



## 1 States of matter

### 1.1 Solids, liquids and gases

#### Core

- 1 State the distinguishing properties of solids, liquids and gases
- 2 Describe the structures of solids, liquids and gases in terms of particle separation, arrangement and motion
- 3 Describe changes of state in terms of melting, boiling, evaporating, freezing and condensing
- 4 Describe the effects of temperature and pressure on the volume of a gas

#### Supplement

- 5 Explain changes of state in terms of kinetic particle theory, including the interpretation of heating and cooling curves
- 6 Explain, in terms of kinetic particle theory, the effects of temperature and pressure on the volume of a gas

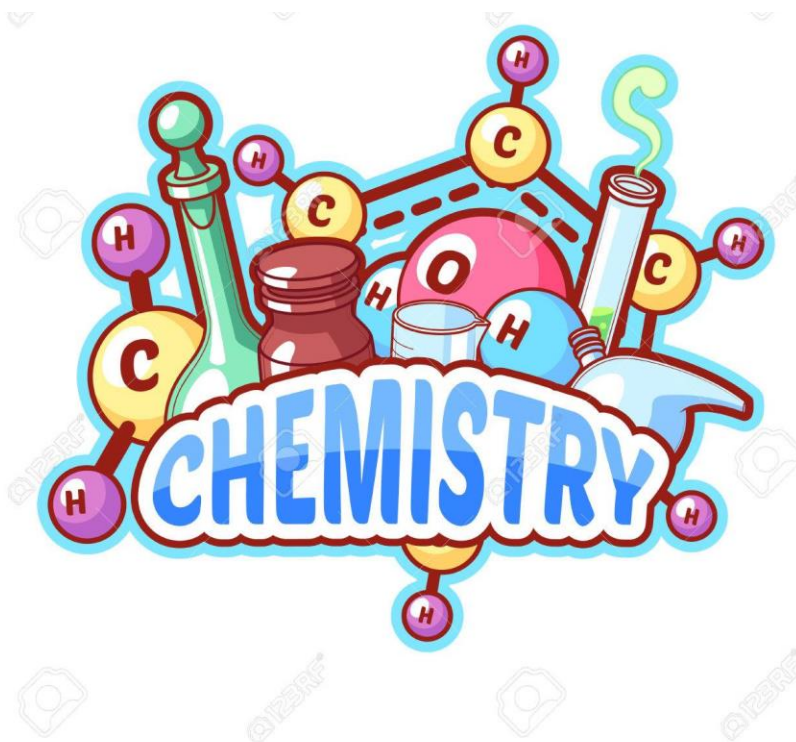
### 1.2 Diffusion

#### Core

- 1 Describe and explain diffusion in terms of kinetic particle theory

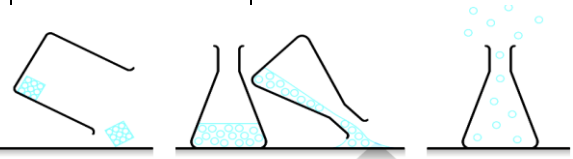
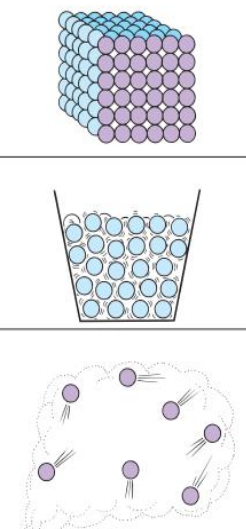
#### Supplement

- 2 Describe and explain the effect of relative molecular mass on the rate of diffusion of gases



**Matter** is anything which occupies space and has a mass

Property	Solid	Liquid	Gas
<b>Arrangement [distance &amp; pattern]</b>	Very close & regularly arranged forming lattice	Close & irregular (random)	Further apart & random
<b>Separation</b>	Packed close to each other	Close to each other but less than solid	Very far apart
<b>Type of motion</b>	Vibrate at their position	Slide over each other	Move quickly & in all directions
<b>Force of attraction</b>	Very strong	Less strong	Weak (Not exist)
<b>Volume &amp; shape</b>	Fixed volume & shape	Fixed volume & takes the shape of the container	No fixed volume & takes the shape of the container

