A level Chemistry Transition pack

Bridging the Gap between GCSE and A Level Chemistry

Transition skills

Basic Chemical Competencies

1.1 Balancing equations

Balance the equations below.

1. …..C + …..O_2 ⟶ …..CO

2. …..Ba + …..H_2O ⟶ …..$Ba(OH)_2$ + …..H_2

3. …..C_2H_6 + …..O_2 ⟶ …..CO_2 + …..H_2O

4. …..HCl + …..$Mg(OH)_2$ ⟶ …..$MgCl_2$ + H_2O

5. …..N_2 + …..O_2 ⟶ …..NO

6. …..Fe_2O_3 + …..C ⟶ …..Fe + …..CO_2

7. …..CH_3CH_2OH + …..[O] ⟶ …..CH_3COOH + …..H_2O

8. …..HNO_3 + …..CuO ⟶ …..$Cu(NO_3)_2$ + H_2O

9. …..Al^{3+} + …..e^- ⟶ …..Al

10. …..$[Fe(H_2O)_6]^{3+}$ + …..CO_3^{2-} ⟶ …..$Fe(OH)_3(H_2O)_3$ + …..CO_2 + …..H_2O

(10 marks)

1.2 Constructing ionic formulae

1. For each of the following ionic salts, determine the cation and anion present and use these to construct the formula of the salt. (5 marks)

a. Magnesium oxide
b. Sodium sulfate
c. Calcium hydroxide
d. Aluminium oxide
e. Copper(I) oxide

2. When an acid is added to water it dissociates to form H^+ ions (which make it acidic) and an anion. These acidic hydrogen atoms can be used to determine the charge on the anion. Deduce the charge on the anions in the following acids. The acidic H atoms, H^+, have been underlined for you. (5 marks)

a. $\underline{H}_2SO_3$
b. $\underline{H}NO_3$
c. $\underline{H}_3PO_4$
d. $HCOO\underline{H}$
e. $\underline{H}_2CO_3$

1.3 Writing equations from text

The following questions contain a written description of a reaction. In some cases the products may be missing as you will be expected to predict the product using your prior knowledge.

For more advanced equations you may be given some of the formulae you need.

For each one, write a balanced symbol equation for the process. (10 marks)

1. The reaction between silicon and nitrogen to form silicon nitride Si_3N_4.

.....

2. The neutralisation of sulfuric acid with sodium hydroxide.

.....

3. The preparation of boron trichloride from its elements.

.....

4. The reaction of nitrogen and oxygen to form nitrogen monoxide.

.....

5. The combustion of ethanol (C_2H_5OH) to form carbon dioxide and water only.

.....

6. The formation of silicon tetrachloride ($SiCl_4$) from SiO_2 using chlorine gas and carbon.

.....

7. The extraction of iron from iron(III) oxide (Fe_2O_3) using carbon monoxide.

.....

8. The complete combustion of methane.

.....

9. The formation of one molecule of ClF_3 from chlorine and fluorine molecules.

.....

10. The reaction of nitrogen dioxide with water and oxygen to form nitric acid.

.....

Basic Mathematical Competencies

2.1 Significant figures, decimal places and rounding

For each of the numbers in questions 1–6, state the number of significant figures and the number of decimal places.

		Significant figures	Decimal places
1	3.131 88		
2	1000		
3	0.000 65		
4	1006		
5	560.0		
6	0.000 480		

(6 marks)

