Particle model of matter

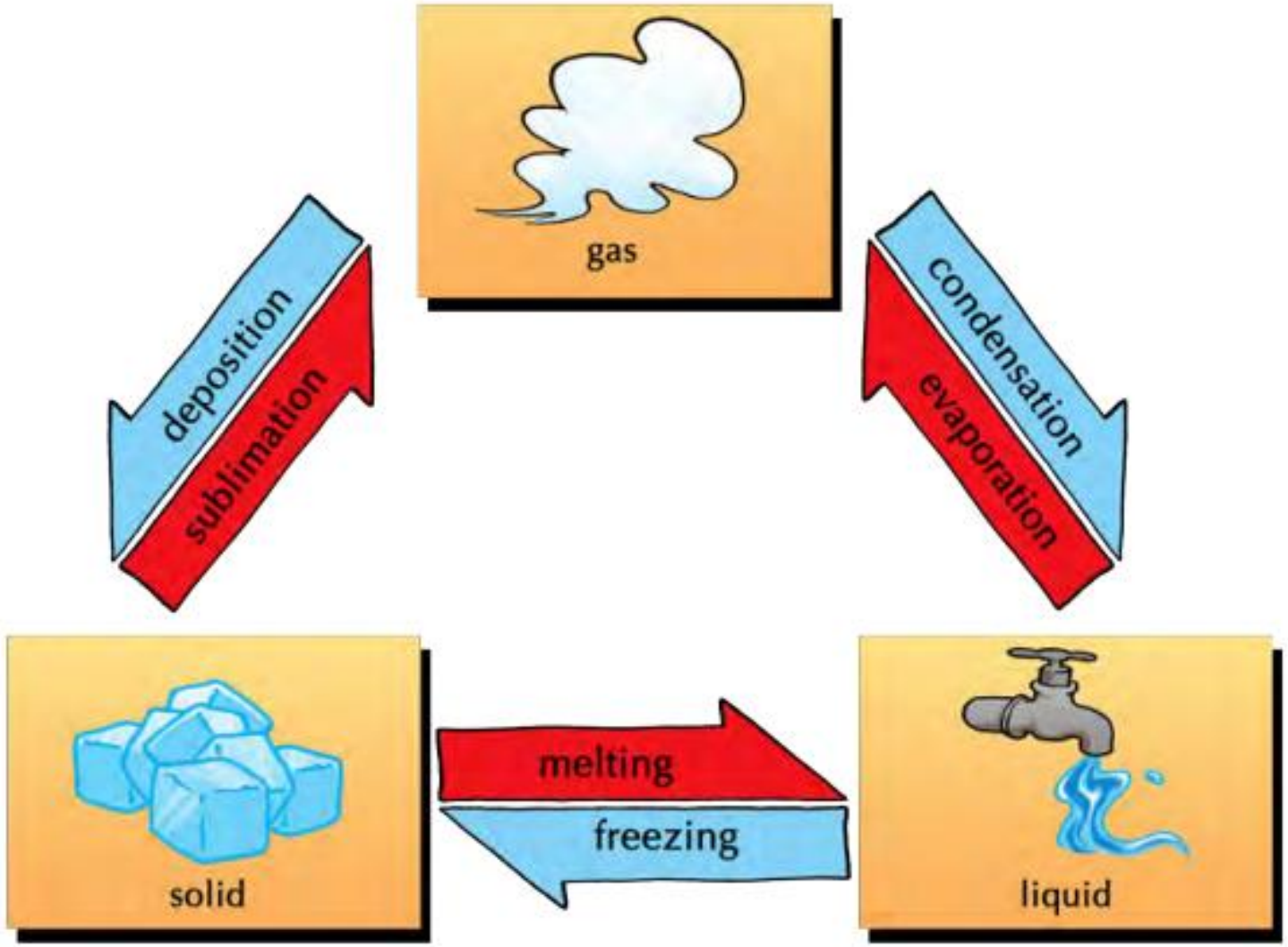
- Theories are similar to models.
- They explain scientific phenomena (things and events that can be described and explained in scientific terms) using pictures and words

What does the particle model of matter teach us?

