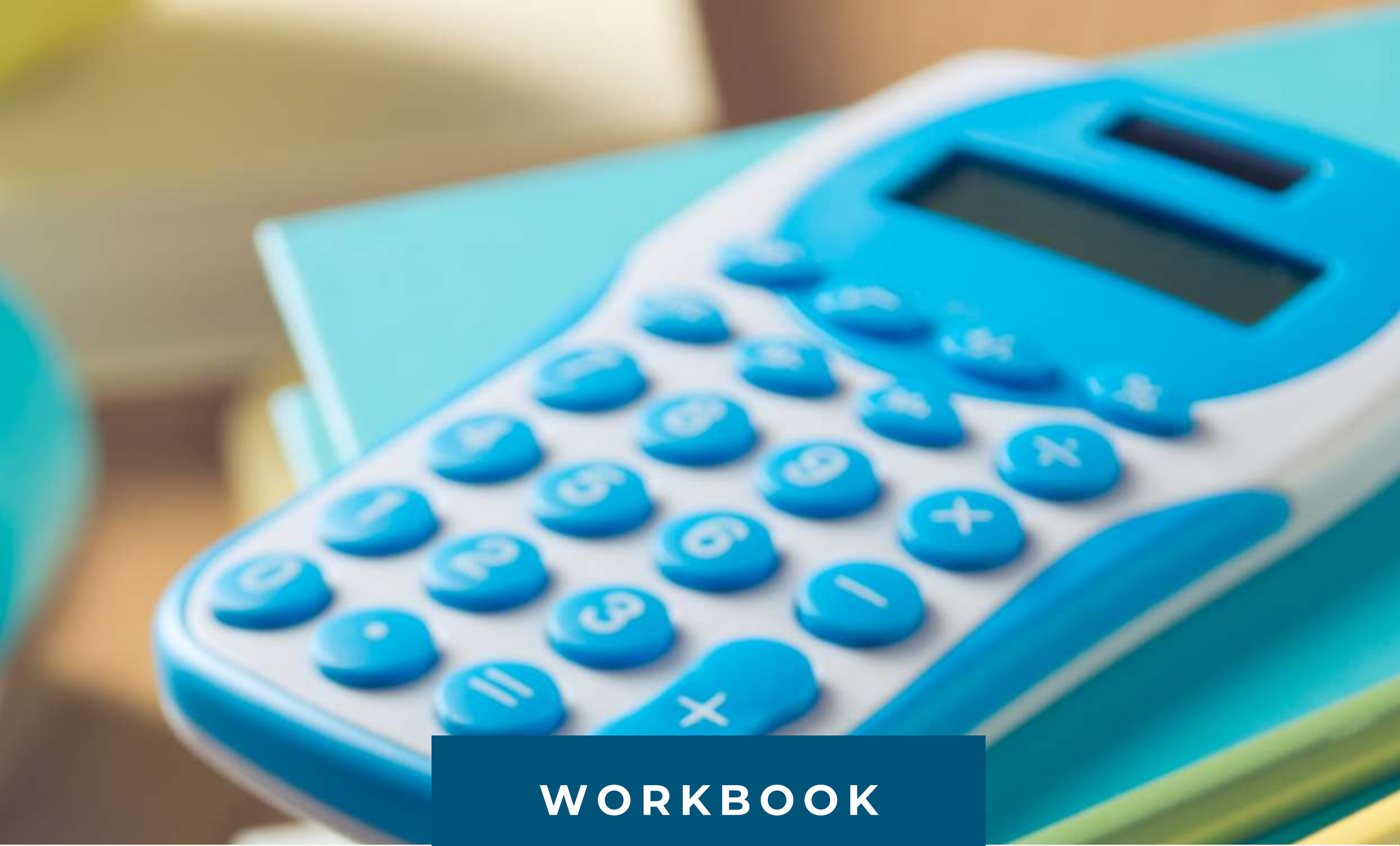


WORKBOOK

Online Chem Tuition

Quantitative Chemistry

TOPIC THREE

4TH APRIL

HELLO!

Welcome to your AQA GCSE Chemistry revision session. This workbook is designed to be straightforward and directly aligned with what I'll cover in the live lesson, it offers a practical way to apply your knowledge as you learn.

What's in the Workbook:

- **Questions**: These are selected to match the lesson topic, providing you with a chance to practice and solidify your understanding.
- **Symbols Guide**:
  - HT - Indicates advanced content aimed at **Higher Tier** students.
  - - Signifies material for **GCSE Chemistry** students only.

