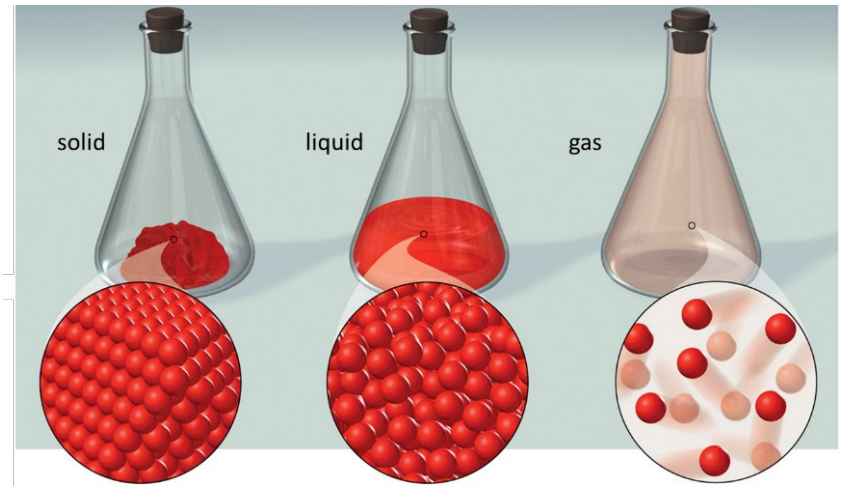
Matter exists in different states – solid, liquid and gases

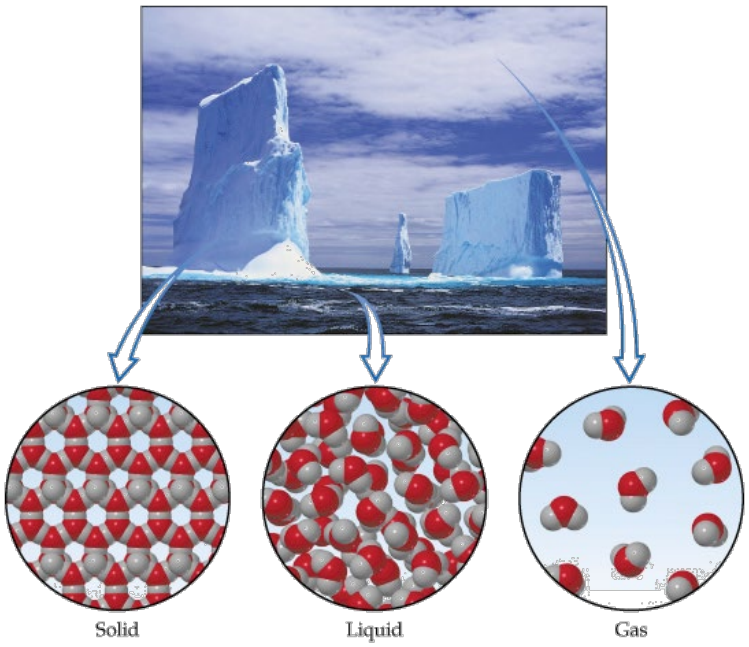


All matter can be found as either a solid, liquid or gas depending upon the temperature. Each type of matter has its own specific temperature ranges that it will exist in each of these three states. Gases, liquids and solids can be made up of atoms, molecules, and/or ions.

Water as a solid, liquid and gas

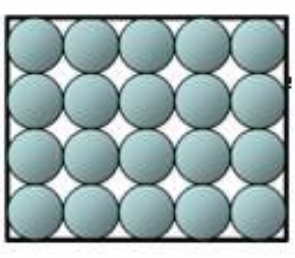
Water is a compound but a very unusual one, because it can be found on Earth naturally as a solid, liquid and a gas.

In solid state, it forms the ice at the poles and covers land in winter and high mountains. In a liquid state it fills our oceans and lakes, as well as creates ground water stored for thousands of years. As a gas, water is found in our atmosphere, the amount is known as the air humidity.

