C2.1 Purity and Separating Mixtures

Learning Objectives	Keypoints
Define relative atomic mass and relative formula mass	Relative atomic mass, Ar, is the average mass of an atom of an element compared to 1/12 of an atom of ^{12}C. Relative formula mass, Ar, is the average mass of a unit of a substance compared to 1/12 of an atom of ^{12}C.
Calculate relative formula masses from formulae	The chemical formula tells us how many atoms of each element there are in a compound. To calculate the relative formula mass, add together the relative atomic masses of each atom in a formula.
Calculate the empirical formula of a compound	The empirical formula is the simplest whole number ratio of atoms of each element in a compound. To calculate the empirical formula divide each of the numbers in the chemical formula by the highest common factor e.g. $C_6H_{12}O_2$ would become C_3H_6O as the highest common factor is 2. If we have a diagram of the molecule then we can calculate the empirical formula of a chemical by counting up the number of atoms of each element in the molecule and then dividing by the highest common factor.
Calculate relative formula masses in balanced equations	In a balanced chemical equation, the sum of all of the relative formula masses of the reactants must equal the sum of all of the relative formula masses of the products. We can use this to calculate the relative formula mass of a substance if we know the relative formula masses of all of the other reactants and products.
Explain what purity means	A pure substance is one that contains only one type of element or compound.
Explain that many useful materials are mixtures	Mixtures are impure. They contain more than one type of element or compound. Useful examples include paint and alloys. Alloys are mixtures of more than one element, of which at least one must be a metal. Alloys are useful because their properties are different from the elements that make up the alloy.
Use melting point data to distinguish pure substances from impure substances	A melting point is the temperature at which a substance turns from a solid into a liquid. Impurities lower the melting point. Impurities mean that the substance melts over a larger range of temperatures. When finding the melting point of a substance, it needs to be stirred and heated slowly. This is make sure that the whole sample is heated and that the whole ample is at the same temperature throughout.
Describe and explain how filtration and crystallisation work	Filtration separates an insoluble solid from a solution. Filter paper is placed inside a funnel which is placed inside a conical flask. The filter paper has tiny holes in it. Any substances which are dissolved will be small enough to pass through these tiny holes and so will enter the conical flask alongside the solvent (usually water). This mixture is called the filtrate. Any insoluble solids will be larger and will not pass through the holes in the filter paper. They will collect on the filter paper. We call this the residue. Crystallisation occurs when you have a saturated solution. This means that the maximum amount of solute has been dissolved and if any more is added then it will not dissolve. To obtain a saturated solution we heat a solution until crystals of solid start to form. The heat is then removed and the solution is left to cool. The crystals that form can then be separated from the solution by filtering.

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Describe and explain how simple distillation and fractional distillation work	Distillation works because different liquids have different boiling points. In simple distillation a solvent is separated from a solution. This works because if the solvent has a much lower boiling point that the solute. Therefore the solvent boils when the solution is heated, but the solute does not and is left behind in the flask. A condenser is used to cool the evaporated solvent and condense it to give the liquid. Fractional distillation separates two or more liquids. The setup is the same as distillation except a fractionating column is used to help separate the liquids out better.
Describe how paper and thin-layer chromatography work	All types of chromatography have a stationary phase and a mobile phase. Compounds are separated using chromatography as different compounds will have different preferences for the stationary and mobile phases. If a compound prefers the mobile phase then it will travel further, if it favours the stationary phase then it will travel a shorter distance. In paper chromatography the stationary phase is paper and the mobile phase is a solvent – usually but not always water. Each component of the mixture will produce a different spot. In thin layer chromatography, the stationary phase is a thin layer of silica or alumina powder over a plastic or glass plate.
Calculate retention factor (Rf) values from chromatograms	Rf = (distance travelled by substance) ÷ (distance travelled by solvent)
Describe how gas chromatography works	In gas chromatography, the mobile phase is a carrier gas such as nitrogen. The carrier gas needs to be unreactive. The stationary phase is silica or alumina packed onto a metal column. Each component will have a different retention time. The area under the peak is proportional to the amount of substance present.
Suggest suitable chromatography methods for distinguishing pure from impure substances	Paper chromatography is cheaper than thin layer chromatography, but tlc is quicker and more sensitive. There is also more choice of stationary and mobile phases as different tlc plates and solvents can be used.
Suggest suitable purification methods when given information about the substances involved	To separate a soluble solid from a solvent: If you want to isolate the solid then use crystallisation, if you want to isolate the solvent then use simple distillation. To separate an insoluble solid from a soluble solid dissolve the soluble solid and then filter to remove the insoluble solid. To separate two or more liquids use fractional distillation. To separate 2 or more soluble solids use paper chromatography or thin layer chromatography.
Keywords: alloy, balanced chemical equation, boiling point, carrier gas, chemical formula, chromatography, chromatogram, condensed, condenser, crystallisation, dissolves, empirical formula, evaporates, filtrate, filtration, fraction, fractional distillation, fractionating column, gas chromatography, impure substance, insoluble, melting point, mixture, mobile phase, paper chromatography, periodic table, phases, pure substance, purity, relative atomic mass, relative formula mass, residue, saturated solution, simple distillation, solubility, soluble, solute, solution, solvent, stationary phase, thin layer chromatography, vapour	