

- The use of kinetic theory to explain the different states of matter.
- Simple diagrams to illustrate the difference between solids, liquids and gases.
- The particles of solids, liquids and gases have different amounts of energy.

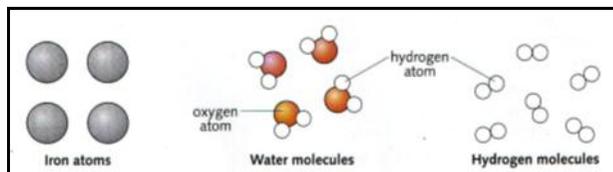
### KINETIC THEORY OF MATTER

- **Kinetic theory** is an idea or model which enables us to have a clearer understanding of the behaviour of matter in different situations.
- According to kinetic theory, all matter is made up of **tiny particles\*** which are **continually moving**. The **higher the temperature** of a substance, the **faster** its particles are moving.

\* There are **118 elements** from which everything is made up.  
An **atom** is the smallest possible amount of an element.  
A **molecule** consists of two or more atoms which are chemically bonded together.

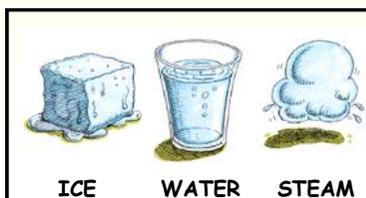
In elemental substances, such as iron for example, the 'moving particles' referred to in kinetic theory are atoms.

In most substances however, the 'moving particles' are in fact molecules. For example, in water ( $H_2O$ ) the particles are molecules consisting of 2 atoms of hydrogen chemically bonded to an atom of oxygen.



- The three main states in which matter can exist are **solid, liquid and gas**. We are used to seeing some substances in all three states... water, for example, is quite familiar as ice, water and steam.

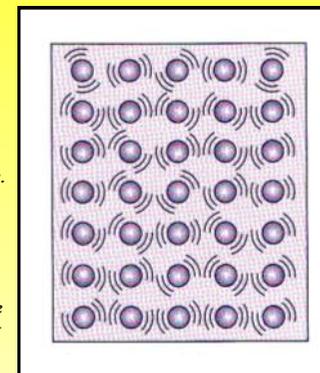
Some substances are usually only experienced in one state ... e.g. iron as a solid and hydrogen as a gas.



### SOLIDS

The particles in a **solid** :

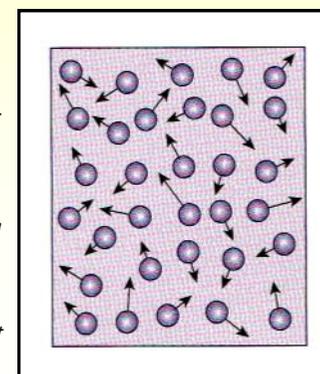
- Are **packed closely together**. *This is why solids are often very dense and very difficult to compress.*
- Are **held in a fixed pattern** or crystal structure by strong forces which act between them. *This is why solids have a definite shape.*
- **Vibrate about their fixed positions** in the structure. *When a solid is heated, the particles vibrate more rapidly and their separation increases. We notice the increase in kinetic energy of the particles as a rise in the solid's temperature and the increased separation means that the solid expands.*



### LIQUIDS

The particles in a **liquid** :

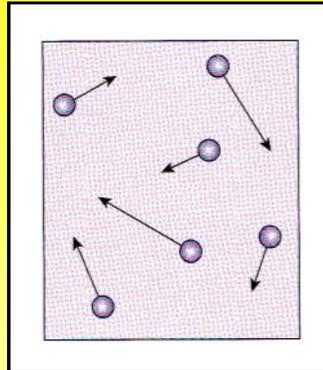
- Are **almost as tightly packed as they are in solids**. *This is why liquids are also very difficult to compress.*
- Are **held together by attraction forces**, but there is **no fixed pattern** and they can **move rapidly past each other in all directions**. *This is why liquids have a definite volume, but unlike solids, they take the shape of the lower part of the vessel which contains them.*
- Are also **vibrating, but not about fixed positions**. *When a liquid is heated the particle movement becomes more energetic and their separation increases more dramatically than it does in solids. This is seen as a rise in temperature and an expansion which is larger than that in solids.*



**GASES**

The particles in a gas:

- Are **very widely separated** (about 10 x further apart than in a liquid). *This is why gases have very low densities, no fixed shape and are so compressible.*
- Have **no fixed positions** and the forces between them are very weak.
- Are in a state of **continuous, rapid, random motion**. *This is why a gas will occupy all the space which is available to it.*