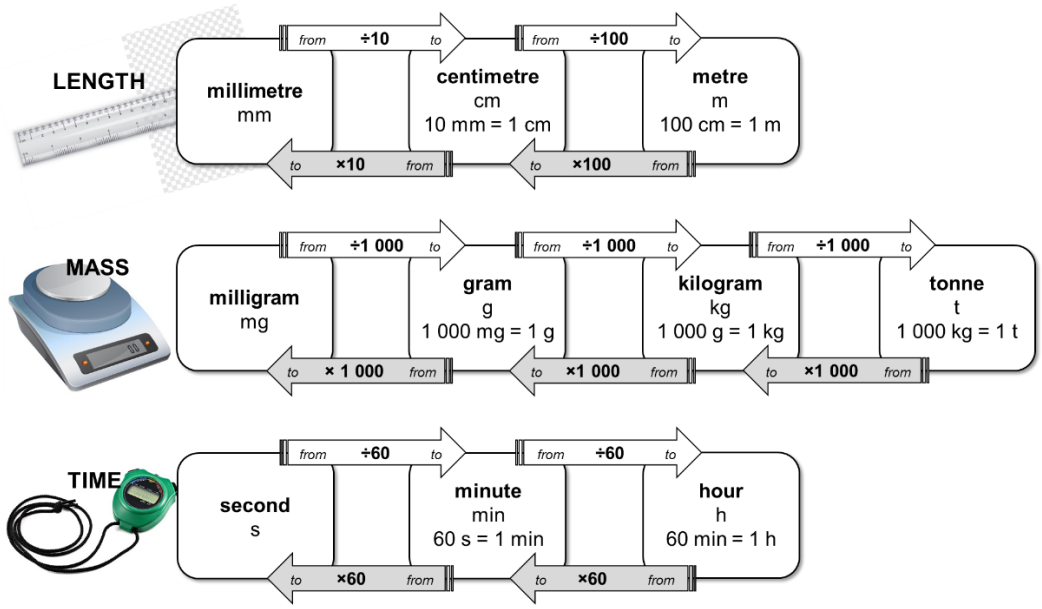
7. Round the following numbers to (i) 3 significant figures and (ii) 2 decimal places.

a. 0.075 84
b. 231.456

(4 marks)

2.2 Unit conversions 1 – Length, mass and time

Mo's teacher has drawn a diagram on the board to help him with converting quantities from one unit into another.



For example, to convert a length in millimetres into units of centimetres, divide by 10, eg 10 mm = 1 cm.

Use the diagram to help with the following unit conversions. (10 marks)

1. A block of iron has a length of 1.2 cm. Calculate its length in millimetres.

2. The width of the classroom is 7200 cm. Calculate its length in metres.

3. A reaction reaches completion after 4½ minutes. Convert this time into seconds.

4. The stop clock reads 2 min 34 s. Convert this time into seconds.

5. A method states that a reaction needs to be heated under reflux for 145 min. Calculate this time in hours and minutes.

6. A factory produces 15 500 kg of ammonia a day. Calculate the mass of ammonia in tonnes.

7. A paper reports that 0.0265 kg of copper oxide was added to an excess of sulfuric acid. Convert this mass of copper oxide into grams.

8. A packet of aspirin tablets states that each tablet contains 75 mg of aspirin. Calculate the minimum number of tablets that contain a total of 1 g of aspirin.

9. A student measures a reaction rate to be 0.5 g/s. Convert the rate into units of g/min.

10. A factory reports that it produces fertiliser at a rate of 10.44 kg/h. Calculate the rate in units of g/s.

2.3 Unit conversions 2 – Volume

The SI unit for volume is **metre cubed, m^3**. However as volumes in chemistry are often smaller than 1 m^3, fractions of this unit are used as an alternative.

centimetre cubed, cm^3	**decimetre cubed, dm^3**
centi- *prefix* one hundredth	**deci-** *prefix* one tenth
1 cm = $\frac{1}{100}$ m so,	1 dm = $\frac{1}{10}$ m so,
1 cm^3 = $\left(\frac{1}{100}\right)^3$ m^3 = $\left(\frac{1}{1\,000\,000}\right)$ m^3	1 dm^3 = $\left(\frac{1}{10}\right)^3$ m^3 = $\left(\frac{1}{1\,000}\right)$ m^3

1. Complete the table by choosing the approximate volume from the options in bold for each of the everyday items (images not drawn to scale). (1 mark)

1 cm^3 **1 dm^3** **1 m^3**

			
	drinks bottle	sugar cube	washing machine
Approx. volume			

2. Complete the following sentences; (1 mark)

To convert a volume in **cm^3** into a volume in **dm^3**, divide by.....

To convert a volume in **cm^3** into a volume in **m^3**, divide by.....

3. a. A balloon of helium has a volume of 1600 cm^3. What is its volume in units of dm^3?

b. The technician has prepared 550 cm^3 of HCl(aq). What is its volume in units of m^3?

