TOPIC 1.2: SEPARATION TECHNIQUES

THE ABOUT

CHAPTER ANALYSIS

TIME

- Relatively straight forward chapter
- 2 **key** concepts
- 4 **advanced** concepts

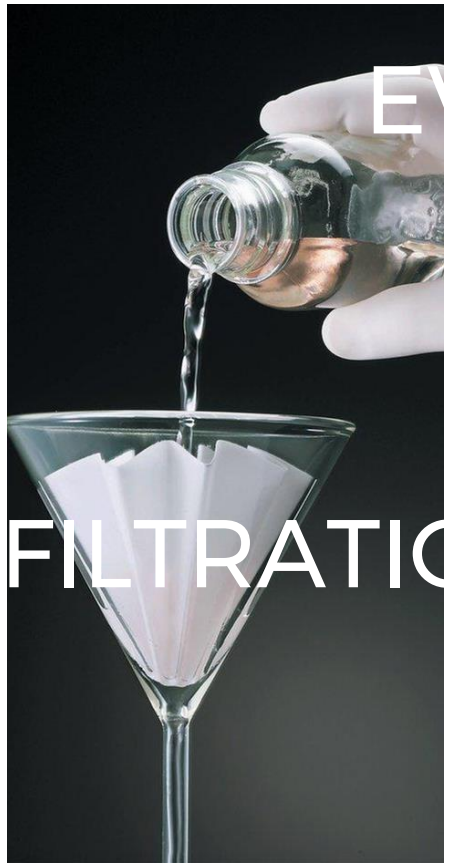
EXAM

- Usually tested in MCQs
  - 2009 (3), 2012 (1), 2013 (2), 2014 (2), 2015 (1)
- Tested as add-on to other chapters
  - Salts, Fuels & Crude Oil

WEIGHTAGE

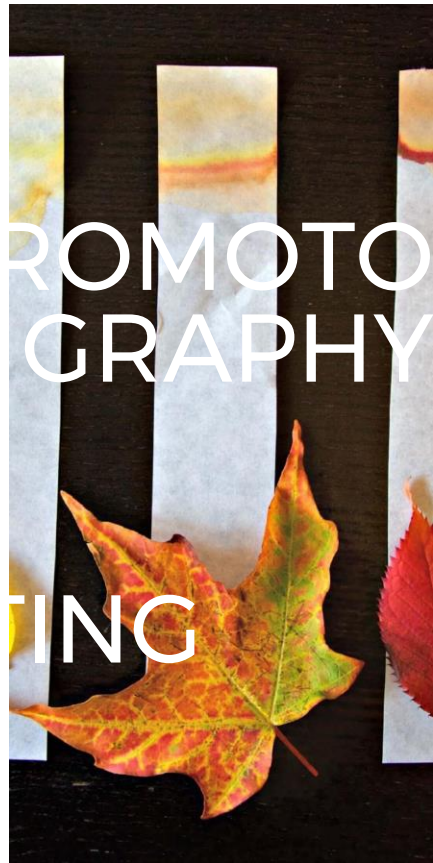
- Light overall weightage
- Constitute to **0.5%** of marks for past 5 year papers

