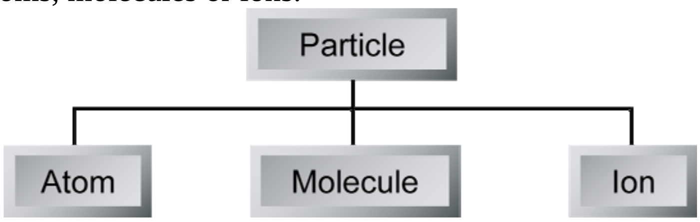
The structure of Atom I

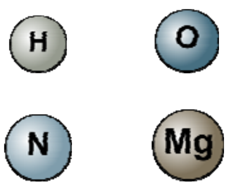
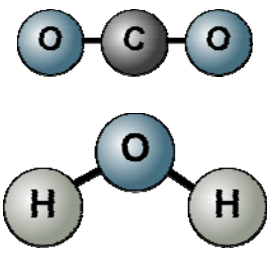
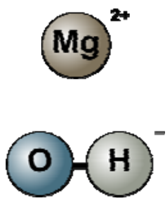
Matter

<u>Matter</u>
Matter is anything that occupies **space** and has **mass.**

<u>The particle theory of matter</u>
The particle theory of matter states that matter is made up of a large number of **tiny** and **discrete** particles.

<u>Atom, Molecule and Ion</u>
The particles can be atoms, molecules or ions.

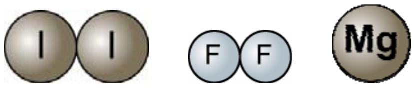
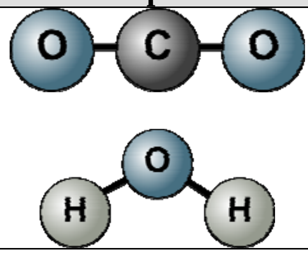


Atom	Molecule	Ion
The atom is the smallest, indivisible particle of an element. Atoms of the same element are exactly alike and are different from the atoms of all other elements.	Molecules are the smallest particles of an element or compound that are made up of two or more atoms.	Ions are particles that are charged due to loss or gain of electrons. Ions which are positively charged are called **cations**. Ions which are negatively charged are called **anions**.
Example: 	Example: 	Example: 

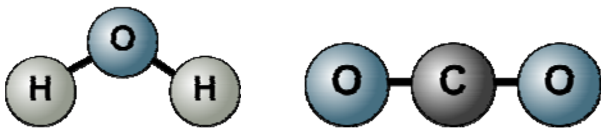
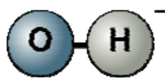
Element and Compound

1. Matter can either exist as an **element** or a **compound.**

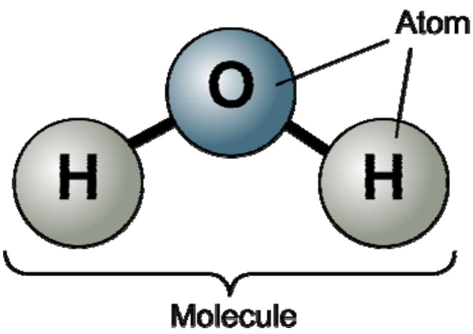
Element	1. <u>Chemical element</u> is the class of atoms with the same number of protons in the nucleus. 2. An element consists of only one type of atom. 3. Element can be either atoms or molecules.
Compound	1. A compound is any substance composed of identical molecules consisting of atoms of two or more elements. 2. A compound is made up of either molecules or ions.

