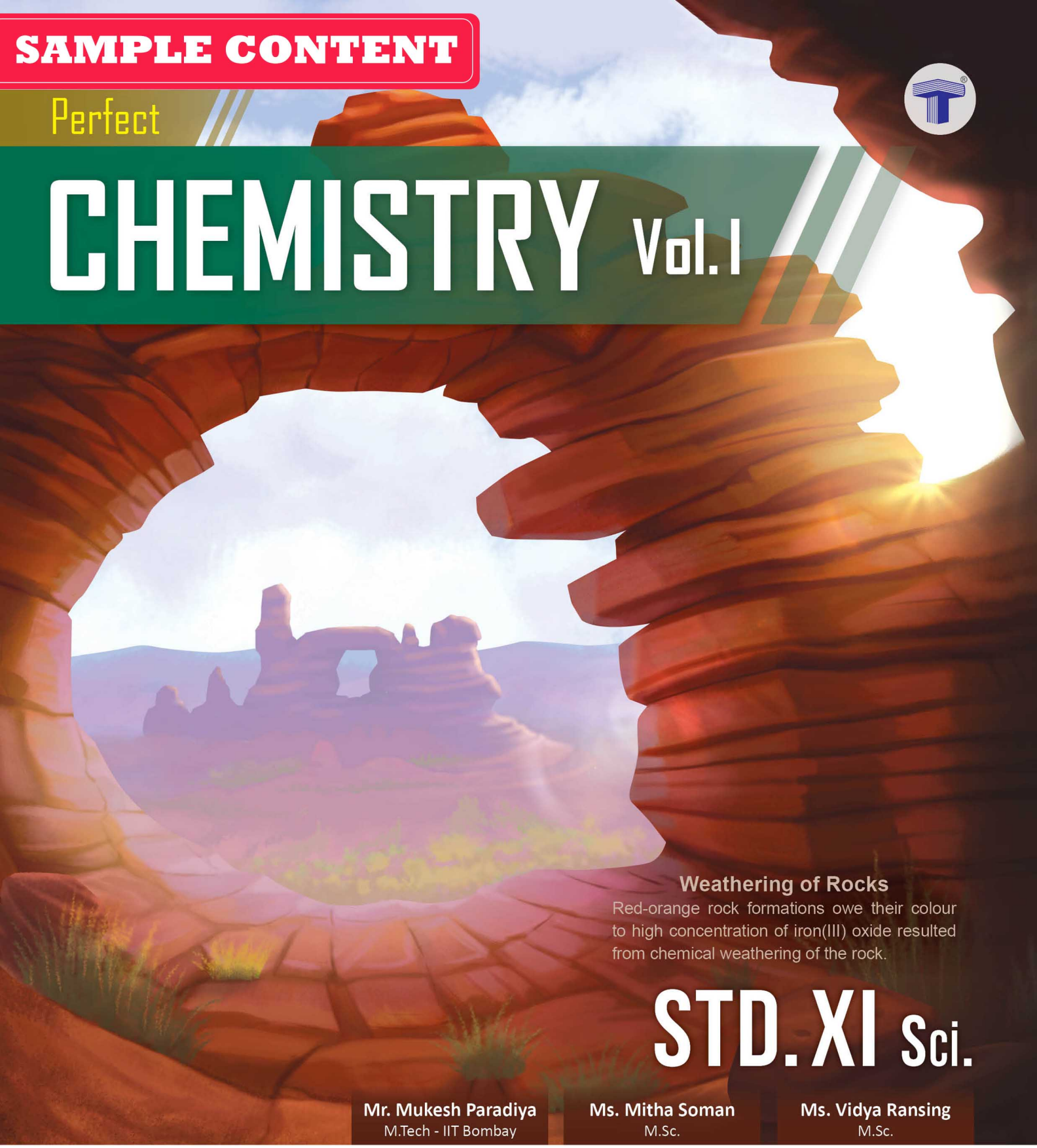
SAMPLE CONTENT

Perfect

CHEMISTRY Vol. I



Weathering of Rocks

Red-orange rock formations owe their colour to high concentration of iron(III) oxide resulted from chemical weathering of the rock.

STD. XI Sci.

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Target Publications® Pvt. Ltd.

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PERFECT CHEMISTRY (Vol. I)

Std. XI Sci.

Sample Content

Salient Features

- Written as per the latest textbook
- Subtopic-wise segregation for powerful concept building
- Complete coverage of Textual Exercise Questions, Intext Questions and Numericals
- Extensive coverage of New Type of Questions
- 'Solved Examples' provided to cover numerical aspect of the topic in detail
- 'Apply Your Knowledge' section for application of concepts
- 'Quick Review' at the end of every chapter facilitates quick revision
- A compilation of all 'Important Formulae'
- 'Competitive Corner' presents questions from prominent competitive examinations
- About the chapter, Reading Between the Lines, Enrich Your Knowledge, Gyan Guru, Strategy, Connections, Caution, NCERT Corner are designed to impart holistic education
- Includes Theory questions, Numericals and MCQs for practice
- Topic Test at the end of each chapter for effective preparation
- Video links provided via QR codes for boosting conceptual retention
- QR Code to access the Solutions of Numericals for Practice and Reduced Syllabus as per Board Notification

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PREFACE

"I never teach my pupils; I only attempt to provide the conditions in which they can learn." – Albert Einstein

'Perfect Chemistry Vol. I, Std. XI Sci.' forms a part of **'Target Perfect Notes'** prepared as per the new textbook of Maharashtra State Board. It focuses on active learning along with making the process of education more interesting and builds up the students' knowledge quotient in the process.

Every chapter in this book begins with ***'About the Chapter'*** that offers a brief introduction of the chapter. The chapter is **segregated subtopic-wise** and encompasses all textual content in the format of Question-Answers. The questions titled under 'Use your brain power', 'Can you tell', 'Can you recall', 'Problems', 'Try this' and various similar titles pave the way for a robust concept building. For the students to gain a better understanding of the concept lying behind the answer, **'Reading between the lines'** (*not a part of the answer*) has been provided as deemed necessary. Numericals along with their step-wise solutions are covered under the heading of '**Solved Examples'** at the end of each subtopic. Few selected numericals have also been solved using log-tables. '**Quick Review'** has been provided for instant revision. Formulae covered in the chapter are compiled together as '**Important Formulae'** at the end of the chapter. '**Exercise',** '**Multiple Choice Questions'** and **'Topic Test'** (as per latest paper pattern) are added to enable students assess their range of preparation and knowledge of each topic. QR codes have been provided for students to access the 'Solutions to Numericals for practice' and 'Answers' given for the Topic Test. **Notes** are introduced to cover additional bits of relevant information on each topic as seemed required. **Log-table** has been provided for students' use at the end of the book.

*Our **Perfect Chemistry Vol. I, Std. XI Sci.** adheres to our vision and achieves several goals: **building concepts, developing competence to solve numerical, recapitulation, self-study, self-assessment** and **student engagement**—all while encouraging students toward cognitive thinking.*

The flow chart on the adjacent page will walk you through the key features of the book and elucidate how they have been carefully designed to maximize the student learning.

We hope the book benefits the learner as we have envisioned.