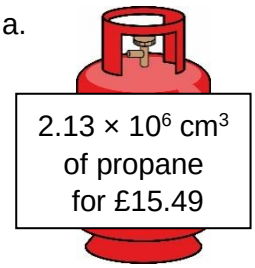
c. An experimental method requires 1.35 dm^3 of NaOH(aq). What volume is this in cm^3?

d. A swimming pool has a volume of 375 m^3. What volume is this in cm^3?

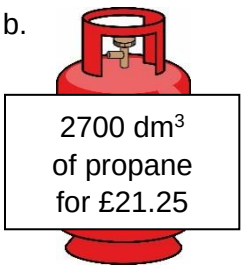
e. A 12 g cylinder of CO_2 contains 6.54 dm^3 of gas. What volume of gas is this in units of m^3? (5 marks)

4. Which cylinder of propane gas is the best value for money? (3 marks)

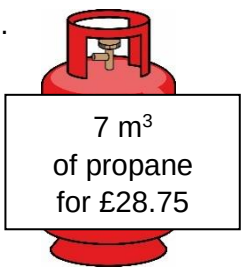
a.



b.



c.



2.4 Rearranging equations

1. The amount of substance in moles (n) in a solution can be calculated when the concentration given in mol/dm^3 (c) and volume (v) in cm^3 are known by using the equation:

$$n = \frac{cv}{1000}$$

a. Rearrange this equation making c the subject of the equation. (1 mark)

b. Rearrange this equation making v the subject of the equation. (1 mark)

2. The density of a substance can be calculated from its mass (m) and volume (v) using the equation:

$$d = \frac{m}{v}$$

a. Rearrange this equation so that the mass of a substance can be calculated given its density and volume. (1 mark)

Chemists most commonly work with masses expressed in grams and volumes in cm^3. However, the SI unit for density is kg/m^3.

b. Write an expression for the calculation of density in the SI unit of kg/m^3 when the mass (m) of the substance is given in g and the volume (v) of the substance is given in cm^3. (2 marks)

3. The de Broglie relationship relates the wavelength of a moving particle (λ) with its momentum (p) through Planck's constant (h):

$$\lambda = \frac{h}{p}$$

a. Rearrange this equation to make momentum (p) the subject of the formula. (1 mark)

Momentum can be calculated from mass and velocity using the following equation.

$$p = mv$$

b. Using this equation and the de Broglie relationship, deduce the equation for the velocity of the particle. (2 marks)

4. The kinetic energy (KE) of a particle in a time of flight mass spectrometer can be calculated using the following equation.

$$KE = \frac{1}{2}mv^2$$

Rearrange this equation to make v the subject of the equation. (2 marks)

2.5 Quantity calculus (unit determination)

1. Determine the units of density given that

$$density = \frac{mass(g)}{volume\ (cm^3)}$$

(1 mark)

2. Determine the units of concentration given that

$$concentration = \frac{number\ of\ moles\ (mol)}{volume\ (dm^3)}$$

(1 mark)

3. Pharmacists often calculate the concentration of substances for dosages. In this case the volumes are smaller, measured in cm^3, and the amount is given as a mass in grams. Determine the units of concentration when

$$concentration = \frac{mass\ (g)}{volume\ (cm^3)}$$

(1 mark)

4. Rate of reaction is defined as the *'change in concentration per unit time'*. Determine the units for rate when concentration is measured in mol dm^{-3} and time in seconds.

(1 mark)

5. Pressure is commonly quoted in pascals (Pa) and can be calculated using the formula below. The SI unit of force is newtons (N) and area is m^2.

$$pressure = \frac{force}{area}$$

Use this formula to determine the SI unit of pressure that is equivalent to the Pascal.

(1 mark)

6. Determine the units for each of the following constants (K) by substituting the units for each part of the formula into the expression and cancelling when appropriate. For this exercise you will need the following units [ ] = mol dm^{-3}, rate = mol dm^{-3} s^{-1}

2.6 Expressing large and small numbers

Standard form and scientific form

Large and small numbers are often expressed using powers of ten to show their magnitude. This saves us from writing lots of zeros, expresses the numbers more concisely and helps us to compare them.

In standard form a number is expressed as;

$$a \times 10^n$$

where ***a*** is a number between 1 and 10 and ***n*** is an integer.