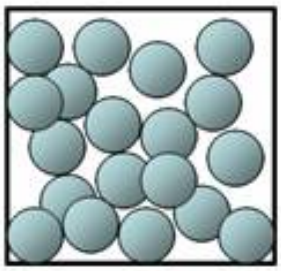


Models for particle arrangement for solid, liquid and gases

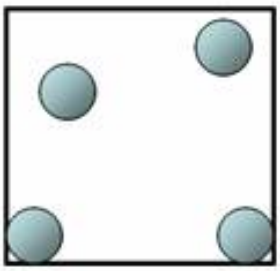
Solid particles are packed closely and only vibrate in a fixed position (low energy).
Liquid particles are also packed closely but the particles move around more (more energy than solid particles).
Gas particles have a lot of space between them and move around quickly (particles contain a large amount of energy).



Solid State



Liquid State



Gas State

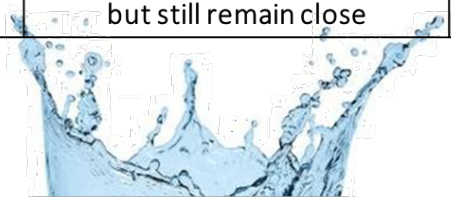
Particles of different states have different strength forces holding them together

The strength of the forces holding the particles together in matter decreases from solid to liquid to gas. Forces are the strongest between particles in solids where they are held close together. Forces are slightly less with particles in liquids. The particles can move past each other but still are close. Forces are weak between particles in a gas and they move freely away from each other.

Note: strength of forces varies depending on the type of matter but forces still decrease from solid to liquid to gas

Particles are arranged and move differently in solids, liquids and gases

Properties of Gases, Liquids and Solids		
gas	liquid	solid
takes the shape and volume of its container particles can move past one another	takes the shape of the part of the container which it occupies particles can move/slide past one another	retains a fixed volume and shape rigid - particles locked into place
Spreads to fill container particles have weak bonding so they spread by moving rapidly apart from each other	Does not spread to fill a container **particles remain bonded to each other closely and only move past each other but do not spread**	Does not spread to fill a container particles are bonded to each other closely and stay fixed in place so do not spread
compressible lots of free space between particles	not easily compressible little free space between particles	not easily compressible little free space between particles
flows easily particles can move past one another	flows easily particles can move/slide past one another	does not flow easily rigid - particles cannot move/slide past one another
Not dense Particles have large spaces between them	Dense Particles move past each other but still remain close	Dense Particles are closely packed to each other

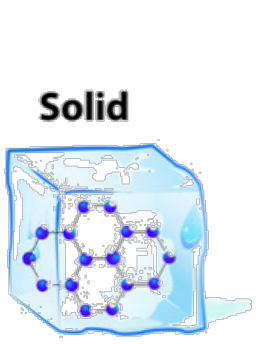


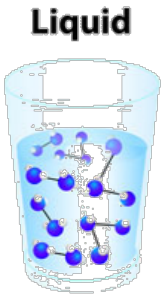
GZ Science Resources

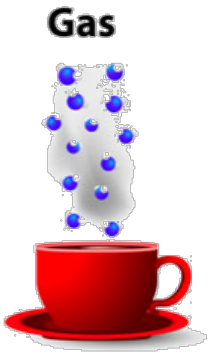
The properties of different states - spreading

All particles to move.

- **Gas** particles move more than liquid and solid particles, so they spread out from each other to completely fill a container. (the volume of gas **does** increase)
- **Liquid** particles move past each other and spread to fill a container from the bottom up. (the volume of liquid **does not** increase)
- **Solid** particles do not move apart from each other so do not spread to fill a container.



