AS PREP WORK

PART 1: MEASURING AMOUNT OF SUBSTANCE

MASS	**VOLUME**	**MOLAR MASS**	**AVOGADRO**
CONCENTRATION	**ATOM**	**ION**	**MOLECULE**

MEASUREMENTS IN CHEMISTRY

Mass

Convert the following into grams:

a) 0.25 kg
b) 15 kg
c) 100 tonnes
d) 2 tonnes

Volume

Convert the following into dm^3:

a) 100 cm^3
b) 25 cm^3
c) 50 m^3
d) 50000 cm^3

Tip – always use standard form for very large and very small numbers!

What is a mole?

Atoms and molecules are very small – far too small to count individually!

It is important to know how much of something we have, but we count particles in MOLES because you get simpler numbers

$$1 \text{ mole} = 6.02 \times 10^{23} \text{ particles}$$

$(6.02 \times 10^{23}$ is known as Avogadro's number)

a) If you have 2.5×10^{21} atoms of magnesium, how many moles do you have?

b) If you have 0.25 moles of carbon dioxide, how many molecules do you have?

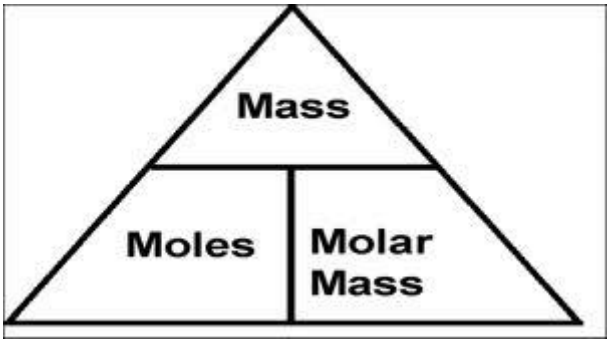
How can you work out how many moles you have?

a) From a measurement of **MASS**:

You can find the number of moles of a substance if you are given its **mass** and you know its **molar mass**:

number of moles = mass/molar mass

$n = m/m_r$



Mass MUST be measured in grams!

Molar mass has units of $gmol^{-1}$

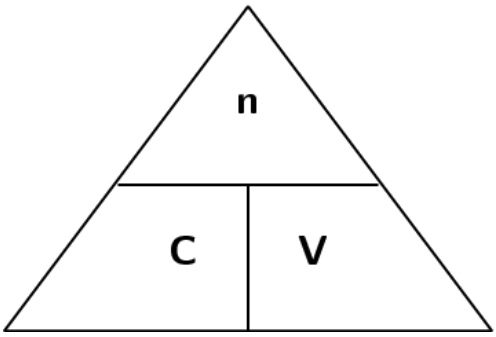
1. Calculate the number of moles present in:	2. Calculate the mass of:	3. Calculate the molar mass of the following substances:
a) 2.3 g of Na	a) 0.05 moles of Cl_2	a) 0.015 moles, 0.42 g
b) 2.5 g of O_2	b) 0.125 moles of KBr	b) 0.0125 moles, 0.50 g
c) 240 kg of CO_2	c) 0.075 moles of $Ca(OH)_2$	c) 0.55 moles, 88 g
d) 12.5 g of $Al(OH)_3$	d) 250 moles of Fe_2O_3	d) 2.25 moles, 63 g
e) 5.2 g of PbO_2	e) 0.02 moles of $Al_2(SO_4)_3$	e) 0.00125 moles, 0.312 g

b) From a measurement of AQUEOUS VOLUME:

You can find the number of moles of a substance dissolved in water (aqueous) if you are given the **volume** of solution and you know its **molar concentration**:

number of moles = aqueous volume x molar concentration

n = V x C



Aqueous volume MUST be measured in dm^3!

concentration has units of $moldm^{-3}$

If you know the molar mass of the substance, you can convert the molar concentration into a mass concentration:

Molar concentration ($moldm^{-3}$) x m_r = mass concentration (gdm^{-3})

1. Calculate the number of moles of substance present in each of the following solutions:	2. Calculate the molar concentration and the mass concentration of the following solutions:	3. Calculate the molar concentration and the mass concentration of the following solutions:
a) 25 cm^3 of 0.1 $moldm^{-3}$ HCl	a) 0.05 moles of HCl in 20 cm^3	a) 35 g of NaCl in 100 cm^3
b) 40 cm^3 of 0.2 $moldm^{-3}$ HNO_3	b) 0.01 moles of NaOH in 25 cm^3	b) 20 g of $CuSO_4$ in 200 cm^3
c) 10 cm^3 of 1.5 $moldm^{-3}$ NaCl	c) 0.002 moles of H_2SO_4 in 16.5 cm^3	c) 5 g of HCl in 50 cm^3
d) 5 cm^3 of 0.5 $moldm^{-3}$ $AgNO_3$	d) 0.02 moles of $CuSO_4$ in 200 cm^3	d) 8 g of NaOH in 250 cm^3
e) 50 cm^3 of 0.1 $moldm^{-3}$ H_2SO_4	e) 0.1 moles of NH_3 in 50 cm^3	e) 2.5 g of NH_3 in 50 cm^3

c) From a measurement of GASEOUS VOLUME:

