

Lesson #3: Separation Techniques

Motivator: Orally quiz students to see if they can determine whether the following examples represent a chemical or physical change. Students should also give a reason for their answer.

- a. Tarnishing silver (c) – colour change
- b. Souring of milk (c) – property of smell changed
- c. Evaporation of water (p) – phase change: water is simply in the gas state (i.e., it's still water)
- d. Boiling of alcohol (p) – phase change
- e. Dissolving of sugar (p) – The original properties are retained in the mixture
- f. Burning paper (c) – colour change and gas released.

Notes:

We can often take advantage of differences in physical properties to separate substances in mixtures.

1. **Hand separation** – Simply separating components by hand. One can also make use of a sieve to separate smaller components from larger ones, or one can use a magnet to separate iron from a non-magnetic substance like sulfur.
2. **Filtration** – Filter paper can be used to separate solids that have not dissolved in a liquid. The paper captures the solid (i.e., the residue) while the liquid portion with any dissolved materials (i.e., the filtrate) pass through the paper.
3. **Distillation** – Separates liquid – liquid mixtures by heating the mixture to the lowest boiling point. The substance that boils first is captured in a condenser. The purified liquid is called the **distillate**.

See diagram on the next page before showing the video. There is also a diagram on pg. 54 of the Hebden workbook.

<http://www.youtube.com/watch?v=h7MAjTwp31Q&feature=related>

(distillation video)

Orally: *Let's take a mixture of water and methanol.*

Water – b.p = 100°C

Methanol – b.p = 65°C and is flammable

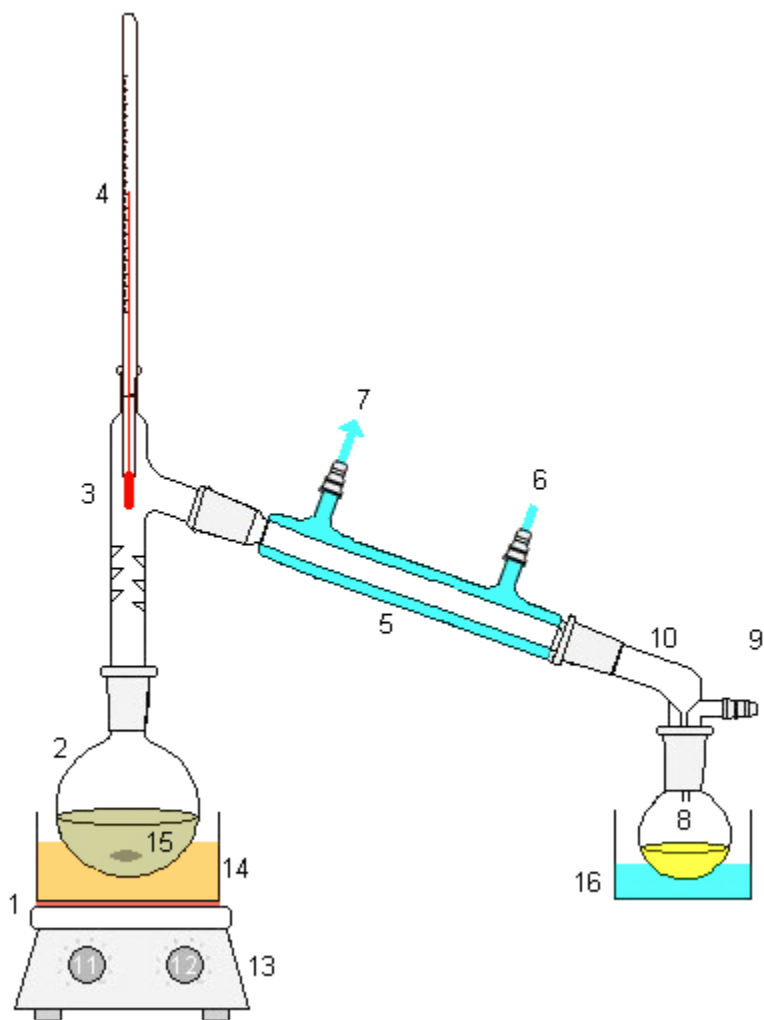
Heat the mixture. It will boil at 65°C and the temperature will stop increasing. The hot methanol vapour will come in contact with the cold condenser and convert the methanol gas into methanol liquid. The distillate drips into the collection flask.

Q: How can we tell that the distillate is methanol?

