SANDWICH TECHNOLOGY SCHOOL

Chemistry A Level Transition work

Summer 2021

Within this transition guide you will find some key topics you have studied at GCSE. By revisiting them before you start your A Level course you will be giving yourself the best possible chance of success when term starts.

Welcome to Chemistry A Level!

Please complete the tasks within the booklet, then use the answer pages at the back to correct and mark your work. Please bring your marked work to your first lesson of Chemistry.

There are 10 tasks:

1. **Calculating protons, neutrons and electrons**
2. **Ions**
3. **Writing Formulae**
4. **Symbol equations**
5. **Writing balanced symbol equations**
6. **Maths skills**
7. **Molar mass**
8. **Caluclating moles 1**
9. **Calculating moles 2**
10. **Calcualting moles 3**

You will also find other information and links to help you and give you some wider knowledge of Chemistry!

What can I use to help me prepare for A-level?

• GCSE revision guides - use to ensure you have the foundation knowledge needed.

• CGP 'Head Start to Chemistry book – perfect for bridging the gap between GCSE and A-level knowledge. Can be bought online for approximately £5.

• OCR Website https://ocr.org.uk/qualifications/as-and-a-level/chemistry-a-h032-h432-from-2015/ if you want to find out more about the course you will be studying

Lots of time on your hands… have a look at some of these

Well done for choosing A Level Chemistry to help get you prepared this is a booklet of revision activities for you.

But first a few optional extras…

If you have ever wondered to yourself the importance of Chemistry just listen to the news at the moment, wash your hands with soap and water, we need to develop new drugs, bleach is used to kill Covid 19 on surfaces. None of this would be possible without Chemistry.

As you have time these video links may be interesting

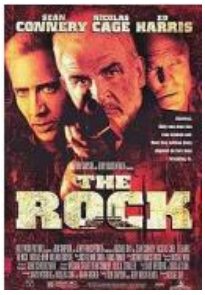
This link is about how soap works. If you watch this, you know the science about washing your hands.
https://www.acs.org/content/acs/en/pressroom/reactions/videos/2020/can-soapreally-kill-the-coronavirus.html

This link is about drug development at a company called Roche. They explain it normally takes 12 years before a drug can actually be prescribed by a doctor
https://www.youtube.com/watch?v=attNofZ7AnY

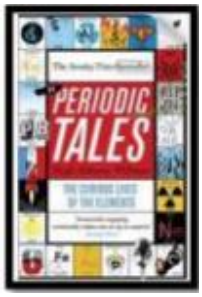
This link is a documentary on thalidomide. A wonder drug which shows you what can happen if scientific research is not thorough enough.
https://www.youtube.com/watch?v=YOBmga0wcew

Film - Erin Brockovich A lone woman, armed only with indomitable sass and her native wit, goes up against the corporate big boys and beats the bejesus out of them. The story's based-- actual events, when the real Erin (who appears briefly in the film as a kindly waitress) brought a massive lawsuit against utilities giant Pacific Gas and Electric for spreading toxic pollution.

Film - Cars 2 (while you are at it, you may as well watch 1 and 3) Cars run on petrol? Or do they? It is highly combustible and causes some issues in this film. There is also a link to biofuels. Also remember in this series, the sponsor of lightning McQueen is Rusteze. Rusteze prevents the corrosion of iron.



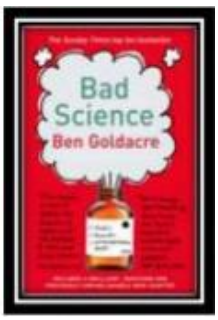
Film - The Rock In the film, an FBI chemist and a former SAS captain are tasked with stopping a group of rogue US Force Recon Marines who have seized Alcatraz Island, taking hostages while doing so, and are threatening to launch rockets filled with nerve gas over San Francisco unless they are paid $100 million. It is also set on a rock! Lots of chemical substances are extracted from rocks.



Book - Title Periodic Tales: The Curious Lives of the Elements (Paperback)
Author(s) Hugh Aldersey-Williams

ISBN 0141041455

Link https://amzn.to/2Y0CYyA This book covers the chemical elements, where they come from and how they are used. There are loads of fascinating insights into uses for chemicals you would have never even thought about.