- Publisher

Edition: Third

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we've nearly missed something or want to applaud us for our triumphs, we'd love to hear from you.
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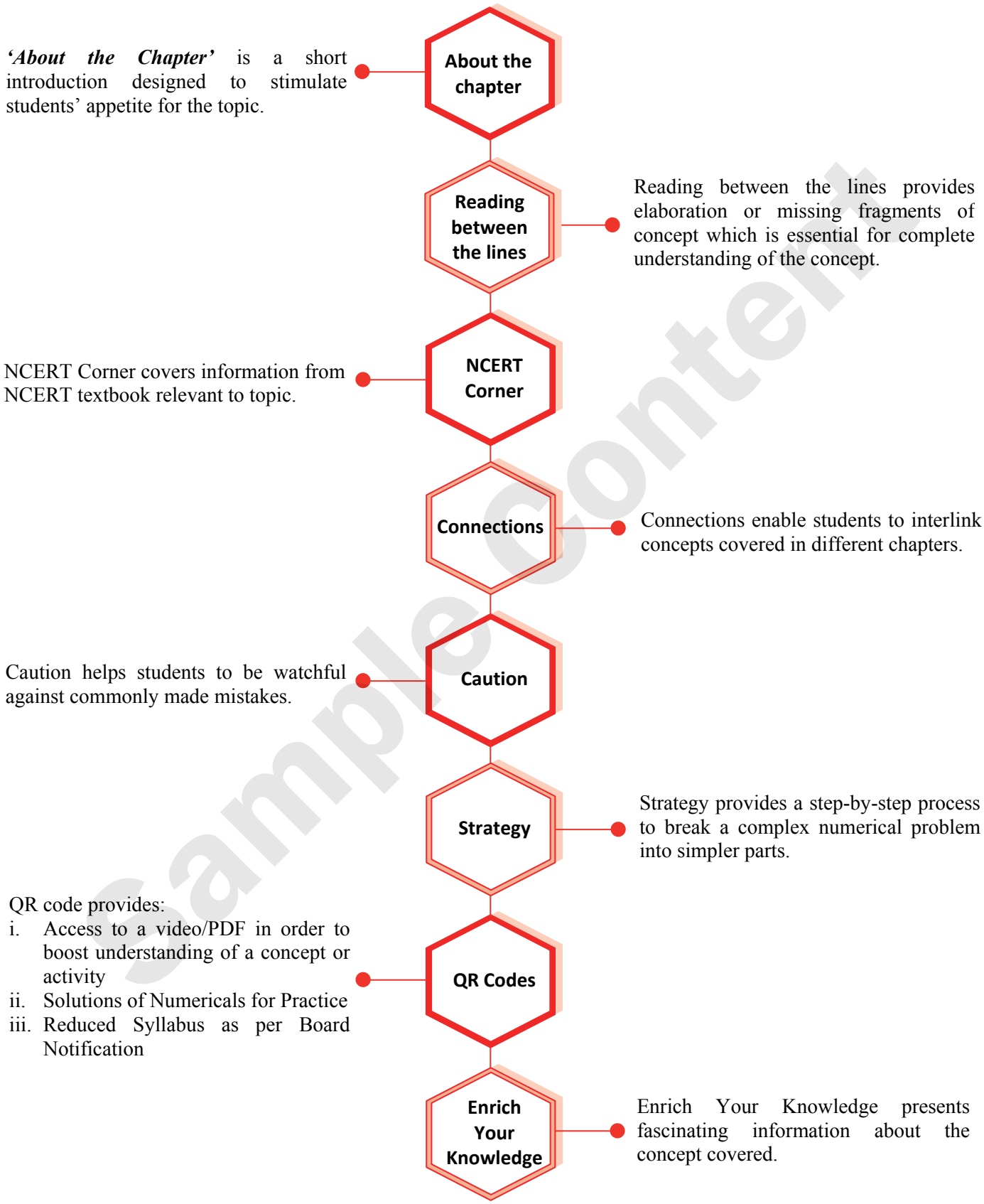
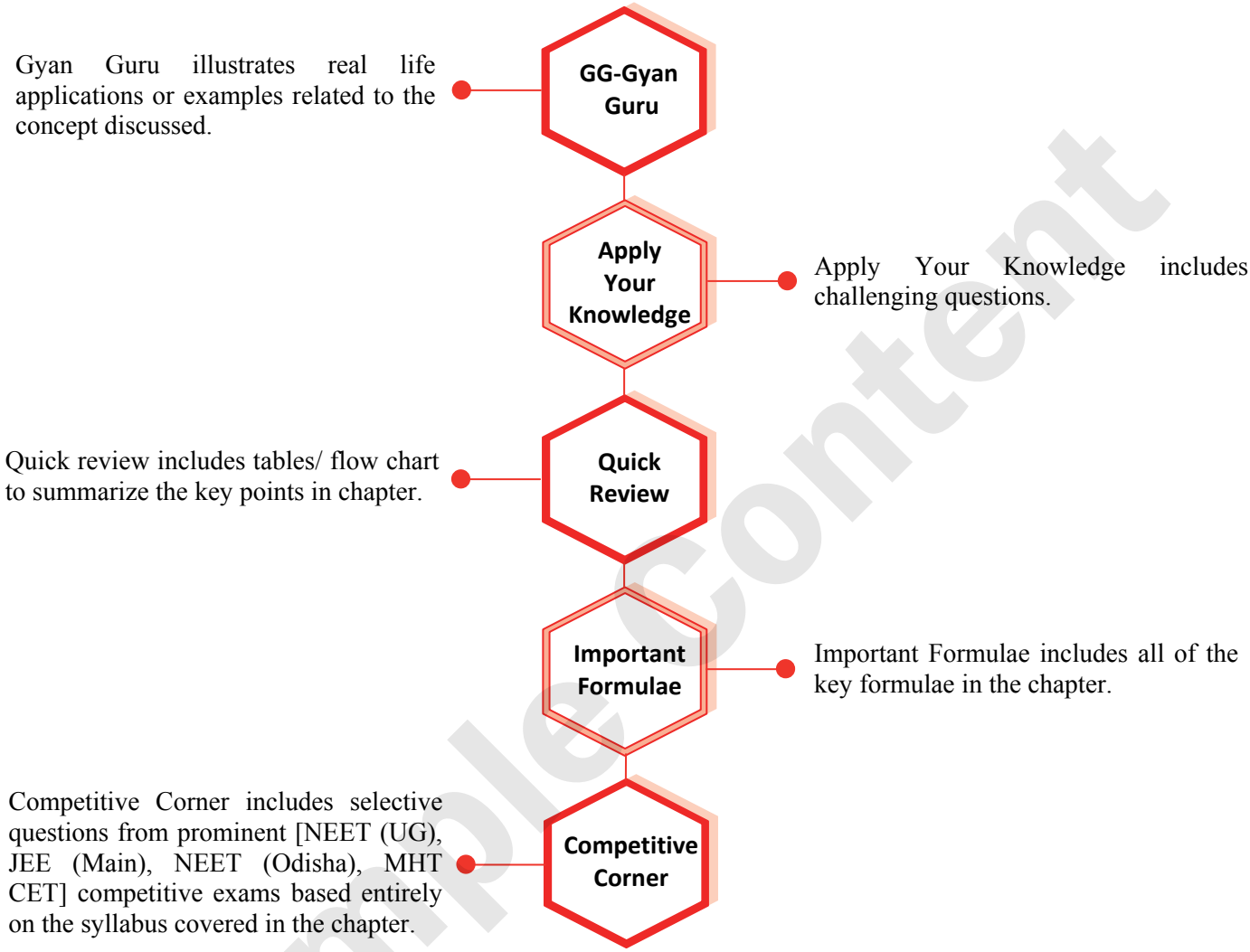
KEY FEATURES



Sample Content

Continued…

KEY FEATURES



Sample Content

CONTENTS

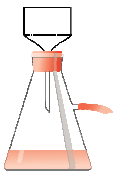
[Reference: Maharashtra State Board of Secondary and Higher Secondary Education, Pune - 04**]**

Note:
1. * mark represents Textual Exercise question.
2. # mark represents Intext question.
3. + mark represents Textual examples.
4. 🔔 symbol represents textual questions that need external reference for an answer.
5. This Reference Book is based on the Entire Textbook (Complete Syllabus) of Chemistry Prescribed by Maharashtra State Board. Ⓡ symbol represents the content that belongs to the Reduced Syllabus as issued by State Board.
6. Table provided at the beginning of the chapter facilitates students to find out Textual Exercise Questions given in this book.
7. Chapters 10 to 16 are a part of Perfect Chemistry Vol. II, Std. XI Sci.

Sample Content

Sample Content

3 Basic Analytical Techniques



About the chapter…

Various methods are used in laboratory to separate or purify a substance prior to its analysis. This chapter introduces students to methods/techniques such as filtration, crystallization, distillation, solvent extraction and chromatography which are commonly employed for separation and purification of substances.

CONTENTS AND CONCEPTS

TEXTBOOK EXERCISE QUESTIONS

Textbook Exercise Question No.	Target Notes: Subtopic No.	Question No.	Page No.
Q.1 Choose the correct option			
A	3.2	3	85
B	3.3	9	85
C	3.5	11	85
D	3.3	6	85
E	3.5	16	86
Q.2 Answer the following			
A	3.2	17	74
B	3.2	5	72
C	3.3	24	76
D	3.2	8	73
E	3.5	49	81
F	3.3	25	76
G	3.5	41	80

Textbook Exercise Question No.	Target Notes: Subtopic No.	Question No.	Page No.
Q.2 Answer the following (cont'd)			
H	3.4	33	78
I	3.5	46	81
J	3.5, 3.2	39, 10	79, 73
K	3.3	30	77
L	3.4, 3.3	32, 21	78, 75
M	3.2	13	74
N	3.5	40	80
O	3.5	43	80
P	3.5	51	82
Q	3.5	53	82
Q.3.	3.2	6	72
Activity	---	56	83

R 3.1 INTRODUCTION

Q.1. Give reason: Purification of a chemical substance is important before investigating its composition and properties.

Ans:

i. Chemical substances occur in nature in impure stage.
ii. Also, chemical substances synthesized in the laboratory are obtained in crude and impure form.
iii. Impurities present in the chemical substances may interfere with the properties to be determined (**e.g.** melting point or boiling point).
iv. Therefore, before investigating composition and properties of a given chemical substance, it is important to obtain it in the pure form.

3.2 PURIFICATION OF SOLIDS

Q.2. What are the different types of impurities that a solid may contain?

Ans: A solid substance may contain two types of impurities:

i. Impurities which are soluble in the same solvent as the main substance.
ii. Impurities which are not soluble in the same solvent as the main substance.

Sample Content

Q.3. For which of the following cases, is the process of filtration feasible? Why?

Case 1: A solid substance containing impurities which are soluble in the same solvent as the main substance.

Case 2: A solid substance containing impurities which are not soluble in the same solvent as the main substance.

Ans: Impurities which are not soluble in the same solvent as the main compound can be separated by a simple process called filtration. Hence, for 'Case 2', filtration is more feasible.

Q.4. Describe the process of filtration with a neat and labelled diagram.

Ans:

i. Impurities which are not soluble in the same solvent as the main compound can be separated by a simple process called filtration.

ii. Procedure:

a. A circular piece of filter paper is folded to form a cone and fitted in the funnel.

b. The funnel is fixed on a stand and a beaker is kept below.

