

**Class: 11th**

**Subject: Chemistry**

**Unit 15: BASIC SEPARATION TECHNIQUES**

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❖ **Important MCQs:**

**1. The primary objective of qualitative analysis in analytical chemistry is to:**

- (a) Determine the mass of a compound
- (b) Identify the elements present in a compound ✓

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(c) Measure concentration accurately

(d) Separate mixtures completely

**2. In analytical chemistry, quantitative analysis is mainly concerned with:**

(a) Identifying unknown substances

(b) Studying reaction mechanisms

(c) Determining the relative amounts of components in a compound

(d) Observing physical properties

**3. Which of the following correctly represents the first step in a complete quantitative analysis?**

(a) Measurement of analyte

(b) Separation of components

(c) Obtaining a representative sample

(d) Drawing conclusions

**4. Why is the separation of the desired constituent important before measurement?**

(a) To increase reaction speed

(b) To avoid interference from other substances

(c) To reduce cost

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(d) To change physical state

**5. The final step in quantitative analysis involves:**

(a) Sample collection

(b) Separation

(c) Measurement

(d) Drawing conclusion from the analysis

**6. Which method is used to separate an insoluble solid from a liquid?**

(a) Distillation

(b) Filtration

(c) Chromatography

(d) Crystallization

**7. In the mixture of sand and salt, sand is:**

(a) Soluble in water

(b) Insoluble in water

(c) Volatile

(d) Reactive



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**8. The homogeneous mixture formed after dissolving salt in water is called:**

- (a) Suspension
- (b) Colloid
- (c) Solution
- (d) Residue

**9. The first step in filtration is to:**

- (a) Heat the mixture
- (b) Select a suitable solvent
- (c) Add acid
- (d) Evaporate solution

**10. Filter paper is placed inside a:**

- (a) Beaker
- (b) Funnel
- (c) Test tube
- (d) Flask

**11. The angle of a standard filtration funnel is usually:**

- (a) 30°

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(b) 45°

(c) 60°

(d) 90°

**12. The filtration process using ordinary filter paper is generally:**

(a) Fast

(b) Instant

(c) Slow

(d) Violent

**13. Fluted filter paper has a structure that is:**

(a) Flat

(b) Smooth

(c) Fan-like with folds

(d) Circular

**14. The main advantage of fluted filter paper is to:**

(a) Decrease purity

(b) Increase filtration speed

(c) Change composition

(d) Reduce temperature

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**15. Gooch crucible contains a bottom that is:**

- (a) Solid
- (b) Perforated
- (c) Plastic
- (d) Sealed

**16. Gooch crucible is mainly used when:**

- (a) Cooling is required
- (b) High temperature ignition is needed
- (c) Mixing is required
- (d) Color change occurs

**17. In Gooch crucible, perforations are covered with:**

- (a) Sand
- (b) Cotton
- (c) Paper pulp or filter paper
- (d) Glass wool

**18. Sintered glass crucible contains:**

- (a) Metal disc
- (b) Plastic sheet

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(c) Porous glass disc

(d) Paper layer

**19. The main advantage of sintered glass crucible is that it:**

(a) Requires preparation

(b) Needs paper pulp

(c) Is ready to use without preparation

(d) Cannot be reused

**20. Suction filtration is used to:**

(a) Slow down filtration

(b) Speed up filtration

(c) Heat solution

(d) Change state



**21. Crystallization gives pure substance because:**

(a) Impurities evaporate

(b) Only solute forms a regular crystal lattice while impurities remain in solution

(c) Solvent reacts with impurities

(d) Crystals absorb impurities

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**22. If a solvent dissolves equal amount of solute at high and low temperature, then it is:**

- (a) Ideal solvent
- (b) Poor solvent for crystallization
- (c) Strong solvent
- (d) Volatile solvent

**23. Which condition is most suitable for selecting a solvent for crystallization?**

- (a) High solubility at room temperature
- (b) No solubility at boiling point
- (c) Large difference in solubility with temperature change
- (d) Chemical reactivity with solute

**24. Hot filtration is carried out quickly to:**

- (a) Reduce temperature
- (b) Prevent crystallization during filtration
- (c) Increase solubility
- (d) Remove solvent

**25. If solution is cooled too rapidly during crystallization, the crystals formed will be:**

- 
- (a) Large and pure
  - (b) Small and impure
  - (c) Colorless
  - (d) Insoluble

**26. Which step ensures removal of insoluble impurities in crystallization?**

- (a) Cooling
- (b) Heating
- (c) Hot filtration
- (d) Drying

**27. The function of water bath in crystallization is to:**

- (a) Cool the solution
- (b) Avoid fire hazard with inflammable solvents
- (c) Increase pressure
- (d) Filter impurities

**28. Why is Gooch crucible preferred after crystallization?**

- (a) It increases solubility
- (b) It allows rapid filtration using suction

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(c) It reacts with solute

(d) It heats crystals

**29. Which drying method is most suitable for heat-sensitive crystals?**

(a) Oven drying

(b) Direct heating

(c) Vacuum desiccator

(d) Boiling

**30. Drying agents like  $\text{CaCl}_2$  in a desiccator work by:**

(a) Cooling crystals

(b) Absorbing moisture from surroundings

(c) Reacting with solute

(d) Increasing temperature

**31. If impurities also crystallize with the solute, the solvent used is:**

(a) Ideal

(b) Unsuitable

(c) Pure

(d) Neutral

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**32. Moderate cooling in crystallization is important to:**

- (a) Speed up reaction
- (b) Form well-defined crystals ✓
- (c) Increase impurities
- (d) Evaporate solvent

**33. The mother liquor refers to:**

- (a) Pure crystals
- (b) Remaining solution after crystallization ✓
- (c) Solvent only
- (d) Impurities only

**34. A saturated solution in crystallization is one that:**

- (a) Contains no solute
- (b) Contains maximum dissolved solute at a given temperature ✓
- (c) Is diluted
- (d) Is impure

**35. The main reason for using mixed solvents in crystallization is:**

- (a) Increase cost
- (b) Improve solubility conditions for proper crystallization ✓

- 
- (c) Increase impurities
  - (d) Reduce temperature

**36. Simple distillation is mainly used to:**

- (a) Separate two solids
- (b) Separate solvent from a solution
- (c) Separate gases
- (d) Perform chemical reactions

**37. Sea water is purified by distillation because it contains:**

- (a) Insoluble impurities
- (b) Volatile compounds
- (c) Dissolved salts and impurities
- (d) Gases only



