



Separation Techniques

Ways to separate mixtures

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Why We Need Separation Techniques?

- Deal with the separation of mixtures to **enhance purity** of substances
- Are important because most substances are **needed in their pure state**.

Criteria of Purity

A pure solid has a sharp and constant **melting point**.

A pure liquid

QUESTION: How do impurities affect the melting/boiling point?



Methods Based on Physical Properties

- Substances in a mixture are **physically combined**, so processes based on **differences in physical properties** are used to separate component.
- Particles size
- Solubility
 - Insoluble/soluble
 - Degree of solubility
- Density
- Magnetic (iron) vs. non-magnetic
- Sublimation (solid → gas)



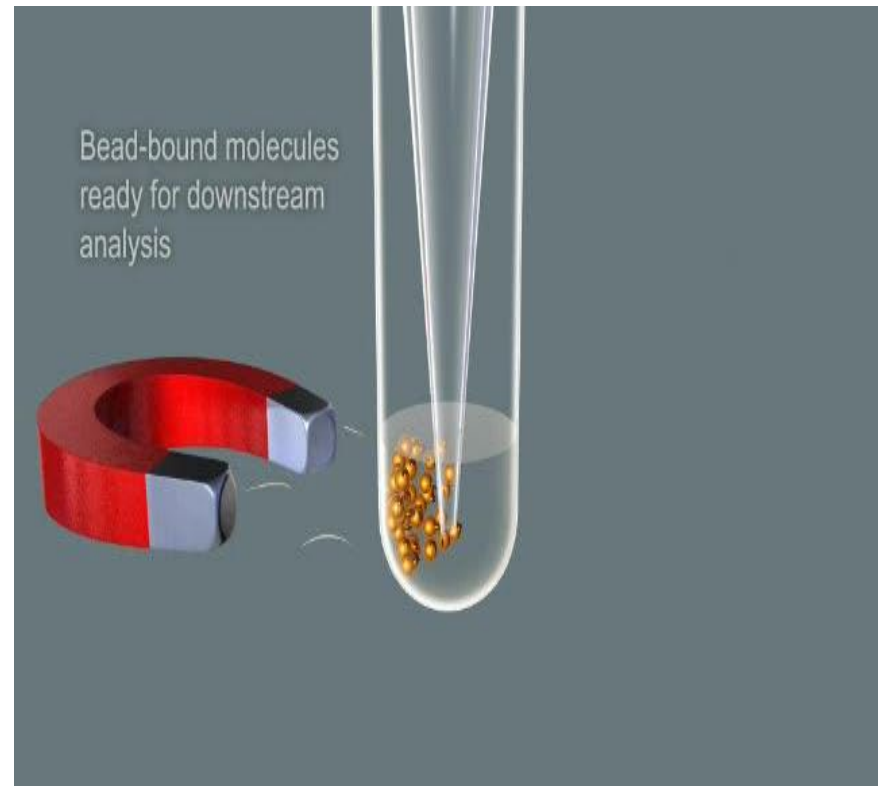
Techniques of Separating Mixtures

- Numerous techniques have been developed to separate mixtures to study components
 - **MAGNETISM**
 - Decantation
 - Evaporation
 - **SUBLIMATION**
 - Filtration
 - Centrifugation
 - Extraction
 - Distillation
 - Crystallization
 - Adsorption
 - Chromatography



MAGNETISM

- A magnet can be used to separate a magnetic substance from a non-magnetic substance.
- A magnetically susceptible material is extracted from a mixture using a magnetic force.





DECANTATION

- It is simply to pour off of upper liquid layer
- Used to separate a liquid from an insoluble solid. The solid stays in the bottom.





EVAPORATION

- Evaporation to dryness is used to separate a dissolved solid from a liquid. The dissolved solid must be heat-stable.
- In this method, the mixture is heated.

When the mixture has completely evaporated, no water is left behind.

The solid salt left behind
as the residue.





Evaporation of sea water to produce salt





SUBLIMATION

(Separating a solid that sublimes on heating)

- Sublimation is the process whereby the substances changes from the solid that sublimes upon heating from another substance with a high melting point.
- The mixture is placed in an evaporating dish. An inverted funnel is placed over the mixture. On gentle heating, the salt sublimes and deposited on cold filter funnel.
- This method has limited uses because very few solids will sublime on heating. For e.g. ammonium salts, iodine, dry ice (CO_2)

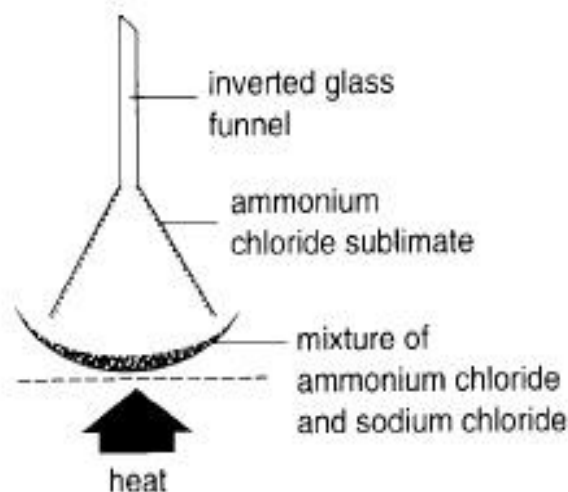
Separating a mixture of solids

(2) Sublimation

used when one of the solid sublimes

Eg.