- The particle model describes matter in a very specific way. It describes four important aspects of matter:
  - • All matter is made up of particles that are incredibly small - much too small to see with the naked eye. The particles can be atoms or combinations of atoms that are bonded.
  - • There are forces between the particles.
  - • The particles in matter are always moving. The more energy they have, the faster they move.
  - • The spaces between the particles in matter are empty. You might assume that the spaces between particles are filled with air, but this is not the case. They contain nothing at all.

Why is the particle model of matter so useful?

- The particle model of matter is one of the most useful scientific models because it describes matter in all three states.
- Understanding how the particles of matter behave is vital if we hope to understand science!
- The model also helps us to understand what happens to the particles when matter changes from one state to another.



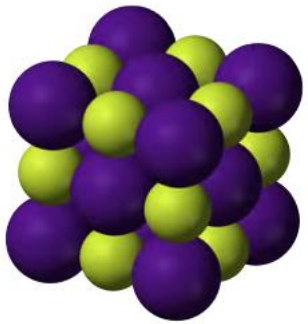
The change of states

Solids, liquids . and gases

- We can use the particle model to help us understand the behaviour of each of the states of matter.
- r. For any matter, the individual particles of that matter are exactly the same in all three states, solid, liquid and gas.
- It is the behaviour of the particles that changes in each state

The solid state

- Solids keep their shape and cannot be compressed
- In a solid, the particles are packed close to each other in fixed positions.
- They are locked into place, and this explains why solids have a fixed shape

Macroscopic view of sodium chloride	Submicroscopic view of sodium chloride
	
Table salt crystals are hard and have a fixed shape.	Can you see how the chloride atoms (purple) alternate with the sodium atoms (yellow) in a fixed arrangement?

- the particles in a solid (table salt) are packed in a regular arrangement.
- There are very small spaces between the particles in a solid.
- Particles are held together by forces of attraction. In solids, these forces are strong enough to hold the particles firmly in position.
- The particles in a solid move a little bit. They vibrate in their fixed positions.
- The more energy the particles have, the faster and more strongly they vibrate.