You can find the number of moles of a gas if you are given the **volume** of the gas and its **pressure** (in kPa) and **absolute temperature (in K)**:

$$\textbf{number of moles} = \frac{\textbf{pressure x volume}}{\textbf{R x temperature}} = \textbf{PV/RT}$$

Volume of gas must be in m^3

Pressure must be in Pa

Temperature must be in K

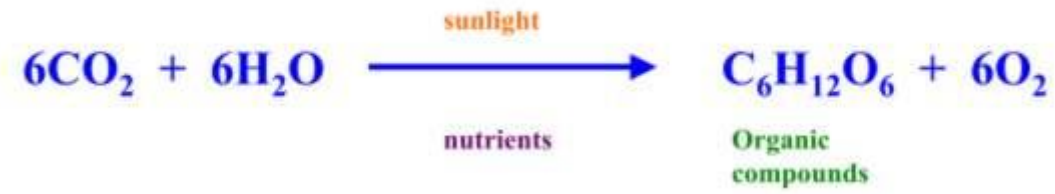
R is the molar gas constant (8.31 $Jmol^{-1}K^{-1}$)

1. Calculate the number of moles present in:	2. Calculate the volume of gas occupied by:	3. Calculate the mass of the following gas samples:
a) 48 dm^3 of O_2 at 298 K and 100 kPa	a) 0.05 moles of Cl_2 at 298 K and 100 kPa	a) 48 dm^3 of O_2 at 298 K and 100 kPa
b) 1.2 dm^3 of CO_2 at 298 K and 100 kPa	b) 0.25 moles of CO_2 at 298 K and 100 kPa	b) 1.2 dm^3 of CO_2 at 298 K and 100 kPa
c) 200 cm^3 of N_2 at 273 K and 250 kPa	c) 28 g of N_2 at 273 K and 250 kPa	c) 200 cm^3 of N_2 at 273 K and 250 kPa
d) 100 dm^3 of Cl_2 at 30 ^oC at 100 kPa	d) 3.2 g of O_2 at 30 ^oC at 100 kPa	d) 100 dm^3 of Cl_2 at 30 ^oC at 100 kPa
e) 60 cm^3 of NO_2 at 25 ^oC and 100 kPa	e) 20 g of NO_2 at 25 ^oC and 100 kPa	e) 60 cm^3 of NO_2 at 25 ^oC and 100 kPa

AS PREP WORK

PART 2: USING CHEMICAL EQUATIONS

MASS **AQUEOUS VOLUME** ` **MOLAR MASS**



GASEOUS VOLUME **MOLES** **CONCENTRATION**

How many moles?

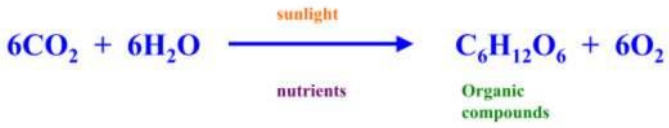
1) Erder weighs a sample of $CaCO_3$ and records a mass of 5.0 g. How many moles of calcium carbonate are present?

2) Aishah measures out 50 cm^3 of 0.1 $moldm^{-3}$ hydrochloric acid. How many moles of hydrochloric acid are present?

3) Humaira collects 48 cm^3 of carbon dioxide in a gas syringe at 298 K and 100 kPa. How many moles of carbon dioxide are present?

Using Chemical Equations

Chemical Equations show the ratio in which different species react in a chemical equation.



This equation shows that **6** moles carbon dioxide of react with **6** mole of water to make **1** mole of glucose and **6** moles of oxygen.

6: 6: 1: 6

a) How many moles of water are needed to react with 0.03 moles of carbon dioxide?
b) How many moles of glucose can you make from 0.03 moles of carbon dioxide?
c) How many moles of oxygen can you make from 0.03 moles of carbon dioxide?

Equation 1: $Mg + 2\,HCl \rightarrow MgCl_2 + H_2$

a) How many moles of magnesium would be needed to react with 0.01 moles of hydrochloric acid?
b) How many moles of hydrogen could be produced from 0.01 moles of hydrochloric acid?

Equation 2: $2\,H_2S + 3\,O_2 \rightarrow 2\,SO_2 + 2\,H_2O$

a) How many moles of oxygen are needed to react with 0.5 moles of hydrogen sulphide?
b) How many moles of sulphur dioxide can be made from 0.5 moles of hydrogen sulphide?