- mixture of iodine + copper;
- mixture of ammonium chloride + sodium chloride



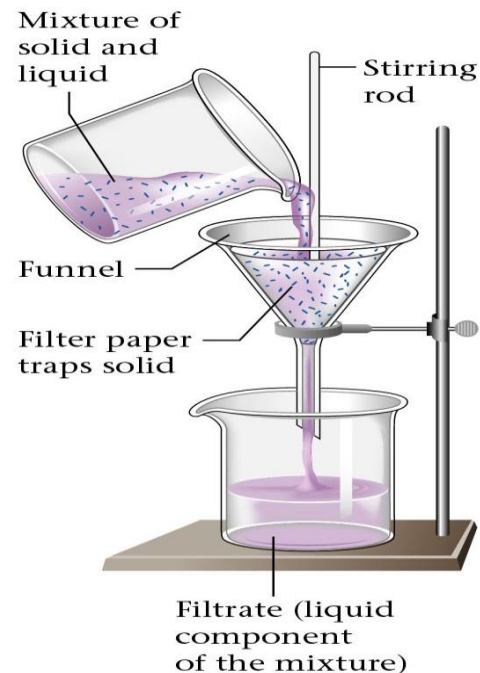


FILTRATION

- Used to separate heterogeneous mixtures composed of solids and liquids
- Uses a porous barrier to separate the solid from the liquid
- Liquid passes through leaving the solid in the filter paper

GRAVITY FILTRATION (to remove solid impurities from a liquid or solution)

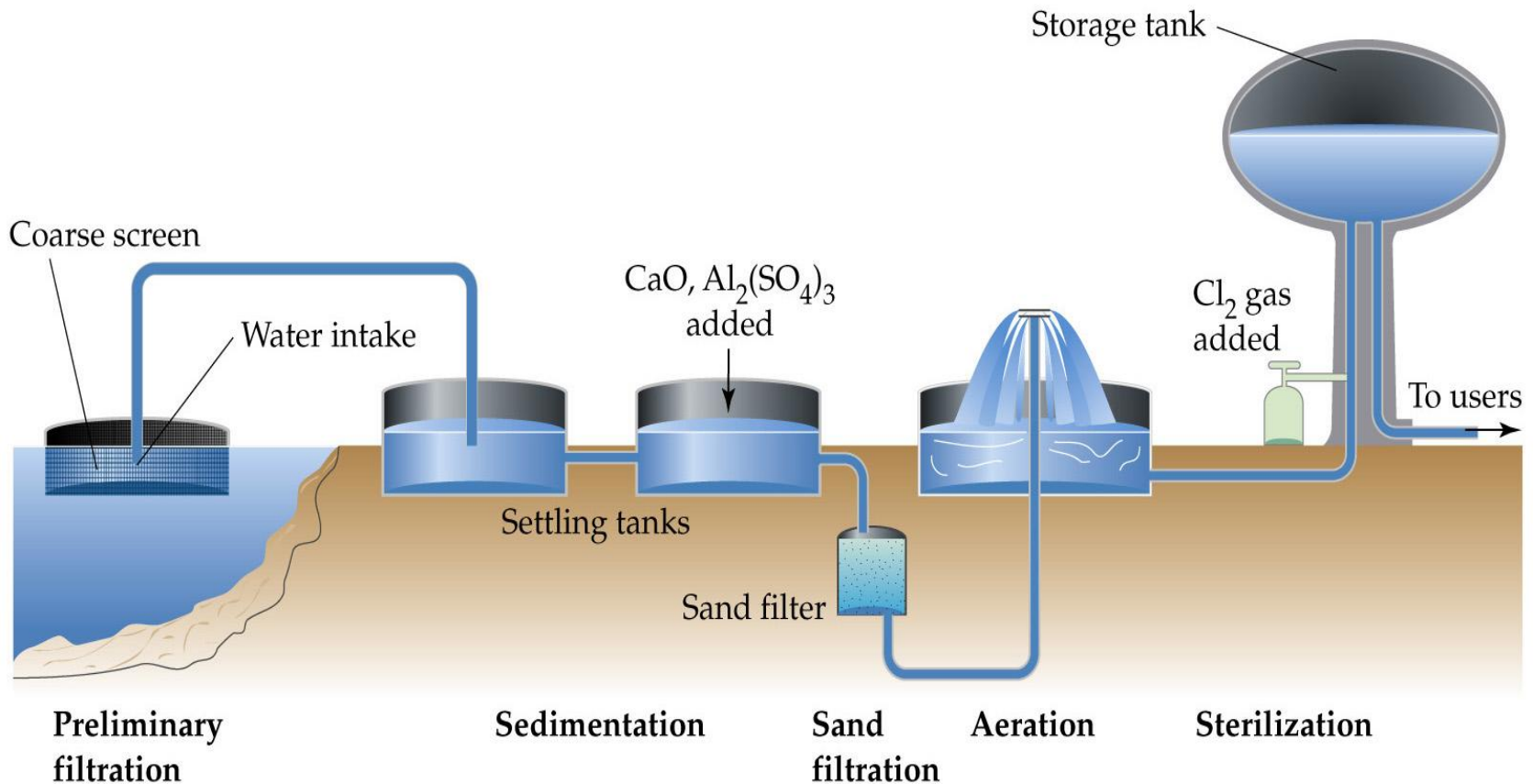
VACUUM FILTRATION (to remove solid substance usually an organic from reaction mixture under vacuum)