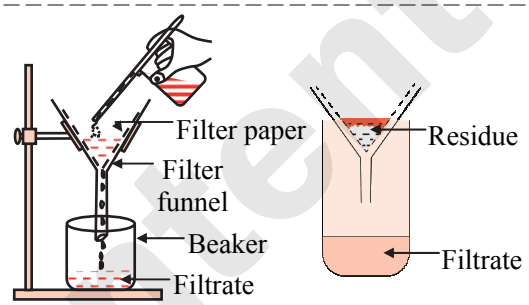
c. The mixture which has to be purified is added to a suitable solvent in which the main compound dissolves.

d. The paper is made moist, and the solution to be filtered is poured on the filter paper.

iii. The insoluble part remaining on the filter paper is called residue and the liquid which pass through the filter paper and collected in the beaker is called filtrate.

iv. This process is similar to separating tea leaves from decoction of tea or sand from mixture of sand and water.

v. Diagram:



Process of filtration

***Q.5. What do you understand by the terms:**

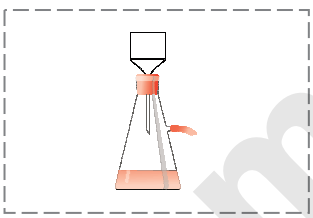
i. Residue **ii. Filtrate**

Ans:

i. Residue: *In the process of filtration, the insoluble (undissolved) impurities which remain on the filter paper are called* ***residue****.*

ii. Filtrate: *In the process of filtration, the liquid which pass through the filter paper and collected in the beaker is called* ***filtrate****.*

***Q.6. Label the diagram and explain the process in your words.**

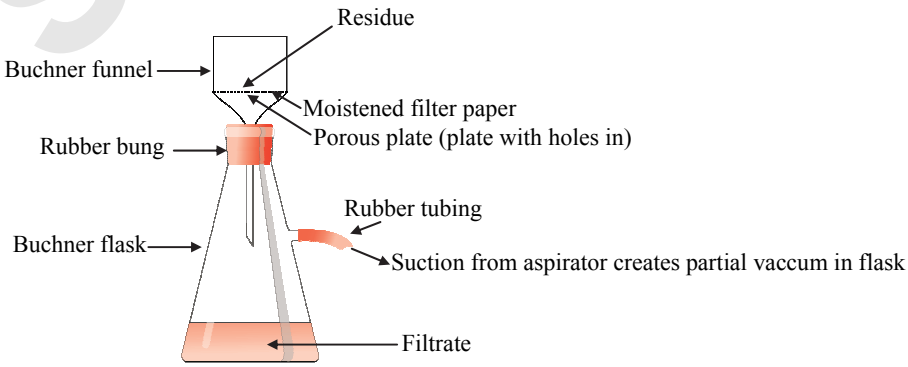


OR

Describe the process of filtration under suction with a neat and labelled diagram.

Ans:

i. *When filtration is carried out using a vacuum pump it is called* ***filtration under suction****.* It is a faster and more efficient technique than simple filtration. The diagram is as follows:



Setup for filtration under suction

Sample Content

ii. Procedure:

a. The assembly for filtration under suction consists of a thick wall conical flask with a side arm (Buchner flask).
b. The flask is connected to a safety bottle by rubber tube through the side arm.
c. Buchner funnel (a special porcelain funnel with a porous circular bottom) is fitted on the conical flask with the help of a rubber cork.
d. A circular filter paper of correct size is placed on the circular porous bottom of the Buchner funnel and the funnel is placed on the flask.
e. Filter paper is moistened with a few drops of water or solvent.
f. Suction is created by starting the pump and filtration is carried out.
iii. Crystals are collected on the filter paper and filtrate in the flask.

Q.7. Why is safety bottle used when filtration is carried out under suction?
Ans: The safety bottle is used to prevent sucking of the filtrate into suction pump.

***Q.8. Why is paper moistened before filtration?**
Ans: Before filtration, filter paper is moistened with appropriate solvent to ensure that it sticks to the funnel and does not let the air to pass through the leaks.

Q.9 Name the steps involved in the process of crystallization.
Ans: Steps involved in the process of crystallization:

i. Preparation of a saturated solution
ii. Hot filtration
iii. Cooling of the filtrate
iv. Filtration

***Q.10. Define: Saturated solution**
Ans: *A **saturated solution** is a solution which cannot dissolve additional quantity of a solute.*

Q.11. How is saturated solution of the crude solid prepared?
Ans:

i. A saturated solution of the crude solid is prepared by boiling it in a small but sufficient quantity of a suitable solvent.
ii. The main solute from the sample of the crude solid dissolves to form a saturated solution on boiling.

Note: The solution is not saturated with respect to the soluble impurities, as they are in small proportion.

Q.12. Explain the following steps with respect to the process of crystallization.
i. Preparation of a saturated solution
ii. Hot filtration
iii. Cooling of the filtrate
iv. Filtration
Ans:

i. Preparation of a saturated solution:

a. A saturated solution of the crude solid is prepared by boiling it in a small but sufficient quantity of a suitable solvent.
b. On doing so the main solute forms an almost saturated solution, but the solution is not saturated with respect to the soluble impurities, as they are in small proportion.

ii. Hot filtration: The hot saturated solution is quickly filtered to remove undissolved impurities as residue. Filtration under suction can be employed for rapid filtration.

iii. Cooling of the filtrate:

a. The hot filtrate is allowed to cool.
b. On cooling, the filtrate becomes supersaturated with respect to the main dissolved solute because solubility of a substance decreases with lowering of temperature.
c. The excess quantity of the dissolved solute comes out of the solution in the form of crystals.
d. The dissolved impurities, however, do not supersaturate the solution, as their quantity is small.
e. These continue to stay in the solution in dissolved state even on cooling. Therefore, the separated crystals are free from soluble impurities.

iv. Filtration:

a. The crystals obtained on cooling are further purified by filtration to remove insoluble impurities.
b. The filtrate obtained is called as **mother liquor**.
c. The crystals obtained after filtration are free from soluble as well as insoluble impurities.

Sample Content

***Q.13. List the properties of solvents which make them suitable for crystallization.**

Ans: The solvent to be used for crystallization should have following properties:

i. The compound to be crystallized should be least or sparingly soluble in the solvent at room temperature but highly soluble at high temperature.

ii. Solvent should not react chemically with the compound to be purified.

iii. Solvent should be volatile so that it can be removed easily.

Q.14. Name the common solvents used in the process of crystallization.

Ans: The commonly used solvents are water, ethyl alcohol, methyl alcohol, acetone, ether or their combinations.

Q.15. Describe the process of crystallization of common salt from impure sample with the help of a diagram.

Ans:

i. Impure sample of a common salt is added to the required quantity of water and stirred with a glass rod.

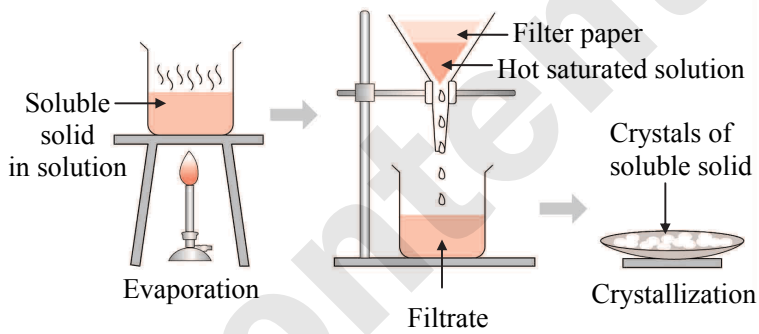
ii. More amount of salt is added and the solution is heated till no more salt dissolves.

iii. The hot saturated solution is filtered off to remove insoluble impurities while the filtrate is collected in an evaporating dish.

iv. The filtrate is allowed to cool which results in the formation crystals of pure salt (NaCl) leaving behind the soluble impurities.

v. The crystals are filtered and dried.

vi. Diagram:



Process of crystallization

Q.16. Which solvent is used for the purification of copper sulphate and benzoic acid?

Ans: The solvent used for the purification of copper sulphate and benzoic acid is water.

***Q.17. Which of the following techniques is used for purification of solid organic compounds?**
Crystallization or distillation

Ans: Solid (crude/impure) organic compounds can be purified by crystallization.

READING BETWEEN THE LINES

Distillation technique is employed for purification of liquids i.e., to separate volatile liquids from non-volatile impurities).

Q.18. Define: Fractional crystallization

Ans: ***Fractional crystallization*** *is a process wherein two or more soluble substances having widely different solubilities in the same solvent at same temperature are separated by crystallization.*

Q.19. Give a brief description of the principle of fractional crystallization.