The liquid state

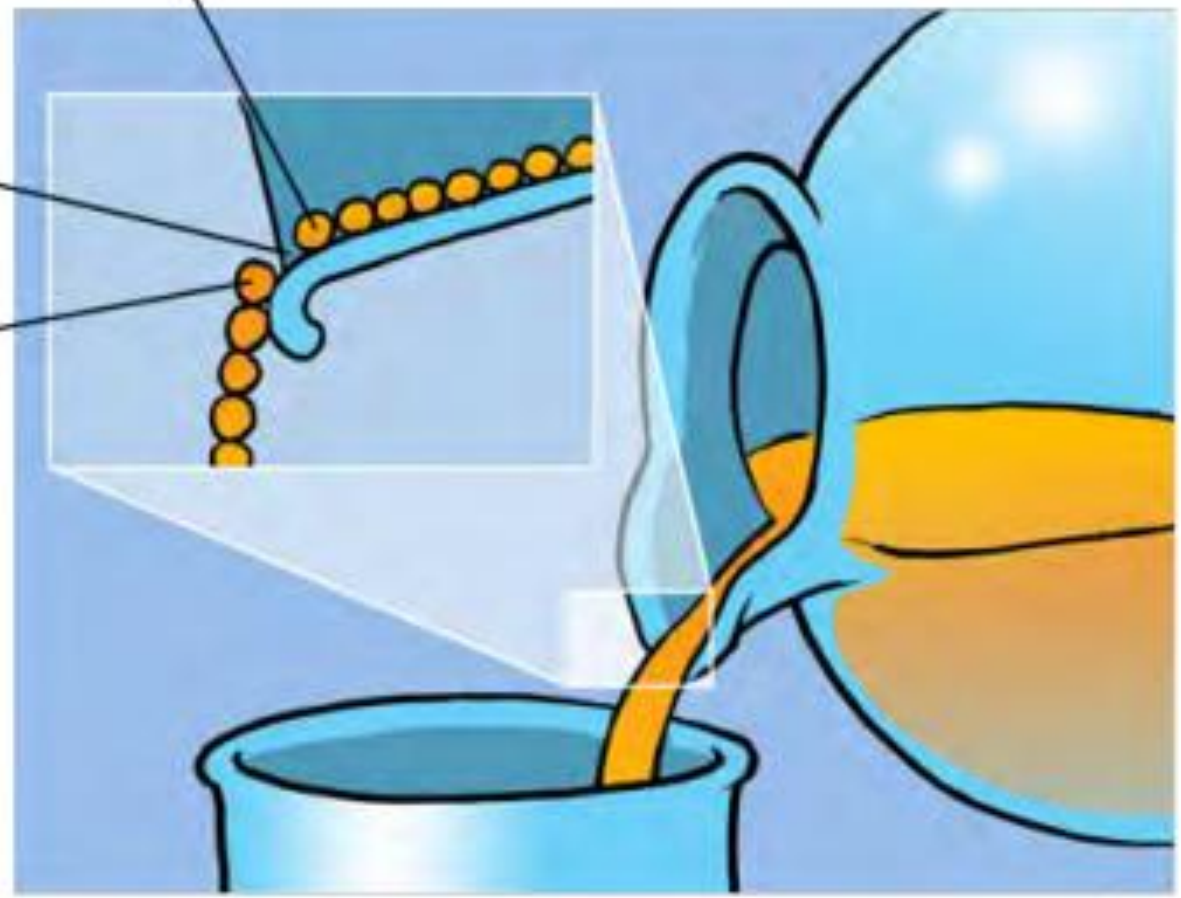
- An important characteristic of liquids is that they flow. They fill containers they are poured into. Liquids are also not very compressible
- particles do not have fixed positions. They move about freely, but they stay close together because the forces of attraction between them are quite strong, but not as strong as in solids.
- a liquid always takes the shape of the container it is in? Within the liquid, the particles slip and slide past each other. This is why liquid flows. Their particles are free to move around, filling the spaces left by other particles.

- The particles in a liquid have small spaces between them, but not as small as in solids.
- The particles in a liquid are loosely arranged which means they do not have a fixed shape like solids, but they rather take the shape of the container they are in.
- The speed at which the particles move around inside the liquid depends on the energy of the particles.
- When we heat a liquid, we are giving the particles more energy and speeding them up. In gases, the particles move at even greater speeds.