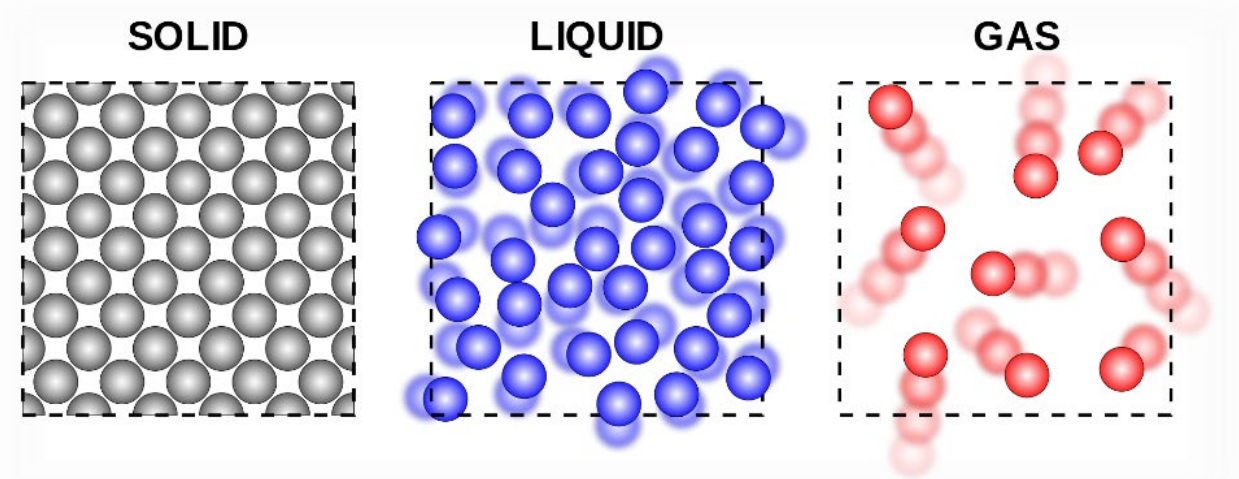




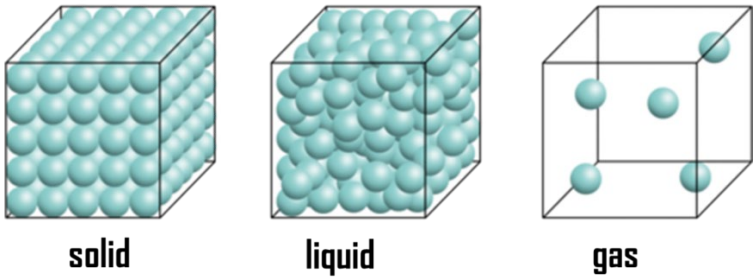
The properties of different states - compressibility

To compress means to push particles closer together and makes the overall volume smaller that the matter takes up.

- Particles in a **solid** are very close together and cannot be compressed.
- Particles in a **liquid**, although being able to move past each other, are also very close so cannot be compressed.
- Particles in a **gas** have large spaces between them so can be compressed.



The properties of different states – density

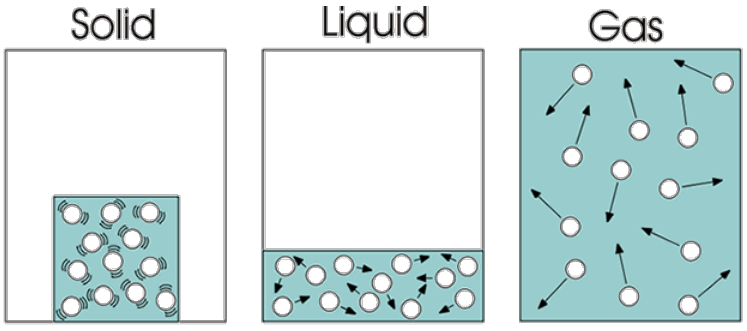


Density is a measure of the number of particles per unit volume. If a substance has more particles in the same volume than another, it is said to be denser. A substance that is in a solid and liquid state is denser than when it is in a gas state. Note: different substances have different densities, but the general pattern is that the density decreases from solid/liquid to gas

The properties of different states – shape

The shape of a substance is linked to its state and the strength of the forces between particles

