

Exploring Mixtures and their Separation

- Question Bank

Class 9 Science (Exploration Edition) | Chemistry Chapter 3

Line Spacing: 1.15

Segment 1: Easy Level

1. Multiple Choice Questions (20 Questions)

1. Which of the following is a pure substance?
 - A) Air
 - B) Distilled water
 - C) Milk
 - D) Brass
2. A mixture of sand and water can be separated by:
 - A) Sublimation
 - B) Filtration
 - C) Distillation
 - D) Centrifugation
3. Which of the following forms a heterogeneous mixture?
 - A) Salt dissolved in water
 - B) Sugar dissolved in water
 - C) Chalk powder mixed with water
 - D) Alcohol in water
4. The component of a solution that is dissolved in another substance is called the:
 - A) Solvent
 - B) Solute
 - C) Suspension
 - D) Emulsion
5. Tincture of iodine has antiseptic properties. This solution is made by dissolving:
 - A) Iodine in potassium iodide
 - B) Iodine in alcohol
 - C) Iodine in water
 - D) Iodine in vaseline
6. Which of the following is a characteristic of a compound?
 - A) It has a variable composition
 - B) It shows the properties of its constituent elements
 - C) Its constituents can be separated by physical methods
 - D) It has a fixed melting and boiling point
7. The process used to separate cream from milk is:
 - A) Evaporation
 - B) Centrifugation
 - C) Filtration
 - D) Fractional distillation
8. Which of the following will show Tyndall effect?
 - A) Salt solution

- B) Milk
 - C) Copper sulphate solution
 - D) Sugar solution
9. A solution that has dissolved as much solute as it is capable of dissolving at a given temperature is called:
- A) Unsaturated solution
 - B) Saturated solution
 - C) Super-saturated solution
 - D) Dilute solution
10. Sulphur dissolves completely and cleanly in:
- A) Water
 - B) Carbon disulphide
 - C) Alcohol
 - D) Hydrochloric acid
11. The method of separating a mixture of camphor and salt is:
- A) Evaporation
 - B) Sublimation
 - C) Filtration
 - D) Decantation
12. An alloy is considered a:
- A) Heterogeneous mixture
 - B) Homogeneous mixture
 - C) Pure compound
 - D) Element
13. The clear liquid that remains above a settled sediment is called the:
- A) Filtrate
 - B) Residue
 - C) Supernatant
 - D) Solute
14. Two immiscible liquids can be separated by using a:
- A) Separating funnel
 - B) Filter paper
 - C) Distillation flask
 - D) Centrifuge tube
15. Boron, Silicon, and Germanium are examples of:
- A) Metals
 - B) Non-metals
 - C) Metalloids
 - D) Compounds
16. Which of the following is a physical change?
- A) Burning of wood
 - B) Melting of wax
 - C) Rusting of iron
 - D) Cooking of food
17. The size of solute particles in a true solution is less than:
- A) 1 nm
 - B) 10 nm
 - C) 100 nm
 - D) 1000 nm
18. Air is a mixture of gases. The major component serving as the solvent is:
- A) Oxygen

- B) Carbon dioxide
 - C) Nitrogen
 - D) Argon
19. Muddy water is an example of a:
- A) True solution
 - B) Colloidal solution
 - C) Suspension
 - D) Compound
20. The technique of chromatography is based on difference in:
- A) Boiling points
 - B) Solubilities in the same solvent
 - C) Densities
 - D) Particle sizes

MCQ Answer Key (Easy): 1-B, 2-B, 3-C, 4-B, 5-B, 6-D, 7-B, 8-B, 9-B, 10-B, 11-B, 12-B, 13-C, 14-A, 15-C, 16-B, 17-A, 18-C, 19-C, 20-B

2. Subjective Questions (20 Questions)

1. Define a pure substance with two examples.
2. What is meant by a homogeneous mixture? Give one daily life example.
3. Classify the following as a mixture or a pure substance: Air, Iron, Water, Brass.
4. State the principle behind filtration.
5. Explain why sugar dissolved in water is considered a mixture and not a compound.
6. Identify the solute and solvent in a soda water drink.
7. What is a saturated solution? How does temperature affect saturation?
8. Name the separation technique used to get salt from seawater.
9. Define the Tyndall effect. Why don't true solutions show it?
10. Give two main properties of a suspension.
11. How can you separate a mixture of sand, iron filings, and ammonium chloride?
12. Differentiate between physical changes and chemical changes with one example each.
13. What are metalloids? Name two metalloids.
14. Why is milk classified as a heterogeneous mixture even though it looks uniform?
15. Name a technique used to separate pigments from natural flower extracts.
16. Explain the difference between a residue and a filtrate during filtration.
17. What is an alloy? Give the composition of brass.
18. Can we separate a mixture of alcohol and water using a simple separating funnel? Why or why not?
19. Define the term 'solubility'.
20. How can you convert a saturated solution into an unsaturated solution without adding more solvent?