**38. The liquid obtained after condensation in distillation is called:**

- (a) Residue
- (b) Filtrate
- (c) Distillate
- (d) Solute

**39. The substances left behind in the distillation flask are called:**

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(a) Filtrate

(b) Residue

(c) Solvent

(d) Distillate

**40. Boiling chips are added during distillation to:**

(a) Increase boiling point

(b) Prevent bumping of liquid

(c) Change composition

(d) Speed up condensation

**41. The function of a condenser in distillation is to:**

(a) Heat vapours

(b) Convert vapours into liquid

(c) Filter impurities

(d) Increase pressure

**42. In fractional distillation, liquids are separated based on difference in:**

(a) Density

(b) Color

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(c) Boiling points

(d) Volume

**43. Fractional distillation is used for separating:**

(a) Insoluble solids

(b) Immiscible liquids

(c) Miscible liquids

(d) Gases only

**44. The minimum difference in boiling points required for effective fractional distillation is about:**

(a) 5°C

(b) 10°C

(c) 25°C

(d) 50°C

**45. The distillation column is filled with glass beads to:**

(a) Increase temperature

(b) Increase surface area for condensation

(c) Absorb impurities

(d) Reduce pressure

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**46. In a mixture of ethanol and water, ethanol distills first because it:**

- (a) Has higher density
- (b) Has lower boiling point
- (c) Is insoluble
- (d) Is heavier

**47. The boiling point of ethanol is approximately:**

- (a) 50°C
- (b) 78°C
- (c) 90°C
- (d) 100°C



**48. During fractional distillation, temperature remains constant at 78°C because:**

- (a) Water is boiling
- (b) Ethanol is distilling
- (c) Mixture is cooling
- (d) Pressure is changing

**49. When temperature rises above 78°C in ethanol-water mixture, it indicates:**

- 
- (a) Ethanol is finished distilling
  - (b) Water has evaporated completely
  - (c) Reaction has stopped
  - (d) Pressure has increased

**50. The second distillate collected at 100°C in ethanol-water mixture is:**

- (a) Ethanol
- (b) Salt
- (c) Water
- (d) Residue

**51. Chromatography is mainly used for:**

- (a) Heating substances
- (b) Separation of mixtures
- (c) Increasing solubility
- (d) Evaporation of liquids

**52. In chromatography, separation is based on:**

- (a) Density difference
- (b) Distribution between stationary and mobile phase

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(c) Boiling point difference

(d) Magnetic properties

**53. The stationary phase in chromatography can be:**

(a) Only gas

(b) Only solid

(c) Solid or liquid supported on solid

(d) Only liquid

**54. The mobile phase in chromatography may be:**

(a) Only solid

(b) Gas or liquid

(c) Only solid

(d) Metal



**55. Adsorption chromatography involves stationary phase as:**

(a) Gas

(b) Liquid

(c) Solid

(d) Plasma

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**56. Which of the following is an example of adsorption chromatography?**

- (a) Paper chromatography
- (b) Gas-liquid chromatography
- (c) Thin layer chromatography (TLC)
- (d) Solvent extraction

**57. Partition chromatography involves stationary phase as:**

- (a) Solid
- (b) Liquid
- (c) Gas
- (d) Metal



**58. Paper chromatography is a type of:**

- (a) Adsorption chromatography
- (b) Partition chromatography
- (c) Distillation
- (d) Filtration

**59. In paper chromatography, the mobile phase usually is:**

- (a) Water only

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(b) Organic solvent mixture

(c) Solid powder

(d) Air only

**60. In ascending paper chromatography, solvent moves:**

(a) Downward

(b) Sideways

(c) Upwards by capillary action

(d) Randomly

**61. The pencil line in paper chromatography is drawn:**

(a) At the top of paper

(b) In the middle

(c) Near the bottom of paper

(d) Outside the paper

**62. The purpose of covering the chromatography tank is to:**

(a) Increase evaporation

(b) Prevent contamination and maintain atmosphere

(c) Cool solvent

(d) Stop reaction

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**63. The final pattern obtained after chromatography is called:**

- (a) Spectrum
- (b) Chromatogram
- (c) Residue
- (d) Distillate

**64. Colourless spots in chromatography are detected using:**

- (a) Heat
- (b) UV light or locating agents
- (c) Pressure
- (d) Filtration

**65. The R<sub>f</sub> value is used to:**

- (a) Measure density
- (b) Identify and compare substances
- (c) Increase solubility
- (d) Separate solvents

**66. The purity of a liquid compound is commonly checked by comparing its:**

- (a) Color with standard

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(b) Boiling point with literature value ✓

(c) Smell with standard

(d) Density only

**67. Liquids are generally purified by:**

(a) Filtration

(b) Distillation at normal or reduced pressure ✓

(c) Crystallization

(d) Chromatography

**68. A pure liquid shows boiling point that is:**

(a) Variable

(b) Constant and sharp at a fixed temperature ✓

(c) Always increasing

(d) Always decreasing

**69. Impure liquids are characterized by:**

(a) Sharp boiling point

(b) No boiling point

(c) Boiling over a range of temperatures ✓

(d) Constant density

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**70. Aspirin is mainly classified as:**

- (a) Antibiotic
- (b) Analgesic and antipyretic
- (c) Antiseptic
- (d) Fertilizer

**71. Aspirin is synthesized by reacting salicylic acid with:**

- (a) NaOH
- (b) Acetic anhydride in presence of  $H_2SO_4$
- (c) HCl
- (d) Ethanol only

**72. Concentrated  $H_2SO_4$  in aspirin preparation acts as:**

- (a) Product
- (b) Catalyst
- (c) Solvent
- (d) Impurity remover only

**73. Water is added after aspirin formation to:**

- (a) Dissolve aspirin completely
- (b) Precipitate aspirin from solution

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(c) Increase reaction rate

(d) Neutralize acid only

**74. The crude aspirin obtained after reaction is separated by:**

(a) Sublimation

(b) Filtration of precipitate

(c) Distillation

(d) Evaporation only

**75. Purification of crude aspirin is done by:**

(a) Distillation

(b) Crystallization in water

(c) Filtration only

(d) Heating strongly

**76. Pure aspirin has a sharp melting point at:**

(a) 100°C

(b) 120°C

(c) 136°C

(d) 150°C

**77. A sharp melting point indicates that the substance is:**

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(a) Impure

(b) Pure compound

(c) Mixture

(d) Volatile

**78. If a substance melts over a range of temperatures, it is considered:**

(a) Pure

(b) Impure

(c) Highly stable

(d) Insoluble

**79. Mixed melting point method is used to:**

(a) Increase purity

(b) Confirm identity and purity of compound

(c) Change melting point

(d) Separate mixtures

**80. In mixed melting point test, if no depression in melting point is observed, it means:**

(a) Sample is impure

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(b) Sample is identical and pure ✓

(c) Reaction failed

(d) Compound decomposed

## ❖ Important Short Questions:

### 1. What is analytical chemistry?

#### Answer:

Analytical chemistry is the branch of chemistry that deals with the chemical characterization of substances. It involves identifying what elements or compounds are present and determining their amounts.

#### Example:

Testing a water sample to find how much salt (NaCl) is present in it.

### 2. Differentiate between qualitative and quantitative analysis.

#### Answer:

- **Qualitative analysis:** It is used to identify what substances are present in a compound.
- **Quantitative analysis:** It is used to determine how much of each substance is present.