9 DIFFERENT SEPARATION TECHNIQUES



DIFFERENT SEPARATION TECHNIQUES

9 IN TOTAL



MUST KNOW

PURE SUBSTANCE VS IMPURE MIXTURE

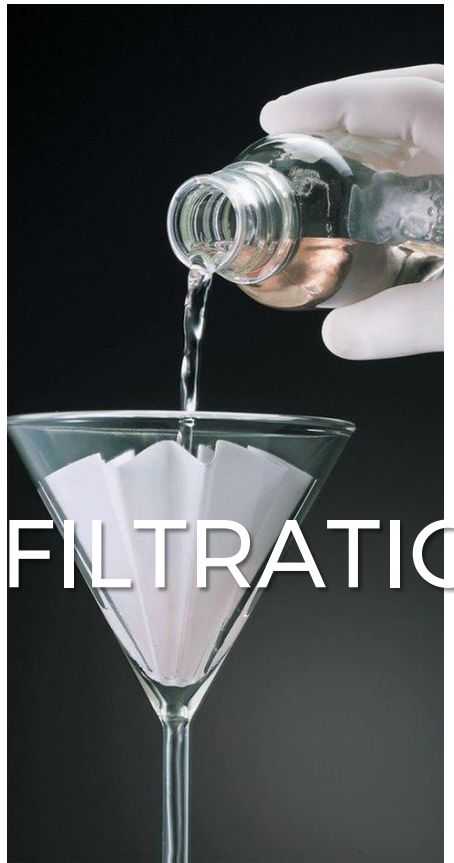
	Pure Substance	Impure Mixture
Definition	**Only one** type of substance	**Two or more** substances
Physical properties	**Fixed** proportion	Any ratio
	Fixed M.P. & B.P.	Have a **range of M.P. & B.P.**
	Single spot on chromatogram	Multiple spots on a chromatogram

MUST KNOW

COMPOUND VS MIXTURE

	Compound	**Mixture**
Formation	**Chemically** combined	**Physically** combined
Separation technique	Can be separated using chemical methods (Decomposition, electrolysis, reduction with carbon)	Can be separated using physical methods (**separation techniques**)
Composition	**Fixed** ratio	Any ratio
m.p/b.p	**Fixed** mp & bp	Have a **range of M.P. & B.P.**

Let’s get over the 3 simpler ones first



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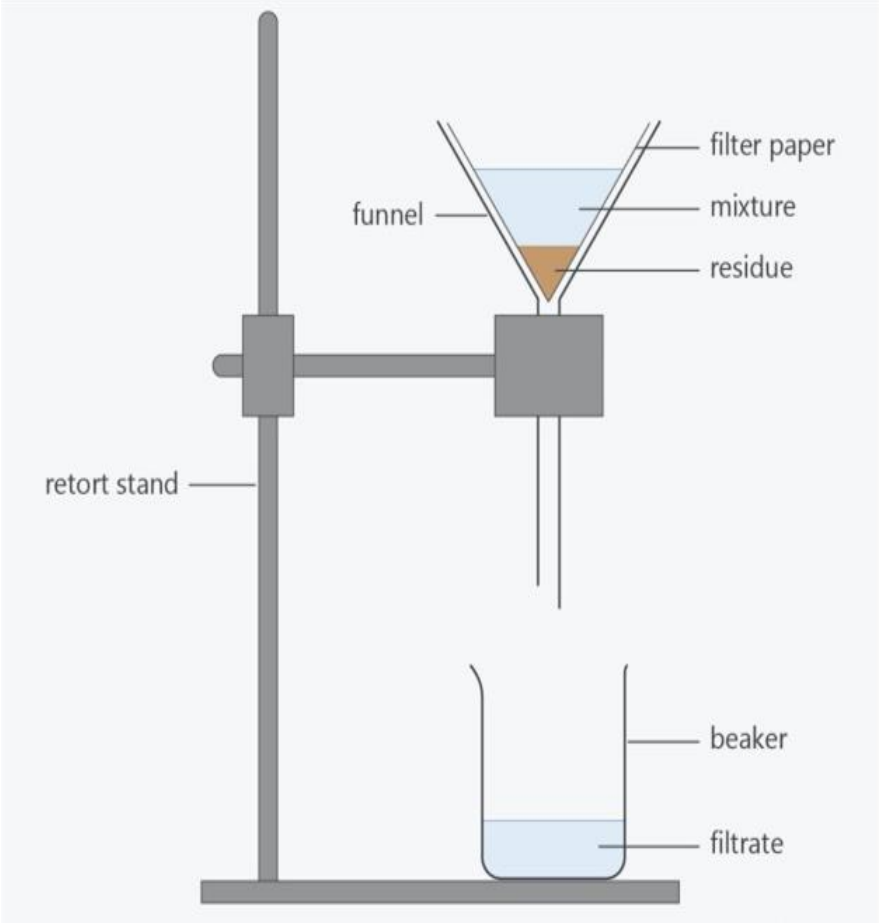
FILTRATION



