Chemistry 3: Quantitative Chemistry KNOWLEDGE ORGANISER (triple)

KPI:1 (p43)
Describe the conservation of mass, explaining the mass changes involving gases and balance equations

Conservation of mass
Atoms are the smallest particles of an element that can take part in a chemical reaction. During any chemical reaction no particles are created or destroyed: the atoms are simply rearranged from the reactants to the products. The products may have different properties to the reactants.
Mass is never lost or gained in chemical reactions. We say that mass is always **conserved**. In other words, the total mass of products at the end of the reaction is equal to the total mass of the reactants at the beginning.
This fact allows you to work out the mass of one substance in a reaction if the masses of the other substances are known.

KPI:2 (p41 - 42)
Calculate the formula mass of compounds and relate this to moles and Avogadro's constant

Chemists measure the amount of a substance in a unit called 'the **mole**'. This is a convenient way of counting atoms. It allows chemists to make predictions about the masses of different substances that are involved in reactions.
One mole is the **Avogadro number of particles** (atoms, molecules, ions or electrons) **in a substance**.

KPI:3 (p44 - 45)
Calculate the masses of reactants or products, identifying which reactant is limiting or in excess

A reaction stops when all the particles of one of the reactants are used up. In a reaction involving two reactants:
The limiting reactant is the one that is all used up at the end of the reaction
The reactant in **excess** is still there at the end of the reaction (although in a smaller amount than at the start). For example, magnesium reacts with hydrochloric acid. When the reaction is over:
Magnesium is the limiting reactant if it is all gone at the end
Hydrochloric acid is the limiting reactant if some magnesium is left at the end

KPI:4 (p44)
Use moles to calculate the balancing numbers in an equation

Calculate the number of moles of carbon dioxide molecules in 22 g of CO_2. A_r (relative atomic mass) of C = 12, A_r of O = 16. M_r (relative formula mass) of carbon dioxide = 12 + 16 + 16 = 44, so the number of moles = 22 ÷ 44 =**0.5 mol**

KPI:5 (p46)
Calculate the concentrations of solution and use these in titration calculations

If you know the concentration of one of the reactants present in a titration, you can work out the concentration of the other reactant.
Worked example 1
25 cm^3 of dilute hydrochloric acid is neutralised by 20 cm^3 of 0.5 mol/dm^3 sodium hydroxide. What is the concentration of the hydrochloric acid?
Step 1: Convert volumes to dm^3
25 cm^3 of HCl = 25 ÷ 1000 = 0.025 dm^3
20 cm^3 of NaOH = 20 ÷ 1000 = 0.020 dm^3
Step 2: Determine the number of moles of sodium hydroxide
moles of NaOH = concentration × volume
moles of NaOH = 0.5 × 0.020 = 0.010 mol

Step 3: Work out the number of moles of acid using the balanced equation
HCl(aq) + NaOH(aq) → NaCl(aq) + H2O(l)
In this reaction, one mole of HCl reacts with one mole of NaOH. This is a 1:1 ratio.
Therefore, in our titration, 0.010 mol of NaOH must neutralise 0.010 mol of HCl.
Step 4: Calculate the concentration of the acid
concentration of HCl = number of moles ÷ volume
concentration of HCl = 0.010 ÷ 0.025 = 0.4 mol/dm^3
The concentration of the HCl is **0.4 mol/dm^3**.

KPI:6 (p49)
Calculate percentage yield and explain loss of yield in reactions

In a manufacturing process 12 tonnes of product are predicted but only 10 tonnes are obtained. What is the percentage yield?

Percentage yield = (actual yield x 100%) / predicted yield
percentage yield = (10 x 100) / 12
percentage yield = (1000) / 12 = **83.3%**

KPI:7 (p48)
Calculate atom economy and describe it's economic and environmental importance

$$\%\ \text{Atom Economy} = \frac{\text{Molar Mass of Product}}{\text{Molar Mass of All Reactants}} \times 100\%$$

$$= \frac{206.29\ \text{g/mol}}{(134.22 + 102.09 + 2.02 + 28.01)\ \text{g/mol}} \times 100\%$$

$$= \frac{206.29\ \text{g/mol}}{266.34\ \text{g/mol}} \times 100\%$$

% Atom Economy = 77%

KPI:8 (p46)
Calculate the volume of gases

One mole of any gas has a volume of 24 dm^3 or 24,000 cm^3 at **rtp** (room temperature and pressure). This volume is called the **molar volume of a gas**.
This equation shows how the volume of gas in dm^3 at rtp is related to the number of moles:
volume of gas at rtp = number of moles × 24