COMPREHENSIVE ANSWER KEY

Chapter 5 – Exploring Mixtures and Their Separation

Class IX Science • Revision – 1 • High Difficulty Level

Q1. Distinguish between a solution, colloid, and suspension on particle size, stability, visibility, and filtration.

Property	Solution (True Solution)	Colloid	Suspension
Particle Size	< 1 nm (< 10^{-9} m)	1 nm to 1000 nm (10^{-9} m – 10^{-6} m)	> 1000 nm (> 10^{-6} m)
Stability	Completely stable; solute never settles out.	Stable; particles do not settle upon standing.	Unstable; solute particles settle under gravity.
Visibility	Particles invisible even under electron microscopes.	Invisible to naked eye; detectable by scattered light path.	Particles visible to naked eye or standard microscope.
Filtration	Passes through ordinary filter paper & semi-permeable membranes.	Passes through filter paper; retained by ultra-filtration membranes.	Retained completely on ordinary filter paper as residue.

Q2. Give scientific reasons:

- **(a) Salt solution cannot be separated by filtration:** Sodium chloride dissolves to form individual Na^+ and Cl^- ions of molecular dimension (< 1 nm), which are significantly smaller than the microporous openings of ordinary filter paper. Thus, both solvent and solute pass through unhindered.
- **(b) Colloids show the Tyndall effect:** Colloidal particles possess dimensions (1–1000 nm) comparable to the wavelengths of visible light. When a focused beam strikes these dispersed phase particles, light is scattered in all directions, rendering the beam's trajectory visible.
- **(c) Crystallisation is preferred over evaporation to dryness:**
  - Certain heat-sensitive compounds decompose or get charred upon heating to extreme dryness (e.g., sugar).
  - Soluble impurities remain dissolved in the mother liquor during crystal formation, delivering a pure product, whereas evaporation precipitates all non-volatile impurities along with the salt.

Q3. Separation sequence: Iron filings, sand, common salt, and ammonium chloride.

1. **Magnetic Separation:** Roll a strong bar magnet across the dry mixture to isolate **iron filings**.
   Property exploited: Magnetic attraction / ferromagnetism of iron.
2. **Sublimation:** Heat the remaining mixture in an evaporating dish covered with an inverted funnel plugged with cotton. **Ammonium chloride** sublimes into vapor and deposits as a solid on the cold walls.
   Property exploited: Sublimability of ammonium chloride vs non-sublimability of sand and salt.
3. **Dissolution and Filtration:** Add distilled water to dissolve the common salt, then pass the suspension through filter paper. **Sand** is collected on the filter paper; wash and dry it.
   Property exploited: Differential solubility in water (salt is soluble; sand is insoluble).

4. **Crystallisation / Evaporation:** Heat the aqueous filtrate to evaporate water and obtain pure crystals of **common salt (NaCl)**.
   Property exploited: Non-volatility of salt compared to the volatile solvent (water).

Q4. Arrange suitable separation techniques for oil, water, dissolved salt, and suspended sand.

1. **Filtration:** Filter the entire heterogeneous mixture through filter paper.
   Justification: Suspended sand consists of insoluble solid particles that are filtered out first to avoid clogging the stopcock of the separating funnel.
2. **Separating Funnel:** Pour the sand-free filtrate into a separating funnel and let it settle into two distinct layers. Run off the denser bottom layer (aqueous salt solution) and retain the upper layer (**oil**).
   Justification: Oil and water are immiscible liquids possessing distinct specific gravities/densities.
3. **Distillation:** Place the aqueous salt solution into a distillation flask fitted with a Liebig condenser. Heat to collect pure condensed **water** in the receiver flask and leave solid **salt** in the flask.
   Justification: Exploits the wide boiling point gap between water (100°C) and salt (> 1400°C).

Q5. Two miscible liquids have boiling points 78°C and 100°C. Suitable method & why separating funnel fails.

- **Suitable Method: Fractional Distillation**.
- **Reason:** The difference between their boiling points is 100°C - 78°C = 22°C (22 K), which is less than the standard threshold of 25°C (25 K). The fractionating column provides repeated vaporization-condensation cycles, yielding efficient fractional separation.
- **Why a separating funnel is unsuitable:** A separating funnel operates strictly on *immiscibility* and *density differentials* between two distinct phases. Miscible liquids dissolve into each other completely, creating a homogeneous, single-phase solution with no meniscus to separate.

Q6. Treatment of river water containing mud, dissolved salts, microorganisms, and insoluble impurities.

- **Why filtration alone is insufficient:** Filtration eliminates only coarse insoluble particles (mud, grit). It cannot trap dissolved chemical salts or neutralize pathogenic microbes (bacteria, cysts), leaving water chemically unsafe and biologically hazardous.
- **Suitable purification sequence:**
  1. **Sedimentation & Coagulation:** Add alum to aggregate microscopic colloidal mud particles into heavier flocs that settle out rapidly.
  2. **Sand Filtration:** Pass clarified water through graded layers of coarse sand and gravel to trap residual suspended solids.
  3. **Activated Charcoal Adsorption:** Pass through activated carbon beds to adsorb dissolved organic contaminants, odors, and coloring pigments.
  4. **Disinfection / Chlorination:** Treat with chlorine gas, bleaching powder, or ozone/UV radiation to kill harmful microorganisms.
  5. *(For desalting / drinking):* **Reverse Osmosis (RO)** or **Distillation** to reduce excess dissolved mineral salts.