Ans: Fractional crystallization is based on the differences in solubilities of two or more compounds in the same solvent at the same temperature. That is, the substance which is least soluble crystallizes out first and the most soluble substance crystallizes out last.

e.g. Mixture of two solutes A and B can be purified by fractional crystallization as follows:

i. **Preparation of a saturated solution:** Mixture of two solutes A and B are dissolved in a suitable hot solvent to prepare a saturated solution.

ii. **Hot filtration:** The hot saturated solution is filtered to remove insoluble impurities.

iii. **Cooling of the filtrate:** Hot filtrate is allowed to cool. On cooling, the solute which is least soluble crystallizes out first leaving behind the most soluble substance in the mother liquor.

iv. **Filtration:** The crystals formed are filtered, washed with solvent and dried. Crystals obtained will be of a solute which is least soluble in a given solvent.

v. **Concentration of a mother liquor:** The mother liquor is concentrated by evaporating the solvent. These crystals are filtered and dried to obtain the second purified component (which was more soluble in given

Sample Content

NCERT Corner

Sublimation:

Certain organic solids, on heating, directly change from solid to vapour state. Such substances are called ***sublimable*** *and this process is called* ***sublimation****.*

Principle:

Sublimation is the process used for the separation of sublimable volatile compounds from non-sublimable impurities.

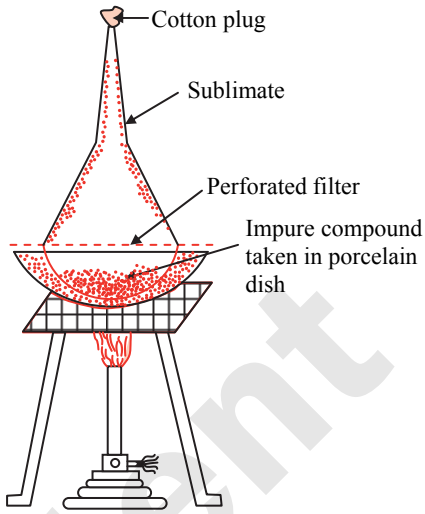
Procedure:

i. In this process, the impure solid is taken in a porcelain dish and covered with perforated filter paper.

ii. An inverted funnel with its stem being plugged with a little cotton and the sides kept cooled, is placed over it.

iii. The dish is heated gently over sand bath and the substance volatilizes and gets collected on the inner cold surface of the inverted funnel, while the impurities are left in the dish.

iv. The perforated filter paper permits the vapours to go up but checks the sublimate from falling back to the dish.



Sublimation process

e.g. The process is generally used for the purification of camphor, naphthalene, anthracene, benzoic acid, etc. containing non-volatile impurities.

3.3 DISTILLATION

Q.20. Which type of impure liquids can be purified by the process of distillation?

Ans: Distillation technique can be employed for the purification of

i. volatile liquids from non-volatile impurities.

ii. liquids having sufficient difference in their boiling point.

***Q.21. Define: Distillation**

Ans: *The process in which liquid is converted into its vapour phase at its boiling point and the vapour is then condensed back to liquid on cooling is known as* ***distillation****.*

Q.22. Explain the construction of simple distillation unit using neat labelled diagram.

Ans:

i. The apparatus used for simple distillation is shown in the adjacent figure:

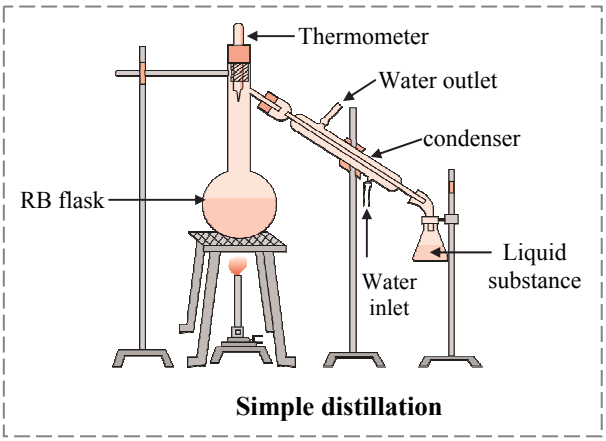
ii. It consists of round bottom flask fitted with a cork having a thermometer.

iii. The flask has a side arm through which it is connected to a condenser.

iv. The condenser has a jacket with two outlets through which water is circulated.

v. The liquid to be distilled is taken in the round bottom flask fixed by clamp.

vi. The flask is placed in a water bath or oil bath or sometimes wire gauze is kept on a stand as shown in the figure.



Simple distillation

Q.23. State the principle involved and describe the process to separate acetone and water from their mixture.

Ans:

i. Acetone and water can be separated from their mixture by simple distillation.

ii. **Principle:** Acetone and water are two miscible liquids having an appreciable difference (more than 30 K) in their boiling points. Acetone boils at 56 °C while boiling point of water is 100 °C. When the mixture of acetone and water is heated and temperature of the mixture reaches 56 °C acetone will distil out first. Once all acetone distils out, and when the temperature rises to 100 °C water will distil out.

Sample Content

iii. Process to separate acetone and water from their mixture:

a. Take the mixture of water and acetone in the distillation flask.

b. Heat the flask on a water bath carefully. At 56 °C acetone will distil out, collect it in receiver.

c. After all acetone distilled, change the receiver. Discard a few mL of the liquid. As the temperature reaches 100 °C water will begin to distil. Collect this in another receiver.

ENRICH YOUR KNOWLEDGE

If the liquid to be purified is highly volatile and inflammable, then distillation flask is heated on water bath. If the boiling point of liquid is very high, then the flask is heated on sand bath.

i. Acetone (boiling point 329 K) is distilled by using simple distillation (The flask is heated on a water bath as acetone is volatile).

ii. Carbon tetrachloride (boiling point 350 K) is distilled by using simple distillation (The flask is heated on a water bath as carbon tetrachloride is volatile).

iii. Aniline (boiling point 458 K) is distilled by using simple distillation (The flask is heated on a sand bath as aniline is non-volatile).

iv. Many organic liquids like benzene (boiling point 353 K), methyl alcohol (boiling point 338 K), etc. can be purified by simple distillation.

v. Sea water can be purified by heating the flask on tripod stand using wire gauze.

***Q.24. Why is a condenser used in distillation process?**

Ans: In the process of distillation, a liquid is converted into its vapour and the vapour is then condensed back to liquid on cooling. The condenser has a jacket with two outlets through which water is circulated. Hence, to provide efficient cooling, a condenser is used.

***Q.25. What will happen if the upper outlet of the condenser is connected to the tap instead of the lower outlet?**

Ans:

i. If water enters through upper outlet of condenser, the water will quickly flow down under the influence of gravity. This allows only a small section of the condenser to be cooled enough.

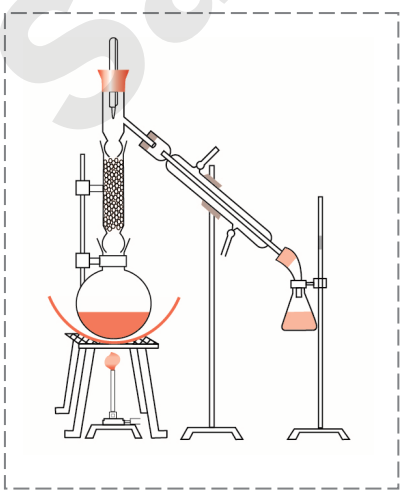
ii. If water enters through lower outlet of condenser, the entire condenser will be filled with water before it leaves out providing maximum cooling to the condenser. This results in maximum recovery of purified liquid.

Hence, water must be allowed to enter through lower outlet of condenser during distillation process.

Q.26. What is the advantage of fractional distillation over simple distillation?

Ans: If in a mixture, the difference in boiling points of two liquids is not appreciable/large, they cannot be separated using simple distillation. To separate such liquids, fractional distillation is used.

Q.27. Label the following diagram and explain the process by giving example.



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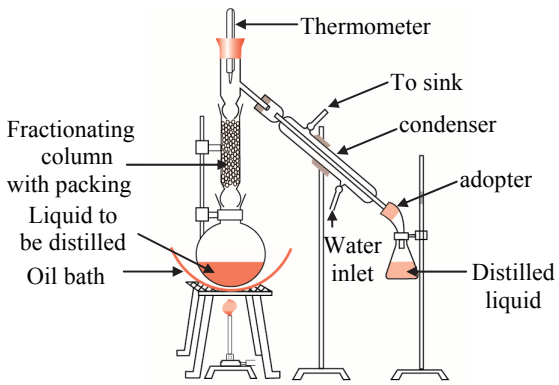
Ans: The labelled diagram is as follows:



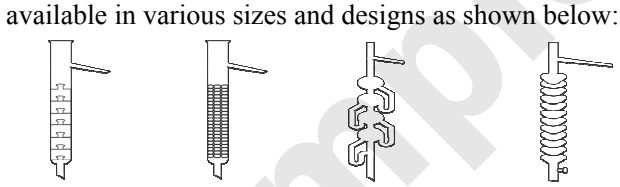
Fractional distillation

i. In fractional distillation, vapours first pass through the fractionating column.
ii. Vapours of more volatile liquid with lower boiling point rise up more than the vapours of liquid having higher boiling point.

e.g.
a. Suppose we have a mixture of two liquid 'A' and 'B' having boiling points 363 K and 373 K respectively.
b. 'A' is more volatile and 'B' is less volatile. As the mixture is heated, vapours of 'A' along with a little vapours of 'B' rise up and come in contact with the large surface of the fractionating column.
c. Vapours of 'B' condense rapidly into the distillation flask. While passing through the fractionating column, there is an exchange between the ascending vapours and descending liquid. The vapours of 'B' are scrubbed off by the descending liquid, this makes the vapours richer in 'A'.
d. This process is repeated each time the vapours and liquid come in contact with the surface in the fractionating column.
e. Rising vapours become richer in 'A' and escape through the fractionating column and reach the condenser while the liquid in the distillation flask is richer in 'B'.
f. The separated components are further purified by repeating the process.