Segment 2: Moderate Level

1. Multiple Choice Questions (20 Questions)

1. To make a saturated solution, 36 g of sodium chloride is dissolved in 100 g of water at 293 K. The concentration by mass percentage is:
 - A) 36%
 - B) 26.47%

- C) 30%
D) 20%
2. Acetone (boiling point 56°C) and water (boiling point 100°C) are miscible. They can be separated by:
A) Simple distillation
B) Fractional distillation
C) Separating funnel
D) Steam distillation
3. The blue/black ink color can be separated into its component dyes by chromatography because:
A) The dyes have different boiling points
B) The component dyes move at different speeds on the paper due to differing solubility
C) One dye reacts chemically with the paper
D) The dyes have different densities
4. When a beam of light is passed through a colloidal solution, the path of light becomes visible due to:
A) Reflection of light
B) Refraction of light
C) Scattering of light
D) Absorption of light
5. Which of the following is an example of a gel colloid?
A) Cheese
B) Smoke
C) Milk of magnesia
D) Fog
6. Iron filings and sulphur powder are mixed and heated strongly. The product formed:
A) Is attracted by a magnet
B) Dissolves in carbon disulphide to leave iron
C) Reacts with dilute HCl to produce foul-smelling hydrogen sulphide gas
D) Retains the individual properties of iron and sulphur
7. During fractional distillation, the purpose of glass beads in the fractionating column is to:
A) Provide a cold surface for the vapors to condense and re-vaporize repeatedly
C) Absorb impurities from the chemical mixture
C) Increase the boiling point of the component with the lower boiling point
D) Chemically catalyze the separation process
8. A solution contains 50 mL of alcohol mixed with 150 mL of water. The volume-volume percentage concentration of the solution is:
A) 33.3%
B) 25%
C) 20%
D) 40%
9. Which of the following statements is incorrect regarding colloids?
A) They are stable and do not settle down when left undisturbed
B) They can be separated from the mixture by filtration using standard filter paper
C) They are heterogeneous in nature
D) The size of their particles lies between 1 nm and 1000 nm
10. The process of loading used during purification of water involves adding alum to:
A) Kill harmful bacteria and pathogens
B) Coagulate and settle down suspended clay and mud particles
C) Remove dissolved salts
D) Deodorize the water supply

11. A mixture of nitrogen and oxygen gases from the air can be isolated individually by liquefied air distillation because:
- A) Nitrogen liquefies faster than oxygen
 - B) Nitrogen has a lower boiling point (-196°C) than oxygen (-183°C)
 - C) Oxygen is more chemically active at low temperatures
 - D) Nitrogen floats on top of liquid oxygen
12. Which of the following represents a chemical change?
- A) Passing electric current through water to yield hydrogen and oxygen gases
 - B) Dissolving salt in water
 - C) Magnetizing an iron nail
 - D) Crystallization of copper sulphate
13. The dispersed phase and dispersing medium in 'fog' are respectively:
- A) Gas, Liquid
 - B) Liquid, Gas
 - C) Liquid, Liquid
 - D) Solid, Gas
14. A test tube contains a clear liquid. On heating it to dryness, a white crystalline residue is left behind. This indicates the initial liquid was a:
- A) Element
 - B) Compound
 - C) Homogeneous mixture
 - D) Heterogeneous suspension
15. If the solubility of potassium nitrate at 313 K is 62 g per 100 g of water, how much potassium nitrate will deposit if a saturated solution containing 50 g of water is cooled from 313 K to 293 K (solubility at 293 K is 32 g per 100 g water)?
- A) 30 g
 - B) 15 g
 - C) 20 g
 - D) 10 g
16. An emulsion is a colloidal system consisting of:
- A) Two miscible liquids
 - B) Two immiscible liquids distributed within each other
 - C) A solid dispersed in a liquid
 - D) A gas trapped inside a liquid matrix
17. The fractionating column is essential for separating miscible liquids whose boiling points differ by less than:
- A) 50 K
 - B) 25 K
 - C) 100 K
 - D) 75 K
18. Which element among the following is a liquid at just slightly above room temperature (around 303 K)?
- A) Mercury
 - B) Gallium
 - C) Iodine
 - D) Bromine
19. A component 'X' sublimes at 150°C without melting. Component 'Y' melts at 200°C and boils at 400°C . How can a dry solid mixture of X and Y be separated?
- A) Simple Distillation at 150°C
 - B) Sublimation heating up to 160°C
 - C) Filtration using hot water