Using the Workbook During Lesson:

- **Stay Engaged**: Be ready to participate and use the workbook alongside the lesson. You can use the chat to ask questions or get help.
- **Peer Learning**: Take advantage of the group setting. Your classmates' questions can provide additional insights.

Zoom Lesson:

Make sure you have your workbook and a pen ready and join us here.

See you on Zoom!

ALISON GREEN

Online Chem Tuition

CONSERVATION OF MASS

CONSERVATION OF MASS

The law of conservation of mass states that no atoms are lost or made during a chemical reaction. This means the total mass of the reactants equals the total mass of the products. In some chemical reactions, it might seem like the mass changes, but this usually happens because a gas is involved as a reactant or product, and its mass wasn't accounted for.

APPEARS TO DECREASE IN MASS

When a metal reacts with oxygen, the resulting oxide has a greater mass than the original metal because the mass of the oxygen gas that reacted is added.

APPEARS TO INCREASE IN MASS

In the thermal decomposition of metal carbonates, carbon dioxide gas is produced and released into the atmosphere, leaving behind only the metal oxide as a solid. This makes it appear as if mass is lost.

BALANCED CHEMICAL EQUATIONS

A chemical equation is balanced when it accurately represents the conservation of mass, with an equal number of each type of atom on both sides of the equation. Balancing equations is crucial for the quantitative interpretation of chemical reactions.

CHEMICAL MEASUREMENTS

UNCERTAINTY

Whenever a measurement is made there is always some uncertainty about the result obtained.

ESTIMATING USING THE RANGE

The range of a set of measurements, calculated as the difference between the highest and lowest values, serves as a simple measure of uncertainty. It provides insight into the spread of data around the mean.

RELATIVE FORMULA MASS

RELATIVE FORMULA MASS

The relative formula mass of a compound is the sum of the relative atomic masses of the atoms in the formula. It is used in calculations involving the masses of reactants and products.

IN BALANCED EQUATIONS

the sum of the relative formula mass of reactants = sum of the relative formula mass of products

CALCULATING % BY MASS

$$\%\ of\ an\ element = \frac{mass\ of\ an\ element\ in\ the\ compound}{relative\ formula\ mass\ M_r} \times 100$$

% by mass of Fe in Fe_2O_3 = ((2 x 56)/160)x100 = 70%

Q1. A student investigated the law of conservation of mass. This is the method used.

1. Pour silver nitrate solution into a beaker labelled A.
2. Pour sodium iodide solution into a beaker labelled B.
3. Measure the masses of both beakers and their contents.
4. Pour the solution from beaker B into beaker A.
5. Measure the masses of both beakers and their contents again.

The table shows the student's results.

	Mass before mixing in g	Mass after mixing in g
Beaker **A** and contents	78.26	108.22
Beaker **B** and contents	78.50	48.54

Explain how the results demonstrate the law of conservation of mass.
You should use data from Table 3 in your answer.

[2 marks]

AQA June 20 H Q3.1

Q2. Element R is extracted from its oxide by reduction with hydrogen.
The equation for the reaction is: $3H_2 + RO_3 \rightarrow R + 3H_2O$

Q2.a) The sum of the relative formula masses (Mr) of the reactants ($3H_2 + RO_3$) is 150 Calculate the relative atomic mass (Ar) of R.
Relative atomic masses (Ar): H = 1 O = 16

[2 marks]

AQA June 21 H Q3.1

Q2.b) Identify element R.
You should use:

- your answer to question Q2.a)
- the periodic table.

[1 mark]

AQA June 21 H Q3.2

AMOUNT OF SUBSTANCE

HT MOLES

Chemical amounts are measured in moles. The symbol for the unit mole is mol. The mass of one mole of a substance in grams is numerically **equal to its relative formula mass.**

HT CALCULATING MOLES

$$moles = \frac{mass\ (g)}{M_r} \qquad \text{Mass} = \text{mol} \times M_r$$

e.g. number of moles in 36 g of water = 36/18 = 2 mol

e.g. mass of 0.25 mol of carbon dioxide molecules = 44 × 0.25 = 11 g

HT AVOGADRO CONSTANT

The number of **atoms, molecules or ions** in a mole of a given substance is the Avogadro constant. The value of the Avogadro constant is 6.02×10^{23} per mole.

So in 0.5 mol water = $6.02 \times 10^{23} \times 0.5$ = 3.01×10^{23} water **molecules**

The number of hydrogen **atoms** (2 per molecule) is therefore 6.02×10^{23} atoms.