Eg, 160 000 would be expressed as 1.6×10^5

Sometimes scientists want to express numbers using the same power of ten. This is especially useful when putting results onto a graph axis. This isn't true standard form as the number could be smaller than 1 or larger than 10. This is more correctly called **scientific form**.

Eg, 0.9×10^{-2}, 2.6×10^{-2}, 25.1×10^{-2} and 101.6×10^{-2} are all in the same scientific form.

1. Express the following numbers using standard form.

a. 1 060 000
b. 0.001 06
c. 222.2

(3 marks)

2. The following numbers were obtained in rate experiments and the students would like to express them all on the same graph axes. Adjust the numbers to a suitable scientific form.

0.1000	0.0943	0.03984	0.00163

(3 marks)

3. Calculate the following without using a calculator. Express all values in standard form.

a. $\frac{10^9}{10^5}$

b. $\frac{10^7}{10^{-7}}$

c. $\frac{1.2 \times 10^6}{2.4 \times 10^{17}}$

d. $(2.0 \times 10^7) \times (1.2 \times 10^{-5})$

(4 marks)

Basic Practical Competencies

3.1 Laboratory equipment

Practical work is a key aspect in the work of a chemist.

To help you plan effective practical work it is important that you are familiar with the common laboratory equipment available to you.

1. For each of the pieces of glassware shown in the images below, state their name and give a possible volume(s).

a. 

Name:

.....

Possible volume(s):

.....

b. 

Name:

.....

Possible volume(s):

.....

c. 

Name:

.....

Possible volume(s):

.....

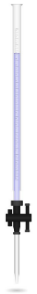
d. 

Name:

.....

Possible volume(s):

.....

e. 

Name:

.....

Possible volume(s):

.....

f. 

Name:

.....

Possible volume(s):

.....

(6 marks)

2. Name the common laboratory equipment in the images below. (4 marks)

a. 

.....

b. 

.....

c. 

.....

d. 

Task 4 – Atoms, Ions and Isotopes

1. Complete the table to show the location, relative charge and relative mass of each sub-atomic particle found within an atom

Sub-atomic particle	Location	Relative charge	Relative mass
Neutron			
Electron			
Proton			

2. Use the table to describe the distribution of mass and charge within an atom

_____

_____

_____

3. Give precise definitions for the following key terms

Atomic (proton) number: _____

_____

Mass (nucleon) number: _____

_____

4. Complete the missing data in the table below - use the 2 definitions above, and your understanding of atomic structure

Atom	Atomic No.	Mass No.	No. of protons	No. of electrons	No. of neutrons
N					
K					
	5	11			
			18		22
		40			20
				55	78

5. Complete the missing data in the table below - use the example given, and your understanding of atomic structure and how atoms become ions

Atom	Metal or non-metal atom	Atomic No.	Electron Configuration	Gains /loses e-	No. of e- gained/loss	Ion formula produced	Electronic configuration
Li	Metal	3	2,1	loses	1e-	Li^+	$[2]^+$
Na							
Mg							
Al							
F							
O							
S							

Atom	Atomic No.	Mass No.	Ion Formula	No. of p+	No. of e-	Electronic config.	No. of n
Ca							
Cl							

6. Use dot & cross diagrams to model the ionic bonding in a) magnesium oxide and b) aluminium oxide:
Tip – only show the ions formed (not the atoms they come from) and if more than one ion is needed show how many e.g. if 2 oxygen ions are needed, show in this format: 2 x [ ]$^{?/-}$

a) magnesium oxide:

b) aluminium oxide:

7. Give a precise definition of the keyterm ‘isotope’
Tip: within your definition include the words: proton, electron, neutron, atomic number, mass number

Isotope: _____

_____

_____

8. Complete the missing data on the isotopes of carbon in the table below - use your definition above, and your understanding of atomic structure and isotopes

Example	Atom	Atomic No.	Mass No.	No. of protons	No. of electrons	No. of neutrons
1		6	12			
2	C					7
3				6		8
4					7	8

Qu: Which is NOT an isotope of carbon? Justify your choice _____

_____

_____

Qu: Explain, if any, the difference in reactivity between the 3 carbon isotopes? Tip: ask yourself ‘do they all react with oxygen to produce carbon dioxide or only some?’. Give a reason for your answer.