Book - Title Bad Science (Paperback)

Author(s) Ben Goldacre

ISBN 000728487X

Link https://amzn.to/2yBy2FN Here Ben Goldacre takes apart anyone who published bad / misleading or dodgy science – this book will make you think about everything the advertising industry tries to sell you by making it sound 'science-y'

Task 1 – Calculating protons, neutrons, and electrons

- At A level Chemistry you will learn some slightly different rules about electronic structure, but you still need to be able to calculate the number of protons, neutrons and electrons in atoms and ions.
- Remember atoms are neutral because they contain the same number of protons and electrons.
- Ions are formed from the loss or gain of electrons. Positive ions have lost electrons and negative ions have gained electrons.

Complete the table

Species	Atom / ion	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{14}_{7}N$	atom					
$^{31}_{15}P$	atom					
	atom	3	7			
	atom	10			10	
	atom		40	20		
	atom		40		22	
	atom			4	5	
	atom	82			126	
	atom	35			44	
	atom	35			46	
$^{23}_{11}Na^{+}$						
$^{16}_{8}O$						
$^{16}_{8}O^{2-}$						
		17	35			18
		19			20	19
		19			20	18
				20	20	18
		1			0	0
		53			74	54
			14		7	10

Task 2 – Ions

You will find A level Chemistry much easier if you learn common ions and can then use these ions to write chemical formulae

- Learn the charges of these common ions. Make revision cards? Use read/cover/rewrite. Whatever works for you. You need to do this regularly. Not just once or twice, every day/week until you know all of them.

Positive ions

Any group 1 metal	+1
Any group 2 metal	+2
zinc	Zn^{2+}
silver	Ag^{+}
hydrogen	H^{+}
ammonium	NH_4^{+}

Negative ions

Group 7 non metals	-1
Group 6 non-metals	-2
nitrate	NO_3^{-}
hydroxide	OH^{-}
hydrogencarbonate	HCO_3^{-}
carbonate	CO_3^{2-}
sulphate	SO_4^{2-}
phosphate	PO_4^{3-}

Task 3 – Writing formulae

Now you know the common ions you need to be able to write the formulae of compounds. There is no such thing as a word equation at A level and you are expected to be able to work out the formulae of the compound yourself.

Here are some worked examples

If you know the ions present, you can then write down a formula for a compound; remembering an ionic compound should have no overall charge.
E.g. Find the formula for sodium oxide

Step 1 – Which ions are present?
Sodium is in group 1, so the ion is Na^+

Oxygen is in group 6, so the ion is O^{2-}

Step 2 – Obtain equal numbers of positive and negative charges
To have equal numbers of positive and negative charges, you would need 2 sodium ions for each oxide ion.

Step 3 – Write the formula
The formula is therefore **Na_2O**

E.g. Find the formula for barium nitrate

Step 1 – Which ions are present?
Barium is in group 2, so the ion is Ba^{2+}

Nitrate ions are NO^{3-} (You will have learnt this!)

Step 2 – Obtain equal numbers of positive and negative charges
To have equal numbers of positive and negative charges, you would need 2 nitrate ions for each barium ion.

Step 3 – Write the formula
The formula is therefore **$Ba(NO_3)_2$**

NB. Notice the brackets around the nitrate group. Brackets must be written around any ion containing more than 1 type of atom (known as a complex ion). In any other situation they are unnecessary.

E.g. Find the formula for iron(III) sulphate

Step 1 – Which ions are present?
Iron(III) tells you the ion is Fe^{3+}

Sulphate ions are SO_4^{2-} (you will have learnt this)

Step 2 – Obtain equal numbers of positive and negative charges
To have equal numbers of positive and negative charges, you would need 2 iron(III) ions for every 3 sulphate ions, to give 6+ and 6- in total

Step 3 – Write the formula
The formula is therefore **$Fe_2(SO_4)_3$**

NB. Ion charges are not shown in formulae.