3. The next particle can move into the opening leaving a new opening behind it.

2. An opening is left.

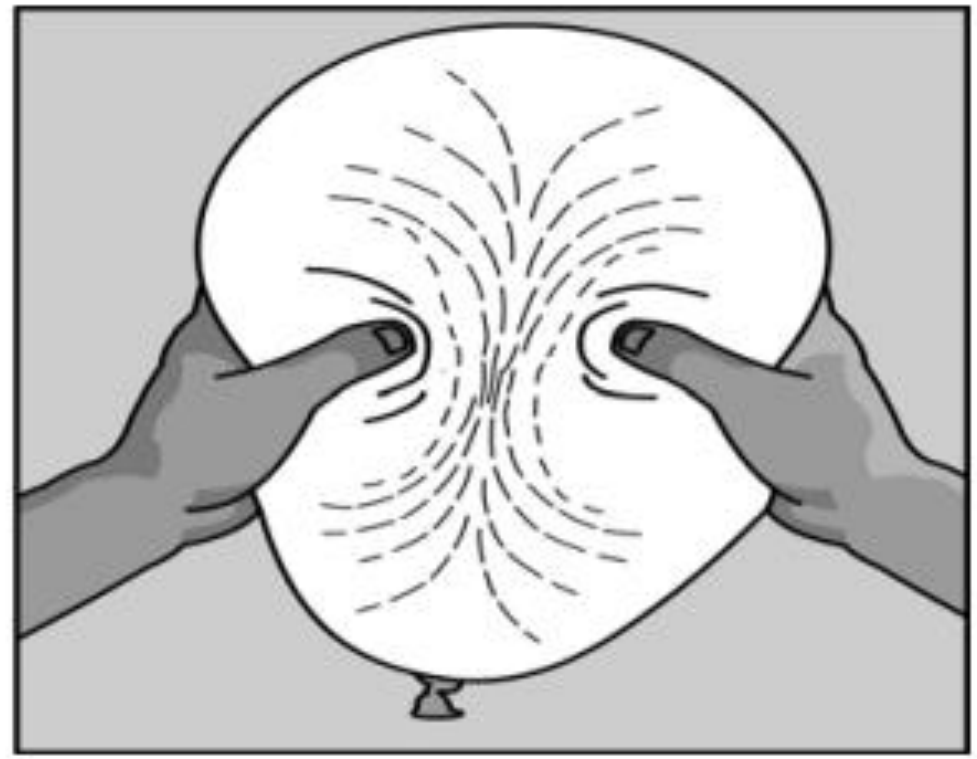
1. This particle falls down due to gravity.



The gaseous state

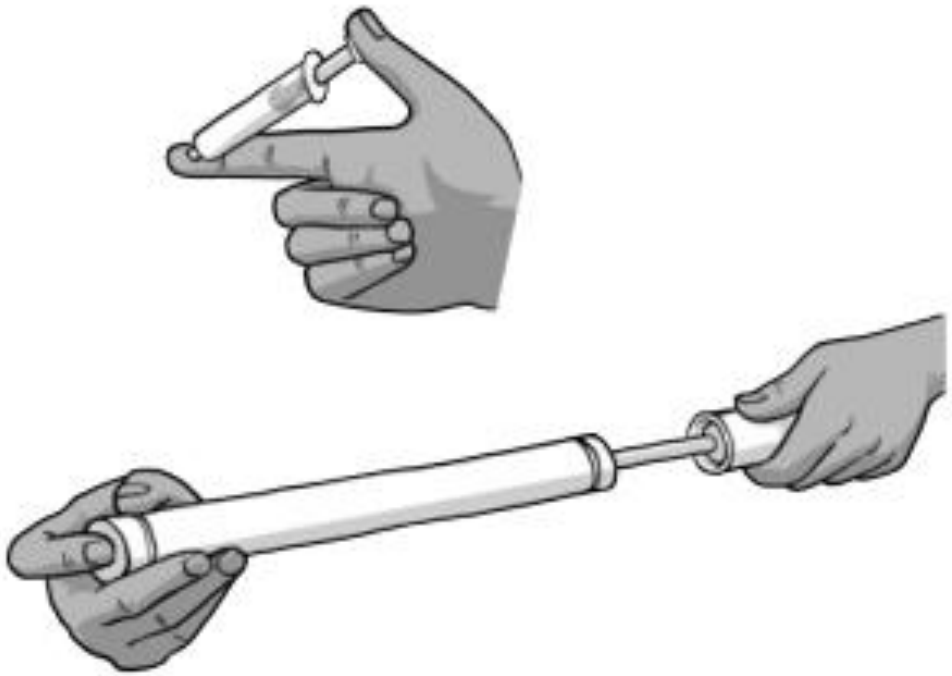
- Gases spread out quickly to fill all the space available to them. Think of when you blow up a balloon.
- The air that you blow into the balloon fills up the whole balloon. A gas will fill the entire space that is available to it.
- This is because the particles in a gas have no particular arrangement. Gases do not have a fixed shape.
- Think about the balloon again: the gas fills the entire space inside the balloon. You can squeeze the balloon, changing the shape

Gases fill the space available to them.