ENRICH YOUR KNOWLEDGE

Fractionating columns are glass columns and are available in various sizes and designs as shown below:



Fractionating columns

NCERT Corner

Theoretical Plate:

Each successive condensation and vaporisation unit in the fractionating column is called a **theoretical plate**. Commercially, columns with hundreds of plates are available.

Q.28. Give two examples of a mixture that can be separated by fractional distillation.
Ans:
i. Mixture of acetone (b.p. 329 K) and methyl alcohol (b.p. 337.7 K)
ii. Mixture of acetone (b.p. 329 K) and benzene (b.p. 353 K)

Q.29. Give one industrial application of fractional distillation.
Ans: Fractional distillation is used in petroleum industry to separate different fractions of crude oil.

***Q.30. What is the difference between simple distillation and fractional distillation?**
Ans:

No.	Simple distillation	Fractional distillation
i.	If in a mixture the difference in boiling points of two liquids is appreciable/large, they are separated from each other using the simple distillation.	If in a mixture the difference in boiling points of two liquids is not appreciable/large, they are separated from each other using the fractional distillation.
ii.	Simple distillation assembly is used.	Fractionating column is fitted in distillation assembly.
e.g.	Mixture of acetone (b.p. 329 K) and water (b.p. 373 K) can be separated by this method.	Mixture of acetone (b.p. 329 K) and methanol (b.p. 337.7 K) can be separated by this method.

Sample Content

Q.31. Write a short note on distillation under reduced pressure.

Ans:

i. Liquids having very high boiling points or which decompose on heating are purified by the method of distillation under reduced pressure.

ii. In this method, the liquid is made to boil at a temperature lower than its normal boiling point by reducing the pressure on its surface.

iii. The external pressure is reduced using a water pump or vacuum pump.

e.g. Glycerol can be separated from soap by using this method.

NCERT Corner

Steam Distillation:

i. ***Steam distillation*** *is a technique used to purify liquids which are steam volatile (i.e. having boiling point less than 373 K) and are immiscible with water.*

ii. In this method, the steam from a steam generator is passed through a heated distillation flask containing the liquid and fitted with water condenser and a receiver.

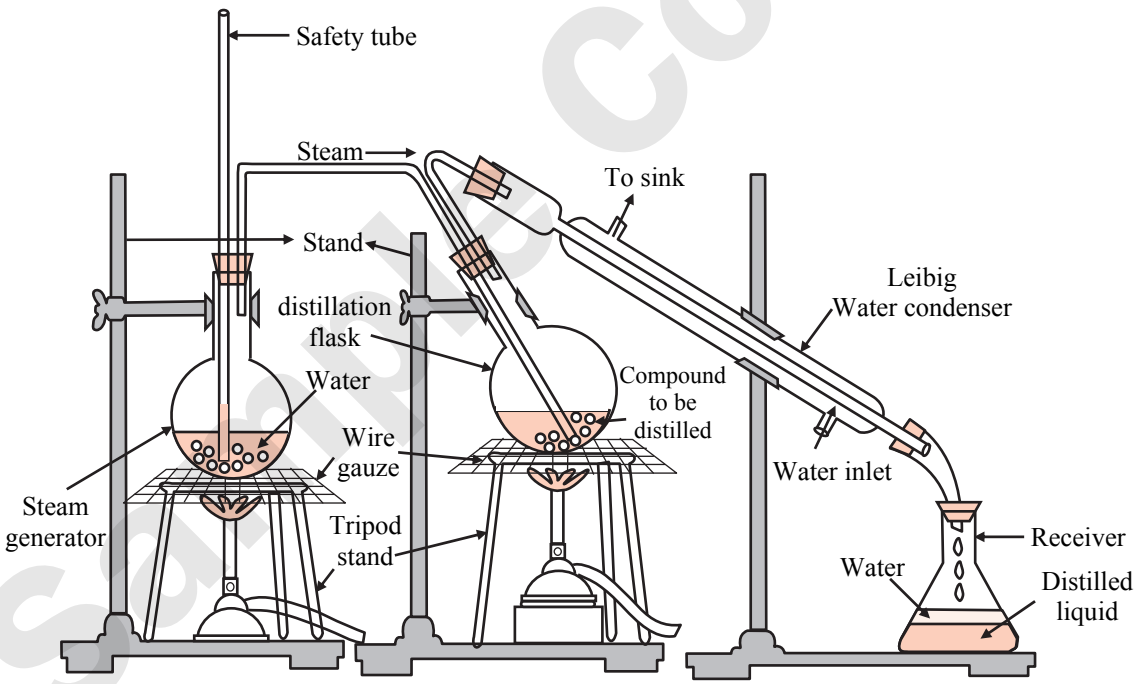
iii. The liquid boils when the sum of vapour pressures of the liquid (p_1) and water (p_2) becomes equal to the atmospheric pressure (p) i.e., when $p = p_1 + p_2$.

iv. The mixture of the steam and liquid is distilled out and the liquid is separated from the distillate by using a separating funnel.

v. Since the vapour pressure of the liquid (p_1) is less than the atmospheric pressure (p), the liquid vapourises at a temperature lower than its boiling point.

e.g. a. Aniline is separated from a mixture of aniline and water by the method of steam distillation.

b. p-Nitrophenol and o-nitrophenol are separated by steam distillation.



Steam distillation

3.4 SOLVENT EXTRACTION

***Q.32. Define: Solvent extraction**

Ans: ***Solvent extraction*** *is a method used to separate an organic compound present in an aqueous solution, by shaking it with a suitable organic solvent in which the compound is more soluble than water.*

***Q.33. Which properties of solvents are useful for solvent extraction?**

Ans:

i. Organic compound must be more soluble in the organic solvent, than in water.

ii. Solvent should be immiscible with water and be able to form two distinct layers.

Sample Content

Q.34. Write the principle of solvent extraction and explain the process with labelled diagram.

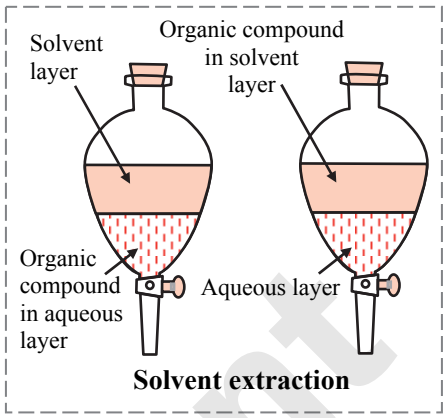
Ans: **Principle:** Extraction of compound takes place based on the difference in solubility of compound in two liquids.

i. In this process, the solute distributes itself between two immiscible liquids. From the aqueous phase the solute gets extracted in the organic phase.

ii. On shaking for a few times with small volumes of organic phase, most of the solute gets extracted into the organic phase.

iii. Then solute is then recovered from organic solvent either by evaporation of organic solvent or distillation.

iv. Diagram



Solvent extraction

Q.35. Write a short note on continuous extraction method.

Ans:

i. During solvent extraction, if the solute is found to be less soluble in organic phase, then continuous extraction method is employed.

ii. In this method, the same amount of organic solvent is used repeatedly for extraction.

iii. This ensures that the most of the solute gets extracted in the organic phase.

iv. This technique involves continuous distillation of the solvent within the same assembly. Hence, the use of large quantity of organic solvent is avoided.

Q.36. Internet my Friend *(Textbook page no. 31)*

Get more information about continuous extraction/Soxhlet extraction.

Ans: *Students are expected to refer 'Soxhlet extraction' on YouTube channel 'Royal Society of Chemistry'.*

Q.37. Match the following:

	Process		Used in the purification/separation of
i.	Crystallization	a.	Acetone and benzene
ii.	Simple distillation	b.	Benzoic acid and water
iii.	Fractional distillation	c.	Impure copper sulphate
iv.	Solvent extraction	d.	Acetone and water

Ans: i – c, ii – d, iii – a, iv – b

3.5 CHROMATOGRAPHIC TECHNIQUES

Q.38. What is chromatography? Explain the principle behind it.

Ans: ***Chromatography*** *is a technique used to separate components of a mixture, and also purify compounds.*

Principle: The principle of separation of substances in chromatography is based on the distribution of the solutes in two phases. i.e., stationary phase and mobile phase.

i. Chromatography uses two phases for separation.

ii. This technique is based on the difference in rates at which components in the mixture move through the stationary phase under the influence of the mobile phase.

iii. In this technique, first the mixture of components is loaded at one end of the stationary phase and then the mobile phase is allowed to move over the stationary phase. The mobile phase can be a pure solvent or a mixture of solvents.

iv. Depending on the relative affinity of the components toward the stationary phase and mobile phase, they remain on the surface of the stationary phase or move along with the mobile phase, and gradually get separated.

***Q.39. Define: Stationary phase**

Ans: ***Stationary phase*** *is a solid or a liquid supported on a solid which remains fixed in a place and on which different solutes are adsorbed to different extent.*

Sample Content

***Q.40. Name the different types of chromatographic techniques and explain the principles underlying them.**

Ans: Depending on the nature of the stationary phase i.e., whether it is a solid or a liquid, chromatography is classified into adsorption chromatography and partition chromatography.

i. Adsorption chromatography: This technique is based on the principle of differential adsorption. Different solutes are adsorbed on an adsorbent to different extent.