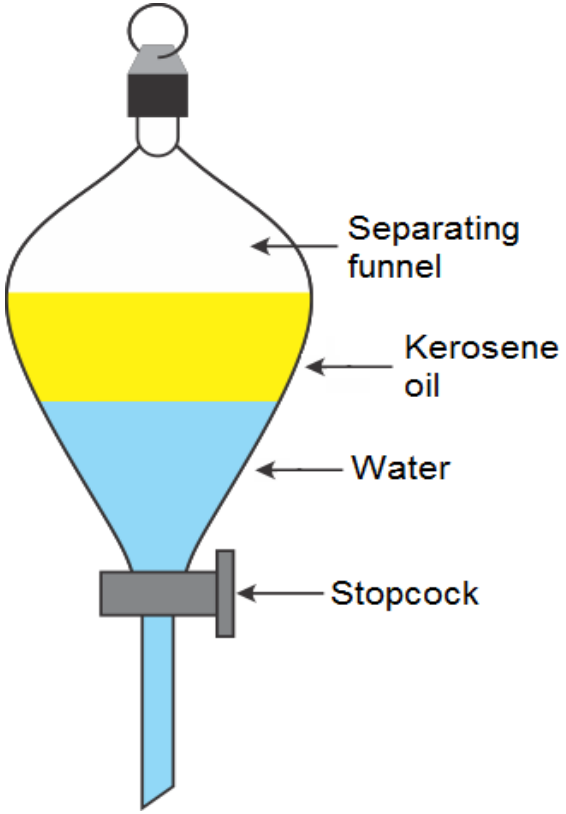
1) Put a filter paper onto the filter funnel.

2) Pour the mixture into the filter funnel.

3) The **residue** will remain in the filter funnel while the **filtrate** will be collected in the beaker.

MUST KNOW

SEPARATING FUNNEL (IMMISCIBLE LIQUIDS)



1) Oil and water are **immiscible** (do not dissolve with each other).

2) Oil which is **less dense** than water will float on top of water.

3) Open the tap and collect the water in a beaker.

4) Drain out the leftover water and some of the oil and throw the impure mixture away.

5) Collect the remaining oil in a separate beaker.

MUST KNOW

MAGNETIC SEPARATION

Magnetic Materials

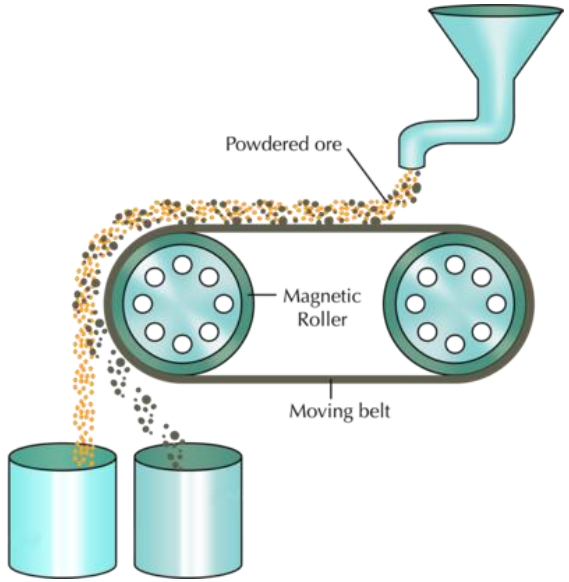
Nickel

I ron

C obalt

S teel

Magnetic separation is used to separate magnetic material from a mixture with other non-magnetic materials. (Scrapeyard)



St' Nics girls are pretty right? Know a Nicholas that is handsome? Are you attracted? That's right, magnetic material.

KEY CONCEPT

Many students are confused when it comes to these 2 separation techniques:

How **exactly are they different and in which scenarios** do we use them?