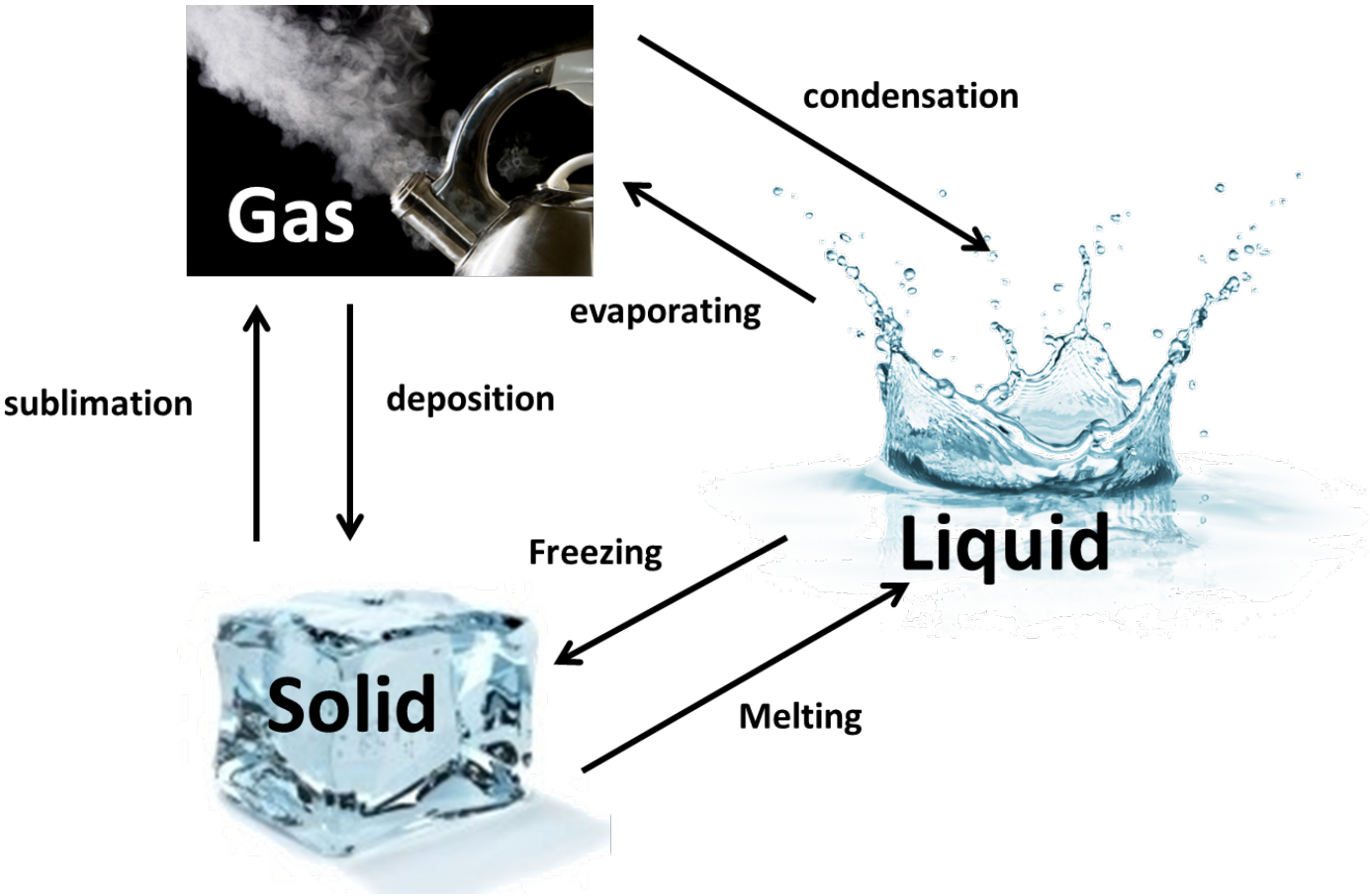
- **Solids** remain in a fixed shape – the particles vibrate (shake in one spot) but remain tightly joined to each other with strong forces holding them together.
- **Liquids** take the shape of the container – the particles can move past each other but are still joined, just with forces that are weaker.



- **Gases** fill any container they are in – the particles move fast and are not joined to each other due to the very weak forces between particles.

Matter can change from one state to another

If energy is absorbed or released by the particles, which make up the matter, it can change state. A change of state is a physical reaction and it is reversible.



Solid to liquid – melting

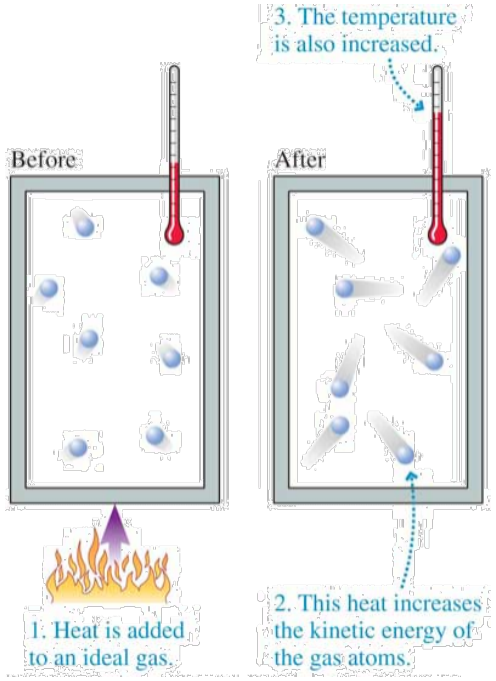
Particles of substances **vibrate (move on the spot) faster** as they change in state from solid to liquid. This means that the **bonds** between the particles begins to get **weaker**. At the point when the particles change from a solid to a liquid, called melting point, the forces holding the particles together is partly overcome and the **particles start to slide past each other**.