#### Example:

- **Qualitative:** Finding presence of chlorine in a compound.

- 
- **Quantitative:** Measuring percentage of NaCl in a sample.

### 3. What are the main steps of quantitative analysis?

#### Answer:

- Obtaining a sample for analysis
- Separation of desired component
- Measurement and calculation of results
- Drawing conclusion

#### Example:

Analyzing salt in seawater: sample → separation → measurement → final result.

### 4. Define filtration.

#### Answer:

Filtration is a physical separation method used to separate an insoluble solid from a liquid using a filter medium.

#### Example:

Separating sand from water using filter paper.

### 5. What is meant by filtrate and residue?

#### Answer:

- **Filtrate:** The liquid that passes through the filter paper.
- **Residue:** The solid left on the filter paper.

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**Example:**

In sand-water mixture:

- Water = filtrate
- Sand = residue

**6. What is the role of filter paper in filtration?****Answer:**

Filter paper acts as a porous medium that allows liquid to pass through while retaining solid particles.

**Example:**

In sand-water mixture, sand is trapped while water passes through.

**7. What is a fluted filter paper? Why is it used?****Answer:**

A fluted filter paper is an accordion-shaped folded filter paper with alternate ridges and grooves.

**Use:**

It is used to increase the speed of filtration by providing more surface area.

**Example:**

Used in laboratories for quick separation of precipitates.

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## 8. What is a Gooch crucible?

### Answer:

A Gooch crucible is a porcelain crucible with a perforated base, used for filtration under suction.

### Example:

Used to filter fine precipitates in chemical analysis using a vacuum pump.

## 9. What is the function of a sintered glass crucible?

### Answer:

It is used for rapid filtration of solutions without using filter paper. It contains a porous glass disc that acts as a filter.

### Example:

Used for filtering solutions like acids or  $\text{KMnO}_4$  where filter paper may react.

## 10. Define crystallization.

### Answer:

Crystallization is a purification method in which a solute is dissolved in a hot solvent and then forms pure crystals upon cooling.

### Example:

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Purification of common salt from impure salt solution by crystallization.

### **11. Characteristics of an ideal solvent for crystallization**

**Answer:**

An ideal solvent should:

- Dissolve a large amount of solute at high temperature but very little at room temperature
- Not react chemically with the solute
- Not dissolve impurities (or impurities should not crystallize)
- Give pure, well-formed crystals on cooling
- Be cheap, safe, and easily removable

**Example:**

Water is commonly used for crystallizing salt.

### **12. Why is hot filtration used in crystallization?**

**Answer:**

Hot filtration is used to remove insoluble impurities from a hot saturated solution without allowing the solute to crystallize during filtration.

**Example:**

Filtering hot salt solution to remove sand before crystallization.

### **13. What is mother liquor?**

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**Answer:**

Mother liquor is the remaining liquid solution after crystals have formed.

**Example:**

After crystallizing salt, leftover salty water is mother liquor.

**14. Importance of slow cooling in crystallization****Answer:**

Slow cooling allows the formation of large, pure, well-shaped crystals.

**Example:**

Slow cooling of salt solution produces pure salt crystals.

**15. Define simple distillation****Answer:**

Simple distillation is a method used to separate a solvent from a solution or liquids with large boiling point difference.

**Example:**

Purifying water from seawater.

**16. Function of boiling chips in distillation****Answer:**

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Boiling chips provide smooth boiling and prevent bumping (sudden boiling).

**Example:**

Used in distillation of seawater to avoid splashing.

**17. Distillate and residue**

**Answer:**

- **Distillate:** The liquid collected after condensation
- **Residue:** The substance left in the flask

**Example:**

In seawater distillation: water = distillate, salts = residue.

**18. Define fractional distillation**

**Answer:**

Fractional distillation is a method used to separate two miscible liquids with close boiling points using a fractionating column.

**Example:**

Separation of ethanol and water.

**19. Role of fractionating column**

**Answer:**

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It provides a large surface area for repeated condensation and vaporization, improving separation of liquids.

**Example:**

Used in ethanol-water separation.

**20. Why fractional distillation is used instead of simple distillation?**

**Answer:**

Because fractional distillation is needed when liquids have small difference in boiling points (about 25°C or less).

**Example:**

Ethanol (78°C) and water (100°C).

**21. Define chromatography**

**Answer:**

Chromatography is a technique used to separate components of a mixture based on their distribution between stationary and mobile phases.

**Example:**

Separating dyes in ink.

**22. Difference between stationary and mobile phase**

**Answer:**

- 
- **Stationary phase:** Fixed phase (solid or liquid on solid)
  - **Mobile phase:** Moving phase (liquid or gas)

**Example:**

In paper chromatography: paper = stationary, solvent = mobile.

**23. What is paper chromatography?**

**Answer:**

It is a type of partition chromatography where components are separated using paper as stationary phase and solvent as mobile phase.

**Example:**

Separation of ink colors.

**24. What is Rf value?**

**Answer:**

Rf value is the ratio of distance traveled by a component to the distance traveled by solvent.

**Formula:**

$R_f = \text{distance moved by solute} / \text{distance moved by solvent}$

**Example:**

Used to identify amino acids in a mixture.

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## 25. How is purity checked using melting point method?

### Answer:

A pure substance melts at a sharp, fixed temperature, while impure substances melt over a range.

### Example:

Pure aspirin melts at 136°C; impure aspirin melts over a range below this temperature.

## ❖ Important Long Questions

🌟 **Q1. Explain in detail the process of filtration. Describe different types of filter media used and their applications.**

### Answer:

#### Definition of Filtration

Filtration is a physical separation technique used to separate an insoluble solid from a liquid by passing the mixture through a porous material (filter medium) which allows the liquid to pass but retains the solid particles.

#### Principle of Filtration

The principle of filtration is based on the difference in particle size:

- Liquid particles are very small and pass through the pores of the filter medium.

- 
- Solid particles are larger and cannot pass, so they are retained on the filter medium.

### **Process of Filtration**

1. A mixture of solid and liquid is prepared.
2. It is poured into a funnel containing a suitable filter medium.
3. The liquid passes through the pores due to gravity.
4. The solid particles remain on the filter medium.
5. The separated liquid is collected in a container below.

### **Example**

#### **Sand and water mixture:**

- Sand is insoluble in water, so it remains on the filter paper, while water passes through.

#### **Salt solution with sand:**

- Salt dissolves in water (solution passes through), but sand is removed by filtration.

### **Filter Media Used in Filtration**

Filter media are materials that allow liquid to pass but stop solid particles. The main types are:

#### **1. Filter Paper**

Filter paper is the most commonly used filter medium in laboratories.