- D) Separating funnel after melting
20. Which of the following setups is correct to separate a mixture of volatile and non-volatile components?
- A) Evaporating dish heated over a water bath
 - B) Standard filter paper with a glass funnel
 - C) Addition of a magnet directly to the fluid container
 - D) Centrifugation machine running at 500 RPM

MCQ Answer Key (Moderate): 1-B, 2-A, 3-B, 4-C, 5-A, 6-C, 7-A, 8-B, 9-B, 10-B, 11-B, 12-A, 13-B, 14-C, 15-B, 16-B, 17-B, 18-B, 19-B, 20-A

2. Subjective Questions (20 Questions)

1. How will you separate a mixture containing kerosene and petrol (difference in their boiling points is more than 25°C), which are miscible with each other? Describe the setup.
2. Calculate the mass of sodium sulphate required to prepare its 15% (mass/mass) solution in 250 g of pure water.
3. Why does heating a mixture of iron and sulphur lead to a chemical change, while simple grinding remains a physical mix? Detail the observations with dilute hydrochloric acid.
4. Describe an experiment to show that the components of air can be separated based on their boiling points.
5. Explain the operational mechanics of fractional distillation and how the fractionating column ensures high purity.
6. Classify the following colloids according to their type (sol, gel, emulsion, aerosol): Shaving cream, Face cream, Sponge, Jelly.
7. Explain the industrial purification process of drinking water in municipal waterworks step-by-step using a flow schematic description.
8. A solution contains 45 g of common salt mixed into 350 g of water. Find its mass percentage concentration.
9. What happens when a hot saturated solution of copper sulphate is allowed to cool slowly to room temperature? What is this technique called?
10. Explain why colloids do not settle down like suspensions even though they are heterogeneous. What keeps them stable?
11. Suggest a sequence of separation methods to isolate components from a four-part mixture of iron filings, common salt, sand, and iodine crystals.
12. How can you distinguish between a true solution, a colloidal solution, and a suspension using only a laser torch and filter paper?
13. Water is a compound whereas air is a mixture. Justify this statement with three distinct comparative arguments.
14. Why is chromatography considered a refined analytical separation tool compared to simple evaporation?
15. An analytical chemist wants to separate two miscible liquids A (BP 78°C) and B (BP 82°C). Suggest the ideal modification to a standard distillation setup to successfully isolate them.
16. Define dispersed phase and dispersing medium. Identify both parts for milk and smoke.
17. Explain the role of alum in loading suspended particles during water treatment. What chemical property allows this to happen?
18. Can a mixture of two solids with highly similar solubilities in water be completely separated by simple cooling crystallization? Why or why not?
19. A student is given a mixture of naphthalene and benzoic acid. Knowing both are organic solids but only naphthalene sublimes readily at lower temperatures, outline a separation strategy.

20. Why does a solution of common salt look clear, while adding wheat flour to water creates an opaque appearance that blocks light paths?

Segment 3: Difficult Level

1. Multiple Choice Questions (20 Questions)

1. The solubility of a salt 'Z' at 298 K is 40 g per 100 g of water. If a solution containing 15 g of 'Z' in 50 g of water at 323 K is cooled down to 298 K, what will happen?
A) 5 g of salt will precipitate
B) No salt will precipitate, but the solution becomes unsaturated
C) No salt will precipitate, and the solution becomes exactly saturated
D) The solution stays clear but becomes a supersaturated system containing an excess solute
2. Three miscible liquids X, Y, and Z have boiling points 65°C, 98°C, and 110°C respectively. During fractional distillation of this mixture, which liquid will collect first in the distillate receiver, and which will remain last in the boiling flask?
A) X first, Z last
B) Z first, X last
C) Y first, Z last
D) X first, Y last
3. A technical mixture contains three distinct salts: NaCl, NH₄Cl, and BaSO₄. The sequence of processes required to extract all three components cleanly in their solid states is:
A) Sublimation, dissolution in water, filtration, evaporation
B) Dissolution, evaporation, filtration, sublimation
C) Filtration, sublimation, crystallization
D) Sublimation, filtration, evaporation, dissolution
4. Two substances A and B react to form a product C according to the scheme: $A + B \rightarrow C$. Which of the following statements about C is strictly accurate?
A) C will exhibit intermediate properties of both A and B
B) The ratio of weights of A and B combining to form C can vary based on reaction conditions
C) The composition of C is always fixed by mass
D) C can be broken down back into A and B using fractional crystallization
5. A solution contains a mixture of ethanol (BP 78.3°C) and methanol (BP 64.7°C). To isolate them cleanly, a standard distillation column is insufficient. The efficiency of separation can be raised significantly by:
A) Increasing the length of the fractionating column packing to provide more theoretical plates
B) Increasing the heating rate of the distillation flask
C) Lowering the external atmospheric pressure directly
D) Adding more water into the binary mixture
6. The mass percentage concentration of a saturated solution of a salt is 25%. What is the actual solubility of the salt in grams per 100 g of solvent?
A) 25 g
B) 33.33 g
C) 20 g
D) 50 g
7. A colloid system is formed by dispersing a gas into a solid medium. This specific category