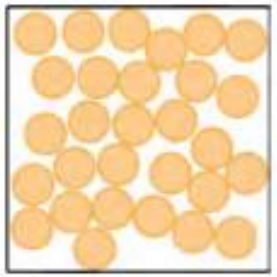
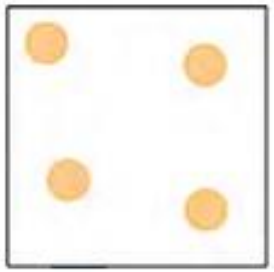


Gases do not have a fixed shape.

- Gas particles move very fast, much faster than in solids and liquids. The particles in a gas possess a lot of energy.



- In gases, the forces between particles are very weak. This explains why the particles in gases are not neatly arranged.
- They are not held together tightly and there are large spaces between them.
- These spaces are much larger than in the solid and liquid state.
- Gases can be compressed, because their particles can be forced closer together..

	Solid	Liquid	Gas
			
Arrangement of particles			
Movement of particles			
Forces between particles			
Spaces between particles			

1. Use the particle model of matter to explain why solids have a fixed shape, but gases fill the shape of the container they are in.

2. Use the particle model of matter to explain why you can compress a gas easily, but you cannot compress a liquid very easily.

3. Think of a bag of cake flour. You can pour the cake flour out of the bag and into a mixing bowl. Does this mean the flour is a liquid? Explain whether you think the cake flour (and all powders) are solids or liquids.

Diffusion

Have you ever noticed how quickly smells travel? Perhaps you have walked past a rubbish bin, and smelled the garbage.

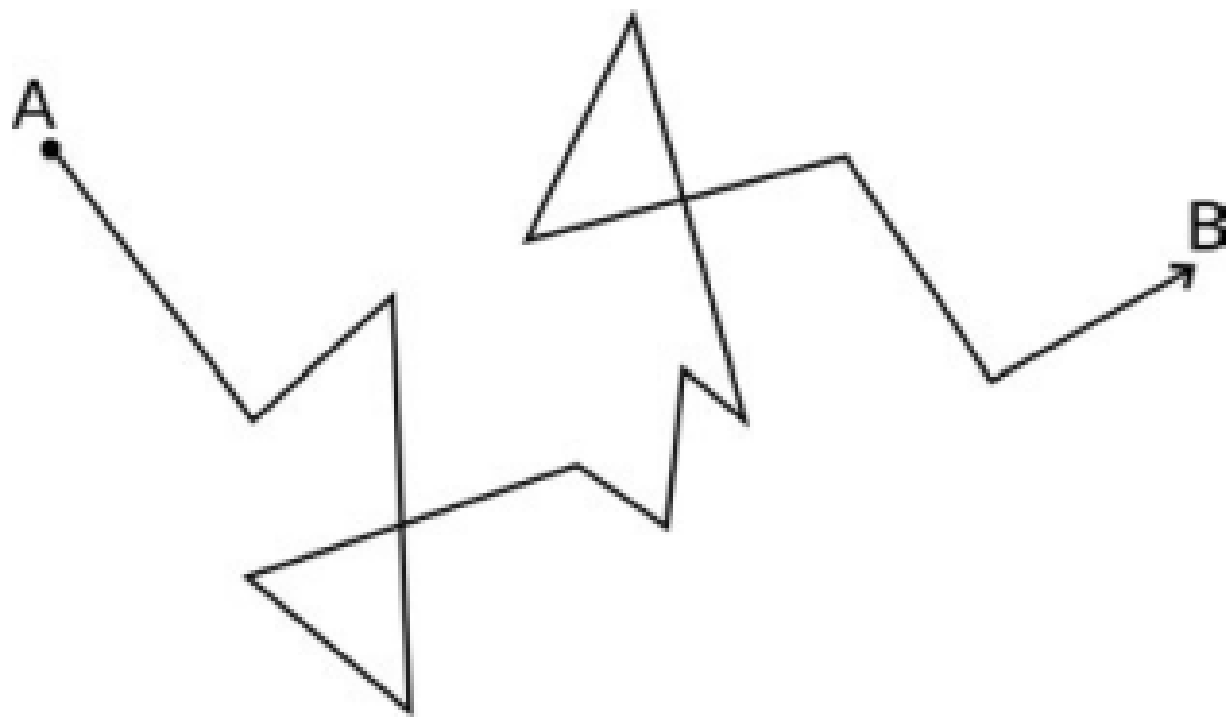
You can often smell garbage bins when you walk past them.