A: Try burning it! We could also check the density of the distillate. Methanol is ~ 0.79 g/mL while water is 1.0 g/mL.

Q: Will the distillate be 100% pure methanol? Why?

A: No, because some water vapour is still produced below it's boiling point.



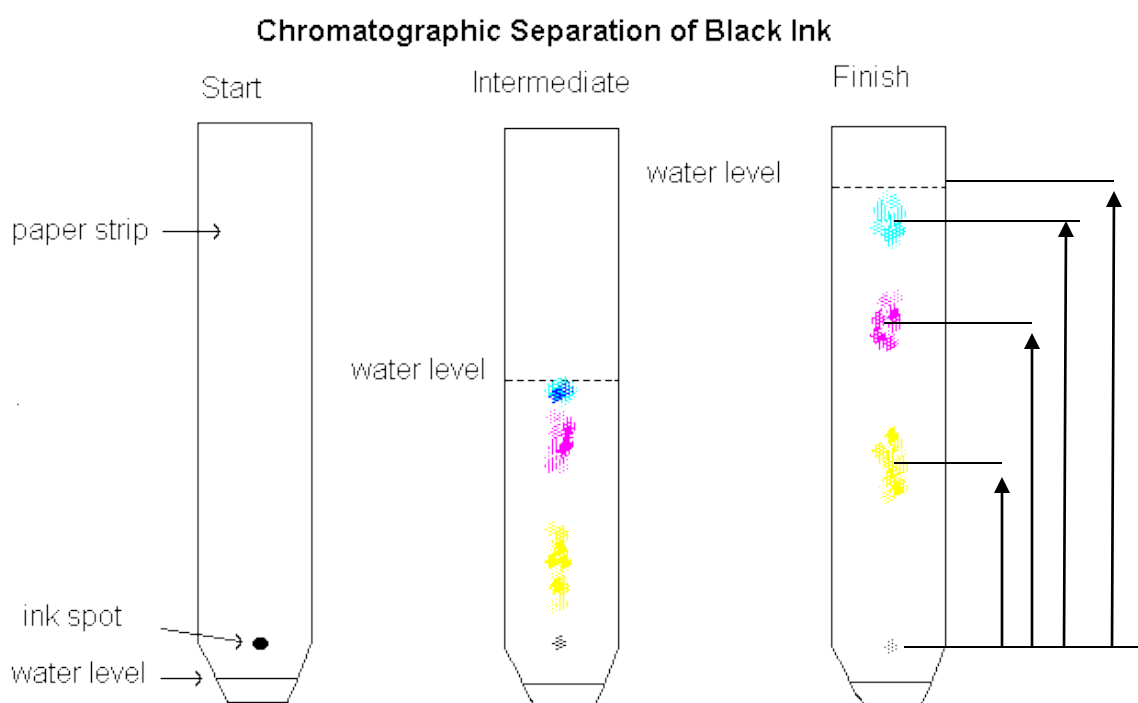
Chromatography: - separate mixtures of dissolved substances by using the solubility differences of different solutes in different solvents.

Orally: A solute is the component that is dissolved and the solvent causes the solute to dissolve in it. More will be said about this in the chapter on solutions.

The more soluble the solute molecule is, the further it can be carried by the solvent.

<http://www.youtube.com/watch?v=fLc36wxLrVI>

(Chromatography video shows how dyes separate into components)



A quantitative characteristic known as the ratio of fronts (i.e., R_f) value is used to identify specific compounds. When an R_f is determined for an unknown mixture, we can check the resulting component R_f 's against known values and potentially identify the components of the mixture.

$$R_f = \frac{\text{Solute distance}}{\text{Solvent distance}}$$

e.g., Calculate the R_f of the yellow component (i.e., the solute) if yellow travelled 6.0 cm and the

water (i.e., the solvent) travelled 14.0 cm. $R_f = \frac{6.0 \text{ cm}}{14.0 \text{ cm}} = 0.43$

The R_f value is unitless.

Orally: *Think about the R_f value as a percentage. For the example above, the R_f value is indicating that the yellow moved 43% of the distance that the water did.*

Now if we looked up the R_f's of all known yellow dyes we might see something like:

Yellow dye #1 (R_f = 0.56) Yellow dye #2 (R_f = 0.79) Yellow dye #3 (R_f = 0.42), etc, etc.

