3.3 Chemistry: Elements, Compounds and Mixtures, Experimental Design and Purification

1. Elements: A substance that is made up of only one type of atom. It cannot be chemically split into simpler substances.
    a. Simplest Substance
    b. Cannot be broken down further by chemical methods
    c. An atom of an element is a particle representing an element that is not chemically bonded with other atoms
    d. A molecule of an element is a particle representing an element that is chemically bonded with other atoms of the same kind
    e. Elements are considered pure
    f. 1 type of atom
    g. 1 substance
2. Compounds: A substance that contains two or more elements chemically joined together.
    a. Molecule of a compound is a particle representing a compound with 2 or more atoms chemically bonded together
    b. Atoms must be of 2 or more different kinds (elements)
    c. 1 substance
3. Mixtures: A substance that contains two or more substances physically together but not reacted with one another chemically.
    a. Can consist of 2 or more elements not chemically bonded together – E.g. O_2 and H_2 mixture
    b. Can consist of 1 or more elements not chemically bonded with 1 or more compounds – E.g. Air
    c. Can consist of 2 or more compounds not chemically bonded together – E.g. Salt Water (NaCl + H_2O

Exercise

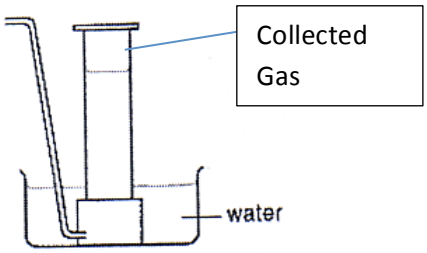
Compare the similarity and differences of the three types of substances.

Production, Collection and Testing of a Gas

The usual apparatus for measuring the volume of gas is the gas syringe.

Collection of a gas depends on its solubility in water and its density compared to that of air.

Downward water displacement can be used if the gas is insoluble (E.g. Hydrogen, Methane). Note that the gas is pure when collected.



Downward delivery is used if the gas is denser than air (E.g. CO_2, Cl_2, Br_2).

Upward delivery is used if the gas is less dense than air. (E.g. He)

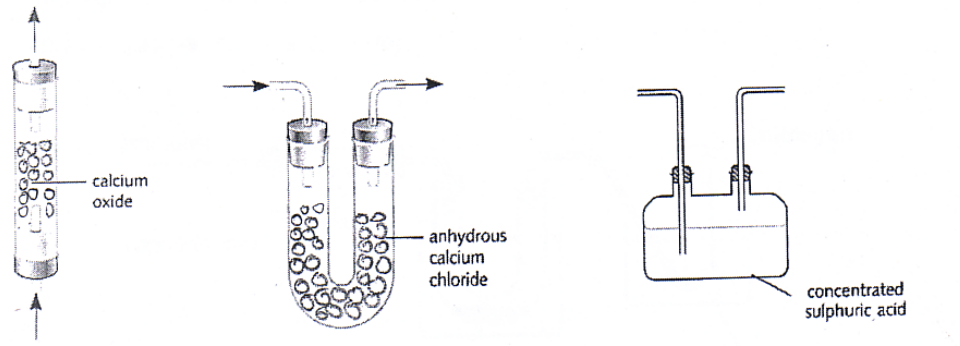
Drying of Gases (Removal of moisture)

Gases are usually contaminated with water vapour. Hence, the mixture is passed through a drying agent to dry the gas (remove moisture).

There are 3 types of drying agents:

1. Basic/Alkaline drying agents (E.g. CaO) – Cannot dry acidic gases, such as CO_2
2. Acidic drying agents (E.g. H_2SO_4) – Cannot dry basic/alkaline gases, such as NH_3 (ammonia)
3. Neutral drying agents (E.g. $CaCl_2$) – Can dry neutral, acidic, and basic gases

There are 3 setups that can be used for drying:



The first setup can ONLY be used for solid drying agents.

The second can be used for both solid and liquid drying agents.

The last one can ONLY be used for liquid drying agents.

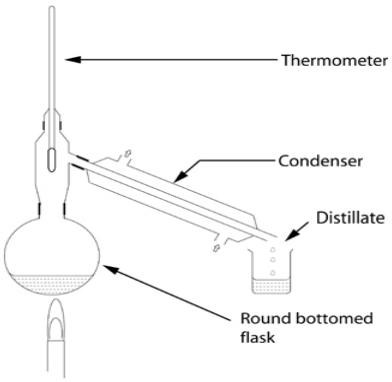
After these processes, the gas can be tested.

Purification Techniques

1. Dissolving, Filtering and Evaporating – Used for a mixture of soluble and insoluble impurities in the substance. Steps are to extract the solute ONLY.
   E.g.: A mixture of sand and NaCl only.
2. Crystallization –

Take note that water molecules must be present because they are what give the crystal its shape. As such, excessive heating would result in crystals not forming. (*NOTE: General rule of thumb is to heat the solution up on an evaporating dish until only 1/3 of the solution remains because this is when the solution is saturated, and then allow the solution to cool)
E.g.: Crystallization of Cu(II)SO_4 (Copper (II) Sulfate) from its solution

3. Sublimation – Some solid substances become gaseous when heated under room conditions, without going through the liquid state. Examples include NH_4Cl (ammonium chloride), I_2 (iodine), and dry ice (CO_2). Heat the mixture in an evaporating dish and invert a filter funnel over the dish. The sublimed solid will solidify as a deposit on the cooler inner surface of the funnel.
   E.g.: Mixture of NaCl and NH_4Cl only.
4. Separating funnel – When two immiscible liquids have to be separated.
   E.g.: Oil and water
5. Simple distillation – Used to obtain solvent from a solution



IMPORTANT NOTES
1. Broken porcelain is used as boiling chips to ensure the smooth boiling by allowing formation of smaller air bubbles.
2. The thermometer is placed at the exit of the flask to measure the temperature of the pure vapour exiting the flask, and hence determines the boiling point of the solvent.
3. The cooling water enters the condenser from the bottom to ensure

that the bottom is the coolest part, so any vapour that did not condense earlier would condense here, and so no vapour can escape.
E.g.: Get water from salt solution.

6. Fractional Distillation – Used when separation of a mixture of miscible liquids with different boiling points is required. Note that the liquid with the lower boiling point will be collected first, and during that evaporation process, the reading on the thermometer will remain constant. After completion, the reading will begin to rise again.
   IMPORTANT NOTES:
   1. Do not use a Bunsen burner if flammable liquids must be separated (naked flames must not be used to heat flammable liquids); instead use an electric heater.
   2. The tiny glass beads in the fractionating column are there to increase the surface areas for the condensation of vapour, making the separation of the 2 vapours more efficient.
   3. The reading will first record the boiling point of the liquid which has a lower boiling point, and after all the vapour of that liquid has entered the condenser the thermometer will then record the boiling point of the other liquid.
   E.g.: Separate a mixture of water and ethanol (100°C vs. 78°C)
7. Reverse Osmosis – High pressure is used to force impure water through a membrane which has millions of tiny pores. Only water molecules can pass through the pores, leaving solute particles behind.