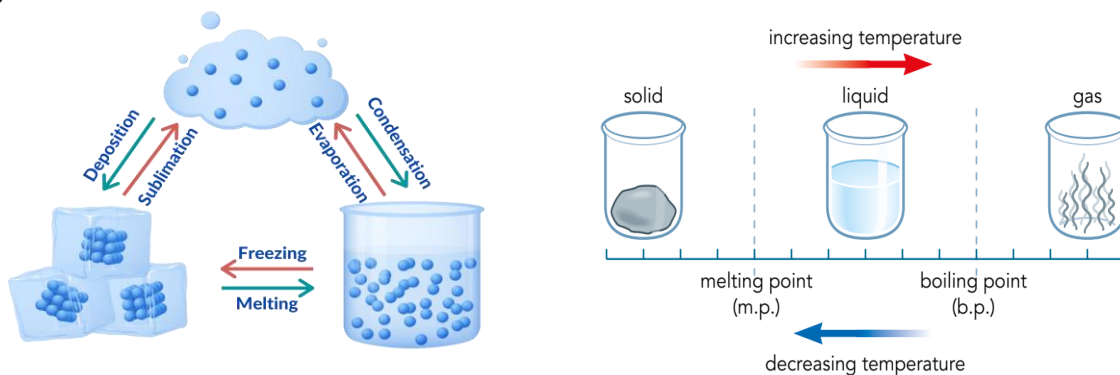


A solid cannot flow. It has a definite shape and volume.

A liquid can flow; it is a fluid. It has a definite volume but takes the shape of its container.

A gas is a fluid and spreads throughout its container. It has no definite volume.

### Changes of state



Remember that **deposition, freezing & condensation** are **exothermic** processes

Remember that **sublimation, melting & boiling** are **endothermic** processes

#### Examples of sublimation

Ammonium chloride/Dry ice (solid carbon dioxide)/Iodine



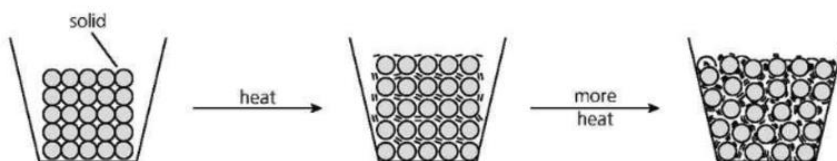
**1** Ice changes to water when it is warmed. This change is called **melting**. The thermometer shows  $0^{\circ}\text{C}$  until all the ice has melted. So  $0^{\circ}\text{C}$  is called its **melting point**.

**2** When the water is heated, its temperature rises. As it warms up, some of it changes from liquid to gas, which goes into the air. This is called **evaporation**.

**3** Now the water is **boiling**. It evaporates fast. The gas it forms is called **steam**. The thermometer shows  $100^{\circ}\text{C}$  while the water boils off.  $100^{\circ}\text{C}$  is its **boiling point**.

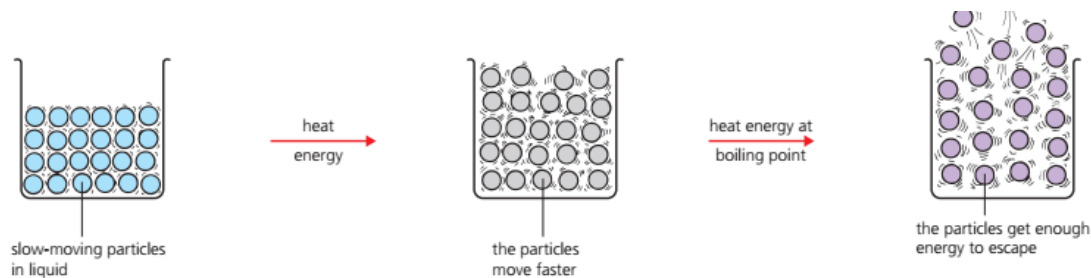


### In Melting



By heating the particles their K.e. increases so the temperature rises and the particles vibrate more. When the temperature reaches the melting point, the energy gained by the particles will be enough to break (or weaken) the attractive forces holding the solid particles and finally the solid changes into liquid

### In Boiling



By heating the particles, they gain more energy, so the kinetic energy increases and they move faster. The reading of the thermometer will increase. At the boiling point the energy supplied is no longer increasing the kinetic energy of the particles but it breaks the forces of attraction between the particles in the liquid state and the particles enter the gas state by moving randomly quickly in all directions.