Your turn

Work out the formulae of the following compounds:-

1. lead(II) oxide

2. sodium bromide

3. magnesium sulphate

4. potassium carbonate

5. ammonium sulphide

6. calcium nitrate

7. iron(III) hydroxide

8. copper(II) carbonate

9. aluminium sulphate

10. ammonium nitrate

11. rubidium iodide

12. chromium(III) oxide

13. calcium oxide

14. silver nitrate

15. iron(III) fluoride

Task 4: Symbol Equations

Writing a correct, balanced symbol equation is one of the most important skills you will need in A level Chemistry. To be successful in this you need to be able to count up how many of each sort of atom there are. First you need to be clear what all the numbers mean.

What all the numbers mean

A symbol alone means 1 atom of the element, e.g. Na means 1 atom of sodium.

2Na means 2 separate atoms of sodium.

N means 1 atom of nitrogen.

N_2 means 2 atoms of nitrogen joined together to make a molecule.

$3N_2$ means 3 separate nitrogen molecules, each containing 2 atoms of nitrogen joined together – i.e. 6 atoms of nitrogen altogether.

H_2O means 1 molecule of water, containing 2 hydrogen atoms joined to 1 oxygen atom.

$5H_2O$ means 5 separate molecules of water, containing a total of 10 atoms of hydrogen and 5 atoms of oxygen.

H_2SO_4 means 1 molecule of sulphuric acid, containing 2 atoms of hydrogen, 1 atom of sulphur and 4 atoms of oxygen.

Points to note

- The small subscripted numbers in a formula refer only to the atom immediately in front of them, e.g. the 4 in H_2SO_4. The only exception is formulae with brackets. E.g. in $Ca(OH)_2$ the 2 applies to the oxygen and the hydrogen.
- A big number in front of a formula multiplies up the whole of that formula. E.g. $5CH_4$ means 5 lots of CH_4 – 5 carbon atoms and 20 hydrogen atoms.
- When you are writing equations you must never alter the formula by adding or changing a small number. But you can write any large number you wish in front of a formula.

Balancing Equations

This describes the process where you adjust the large numbers in equations. The aim is to make sure the number of each type of atom is the same on both the left-hand and right-hand sides of the equation.

Step 1
Write the equation using correct formulae. (Remember many gases like hydrogen, oxygen chlorine etc exist as molecules, i.e. H_2, O_2, Cl_2).

Step 2
Work across the equation from left to right, checking one element after another, adding large numbers where necessary. If an element appears in several places leave it until the end.

Step 3
Check everything at the end to make sure you have not changed something that you've already counted.

E.g. Equation to be balanced:-

$Zn + HCl \rightarrow ZnCl_2 + H_2$

Count the zinc atoms: 1 on each side – balanced

Count the hydrogen atoms: 1 on left, 2 on right.
If you end up with 2 hydrogens you must have started with 2.
Therefore change HCl to 2HCl. **NOT** H_2Cl – there is no such substance!
This gives:-

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$
Count the chlorines: 2 on each side.

Quick recheck – all balanced. This is the correct balanced equation.

Try and balance these examples: -

1. $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$

2. $CH_4 + O_2 \rightarrow CO_2 + H_2O$

3. $C_8H_{18} + O_2 \rightarrow CO_2 + H_2O$

4. $NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$

5. $Na + S \rightarrow Na_2S$

6. $Fe_2O_3 + CO \rightarrow Fe + CO_2$

7. $Ag_2O \rightarrow Ag + O_2$

8. $Mg + HCl \rightarrow MgCl_2 + H_2$

Task 5: Putting tasks 2-4 together

Now you have learnt/reminded yourself about ions, how to write chemical formula and how to balance equations. Write balanced symbol equations for the following reactions:-

1. sodium carbonate + hydrochloric acid (HCl) → sodium chloride + carbon dioxide + water.

2. sodium hydroxide + sulphuric acid (H_2SO_4) → sodium sulphate + water.

3. sodium + water → sodium hydroxide + hydrogen

4. iron(III) oxide + nitric acid (HNO_3) → iron(III) nitrate + water

5. Chromium (III) oxide + Aluminium → Chromium + Aluminium oxide

6. Copper carbonate + Nitric acid → copper nitrate + carbon dioxide + water

7. Lead(II) nitrate + potassium iodide → Lead iodide + Potassium nitrate

Task 6. Maths skills- significant figures

Using the correct number of significant figures is important in chemistry as answers are often asked to a certain amount.