TWO METHODS
EVAPORATION TO DRYNESS
CRYSTALLISATION

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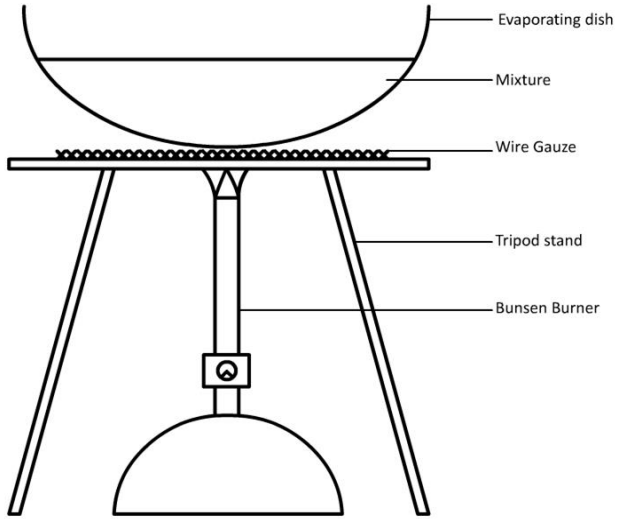
EVAPORATION TO DRYNESS



For this method, the solution is heated until all the **water is evaporated** completely, **leaving behind only the solid.**

However, a **limitation** to this method is that it **cannot be used for solids that decompose on heating**.

For example, sugar decomposes upon heating, salt however does not.

*A saturated solution contains the maximum amount of solute that can be dissolved in the solvent at a particular temperature.

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CRYSTALLISATION

Crystallisation is different from evaporation to dryness.

The aim of crystallisation aim is not to evaporate ALL of the water, but rather it focuses on heating it till saturation. After which, it is left to cool in order to obtain the crystals.

This **is used for crystals that decompose upon heating to be collected.** (ie: sugar)

Steps:

1) Heat the solution till saturation.
2) Allow the saturated solution to cool and pure solid crystals will form slowly.
3) Filter to collect the crystals.
4) Wash the crystals with cold distilled water and dry between sheets of filter paper.

Ultimately, what it boils down to the nature of the salt.

The critical question to ask is:

Will the solute **decompose under heating**?

If yes, use crystallisation.

If not, use evaporation to dryness.

Example:
Sugar decomposes under heat, crystallisation is the correct choice.
Salt has high melting & boiling point, evaporation to dryness will get the job done.

EVAPORATION TO DRYNESS VS CRYSTALLISATION

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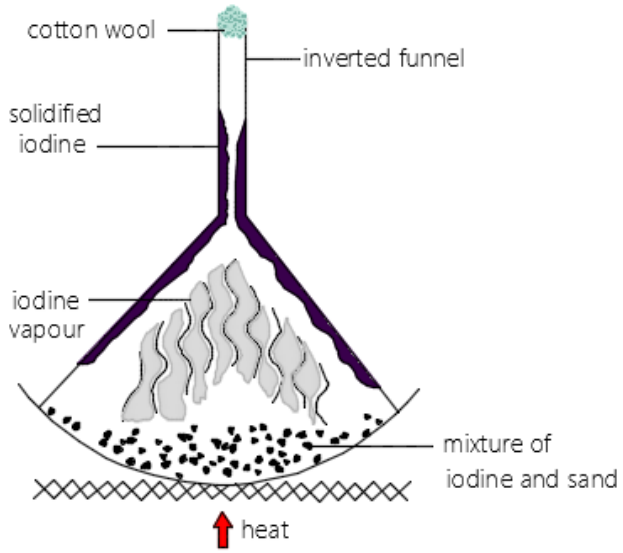
SUBLIMATION



1) Heat the mixture (iodine+ sand) and the volatile compound (iodine) will start to sublime (solid to gas).

2) Place a cool funnel over the evaporating dish. The gaseous iodine will condense on the cool funnel and form pure iodine in solid state.

3) Collect the iodine crystals.

When do we do simple distillation and when do we do fractional distillation?

