GCSE

# SCIENCE: States of matter and mixtures

| Keyword | Definition |
|---|---|
| Substance | A material with particular properties |
| Matter | Anything that has mass and takes up space. |
| Solute | Substance that dissolves in a liquid to make a solution |
| Solvent | The liquid in which a solute dissolves to make a solution |
| Solution | Formed when a substance has dissolved in a liquid eg salt (solute) dissolves in water (solvent) forming salt water (solution). |
| Insoluble | Describes a substance that cannot be dissolved in a certain liquid eg nail varnish is insoluble in water. |
| Compound | A substance that can be split into simpler substances because it contains two or more different elements chemically joined together. |
| Mixture | Two or more substances jumbled together but not chemically joined together. Many mixtures can be easily separated. Melt over a range of temperatures eg 4 – 9 ˚C |
| Element | A substance made of only atoms with the same number of protons in the nucleus. |
| Pure | A single substance, with a fixed composition, that does not have anything else mixed with it eg a gold bar. Melt at a specific temperature eg 25 ˚C. As opposed to daily use of pure often used to mean natural or clean. |
| Impure | A mixture of different substances eg air contains, water, oxygen, carbon dioxide, nitrogen etc |

**States of matter and changes of state**

- See 'How to be a scientist' - knowledge organiser. You need to know the state names, names of state changes and properties of each state.
- Gas to solid or solid to gas is called sublimation.
- The properties of each state of matter depend on the forces between molecules.
- When substances change state it is a physical change (easily reversed by heating or cooling and no new substances are created).
- A chemical change results in the formation of a new substance.
- On a graph showing temperature and time horizontal lines show a change of state for a pure substance (ie temperature does not change during a change of state for pure substances).

**Worked example – explain what happens when a gas is cooled.**

- When cooled particles in the gas lose energy.
- The particles vibrate less strengthening the bonds between them making the gas' volume decrease.
- At a certain temperature the bonds between particles become strong enough to hold them together. This is called condensing and the gas changes to a liquid.
- As the liquid is cooled the bonds continue to strengthen, the volume continues to decrease and particle energy continues ot decreases.
- At a certain temperature particles have lost enough energy for the particles to be held together even more tightly fixing them to a particular point. This is called freezing; the liquid is now a solid.
- As cooling continues particles continue to lose energy and vibrate less and less.

**Predicting state from data**

- Look at the given temperature.
- If this temperature is less than the melting point (MP) of a substance it will be a solid.
- If this temperature is between the melting and boiling points (BP) of a substance it will be a liquid.
- If this temperature is above the boiling point the substance will be a gas.

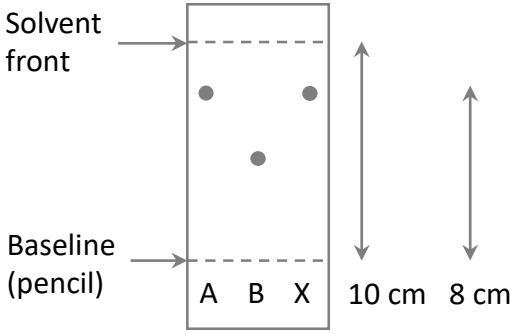
| Substance | MP / ˚C | BP / ˚C | State at 30 ˚C |
|---|---|---|---|
| A | 450 | 700 | solid |
| B | -200 | -10 | gas |
| C | 7 | 85 | liquid |

| Separation method | Used to separate… | Example mixture | Notes on method |
|---|---|---|---|
| Simple distillation | a solvent and solute from a solution | Water and salt from salt water | Can only be used to separate substances with very different boiling points |
| Fractional distillation | a mixture of liquids with different boiling points | Fractions from crude oil | Substance with lowest BP collected first, highest BP collected last |
| Filtration | a mixture of a liquid and solid | Sand from rock salt | Insoluble solid impurities can be removed from solutions this way |
| Crystallisation | a solute from a solution (solvent is lost) | Copper sulfate from copper sulfate solution | The solvent will evaporate leaving crystals of the solute. Using an oven will speed this up. |
| Paper chromatography | and identify soluble substances from a mixture | Identify dyes used to make an ink | Mobile phase – solvent in which molecules move eg water<br>Stationary phase – molecules cannot move eg paper |

**Chromatography**

- The rate a substance travels up the stationary phase differs for each substance. It depends on how soluble they are in the mobile phase and how strongly they are attracted to the stationary phase.
- Very soluble substances that are weakly attracted to the stationary phase will travel furthest up the paper.
- Chromatography can be used to see if a substance is pure or if it is a mixture.

**Worked example**




- $R_f$ of X = 8 ÷ 10 = 0.8
- X is made of A (A and X travelled same distance)
- X is made of only one substance (only one dot).

- $R_f$ factors can be used to identify what substances are in a mixture by comparison to a known substances $R_f$ value.
- $R_f$ values are always less than 1.
- $R_f = \frac{distance\ travelled\ by\ solute}{distance\ travelled\ by\ solvent}$

**Water treatment and analysis**

- Waste and ground water can be made potable (drinkable) using the following processes:

1. **Filtration** – large solids (sand, twigs etc) are removed by wire mesh and gravel and sand beds
2. **Sedimentation** – the water is held in large tanks to let smaller particles settle to the bottom
3. **Chlorination** – Chlorine gas bubbled through water to **kill** bacteria and other microbes

- Distillation can be used to make seawater drinkable. It requires a lot of energy to do and is therefore expensive.
- Water used for chemical analysis must be pure. Tap water contains dissolved substances that can affect experiments and give false results if used in chemical analysis.