



eduresourceza.com

C2. The nature of matter

C2.01 The states of matter

Matter - all the substances and materials of which the universe is composed

- They have MASS and SPACE

Atom

Molecule: 1. more than one atom chemically bonded

2. Fixed number of atoms

Compound: more than one type of atom chemically bonded

Mixture: more than one substance which can be physically compound

Ion: charged particle - the number of atom and electron is not equal

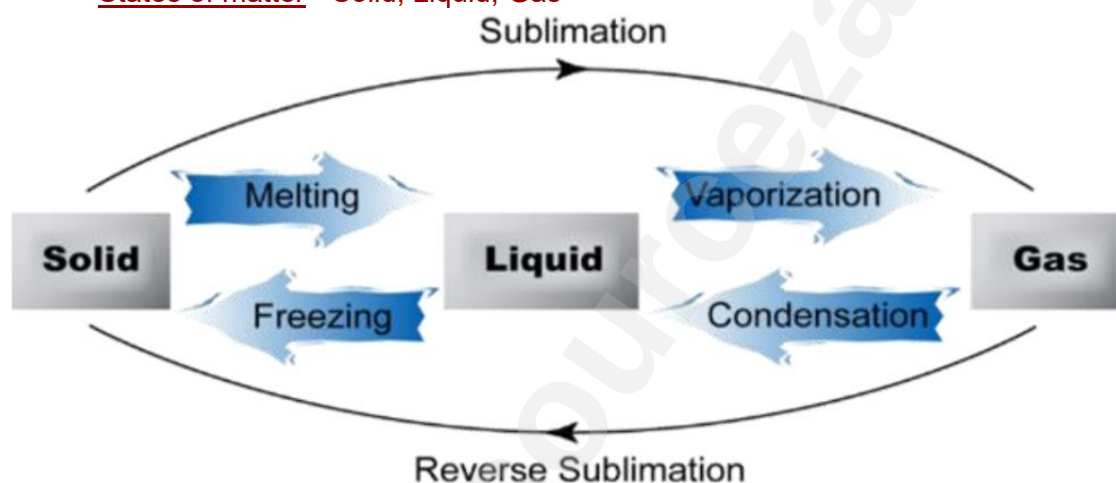
- Polyatomic ions: CO_3 , SO_4

Element: 1 type of atom

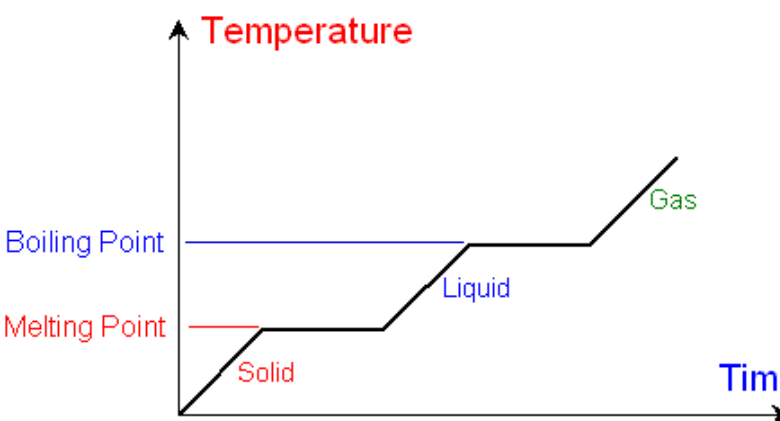
Giant structure: does not have fixed number of atoms

Molecule:

- Chemistry: how matter behaves, how they change into another
- States of matter - Solid, Liquid, Gas



Physical state	volume	density	shape	fluidity
solid	Fixed volume	high	Definite shape	No flow
liquid	Fixed volume	Moderate	No definite shape	Flow easily
gas	No fixed volume	low	No definite shape	Flow easily



1. Additional notes

- Volatile(Volatility): - easy evaporation
- Low boiling point
- Surrounding pressure↓ boiling point ↓