**Melting and freezing** take place at the same temperature

**Boiling and condensation** take place at the same temperature



1. Remember that **evaporation** takes place below the boiling point at any temperature over a range of temperatures, while **boiling** takes place at definite temperature.

2. In **evaporation** some particles in the surface of the liquid have enough energy to escape from the surface to become a gas, they are faster than other particles in the liquid, so evaporation takes place only at the liquid surface, which is different than **boiling** where the gas bubbles come from the inside of the liquid throughout it.

3. **Boiling** is faster than **evaporation**.

4. In **boiling** bubbles are seen while in **evaporation** no bubbles.

Boiling	Evaporation
Occurs at <b>fixed</b> temperature	Occurs at <b>any</b> temperature
Quick Process	Slow Process
Takes place <b>throughout</b> the liquid	Takes place only at the liquid <b>surfaces</b> .
<b>Bubbles</b> are formed in the liquid	<b>No bubbles</b> are formed in the liquid

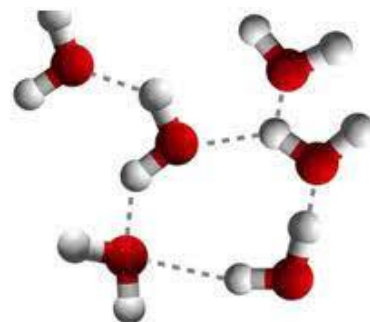
**REMEMBER**

**volatile:** term that describes a liquid that evaporates easily; it is a liquid with a low boiling point because there are only weak intermolecular forces between the molecules in the liquid

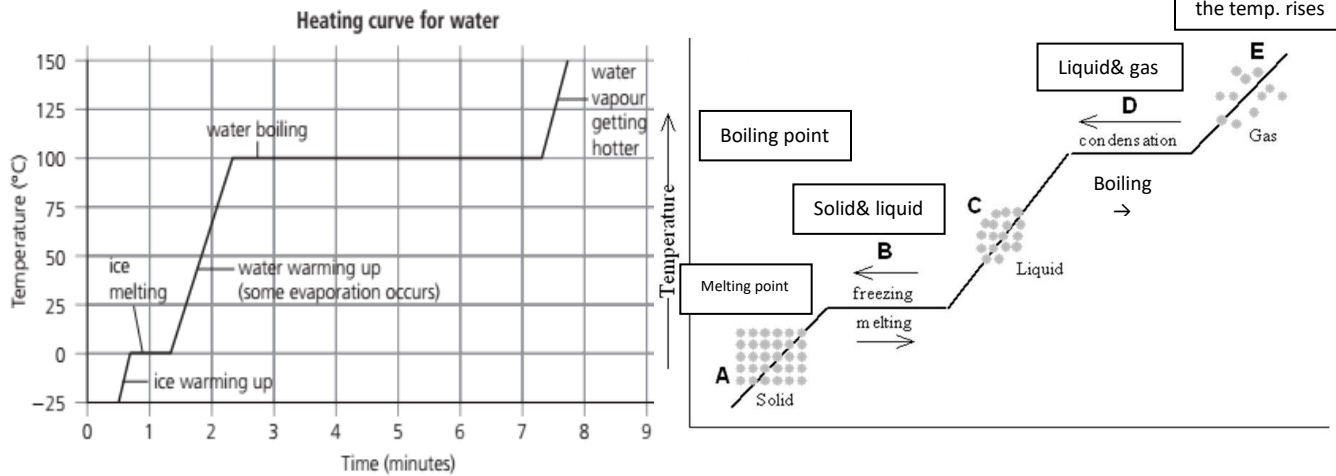
### How much heat is needed?

The amount of heat needed to melt or boil a substance is different for every substance. That's because the particles in each substance are different, with different forces of attraction between them.

The stronger the forces, the more heat energy is needed to overcome them. So the higher the melting and boiling points will be.