Significant Figures

Remember the following points when thinking about significant figures: -

- Zeros between digits are significant. E.g. 2008 has four significant figures (sig fig)
- Zeros to the left of a digit are not significant. E.g. 0.0000002 has just one sig fig.
- Zeros at the end of a decimal are significant. E.g. 2.000430 has seven sig fig.
- The rules are the same when a number is in standard form. E.g. 6.022 x 1023 has four sig fig.

Rounding Off

To round off a number, round up if the last figure is between 5 and 9 inclusive and round down if it is between 0 and 4 inclusive.

E.g. the number 360.99 rounded to: -

4 sig fig is 361.0 (rounded up – the fifth figure is 9)
3 sig fig is 361 (rounded up – the fourth figure is 9)
2 sig fig is 360 (rounded down – the third figure is 0)
1 sig fig is 400 (rounded up – the second figure is 6)

Always look one figure beyond the number you are rounding to. E.g. to round to 3 sig fig look at the fourth figure.

Complete the table:

Full number	1 sf	2 sf	3 sf	4 sf	5 sf
9.378652					
4204274					
0.903521					
0.00239482					

Task 7: Molar mass

In A level Chemistry there is lots of Maths and lots of calculations are based around moles. If you remember from GCSE, moles are a unit that Chemists use to compare the amounts of atoms.

1 mole of any element/molecule or compound contains 6.02×10^{23} atoms/molecules.

The mass of this is equal to the relative atomic mass OR sum of the relative atomic masses; at A level this is known as the molar mass

E.g. Na_2CO_3 contains 2 sodium (23.0), 1 carbon (12.0) and 3 oxygen (16.0)

$(23.0 \times 2) + 12.0 + (16.0 \times 3) = 106.0$ g mol^{-1}

Work of the molar mass of the following:

1. $CuCO_3$

2. $AgNO_3$

3. H_2SO_4

4. $Al2O_3$

5. $Mg(OH)_2$

6. $Al(NO_3)_3$

7. $(NH_4)_2SO_4$

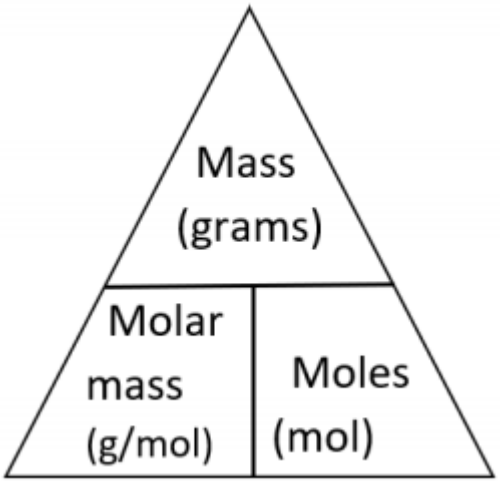
8. $(NH_4)_3PO_3$

9. $Ca_3(PO_4)_2$

10. $CuSO_4.5H_2O$

Task 9: Calculating moles (1)

These activities use this equation: moles (mol) = mass(g)/Molar Mass (g mol^{-1})



1) Calculate the number of moles of each of the following substances. Give your answers to 3 sig figs.
    a) 90.0 g of H_2O

    b) 20.0 g of C_4H_{10}

    c) 685 g of NH_3

    d) 102 kg of O_2

    e) 2.00 kg of Al_2O_3

2) Calculate the mass of each of the following substances. Give your answers to 3 sig figs.
    a) 4.00 moles of N_2

    b) 0.100 moles of HNO_3

    c) 0.0200 moles of K_2O

    d) 2.50 moles of PH_3

    e) 0.400 moles of C_2H_5OH

3) Calculate the molar mass of each of the following substances. Give your answers to 3 sig figs.
    a) 0.0200 moles of a substance with a mass of 1.64 g.