Melting	Gained	Endothermic
Boiling	Gained	Endothermic
Condensing	Lost	Exothermic
Freezing	Lost	Exothermic
Sublimation	Gained	Endothermic
Reverse sublimation	Lost	Exothermic

2. Pure substance

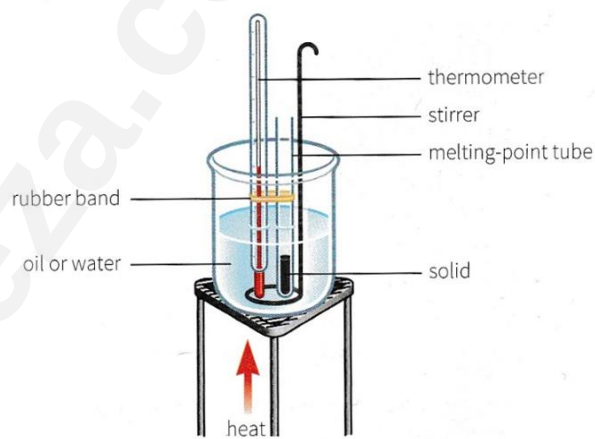
Pure substance - consists of one substance

- Values of m.p and b.p is precise and predictable
- Check the identity of an unknown substances

3. The effect of impurities

The presence of an impurity in a substance

- Lowers the melting point
- raises the boiling point



4. Types of mixture

Mixture

Solution: 용해 - states are completely mixed to become one state

- Solute: 용질, solid in solution - cannot be seen
- Solvent: 용매, liquid

5. Solutions

Solution: One solution is dissolved in another

Miscible: liquid is able to be mixed

C2.02 Separating & purifying substances

METHOD OF SEPARATION

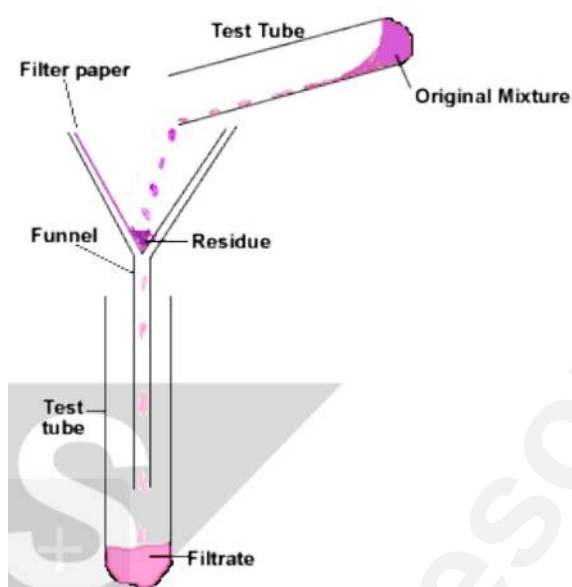
USED TO SEPARATE

Filtration	A solid from a liquid
Evaporation	A solid from a solution
Crystallization	A solid from a solution
Simple Distillation	A solvent from a solution
Fractional Distillation	Liquids from each other
Chromatography	Different substances from a solution

1. Separate mixture of soils

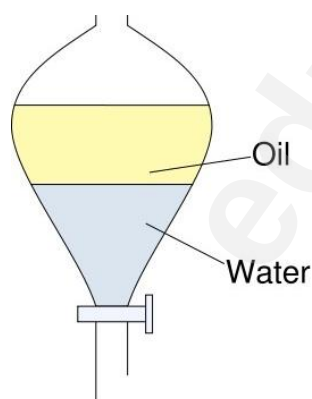
- Use magnetic properties, density, different solubility