HT CALCULATING MASSES USING BALANCED EQUATIONS

- Use the data in the questions to identify the mass that is given and the unknown mass to calculate.
- Work out the Mr of these two substances.
- Calculate the moles of the substance with the given mass (moles = mass/Mr).
- Use the balanced equation and moles calculated in 2. to find the moles of the unknown substance.
- Find the mass of the unknown substance. (mass = moles x Mr)

Example: Calculate the mass of oxygen needed to react with 10.0 g of magnesium to form magnesium oxide.

$2Mg + O_2 \rightarrow 2MgO$

Masses 10 g ?
Mr 24 32
Moles Mg = 10/24 = 0.42 mol
Ratio 2 : 1
Moles O_2 = 0.42 / 2 = 0.21 mol
Mass O_2 = 0.21 x 32 = 6.7 g

HT USING MOLES TO BALANCE EQUATIONS

- Calculate the Mr of all substance.
- Calculate moles (mass/Mr)
- Use the numbers to write the chemical equation.

Example: 64 g of methanol, CH_3OH, reacts with 96 g of oxygen gas to produce 88 g of carbon dioxide and 72 g of water. Deduce the balanced equation for the reaction.

Mr: CH_3OH = 32, O_2 = 32, CO_2 = 44, H_2O = 18
Calc mass / Mr: CH_3OH = 64/32 = **2**, O_2 = 96/32 = **3**, CO_2 = 88/44 = **2**, H_2O = 72/18 = **4**
Equation: **2** CH_3OH + **3** O_2 → **2** CO_2 + **4** H_2O

HT LIMITING REACTANTS

In reactions where the quantities of reactants are not in the exact ratio required by the balanced equation, one reactant will be used up before the other - limiting reactant. This determines the maximum amount of product that can be formed. The reactant that is left over is described as being in excess.

PERCENTAGE YIELD

Percentage yield measures the efficiency of a chemical reaction in terms of the amount of product produced.

$$\text{Percentage Yield} = \left(\frac{\text{Actual Yield}}{\text{Theoretical Yield}}\right) \times 100\%$$

ATOM ECONOMY

This gives a percentage indicating the efficiency of the reaction in converting reactants into useful products.

$$\text{Atom Economy} = \left(\frac{\text{Relative Formula Mass of Desired Products}}{\text{Relative Formula Mass of All Reactants}}\right) \times 100\%$$

Q3. Calculate the number of C_{70} molecules that can be made from one mole of carbon atoms.
The Avogadro constant = 6.02×10^{23} per mole

[3 marks]
AQA June 22 H Q3.5

Q4. A teacher investigated the reaction of iron with chlorine. The word equation for the reaction is: iron + chlorine → iron chloride
The teacher weighed: • the glass tube • the glass tube and iron before the reaction • the glass tube and iron chloride after the reaction.
The table shows the teacher's results

	Mass in g
Glass tube	51.56
Glass tube and iron	56.04
Glass tube and iron chloride	64.56

Calculate the simplest whole number ratio of:
moles of iron atoms : moles of chlorine atoms
Determine the balanced equation for the reaction.
Relative atomic masses (Ar): Cl = 35.5 Fe = 56

[6 marks]
AQA June 20 H Q8.6

Q5. 0.24 g of copper was produced by the electrolysis of copper nitrate solution. Determine the number of copper atoms produced.
Give your answer to 3 significant figures.
Relative atomic mass (Ar): Cu = 63.5
The Avogadro constant = 6.02×10^{23} per mole

[3 marks]
AQA June 21 H Q7.8

Q6. A teacher found that the oxide of copper produced 2.54 g of copper and 0.72 g of water. Two possible equations for the reaction are:

Equation 1: $Cu_2O + H_2 \rightarrow 2Cu + H_2O$

Equation 2: $CuO + H_2 \rightarrow Cu + H_2O$

Determine which is the correct equation for the reaction in the teacher's experiment.
Relative atomic masses (Ar): H = 1 O = 16 Cu = 63.5

[3 marks]
AQA June 19 H Q8.4

Q7. 40 kg of titanium chloride was added to 20 kg of sodium. The equation for the reaction is: $TiCl_4 + 4\ Na \rightarrow Ti + 4\ NaCl$

HT

Relative atomic masses (Ar): Na = 23 Cl = 35.5 Ti = 48
Explain why titanium chloride is the limiting reactant.
You **must** show your working.