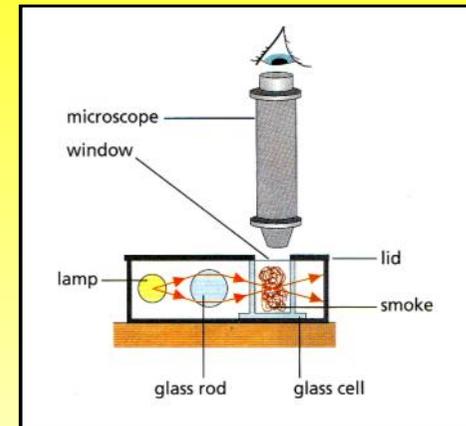
**SUMMARY OF THE PROPERTIES OF SOLIDS, LIQUIDS AND GASES**

PROPERTY	SOLID	LIQUID	GAS
Definite shape.	YES	NO	NO
Can be significantly compressed.	NO	NO	YES
Comparative density.	HIGH	HIGH	LOW
Ability to flow (fluidity).	NO	YES	YES
Ability to transmit forces.	YES	NO	NO
Expands to fill all available space.	NO	NO	YES

**PRACTICAL WORK**

**1. BROWNIAN MOTION**

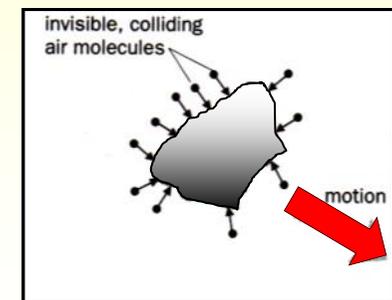
- A small glass cell is filled with smoke and then closed with a thin glass window. The cell is illuminated as shown and the smoke is viewed through the microscope.



Careful adjustment of the microscope allows the observer to see bright specks **jiggling around haphazardly**. These specks are smoke particles which are made visible as the light reflects off them.

The effect, known as **Brownian Motion** provides evidence in favour of the kinetic theory explanation of the motion of gas particles (molecules).

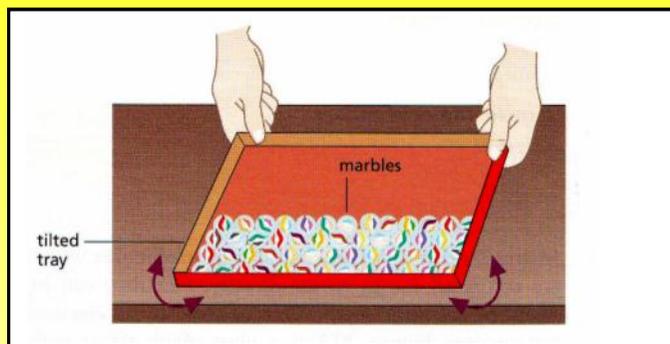
- The smoke particles are much bigger than the air molecules, but have such a small mass that they are jostled about as thousands of air molecules bump into them at random.



The net effect is that the smoke particles are pushed around, first in one direction and then in another, causing the observed **jiggling** motion.

## MODELLING A LIQUID

- The **liquid state** can be modelled using marbles (to represent the molecules) in a shallow, tilted tray as shown in the diagram below.



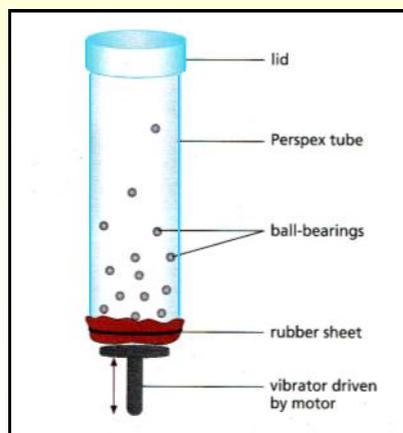
When the tray is shaken to and fro:

- The marbles can be seen to move around, but most stay in the lower half of the tray (*This shows that a liquid has a definite volume.*)
- A few marbles actually jump into the upper half of the tray (*These represent the more energetic liquid molecules which evaporate from the surface and become gas molecules.*)

## MODELLING A GAS

- The small ball-bearings represent the **molecules in a gas**. The greater the frequency of vibration, the more often the ball-bearings have collisions with the lid, the tube and with each other. This represents a **gas at higher temperature**.

If a polystyrene ball of about 1 cm diameter is dropped into the tube, it is seen to move about irregularly as it is hit by the ball-bearings. This represents **Brownian motion**.



- According to **kinetic theory**, what does matter consist of?
  - Name the **three main states** in which matter exists.
  - Name a common substance which we are used to seeing in all three states. What is the name given to this substance in each of the states.
- For each of the three states of matter, what can you say about :
  - The **relative separation of the particles**.
  - The **way in which the particles are arranged** and the **strength of the forces between them**.
  - The **motion of the particles**.
- Use **kinetic theory** to explain each of the following :
  - Solids are often **very dense** and **almost incompressible**.
  - Solids **expand when they are heated**.
  - Liquids and gases **can flow**, but solids **cannot flow**.
  - Gases have a **very low density** and they are **easy to compress**.
  - A gas will **occupy all the space which is available to it**.