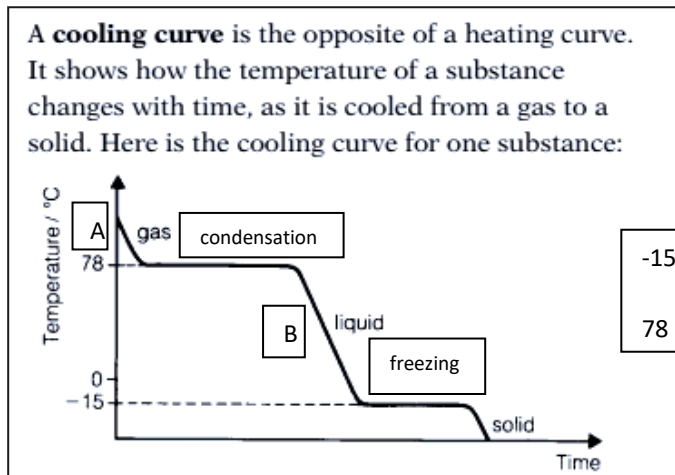
## Heating curve:



Remember that during A, C the heat increases the K.E. of the particles and the temperature rises so the particles **vibrate faster** if they are **in solid state (A)** or **move faster** if they are **in a liquid state (C)**.

Remember that at the melting (B) and the boiling (D) points the thermometer does not show any rise in the temperature because the energy gained by heating will not increase the kinetic energy of the molecules as it becomes enough to overcome the attraction forces between the molecules and they change from state to another, these changes are endothermic.

The temperature will not rise anymore during melting till all the solid particles melt (solid to liquid) and during boiling till all the liquid particles boil (liquid to gas).

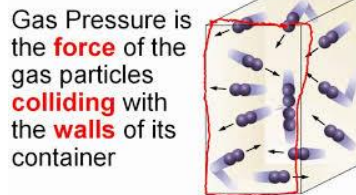


-15 is the melting/freezing point  
78 is the boiling/condensation point

During (A), the particles move more slowly, the kinetic energy of the particles decreases so the temperature decreases. During condensation, no decrease in the temperature, the particles

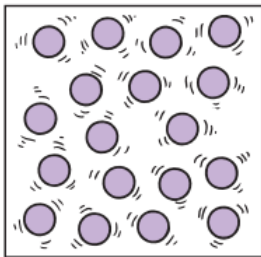
become closer to each other and stronger attractive forces hold the molecules together until the gas is completely condensed to liquid, during this energy is given out (exothermic reaction).

During (B), the particles of the liquid slow down, the kinetic energy of the particles again decreases, so the temperature decreases. During the freezing, no decrease in the temperature, the particles become much closer and stronger attractive forces hold the molecules together until the liquid is completely freezed into solid, during this energy is given out (exothermic reaction).

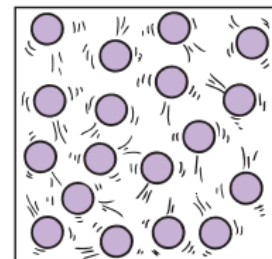
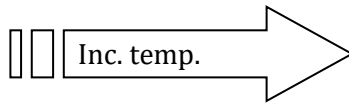


**When you heat a gas**

1. Effect of temperature on pressure



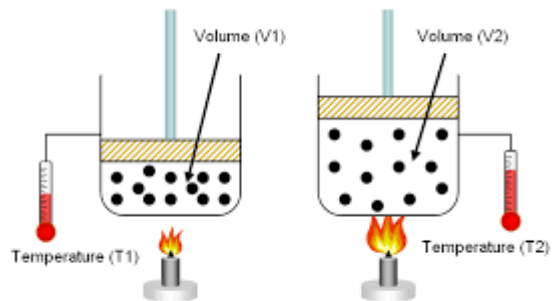
The particles in this gas are moving fast. They hit the walls of the container and exert pressure on



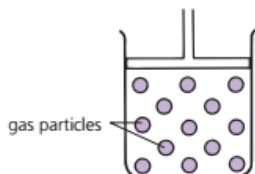
... the particles take in heat energy and move even faster. They hit the walls more often, and with more force. So the gas pressure increases.

2. Effect of temperature on volume

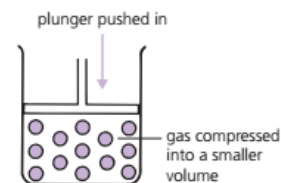
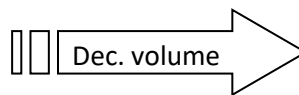
The same is true for all gases, at constant pressure:  
**When you heat a gas, its volume increases.**  
**When you cool a gas, its volume decreases.**



3. Effect of volume on pressure



There is a lot of space between the particles in a gas. You can **compress** the gas, or force its particles closer, by pushing in the plunger ...



... like this. Now the particles are in a smaller space – so they hit the walls more often. So the gas pressure increases.