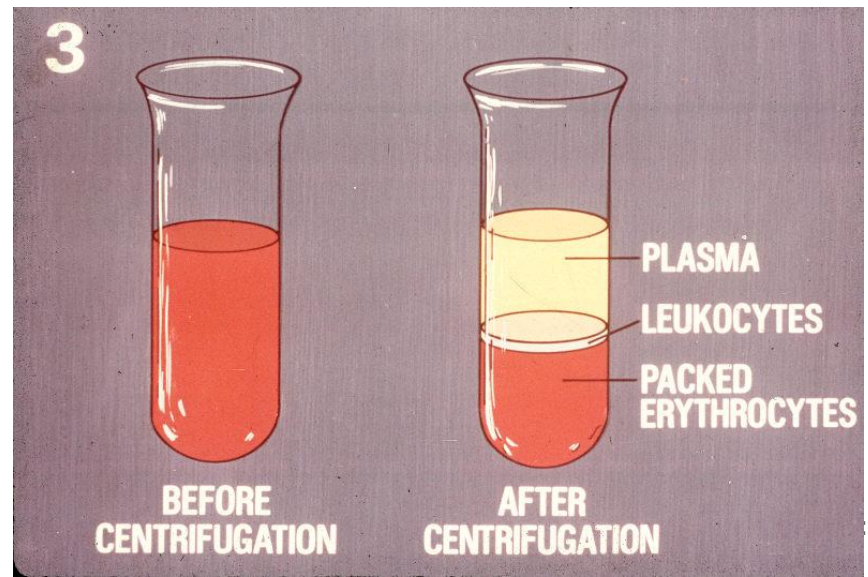
Water Purification Plant

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+ CENTRIFUGATION

- Centrifugation used to separate solids from liquids, or separates two immiscible liquids, on the basis of density.
- Involves the use of the centrifugal force. More dense components migrate away. Solid particles remain on the bottom.
- It separates insoluble materials (usually a solid) from a liquid, where normal filtration does not work well; followed by decantation.



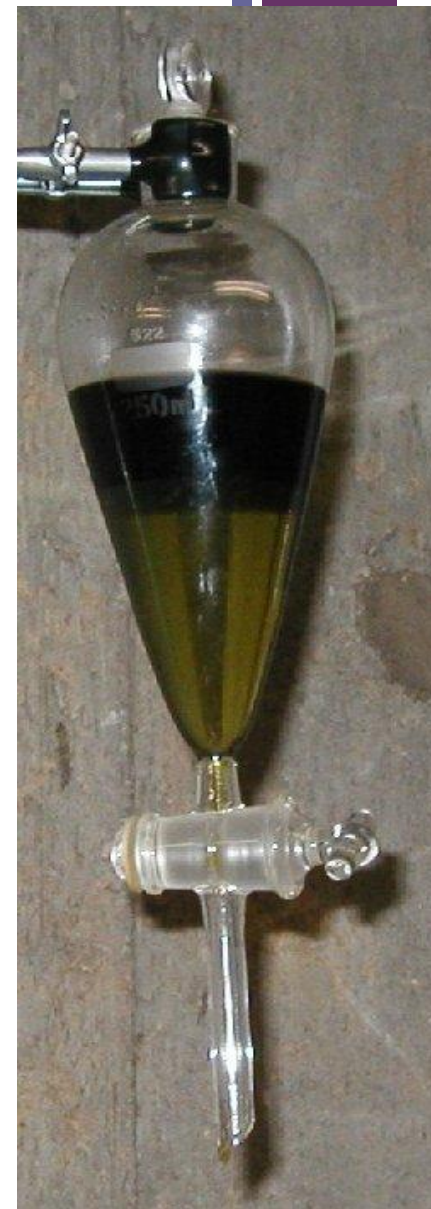


EXTRACTION

- EXTRACTION (to separate a desired substance from a reaction mixture or natural source)
- LIQUID-LIQUID EXTRACTION (depends on the solubility of a substance in two immiscible liquids so that most of the substance can be transferred from one liquid to the other. Example acetanilide in water and dichloromethane)
- LIQUID-SOLID EXTRACTION (method is used to separate substances from natural products and other solid mixtures)

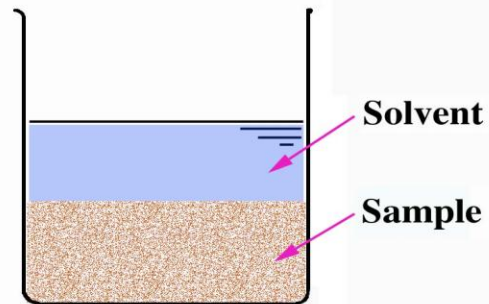
+ Liquid-Liquid Extraction (Separating Funnel)

- Separating immiscible liquids.
- Liquids that do not dissolve in each other are described as immiscible. Oil and water are immiscible in each other.
- Pour the mixture of oil and water into the separating funnel. Wait until two layers are formed. Water is denser than oil. It will form the bottom layer. Open the tap. Allow water (the bottom layer) to run into a beaker. Close the tap, before the top layer runs out. Place another beaker below the funnel. Open the tap to allow the oil to run out.

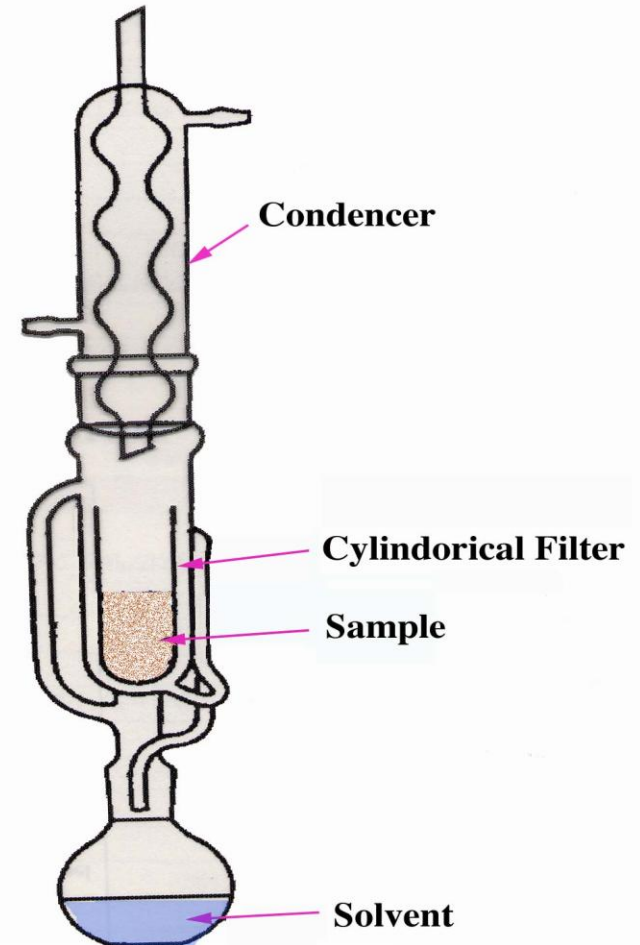


+ Liquid-Solid Extraction (Soxhlet Extractor)

■ Used for
the extraction
of compounds
of limited
solubility
in solvents.