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**Types:**

- **Normal filter paper:** Folded into a cone and placed in a funnel
- **Fluted filter paper:** Folded like a fan with ridges and grooves

**Applications:**

- Used for routine laboratory filtration
- Separating precipitates from solutions
- Fluted paper is used when fast filtration is required

**2. Gooch Crucible**

A Gooch crucible is a porcelain crucible with a perforated base.

**Features:**

- Used with vacuum (suction filtration)
- Base is covered with filter paper or asbestos mat
- Suitable for heating precipitates

**Applications:**

- Filtration of fine precipitates
- Used in analytical chemistry requiring accurate separation

**3. Sintered Glass Crucible**

- It is a glass crucible with a porous glass disc at the bottom.

**Features:**

- No filter paper is needed

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- Chemically resistant
  - Can be used with strong acids and reactive solutions

### **Applications:**

- Filtration of corrosive solutions
- Rapid and efficient laboratory filtration
- Importance of Proper Pore Size Selection

### **The pore size of the filter medium is very important:**

- If pores are too large, small solid particles pass through → poor separation
- If pores are too small, filtration becomes very slow
- Correct pore size ensures efficient and accurate filtration

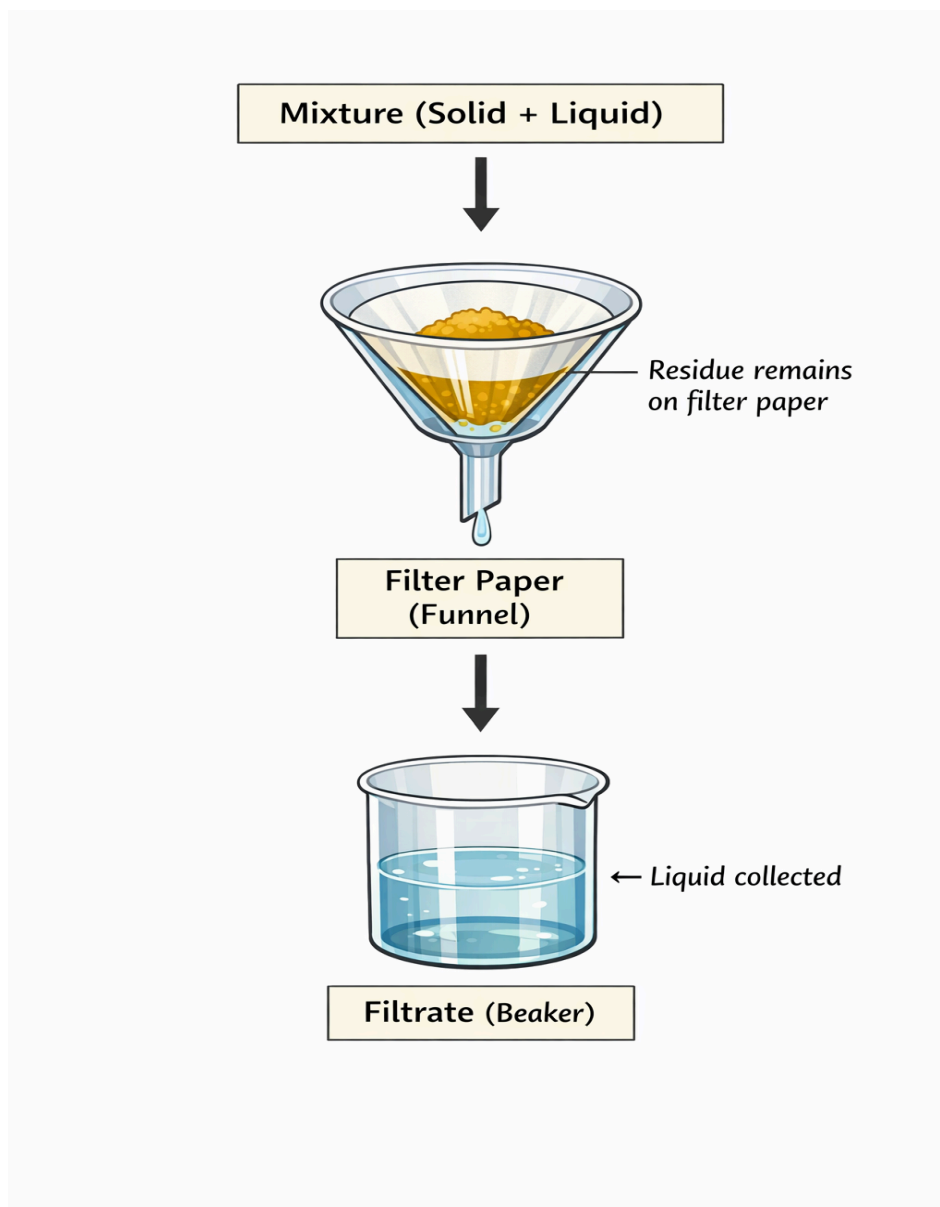
### **Definitions**

**Filtrate:** The liquid that passes through the filter medium and is collected below.

**Residue:** The solid particles that remain on the filter medium after filtration.

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## Diagram:



## Summary:

**Thus**, filtration is an important laboratory technique used to separate insoluble solids from liquids using suitable filter media such as filter

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paper, Gooch crucible, or sintered glass crucible depending on the nature of the mixture and required accuracy.

☀ **Q2. Describe the process of crystallization. Explain its steps and characteristics of an ideal solvent with examples.**

**Answer:**

### **Definition of Crystallization**

Crystallization is a purification technique used to obtain a pure solid from its impure sample by dissolving it in a suitable solvent at high temperature and then allowing it to form pure crystals on cooling.

### **Principle of Crystallization**

The principle of crystallization is based on the difference in solubility of a substance at different temperatures:

- At high temperature, the solute dissolves in large amount in the solvent.
- At low temperature, solubility decreases and excess solute comes out as crystals.

### **Steps of Crystallization Process**

#### **1. Preparation of Saturated Solution**

The impure solid is dissolved in a suitable solvent at high temperature until a saturated solution is formed.

#### **2. Hot Filtration**

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- The hot saturated solution is filtered to remove insoluble impurities.
  - This prevents premature crystallization during filtration.

### **3. Slow Cooling**

- The clear solution is allowed to cool slowly at room temperature.
- This helps in formation of large, pure and well-defined crystals.

### **4. Separation of Crystals**

- The mixture of crystals and mother liquor is separated using a Gooch crucible under vacuum filtration.

### **5. Drying of Crystals**

The crystals are dried:

- either in air
- or in a vacuum desiccator
- or in an oven (if heat stable)

### **Characteristics of an Ideal Solvent**

An ideal solvent for crystallization should have the following properties:

- It should dissolve a large amount of solute at high temperature
- It should dissolve very little solute at low temperature
- It should not react chemically with the solute
- It should not dissolve impurities (or impurities should remain insoluble)

- 
- It should form pure, well-shaped crystals on cooling
  - It should be safe, cheap, and easily removable

### **Examples of Solvents**

- Water (most commonly used)
- Ethanol
- Acetic acid
- Chloroform
- Carbon tetrachloride

Sometimes a mixture of solvents is used if a single solvent is not suitable.