    b) 5 moles of a substance with a mass of 140g

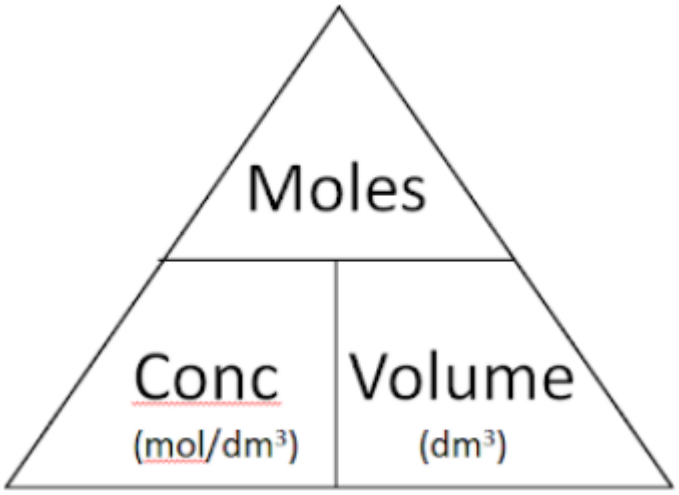
    c) 0.125 moles of a substance with a mass of 9.25g

    d) 4.50×10^{-2} moles of a substance with a mass of 3.825g

    e) 2.5×10^{-2} moles of a substance with a mass of 2.65g

Task 9: Calculating moles (2)

These activities use this equation: moles (mol) = concentration ($moldm^{-3}$) x volume (dm^3).



This equation is used when we are comparing quantities of atoms in solution.
$1dm^3 = 1000cm^3$

$dm^3 = cm^3 \div 1000$

1) Calculate the number of moles in the following solutions.
   a) 100 cm^3 of 0.20 $moldm^{-3}$ HNO_3

   b) 25 cm^3 of 1.50 $moldm^{-3}$ KOH

   c) 50 cm^3 of 0.10 $moldm^{-3}$ H_2SO4

   d) 265 cm^3 of 0.050 $moldm^{-3}$ KOH

   e) 500 cm^3 of $1.32x10^{-5}$ $moldm^{-3}$ H_2SO_4

2) Calculate the concentration of the following solutions in $moldm^{-3}$

a) 0.10 moles of NaCl in 200 cm^3

b) 0.20 moles of H_2SO_4 in 100 cm^3

c) 0.020 moles of NaOH in 25 cm^3

d) 3.20 moles of H_2SO_4 in 875 cm^3

e) $3.35x10^{-3}$ moles of NaOH in 250 cm^3

You can convert the concentration of a solution in $moldm^{-3}$ to gdm^{-3} by:

Concentration in $moldm^{-3}$ x molar mass = concentration in gdm^{-3}

Convert your answers from part 2 (a-e) into gdm^{-3}

a)

b)

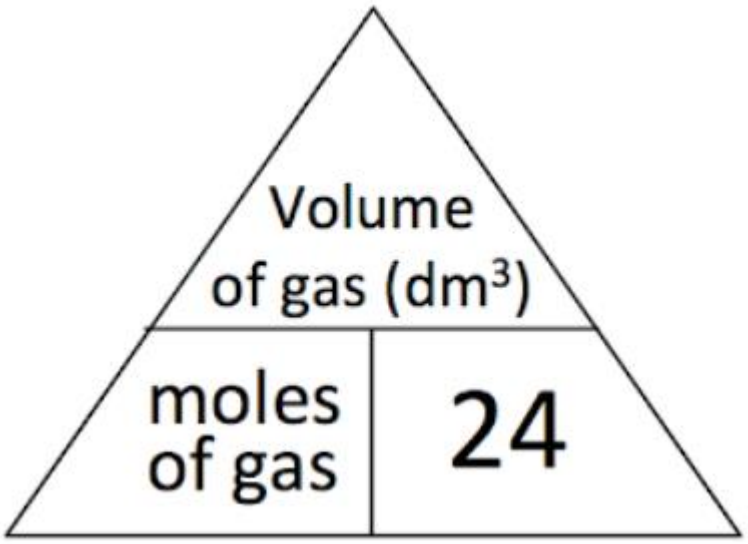
c)

d)

e)

Task 10: Calculating moles (3)

These activities use this equation: moles (mol) = volume (dm^3) x 24(dm^3)
24dm^3 is the molar gas volume, the volume that 1 mole of any gas fills.



