WORKSHEET 3

1 In this experiment you will determine the relative atomic mass, A_r, of magnesium by a titration method.

FB 1 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.
FB 3 is 0.120 mol dm^{-3} sodium hydroxide, NaOH.
magnesium ribbon
bromophenol blue indicator

(a) Method

Reaction of magnesium with FB 1

- Pipette 25.0 cm^3 of **FB 1** into the 250 cm^3 beaker.
- Weigh the strip of magnesium ribbon and record its mass.

mass of magnesium = 0.20 g

- Coil the strip of magnesium ribbon loosely and then add it to the **FB 1** in the beaker.
- Stir the mixture occasionally and wait until the reaction has finished.

Dilution of the excess acid

- Transfer all the solution from the beaker into the volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution before using it for your titrations.
- Label this solution of hydrochloric acid **FB 2**.

Titration

- Fill the burette with **FB 2**.
- Rinse the pipette out thoroughly. Then pipette 25.0 cm^3 of **FB 3** into a conical flask.
- Add several drops of bromophenol blue indicator.
- Perform a rough titration, by running the solution from the burette into the conical flask until the mixture just becomes yellow.
- Record your burette readings in the space below.

Final burette reading/cm^3	25.60
Initial burette reading/cm^3	0.00
Volume of FB2 used/cm^3	25.60

The rough titre is 25.60 cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of **FB 2** added in each accurate titration.

	1	2	3	4
Final burette reading/cm^3	25.30	35.20	42.00	
Initial burette reading/cm^3	0.00	10.20	16.80	
Volume of FB2 used/cm^3	25.30	25.20	25.20	
		✓	✓	

I	
II	
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V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value for the volume of **FB 2** to be used in your calculations.
Show clearly how you have obtained this value.

$$\frac{25.20 + 25.20}{2}$$

25.0 cm^3 of **FB 3** required ....25.20..... cm^3 of **FB 2**. [1]

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the number of moles of sodium hydroxide present in 25.0 cm^3 of solution **FB 3**.

$n = cV$

$= 0.120 \times \frac{25.0}{1000}$

moles of NaOH = ...3.00×10^{-3}.... mol

(ii) Give the equation for the reaction of hydrochloric acid, HC*l*, with sodium hydroxide, NaOH. State symbols are **not** required.

....$HCl + NaOH \longrightarrow NaCl + H_2O$....

Deduce the number of moles of hydrochloric acid in the volume of **FB 2** you calculated in **(b)**.

mole ratio NaOH : HCl

1 : 1

3.00×10^{-3} : x

moles of HC*l* = ...3.00×10^{-3}.... mol

(iii) Calculate the number of moles of hydrochloric acid in 250 cm^3 of **FB 2**.

25.20 cm^3 —— 3.00×10^{-3}

250 cm^3 —— x

moles of HC*l* in 250 cm^3 of **FB 2** = ...0.0298.... mol

(iv) Calculate the number of moles of hydrochloric acid in 25.0 cm^3 of **FB 1**.

$n = cV$

$= 2.00 \times \frac{25.0}{1000}$

moles of HC*l* in 25.0 cm^3 of **FB 1** = ...0.0500.... mol

(v) In **(a)**, you reacted 25.0 cm^3 of **FB 1** with your weighed piece of magnesium. After the reaction, the unreacted hydrochloric acid was used to prepare 250 cm^3 of **FB 2**.

Use your answers to **(iii)** and **(iv)** to calculate the number of moles of hydrochloric acid that reacted with the magnesium ribbon.

0.0500 − 0.0298

moles of HCl reacting with Mg = 0.0202 mol

(vi) Complete the equation below, for the reaction of magnesium with hydrochloric acid. State symbols **are** required.

$Mg_{(s)}$ + 2 HC$l_{(aq)}$ → MgC$l_{2\,(aq)}$ + $H_{2\,(g)}$

Use your answer to **(v)** to calculate the number of moles of magnesium used.

mole ratio Mg : HCl
1 : 2
x : 0.0202

moles of Mg = 0.0101 mol

(vii) Use your answer to **(vi)** to calculate the relative atomic mass, A_r, of magnesium.

$n = \frac{m}{Ar}$

$0.0101 = \frac{0.20}{Ar}$

A_r of Mg = 19.80

[6]

(d) **(i)** State **one** observation that proves that the hydrochloric acid in **FB 1** was in excess for the reaction with the magnesium ribbon.