### **Example of Crystallization**

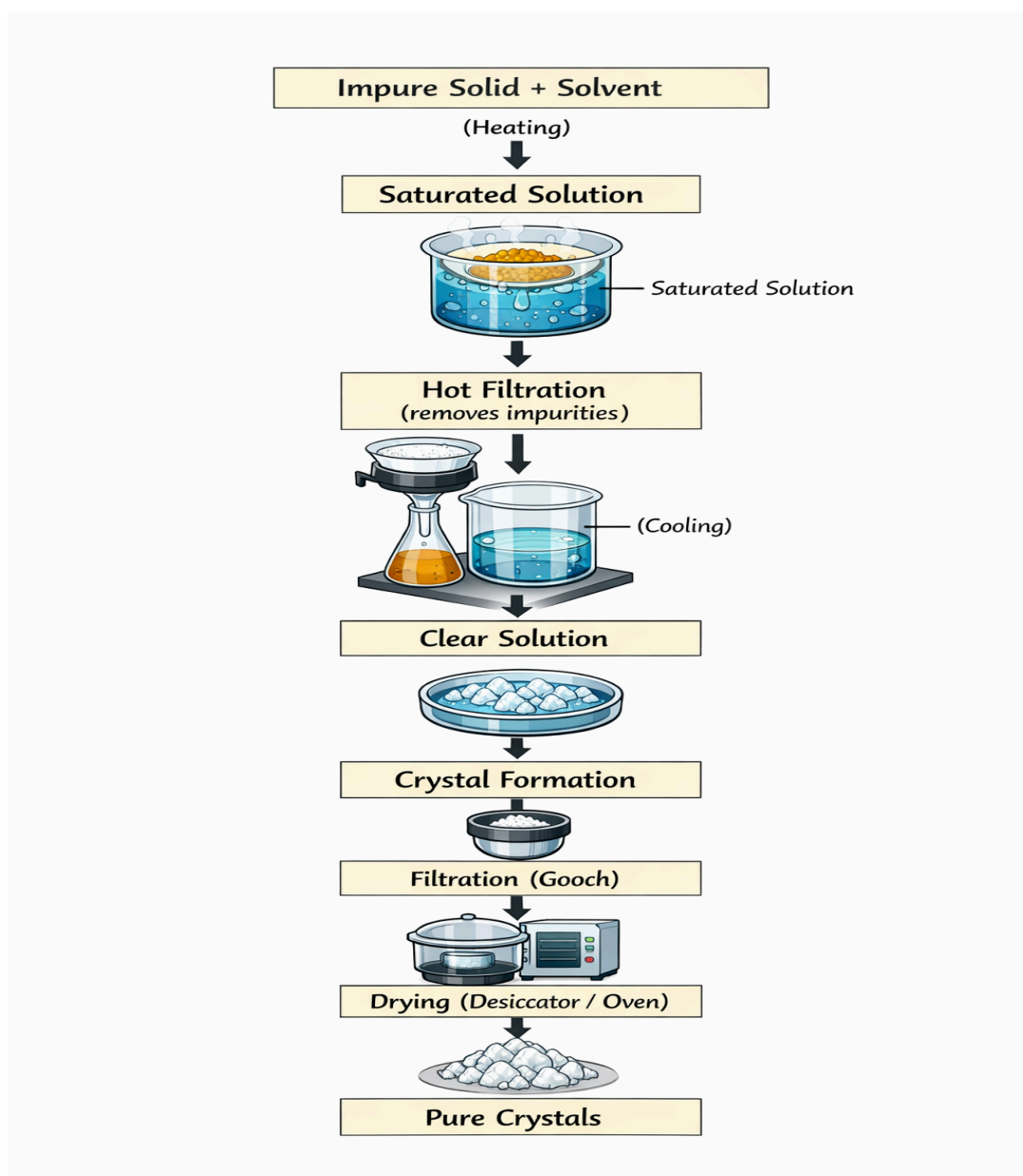
#### **1. Purification of Common Salt**

Impure salt is dissolved in hot water, filtered, cooled, and pure salt crystals are obtained.

#### **2. Purification of Aspirin**

Aspirin is crystallized in water to remove impurities like salicylic acid and obtain pure aspirin crystals.

## Diagram:



**Summary:** Thus, crystallization is an important purification method that uses temperature-dependent solubility to obtain pure solid crystals from impure substances.

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☀️ **Q3. Explain simple distillation and fractional distillation in detail. Also describe their working principles with examples and differences.**

**Answer:**

### **Definition of Distillation**

Distillation is a separation technique used to separate components of a mixture based on differences in their boiling points by evaporation and condensation.

### **1. Simple Distillation**

#### **Definition**

Simple distillation is used to separate a solvent from a solution or two liquids with a large difference in boiling points.

#### **Principle**

It works on the principle that:

- The component with lower boiling point evaporates first
- Vapour is then condensed back into liquid

#### **Process**

- Mixture is placed in a distillation flask
- Heated gently using Bunsen burner
- Vapours pass into condenser

- 
- Cold water in condenser cools vapours
  - Vapour condenses into liquid (distillate)
  - Residue remains in flask

### **Example**

- Purification of sea water to obtain pure water

## **2. Fractional Distillation**

### **Definition**

Fractional distillation is used to separate two miscible liquids with close boiling points.

### **Principle**

- Liquids are separated based on small differences in boiling points ( $\approx 25^\circ\text{C}$  or less)
- Repeated evaporation and condensation occur in fractionating column

### **Process**

- Mixture is heated
- Vapour enters fractionating column filled with glass beads
- Higher boiling liquid condenses and returns
- Lower boiling liquid passes through and is collected first
- Temperature rises and second liquid is collected

### **Example**

- 
- Separation of ethanol and water

### **Summary:**

Distillation is an important purification technique used in laboratories and industries for separating liquids based on boiling points.

🌟 **Q4. Explain paper chromatography in detail. Describe its procedure, principle, and applications with diagram.**

### **Answer:**

#### **Definition of Chromatography**

Chromatography is a separation technique used to separate components of a mixture based on their distribution between stationary and mobile phases.

#### **Principle of Chromatography**

It works on the principle of:

- Different substances have different affinities for stationary and mobile phases
- Components move at different speeds leading to separation

#### **Paper Chromatography**

##### **Definition**

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Paper chromatography is a type of partition chromatography in which separation occurs using paper as stationary phase and a solvent as mobile phase.

