluble impurities largely remain in the mother liquor.

◆ **WHY BETTER THAN EVAPORATION** Some solids decompose, char or lose water of crystallisation on strong heating. Complete evaporation may also trap soluble impurities. Crystallisation gives **higher purity** and better crystal form.

Application	Why crystallisation is suitable
Copper sulphate	Forms characteristic blue crystals.
Alum	Purifies crystals from impure samples.
Sea salt	Removes many dissolved impurities.
Sugar industry	Produces controlled sugar crystals.

◆ **INDUSTRY LINK** Crystal size affects filtration, drying, storage and product quality in pharmaceuticals, fertilizers, chemicals and food processing.

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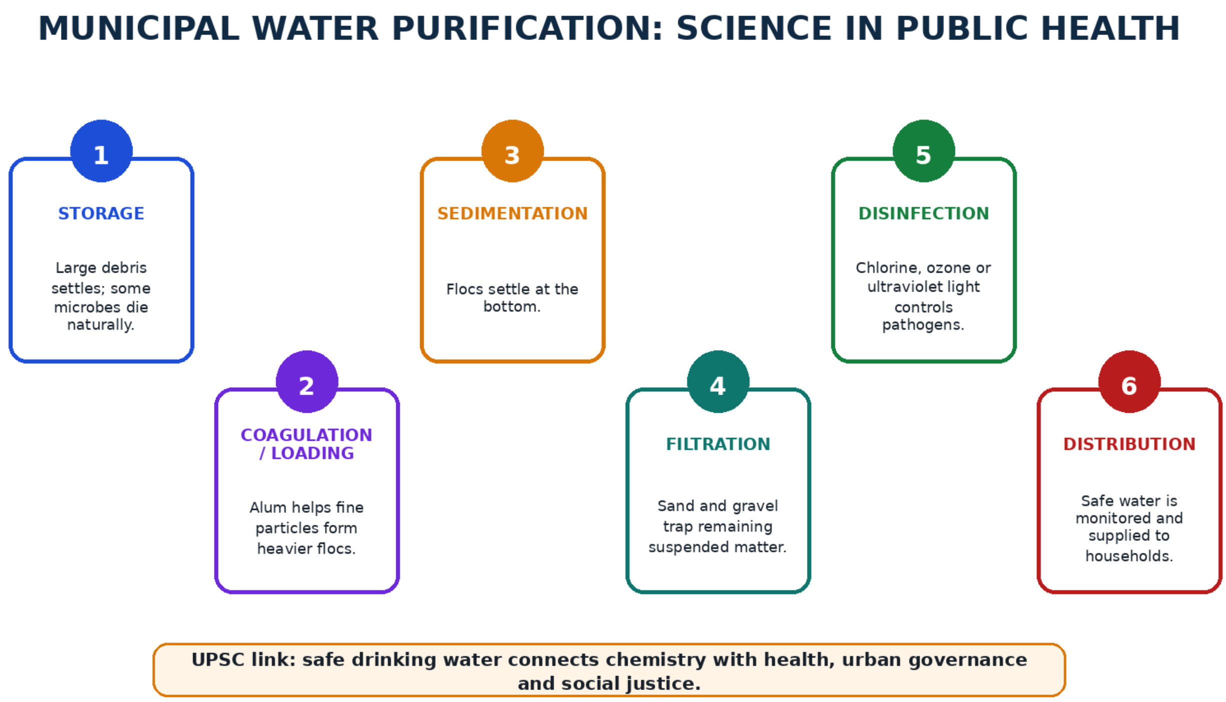
Water Purification: From Reservoir to Household

Separation techniques combine to protect public health.



No single step removes every impurity. A treatment plant combines **sedimentation**, **coagulation**, **filtration** and **disinfection**. The exact process depends on source-water quality and local standards.

◆	**KEY DISTINCTION** Filtration removes many suspended particles but does not guarantee that pathogens are absent. **Disinfection** is a separate protective step.
◆	**MAIN EXAMINATION LINK** Safe drinking water is not only a scientific issue; it involves urban planning, funding, laboratory monitoring, distribution losses, equity and public accountability.

17

Physical and Chemical Changes

The decisive question is whether a new substance is formed.

PHYSICAL CHANGE AND CHEMICAL CHANGE

PHYSICAL CHANGE

- No new substance
- Composition remains the same
- Often reversible
- Examples: melting, boiling, cutting, dissolving

CHEMICAL CHANGE

- New substance is formed
- Chemical composition changes
- Often difficult to reverse
- Examples: burning, rusting, electrolysis

Candle burning shows both: wax melts physically, while wax vapour burns chemically.