Magnesium ribbon was dissolved.

(ii) A student carried out exactly the same experiment but used 1.00 g of magnesium ribbon. State and explain why the student's experiment could not be used to determine the value for the A_r of magnesium.
Include a calculation in your answer.

$n = \frac{m}{Ar} = \frac{1}{24.3} = 0.0412$ mol of Mg, so atleast 0.082 moles of HCl required.

So HCl would become Limiting and Mg would be in excess

[3]

[Total: 17]

2 In this experiment you will determine the relative atomic mass of magnesium by thermal decomposition of hydrated magnesium sulfate.

$$MgSO_4.7H_2O(s) \rightarrow MgSO_4(s) + 7H_2O(g)$$

FB 4 is hydrated magnesium sulfate, $MgSO_4.7H_2O$.

(a) Method

Record all your weighings in the space below.

- Weigh the crucible with its lid.
- Transfer all **FB 4** into the crucible.
- Weigh the crucible, lid and **FB 4**.
- Place the crucible on the pipe-clay triangle.
- Heat the crucible gently with the lid **on**, for about one minute.
- Then heat the crucible strongly, without the lid, for a further four minutes.
- Leave the crucible and its contents to cool with the lid on, for several minutes.
- **While the crucible is cooling, begin work on Question 3.**
- When the crucible has cooled, weigh it, with the lid and contents.
- Calculate and record the mass of anhydrous magnesium sulfate produced and the mass of water lost.

mass of crucible + Lid /g	26.14
mass of crucible + Lid + FB4 /g	28.64
mass of crucible + Lid + FB4 after heating /g	27.36
mass of anhydrous MgSO4 /g	1.22
mass of water Lost /g	1.28

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II	
III	

[3]

(b) Calculations

(i) Calculate the number of moles of water lost during heating.
(Use the data in the Periodic Table on page 12.)

$\frac{1.28}{18}$ =

moles of H_2O = 0.0711 mol

(ii) Use the **equation above** and **your answer to (i)** to calculate the number of moles of anhydrous magnesium sulfate produced.

mole ratio

MgSO4 : H2O

1 : 7

x : 0.0711

moles of $MgSO_4$ = 0.0102 mol

(iii) Use your weighings and your answer to **(ii)** to calculate the relative formula mass, M_r, of anhydrous magnesium sulfate.

$n = \frac{m}{A_r}$

$0.0102 = \frac{1.22}{A_r} = 119.6$

M_r of $MgSO_4$ = ...120........

(iv) From your answer to **(iii)**, calculate the relative atomic mass, A_r, of magnesium.

$SO_4 = 32.1 + 64 = 96.1$

$MgSO_4 : 120$

$Mg = 120 - 96.1$

$= 23.9$

A_r of Mg = ...23.9.....

[4]

(c) **(i)** How could the experiment be improved to ensure that the magnesium sulfate had been completely dehydrated?

Reheat, until we get constant mass of anhydrous $MgSO_4$.

....

(ii) Why is the lid put on the crucible during cooling?

To prevent addition of water moistures from air.

....

[2]

[Total: 9]

3 **Qualitative Analysis**

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

(a) **FB 5** is a solution containing one cation and one anion.
Carry out test-tube tests to find out whether the cation in **FB 5** is magnesium and whether the anion is sulfate.

- State what reagents you used.
- Record the observations you made in a table.
- State your conclusions about which ions are present.

tests	Observations	Conclusion
a) To 1cm depth of solution, add 1cm depth of aq. NaOH then in excess	white ppt. insoluble in excess	Mg^{2+} present
b) To 1cm depth of solution, add 1cm depth of aq. NH_3 then in excess	white ppt. insoluble in excess	
c) To 1cm depth of solution add 1cm depth of aq. $Ba(NO_3)_2$	no change	SO_4^{2-} absent
add dilute HCl	—	

[4]

(b) **FB 6** is a salt containing one cation and one anion from those listed on pages 10 and 11.

(i) Place a **few** crystals of **FB 6** in a hard-glass test-tube.
Heat gently at first and then strongly.
Leave the test-tube and its contents to cool.

Record **all** your observations below.