_____

_____

_____

_____

Qu: Name one physical property that may differ between the isotopes of the same element? Justify

_____

_____

_____

Task 5 Chemical mathematics

1. Give precise definitions for the following keyterms (LO1&2)....

Molecular formula: _____

_____

Empirical formula: _____

_____

Use your understanding from GCSE & the table below to help practise calculating the empirical formula.

1. **List all of the elements in the compound**
2. **Underneath, write the mass or % given in the question**
3. **Calculate moles - ÷ each mass or % from step 2 by the Ar for each element**

If the numbers are not ALL whole numbers....

4. **Identify the element in the smallest amount and divide each answer to step 3 by this.**
5. **Use this whole number ratio to give the simplest ratio of atoms of each element in the formula**

2. A hydrocarbon has 80% carbon and 20 %hydrogen. Calculate its empirical formula.

Ratio of atoms: ___ : ____ Empirical Formula: _____

3. 2.70g of aluminium is combined with 10.65g of chlorine. What is the empirical formula of this product?

Ratio of atoms: ___ : ____ Empirical Formula: _____

The **mole** is a **unit** for an **amount of substance** (and is given the symbol **'n'**) – it is a standard pack (number) of particles.

This count of atoms is called the **Avogadro constant (N_A)** & is equal to **6.02×10^{23} mol^{-1}**

IMPORTANT DEFINITIONS

The **Avogadro constant** (N_A) is the number of atoms per mole of the carbon-12 isotope (6.02×10^{23} mol^{-1}).

A **mole** is the amount of any substance containing as many particles as there are carbon atoms in exactly 12g of the carbon-12

Basically if the amount of substance you want is 1 mole you would need to count out 6.02×10^{23} mol^{-1} atoms/molecules of that substance.

However, because atoms weigh different amounts (depending on the element) one mole of substance will have a different mass. For example:

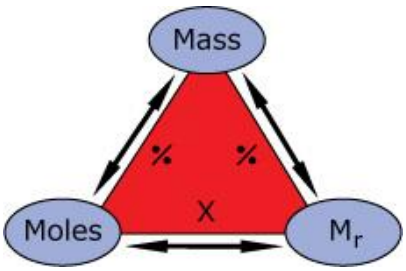
1 mole of carbon-12 would contain 6.02×10^{23} carbon -12 atoms and weigh 12g

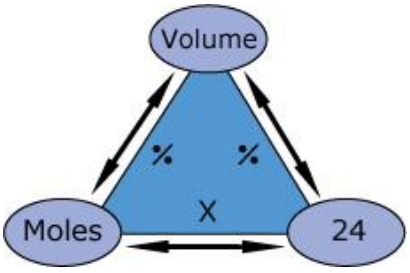
...but...

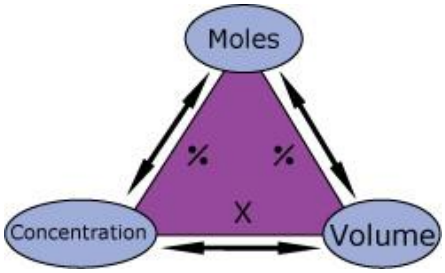
1 mole of sodium-23 would also contain 6.02×10^{23} carbon -12 atoms but weigh 23g

The **mass of one mole** is easy to work out as it is the **relative formula mass in grams** for that substance. This is referred to as **molar mass, M**, and has **the units $gmol^{-1}$.**

Mole formulae – you will need to learn these equations as they are not provided in the exam

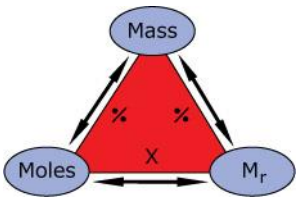






4. Use the formula triangle given to deduce the formula required to calculate mass:

Mass =



5. Use this formula to calculate the mass of each of the following...

(a) 2.50 mol of hydrogen, H_2

Mass of H_2: _____ g

(b) 0.500 mol of sodium chloride, NaCl.