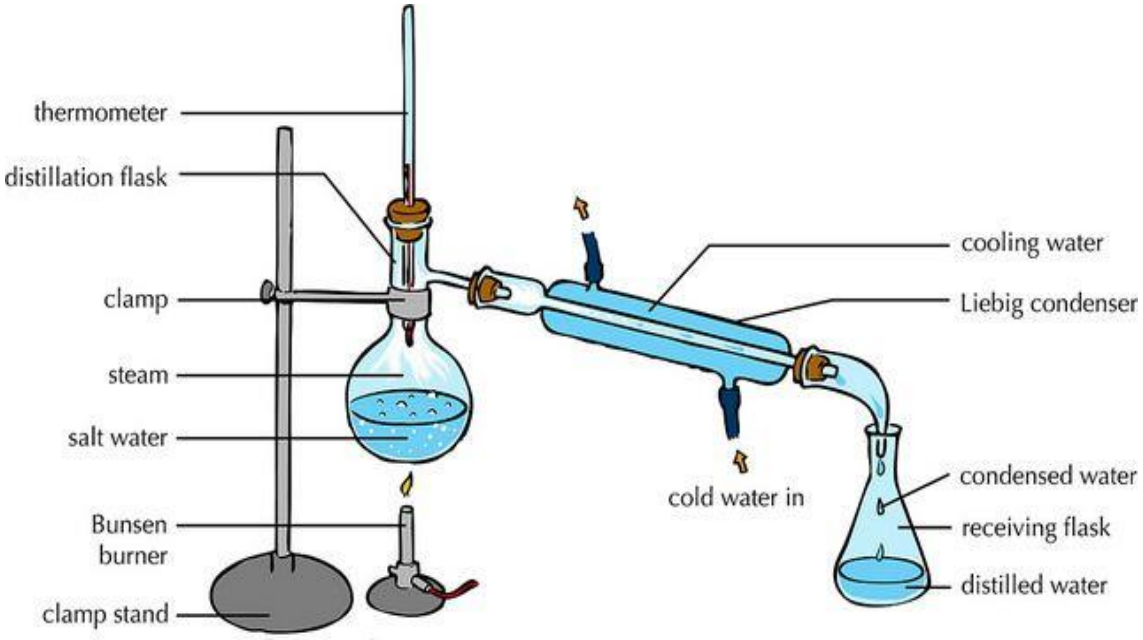
Is one method better than the other?