Has anyone ever set off a stink bomb near you?!

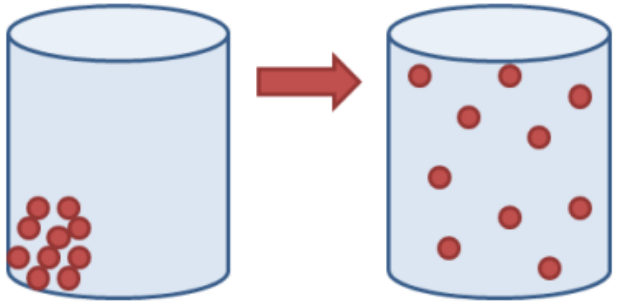
- Most smells travel fast, because their particles mix with air and get into our noses when we breathe.

Random movement of particles

- The particles in liquids and gases are constantly moving.
- Their movements are unpredictable: we say the particles move randomly.
- It is the random movement of the particles that allow liquid and gaseous substances to diffuse
- When a gas particle travels from point A to point B, it will collide with many other gas particles along the way - up to eight billion collisions every second!
- Only a few of those collisions are shown in the diagram. Each time the particle collides, it will change direction.
- This means the actual distance travelled by the particle is much further than the direct distance between points A and B.


A
B

- The process responsible for the mixing and spread of particles in a gas and liquid is called diffusion.
- We can define diffusion as the random movement of liquid or gas particles from a high concentration to a low concentration to spread evenly.

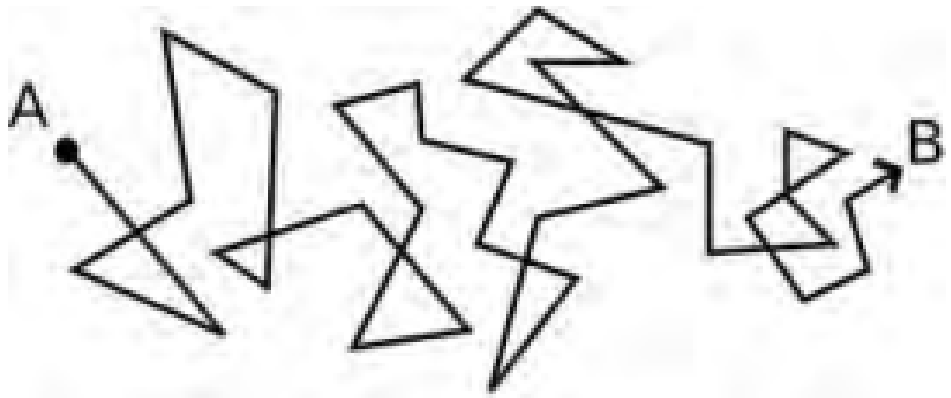
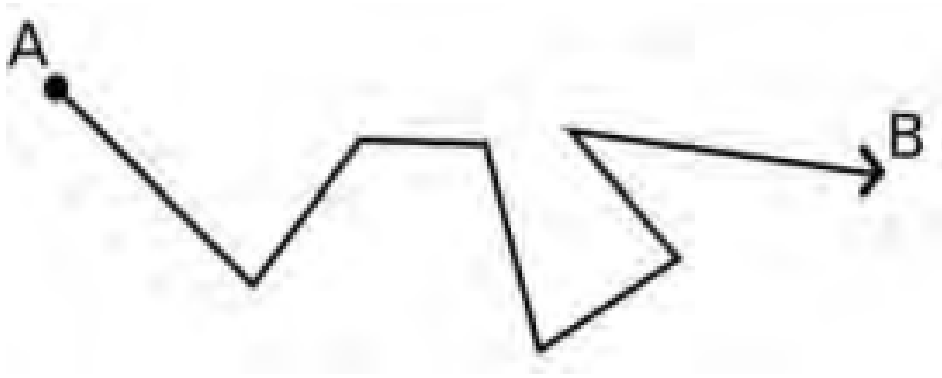