Equation 3: $4\,K + O_2 \rightarrow 2\,K_2O$

a) How many moles of oxygen are needed to react with 0.05 moles of potassium?
b) How many moles of potassium oxide can be made from 0.05 moles of potassium?

Calculating Reacting Quantities from Chemical Equations

You perform these calculations in three steps:

- **calculate the number of moles of one of the substances (you will either be given the mass, or the aqueous volume and the concentration, or the gaseous volume)**
- **use the equation to work out the number of moles of the other substance**
- **use one of the mole relationships to work out the quantity you need**

1) What volume (in dm^3) of hydrogen is produced at 298 K and 100 kPa when 194 g of magnesium is reacted with hydrochloric acid?

$$Mg + 2\,HCl \rightarrow MgCl_2 + H_2$$ (3)

2) What volume (in cm^3) of 0.5 $moldm^{-3}$ hydrochloric acid is required to react completely with 1.94 g of magnesium?

$$Mg + 2\,HCl \rightarrow MgCl_2 + H_2$$ (3)

3) What volume (in dm^3) of oxygen at 298 K and 100 kPa is needed to react with 8.5 g of hydrogen sulphide (H_2S)?

$$2\,H_2S + 3\,O_2 \rightarrow 2\,SO_2 + 2\,H_2O$$ (3)

4) What mass of potassium oxide is formed when 7.8 g of potassium is burned in excess oxygen?

$$4\,K + O_2 \rightarrow 2\,K_2O$$ (3)

5) What volume of oxygen (in dm^3) at 298 K and 100 kPa is required to oxidise 10 g of ammonia to NO?

$$4\,NH_3 + 5\,O_2 \rightarrow 4\,NO + 6\,H_2O$$ (3)

6) What mass of aluminium oxide is produced when 135 g of aluminium is burned in oxygen?

$$2\ Al + 3\ O_2 \rightarrow Al_2O_3$$ (3)

7) What mass of iodine is produced when 2.4 dm^3 of chlorine gas reacts with excess potassium iodide at 298 K and 100 kPa?

$$Cl_2 + 2\ KI \rightarrow 2\ KCl + I_2$$ (3)

8) What volume (in dm^3) of hydrogen is needed to react with 32 g of copper oxide at 200 ^oC and 100 kPa?

$$CuO + H_2 \rightarrow Cu + H_2O$$ (3)

9) What volume of oxygen is formed at 398 K and 100 kPa when 735 g of potassium chlorate decomposes?

$$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$$ (3)

10) What volume of hydrogen is produced when 195 g of potassium is added to water at 298 K and 100 kPa?

$$2\ K + 2\ H_2O \rightarrow 2\ KOH + H_2$$ (3)

11) What mass of calcium carbonate is required to produce 1.2 dm^3 of carbon dioxide at 398 K and 100 kPa?

$$CaCO_3 \rightarrow CaO + CO_2$$ (3)

12) What mass of magnesium oxide is formed when magnesium reacts with 6 dm^3 of oxygen at 298 K and 100 kPa?

$$2\ Mg\ +\ O_2\ \rightarrow\ 2\ MgO$$ (3)

13) What volume of carbon dioxide (in dm^3) is produced when 5.6 g of butene (C_4H_8) is burnt at 298 K and 100 kPa?

$$C_4H_8\ +\ 6\ O_2\ \rightarrow\ 4\ CO_2\ +\ 4\ H_2O$$ (3)

14) The pollutant sulphur dioxide can be removed from the air by reaction with calcium carbonate in the presence of oxygen. What mass of calcium carbonate is needed to remove 480 dm^3 of sulphur dioxide at 298 K and 100 kPa?

$$2\ CaCO_3\ +\ 2\ SO_2\ +\ O_2\ \rightarrow\ 2\ CaSO_4\ +\ 2\ CO_2$$ (3)

15) 25 cm^3 of a solution of sodium hydroxide reacts with 15 cm^3 of 0.1 mol/dm^3 HCl. What is the molar concentration of the sodium hydroxide solution?

$$HCl + NaOH \rightarrow NaCl + H_2O$$ (3)

Links between GCSE and A level Chemistry

The questions that follow are from the AS content, that follows on from the basics covered at GCSE. If you can't answer any of the below make sure you are using your GCSE revision guide to review this so you know it come September.

1.1 Module 1: Atoms and Reactions

1.1.1 Atoms

Candidates should be able to:

Atomic structure

(a) describe protons, neutrons and electrons in terms of relative charge and relative mass;

particle	relative mass	relative charge
proton		
neutron		
electron		

(b) describe the distribution of mass and charge within an atom;

particle	where found
proton	
neutron	
electron	

The mass of an atom depends on the.....

The mass of an atom is concentrated.....

The positively charged particles in an atom are found.....

The negatively charged particles in an atom are found.....

Atoms are neutral because.....