Example	Classification	Reason
Melting ice	Physical	Water remains H2O.
Dissolving salt in water	Physical	Salt can be recovered; no new substance.
Rusting iron	Chemical	Iron oxides form.
Burning paper	Chemical	New gases and ash form.
Electrolysis of water	Chemical	Hydrogen and oxygen are produced.
Candle burning	Both	Wax melts; wax vapour reacts with oxygen.

◆ **EXAM TRAP** Reversibility alone is not a perfect test. Some physical changes are difficult to reverse, and some chemical changes can be reversed under suitable conditions. Formation of a **new substance** is the better criterion.

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Elements: Metals, Non-Metals and Metalloids

An element cannot be broken into simpler substances by ordinary chemical reactions.

ELEMENTS: METALS, NON-METALS AND METALLOIDS

METALS

- Lustrous
- Good conductors
- Malleable
- Ductile
- Sonorous

Examples: Fe, Cu, Al; Hg is liquid

NON-METALS

- Often dull
- Poor conductors
- Not malleable
- Not ductile
- Not sonorous

Examples: O, S, C; Br is liquid

METALLOIDS

- Intermediate behaviour
- Semiconducting
- Brittle solids
- Technology importance
- Context-dependent properties

Examples: B, Si, Ge

Metals, non-metals and metalloids show broad trends, but competitive examinations frequently test **exceptions**. Properties must be treated as tendencies, not absolute rules.

Typical statement	Important exception
Metals are solid at room temperature.	Mercury is liquid; gallium and caesium melt near room temperature.
Non-metals are poor conductors.	Graphite conducts electricity.
Non-metals are dull.	Iodine is lustrous.
Metals are hard.	Sodium and potassium are soft.
Non-metals are solid or gas.	Bromine is liquid at room temperature.

◆ **TECHNOLOGY LINK** Silicon and germanium are metalloids with semiconducting behaviour. Their controlled conductivity is fundamental to electronics, solar cells and digital infrastructure.

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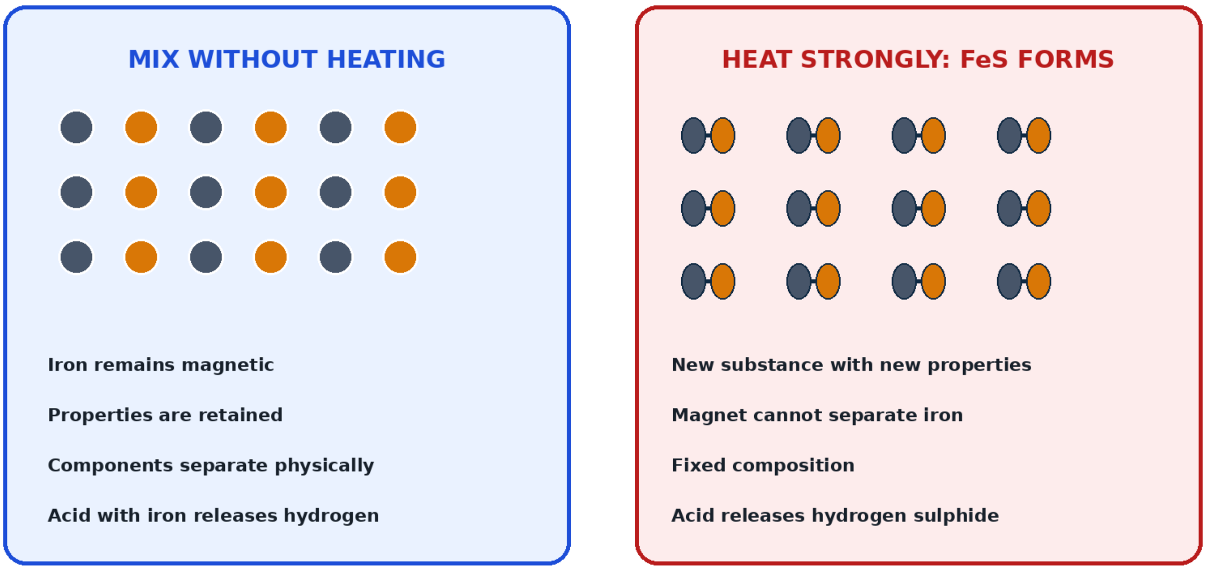
Compounds: Fixed Ratio and New Properties

Chemical combination creates a new substance.

A **compound** contains two or more elements chemically combined in a **fixed proportion**. Its properties are different from those of its constituent elements, and separation requires a chemical or electrochemical process.

IRON + SULPHUR: MIXTURE OR COMPOUND?