Left Method



Soxhlet Extractor Method

lavender Oil Extraction

- This slide shows how lavender oil is made. Lavender flowers are placed into a large steamer and the steam extracts the oil. Steam and lavender oil are then cooled. The lavender oil being less dense floats on the surface of the cooled water. Some lavender oil dissolves in the water. This water is used over and over again increasing the concentration of the lavender solution. This can then be sold as “Lavender water’ a popular fragrance in Victorian England.

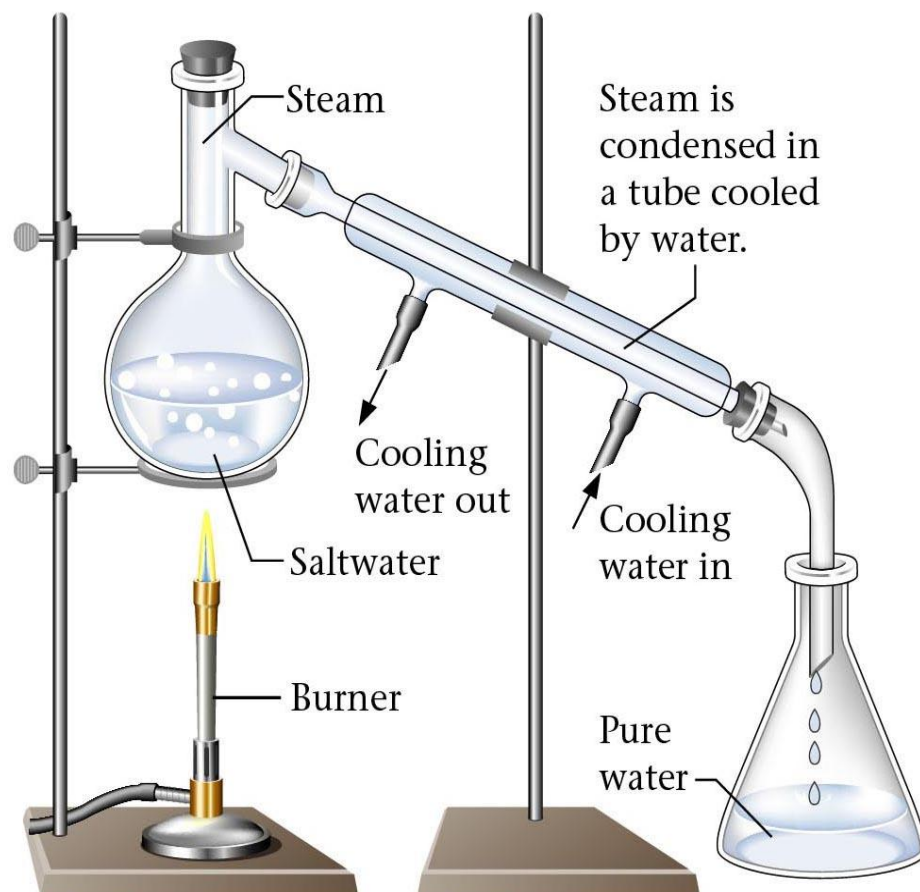




DISTILLATION

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- Used to separate homogeneous mixtures
- Based on differences in boiling points of substances involved



(a)

+ Types of Distillation

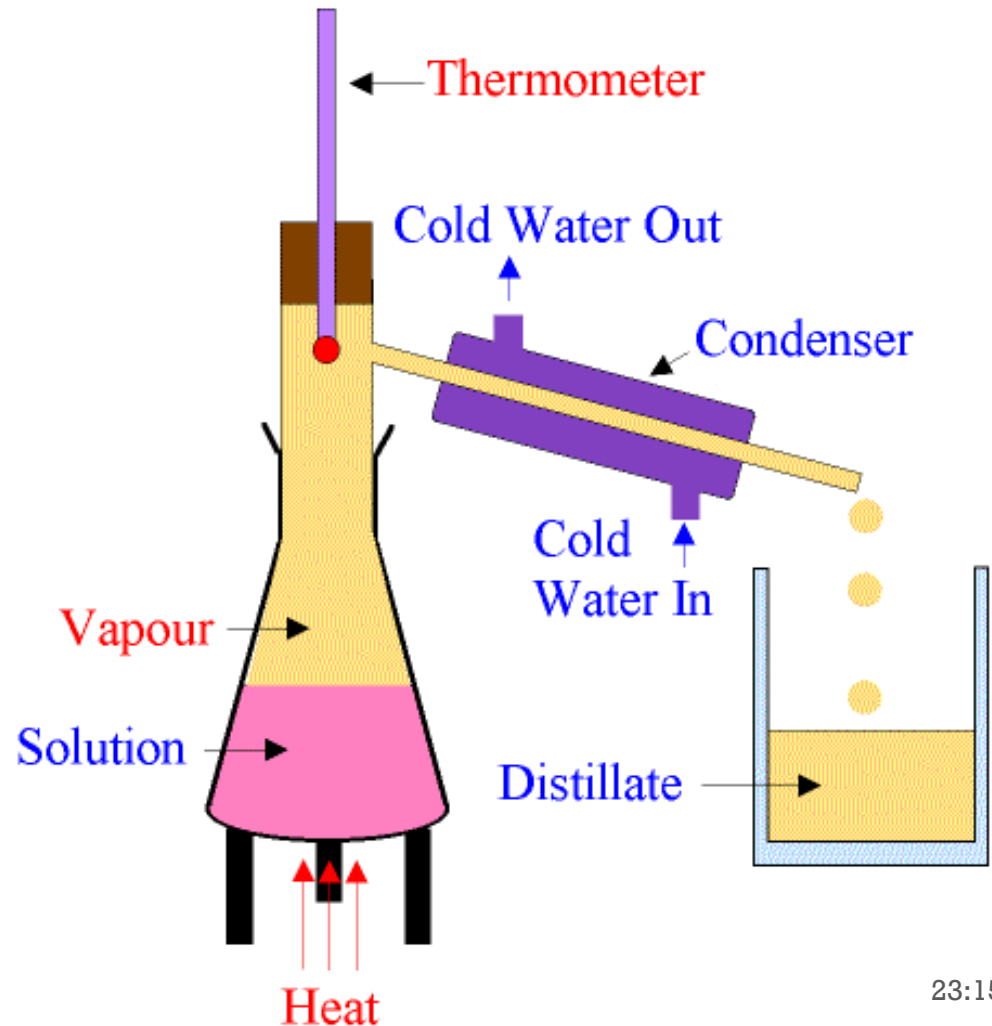
- Simple distillation
- Fractional distillation