Liquid to gas – boiling

Particles of substances **move around even faster** as they change in state from liquid to gas. This means that the **bonds** between the particles get **even more weaker**. At the point when the particles go from a liquid to a gas, called boiling point, the forces holding the particles together is completely overcome and the **particles move away from each other freely**.

Temperature is a measure of the movement in particles. (Extension)

The particles in a gas are in constant motion. Temperature is a measure of the speed with which they move. The higher the temperature, the faster the particles move.

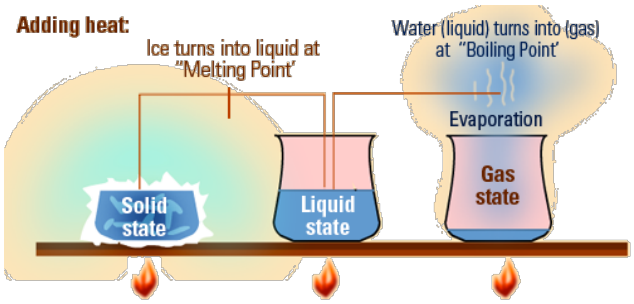


Melting and boiling points

The temperature at which a substance changes from a solid into a liquid is called its **melting point.** The temperature at which a substance changes from a liquid into a gas is called its **boiling point**.

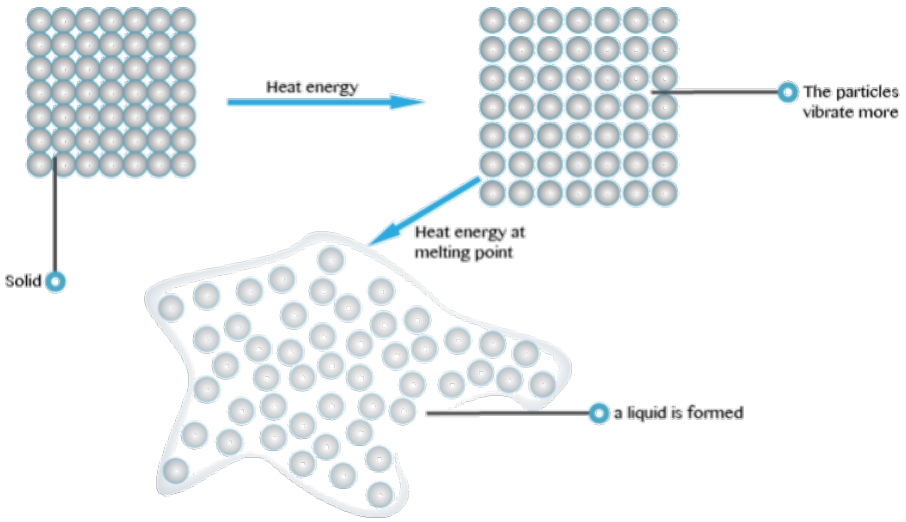
Different types of substances have different melting and boiling points – these are determined by how strong the bonds are between particles or molecules.

(When a molecule melts or boils it is the bonds between the molecules that break **not** the bonds inside a molecule holding the atoms together)



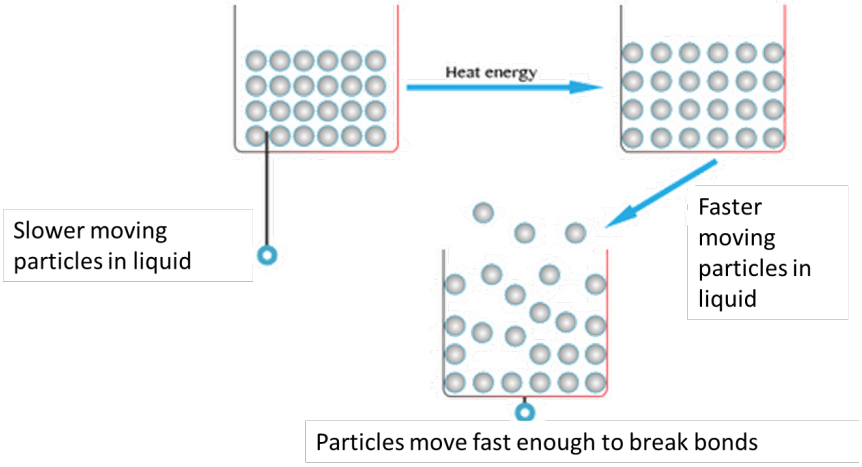
Melting points of water

The **melting point of water is 0°C.** This is the temperature where the water molecules have enough movement to overcome the forces holding particles in a fixed position of a solid state and the particles start sliding past each other in a liquid state.



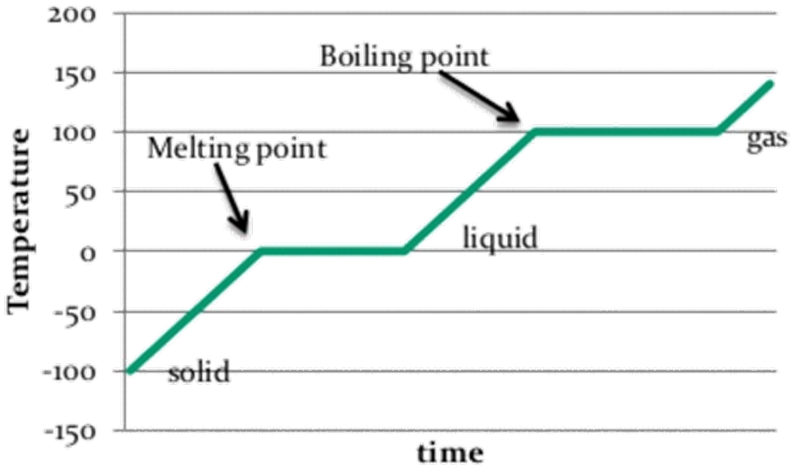
Boiling point of water

The **boiling point of water is 100˚C**. This is the temperature where the water molecules have enough movement to completely overcome the forces holding particles together and they break away from each other and form a gas.



Melting and boiling points of water - graph

The melting point and boiling point are just **average temperatures** when a change of state occurs. For example, some water particles will change from liquid to gas at much lower temperatures than 100˚C, such as water evapourating off a road after rain.



Melting and boiling points of water

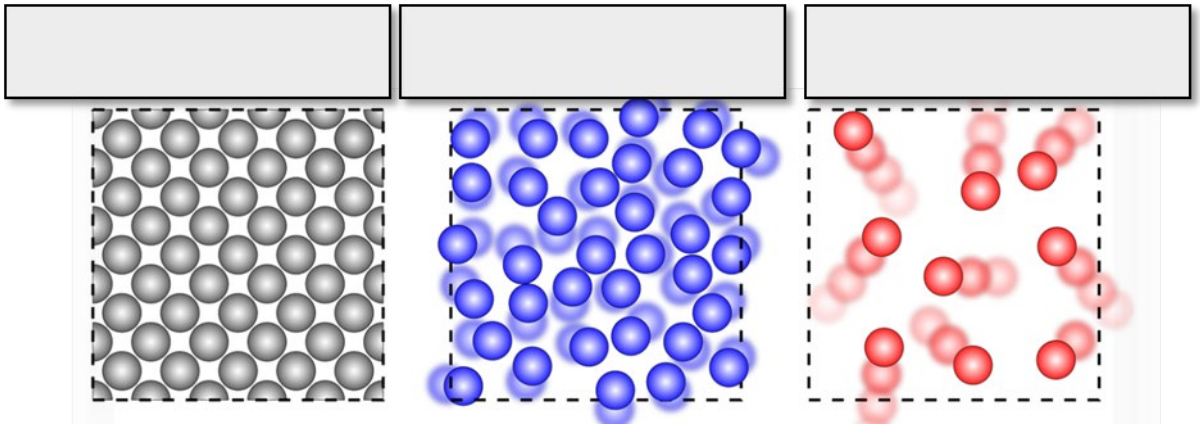
Element	M.P. ^{0}C	B.P. ^{0}C	At Room temp
Copper	1,083	2,567	Solid
Magnesium	650	1107	Solid
Oxygen	-218.4	-183	Gas
Carbon	3,500	4827	Solid
Helium	-272	-268.6	Gas
Sulphur	112.8	444.6	Solid
Mercury	-38.87	356.5	Liquid

Melting and boiling point of other substances

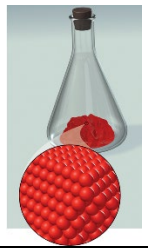
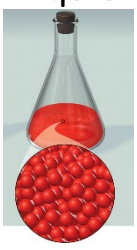
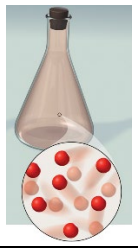
The boiling point and melting point of a substance depends upon the **strength of the force** holding the particles together. If it is a strong force, then the boiling and melting points are high. If it is a low force, then the melting and boiling points are much lower.

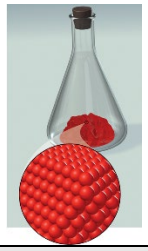
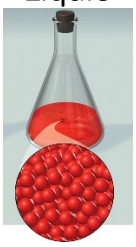
Each type of substance has its own melting and boiling point.

1. Complete the labels on the following particle diagrams of STATES



2. Use information from the notes, **make predictions** with explanations. You may also like to complete the practical work to compare your predictions with observations

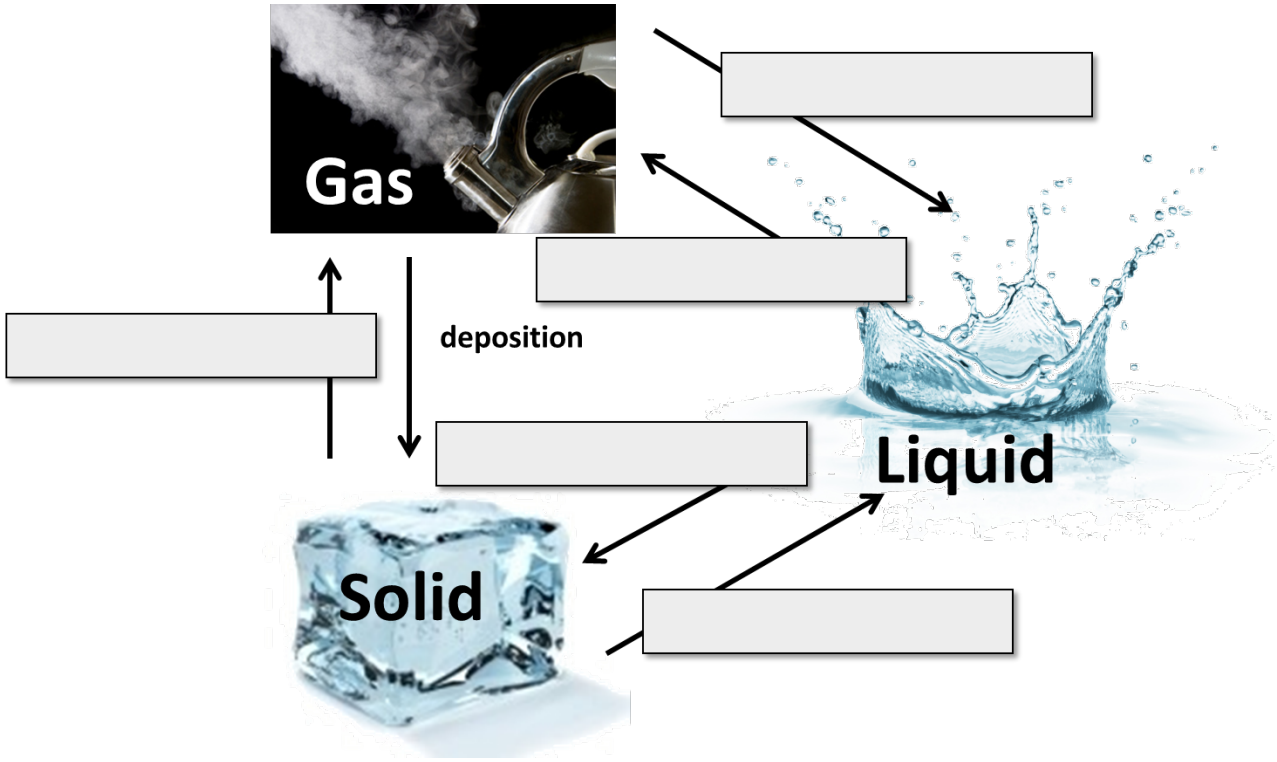
Solid, liquid, gas Property	Practical instructions	Predictions		
		Solid 	Liquid 	Gas 
Compressibility	**Solid:** Use a syringe with sand and try to squeeze **Liquid:** Use a syringe with water and try to squeeze **Gas:** Use a syringe with air and try to squeeze	**Question:** Can you push particles closer together and make the overall volume smaller?		
Fluidity / flow	**Solid:** A lump of beads glued together moved from container to container **Liquid:** a container filled with polystyrene beads and move to another container **Gas:** A straw blown into a sealed container with a few beads **Demonstration:** Gas: warm a crystal of iodine	**Question:** Do the particles move steadily and continuously in a current or stream?		

Solid, liquid, gas Property	Practical instructions	Predictions		
		Solid 	Liquid 	Gas 
Diffusion	**Solid:** lump of metal in water **Liquid:** coloured ice cubes in water **Gas:** put a burning taper into a beaker of CO_2 to show that it fills its container	**Question:** Do particles move from an area of high concentration to an area of low concentration (spread out)?		
Shape	**Solid:** observe the shapes of wooden corks. Do they change shape? **Liquid:** observe different shaped containers filled with the same volume of coloured water. **Gas:** DEMONSTRATION Nitrogen dioxide moving (gas) from one container to another to show shape and volume properties. (demonstrate under fume hood as gas poisonous)	**Question:** Does the substance remain in a fixed shape, take the shape of the container or fill any container they are in?		

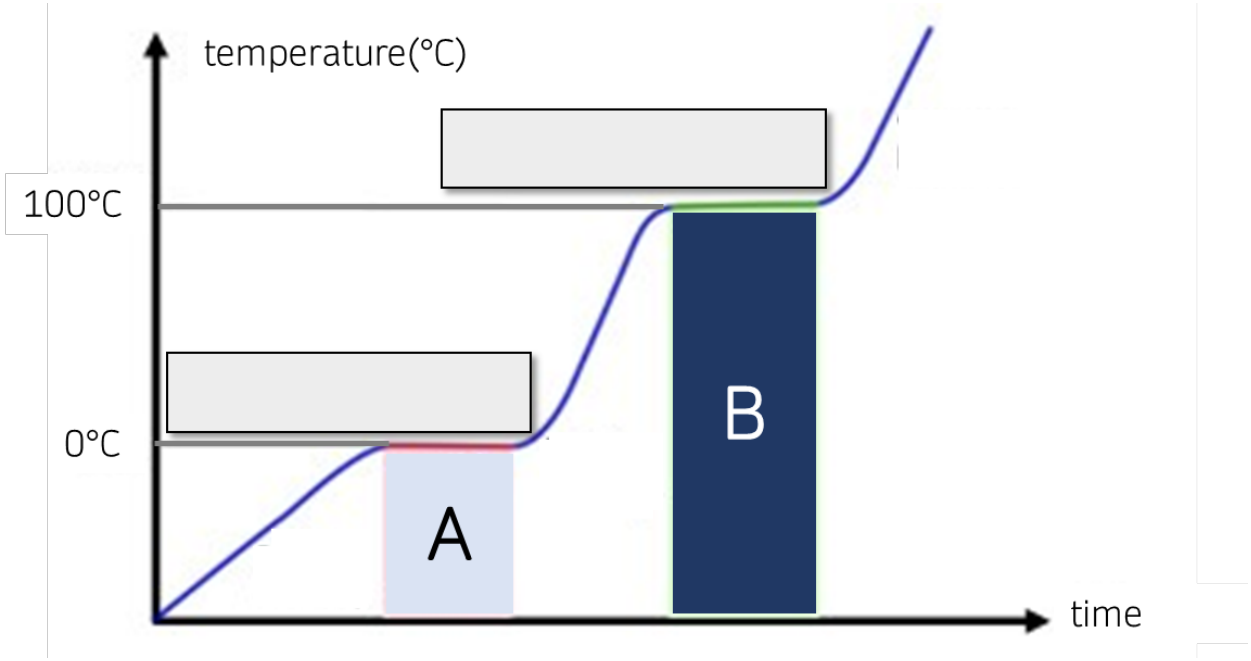
3. Substances can be found in the three different states on Earth. Fill in the chart below to give at least three examples

Solid	liquid	Gas

4. Substances can change from one state to another. Compete the changes of state



5. Below is a graph showing the temperature of water over time as it is heated. Label the diagram with the **melting and boiling points,** Complete chart to show the states at A and B



A	
B	