Adsorption chromatography is further classified into two types:

a. Column chromatography b. Thin-layer chromatography

ii. Partition chromatography: This technique is based on continuous differential partitioning of components of a mixture between stationary and mobile phases. For example, paper chromatography

***Q.41. Give names of two materials used as stationary phase in chromatography.**

Ans:

i. Alumina ii. Silica gel

Q.42. Give a brief description of column chromatography with an illustration.

Ans: Column chromatography involves the separation of components over a column of stationary phase. The stationary phase material can be alumina, silica gel.

Procedure:

i. A slurry of the stationary phase material is filled in a long glass tube provided with a stopcock at the bottom and a glass wool plug at the lower end.

ii. The mixture to be separated is dissolved in a suitable solvent and then it is loaded on top of adsorbent column.

iii. A suitable mobile phase which could be a single solvent or a mixture of solvents is then poured over the adsorbent column.

iv. The mixture along with the mobile phase slowly moves down the column.

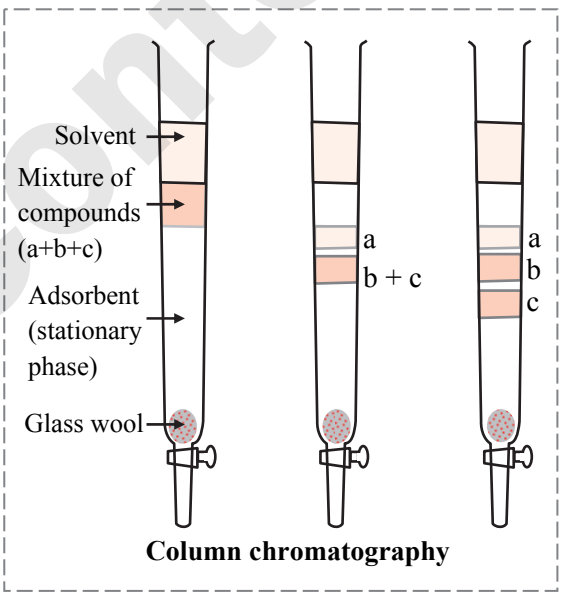
v. The solutes get adsorbed on the stationary phase and depending on the degree to which they are adsorbed, they get separated from each other.

vi. The component which is readily adsorbed are retained on the column and others move down the column to various distances forming distinct bands.

vii. The component which is less strongly adsorbed is desorbed first and leaves the column first, while the strongly adsorbed component is eluted later.

viii. The solutions of these components are collected separately.

ix. These different components can be recovered by evaporating the solvent.



Column chromatography

***Q.43. Why do we see bands separating in column chromatography?**

Ans:

i. In column chromatography, the solutes get adsorbed on the stationary phase and depending on the degree to which they are adsorbed, they get separated from each other.

ii. The component which is readily adsorbed are retained on the column and others move down the column to various distances forming distinct bands.

Hence, we see bands separating in column chromatography.

Q.44. How is TLC plate or chromplate prepared?

Ans: TLC plate or chromplate is prepared by applying a thin layer (0.2 mm thick) of adsorbent silica gel or alumina spread over a glass plate.

Q.45. Describe the process of thin layer chromatography (TLC) and separation of components in it.

Ans:

i. Process:

a. A thin layer (about 0.2 mm thick) of an adsorbent like silica gel or alumina is spread over a thin glass plate (called chromplate or TLC plate). This plate acts as a stationary phase.

b. With the help of a capillary tube, the solution of the mixture to be separated is spotted at above 2 cm (on base line) from one end of the TLC plate.

Sample Content

c. The TLC plate is then placed in a closed jar containing a suitable solvent (mobile phase or eluant).

d. As the mobile phase rises up the plate, the components of the mixture move up along with the mobile phase to different distances depending upon their degree of adsorption, thus resulting in complete separation.

ii. Separation of components:

a. If the components are coloured, they appear as separated coloured spots on the plate.

b. If the components are not coloured but have property of fluorescence, they can be visualised under UV light, or the plate can be kept in a chamber containing a few iodine crystals. The Iodine vapours are adsorbed by the components and the spots appear brown.

c. Amino acids are visualised by spraying the plate with a solution of ninhydrin. This is known as spraying agent.

ENRICH YOUR KNOWLEDGE

Thin layer chromatography (TLC)

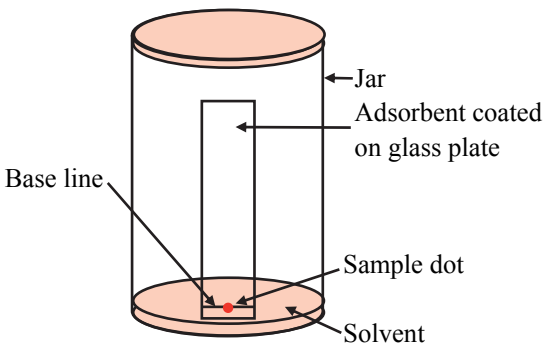


Fig. a

TLC setup

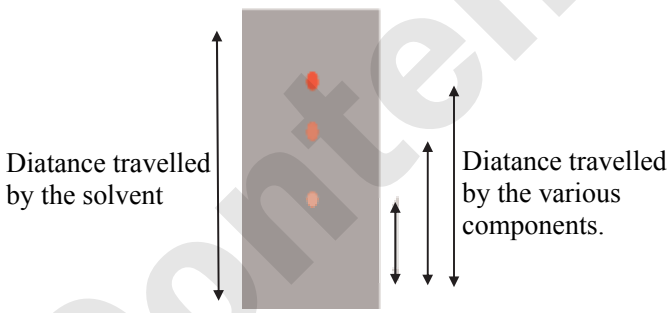


Fig. b

Developed chromatogram

***Q.46. Why should spotting of mixture be done above the level of mobile phase?**

Ans:

i. If spotting of a mixture is done at the level of mobile phase, then solvent will come in contact with the sample spot.

ii. Sample spot will dissolve in the mobile phase and its components will move all over the plate resulting in no distinct separation.

Hence, spotting of mixture should be done above the level of mobile phase.

Q.47. Name the physical state each of stationary phase and mobile phase in partition chromatography.

Ans: In partition chromatography, both stationary and mobile phases are in liquid state.

Q.48. State the principle of partition chromatography.

Ans: Partition chromatography is based on continuous differential partitioning of components of a mixture between stationary and mobile phases.

***Q.49. What is the stationary phase in paper chromatography?**

Ans: Paper chromatography is a type of partition chromatography in which a special quality paper, namely Whatman paper 1 is used. The water trapped in the fibres of the paper acts as stationary phase.

Q.50. Describe the process of paper chromatography.

Ans: Process of paper chromatography:

i. The mixture of the compound to be analysed is dissolved in a suitable solvent and spotted on the chromatography paper about 2 cm from one end of the paper using a glass capillary.

ii. The paper is then suspended in a chamber containing the mobile phase.

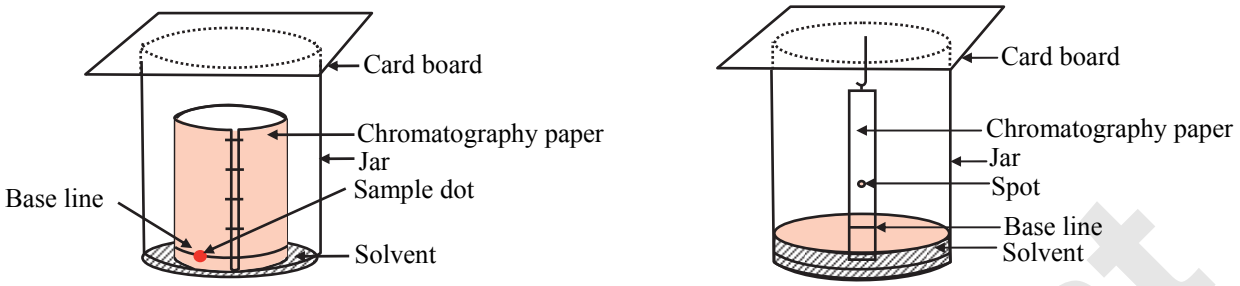
iii. The mobile phase rises up the paper and flows over the spot, due to capillary action.

iv. Different solutes are retained differently on the paper depending on their selective partitioning between the two phases. The paper strip so developed, is known as chromatogram.

Sample Content

ENRICH YOUR KNOWLEDGE

Paper chromatography:



Paper chromatography

***Q.51. How do you visualize colourless compounds after separation in TLC and paper chromatography?**

Ans:

i. **Thin-layer chromatography (TLC):** If components are colourless but have the property of fluorescence then they can be visualized under UV light, or the plate can be kept in a chamber containing a few iodine crystals. The iodine vapours are adsorbed by the components and the spots appear brown. Also, spraying agent like ninhydrin can also be used (for amino acids).

ii. **Paper Chromatography:** The spots of the separated colourless components may be observed either under ultra-violet light or by the use of an appropriate spraying agent.

Q.52. Name the following:

i. A glass plate coated with a thin layer of silica gel.

ii. A spraying agent used for the visualization of amino acids.