2. Separating insoluble solids from liquids - **Filtration**



- Residue: ones which are left
- Filtrate: filtered liquid

3. Separating immiscible liquids



- Separate denser(lower) layer by tapping off at the bottom

4. Separating solutions

1. Distillation

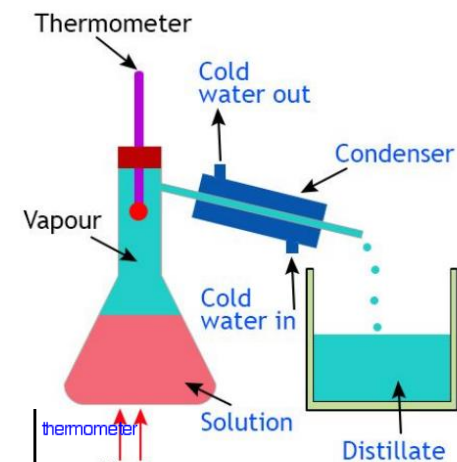
Used to separate the solvent from a solution

Example

Solution: sea water

Water evaporates and goes through condenser

Distillate: Water



2. Fractional distillation

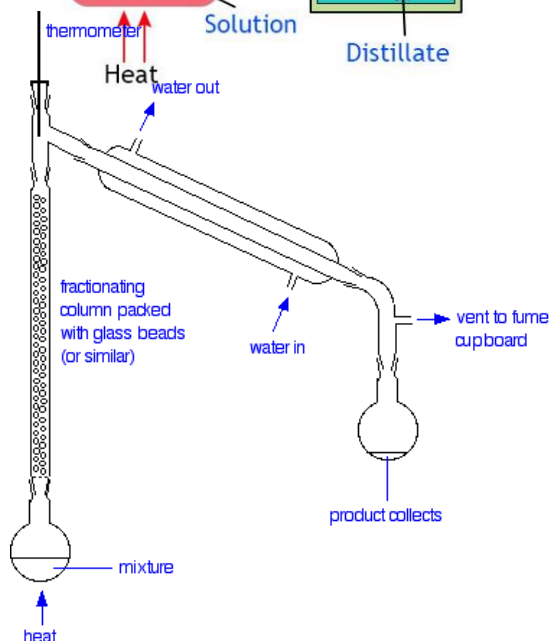
Used when More than two miscible liquids is in the mixture

Example

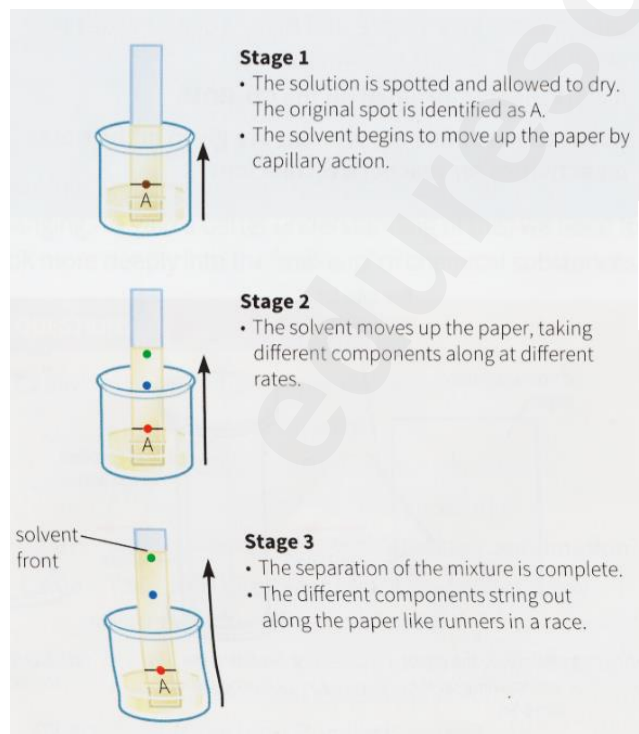
ethanol b.p: 78c

Water b.p: 100c

1. Water vapours enter the fractionating column
2. Provides large surface area for condensation
3. Temperature becomes below 100
4. Ethanol goes through condenser
5. Water drips back



3. Chromatography



To separate different substances from a solution

- Most soluble moves fastest up the paper
- Run is stopped before the solvent front
- Paper: **chromatogram**

$$R_f \text{ Value} = \frac{\text{Distance moved by solute}}{\text{Distance moved by solvent}}$$