of colloid is termed a:

- A) Solid Sol
 - B) Solid Foam
 - C) Gel
 - D) Solid Aerosol
8. An unknown crystalline solid 'S' is completely insoluble in cold water but dissolves readily in hot water. It is mixed with sand. The most optimal way to get pure crystals of 'S' away from the sand is:
- A) Sublimation at high temperature
 - B) Mix with cold water, filter, and dry the residue
 - C) Mix with hot water, filter while hot, and allow the filtrate to cool down slowly
 - D) Centrifuge the solid mixture at high speeds
9. When a mixture of carbon disulphide and water is shaken thoroughly in a vessel and allowed to stand for 10 minutes, it separates into two distinct layers. This confirms that:
- A) They form a true solution at equilibrium
 - B) They are completely immiscible liquids with different densities
 - C) They have reacted to produce a brand new dense compound
 - D) Carbon disulphide has broken down into carbon and sulphur
10. A student evaluates four paper chromatography runs with a solvent front moving 10 cm. Spot A moves 2 cm, Spot B moves 5 cm, Spot C moves 8 cm. Which spot possesses the highest relative affinity/solubility toward the mobile solvent phase compared to the stationary paper phase?
- A) Spot A
 - B) Spot B
 - C) Spot C
 - D) All have equal affinity
11. Consider three systems: (i) 10 g of chalk in 100 mL water, (ii) 10 g of starch cooked in 100 mL water, (iii) 10 g of glucose in 100 mL water. If these are passed through standard quantitative filter papers, what will be recovered on the filter papers as a residue?
- A) Chalk only
 - B) Chalk and starch
 - C) Starch and glucose
 - D) Starch only
12. A saturated solution of a salt is prepared at 60°C and then sealed hermetically. Over time, the ambient temperature drops to 20°C without any external vibration or dust entry. No crystals form initially, creating an unstable clear fluid. This liquid phase is currently:
- A) Unsaturated
 - B) Saturated
 - C) Supersaturated
 - D) An ideal true solution
13. Which of the following processes involves both physical and chemical changes occurring simultaneously?
- A) Electrolysis of acidified water
 - B) Burning of a wax candle
 - C) Heating of platinum wire in air
 - D) Fractional distillation of petroleum crude oil
14. A mixture containing fine iron dust and aluminum dust needs to be separated cleanly. Since both are metals, magnetic separation is attempted, but due to strong static aggregation, it fails. What chemical separation trick can be used based on their unique physical or chemical properties without destroying both?
- A) Dissolve the mixture in excess carbon disulphide