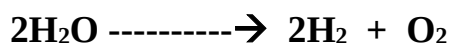
Orally: *Q: Based on the reference material, what conclusion can be made about the yellow component in the unknown mixture?*

A: The yellow dye in the unknown mixture is probably Yellow dye #3.

Orally: *There are a number of other separation techniques that are in your book (pg. 55 – 56) which we will not cover at this time. All of these separation techniques depend on differences in physical properties; some separation techniques are possible using chemical means.*

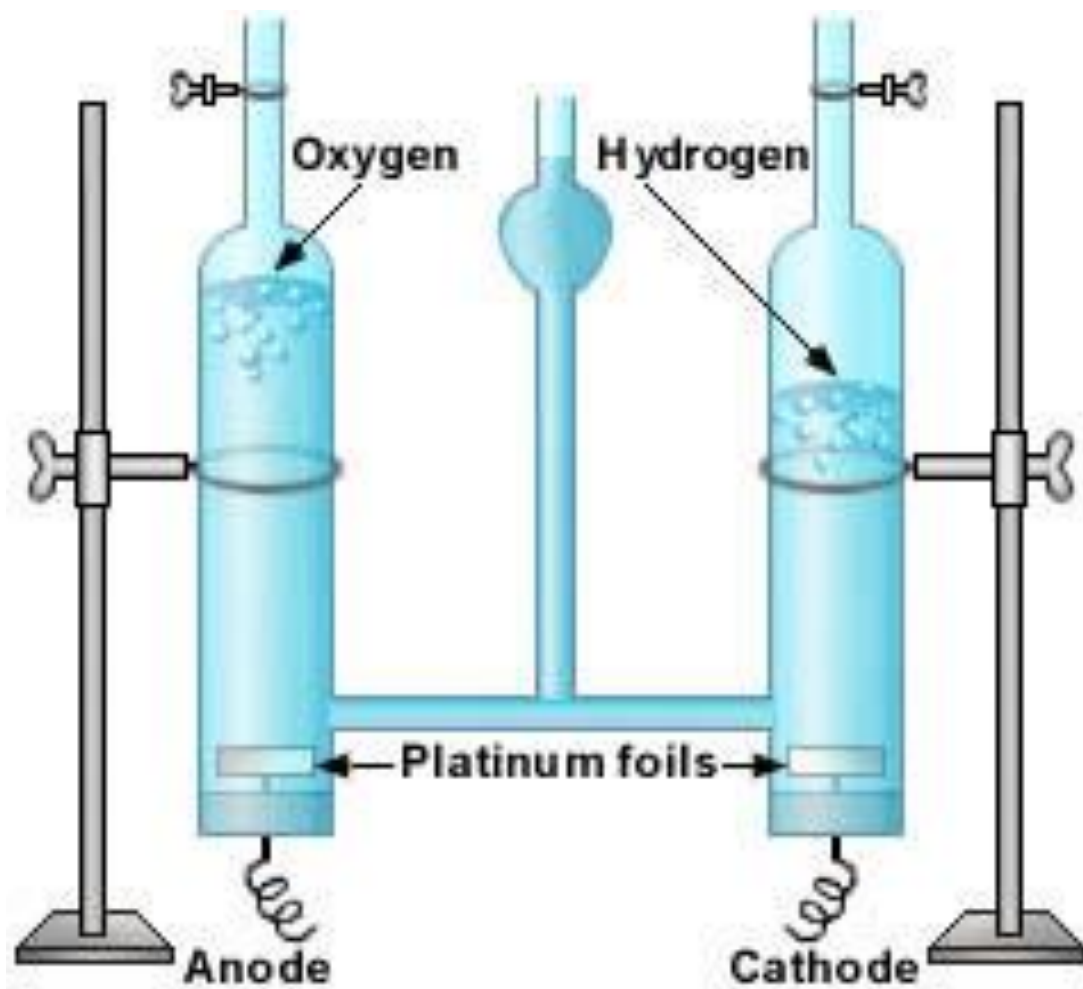
Electrolysis – the application of electricity can be used to separate components in compounds.

e.g., the Hoffman apparatus can be used to separate hydrogen and oxygen from the compound water according to the following balanced equation: (See the diagram below).



Q: Since hydrogen and oxygen are both flammable and colourless, how can we tell which electrode is producing which gas?

A: Hydrogen is produced in a 2:1 ratio to oxygen, so twice the volume of hydrogen will be produced.



Assignment: Hebden Workbook – pg. 58 #46, 47a,c,e, 53, and 57.