- **Locating agents** - it enables distinction between colourless substances
- Agents reacts with samples - makes colour

5. Methods to identify the purity

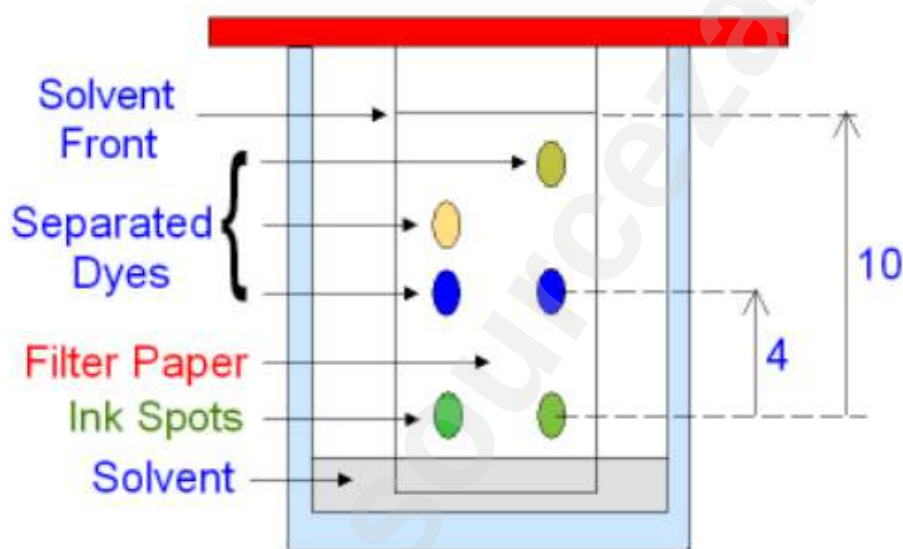
1. If pure, it should give one spot on the chromatogram
2. Compare R_f value with original
3. Compare boiling point and melting point

eduresourceza.com

Paper Chromatography

You need to know what paper chromatography and how to carry it out and interpret data from it.

- **Paper chromatography** is:
 - Analytical technique for separating and identifying mixtures of colour compounds.
1. On bottom of a chromatography paper, a line is drawn, and a sample mixture is dropped
 2. The chromatography paper is then dipped into a suitable solvent (ethanol or water)
 - The spot of sample must be above the surface of the solvent.
 3. The solvent moves up the paper through capillary action, and the mixture is drawn up with the solvent, travelling up.
 4. The speeds of the travel of each compound in the mixtures are different



- Using a factor called the "**retention factor**" or the R_f , the compounds can be identified easily.
- The retention factor can be calculated using the formula:
 - **$R_f = \text{distance moved by the compound} \div \text{distance moved by the solvent}$**
- And since each compound will have a unique retention factor (if the experiment is done under the same conditions), comparing the experimental R_f with a known chart of R_f will allow the identification of the compound.

$$R_f \text{ Value} = \frac{\text{Distance moved by solute}}{\text{Distance moved by solvent}}$$

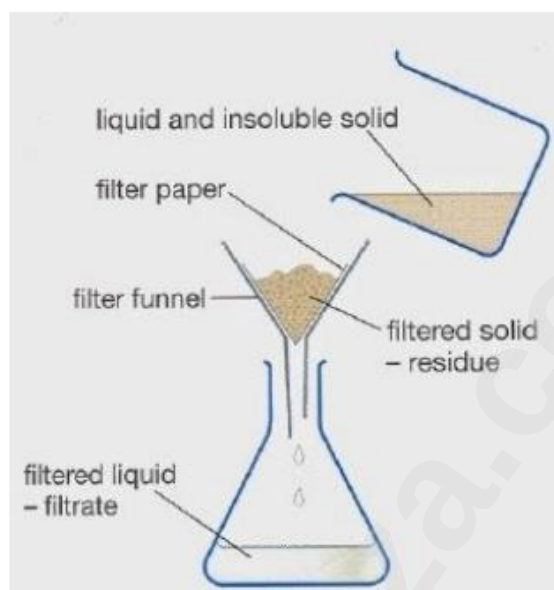
To separate different substances from a solution

- Most soluble moves fastest up the paper
- Run is stopped before the solvent front
- Paper: **chromatogram**

Filtration

Gravity filtration **separates the insoluble solid** impurities from a mixture, but **not** dissolved solids.