KEY CONCEPT

FATHER & SON
SIMPLE DISTILLATION &
FRACTIONAL DISTILLATION

KEY CONCEPT

SIMPLE DISTILLATION



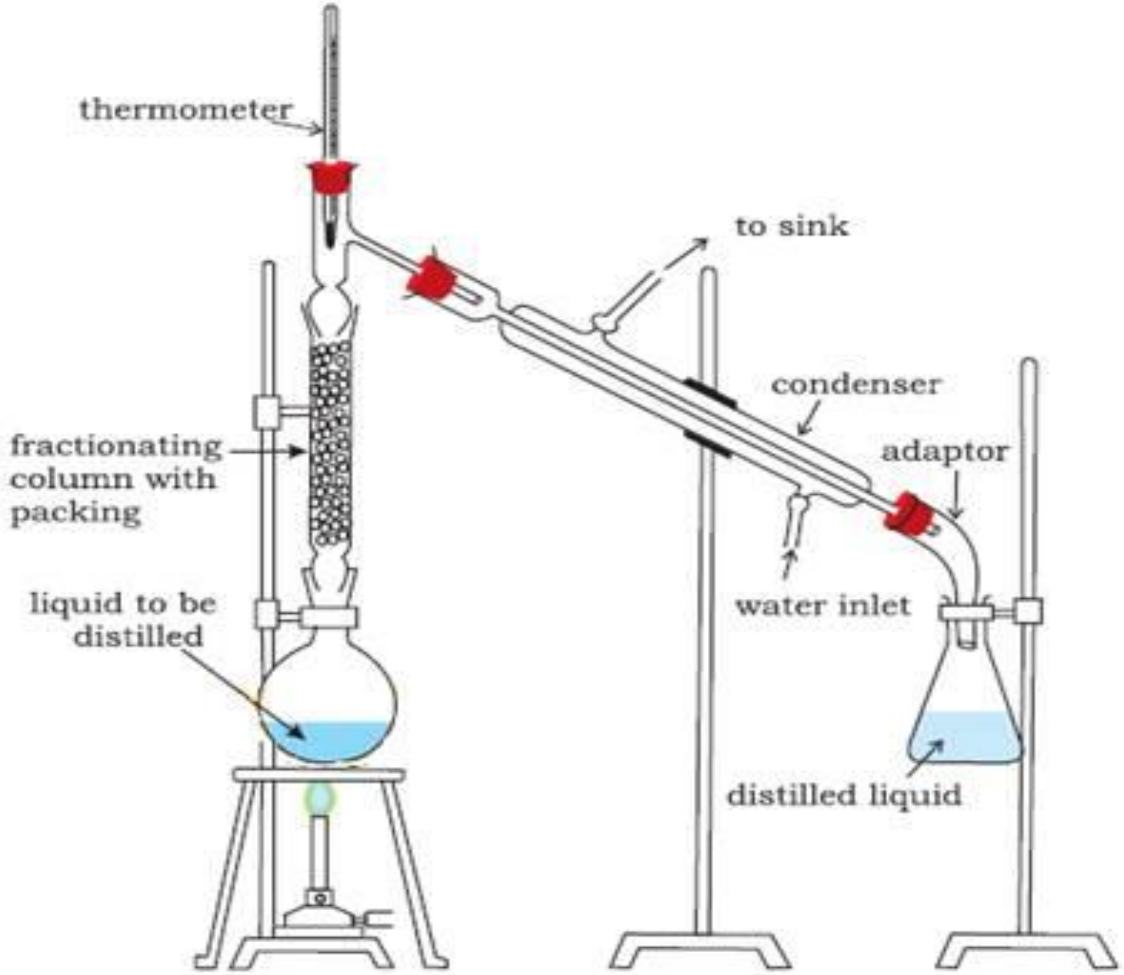
1) Heat the solution in a round-bottomed flask for even heat distribution. Boiling chips are added to prevent vigorous movement of liquid which ensure smooth boiling.

2) The water boils and water vapour rises and enters the condenser. The water vapour cools down in the condenser and is collected as a distillate.

3) The **distillate** is collected in a conical flask to prevent spillage.

KEY CONCEPT

FRACTIONAL DISTILLATION



1) Heat the mixture. The liquid with the lowest boiling point will be the first to be vaporised.

2) Its vapour will rise up to the top of the fractionating column, cooled as it passes through the condenser and be collected as the distillate. Ensure the temperature remains the same until all of first vapour has condensed.

3) Collect the distillate in the conical flask.

4) Repeat the process and collect the different substances that were in the mixture.

ADVANCED

things to note

Understanding the science behind fractional distillation

Difference in boiling points

The rationale behind fractional distillation is the miscible liquids in the solution having a minimum of **at least 10°C** difference in boiling point.

By boiling the liquids at their respective boiling point, it allows us to separate them.

Purpose of fractionating column

A fractionating column contains a large number of glass beads, creating **a larger surface area for condensation of vapours** for substances that have yet to reach their boiling point. This would only allow the intended vapour to escape.

Purpose of thermometer

The thermometer is placed at the tip of the fractionating column, right before the gas enters the condenser.

By doing so, we can **monitor the temperature of the gas that is escaping** accurately, allowing us to adjust the intensity of the heat accordingly.

KEY CONCEPT

FATHER & SON
SIMPLE DISTILLATION &
FRACTIONAL DISTILLATION

So in which situations is simple distillation used and which situations do we use fractional distillation?

*Key concept from Fuel and Crude Oil chapter in Organic Chemistry.

