MIXTURES AND THEIR SEPARATIONS

Pure Substances show the following characteristics:

1. Definite and constant composition
2. Definite and constant physical properties, such as fixed melting and boiling points, under a given set of conditions
3. Distinct chemical properties
4. Show a single spot when analysed by chromatography

To determine if a substance is pure, then its melting points should not differ by more than 1°C

Mixtures

A mixture is made of two or substances that are not chemically combined together. Examples of mixtures are:

- Mixtures of elements such as copper and zinc (brass)
- Mixtures of elements and compounds, (air)
- Mixtures of several compounds (oil)

Mixtures melt and boil over a range of temperatures rather than at fixed points. This is due to their composition. The properties of the mixture are a combination of the properties of the different substances it contains. The components of a mixture can be separated relatively easily by using physical means (e.g. filtration and distillation).

There are two broad categories of mixtures:

Homogenous mixtures – have the same composition throughout. Examples include sodium chloride solution (salt water) and brass (copper and zinc)

Heterogeneous mixtures – have a composition that is not uniform. Examples include a mixture of sand and water, water and milk. In many cases, the different components of a heterogeneous mixture can be readily identified by the naked eye. However, in other cases, such as in blood, and milk, the mixture appears uniform unless viewed through a microscope.

Homogenous Mixtures

Solutions

Solutions are homogenous mixtures of solute and solvent. Solutions can be aqueous (when the solvent is water) or non-aqueous. Solutions can also be of different types:

a gas dissolved in a gas – e.g. air
a liquid in a liquid – e.g. alcohol in water; vinegar (ethanoic/acetic acid) in water; gasoline)
a solid in a solid – e.g. metal alloys (such as bronze, brass, steel)
a gas in a liquid – e.g. carbon dioxide dissolved in water (used to make fizzy drinks)
a solid in a liquid – e.g. sodium chloride in water; glucose in water.

Features of Solutions

1. Solute and solvent are thoroughly mixed
2. Solute and solvent do not separate out when the solution is allowed to stand
3. The particles of the solute are not visible even under a light (optical) microscope)
4. The solution is usually transparent if the solvent is a liquid
5. In many cases, the solute can be separated from the solvent by physical means and vice versa.

Solubility

A solute is considered soluble if it dissolves readily in a given solvent. Sparingly soluble substances dissolve only to a small extent in a given solvent. Often when we think of a solid as insoluble, it is really sparingly soluble. Sugar and sodium chloride are readily soluble in water, but solid iodine is only sparingly soluble in water. Solid iodine dissolves easily in ethanol, but solid sodium chloride is insoluble in ethanol.

A dilute solution contains a small quantity of solute dissolved in the solvent

A concentrated solution contains relatively large quantities of solute dissolved in the solvent.

A saturated solution contains as much solute as can possibly be dissolved in a given solvent at a given temperature and pressure in the presence of undissolved solute. A solution which is saturated at one temperature may not be saturated at another.

A supersaturated solution contains more solute than the solvent can normally dissolve at a given temperature and pressure. Supersaturated solutions are unstable. Disturbances, for example, shaking, stirring or the addition of crystals (seeding) cause a supersaturated solution to throw out excess solute and become saturated.

To define solubility then, we must specify certain conditions, such as the solvent and the temperature. Graphs that show how solubility varies with temperature are called solubility curves.

Factors Affecting the Solubility of a Solute in a Solvent

1. Temperature – Solids dissolve more readily in liquids as temperature increases. However, an increase in temperature decreases the solubility of a gas dissolving in a liquid.
2. Pressure – Pressure affects mainly gases dissolved in liquids, i.e. an increase in pressure increases the solubility of a gas in a liquid.
3. The nature of the solute and the solvent – Ionic and polar covalent substances dissolve more readily in water and other polar solvents. Non-polar substances dissolve readily in non-polar solvents (e.g. hexane, ether, methylbenzene)

The following procedures will increase the rate at which a solid dissolves in a solvent (how quickly it dissolves):

- Crushing increases the surface of the solute exposed to the solvent
- Stirring brings more solvent in contact with solute
- Heating increases the movement of the solute particles, causing more mixing

Heterogeneous Mixtures

Heterogeneous mixtures include suspensions and colloids. In these mixtures, the components do not dissolve in each other; rather one substance is initially dispersed in the other. Then, in the case of a suspension, settling will take place on standing whereas in the colloid, it remains suspended.

Suspensions

A suspension is a heterogeneous mixture which is formed when small solute particles do not dissolve or only partly dissolve in the solvent. For example: mud in water, powdered chalk in water, some medicines (some germicides)

Features of Suspensions

1. Particles are visible to the unaided eye

2. Particles settle out if left to stand
3. The particles can be removed by filter paper
4. Suspensions appear “cloudy”.
5. The particles are not individual atoms or molecules, but are believed to be clusters of them

Colloids

A colloid is a mixture which is in between a solution and a suspension, in that the solute particles are bigger than those of a solution but smaller than those of a suspension. A colloid usually consists of large molecules or groups of molecules (aggregates) held floating in the substance. E.g. fog, aerosol sprays in air (liquid in gas), starch in warm water (solid in liquid).

An emulsion is a special case of a colloidal system. It consists of two immiscible liquid phases in which one liquid in the form of fine droplets is dispersed throughout the other liquid. E.g. milk, salad dressings, mayonnaise, etc.

Features of Colloids

1. The particles cannot be seen with the light microscope
2. The particles do not settle out on standing
3. The particles are intermediate in size between those of a solution and those of a suspension
4. Particles are not small enough to pass through filter paper
5. The particles are big enough to scatter light

Solubility and Solubility Curves

The solubility of any solute is the number of grams of it which dissolves in 100 g of solvent (usually water) at a given temperature and pressure.

N.B. 1 gram of water = volume of 1 cm^3 since the density is 1 g cm^{-3}.

Graphs which show how solubility varies with temperature are known as solubility curves. At a particular temperature:

$$Solubility = \frac{Mass \times 100\ g}{Volume}$$