Simple Distillation

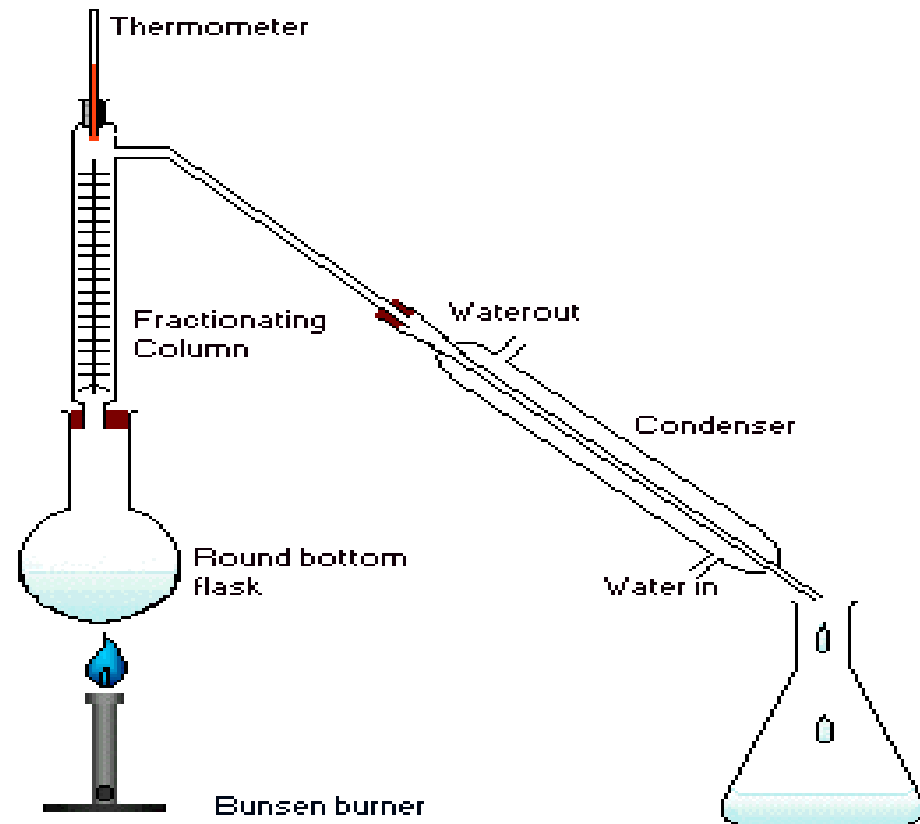
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- This is a technique used to separate a mixture of a soluble substance and a solvent.
- E.g salt and water