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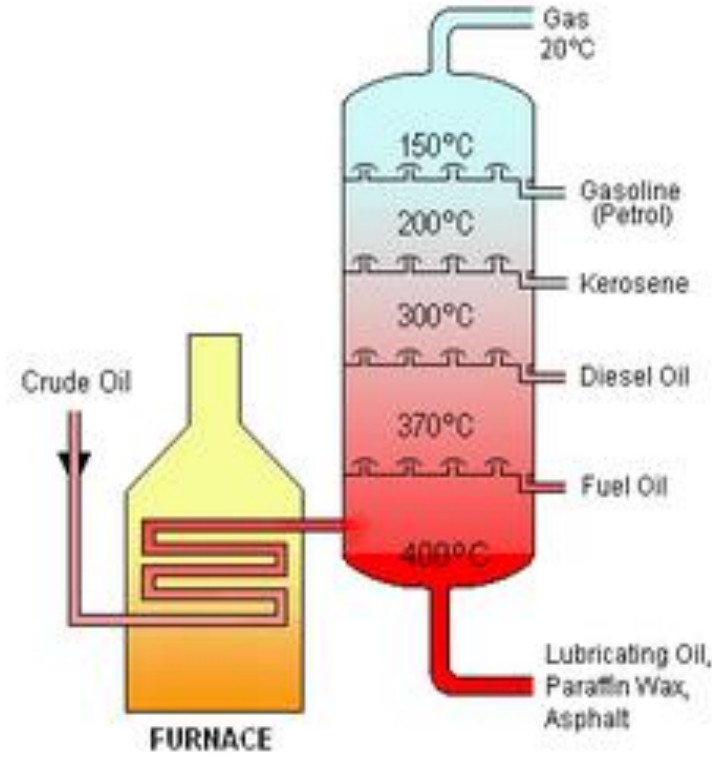
APPLICATION: OIL REFINERY



See you again soon!

MUST KNOW

CHROMATOGRAPHY

Chromatography is used to separate and identify miscible solutes that are dissolved together. (Food substances, dye etc...)

The different components can be identified by comparing their **Rf values (retention factor).**

The Rf value is the ratio of the distance travelled by the substance to the distance travelled by the solvent.

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

Chromatography works under this principle: **the rate at which a particular solute moves relative to the solvent is fixed.**

Given that the R_f value for a specific substance is constant if using the same solvent, substances in the solution can be identified by comparing their R_f values with known values.
(Oo, forensic scientist in the making.)