Element	Compound
	

Example

	
Atom and element	Molecule and element
	
Molecule and compound	Ion and compound

Or



Particulate nature of matter

Diffusion

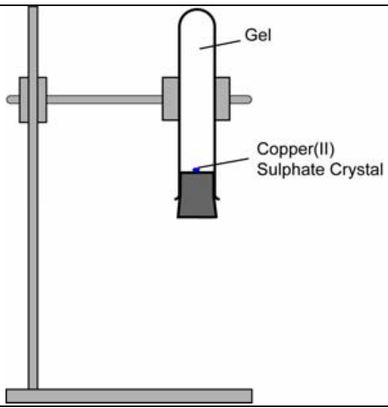
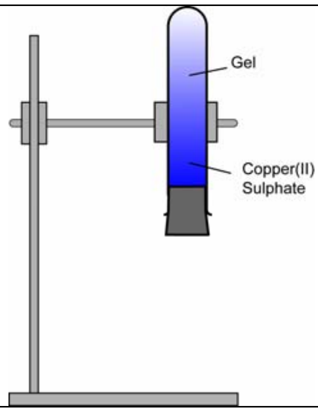
> **<u>Diffusion</u>**
> Diffusion is a process resulting from random motion of molecules by which there is a net flow of matter from a region of high concentration to a region of low concentration.

1. Diffusion is the movement of particles from higher concentration to lower concentration.
2. It is a physical process rather than a <u>chemical reaction</u>.
3. In diffusion, the particles of one substance mingle and move through the particles of another substance.
4. The rate of diffusion is proportional to the average velocity of the particles in matter.

Example of diffusion

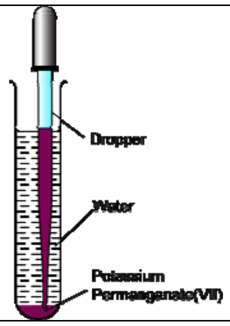
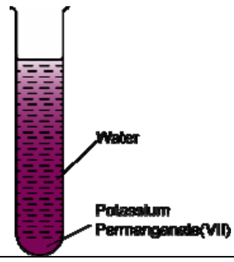
Diffusion in Solid

1. Copper(II) sulphate crystals are made of copper(II) ions and sulphate ions which are tiny and discrete.
2. The particles in the copper(II) sulphate crystal will separate to become ions and diffuse randomly upwards until the whole agar turns blue.
3. Diffusion of solid is defined operationally as the random movement of particles to all directions in a solid.

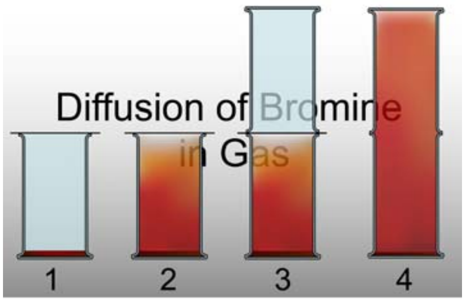
	
Before	**After 1 day**

Diffusion in Liquid

1. Diffusion has taken place in the liquid.
2. The rate of diffusion of the particles in water is faster than the diffusion rate of particles in solid.
3. The occurrence of diffusion proves that potassium permanganate(VII) consist of tiny and discrete particles.

	
Before	**After 30 minutes**

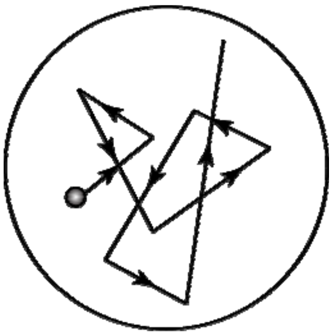
Diffusion in Gas



1. Bromine vapour is made of tiny and discrete molecules that move randomly to fill up space.
2. Bromine vapour moves randomly and diffuses in all directions in air from areas of higher concentration to areas of lower concentration.

Brownian motion

1. **Brownian motion** is the physical phenomenon that minute particles immersed in a fluid move about randomly.
2. It was named for the Scottish botanist Robert Brown, the first to study such fluctuations
3. Brownian movement, an example of diffusion, supports the kinetic theory of matter.
4. Examples of Brownian movement are
   (a) movement of smoke particles in air
   (b) movement of pollen grains in water



Brownian Movement

Kinetic Theory of Matter

1. The characteristics of matter can be described using the kinetic theory of matter.

> The kinetic theory of matter explains the state of matter in solid, liquid and gaseous states based on the following assumptions:
> a) The gas consists of very small particles, each of which has a mass.
> b) These molecules are in constant, **random motion**. The rapidly moving particles constantly collide with each other and with the walls of the container.
> c) There are forces of attraction between particles of matter. These attraction forces will increase as the distance between the particles becomes closer.
> d) The average kinetic energy of the gas particles depends only on the temperature of the system. The higher the temperature, the higher the kinetic energy of the particles.