This equation is used when we are comparing quantities of atoms in gases.
1dm^3 = 1000cm^3

dm3 = cm^3 ÷ 1000

1. Find the volume of the following gases
    a) 4.00 moles of oxygen (O_2)

    b) 0.250 moles of methane (CH_4)

    c) 15.0 moles of argon (Ar)

    d) 0.220 moles of carbon dioxide (CO_2)

    e) 4.26×10^{-3} moles of ethane (C_2H_6)

2. Find the number of moles of the following gases
    a) 48.0 dm^3 of carbon monoxide (CO)

    b) 1.20 dm^3 of hydrogen (H_2)

    c) 360 cm^3 of oxygen (O_2)

    d) 125 cm^3 of helium (H_e)

    e) 643 cm^3 of neon (Ne)

ANSWERS

Task 1

Species	Atom / ion	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{14}_{7}N$	atom	7	14	7	7	7
$^{31}_{15}P$	atom	15	31	15	16	15
$^{7}_{3}Li$	atom	3	7	3	4	3
$^{20}_{10}Ne$	atom	10	20	10	10	10
$^{40}_{20}Ca$	atom	20	40	20	20	20
$^{40}_{18}Ar$	atom	18	40	18	22	18
$^{9}_{4}Be$	atom	4	9	4	5	4
$^{208}_{82}Pb$	atom	82	208	82	126	82
$^{79}_{35}Br$	atom	35	79	35	44	35
$^{81}_{35}Br$	atom	35	81	35	46	35
$^{23}_{11}Na^{+}$	ion	11	23	11	12	10
$^{16}_{8}O$	atom	8	16	8	8	8
$^{16}_{8}O^{2-}$	ion	8	16	8	8	10
$^{35}_{17}Cl^{-}$	ion	17	35	17	18	18
$^{39}_{19}K$	atom	19	39	19	20	19
$^{39}_{19}K^{+}$	ion	19	39	19	20	18
$^{40}_{20}Ca^{2+}$	ion	20	40	20	20	18
$^{1}_{1}H^{+}$	ion	1	1	1	0	0
$^{127}_{53}I^{-}$	ion	53	127	53	74	54
$^{14}_{7}N^{3-}$	ion	7	14	7	7	10

Task 2: Revision activity

Task 3

1. PbO
2. $NaBr$
3. $MgSO_4$
4. K_2CO_3
5. $(NH_4)_2S$
6. $Ca(NO_3)_2$
7. $Fe(OH)_3$
8. $CuCO_3$
9. $Al_2(SO_4)_3$
10. NH_4NO_3
11. RbI
12. Cr_2O_3
13. CaO
14. $AgNO_3$
15. FeF_3

Task 4

1. $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
2. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
3. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ Or $C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$
4. $2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$
5. $2Na + S \rightarrow Na_2S$
6. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
7. $2Ag_2O \rightarrow 4Ag + O_2$
8. $Mg + 2HCl \rightarrow MgCl_2 + H_2$

Task 5

1. $Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$
2. $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
3. $2Na + 2H_2O \rightarrow 2NaOH + H_2$
4. $Fe_2O_3 + 6HNO_3 \rightarrow 2Fe(NO_3)_3 + 3H_2O$
5. $Cr_2O_3 + 2Al \rightarrow 2Cr + Al_2O_3$
6. $CuCO_3 + 2HNO_3 \rightarrow Cu(NO_3)_2 + CO_2 + H_2O$
7. $Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$

Task 6

Full number	1 sf	2 sf	3 sf	4 sf	5 sf
9.378652	**9**	**9.4**	**9.38**	**9.379**	**9.3787**
4204274	4000000	4200000	4200000	4204000	4204300
0.903521	0.9	0.90	0.904	0.9035	0.90352
0.00239482	0.002	0.0024	0.00239	0.002395	0.0023948

Task 7

1. $CuCO_3$ = 100.1
2. $AgNO_3$ = 169.9
3. H_2SO_4 =98.1
4. Al_2O_3 = 102.0
5. $Mg(OH)_2$ = 58.3
6. $Al(NO_3)_3$ = 213.0
7. $(NH4)_2SO_4$ = 132.1
8. $(NH4)_3PO_4$ = 149.0
9. $Ca_3(PO_4)_2$ = 310.3
10. $CuSO_4.5H_2O$ = 249.6