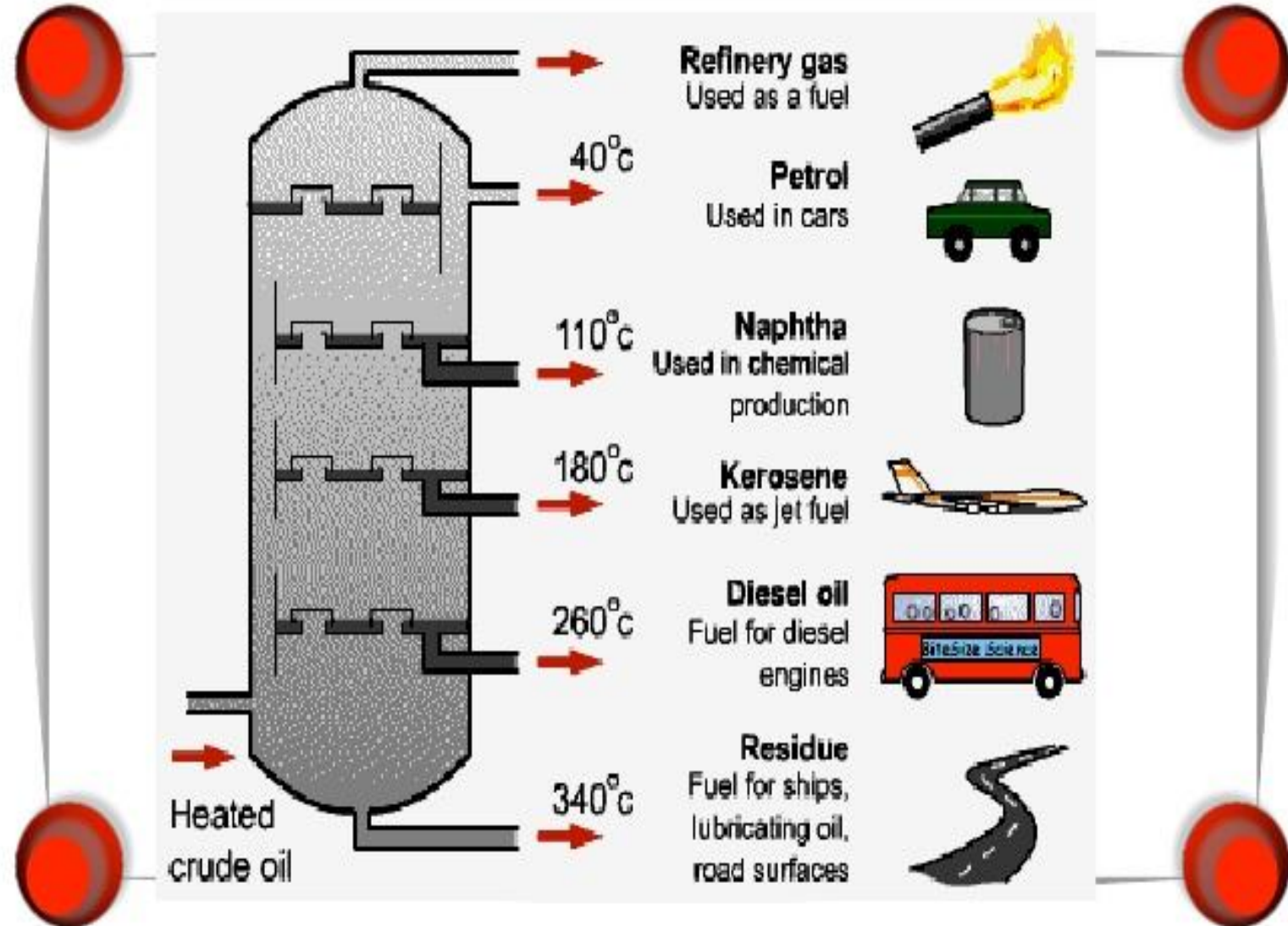
+ Fractional Distillation

- This is the technique used to separate a mixture of two or more miscible liquids with different boiling points.
- A tall fractionating column is used. It allows the separation of different liquids more efficiently. It contains many glass beads which provides a large surface area for the vapour to condense on. The substance with a lower boiling point is distilled first.
- Uses : Separation of liquid air
Separation of crude oil (or petroleum)
Separation of ethanol from glucose solution
- E.g water and ethanol. The boiling point for water is 100 while for ethanol it is 78.





Fractional distillation of crude oil



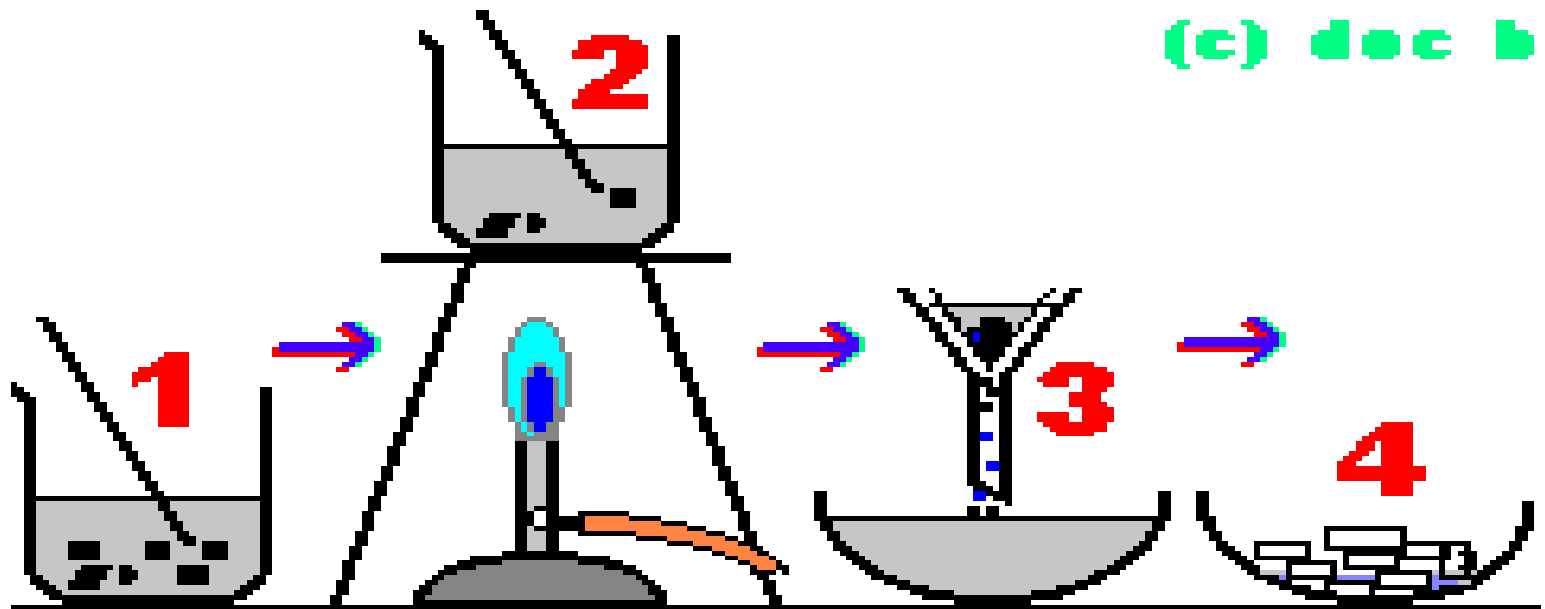
+ CRYSTALLIZATION

- Separation technique that results in the formation of pure solid particles from a solution containing the dissolved substance
- As one substance evaporates, the dissolved substance comes out of solution and collects as crystals
- Produces highly pure solids
- Rocky candy is an example of this



+ Crystallization - the Steps

- the liquid from a solution has evaporated to a point beyond the solubility limit.