◆ **IRON-SULPHUR CASE** Before heating, iron and sulphur form a mixture: a magnet removes iron. After strong heating, **iron sulphide (FeS)** forms, and the original properties are lost.

◆ **ACID TEST** Iron in the mixture can release **hydrogen gas** with dilute acid. Iron sulphide releases **hydrogen sulphide**, recognised by its rotten-egg smell. Classroom gas tests require safety supervision.

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Mixture and Compound: Final Comparison

This table is a high-frequency examination area.

Basis	Mixture	Compound
Formation	Physical mixing	Chemical reaction
Composition	Variable	Fixed ratio
Properties	Constituents retain properties	New properties appear
Energy change	Usually small or not characteristic	Often definite energy change
Formula	No fixed chemical formula	Definite chemical formula
Separation	Physical methods	Chemical/electrochemical methods
Melting/boiling	Often over a range	Pure compound has characteristic values
Example	Iron + sulphur	Iron sulphide

◆ **ANSWER-WRITING LINE** A mixture represents coexistence of substances, whereas a compound represents chemical transformation into a new substance with fixed composition and new properties.

Common Misclassifications

A. Air is a mixture, not a compound.

B. Brass is a mixture, not a compound.

C. Milk is a colloid, not a true solution.

D. Salt water is homogeneous but not a pure substance.

E. Distilled water is a compound and a pure substance when uncontaminated.

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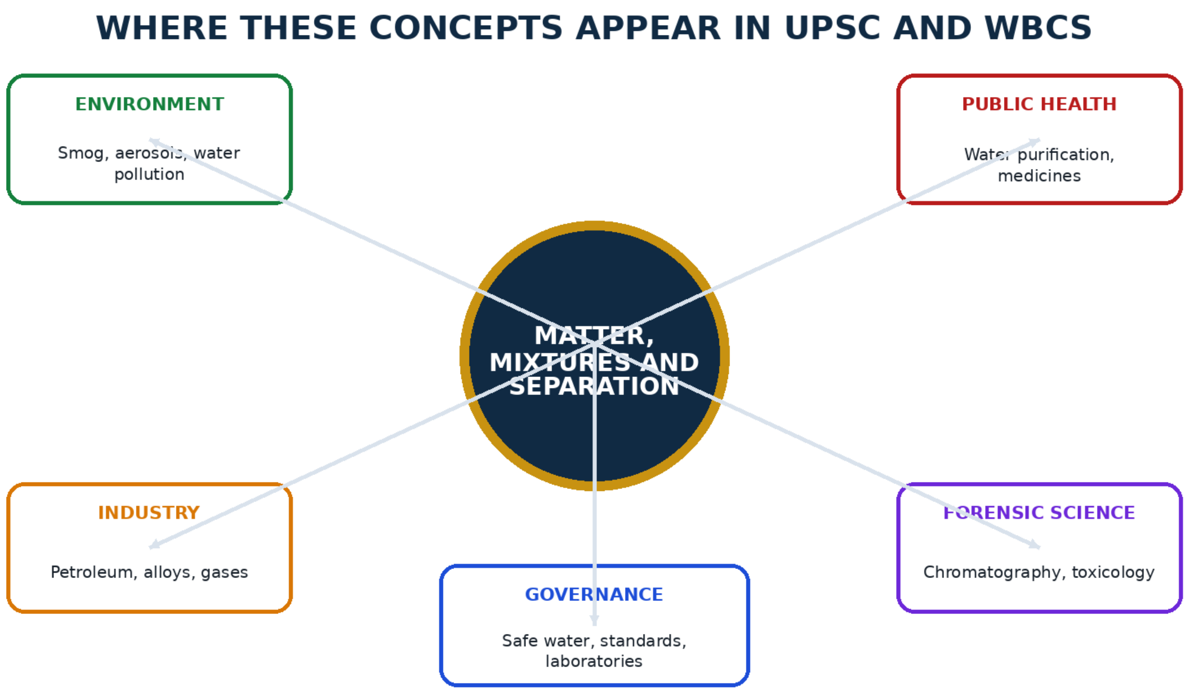
UPSC and WBCS Application Zones

Foundation chemistry becomes meaningful when linked to governance and society.



Theme	Science concept	Application
Air pollution	Aerosols, colloids and suspensions	Smog, particulate matter, visibility and health.
Water governance	Sedimentation, filtration, disinfection	Municipal supply and rural drinking-water systems.
Public health	Solutions and concentration	Medicine dose, disinfectants and oral rehydration solution.
Industry	Distillation and crystallisation	Petroleum, gases, salts, pharmaceuticals.
Forensics	Chromatography and centrifugation	Drugs, inks, blood and toxicology.
Materials	Alloys and compounds	Infrastructure, electronics and manufacturing.