Q7. Separation of copper sulphate, sand, and iron filings with principle at each stage.

- **Stage 1 (Magnetic Separation):** Move a magnet thoroughly across the dry mixture.
  Result: **Iron filings** are attracted and extracted.
  Principle: Magnetic permeability/ferromagnetism of iron vs. non-magnetic sand and $CuSO_4$.
- **Stage 2 (Dissolution & Filtration):** Stir the residue in warm distilled water until copper sulphate completely dissolves; filter the mixture.
  Result: Insoluble **sand** remains on the filter paper as residue; wash and dry it.
  Principle: Copper sulphate is highly soluble in water; sand is completely insoluble.
- **Stage 3 (Crystallisation):** Heat the blue filtrate gently in an evaporating dish until the crystallization point is reached. Allow the concentrated hot solution to cool slowly and undisturbed.
  Result: Pure blue crystals of **copper sulphate** separate out; filter and dry between filter papers.
  Principle: Dramatic decrease in solubility with cooling, inducing spontaneous crystallization of the pure solute.

Q8 & Q9. Assertion and Reason Evaluation

8. Assertion: A suspension can be separated by filtration. **Reason:** Its particles are large enough to be retained by filter paper.
→ Correct Option: A **(Both assertion and reason are true, and reason is the correct explanation of assertion.)**
Explanation: Suspension particles exceed 1000 nm, larger than standard filter paper pore sizes (typically 2–10 μm), so they cannot pass through.

9. Assertion: Fractional distillation is useful for separating miscible liquids with close boiling points. **Reason:** It involves repeated vaporisation and condensation.
→ Correct Option: A **(Both assertion and reason are true, and reason is the correct explanation of assertion.)**
Explanation: The packed fractionating column provides repeated condensation surfaces, progressively enriching the ascending vapors in the lower boiling component.

Q10. Critical evaluation of statement: "If two substances have different boiling points, simple distillation will always separate them effectively."

The student's assertion is **scientifically incorrect** due to two key constraints:

- **Boiling Point Differential Margin:** Simple distillation is effective only when the boiling points differ by **more than 25°C (25 K)**. When difference < 25°C, significant vapor of the higher-boiling component escapes alongside the lower-boiling component, resulting in incomplete separation. Fractional distillation is required.
- **Azeotropic Formation:** Many binary miscible pairs form constant-boiling mixtures (azeotropes) at specific concentrations (e.g., 95.6% ethanol + 4.4% water boils uniformly at 78.15°C). At this point, liquid and vapor compositions are identical, making further separation impossible by conventional distillation.

Q11. Separation of solids P (high hot solubility, sparingly cold soluble) and Q (uniform hot/cold solubility).

- **Technique: Fractional Crystallisation**.
- **Procedure & Scientific Basis:**
  1. Dissolve the mixture in a minimal volume of boiling water until completely dissolved.
  2. Gradually cool the saturated solution to room temperature or chilled conditions in an ice-bath.
  3. As temperature plunges, the solubility of **P** drops sharply, causing it to crystallize and precipitate out of solution.
  4. In contrast, solid **Q** retains practically identical solubility across both temperatures and remains completely dissolved in the mother liquor (as long as minimal solvent was used).

5. Filter the cold mixture to isolate pure crystals of **P** on the filter paper, leaving **Q** in the filtrate.

Q12. Separation scheme for salt and camphor with physical principles.

- **Separation Method: Sublimation**.
- **Procedure:** Place the finely powdered mixture in a porcelain dish. Invert a glass funnel plugged with cotton over the dish. Heat gently over a wire gauze.
- **How it works:**
  - **Camphor:** Exhibits weak intermolecular bonds; upon gentle heating, it sublimates directly from solid to vapor without entering a liquid phase. The vapors condense on the cold inner funnel walls to form pure camphor sublimate.
  - **Salt (NaCl):** A giant ionic lattice characterized by exceptionally high melting (801°C) and boiling points. It remains non-volatile in the dish.

Q13. Suitable Separation Methods (Fill in the blanks)

Mixture to Separate	Prescribed Technique
(a) Cream from milk	**Centrifugation**
(b) Oil and water	**Separating funnel**
(c) Dyes in ink	**Paper chromatography**
(d) Pure water from salt solution	**Simple distillation**
(e) Ammonium chloride from a suitable mixture	**Sublimation**

Q14. MASTER CHALLENGE: Insoluble solid, soluble solid, two immiscible liquids, and iron filings.

Let the components be: **Fe** (Iron filings), **S_{ins}** (Insoluble solid), **S_{sol}** (Solid dissolved in Liquid 1), **L_1** (Lower immiscible liquid), and **L_2** (Upper immiscible liquid).

Stage	Technique	Apparatus Required	Physical Property Exploited	Product Isolated
1	**Magnetic Separation**	Bar / Horseshoe Magnet	Ferromagnetic property of iron	**Iron filings (Fe)**
2	**Gravity Filtration**	Glass funnel, Filter paper, Beaker	Insolubility & particle size > pore size	**Insoluble solid (S_{ins})**
3	**Phase Separation**	Separating Funnel, Iron stand	Immiscibility and density difference	**Liquid 2 (L_2)** [Layer 1] & **Solution (S_{sol} in L_1)** [Layer 2]
4	**Distillation**	Distillation flask, Liebig condenser, Receiver	Difference in boiling points (volatile liquid vs non-volatile solute)	**Liquid 1 (L_1)** [Distillate] and **Soluble solid (S_{sol})** [Residue]