[3 marks]
AQA June 19 H Q8.7

Q8. A mixture contains 1.00 kg of aluminium and 3.00 kg of iron oxide.
The equation for the reaction is: $2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$
Show that aluminium is the limiting reactant.
Relative atomic masses (Ar): O = 16 Al = 27 Fe = 56

HT

[4 marks]

AQA June 20 H Q6.2

Q9. The overall equation for the electrolysis of aluminium oxide is:
$2Al_2O_3 \rightarrow 4Al + 3O_2$
Calculate the mass of oxygen produced when 2000 kg of aluminium oxide is completely electrolysed.
Relative atomic masses (Ar): O = 16 Al = 27

HT

[4 marks]

AQA June 19 H Q7.5

Q10. Calculate the minimum mass in grams of magnesium needed to completely reduce 1.2 kg of silicon dioxide.
The equation is $2\,Mg(s) + SiO_2(s) \rightarrow Si(s) + 2\,MgO(s)$
Relative atomic masses (Ar): O = 16 Mg = 24 Si = 28

HT

[5 marks]

AQA June 22 H Q7.4

Q11. An equation for the reduction of nickel oxide is:
$NiO + C \rightarrow Ni + CO$
Calculate the percentage atom economy for the reaction to produce nickel.
Relative atomic masses (Ar): C = 12 Ni = 59
Relative formula mass (Mr): NiO = 75
Give your answer to 3 significant figures.

[3 marks]
AQA June 18 H Q2.5

Q12. Calculate the percentage atom economy for the production of silver iodide in this reaction. The equation for the reaction is:
$AgNO_3(aq) + NaI(aq) \rightarrow AgI(s) + NaNO_3(aq)$
Give your answer to 3 significant figures.
Relative formula masses (Mr): $AgNO_3$ = 170 NaI = 150 AgI = 235 $NaNO_3$ = 85

[4 marks]
AQA June 20 H Q3.5

Q13. Give **one** reason why reactions with a high atom economy are used in industry.

[1 mark]
AQA June 20 H Q3.6

Q14. For the reaction: $TiCl_4 + 4\ Na \rightarrow Ti + 4\ NaCl$
The percentage yield was 92.3% The theoretical maximum mass of titanium produced in this batch was 13.5 kg. Calculate the actual mass of titanium produced.

[2 marks]
AQA June 18 H Q8.8

CONCENTRATION

CONCENTRATION OF SOLUTIONS

The concentration of a solution can be measured in mass per given volume of solution, eg grams per dm^3 (g/dm^3).

$$\text{concentration} = \frac{\text{mass of solute in g}}{\text{volume in } dm^3}$$

8 g of sodium hydroxide is dissolved in 2 dm^3 of water. Calculate the concentration of the sodium hydroxide solution formed.

concentration = 8/2 = 4 g/dm^3

CALCULATE THE MASS OF SOLUTE

mass of solute in g = concentration in g/dm^3 × volume in dm^3

A solution of sodium chloride has a concentration of 10 g/dm^3.
What mass of sodium chloride is dissolved in 2 dm^3 of the solution?
= 10 g/dm^3 × 2 dm^3 = 20 g

HT USING CONCENTRATIONS OF SOLUTIONS IN MOL/DM³

$$\text{Concentration } (\text{mol}/\text{dm}^3) = \frac{\text{Number of moles of solute}}{\text{Volume of solution in dm}^3}$$

Calculate the concentration (in mol/dm^3) when 5.85 grams of NaCl is dissolved in 250 cm^3 of water.

Moles NaCl = 5.85/58.5 = 0.1 mol, concentration = 0.1/0.25 = 0.4 mol/dm^3

HT G/DM³ TO MOL/DM³

- To convert from g/dm^3 to mol/dm^3:
  - Divide by the Mr

HT MOL/DM³ TO G/DM³

- To convert from mol/dm^3 to g/dm^3:
  - Multiply by the Mr

HT TITRATIONS CALCULATIONS - SEE TOPIC 4

If the concentration of one of the reactants is known (either the acid or the base), then the exact volumes from a titration along with the balanced chemical equation for the reaction can be used to calculate the concentration of the other reactant

25.0 cm^3 of a solution of 0.05 mol/dm^3 sodium carbonate was completely neutralised by 20.00 cm^3 of dilute hydrochloric acid. Calculate the concentration of the hydrochloric acid in mol/dm^3.