- B) Sublimation heating under high vacuum
 - C) Selective dissolution using sodium hydroxide solution which dissolves aluminum but leaves iron untouched
 - D) Handpicking under a magnifying glass
15. An alloy of two metals X and Y is treated with an acid. Metal X reacts to form a soluble salt while metal Y remains completely unreactive and drops to the bottom as a solid powder. This separation relies on a difference in:
- A) Physical melting points
 - B) Chemical reactivity with the acid solvent
 - C) Relative solubilities in non-polar fluids
 - D) Magnetic susceptibilities
16. How does the addition of a non-volatile solute like common salt affect the physical properties of pure water solvent?
- A) It decreases the boiling point and increases the freezing point
 - B) It increases the boiling point and decreases the freezing point
 - C) It leaves both boiling and freezing points completely unaffected
 - D) It increases both the boiling point and the freezing point
17. The distribution of a solute between two immiscible liquid phases in contact with each other is governed by their relative solubilities. This extraction technique is called:
- A) Fractional Distillation
 - B) Solvent Extraction
 - C) Crystallization
 - D) Paper Chromatography
18. Which of the following criteria is the absolute proof of the purity of an organic liquid substance?
- A) It looks perfectly clear and transparent to the naked eye
 - B) It burns completely without leaving any smoke or ash residue
 - C) It has a sharp, constant, reproducible boiling point under standard pressure conditions
 - D) It does not show any Tyndall scattering when a laser passes through it
19. A 200 g sample of a solution contains 20 g of glucose and 30 g of urea dissolved in 150 g of water. The mass percentage of the water solvent in this solution system is:
- A) 75%
 - B) 10%
 - C) 15%
 - D) 85%
20. A colloidal system where liquid droplets are trapped inside a gas medium is categorized as a liquid aerosol. Which of the following fits this description precisely?
- A) Cloud
 - B) Pumice stone
 - C) Milk of Magnesia
 - D) Ruby glass

MCQ Answer Key (Difficult): 1-C, 2-A, 3-A, 4-C, 5-A, 6-B, 7-B, 8-C, 9-B, 10-C, 11-A, 12-C, 13-B, 14-C, 15-B, 16-B, 17-B, 18-C, 19-A, 20-A

2. Subjective Questions (20 Questions)

1. The mass percentage concentration of a salt solution is exactly 20%. Deduce the mass of the salt that must be added to 400 g of this specific solution to raise its total mass percentage concentration to 30%.
2. An inorganic mixture contains three salts: Ammonium chloride, Potassium chloride, and Lead sulphate. Design a complete chemical and physical isolation scheme to separate

each salt in its dry, pure state.

3. Explain why fractional distillation can successfully separate two miscible liquids whose boiling points are very close (e.g., 4 K difference) when simple distillation fails completely. Detail the thermal profile inside the fractionating column.
4. A solution of a specific salt has a density of 1.2 g/mL. If 60 g of this salt is dissolved in enough water to make 500 mL of the solution, calculate the mass-mass percentage concentration of this solution system.
5. Why does muddy water become clear faster when a piece of alum is swirled in it? Explain the colloidal chemistry behind this observation, including particle charge neutralization.
6. A student passes an intense light beam through an aqueous mixture of egg albumin in water and notes a visible track. However, upon passing it through a salt solution, the path is invisible. Explain these observations comprehensively.
7. A chemist has a liquid mixture of two components: one is volatile and the other is non-volatile. The volatile liquid is highly flammable and decomposes at its boiling point. Suggest and defend an ideal physical separation methodology.
8. Differentiate between an element, a compound, and a homogeneous mixture based on three strict criteria: chemical bond formation, composition variability, and action of physical separation forces.
9. The solubility of copper sulphate in water at 293 K is 20 g and at 333 K is 40 g per 100 g of water. If 150 g of a saturated solution of copper sulphate at 333 K is cooled down to 293 K, calculate the exact mass of solid crystals that will precipitate out.
10. Explain how paper chromatography works on a molecular level. Define the terms 'stationary phase', 'mobile phase', and explain why different components move to different heights.
11. A solid mixture contains sulfur powder and iron filings. If the mixture is treated with carbon disulphide, filtered, and the filtrate evaporated, what is recovered? If the original mixture is heated strongly first and then treated with carbon disulphide, what happens? Explain.
12. A technical sample of salt obtained from an industrial mining operation contains small amounts of fine insoluble clay and dissolved magnesium chloride impurities. Outline a purification method to obtain pure sodium chloride crystals.
13. What are the limitations of separating mixtures using simple distillation? Under what specific chemical conditions does one switch to vacuum or steam distillation methods? Explain using Class 9 vocabulary.
14. A mixture contains three liquids A (BP 56°C), B (BP 78°C), and C (BP 100°C). They are completely miscible. Sketch out a multi-stage fractional distillation timeline showing what happens at each temperature plateau.
15. Why are alloys like stainless steel classified as solid solutions or mixtures rather than pure chemical compounds, despite having a completely uniform composition throughout their structure?
16. A saturated solution of sodium chloride is prepared at 80°C. If this solution is cooled suddenly by placing it in an ice-water bath, describe the physical changes that occur at the microscopic level regarding solute-solvent interactions.
17. Explain why the components of a compound can only be separated by chemical or electrochemical reactions, while the components of a mixture can be separated by physical means. Use water and a salt solution to illustrate your answer.
18. A student attempts to filter a colloidal solution of starch in water using standard filter paper and finds that both starch and water pass through completely, leaving no residue. Why did filtration fail? What type of membrane is required to trap colloidal particles?
19. You are given a mixture of organic compounds: anthracene (which sublimates easily) and urea (which dissolves in water but does not sublime). Design a precise protocol to isolate both in pure solid form.