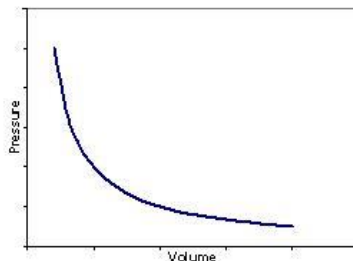
Remember that gases can **expand and compress** the easiest due to the **wide spaces** between the particles and the **fast random motion** of the gas particles in all directions.

4. Effect of pressure on volume

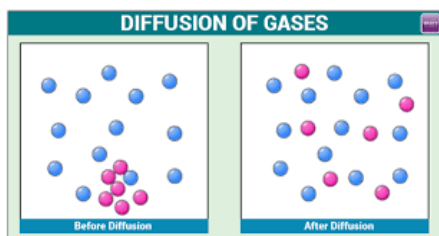
**An increase in pressure means a decrease in volume, for a gas.**  
**A decrease in pressure means an increase in volume, for a gas.**

Changing the external pressure on a sample of a gas produces a change in volume that can easily be seen.

- An increase in external pressure produces a contraction in volume. The gas is compressed.
- A decrease in external pressure produces an increase in volume. The gas expands.



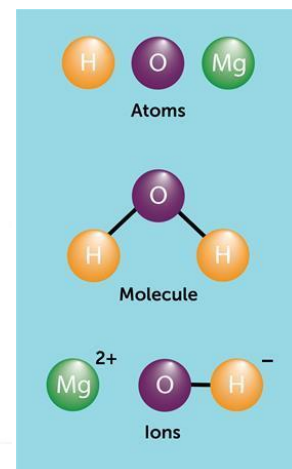
### Diffusion



It is the process of **mixing of particles** due to **collision of particles with each other** from a region of **high concentration to a region of low concentration**

The particles are:

- The smallest particles, that we cannot break down further in chemical reactions, are called **atoms**.
- In some substances, the particles are just single atoms. For example, air contains single atoms of argon.
- In many substances, the particles consist of two or more atoms joined together. These particles are called **molecules**. Water and bromine exist as molecules. Air is mostly nitrogen and oxygen molecules.
- In other substances the particles are atoms or groups of atoms that carry a charge. These particles are called **ions**.



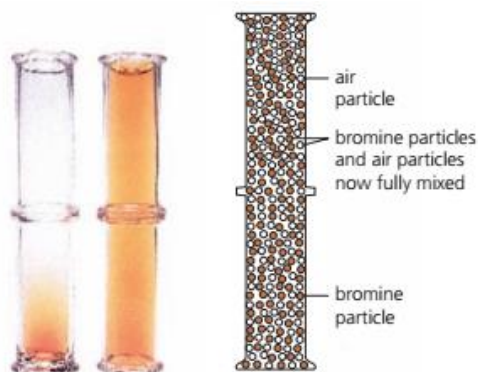
## Evidence in the lab



**1** Place a crystal of potassium manganate(VII) in a beaker of water. The colour spreads through the water. Why? First, particles leave the crystal – it **dissolves**. Then they mix among the water particles.

Remember that diffusion of **solid** in liquid takes place in 2 steps consequently

1. Dissolving
2. Diffusion(mixing)

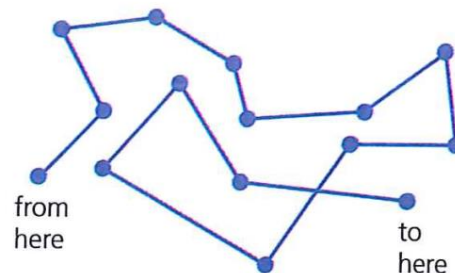


**2** Place an open gas jar of air upside down on an open gas jar containing a few drops of red-brown bromine. The colour spreads upwards because particles of bromine vapour mix among the particles of air.

The colour spreads because the particles of bromine vapours are mixed with the air molecules (mainly the nitrogen molecules) due to the collision between them in all directions from a region of high concentration to a region of low concentration.

How to write the answer for any given example?