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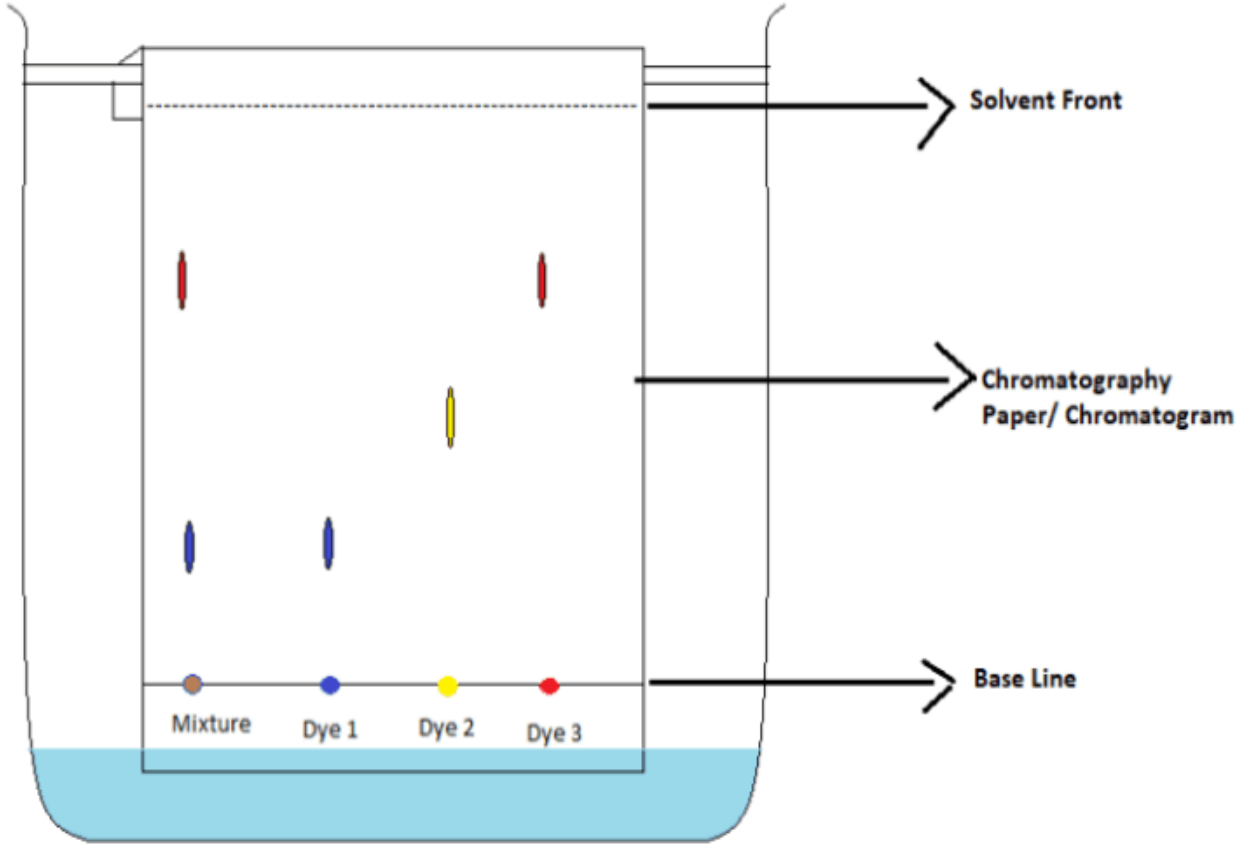
CHROMATOGRAPHY



CHROMATOGRAPHY

Factors affecting the ***differences in R_f values***

- **Solubility of the substances** in the solvent used (The more soluble it is, the easier it is for the substance to travel further and faster.)

- **Molecular masses** of the substances (The lower the molecular mass, the faster a substance travels. Refer to periodic table!)

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things to note

Chromatography is a method used to separate and identify small amounts of solutes that are dissolved in solvents.

Substance solubility in solvent

A **substance's solubility in a particular solvent** is commonly the main reason which results in **differing R_f values**.

Locating Agent

For colourless substances, a **locating agent** is required **to make the colourless solution visible.**

Knowing the names of specific locating agents is not needed. Yay!

Precaution

Starting line should be drawn with pencil instead of ink as the **ink may dissolve in the solute,** causing the results to be inaccurate. Commonly tested!

Try it yourself! (TYS Question)

9. A liquid mixture contains a hydrocarbon and water. The boiling points and densities of the hydrocarbon and of water are shown in the table.

	boiling point/°C	density in g / cm^3
hydrocarbon	130	0.8
water	100	1.0

Which statements about this liquid mixture can be deduced? (N2020/P1/Q31)

1 The hydrocarbon will form a layer below the water layer.
2 The hydrocarbon is methane.
3 The mixture can be separated using a separating funnel.

A 1, 2 and 3 **B** 1 and 2 only
C 1 and 3 only **D** 3 only ( )

Answer:

D
Statement 1: The hydrocarbon will form a layer above the water layer as it is less dense than water.
Statement 2: Methane is a gas at room temperature and pressure.
Statement 3: A separating funnel can be used to separate the two immiscible liquids.

Try it yourself! (TYS Question)

8. A colourless substance is made in an experiment.
Which are possible methods to determine if this substance is pure? (N2020/P1/Q4)

1 Measure the melting point of the substance and compare with the reference value.
2 Measure the boiling point of the substance and compare with the reference value.
3 Test the substance using paper chromatography and a locating agent.

A 1, 2 and 3 **B** 1 and 2 only
C 2 and 3 only **D** 2 only ( )

Answer:

8. **A**
The purity of a substance can be determined using the melting point of a solid, boiling point of a liquid and paper chromatography.

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