In the diagram on the left some particles were placed into an empty container. At first they were close together (at high concentration), but over time they spread out to fill the entire container.

Factors that affect the rate at which particles diffuse

- The mass of the particles: lighter particles will diffuse faster, because on average they move faster.
- The state of the particles: the particles in a gas are always moving fast; we say their average speed is high. The particles in a liquid travel more slowly.
- The temperature of the particles: temperature is a measure of the kinetic energy of the particles. The higher the temperature, the more energy the particles have and the faster they will move and diffuse.
- The size of the spaces between particles: If there are large spaces between the particles of one substance, the particles of another substance can move into those spaces easily.

- Particles diffuse because they are in constant motion.
- gas particles diffused much more quickly than the liquid particles
- A particle in a liquid cannot travel very far before colliding with another particle, because the particles are so close together.
- That means the liquid particles are constantly colliding and are sent into a new direction with each collision.
- This means the rate of diffusion is much slower in liquids than in gases, because the particles of a gas are further apart and collide much less.
- Gas particles can travel further without being sent in a different direction by a collision. This is why gases diffuse more quickly

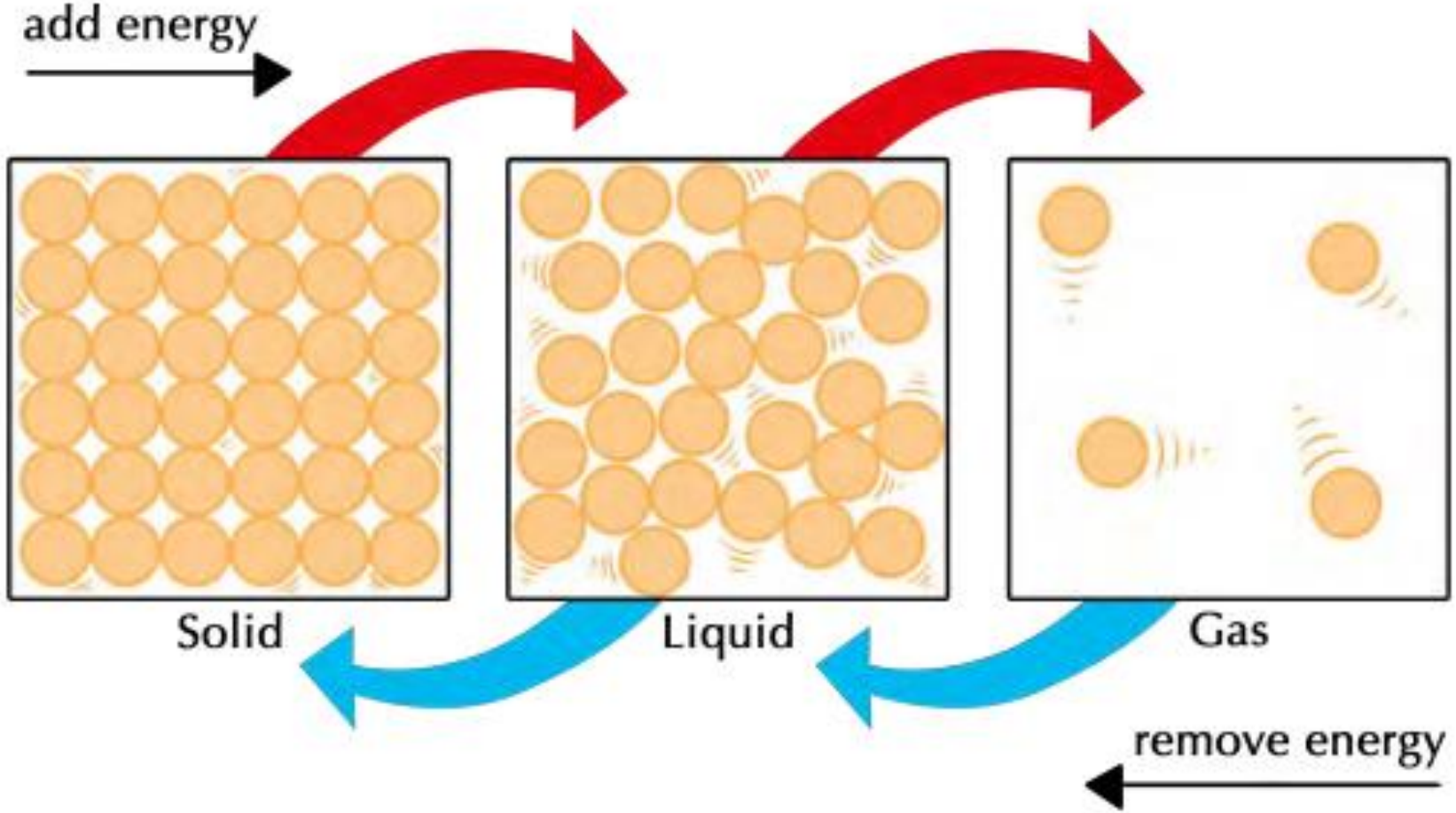
Liquid	Gas
	

Changes of state

- In science, a change of state refers to a change in physical state (e.g. when a liquid changes to a solid)

Changes of state involve energy

- For matter to change from one state to another, its particles must gain or lose energy.



Melting and evaporation are processes that require heating; condensation and freezing are processes that require cooling.

Melting and evaporation

- When a solid is heated to reach its melting point, it will change into a liquid.
- This is a process that we are all familiar with, because we have seen how ice melts.
- For a solid to change into a liquid state, the particles in the solid need to be freed from their fixed positions in the solid state.