20. Explain the underlying scientific principles that allow us to isolate pure oxygen gas, nitrogen gas, and argon gas from ordinary atmospheric air via liquefaction and fractional distillation.

Segment 4: Olympiad Level

1. Multiple Choice Questions (20 Questions)

1. The solubility of an unknown salt 'M' in water is plotted against temperature. It shows a steep positive slope. At 303 K, its solubility is 50 g/100 g water, and at 353 K, it is 90 g/100 g water. An expert dissolves 40 g of 'M' in 50 g of water at 353 K and cools it down to 303 K. The mass of crystals that will drop out of the solution at equilibrium is:
A) 20 g
B) 15 g
C) 10 g
D) 25 g
2. A binary liquid mixture exhibits an azeotropic composition at a specific temperature. This means that the mixture:
A) Can be separated completely by increasing the length of the fractionating column packing
B) Boils at a constant temperature and distills over with an identical composition in both liquid and vapor phases
C) Consists of two completely immiscible liquids that separate into layers instantly
D) Can only be separated by adding a magnetic catalyst
3. A specific volume of an aqueous solution contains two salts, A and B. At room temperature, their solubilities are 25 g and 40 g per 100 g of water respectively. The mixture contains 20 g of A and 38 g of B in 100 g of water. If the solution is evaporated slowly until 50% of the water solvent is removed, which salt will begin to crystallize out first?
A) Salt A only
B) Salt B only
C) Both salts A and B will crystallize simultaneously
D) Neither salt will crystallize
4. In a paper chromatography experiment, the retention factor (R_f value) of a dye component is defined as the ratio of the distance traveled by the solute spot to the distance traveled by the solvent front. If a dye spot moves 4.5 cm while the solvent front moves 6.0 cm, the R_f value is:
A) 1.33
B) 0.75
C) 0.60
D) 0.50
5. A mixture of gases containing helium, neon, and argon needs to be separated. Since they are all chemically inert noble gases, chemical methods are impossible. They can be separated physically by:
A) Selective adsorption on activated charcoal at different low temperatures
B) Passing through a standard quantitative filter paper setup
C) Simple fractional distillation at room temperature
D) Shaking with carbon disulphide solvent
6. The mass fraction of a solute in a solution is defined as the mass of solute divided by the

total mass of the solution. If the mass fraction of a salt in an aqueous solution is 0.20, what is the ratio of the mass of the solute to the mass of the solvent?

- A) 1:5
 - B) 1:4
 - C) 1:3
 - D) 2:5
7. Which of the following colloidal systems is classified as an emulsion?
- A) Mayonnaise
 - B) Butter
 - C) Whipped cream
 - D) Both A and B
8. An organic liquid 'P' is completely immiscible with water. When a mixture of 'P' and water is heated, the system boils at a temperature that is:
- A) Exactly equal to the boiling point of pure water
 - B) Exactly equal to the boiling point of liquid 'P'
 - C) Lower than the boiling points of both pure water and liquid 'P'
 - D) Higher than the boiling points of both pure water and liquid 'P'
9. The Brownian motion observed in colloidal solutions is caused by:
- A) Convection currents arising inside the liquid matrix due to heating
 - B) The continuous, unbalanced bombardment of colloidal particles by the molecules of the dispersing medium
 - C) Attractive gravitational forces operating between the large colloidal particles
 - D) Electrostatic repulsion between oppositely charged ions in the solution
10. A sample of hard water contains dissolved calcium bicarbonate and magnesium chloride. Which of the following physical operations can remove the temporary hardness caused by calcium bicarbonate without adding any chemical reagents?
- A) Simple filtration through a clay filter
 - B) Boiling followed by filtration
 - C) Centrifugation at 5000 RPM
 - D) Paper chromatography
11. A student mixes 100 g of a 10% (mass/mass) salt solution with 200 g of a 20% (mass/mass) salt solution. The final mass percentage concentration of the combined solution system is:
- A) 15%
 - B) 16.67%
 - C) 13.33%
 - D) 18%
12. The purification of colloidal solutions by separating dissolved crystalline impurities through a semi-permeable membrane under a concentration gradient is known as:
- A) Ultrafiltration
 - B) Dialysis
 - C) Peptization
 - D) Coagulation
13. Which of the following properties is a colligative property (a property that depends solely on the number of solute particles present and not on their chemical identity)?
- A) Relative lowering of vapor pressure
 - B) Density of the solution
 - C) Color intensity of the mixture
 - D) Viscosity of the solvent
14. A dry mixture contains three components: iodine, sodium chloride, and ammonium chloride. To separate them cleanly without destroying any component, the correct

sequence of physical operations is:

- A) Heat up to 70°C to sublime iodine, then heat to 340°C to sublime ammonium chloride, then collect NaCl
 - B) Dissolve in water, filter, and crystallize
 - C) Treat with carbon disulphide to dissolve iodine, filter to collect the residue, then separate NaCl and NH₄Cl by selective sublimation
 - D) Both A and C work cleanly depending on thermal control
15. When an intense beam of light is passed through a true solution containing a small trace of fluorescent dye, a weak path is visible due to fluorescence, not scattering. How can a researcher confirm whether a light path visibility is due to the true Tyndall effect or fluorescence?
- A) Check if the scattered light is polarized; Tyndall scattered light is highly polarized
 - B) Filter the solution; if the path disappears, it was fluorescence
 - C) Heat the solution; Tyndall scattering is highly temperature dependent
 - D) Cool the solution to 0°C
16. An alloy sample of gold and copper weighs 50 g in air. When completely immersed in water, it experiences a buoyant force. If the individual densities of gold and copper are known, this measurement can determine the exact mass percentage composition of the alloy without destroying it. This physical method relies on:
- A) Archimedes' principle and density differences
 - B) Fractional crystallization of the metals
 - C) Solvent extraction of copper
 - D) Magnetic susceptibility mapping
17. The separation of isotopes of an element (such as Uranium-235 and Uranium-238) cannot be achieved by standard chemical methods because they have identical chemical properties. It is achieved physically based on a difference in:
- A) Boiling points during fractional distillation
 - B) Rates of gaseous diffusion based on slight mass differences
 - C) Solubilities in organic solvents
 - D) Magnetic alignment in a uniform magnetic field
18. A mixture of two miscible organic liquids, A and B, is subjected to fractional distillation. If liquid A has a significantly higher vapor pressure than liquid B at any given temperature below their boiling points, then:
- A) The vapor phase above the boiling liquid will be highly enriched in component A
 - B) The vapor phase above the boiling liquid will be highly enriched in component B
 - C) Both components will be present in equal amounts in the vapor phase
 - D) Component B will distill over first
19. Which of the following substances can be separated into its constituent elements by a simple chemical heating reaction (thermal decomposition) without needing complex electrolysis?
- A) Sodium chloride
 - B) Mercuric oxide
 - C) Calcium oxide
 - D) Water
20. A student studies the rate of settling of particles in a suspension. According to physics laws applicable to fluid mechanics, the settling velocity of a spherical particle suspended in a viscous fluid is directly proportional to:
- A) The square of the radius of the particle
 - B) The mass of the fluid solvent
 - C) The volume of the container vessel
 - D) The ambient room temperature

MCQ Answer Key (Olympiad): 1-B, 2-B, 3-B, 4-B, 5-A, 6-B, 7-D, 8-C, 9-B, 10-B, 11-B, 12-B, 13-A, 14-D, 15-A, 16-A, 17-B, 18-A, 19-B, 20-A