Ans:

i. Chromplate/TLC plate ii. Ninhydrin

***Q.53. Compare TLC and paper chromatography techniques.**

Ans:

Chromatography technique	TLC	Paper chromatography
Principle	It is based on the principle of differential adsorption. Different solutes are adsorbed on an adsorbent to different extent.	It is based on continuous differential partitioning of components of a mixture between stationary and mobile phases.
Stationary phase	Solid (adsorbent like silica gel or alumina over a glass plate)	Liquid (water trapped in the fibres of a paper)
Mobile phase	Liquid (single solvent/mixture of solvents)	Liquid (single solvent/mixture of solvents)
Visualization of components of a mixture	Similar to TLC the coloured components are visible as coloured spots and the colourless components are observed under UV light or using a spraying agent.	

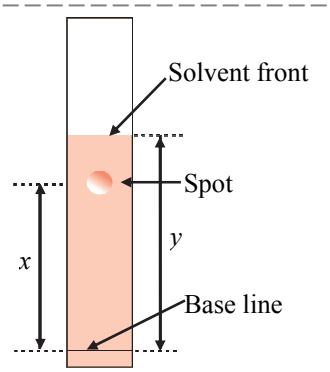
Q.54. Write a short note on R_f value.

Ans:

i. In chromatography, migration of the solute relative to the solvent front gives an idea about the relative retention of the solutes (or components of the mixture) on the stationary phase.

ii. The relative adsorption of solutes is expressed in terms of its R_f value. The symbol R_f stands for Retardation Factor.

$$\therefore \quad R_f = \frac{\text{Distance travelled by the solute from the base line}}{\text{Distance travelled by the solvent from the base line}}$$



Retention factor

Sample Content

Q.55. Internet my friend *(Textbook page no. 33)*

Column chromatography

Ans: *Students are expected to find relevant videos in YouTube on their own.*

***Q.56. Activity: Use any one analytical technique in laboratory and discuss it in groups.**

Ans: *Students are expected to select any one of the analytical techniques described in this chapter to discuss it in groups.*

APPLY YOUR KNOWLEDGE

Q.57. In a chemical laboratory, Priyal was asked to isolate an organic compound from its aqueous solution. She added ethyl acetate to the given sample, separated the organic layer and kept it for evaporation. At the end of her practical, Priyal found few crystals in the beaker which she kept for evaporation. Answer the following questions:

i. In the above passage, which method was used by Priyal for separation? State its principle.

ii. Why do you think the organic compound dissolved in ethyl acetate?

iii. Illustrate the method of separation used in the passage with an example.

Ans:

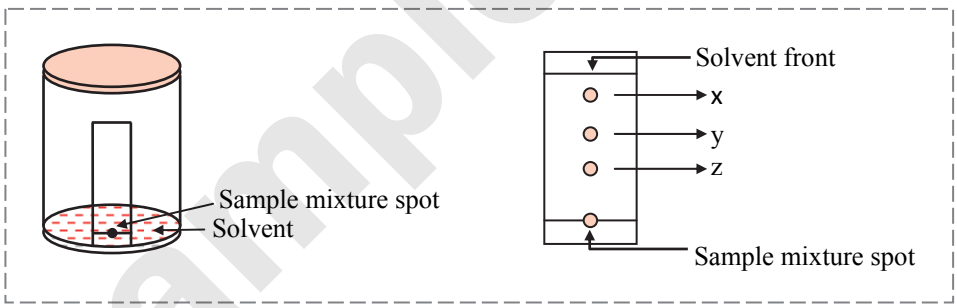
i. Method used: Solvent extraction method.

Refer Q.34. (Principle)

ii. An organic compound (non-polar) dissolves in organic solvents (non-polar) because of the dipole-dipole interactions in between them (like dissolves like). Water is a polar solvent and it is unlikely that the covalent constituents of the organic substance is strong enough to break the ionic bonds. Any substance dissolves in other because it is able to break the bonds between the solvent molecules and form weak bonds with the solvent molecules. Hence, the organic compound will be more soluble in ethyl acetate as compared to water and this helps in its isolation from aqueous solution.

iii. An example for the separation of organic compound using solvents extraction method is: Benzoic acid in water can be extracted from its aqueous solution by using benzene.

Q.58.



Based on the above diagram, answer the following questions:

i. Name the chromatographic technique involved.

ii. From the developed chromatogram, state which has the highest and which has the lowest R_f value?

iii. Based on the TLC, which component would elute out at the end of a column chromatography?

iv. Mention two applications of TLC method.

Ans:

i. Thin layer chromatography

ii. Based on the developed chromatogram, spot 'x' has the highest R_f value while spot 'z' the lowest R_f value.

iii. Based on the TLC, spot 'z' being strongly adsorbed will elute at the end of a column chromatography.

iv. Applications of TLC are:

a. Separation of plant pigments from its mixture.

b. Separation of impurities from a given organic compound.

c. Separation of different amino acid.

Sample Content

QUICK REVIEW

Methods of purifications

Crystallization
Used in purification of solid from impure sample
e.g. Common salt, copper sulphate, benzoic acid

Fractional crystallization
Used for separating the components of a mixture of two or more solids, having different solubilities in the same solvent at the same temperature.

Simple distillation
Used in separation of two liquids having large difference in boiling points
e.g. A mixture of acetone (b.p. 56°C) and water (b.p. 100°C)

Fractional distillation
Used in separation of two liquids having no appreciable difference in boiling points
e.g. A mixture of acetone (b.p. 329 K) and benzene (b.p. 353 K).
A mixture of acetone (b.p. 329 K) and methyl alcohol (b.p.337.7 K).

Distillation under reduced pressure
Used to separate the liquids having very high boiling point or the liquids which decompose on heating.
e.g. Glycerol from soap

Solvent extraction
Used to separate a given organic compound present in aqueous solution
e.g. Benzoic acid from water

Adsorption chromatography
- **Column chromatography** involves separation of a mixture over a column of adsorbent.
- **Thin-layer chromatography** involves separation of a mixture using a glass plate coated with thin layer of the adsorbent.

Partition chromatography
- **Paper chromatography** involves use of special quality paper containing water trapped in it as stationary phase.

IMPORTANT FORMULAE

$$R_f \text{ value} = \frac{\text{Distance travelled by the substance or solute}}{\text{Distance travelled by the solvent}}$$

EXERCISE

3.2 Purification of solids

1. What are the different types of impurities that a solid may contain?

Ans: *Refer Q.2.*

2. Explain the process of filtration.

Ans: *Refer Q.4.*

3. Explain the process of filtration under suction.

Ans: *Refer Q.6.*

4. Describe how impure solid can be purified by crystallization.

Ans: *Refer Q.12.*

5. What are the criteria for the selection of solvent for the process of crystallization?

Ans: *Refer Q.13.*

6. Name any two solvents used in the crystallization process.

Ans: *Refer Q.14.*

Sample Content

7. State and explain the method of purification you will employ for a sample of impure salt.
Ans: *Refer Q.15.*

8. Define fractional crystallization.
Ans: *Refer Q.18.*

9. Write a short note on fractional crystallization.
Ans: *Refer Q.19.*

3.3 Distillation

10. Explain the process of simple distillation in your words.
Ans: *Refer Q.22*

11. Describe fractional distillation of acetone (b.p. 329 K) and methyl alcohol (b.p. 337.7K).
Ans: *Refer Q.27.*

12. Explain fractional distillation of acetone (b.p. 329 K) and benzene (b.p. 353K).
Ans: *Refer Q.27.*

3.4 Solvent extraction

13. State the principle behind solvent extraction process.
Ans: *Refer Q.34. (Principle)*

14. Give reason: use of large quantity of solvent is avoided in continuous extraction method.
Ans: *Refer Q.35.*

R 3.5 Chromatographic techniques

15. Explain the mechanism of chromatographic separation.
Ans: *Refer Q.38.*

16. State the principle behind partition chromatography.
Ans: *Refer Q.48.*

17. Write formula for calculating the R_f value.
Ans: *Refer Q.54. (ii)*

MULTIPLE CHOICE QUESTIONS

1. If a crude solid is made of mainly one substance and has some impurities then it is purified by _____.
(A) crystallization (B) distillation
(C) extraction (D) sublimation

2. Impure common salt can be purified by _____.
(A) crystallization (B) distillation
(C) extraction (D) sublimation

*3. Which of the following methods can be used to separate two compounds with different solubilities in the same solvent?
(A) Fractional crystallization
(B) Crystallization
(C) Distillation
(D) Solvent extraction

4. Which of the following solvents is most commonly used for the crystallization of copper sulphate?
(A) Water (B) Acetone
(C) Ether (D) Methanol

5. In distillation of liquid, water condenser is used _____.
(A) to boil the liquid
(B) to collect the liquid
(C) to condense hot vapours of the liquid
(D) to adsorb the liquid

*6. A mixture of acetone and benzene can be separated by the following method _____.
(A) simple distillation
(B) fractional distillation
(C) distillation under reduced pressure
(D) sublimation

7. Separation of binary mixture of acetone and methyl alcohol is done by _____.
(A) simple distillation
(B) fractional distillation
(C) fractional crystallization
(D) re-crystallization