- The filtered liquid collected at the bottom is called the **filtrate**
- The solid separated in the funnel is called the **residue**.

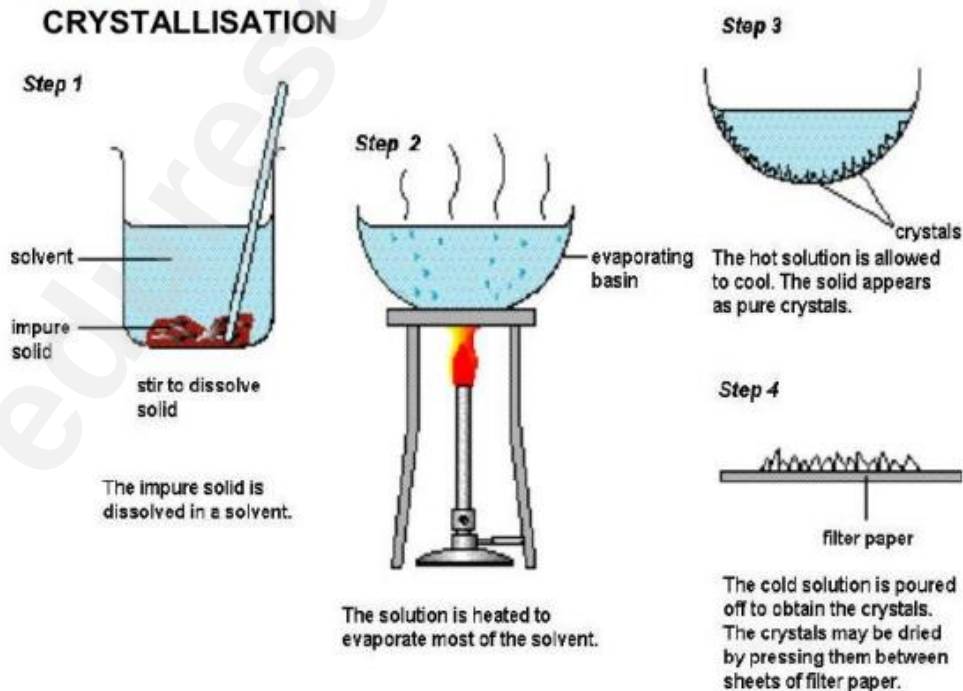


Crystallisation

Crystallisation **separates the dissolved solid from a solution**.

- The solution is left to evaporate on its own. **The liquid is lost.**
 - The liquid content will evaporate, leaving the dissolved solid behind to form a solid crystal.
- Purer solutions will form nicer crystals

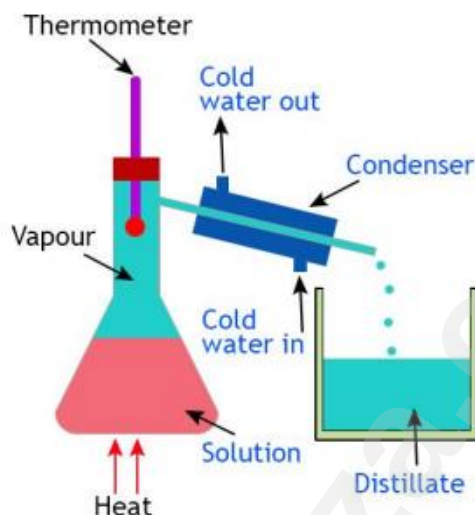
CRYSTALLISATION



Distillation

Distillation **separate the liquid from a solution** of dissolved solid and the desired liquid.