2. Subjective Questions (20 Questions)

1. A saturated solution of an unknown inorganic salt 'X' is prepared at 70°C. The total mass of this saturated solution is 250 g. It is evaporated completely to dryness, leaving behind a solid residue of salt 'X' weighing 70 g. Calculate the solubility of salt 'X' at 70°C in grams per 100 g of water.
2. A triple-component liquid mixture contains water (BP 100°C), ethanol (BP 78.3°C), and acetone (BP 56°C). They are completely miscible with each other. Design a detailed multi-stage fractional distillation protocol to isolate each liquid in a highly pure state, explaining the temperature plateaus and the state of the distillate at each stage.
3. Derive an expression for the final mass percentage concentration of a solution formed by mixing m_1 grams of a solution of concentration $C_1\%$ (mass/mass) with m_2 grams of another solution of the same solute with a concentration of $C_2\%$ (mass/mass).
4. An industrial waste stream contains dissolved copper sulphate, fine suspended sand particles, and dissolved sodium chloride. Propose an integrated physical separation flow chart to recover pure solid copper sulphate crystals, dry sand, and pure solid sodium chloride separately.
5. Explain why a colloidal system like gold sol remains stable for months without settling, focusing on the presence of similar electrical charges on the colloidal particles (zeta potential) and the role of Brownian motion in overcoming gravitational pull.
6. A student is given a mixture of two volatile, miscible liquids whose boiling points differ by only 15 K. They set up a fractional distillation apparatus but notice that the thermometer reading keeps fluctuating wildly and the separation is poor. Diagnose the technical errors in the setup and suggest how to stabilize the thermal gradient within the fractionating column.
7. The solubility of potassium chloride in water is 34.7 g/100 g water at 20°C and 56.7 g/100 g water at 100°C. A chemist dissolves 55 g of potassium chloride in 100 g of boiling water at 100°C and then cools the solution down to 20°C. Calculate the mass of solid salt that crystallizes out at equilibrium, and determine the concentration of the remaining supernatant fluid.
8. Compare and contrast the processes of simple distillation, fractional distillation, vacuum distillation, and steam distillation. For each method, state the specific thermodynamic or physical condition of the components that mandates its selection.
9. A technical sample consists of a solid mixture of benzoic acid, sodium chloride, and fine charcoal powder. Benzoic acid is soluble in hot water but poorly soluble in cold water; sodium chloride is highly soluble in both cold and hot water; charcoal is completely insoluble. Devise a detailed separation strategy to isolate all three components in their pure solid states.
10. Explain the phenomenon of 'coagulation' or 'precipitation' of colloids. Why does adding an electrolyte like magnesium sulphate cause immediate precipitation of a negatively charged clay sol? Classify this under chemical or physical interaction based on Class 9 logic.
11. A solution is prepared by dissolving a certain mass of anhydrous copper sulphate in water. The total mass of the solution is 500 g. A 50 g aliquot of this solution is taken out and evaporated to dryness, yielding 4.5 g of solid residue. Determine the total mass of anhydrous copper sulphate present in the original 500 g solution system and its mass percentage concentration.

12. Explain why the fractional distillation of liquid air allows nitrogen gas to be collected at the top of the fractionating column while oxygen gas remains at the bottom. Base your explanation on their intermolecular forces and boiling points, and write down the sequence of extraction.
13. An alloy of silver and copper is analyzed. Silver does not react with dilute sulfuric acid, whereas copper reacts slowly in hot concentrated sulfuric acid to form soluble copper sulphate. Alternatively, silver dissolves in nitric acid. Using these chemical reactivity differences, outline a protocol to separate a solid sample of this alloy back into pure silver metal and pure copper metal.
14. A mixture of two immiscible liquids, water and chloroform, is placed in a separating funnel. Chloroform has a density of 1.49 g/cm^3 , while water has a density of 1.00 g/cm^3 . Predict which liquid will form the upper layer and which will form the lower layer. Explain how you would safely operate the funnel to complete the separation without cross-contamination.
15. Explain how the principle of 'gaseous diffusion' can be used to separate a mixture of two gases with different molecular masses (such as hydrogen and carbon dioxide) through a porous barrier. How does the rate of diffusion depend on the mass of the gas molecules?
16. A 15% (mass/mass) solution of common salt in water is cooled down to -10°C . Pure ice crystals begin to separate out of the solution, leaving behind a more concentrated brine fluid. Explain this phenomenon in terms of phase separation and why the solute remains in the liquid phase instead of entering the ice crystal lattice.
17. Explain the difference between a true solution and a colloidal solution in terms of colligative properties (such as boiling point elevation). Why does a true solution containing 10 g of salt show a much higher boiling point elevation than a colloidal solution containing 10 g of dispersed starch in the same volume of water?
18. A student sets up a paper chromatography experiment to separate the pigments in a leaf extract. They notice that all the pigments remain at the baseline spot and do not move up the paper at all, even after the solvent front has reached the top. Analyze the cause of this failure and suggest how modifying the polarity of the solvent could resolve the issue.
19. You are given a mixture of three gases: carbon dioxide, oxygen, and nitrogen. Carbon dioxide is easily absorbed by a solution of potassium hydroxide; oxygen reacts rapidly with alkaline pyrogallol solution. Using these selective absorption properties, describe an experimental sequence to determine the volume percentage composition of the original gas mixture.
20. Explain why the purification of drinking water in municipal waterworks requires a sequence of physical steps: sedimentation, loading, filtration, and chlorination. Why cannot chlorination be performed directly on raw river water without undergoing the filtration stages first? Justify from a particle science perspective.