ADSORPTION

- Adsorption removes a soluble impurity from a feed stream by trapping it on the surface of a solid material such as activated carbon which forms strong non covalent chemical bonds with the impurity. Chromatography employs adsorption and desorption on a packed bed of a solid to purify multiple components of a single feedstream.

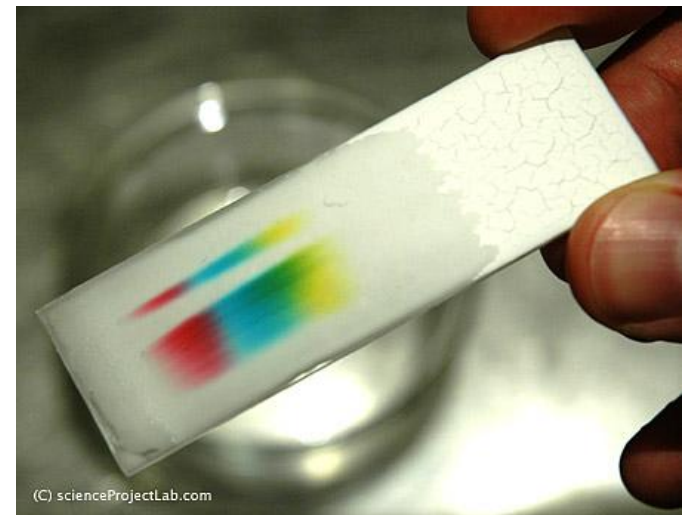


Industrial Adsorbents

- Most industrial adsorbents fall into one of three classes:
- Oxygen-containing compounds – Are typically hydrophilic and polar, including materials such as silica gel and zeolites.
- Carbon-based compounds – Are typically hydrophobic and non-polar, including materials such as activated carbon and graphite.
- Polymer-based compounds - Are polar or non-polar functional groups in a porous polymer matrix such as Ion Exchange Resins.

+ CHROMATOGRAPHY

- Separates components of a mixture based on ability of each component to be drawn across the surface of another material
- Mixture is usually liquid and is usually drawn across chromatography paper
- Separation occurs because various components travel at different rates
- Components with strongest attraction for paper travel the slowest



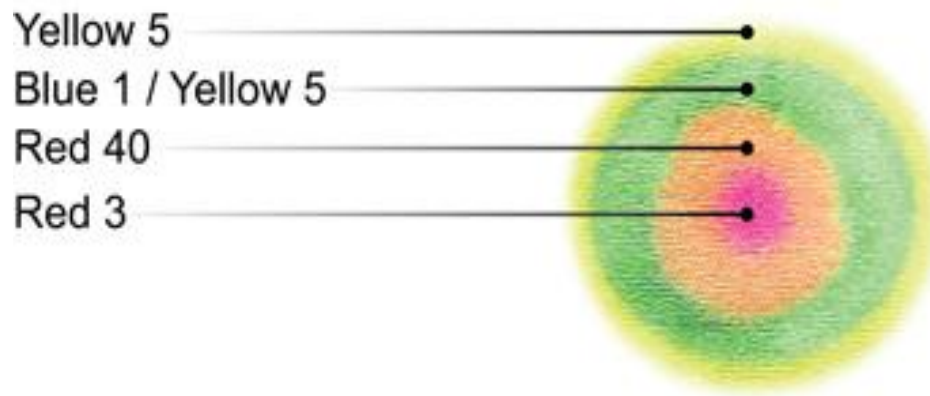


Types of Chromatography

- Radial chromatography
- Ascending chromatography
- Descending chromatography

+ Radial Chromatography

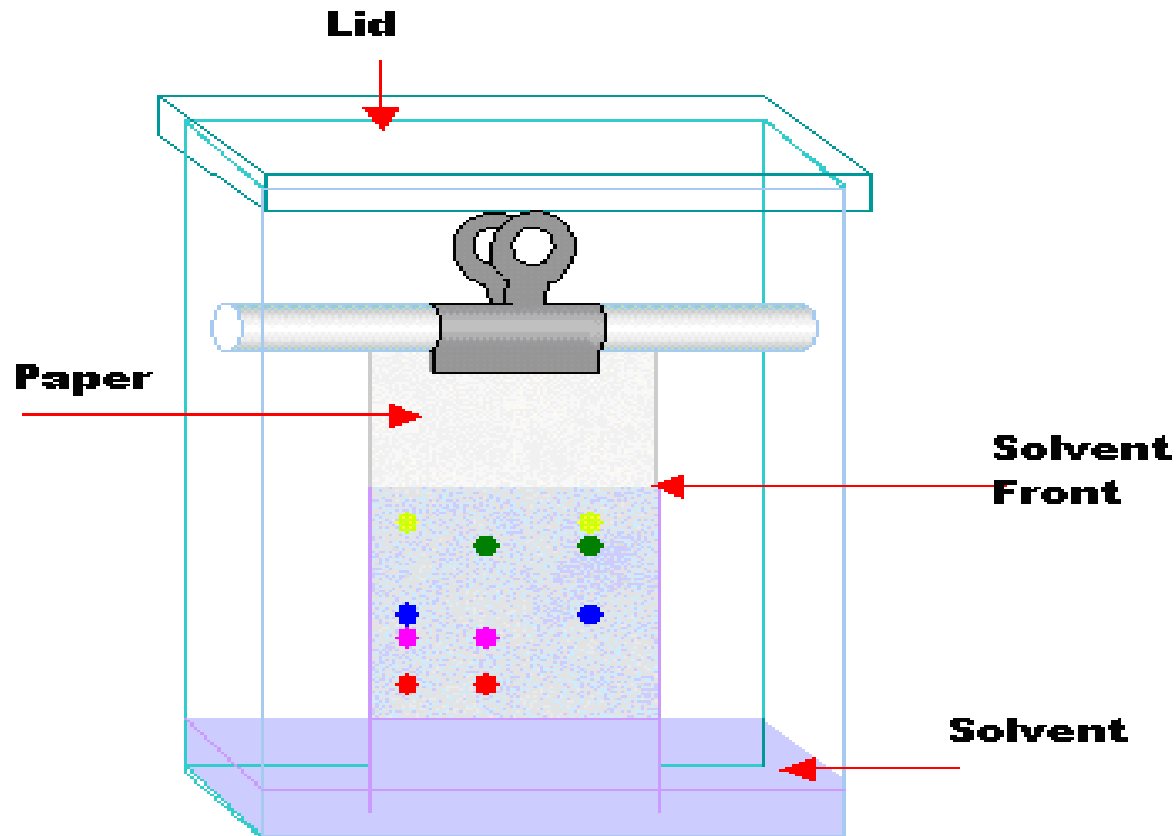
- In this type of chromatography, as the pigment separates, the different colours move outwards.