[The Following Experiment in NOT in the Latest SPM Syllabus]

Activity **To Estimate the Size of an Oil Molecule**

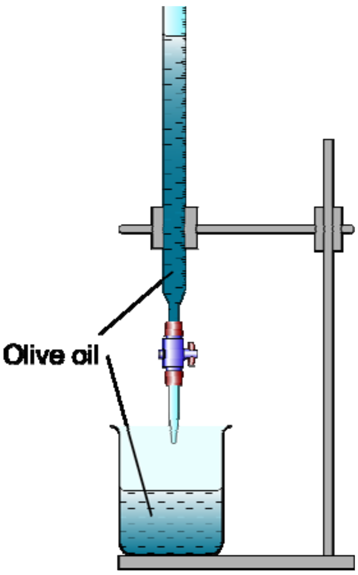
Hypothesis The size of an oil molecule is extremely tiny, in the range of 10-7 cm.

Variables (a) Manipulated : Volume of an oil patch.
(b) Responding : Diameter of an oil patch on the water surface.
(c) Constant : Type of oil.

Materials Palm oil (50cm^3), water, lycopodium powder.

Apparatus Retort stand, burette, beaker, glass rod, petri dish, filter paper, tray

Procedure

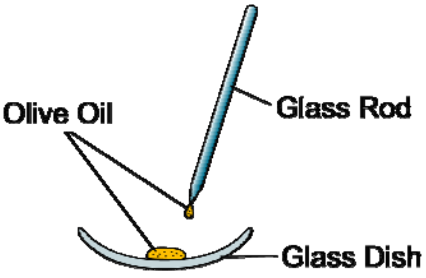


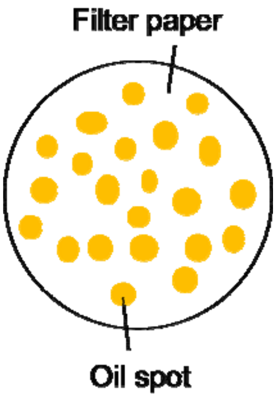
A Find the volume of 50 drops of oil.

1. The burette is filled up with 50 cm^3 of palm oil. The reading is recorded as X cm^3.
2. 50 drops of oil are dropped from the burette into a beaker., the reading is recorded as Y cm^3.
3. The volume of 50 drops of oil is determined.

Initial burette reading = X
Final burette reading = Y
Volume of 50 oil drops = (Y – X) cm^3

$$\text{Volume of one oil drop} = \frac{Y - X}{50}\ \text{cm}^3$$





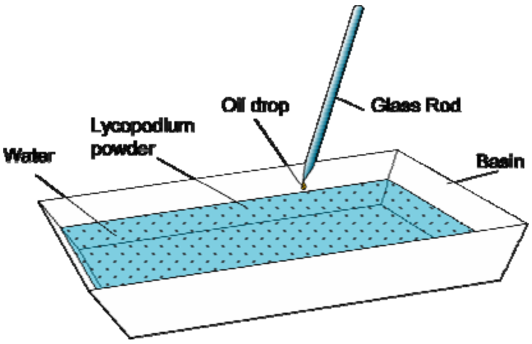
B Find the volume of one oil spot

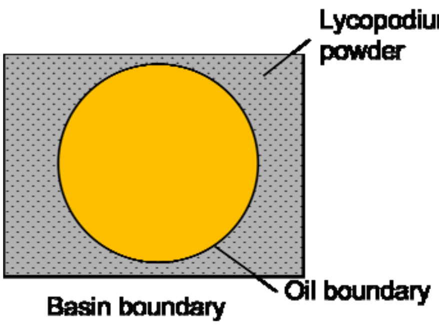
1. A drop of oil is dropped onto a petri dish.
2. By using a fine-tipped glass rod, the oil drop is touched and a tiny drop of oil (droplet) is transferred onto the filter paper.
3. This step is repeated and the number of droplets in one drop of oil is counted until no more oil patches are formed on the filter paper.
4. The number of oil spots on the filter paper is counted and recorded as ***n***.