◆ **MAIN EXAMINATION APPROACH** Do not merely define the process. Explain the **principle**, show the **administrative or social use**, identify a **limitation**, and conclude with the need for scientific monitoring.

22

High-Frequency Examination Traps

Use these corrections for rapid revision.

1. “Pure” in common language and **pure substance** in science are not identical.

2. A homogeneous mixture can have **variable composition**.

3. A colloid is scientifically **heterogeneous**, even when it looks uniform.

4. Ordinary filtration separates suspensions, not true solutions or most colloids.

5. The Tyndall effect is due to **scattering**, not reflection from the container.

6. Saturation changes with **temperature**.

7. Concentration and solubility are different: concentration is actual amount present; solubility is the maximum possible at stated conditions.

8. Evaporation recovers the solute; distillation can recover the solvent.

9. A separating funnel is for **immiscible liquids**, not miscible liquids.

10. Chromatography depends on differential affinity and movement.

11. On warming liquid air, nitrogen vaporises before oxygen.

12. Crystallisation is preferred when heating to dryness may damage the solid.

13. A mixture has no fixed formula; a compound has a definite formula.

14. Graphite is a conducting non-metal; iodine is a lustrous non-metal.

15. Reversibility is not the sole test of physical or chemical change.

◆ **ONE-LINE MASTER KEY** **Fixed composition -> pure substance or compound. Variable composition -> mixture. Scattering without settling -> colloid. Settling and filtration -> suspension.**

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Rapid Revision Matrix

A final page for classroom recall and last-minute revision.

Term	Core meaning	Best example
Pure substance	One chemical substance with fixed composition	Copper, oxygen, distilled water
Mixture	Two or more substances physically combined	Air, soil, brass
Solution	Homogeneous mixture with molecular/ionic particles	Salt water
Solute	Component dissolved	Salt
Solvent	Dissolving medium	Water
Saturated solution	Cannot dissolve more solute at stated temperature	Concentrated salt solution
Suspension	Large particles settle and filter	Chalk in water
Colloid	Intermediate particles; Tyndall effect	Milk
Dispersed phase	Particle-like colloidal component	Fat droplets in milk
Dispersion medium	Continuous colloidal medium	Water in milk
Centrifugation	Density separation by rapid spinning	Cream from milk
Sublimation	Solid changes directly to vapour	Camphor
Chromatography	Different movement due to affinity	Ink colours
Distillation	Vaporisation + condensation	Acetone-water
Crystallisation	Pure crystals from solution	Copper sulphate
Element	Cannot be chemically simplified	Iron
Compound	Elements combined in fixed ratio	Water
Physical change	No new substance	Melting
Chemical change	New substance forms	Rusting

◆ **FINAL STUDY METHOD** For every example, answer three questions: **What type of matter is it? What particle behaviour does it show? Which property can separate its components?**

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Main Examination Enrichment: Three Answer Frameworks

Use foundational chemistry to strengthen science, environment and governance answers.

A. “Safe drinking water is a scientific as well as governance challenge.” Explain.

Introduction: Safe water requires removal of **suspended impurities**, control of **microorganisms** and continuous quality monitoring. Body: explain sedimentation, coagulation, filtration and disinfection; add issues of infrastructure, leakage, laboratory capacity and equitable access. Conclusion: technology succeeds only when supported by accountable institutions and citizen awareness.

B. “Air is a resource mixture.” Discuss with industrial applications.

Introduction: Air is a homogeneous mixture dominated by nitrogen and oxygen. Body: explain liquefaction and **fractional distillation**; connect oxygen with hospitals and steel, nitrogen with food preservation and fertilizers, and argon with welding. Conclusion: efficient separation converts a natural mixture into strategic industrial inputs.

C. “Colloids connect everyday life with environmental science.” Illustrate.

Introduction: Colloids contain dispersed particles that remain suspended and scatter light. Body: use milk, medicines, fog, smoke, paint and wastewater; explain Tyndall effect and coagulation. Conclusion: understanding colloids supports product design, pollution control and public health.

◆ **ANSWER QUALITY CHECK** A strong answer moves through **definition -> principle -> example -> application -> limitation -> conclusion**.

Self-Check Questions

1. Why is milk not a true solution?
2. Why can salt be separated from water by evaporation but sodium chloride cannot be split into sodium and chlorine by a physical method?
3. Why is crystallisation preferred over heating to dryness for some solids?
4. Why does nitrogen separate before oxygen when liquid air is warmed?
5. How does chromatography support forensic investigation?