$Na_2CO_3 + 2\,HCl \rightarrow 2\,NaCl + H_2O + CO_2$

- Calculate the moles for the substance with both volume and concentration given.
- Calculate the moles of the other reactant using the balanced equation.
- Calculate the concentration

- moles Na_2CO_3 = 25.0/1000 x 0.05 = 0.00125 mol
- From balanced equation 1 mol of Na_2CO_3 reacts with 2 mol of HCl therefore mol HCl = 0.00125 x 2 = 0.0025 mol
- Concentration HCl = 0.0025/0.02 = 0.125 mol/dm^3

VOLUME OF GASES

HT CALCULATING VOLUME OF GAS

Under the same conditions of temperature and pressure, equal amounts (in moles) of different gases occupy the same volume. At room temperature (20°C) and standard atmospheric pressure (1 atm), the volume occupied by one mole of any gas is 24 dm^3 or 24000 cm^3.

Calculate the volume of 0.25 mol of hydrogen at room temperature and pressure.

Volume = amount in mol × molar volume = 0.25 × 24 = 6 dm^3

Q15. Calculate the mass of sodium hydroxide in 30.0 cm^3 of a 0.105 mol/dm^3 solution. Relative formula mass (Mr): NaOH = 40

[2 marks]

AQA June 18 H Q9.5

Q16. A student made 250 cm^3 of a solution of citric acid of concentration 0.0500 mol/dm^3. Calculate the mass of citric acid ($C_6H_8O_7$) required. Relative atomic masses (Ar): H = 1 C = 12 O = 16

[3 marks]

AQA June 20 H Q9.4

Q17. 13.3 cm3 of 0.0500 mol/dm^3 citric acid solution was needed to neutralise 25.0 cm^3 of sodium hydroxide solution. The equation for the reaction is: $3NaOH + C_6H_8O_7 \rightarrow C_6H_5O_7Na_3 + 3H_2O$
Calculate the concentration of the sodium hydroxide solution in mol/dm^3

[3 marks]

AQA June 20 H Q9.7

Q18. A student found that 15.5 cm^3 of 0.500 mol/dm^3 dilute sulfuric acid completely reacted with 25.0 cm^3 of potassium hydroxide solution. The equation for the reaction is:

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

Calculate the concentration of the potassium hydroxide solution in mol/dm^3 and in g/dm^3

Relative atomic masses (Ar): H = 1 O = 16 K = 39

[6 marks]

AQA June 19 H Q9.5

Q19. A student found that 25.0 cm^3 of the sodium hydroxide solution was neutralised by 15.00 cm^3 of the 0.0480 mol/dm^3 ethanedioic acid solution. The equation for the reaction is:

$H_2C_2O_4 + 2\ NaOH \rightarrow Na_2C_2O_4 + 2H_2O$

Calculate the concentration of the sodium hydroxide solution in mol/dm^3

[3 marks]

AQA June 21 H Q9.5

Q20. Calculate the volume of oxygen required to react with 50 cm^3 of hydrogen sulfide $2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$

[1 mark]

AQA June 21 H Q8.2

Q21. Si_2H_6 reacts with oxygen. The equation for the reaction is:

$$2Si_2H_6(g) + 7O_2(g) \rightarrow 4SiO_2(s) + 6H_2O(g)$$

30 cm^3 of Si_2H_6 is reacted with 150 cm^3 (an excess) of oxygen.
Calculate the total volume of gases present after the reaction.
All volumes of gases are measured at the same temperature and pressure

[4 marks]

AQA June 22 H Q7.6

Q22. Iron chloride is produced by heating iron in chlorine gas. The equation for the reaction is: $2Fe + 3Cl_2 \rightarrow 2FeCl_3$
Calculate the volume of chlorine needed to react with 14 g of iron.
You should calculate: • the number of moles of iron used • the number of moles of chlorine that react with 14 g of iron • the volume of chlorine needed.
Relative atomic mass (Ar): Fe = 56
The volume of 1 mole of gas = 24 dm^3

[3 marks]

AQA June 21 H Q5.6

ADDITIONAL RESOURCES

Congratulations on completing the workbook!

To further enhance your understanding and support your revision, I've curated a list of additional FREE resources.

VIDEO

THE MOLE

This Facebook Live recording goes through the mole.

ACCESS NOW

VIDEO

TITRATION CALCULATION

This Facebook Live recording goes through titration calculations

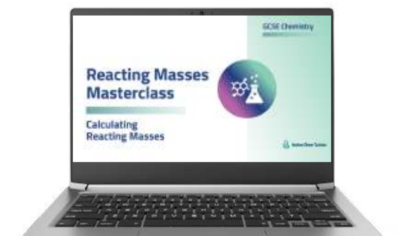
ACCESS NOW

Here are three videos from my recorded masterclasses.

VIDEO

MASS TO MOLES

ACCESS NOW



VIDEO

REACTING MASSES

ACCESS NOW

VIDEO

LIMITING REACTANT

ACCESS NOW