Gentle heating → solid melts on heating

Strong heating → - Solid turns yellow,
- brown gas produced,
- glowing splint relights

Cooling → liquid solidify, and turns pale yellow /white

(ii) Dissolve the remainder of **FB 6** in about 20 cm^3 of distilled water in a boiling tube for use in the following tests.

test	*observations*
To a 1 cm depth of the solution of **FB 6** in a test-tube, add a few drops of aqueous silver nitrate.	no change
To a 1 cm depth of the solution of **FB 6** in a test-tube, add a few drops of dilute sulfuric acid.	no change
To a 1 cm depth of the solution of **FB 6** in a test-tube, add aqueous ammonia.	white ppt soluble in excess

test	*observations*
To a 1 cm depth of the solution of **FB 6** in a boiling tube, add aqueous sodium hydroxide until in excess, then	white ppt soluble in excess
heat the mixture gently and carefully, and test any gas produced, then	No change / damp red litmus paper remains red.
add a small piece of aluminium foil while the mixture is still warm. Test any gas produced.	a colorless gas produced which turned damp red litmus paper blue.

(iii) Deduce the formula of the salt in **FB 6**.

Formula is ......$Zn(NO_3)_2$......

[10]

[Total: 14]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$)
bromide, $Br^-(aq)$	gives cream ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$)
iodide, $I^-(aq)$	gives yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$)
nitrate, $NO_3^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil
nitrite, $NO_2^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, $SO_4^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids)
sulfite, $SO_3^{2-}(aq)$	SO_2 liberated with dilute acids; gives white ppt. with $Ba^{2+}(aq)$ (soluble in excess dilute strong acids)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	"pops" with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1.0 **H** Hydrogen 1										4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **Be** Beryllium 4											10.8 **B** Boron 5	12.0 **C** Carbon 6	14.0 **N** Nitrogen 7	16.0 **O** Oxygen 8	19.0 **F** Fluorine 9	20.2 **Ne** Neon 10
23.0 **Na** Sodium 11	24.3 **Mg** Magnesium 12											27.0 **Al** Aluminium 13	28.1 **Si** Silicon 14	31.0 **P** Phosphorus 15	32.1 **S** Sulfur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
39.1 **K** Potassium 19	40.1 **Ca** Calcium 20	45.0 **Sc** Scandium 21	47.9 **Ti** Titanium 22	50.9 **V** Vanadium 23	52.0 **Cr** Chromium 24	54.9 **Mn** Manganese 25	55.8 **Fe** Iron 26	58.9 **Co** Cobalt 27	58.7 **Ni** Nickel 28	63.5 **Cu** Copper 29	65.4 **Zn** Zinc 30	69.7 **Ga** Gallium 31	72.6 **Ge** Germanium 32	74.9 **As** Arsenic 33	79.0 **Se** Selenium 34	79.9 **Br** Bromine 35	83.8 **Kr** Krypton 36
85.5 **Rb** Rubidium 37	87.6 **Sr** Strontium 38	88.9 **Y** Yttrium 39	91.2 **Zr** Zirconium 40	92.9 **Nb** Niobium 41	95.9 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	**Po** Polonium 84	**At** Astatine 85	**Rn** Radon 86
Fr Francium 87	**Ra** Radium 88	**Ac** Actinium 89 †	**Rf** Rutherfordium 104	**Db** Dubnium 105	**Sg** Seaborgium 106	**Bh** Bohrium 107	**Hs** Hassium 108	**Mt** Meitnerium 109	**Uun** Ununnilium 110	**Uuu** Unununium 111	**Uub** Ununbium 112		**Uuq** Ununquadium 114		**Uuh** Ununhexium 116		**Uuo** Ununoctium 118

*58-71 Lanthanides
†90-103 Actinides

*	140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	**Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	163 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
†	**Th** Thorium 90	**Pa** Protactinium 91	**U** Uranium 92	**Np** Neptunium 93	**Pu** Plutonium 94	**Am** Americium 95	**Cm** Curium 96	**Bk** Berkelium 97	**Cf** Californium 98	**Es** Einsteinium 99	**Fm** Fermium 100	**Md** Mendelevium 101	**No** Nobelium 102	**Lr** Lawrencium 103

Key

a **X** b	a = relative atomic mass **X** = atomic symbol b = proton (atomic) number