### **Phases**

- Stationary phase: Water in cellulose paper
- Mobile phase: Organic solvent

### **Procedure (Ascending Method)**

1. Take chromatography paper
2. Draw a pencil line near bottom
3. Place sample spot on line
4. Suspend paper in solvent tank
5. Solvent rises by capillary action
6. Components move at different speeds
7. Separation occurs
8. Chromatogram is formed

### **Detection of Colourless Spots**

- UV light
- Chemical reagents (e.g., ninhydrin)

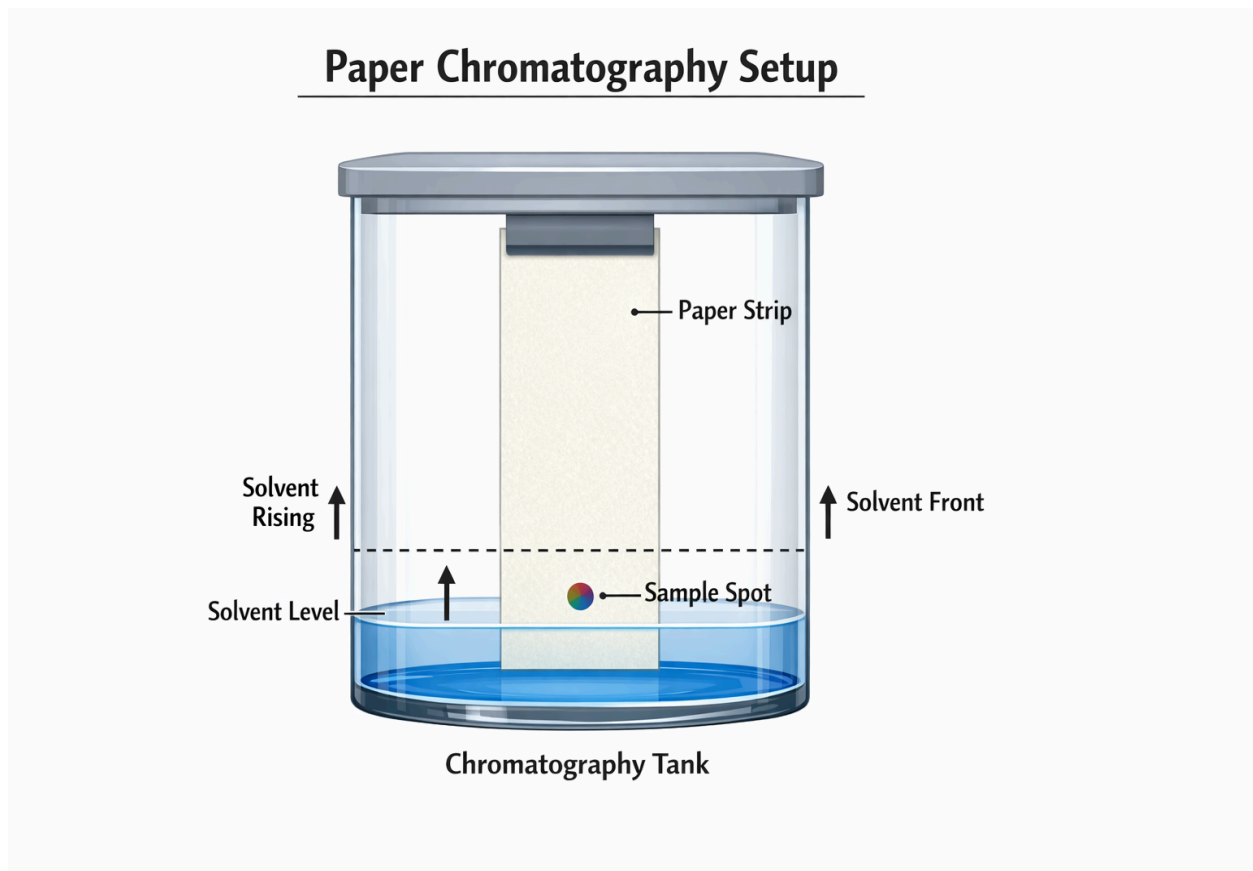
### **Rf Value**

Each component has a specific Rf value:

- Applications

- 
- Separation of dyes in ink
  - Identification of amino acids
  - Checking purity of substances
  - Pharmaceutical analysis

**Diagram:**



**Summary:**

Paper chromatography is a simple and effective method used for separation, identification, and purity testing of chemical substances.

---

☀️ **Q4. Explain paper chromatography in detail. Describe its procedure, types, and applications.**

**Answer:**

### **Definition of Chromatography**

Chromatography is a separation technique used to separate components of a mixture based on their different distribution between two phases:

- Stationary phase
- Mobile phase

It is widely used for separation, identification, and purity testing of chemical substances.

### **Phases in Chromatography**

#### **1. Stationary Phase**

It is the fixed phase in chromatography.

- It does not move
- It can be a solid or liquid supported on solid

**Example:** Water held in cellulose fibres of paper

#### **2. Mobile Phase**

It is the moving phase that carries components of mixture.

- It can be a liquid or gas

- 
- It flows over stationary phase

**Example:** Organic solvent mixture

## Types of Chromatography

### 1. Adsorption Chromatography

- Stationary phase is a solid surface
- Components are separated based on adsorption strength
- Strongly adsorbed substances move slowly

**Example:** Thin Layer Chromatography (TLC), Column chromatography

### 2. Partition Chromatography

- Stationary phase is a liquid film supported on solid
- Components distribute between two liquids (mobile + stationary)

**Example:** Paper chromatography, Gas-liquid chromatography

## Paper Chromatography

### Definition

Paper chromatography is a type of partition chromatography in which separation occurs using paper as stationary phase and a suitable solvent as mobile phase.

### Principle

Different components of a mixture travel at different speeds due to:

- Different solubility in mobile phase

- 
- Different attraction to stationary phase

### **Procedure (Ascending Method)**

1. Take a strip of chromatography paper (Whatman No.1)
2. Draw a pencil baseline near bottom
3. Place a small spot of sample on the line
4. Pour solvent into chromatography tank
5. Suspend paper so lower end dips in solvent
6. Solvent rises upward by capillary action
7. Components separate at different rates
8. Remove paper when solvent reaches near top
9. Mark solvent front and dry paper

### **Chromatogram Formation**

The final pattern formed on paper after separation is called a chromatogram.

- Each separated spot represents a component
- Different distances indicate different substances

### **Detection of Colourless Substances**

Since many compounds are colourless, they are detected by:

#### **1. UV Light**

- Spots become visible under ultraviolet lamp

#### **2. Chemical Locating Agents**

---

**Example:** Ninhydrin

- Reacts with amino acids to form coloured spots
- Applications of Paper Chromatography
- Separation of dyes and pigments in inks
- Identification of amino acids in proteins
- Detection of drugs in pharmaceuticals
- Checking purity of substances
- Analysis of complex chemical mixtures

**Summary:**

Paper chromatography is an important analytical technique used for separating, identifying, and analyzing components of mixtures based on their different movement in stationary and mobile phases.

🌟 **Q5. Explain different methods used to check the purity of a substance with suitable examples.**

**Answer:**

**Importance of Purity Testing**

Purity testing is very important in chemistry because the properties and reactions of a substance depend on its purity. Impure substances may give wrong results in experiments and are not suitable for medical or industrial use.