- When a substance is heated, the particles are given more energy.
- By giving the vibrating particles in a solid more energy, their vibrations will become more and more vigorous, until the solid particles are able to shake themselves loose from their fixed positions.
- The forces between the particles are no longer able to hold them together tightly, and the solid melts

- The particles (which are now in the liquid state) will whizz around faster and faster as they heat up.
- Soon some of the particles near the surface will have enough energy to escape out of the liquid.
- Once they are free from the forces that hold them together in the liquid state, they enter the gas (or gaseous) state.
- The gaseous state is sometimes called the vapour phase, which forms when a liquid evaporates.
- This is why the gaseous state of water is sometimes called water vapour. Clothes hanging outside.
- The higher the temperature of the liquid, the faster it will evaporate.

Is there a difference between evaporation and boiling?

- Evaporation takes place at all temperatures, while boiling occurs at a specific temperature, called the boiling point.
- When a liquid is heated to its boiling point, bubbles form in the liquid and rise up to the surface.
- When this happens, we say the liquid is boiling.
- Evaporation occurs only on the surface of the liquid, while boiling occurs throughout the entire liquid

Condensation and solidifying

- When a gas changes to a liquid, the state change is called condensation.
- Condensation is the opposite of evaporation
- When the temperature of a gas is lowered, it takes energy away from the gas particles.
- The movement of gas particles slows down as their energy decreases and they will start to experience attractive forces.
- These forces cause them to move closer to each other and they eventually return to the liquid state

- What would happen if we cooled the liquid even more? By cooling the liquid, we would be removing energy from it.
- As the liquid particles lose energy, their movement slows down even more.
- As their movements become slower and slower, the attractive forces between become stronger.
- The particles eventually 'lock' into position in the solid state.
- They can no longer move freely and are only able to vibrate in their fixed positions.
- We say the liquid has solidified.