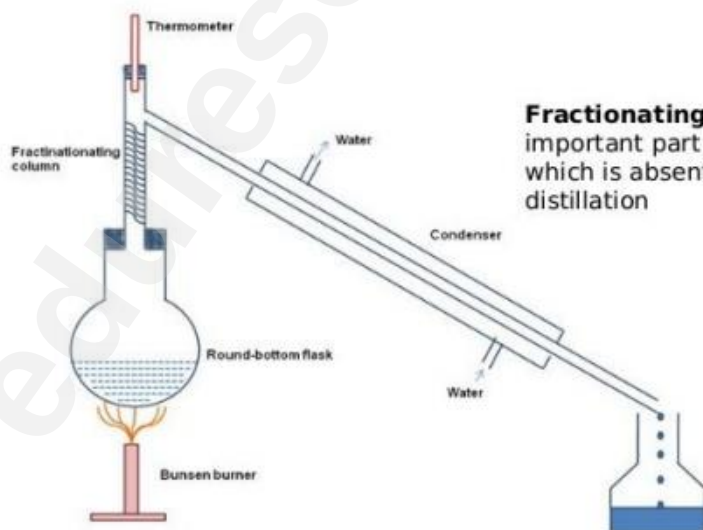
- The solution is heated until the liquid boils away, then the vapour is collected using an apparatus.
 - The vapour is the cooled back to a liquid using a **condenser**
 - The desired liquid is collected into a new container, and the solid residue remains in the heat.



Fractional Distillation

Fractional distillation **separates different mixtures of liquids** with different boiling points.

- For example, a mixture of ethanol (b.p. 78°C) and water (b.p. 100°C) can be separated
 - If the flask is heated to and at 80°C , only the ethanol will boil, not the water
 - The ethanol vapour will be collected in the condenser into a liquid.
 - The water remains in the flask



Fractionating column is important part of this assembly which is absent in simple distillation

These purification methods are all useful to us in many ways

- In food, we do not want any contaminants or unwanted chemicals because they can be harmful
 - They can be removed by purification methods
 - e.g. water purification ensures the safety of drinking water
- In medical productions
 - Any impurities in the drugs might cause harmful side effects
 - Affect the drug effectivity

One method of determining purity is by looking at the melting / boiling points of a substance

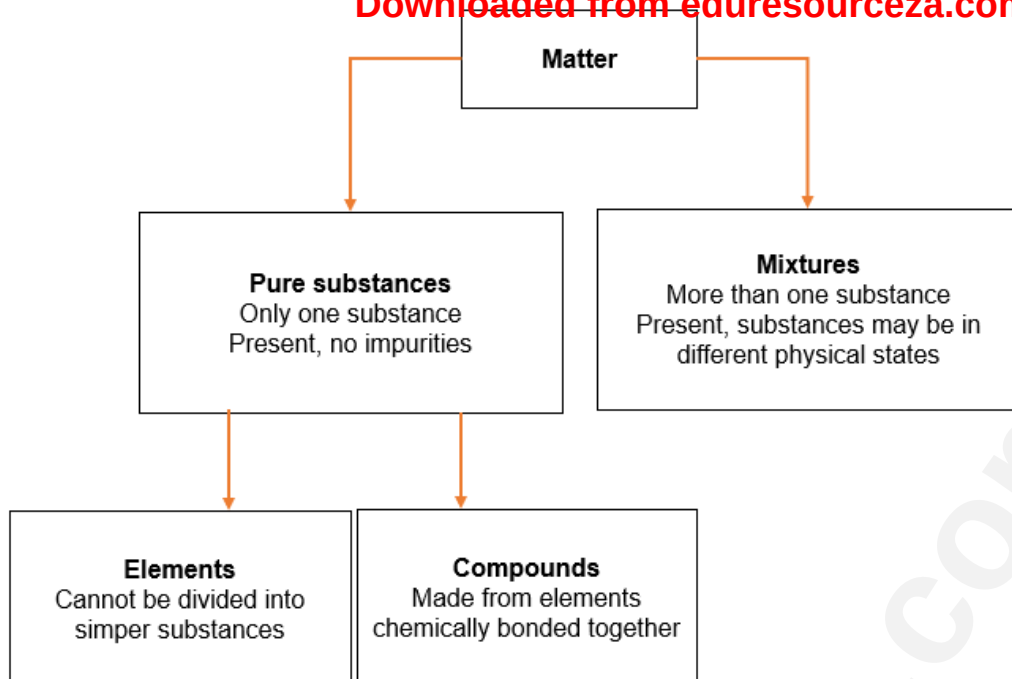
- All chemicals have a specific mp/bp under specific conditions, and these are accurately known
 - e.g. water's melting point is 0°C and boiling point is 100°C at 1 atm.
- If these points change under the same conditions, it means that there is an impurity.
 - For example, salt water, which has impurities of NaCl, has a higher boiling point than pure water.
 - **Solid impurities in liquids increase the boiling point**
 - Salt water will also freeze at a freezing point below 0°C (lower than pure water)
 - **Solid impurities in liquids decrease the freezing/melting point.**