---

Therefore, different physical and analytical methods are used to confirm whether a substance is pure or impure.

## 1. Boiling Point Method (for Liquids)

### Principle:

A pure liquid boils at a fixed and sharp temperature, while an impure liquid boils over a range of temperatures.

### Explanation:

- Pure liquids have uniform composition → constant boiling point
- Impurities disturb boiling point → range instead of fixed value

### Example:

- Pure water boils at 100°C at standard pressure
- Impure water shows boiling over a range below or above 100°C

## 2. Melting Point Method (for Solids)

### Principle:

A pure solid melts at a sharp and definite temperature, while an impure solid melts over a range of temperatures.

### Explanation:

- Pure crystals have a uniform structure → sharp melting point
- Impurities disturb crystal lattice → melting point decreases and becomes broad

---

### **Sharp vs Range Melting Point:**

- Sharp melting point: Indicates purity
- Range melting point: Indicates impurity

### **Example:**

- Pure aspirin melts at 136°C
- Impure aspirin melts below 136°C over a range

### **3. Mixed Melting Point Test**

#### **Principle:**

A sample is mixed with a known pure compound and melting point is determined.

#### **Interpretation:**

- If melting point remains sharp → both are same pure substance
- If melting point decreases or becomes broad → impurities or different substance

#### **Example:**

Mixing unknown sample with pure aspirin:

- If still melts at 136°C → pure aspirin

### **4. Chromatography Method (Rf Value Comparison)**

#### **Principle:**

---

Different substances travel different distances in chromatography depending on their affinity to stationary and mobile phases.

**Rf Value:**

$R_f = \text{distance travelled by substance} / \text{distance travelled by solvent}$

**Explanation:**

- Pure substance → single spot on chromatogram
- Impure substance → multiple spots
- Same  $R_f$  value as standard confirms purity

**Example:**

Aspirin sample compared with pure aspirin and salicylic acid:

Pure aspirin shows single spot with same  $R_f$  value

**Summary:**

Thus, purity of substances can be checked using:

- Boiling point (liquids)
- Melting point and mixed melting point (solids)
- Chromatography ( $R_f$  value comparison)

These methods are essential in ensuring accuracy in chemical analysis and pharmaceutical preparation.

---



## Exercise

**Q.1 Four choices are given for each question. Select the correct choice.**

**I. After the crystals are formed, they are typically separated from the mother liquor by:**

- a) Evaporation
- b) Decantation or filtration
- c) Sublimation
- d) Distillation

**II. The comparative rates at which the solutes move in paper chromatography depend on:**

- a) Size of filter paper
- b)  $R_f$  values of solutes
- c) Temperature
- d) Size of the chromatographic jar

Correct answer: b)  $R_f$  values of solutes

**III. The method that can be used to separate two solid compounds with different solubilities in a solvent is:**

- 
- a) Distillation
  - b) Isolation
  - c) Crystallization
  - d) Filtration

Correct answer: c) Crystallization

**IV. It is suspected that a hand-written legal document has been changed by overwriting some crucial figures. Which technique will you use to check the inks used at suspected places?**

- a) Distillation
- b) Chromatography
- c) Solvent Extraction
- d) Crystallization

Correct answer: b) Chromatography

**V. In chromatography, the components of the mixture are separated based on:**

- a) Their molecular masses
- b) The interaction of the components with stationary as well as mobile phases
- c) The type of solvent used

---

d) The filter paper used

Correct answer: b) The interaction of the components with stationary as well as mobile phases ✓

**VI. The porous material used to separate the solid from the liquid during filtration is called the:**

a) Filtrate

b) Residue

c) Filter medium

d) Solvent

Correct answer: c) Filter medium ✓

**VII. The key difference between simple distillation and fractional distillation is the presence of a:**

a) Condenser with a larger surface area

b) More powerful heat source

c) Fractionating column

d) Vacuum pump

Correct answer: c) Fractionating column ✓

---

**VIII. The essential requirement for separating two liquids by simple distillation is that their boiling points should differ by at least:**

- a) 5°C
- b) 10°C
- c) 25°C
- d) 50°C

Correct answer: c) 25°C 

**Q.2 Attempt the following short-answer questions:**

**a. Why is there a need to crystallize a crude product?**

Crude products obtained after chemical reactions usually contain impurities such as unreacted substances, by-products, or solvent traces. These impurities affect the purity and properties of the product.

**Crystallization is needed to:**

- Remove impurities
- Obtain pure solid crystals
- Improve quality and accuracy of the product

**Example:** Crude aspirin is crystallized to remove salicylic acid and other impurities.

**b. What is the function of fluted filter paper?**

---

Fluted filter paper is used to increase the rate of filtration. Its fan-like folds provide a larger surface area, allowing liquid to pass quickly through the paper.

**Function:**

- Speeds up filtration process
- Prevents clogging of filter paper
- Improves efficiency of separation

**c. What is the difference between a Gooch crucible and a Sintered glass crucible?**

**Gooch Crucible:**

- Made of porcelain
- Has a perforated bottom covered with filter paper or asbestos
- Requires preparation before use

**Sintered Glass Crucible:**

- Made of glass with a porous glass disc
- Does not require filter paper
- Ready to use and more chemically resistant

**Key Difference:**

**Gooch crucible** needs filter medium preparation, while **sintered glass crucible** has an inbuilt filtering surface.

**d. What type of mixtures are filtered through a Gooch crucible?**

---

Gooch crucible is used for filtering fine precipitates from solutions, especially when fast and efficient filtration is required under vacuum (suction filtration).

**Examples:**

- Precipitates formed during chemical analysis
- Substances that need drying or ignition after filtration
- Laboratory analytical samples requiring accurate separation

**e. What is the function of fractionating column during fractional distillation?**

The fractionating column provides a large surface area for repeated condensation and evaporation of vapours.

**Function:**

- Helps in separating liquids with close boiling points
- Allows higher boiling component to condense and fall back
- Lets lower boiling component pass through to the condenser

**Result:** Better and more efficient separation of miscible liquids.

**f. What is the stationary phase in paper chromatography?**

In paper chromatography, the stationary phase is the water molecules trapped in the cellulose fibers of the chromatography paper.

- The paper itself holds water
- This thin layer of water acts as the stationary phase

---

**g. What will happen during paper chromatography if the components of the mixture have a comparable attraction for the stationary phase?**

If components have similar attraction for the stationary phase, then:

- They will move at nearly the same speed
- Separation will be poor or very slow
- Spots may appear close together or overlap
- It becomes difficult to distinguish components clearly

**h. What is meant by the term "developing the chromatogram" in paper chromatography?**

Developing the chromatogram means the process in which:

- The solvent rises on the paper
- The components of the mixture separate into visible spots or bands
- A final pattern is formed on the paper showing separated substances

Final result is called a chromatogram, which is then used for analysis.