(c) describe the contribution of protons and neutrons to the nucleus of an atom, in terms of atomic (proton) number and mass (nucleon) number;

Atomic number = ...

Mass number = ...

(d) deduce the numbers of protons, neutrons and electrons in:

(i) an atom given its atomic and mass number,

(ii) an ion given its atomic number, mass number and ionic charge;

Example:

Species	(i) ^{84}Kr	(ii) $^{63}Cu^{2+}$
number of protons		
number of neutrons		
number of electrons		

(e) explain the term *isotopes* as atoms of an element with different numbers of neutrons and different masses;

Isotopes = ...

Relative Masses

(f) state that ^{12}C is used as the standard measurement of relative masses;

1 atomic mass unit = ...

(g) define the terms *relative isotopic mass* and *relative atomic mass*, based on the ^{12}C scale;

relative isotopic mass = ...

.....

relative atomic mass = ...

.....

(h) calculate the relative atomic mass of an element given the relative abundances of its isotopes;

eg A sample of titanium was found to contain three isotopes, ^{46}Ti, ^{47}Ti and ^{48}Ti. The results of the analysis are shown in the table below.

isotope	^{46}Ti	^{47}Ti	^{48}Ti
relative isotopic mass	46.00	47.00	48.00
percentage composition	8.9	9.8	81.3

Using the information in the table, calculate the relative atomic mass of this sample of titanium. Give your answer to three significant figures.

(i) use the terms *relative molecular mass* and *relative formula mass* and calculate values from relative atomic masses.

relative molecular mass is used to describe .....

relative formula mass is used to describe .....

eg Calculate the relative molecular mass of butane (C_4H_{10})

eg Calculate the relative formula mass of magnesium chloride ($MgCl_2$)

1.1.2 Moles and Equations

Candidates should be able to:

The mole

(a) explain the terms:
- **(i)** ***amount of substance,***
- **(ii)** ***mole*** **(symbol 'mol'), as the unit for amount of substance,**
- **(iii)** **the *Avogadro constant,* N_A, as the number of particles per mole (6.02×10^{23} mol^{-1});**

Amount of substance = ...

.....

Mole = ...

.....

Avogadro Constant = ...

.....

(b) define and use the term *molar mass* (units gmol^{-1}) as the mass per mole of a substance;

Molar mass = ...

.....

Empirical and Molecular Formulae

(c) explain the terms:
- **(i)** **e*mpirical formula* as the simplest whole number ratio of atoms of each element present in a compound,**
- **(ii)** ***molecular formula*** **as the actual number of atoms of each element in a molecule;**

Empirical formula = ...

.....

Molecular formula = ...

.....

(d) calculate empirical and molecular formulae, using composition by mass and percentage compositions;

eg 1 A student reacted 1.44 g of titanium with chlorine to form 5.70 g of a chloride **X**. Determine the empirical formula of X

eg 2 Calculate the empirical formula of a ionic compound which has the following percentage composition by mass: Rb, 7.42%; Ag, 37.48%; I, 55.10%

Chemical equations

(e) construct balanced chemical equations for reactions studied and for unfamiliar reactions given reactants and products;

eg Write a balanced equation to show the formation of $(NH_4)_2SO_3$ from ammonia, water and sulphur dioxide

eg Write a balanced equation to show the reaction of ammonia with oxygen to produce nitrogen monoxide and water

Calculation of reacting masses, mole concentrations and volumes of gases

(f) carry out calculations, using amount of substance in mol, involving:
(i) mass,
(ii) gas volume,
(iii) solution volume and concentration;

Eg 1 0.11 g of pure barium was added to 100 cm^3 of water.

$Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$

(i) Calculate the moles of Ba added to the water.

(ii) Calculate the volume of hydrogen, in cm^3, produced at room temperature and pressure.

(iii) Calculate the concentration, in mol dm^{-3}, of the $Ba(OH)_2(aq)$ solution formed.

Eg 2 A student neutralised 1.50 g of $CaCO_3$ with 2.50 mol dm^{-3} nitric acid, HNO_3. The equation for this reaction is shown below:

$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$

(i) How many moles of $CaCO_3$ were reacted?

(ii) Calculate the volume of 2.50 mol dm^{-3} HNO_3 needed to exactly neutralise 1.50 g of $CaCO_3$.

(iii) Calculate the volume of CO_2 produced at rtp.

(g) deduce stoichiometric relationships from calculations;

Eg 25 cm^3 of a 0.1 $moldm^{-3}$ solution of an acid H_xA reacts with 75 cm^3 of a 0.1 $moldm^{-3}$ solution of NaOH. What is the value of x?
Equation: $H_xA + xNaOH \rightarrow + Na_xA + xH_2O$

(h) use the terms *concentrated* and *dilute* as qualitative descriptions for the concentration of a solution.

concentrated = ...

dilute = ...