6. A closer look at solutions

- **The solubility of solids in liquids**
 - **Soluble:** substances dissolve in a solvent
 - **Insoluble:** substances can't dissolve in a solvent
 - **Concentration:** the mass of solute dissolved in a particular volume of solvent
 - **Dilute:** solute density is small
 - **Concentrated:** solute density is big
 - **Saturated solution:** no more will dissolve at that temperature = solubility
- **The solubility of gases in liquids**
 - Solubility ↑ when pressure ↑ temperature ↑
 - Oxygen is more soluble in water than nitrogen
 - Air dissolved in water - 61% nitrogen 37% oxygen

When a mixture forms	When a compound forms
The substances are simply mixed together No reaction takes place	The substances chemically react together to form a new compound
The composition of the mixture can be varied	The composition of the new compound is always the same
The properties of the substances present remain the same	The properties of the new compound are very different from those of the elements in it
The substances in the mixture can be separated by physical methods Like filtration, distillation, magnetic attraction	The compound cannot easily be separated into its element

C2.03 Atoms and Molecules



1. Chemical reactions and physical changes

1) Chemical changes

- **Decomposition**: compound breaks down to form two or more substances
 - Use heating or electricity
- **Synthesis**: substance is formed by the combination of two or more substances

2) Physical changes

- Not change identity, but change state of substances

2. State characteristic

Solid	Liquid	Gas
Physical properties		
- Particles can vibrate about a fixed point - forces of attraction is very strong and keeps them in a fixed place.	- Particles are free to flow over each other - but the force of attraction between the particles is strong enough to keep them together	- Particles are completely free to move around wherever they want - force of attraction between particle is negligible
Cannot be compressed (there are no spaces between the particles)	Cannot be compressed (they actually can be just a little bit because of the small spaces between the particles)	Can be compressed (there are lots of spaces between particles)
Cannot be poured (unless they are in large lumps, like sand or beads, they can act to "pour")	Can be poured (because the particles can flow over each other)	Can be poured (e.g. carbon dioxide can be poured in air, because it is denser than air)
Fixed volume	Fixed volume	No fixed volume (they expand to take the volume of the container)
Shape depends on solid (Some shapes have fixed shapes (rocks) some solids have no fixed shapes (clay))	Takes the shape of the container (Liquids fill the shape of the container, and always finds horizontal level at the surface)	Takes the shape of the container (gases expand and fill the shape of the container)
Particle theory		
Forces of attraction (intermolecular bonds) are much stronger than the energy of the particles . Therefore the particles do not possess enough energy to break away from the bonds holding each other in fixed points.	Energy of the particles is greater than the forces of attraction (intermolecular bonds), so they can move around. However they do not possess enough energy to completely break away from the bonds, so they are still together.	Energy of the particles is much greater than the forces of attraction (intermolecular bonds), so the particles are completely free to move around wherever they can.
Forces of attraction >>> Energy of particles	Energy of particles > Forces of attraction	Energy of particles >>> Forces of attraction