**i. What is the basic principle of paper chromatography?**

The basic principle of paper chromatography is the distribution of components of a mixture between two phases:

- Stationary phase (water in paper cellulose)

- 
- Mobile phase (solvent)

Different components move at different rates because they have different solubility in mobile phase and different attraction to stationary phase.

### **j. Why is water not generally used as a solvent in paper chromatography?**

Water is not generally used as a solvent because:

- It is already present in the cellulose fibers of the paper (stationary phase)
- If used as mobile phase, separation becomes unclear or ineffective
- It may reduce proper movement of components

**Therefore**, organic solvents are preferred as mobile phase.

### **k. Differentiate between adsorption and partition chromatography.**

Adsorption Chromatography:

- Stationary phase is a solid
- Separation occurs due to adsorption on solid surface
- Strongly adsorbed substances move slowly

**Example:** TLC, column chromatography

**Partition Chromatography:**

- 
- Stationary phase is a liquid film
  - Separation occurs due to distribution between two liquids
  - Components dissolve differently in phases

**Example:** Paper chromatography, gas-liquid chromatography

### **I. How can you check the purity of a compound with the help of paper chromatography?**

Purity can be checked by:

- Running the sample on chromatography paper
- If the compound is pure → only one spot appears
- If the compound is impure → more than one spot appears
- Rf values are compared with standard substances

**Thus**, single spot = pure compound.

### **m. You have prepared a solid sample of glucosazone in the laboratory. How will you proceed to check the purity of the sample?**

To check the purity of glucosazone:

- Perform paper chromatography of the sample
- Spot the glucosazone sample on chromatography paper
- Run alongside a standard pure glucosazone sample
- Develop chromatogram using suitable solvent
- Compare spots and Rf values

---

## Conclusion:

- If only one spot with same  $R_f$  value as standard appears → sample is pure
- If multiple spots appear → sample is impure

## DESCRIPTION QUESTIONS

### ☀ Q.3 Differentiate simple distillation and fractional distillation in construction and applications

#### Answer:

Distillation is a method used to separate components of a mixture based on differences in their boiling points. It is mainly of two types: simple distillation and fractional distillation.

#### 1. Construction Difference

##### Simple Distillation (Construction)

- Consists of a distillation flask, thermometer, condenser, and receiving flask
- No fractionating column is used
- Apparatus is simple and easy to set up
- Vapours directly go from flask to condenser

##### Fractional Distillation (Construction)

- 
- Similar to simple distillation but includes a fractionating column between flask and condenser
  - Column is filled with glass beads or plates
  - Provides large surface area for repeated condensation and evaporation
  - More complex apparatus

## 2. Working Principle Difference

### Simple Distillation

- Used when components have large difference in boiling points
- The more volatile component evaporates first and is condensed

### Fractional Distillation

- Used when components have close boiling points
- Repeated vaporization and condensation occur inside fractionating column
- Ensures better separation

## 3. Applications Difference

### Simple Distillation Applications

- Separation of solvent from solution
- Purification of sea water to obtain pure water
- Removing dissolved salts from water

### Fractional Distillation Applications

- 
- Separation of miscible liquids with close boiling points
  - Example: separation of ethanol and water
  - Industrial separation of petroleum fractions (oil refining)

#### 4. Key Difference Summary

- Simple distillation → used for large boiling point difference
- Fractional distillation → used for small boiling point difference (~25°C or less)
- Fractional distillation uses fractionating column, simple distillation does not

#### Summary:

Both methods are important separation techniques, but their selection depends on the nature of mixture and difference in boiling points of components.

🌟 **Q.4 Describe the criterion to choose the suitable solvent in the process of crystallization.**

#### Answer:

#### Introduction

Crystallization is a purification technique used to obtain pure solid crystals from an impure substance. The success of crystallization mainly depends on the selection of a suitable solvent. A proper solvent ensures maximum purity and good crystal formation.

---

## Criteria for Selecting a Suitable Solvent

A good solvent for crystallization should have the following properties:

### 1. Temperature-Dependent Solubility

- The substance should be highly soluble in the solvent at high temperature
- The substance should be sparingly soluble at low temperature
- This allows formation of crystals on cooling

### 2. Chemical Inertness

- The solvent should not react chemically with the solute
- Otherwise, the product may decompose or form unwanted compounds

### 3. Impurity Behavior

The solvent should either:

- Not dissolve impurities at all, or
- Keep impurities dissolved while solute crystallizes out
- This ensures pure crystal formation

### 4. Formation of Well-Defined Crystals

- On cooling, the solvent should allow the formation of large, pure, and well-shaped crystals
- Poor solvents give oily or impure deposits

---

## 5. Volatility / Easy Removal

- The solvent should be easily removable from crystals by drying or evaporation
- Low boiling point solvents are preferred

## 6. Safety and Cost

The solvent should be:

- Inexpensive
- Safe to handle (non-toxic if possible)
- Easily available in laboratory
- Common Solvents Used
- Water (most common)
- Ethanol
- Acetic acid
- Chloroform
- Carbon tetrachloride

Sometimes a mixture of solvents is used if no single solvent is suitable.

### **Example**

Aspirin crystallization: water is used because aspirin is more soluble in hot water and less soluble in cold water, allowing crystal formation on cooling.

### **Summary:**

---

A suitable solvent for crystallization must ensure high solubility at high temperature, low solubility at low temperature, chemical stability, and easy removal, leading to the formation of pure and well-defined crystals.

★ **Q.5 What is the basic principle of paper chromatography? Give its three practical life applications.**

**Answer:**

### **Basic Principle of Paper Chromatography**

Paper chromatography is based on the partition principle, where the components of a mixture are separated due to their different distribution between two phases:

- **Stationary phase:** Water trapped in the cellulose fibers of chromatography paper
- **Mobile phase:** A suitable organic solvent that moves through the paper

When the solvent moves upward by capillary action, different components of the mixture travel at different speeds depending on:

- Their solubility in the mobile phase
- Their attraction toward the stationary phase

As a result, the components get separated and form distinct spots.

### **Practical Life Applications of Paper Chromatography**

---

## 1. Separation of Dyes and Ink Analysis

Paper chromatography is widely used to:

- Separate different dyes in inks
- Identify components of colored mixtures

**Example:** Checking whether black ink contains multiple colored dyes.

## 2. Pharmaceutical Industry (Drug Analysis)

It is used to:

- Identify and separate components of medicines
- Check purity of drugs

**Example:** Detecting impurities in aspirin or antibiotic drugs.

## 3. Biochemical Analysis (Amino Acids)

It is used in laboratories to:

- Separate amino acids from protein hydrolysis
- Identify different amino acids using locating agents like ninhydrin

**Example:** Analysis of proteins in medical and biological research.

### Summary:

Paper chromatography works on the principle of differential distribution between stationary and mobile phases, and it is widely used in ink analysis, drug testing, and biochemical research.

---

**Note:**

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

**Author: Muhammad Asghar**

**Purpose:** To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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