Task 8

1) Calculate moles
    a) 5.00 mol H_2O
    b) 0.345 mol C_4H_{10}
    c) 40.3 mol NH_3
    d) 319 mol O_2
    e) 19.6 mol Al_2O_3

2) Calculate the mass
    a) 112g N_2
    b) 6.3g HNO_3
    c) 1.88g K_2O
    d) 85g PH_3
    e) 13.4g C_2H_5OH

3) Calculate the molar mass
    a) 82.0 g mol^{-1}
    b) 28.0 g mol^{-1}
    c) 74.0 $gmol^{-1}$
    d) 85.0 g mol^{-1}
    e) 106.0 g mol^{-1}

Task 9

1) Calculate the number of moles in the following solutions.
    a) 0.020 moles HNO_3
    b) 0.0375 moles KOH
    c) $5x10^{-3}$ moles H_2SO_4
    d) 0.0133 moles KOH
    e) $6.60x10^{-6}$ molesH_2SO_4

2) Calculate the concentration of the following solutions in moldm-3
    a) 0.5 $moldm^{-3}$ NaCl
    b) 2 $moldm^{-3}$ H_2SO_4
    c) 0.8 $moldm^{-3}$ NaOH
    d) 3.66 $moldm^{-3}$ H_2SO_4
    e) 0.0134 $moldm^{-3}$ NaOH

3) Convert your answers from part 2 (a-e) into gdm-3
    a) 29.25 gdm^{-3} NaCl
    b) 196.2 gdm^{-3} H_2SO_4
    c) 32 gdm^{-3} NaOH
    d) 359 gdm^{-3} H_2SO_4
    e) 0.536 gdm^{-3} NaOH

Task 10

1. Find the volume of the following gases
    a) 96 dm^3 oxygen (O_2)
    b) 6 dm^3 methane (CH_4)
    c) 360 dm^3 argon (Ar)
    d) 5.28 dm^3 carbon dioxide (CO_2)
    e) 0.102 dm^3 ethane (C_2H_6)

2. Find the number of moles of the following gases
    a) 2 moles carbon monoxide (CO)
    b) 0.05 moles hydrogen (H_2)
    c) 0.015 moles oxygen (O_2)
    d) 0.00521 moles of helium (He)
    e) 0.0268 moles neon (Ne)

The Periodic Table of the Elements

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1																	**18**
1 **H** hydrogen 1.0	**2**											**13**	**14**	**15**	**16**	**17**	2 **He** helium 4.0
3 **Li** lithium 6.9	4 **Be** beryllium 9.0											5 **B** boron 10.8	6 **C** carbon 12.0	7 **N** nitrogen 14.0	8 **O** oxygen 16.0	9 **F** fluorine 19.0	10 **Ne** neon 20.2
11 **Na** sodium 23.0	12 **Mg** magnesium 24.3	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	13 **Al** aluminium 27.0	14 **Si** silicon 28.1	15 **P** phosphorus 31.0	16 **S** sulfur 32.1	17 **Cl** chlorine 35.5	18 **Ar** argon 39.9
19 **K** potassium 39.1	20 **Ca** calcium 40.1	21 **Sc** scandium 45.0	22 **Ti** titanium 47.9	23 **V** vanadium 50.9	24 **Cr** chromium 52.0	25 **Mn** manganese 54.9	26 **Fe** iron 55.8	27 **Co** cobalt 58.9	28 **Ni** nickel 58.7	29 **Cu** copper 63.5	30 **Zn** zinc 65.4	31 **Ga** gallium 69.7	32 **Ge** germanium 72.6	33 **As** arsenic 74.9	34 **Se** selenium 79.0	35 **Br** bromine 79.9	36 **Kr** krypton 83.8
37 **Rb** rubidium 85.5	38 **Sr** strontium 87.6	39 **Y** yttrium 88.9	40 **Zr** zirconium 91.2	41 **Nb** niobium 92.9	42 **Mo** molybdenum 95.9	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57–71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium 204.4	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89–103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium		114 **Fl** flerovium		116 **Lv** livermorium		

Key
atomic number
Symbol
name
relative atomic mass

57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium 144.9	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.2	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.0	71 **Lu** lutetium 175.0
89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium	92 **U** uranium 238.1	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium