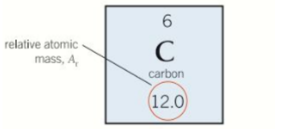
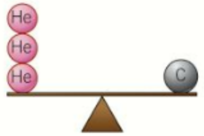
C2.1 Purity and separating mixtures

SECTION 1

Relative atomic mass (A_r) is the mean mass of an atom of an element compared to $\frac{1}{12}$ the mass of a ${}^{12}_{6}C$ (carbon-12) atom





Three helium atoms have the same mass as one carbon atom

A **chemical formula** tells you how many atoms of each element there are in a unit of a substance. The chemical formula for water is H_2O. This tells us a water molecule has two hydrogen atoms and one oxygen atom joined (bonded) together. Some chemical formulae contain brackets for example aluminium sulphate is $Al_2(SO_4)_3$ The 3 outside of the brackets means you must multiply the number of each atom in the brackets by three therefore there are 2 Al atoms, 3 S atoms and 3x4=12 O atoms

<u>Relative Formula Mass</u>

Calculating the Relative Formula mass of Compounds; Add the atomic mass(A_r) of each individual atom in the compound together

Na_2SO_4 A_r Na = 23 S= 32.1 O=16

↓ ↓ ↓

(2x23) + (1x32.1) + (4x16) = 142.1

SECTION 2

Calculating an empirical formula

The chemical formula for butane is C_4H_{10}. Calculate its empirical formula.

Step 1: Find the highest common factor.

The highest common factor of 4 and 10 is 2.

Step 2: Divide the chemical formula by the highest common factor:

$C = \frac{4}{2} = 2$ $H = \frac{10}{2} = 5$

Step 3: Write down the empirical formula:

C_2H_5

A **balanced chemical equation** shows the formulae and number of units for all the substances in a reaction. For example, carbon reacts with oxygen to produce carbon dioxide. If you write down the A_r and M_r values for each substance, you find that the total on the left of the arrow equals the total on the right:

C	+	O_2	→	CO_2
12.0	+	32.0	=	44.0
(1 × 12.0)		(2 × 16.0)		(12.0 + 16.0 + 16.0)

SECTION 3

In science, a pure substance consists of just one element or compound. The melting point of a pure substance is a single temperature. If a substance is impure, its melting point will be lower than the pure substance

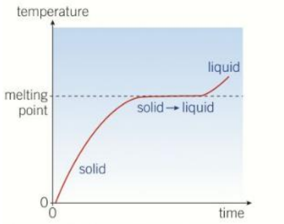
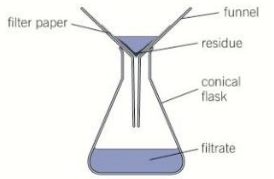


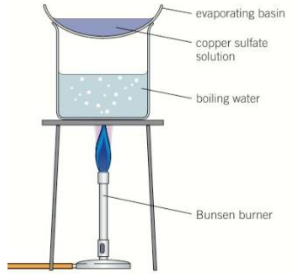
Figure 4 The temperature of a pure substance remains constant while it melts.

SECTION 4

A **solution** forms when one substance dissolves in another. The **solute** is the substance that dissolves, and the **solvent** is the substance it dissolves in. When a substance **dissolves**, its particles separate and become completely mixed with the particles of the solvent.



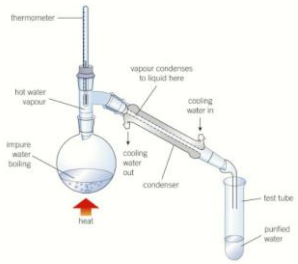
Filtration separates an insoluble solid from a liquid



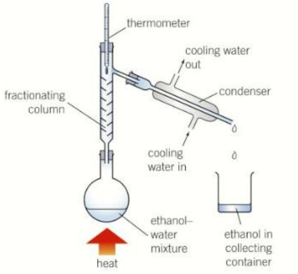
If you heat a solution, the solvent evaporates leaving the solute behind

SECTION 5

Simple distillation separates a solvent from a solution. It relies on the solvent having a lower **boiling point** than the solute. When heated, the solvent leaves the solution in its gas state. It is then condensed back to its liquid state in the condenser.



Fractional distillation two or more substances from a mixture in the liquid state. Each substance must have a different boiling point



SECTION 6

Chromatography relies on two different chemical phases; a stationary phase that does not move and a mobile phase which does move.

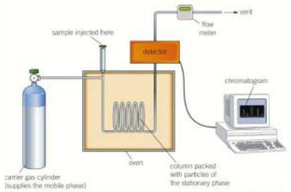


Figure 4 The metal column in gas chromatography is coiled so that it can fit into a very hot oven.

Gas Chromatography separates components of a mixture and measures the amounts of each substance

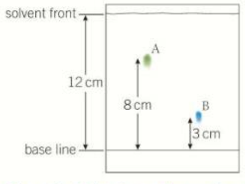


Figure 3 A thin-layer chromatogram for substances A and B.

Thin-layer chromatography

You can use thin-layer chromatography to separate a sample into its components for identification or analysis.

1 Put the solvent into a chromatography tank to a depth of about 1 cm (Figure 2). If the solvent is flammable, make sure that there are no naked flames, and that the room is well ventilated.

2 Add a small amount of the sample to the baseline, taking care not to damage the powder on the plate.

3 Let the solvent travel through the powder, and take the plate out before it reaches the top.

4 Analyse the pattern of coloured spots, which is called a **chromatogram**.

The pattern produced depends on how each component is distributed between the two phases. A component travels further up the plate if it forms stronger bonds with the mobile phase than with the stationary phase. A component will not travel very far if it forms stronger bonds with the stationary phase than with the mobile phase.

Calculating an R_f value

Figure 3 shows the thin-layer chromatogram for two samples. Calculate the R_f value for substance A, giving your answer to two decimal places.

Step 1: Measure the distance travelled by the substance, and the distance travelled by the solvent.

From the diagram, this is 8 cm and 12 cm.

Step 2: Calculate the R_f value:

$$R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

$$R_f = \frac{8\text{ cm}}{12\text{ cm}} = 0.67$$

R_f values vary from 0 to 1, and have no units.