The answer: The particles (.....) of **substance A** mixed with particles (.....) of **substance B** due to collision between the particles. They move randomly from a region of high concentration into low



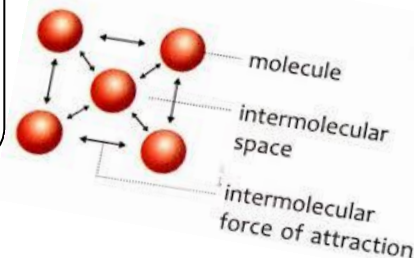
**The rate of diffusion depends on 2 factors:**

- 1.The mass: as the relative molecular mass decreases, the speed increases so the particles diffuse faster (the rate of diffusion increases)
- 2.The temperature: as the particles are heated their kinetic energy increases and they move faster so they diffuse fast (the rate of diffusion increases)

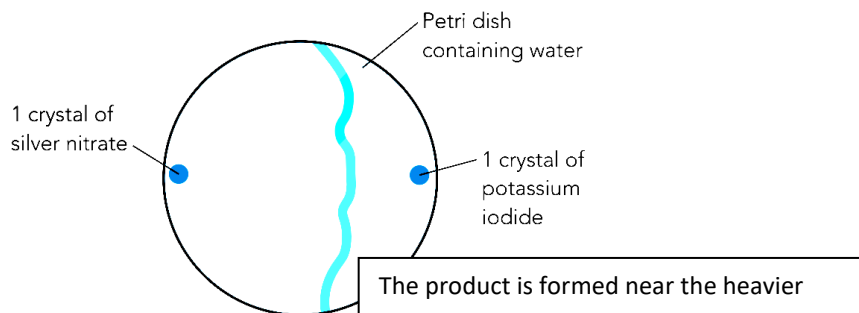
**intermolecular space:** the space between atoms or molecules in a liquid or gas. The intermolecular space is small in a liquid, but relatively very large in a gas.

**Remember that diffusion is fastest in gases due to**

- 1.the rapid movement of the gas particles
- 2.their small relative molecular mass
- 3.the wide spaces between the particles



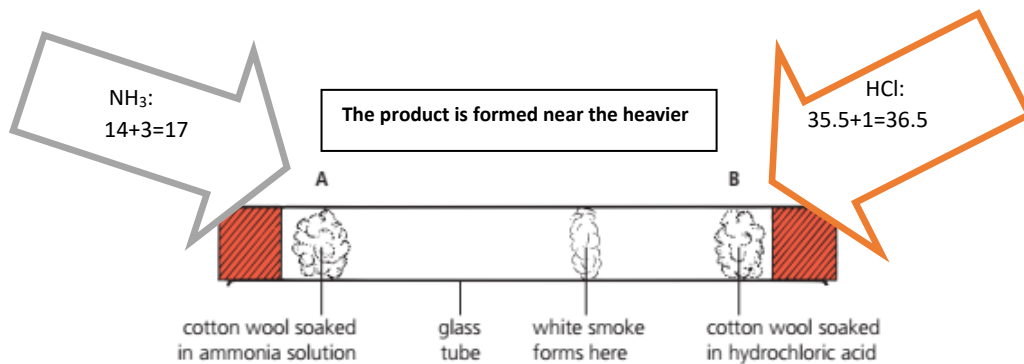
## APPLICATIONS



Remember that **dissolving takes place before diffusion**.

The creamy ppt of silver iodide is formed near potassium iodide because the particles of silver nitrate have lower relative molecular mass so they have higher speed and diffuse faster and the product is not formed in the the middle

Precaution: You should wear gloves because silver nitrate is corrosive and can stain the skin

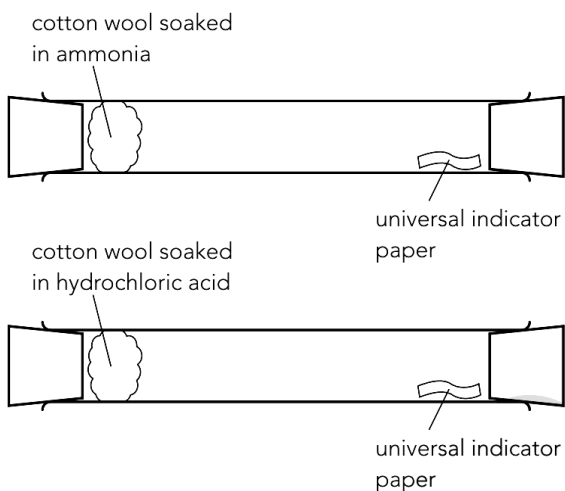


Remember that **evaporation takes place before diffusion** if the reaction will take place between vapours.