3. Diffusion in fluids

Dissolving in fluids

- Example of potassium manganate crystal
 - Water around crystal - becomes purple
 - Particles move off the surface of the crystal into water
 - Crystal dissolves completely - whole solution becomes purple

Diffusion

- The process by which different fluids mix as a result of the random motions of their particles
- Involves movement of particles from a region of higher concentration towards a region of lower concentration
- Doesn't take place in solids
- In liquids is much slower than in gases

Relevant kinetic theory of Diffusion

- Heavier particles move slowly than lighter particles at the same temperature
 - Large molecules slower than smaller ones
- Pressure of a gas - result of collisions of the fast moving particles with the walls of the container
- Average speed of the particles increase with an increase in temperature

C2.04 The structure of the atom

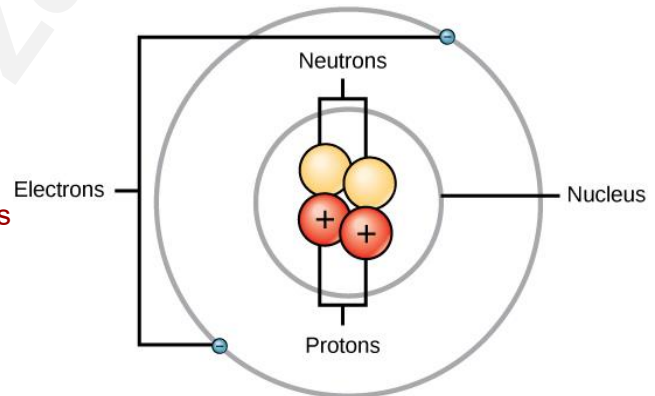
1. Measuring the size of atoms

Spectrometer: Carbon as a standard - give **relative atomic mass**

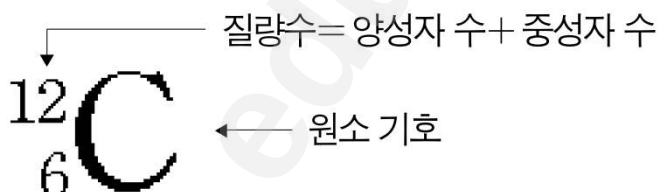
2. Sub-atomic particles

Electron- same number as proton

- Hydrogen - only atom without neutron



Sub-atomic particle	Relative mass	Relative charge	Location in atom
Proton	1	+1	In nucleus
neutron	1	0	In nucleus
electron	1/1840	-1	Outside nucleus



질량수: nucleon(mass) num.

원자 번호 = 양성자 수 = 중성 원자의 전자 수
 원자번호: proton(atomic) num

3. Isotopes

Isotopes: Same proton number but different nucleon number

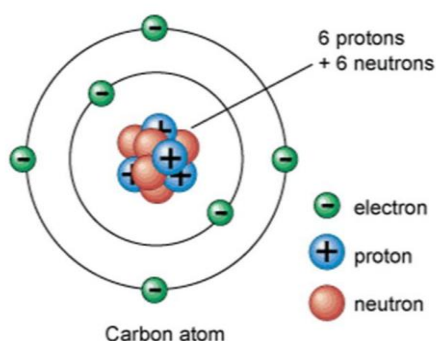
- Same chemical properties - bonds & reacts same
- Different physical properties - density, diffusion rate vary
- **Radioisotopes**: unstable - nuclei break up - radiation

4. Relative atomic mass

Relative atomic mass(A_r): The average mass of naturally occurring atoms of an element on a scale where the carbon atom has a mass of exactly 12 units

C2.05 Electron arrangement in atoms

1 Carbon Atom



- Shell which is further from the nucleus has higher energies
- Shells = energy levels