Number of oil spots on the filter paper = ***n***

$$\text{Volume of one oil spot, } V = \frac{Y - X}{50} \div n$$

$$= \frac{Y - X}{50n}\,\text{cm}^3$$





C Estimating the size of an oil molecule

1. A clean basin is filled with water to a depth of approximately 5 cm.
2. A layer of lycopodium powder is sprinkled lightly over the surface of the water.
3. Using the fine-tipped glass rod, an oil droplet is transferred from the beaker onto the water by touching the tip of the glass rod to the centre of the water surface.
4. The oil will spread rapidly, leaving a layer of oil pushed to one side.
5. The diameter of the oil patch that forms on the water surface is measured and recorded as *d* cm.

Calculation

The oil drop on the water is in the shape of a cylinder with a thickness of one molecule of oil. If the thickness of the oil spot = *t*

$$\text{Volume of oil, V} = \pi\left(\frac{d}{2}\right)^2 t$$

$$t = \frac{4V}{\pi d^2}\,cm$$

Discussion

1. The purpose of spreading the lycopodium powder on the surface of the water is to enable the boundary of the palm oil that has spread to be seen clearly. Thus the diameter of the oil layer can be measured accurately.
2. If the water surface is large, the thickness of the oil layer is approximately the size of an oil molecule.
3. There are two assumptions made in the calculation in this experiment.
   (a) The oil layer on the water surface is one molecule thick. Hence the thickness of the oil layer is the diameter of an oil molecule.

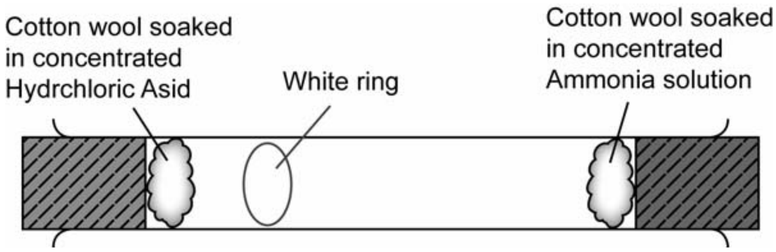
(b) The oil molecule is assumed to be spherical.
4. The actual size of an oil molecule could be smaller than that calculated from the experiment because the oil layer could be several molecules thick.
5. As each oil molecule contains many atoms, the diameter of an atom must be even smaller.

Precaution
1. Ensure that the surface of the water is clean so that a uniform circle of oil drop can be formed.
2. Ensure that they is no wind blow at surrounding so that the surface of the water is still before the oil drop is placed on it.

Conclusion
1. Oil consists of tiny and discrete particles as stated in the particle theory of matter.
2. The diameter of an oil molecule is estimated to be 10^{-7} cm.

Structure Question

Diffusion



The above Diagram shows two cotton wools soaked with concentrated hydrochloric acid and concentrated ammonia solution respectively, placed in a long tube.. After a few minutes, a white fume of ammonium chloride is observed.

Write down the equation of the reaction.

$$HCl + NH_3 \longrightarrow NH_4Cl$$

[1 mark]

Why does the tube need to be plugged at both ends?

So that the vapour of ammonia and hydrochloric acid do not escape to the surrounding.

The mass [1 marks]

Why the tube is placed horizontally?

To avoid the effect of gravitational pull.

[1 mark]

Why does the white fume form nearer to the cotton wool soaked in concentrated hydrochloric acid?

The mass of ammonia molecule is much lower than hydrochloric acid molecule; it can diffuse faster in the air compare to hydrochloric acid and move further in a given time. Therefore the white fume formed nearer to the hydrochloric acid.

[2 mark]

Why does it take several minutes before the white fume appears?

The collision between the ammonia molecule/hydrochloric acid molecule with the air molecule slow down the diffusion rate. Therefore the ammonia molecule and hydrochloric acid molecule take longer time to meet each other.

[2 marks]