Mass of NaCl: _____ g

6. Again, use the formula triangle given to deduce the formula required to calculate the amount of substance

Moles(n) =

7. Use this formula to calculate the amount (in mol) of each substance listed below....

a) 31.0 g of phosphorus molecules, P_4

Amount of P_4: _____ mol

b) 50.0 g of calcium carbonate, $CaCO_3$.

Amount of $CaCO_3$: _____ mol

8. Again, use the formula triangle given to deduce the formula required to calculate molar mass of an unknown substance

Molar mass (M_r) =

9. Use this formula to calculate the molar mass of an 11g gas sample of compound X, which is 0.25mol.

Molar mass: _____ $gmol^{-1}$

Possible identity of the gas sample X: _____

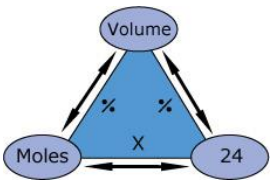
10. Use the formula triangle given to deduce the formula for calculating the amount of gas in mols ...

When volume is in dm^3...

Moles (n) =

When volume is in cm^3...

Moles (n) =



11. Use this formula to calculate the amount of gas (in mol) of....

(a) $3600cm^3$ of hydrogen gas, H_2

Amount of H_2 gas: _____ mol

(b) $4dm^3$ of hydrogen gas, CO_2

Amount of CO_2 gas: _____ mol

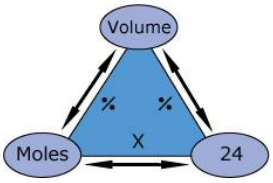
12. Use the formula triangle given to deduce the formula for calculating the volume of gas...

When volume is in dm^3...

Volume (V) =

When volume is in cm^3...

Volume (V) =



13. Use this formula to calculate the volume of gas....

(a) 6 mol of hydrogen gas, SO_2

Volume of SO_2 gas: _____ dm^3

(b) 0.25mol of oxygen gas, O_2

Volume of CO_2 gas: _____ cm^3

14. Complete the following tasks which is more representative of a *simple AS chemistry question*

Tip – you will need to use both mole formulas introduced so far

(a) What is the mass of $84cm^3$ of N_2O?

Mass of N_2O gas: _____ g

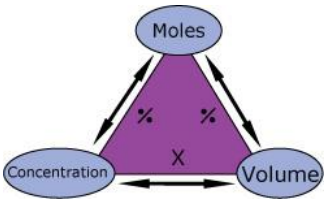
(b) What is the volume of 1.26g of propene, C_3H_6

Volume of C_3H_6 gas: _____ dm^3

15. Use the formula triangle given to deduce the formula for calculating the amount of moles in solution ...

When volume is in dm^3...

When volume is in cm^3...



16. Use this formula to calculate the amount of substance (in mol) for the following solutions....

(a) $4dm^3$ of a 2 $moldm^{-3}$ solution

Amount of solution: _____ mol

(b) $25.0dm^3$ of a 0.15 $moldm^{-3}$ solution

Amount of solution: _____ mol

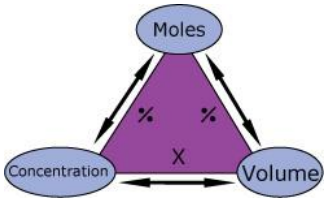
17. Use the formula triangle given to deduce the formula for calculating the volume of solution needed...

When volume is in dm^3...

Volume (V) =

When volume is in cm^3...

Volume (V) =



18. Use this formula to calculate the volume produced in the following solutions....

(a) a solution with a concentration of 2 $moldm^{-3}$ that contains 2 moles of solute.

Volume of solution: _____ dm^3

(b) a solution with a concentration of 0.25 $moldm^{-3}$ that contains 0.005 moles of solute.

Volume of solution: _____ dm^3

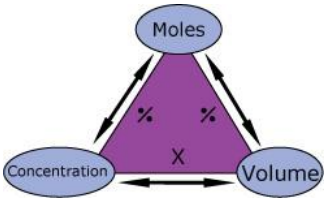
19. Use the formula triangle given to deduce the formula for calculating the concentration of the solution...

When volume is in dm^3...

Concentration (c) =

When volume is in cm^3...

