Science Autumn Term 2 – Chemistry: Calculations Involving Masses (C9)

Section A: Vocabulary

Tier 3 Vocabulary

empirical formula	The formula showing the simplest whole number ratio of atoms of each element in a compound.
molecular formula	The formula showing the actual number of atoms of each element in a molecule of a compound.
relative formula mass	The sum of the relative atomic masses of all the atoms in a formula.
precipitate	An insoluble substance that is formed when two soluble substances react together in solution.
closed system	When substances cannot enter or leave an observed environment, e.g. a stoppered test tube.
conservation of mass	The idea that mass is never lost or gained during a chemical reaction or physical change.
non-enclosed system	When substances can enter or leave an observed environment e.g. stoppered test tube
Avogadro constant	This is the number of particles in one mole of a substance (6.02×10^{23} mol^{-1}).
limiting reactant	The reactant that determines the amount of product formed in a chemical reaction. Any other reactants will be present in excess.
mole	The mass of a mole of a substance is the relative formula mass expressed in grams.
stoichiometry	The molar ratio of the reactants and products in a chemical reaction.

Tier 2 Vocabulary

solute	A substance that dissolves in a liquid to make a solution.
solvent	Describes the liquid in which a substance dissolves to make a solution.

Section B: Relative Formula Mass, Empirical and Molecular Formula

Relative Formula Mass (M_r)

Calculate the M_r of carbon dioxide (CO_2).

$= A_r(C) + (2 \times A_r(O))$
$= 12 + (2 \times 16)$

So, M_r of $CO_2 = 44$

Calcium nitrate has a giant lattice structure. Its formula is $Ca(NO_3)_2$ (for each calcium ion there are two nitrate ions). Calculate the M_r of calcium nitrate.

$= A_r(Ca) + 2(A_r(N) + (3 \times A_r(O)))$
$= 40 + 2(14 + (3 \times 16))$

So, M_r of $Ca(NO_3)_2 = 164$

Calculate the relative formula masses of:

a N_2 **b** NaCl **c** NH_3 **d** H_2SO_4 **e** $(NH_4)_2SO_4$.

Finding an Empirical Formula

Symbol for element	Ca	Cl
Mass (g)	10.0	17.8
Relative atomic mass, A_r	40	35.5
Divide the mass of each element by its relative atomic mass	$\frac{10.0}{40} = 0.25$	$\frac{17.8}{35.5} = 0.5$
Divide the answers by the smallest number to find the simplest ratio	$\frac{0.25}{0.25} = 1$	$\frac{0.5}{0.25} = 2$
Empirical formula	$CaCl_2$	

Caclulate the empirical formula of magnesium carbonate (1.2g Mg, 0.6g C, 2.4g O)

Finding a Molecular Formula

The empirical formula for glucose is CH_2O and its relative formula mass is 180. Determine the molecular formula for glucose.

- Find empirical formula mass $A_r(C) + (2 \times A_r(H)) + A_r(O)$
  $= 12 + (2 \times 1) + 16 = 30$
- Divide M_r by empirical formula mass $\frac{180}{30} = 6$

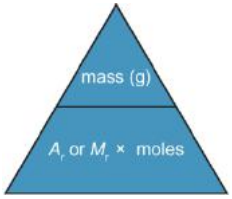
The molecular formula is six times the empirical formula, so the molecular formula is $C_6H_{12}O_6$.

Determine the molecular formula of hydrogen peroxide, with empirical formula HO and M_r 34.

Section C: Conservation of Mass and Moles

Calculate the mass of chlorine needed to make 53.4 g of aluminium chloride.

Write the balanced equation	$2Al + 3Cl_2 \rightarrow 2AlCl_3$
Calculate relative formula masses of the substances needed	$M_r\ Cl_2 = 2 \times 35.5 = 71$ $M_r\ AlCl_3 = 27 + (3 \times 35.5) = 133.5$
Calculate ratio of masses (multiply M_r values by the balancing numbers shown in the equation).	$3Cl_2$ makes $2AlCl_3$ so $3 \times 71 = 213$ g Cl_2 makes $2 \times 133.5 = 267$ g $AlCl_3$
Work out the mass for 1 g of reactant or product. (Here we want 1 g of the product because that's the mass we know already.)	÷ 267: $\frac{213}{267}$ g Cl_2 makes $\frac{267}{267}$ g $AlCl_3$ ÷ 267 0.798 g Cl_2 makes 1 g $AlCl_3$ × 53.4: 42.6 g Cl_2 makes 53.4 g $AlCl_3$ × 53.4
Scale up or down (*from* 1 g *to* the mass you are given)	



1.50 g of ammonium chloride and 4.00 g of calcium hydroxide are heated together to form ammonia.

$2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O$

a Which is the limiting reactant?

b Calculate the mass of ammonia formed.

a The equation shows that 2 mol of NH_4Cl reacts with 1 mol of $Ca(OH)_2$

number of moles of $Ca(OH)_2 = 4.00\ g/(40 + 2(16 + 1)) = 0.0541$ mol

We need: $2 \times 0.0541 = 0.108$ mol NH_4Cl to react with 0.0541 mol of $Ca(OH)_2$.

We have: $1.50\ g/(14 + (4 \times 1) + 35.5) = 0.0280$ mol

We have less than the 0.0541 mol of NH_4Cl needed; NH_4Cl = limiting reactant.

b The equation shows that the number of moles of NH_3 made equals the number of moles of NH_4Cl used.

So, 0.0280 mol of NH_4Cl forms 0.0280 mol of NH_3

mass of NH_3 formed = mol × $M_r = 0.0280 \times (14 + (3 \times 1)) = 0.476$ g