Where the particles of ammonia have lower relative molecular mass so they have higher speed and diffuse faster. The product is not formed in the middle

Precaution: This experiment is performed in a fume cupboard, where hydrogen chloride gas reacts with ammonia gas to form a cloud of white solid ammonium chloride

The same concept is applied if methylamine is used instead of ammonia, its Mr= 31

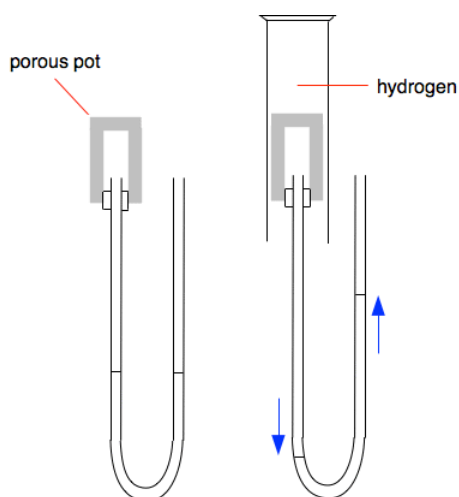


The change in the **colour** of the indicator paper depends on the **nature** of the gas particles

$\text{NH}_3$  turns damp indicator paper into blue,  $\text{HCl}$  turns damp indicator paper into red

The **rate** of the change in the colour depends on the rate of the **diffusion**

The relative molecular mass of  $\text{NH}_3$  is smaller than  $\text{HCl}$  so it diffuses faster and it takes less time to change the colour of the indicator paper



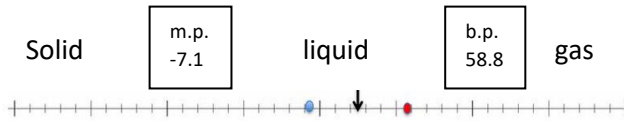
When hydrogen is placed outside the porous pot, hydrogen gas has low relative molecular mass so it can diffuse through the porous pot pressing on the liquid changing its level.

### Applications of diffusion outside the lab

Cooking smells spread. The smells are due to food particles which spread because they are collided (bombarded) by air particles.



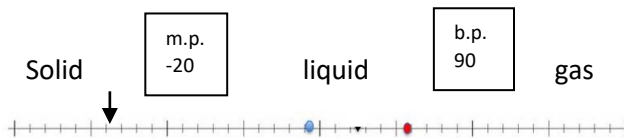
**Remember**



At **25°C** the state of X is .....

Because **25°C** is above its melting point and below its boiling point

-Its state is liquid



At **-25°C** the state of Y is .....

Because **-25°C** is below its melting point and below its boiling point

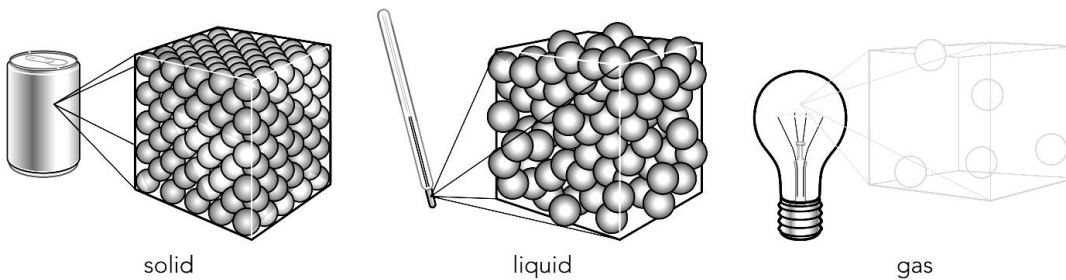
-Its state is solid

**STUDY**

At a given temperature **below the melting point** the substance is **solid**

**Between the melting and boiling points** the substance is **liquid**

**Above the boiling point** the substance is **gas**



### Tips

1. **Solids have definite shape** because the particles are just vibrating in their fixed position
2. **You can not store gases in open containers** because they are moving quickly everywhere outside the container
3. **You can not squeeze a sealed plastic syringe that is completely full of water** because they are no spaces between the particles to become closer to each other
4. **When two solids are placed on top of each other, they do not mix** because the particles of the solid are fixed in their position
5. **Poisonous gases from a factory chimney can affect a large area** because the gas particles diffuse quickly everywhere through the air by colliding with the air particles
6. **In the darkened cinema the dust particles appear to dance in the beam of light** because the dust particles are collided with the air particles