NOTE: This paper cannot separate Blue from Yellow, so that they appear GREEN

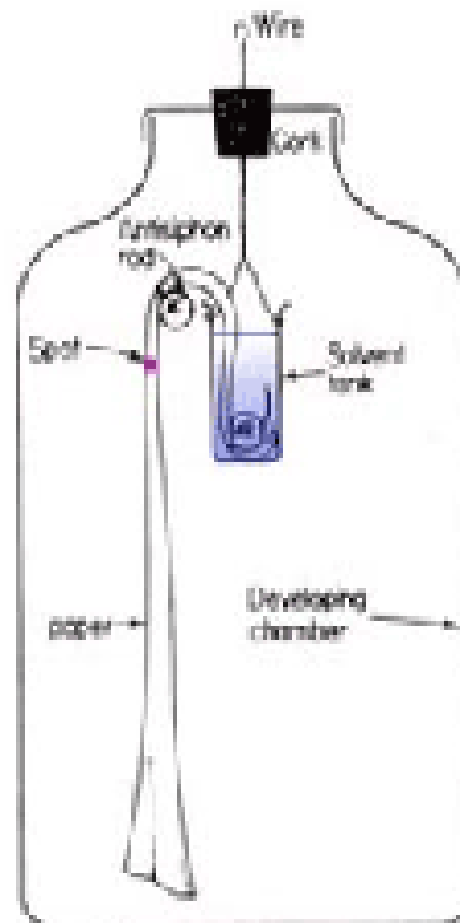
+ Ascending Chromatography

- The solvent moves upwards on the separating media



+ Descending Chromatography

- The solvent moves downwards on the separating media.



The chambers should be saturated with the developing solvent to achieve high resolution.

The size of the spot should be as small as possible

Apparatus for descending paper chromatography

+ Application

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Tie-dye t-shirt

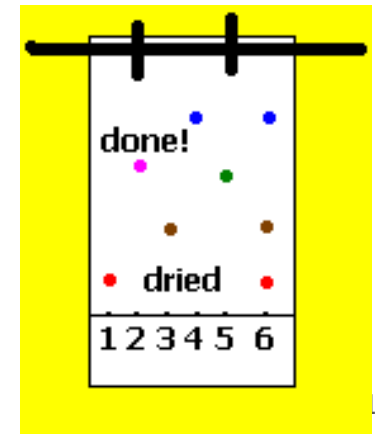
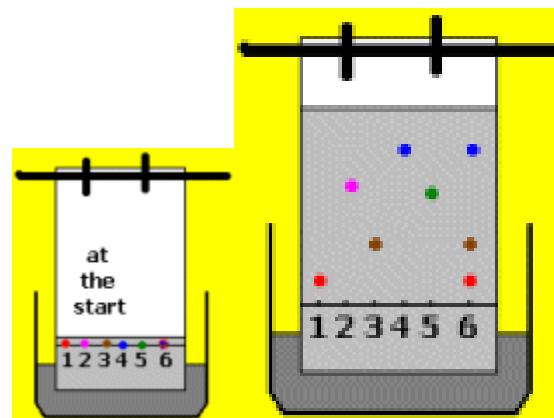
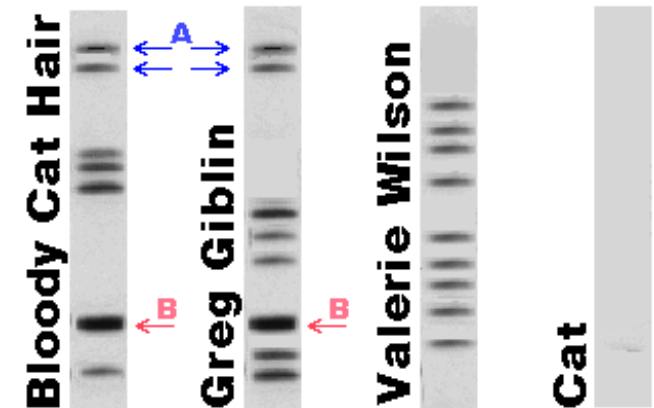
Black pen ink

DNA testing

Tomb of Unknown Soldiers

Crime scene

Paternity testing



+ Calculating Rf Values

- Rf value is a ratio of distance a component sample moves to the distance the solvent moves
- This number is usually expressed as a decimal

◀ Solvent finish 10 cm

◀ 8 cm

Calculating Rf Values

◀ 4 cm

$$R_f = 4/10$$

$$= 0.4$$

$$R_f = 8/10$$

$$= 0.8$$

◀ Starting point



Assignment

For each of the following mixtures, cite an appropriate technique that will aid in separating its components. Explain and justify your answer.

- a. Food dye analysis
- b. Refining of petroleum
- c. Purification of beer to increase the alcohol content
- d. Separating sand, rocks and water mixture
- e. Transferring jasmine leaves extract into another container
- f. Separating milk from whey (milk plasma)