Concentration (c) =



20. Use this formula to calculate the concentration (in $moldm^{-3}$) for the following solutions....

(a) 0.5 moles of solid dissolved in $250cm^3$ of solution

Concentration: _____ $moldm^{-3}$

(b) 0.00875 moles of solid dissolved in $25cm^3$ solution

Concentration: _____ $moldm^{-3}$

Complete the following tasks, which is more representative of a *simple AS chemistry question...*

Tip – you will need to use more than one of the mole formulas introduced so far & use the balanced equation to find the molar ratio

21. Find the mass concentration, in gdm^{-3}, for the following solutions:

(a) 0.0042 moles of HNO_3 dissolved in $250cm^{-3}$ of solution

Mass concentration: _____ gdm^{-3}

(b) 0.5 moles of HCl dissolved in $4dm^3$ of solution

Mass concentration: _____ gdm^{-3}

22. The following reaction can take place, shown in this equation: $\mathbf{NaHCO_{3(s)} \rightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}}$

(a) Balance the equation shown above

(b) What volume of CO_2 is formed by the decomposition of 5.04g of $NaHCO_3$?

Volume of CO_2: _____ dm^3

23. The following reaction can take place, shown in this equation:

$$\mathbf{MgCO_{3(s)} + HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + CO_{2(g)} + H_2O_{(l)}}$$

(a) Balance the equation shown above

(b) 2.529g of $MgCO_3$ reacts with an excess of HNO_3. What volume of CO_2 is formed?

Volume of CO_2: _____ dm^3

(c) The final volume of the solution is 50.0cm^3. What is the concentration of $Mg(NO_3)_{2(aq)}$ formed?

Concentration: _____ $moldm^{-3}$

Extension work

If you have completed all of the tasks above and have time left over, below is a link to an open university short introductory course that is all about metals. Work your way through the course and get yourself a statement of participation certificate as proof that you completed the course.

https://www.open.edu/openlearn/science-maths-technology/chemistry/what-metal/content-section-0?active-tab=description-tab

The link below is to another free course but you do not get a certificate for this and it is a longer course:

https://www.futurelearn.com/courses/everyday-chemistry

Here is a link to the Royal Society of Chemistry website with a focus on kitchen chemistry. There are different investigation that you can look at and there are questions to complete:

https://edu.rsc.org/resources/collections/kitchen-chemistry/

This is a link to an open university short introductory course about life without oil. Once you have completed it, you will receive a certificate of participation as proof of completion.

https://www.open.edu/openlearn/science-maths-technology/living-without-oil/content-section-0?active-tab=content-tab

If you are looking for more to do, please feel free to investigate something of your own choosing, whether it's an experiment you can do at home, a free online learning course that looks interesting or if you would like to see the role that science has in real life and movies, there are links below that you can use.

Videos to watch online

Rough science – the Open University – 34 episodes available

Real scientists are 'stranded' on an island and are given scientific problems to solve using only what they can find on the island.

Great fun if you like to see how science is used in solving problems.

There are six series in total

http://bit.ly/pixlchemvid1a

http://www.dailymotion.com/playlist/x2igjq_Rough-Science_rough-science-full-series/1#video=xxw6pr

or

http://bit.ly/pixlchemvid1b

https://www.youtube.com/watch?v=lUoDWAt259I

A thread of quicksilver – The Open University

A brilliant history of the most mysterious of elements – mercury. This program shows you how a single substance led to empires and war, as well as showing you come of the cooler properties of mercury.

http://bit.ly/pixlchemvid2

https://www.youtube.com/watch?v=t46lvTxHHTA

10 weird and wonderful chemical reactions

10 good demonstration reactions, can you work out the chemistry of …. any… of them?

http://bit.ly/pixlchemvid3

https://www.youtube.com/watch?v=0Bt6RPP2ANI

Chemistry in the Movies

Dantes Peak 1997: Volcano disaster movie.

Use the link to look at the Science of acids and how this links to the movie. http://www.open.edu/openlearn/science-maths-technology/science/chemistry/dantes-peak

http://www.flickclip.com/flicks/dantespeak1.html
http://www.flickclip.com/flicks/dantespeak5.html

Fantastic 4 2005 &2015: Superhero movie

Michio Kaku explains the “real” science behind fantastic four http://nerdist.com/michio-kaku-explains-thereal-science-behind-fantastic-four/

http://www.flickclip.com/flicks/fantastic4.html