8. Which of the following method is used to separate different fractions of crude oil?
(A) Solvent extraction
(B) Simple distillation
(C) Fractional distillation
(D) TLC

*9. Which of the following techniques is used for separation of glycerol from soap in soap industry?
(A) Distillation under reduced pressure
(B) Fractional distillation
(C) Filtration
(D) Crystallization

10. The method used to separate a given organic compound present in aqueous solution by shaking with a suitable solvent in which the compound is more soluble than water is called _____.
(A) simple distillation
(B) fractional distillation
(C) solvent extraction
(D) crystallization

*11. R Which technique is widely used in industry to separate components of mixture and also to purify them?
(A) Steam distillation (B) Chromatography
(C) Solvent extraction (D) Filtration

R 12. Adsorption chromatography is a chromatographic technique based on the principle of _____.
(A) differential adsorption
(B) differential solubility
(C) differential extraction
(D) all of these

Sample Content

R 13. The stationary phase and mobile phase in TLC are _____ respectively.
(A) solid and liquid (B) solid and gas
(C) liquid and solid (D) liquid and liquid

R 14. Which of the following is most commonly used for the visualization of amino acids in chromatography?
(A) Ultraviolet light (B) Spraying agent
(C) Sunlight (D) X-rays

R 15. The stationary phase and mobile phase in partition chromatography are _____ respectively.
(A) solid and liquid (B) solid and gas
(C) liquid and solid (D) liquid and liquid

*16. Colourless components on chromatogram R CANNOT be observed by which of the following?
(A) Using UV light
(B) Using iodine chamber
(C) Using the spraying reagent
(D) Using infrared light

R 17. Paper chromatography is based on the principle of _____.
(A) adsorption (B) partition
(C) solubility (D) volatility

R 18. In paper chromatography, the mobile phase rises up the chromatography paper due to _____.
(A) evaporation of volatile solvent
(B) capillary action
(C) gravitational force
(D) differential adsorption

R 19. Which of the following is a type of partition chromatography?
(A) Column chromatography
(B) Thin layer chromatography
(C) Paper chromatography
(D) Both (B) and (C)

R 20. The principle of differential adsorption is applicable for which of the following chromatographic technique?
(A) Column chromatography
(B) Thin layer chromatography
(C) Paper chromatography
(D) Both (A) and (B)

R 21. Which of the following method will give clean separation of sample of chloroform (organic liquid) and water in short time span?
(A) TLC
(B) Distillation under reduced pressure
(C) Solvent extraction
(D) Simple distillation

ANSWERS TO MULTIPLE CHOICE QUESTIONS

1.	(A)	2.	(A)	3.	(A)	4.	(A)
5.	(C)	6.	(B)	7.	(B)	8.	(C)
9.	(A)	10.	(C)	11.	(B)	12.	(A)
13.	(A)	14.	(B)	15.	(D)	16.	(D)
17.	(B)	18.	(B)	19.	(C)	20.	(D)
21.	(C)						

COMPETITIVE CORNER

1. Which of the following statements is NOT TRUE about partition chromatography? **[JEE (Main) 2017]**
(A) Mobile phase can be a gas.
(B) Stationary phase is a finely divided solid adsorbent.
(C) Separation depends upon equilibration of solute between a mobile and a stationary phase.
(D) Paper chromatography is an example of partition chromatography.

2. Paper chromatography is an example of _____. **[NEET (UG) P-I 2020]**
(A) partition chromatography (B) thin layer chromatography
(C) column chromatography (D) adsorption chromatography

Time: 1 Hour 30 Min | **TOPIC TEST** | **Total Marks: 25**

SECTION A

Q.1. Select and write the correct answer: **[04]**

i. _____ is used to separate two compounds with different solubilities in the same solvent.
(A) Solvent extraction (B) Crystallization
(C) Distillation (D) Fractional crystallization

R ii. In TLC, the stationary phase and mobile phase are _____ respectively.
(A) solid and liquid (B) liquid and solid (C) solid and gas (D) liquid and liquid

iii. Which of the following method is used to separate different fractions of crude oil?
(A) Solvent extraction (B) Simple distillation
(C) Fractional distillation (D) TLC

R iv. Paper chromatography is based on the principle of _____.
(A) adsorption (B) partition (C) solubility (D) volatility

Sample Content

Q.2. Answer the following: **[03]**

i. Why is a condenser used in distillation process?

R ii. Give names of two materials used as stationary phase in chromatography.

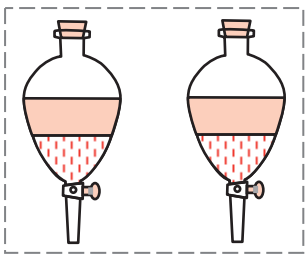
iii. Define: Solvent extraction

SECTION B

Attempt any Four: **[08]**

Q.3. Mention the steps involved in the process of crystallization.

Q.4. Label the following diagram.



R Q.5. Describe the process of paper chromatography.

Q.6. Differentiate between simple distillation and fractional distillation.

R Q.7. Why do we see bands separating in column chromatography?

Q.8. What are the different types of impurities that a solid may contain?

SECTION C

Attempt any Two: **[06]**

R Q.9. i. Why should spotting of mixture be done above the level of mobile phase?
ii. State the principle of partition chromatography.

Q.10. i. Write a short note on continuous extraction method.
ii. Define: Distillation

Q.11. Describe the process of filtration under suction with a neat and labelled diagram.

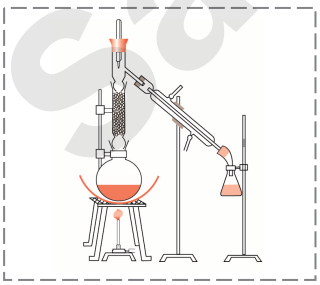
SECTION D

Attempt any One: **[04]**

Q.12. i. What will happen if the upper outlet of the condenser is connected to the tap instead of the lower outlet?

R ii. Name the following:
a. A chromatographic technique in which both stationary and mobile phases are in liquid state.
b. A spraying agent used for the visualization of amino acids.

Q.13. Label the following diagram and explain the process by giving example.



Download the answers of the Topic Test by scanning the given ***Q.R. Code.***

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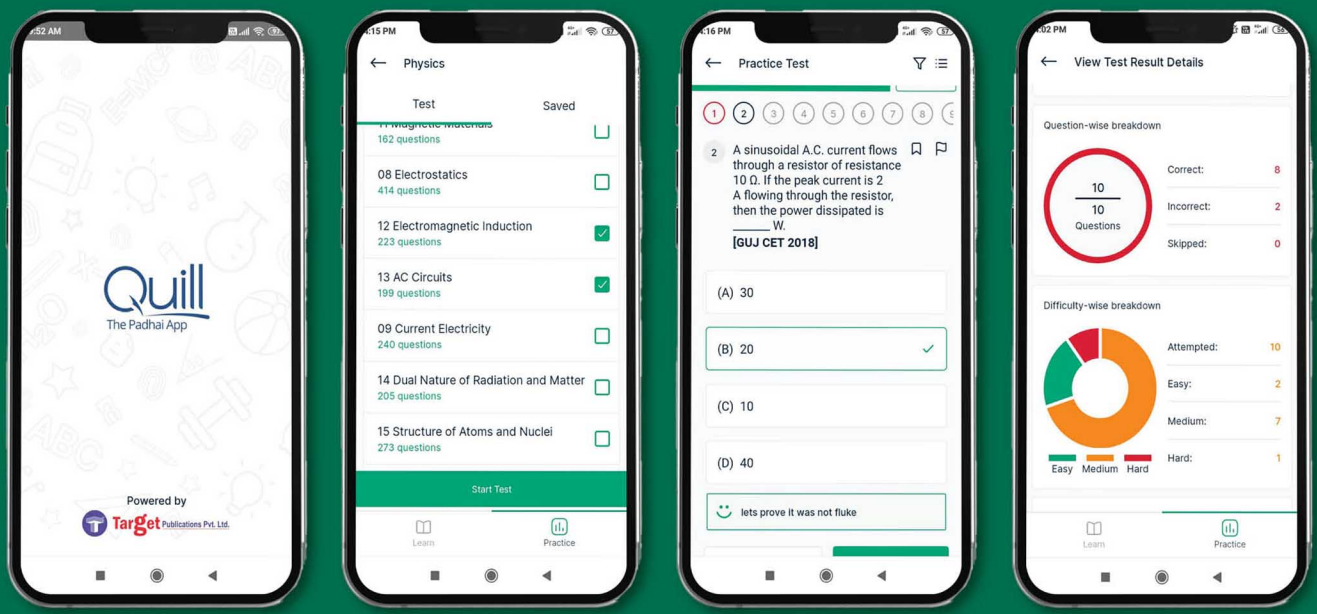

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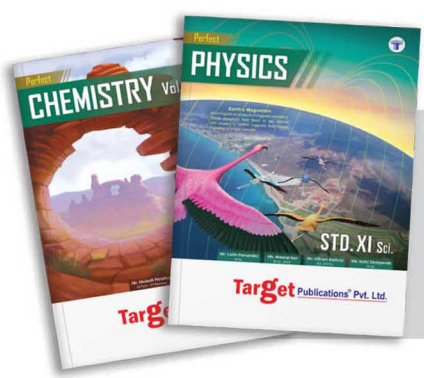

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