Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S24-3410UA0-1

3410UA0-1

THURSDAY, 13 JUNE 2024 – MORNING

CHEMISTRY – Unit 1:
Chemical Substances, Reactions and Essential Resources
HIGHER TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**6**	
3.	**7**	
4.	**5**	
5.	**9**	
6.	**5**	
7.	**7**	
8.	**6**	
9.	**7**	
10.	**12**	
11.	**9**	
Total	**80**	

3410UA01
01

ADDITIONAL MATERIALS

In addition to this examination paper you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

Question **8** is a quality of extended response (QER) question where your writing skills will be assessed.

The Periodic Table is printed on the back cover of this paper and the formulae for some common ions on the inside of the back cover.

Examiner only

Answer **all** questions.

1. The table below gives information about seven elements, **A-G**.

Element	Melting point (°C)	Boiling point (°C)	Electrical conductivity	Malleability
A	839	1484	good	good
B	−23	115	poor	
C	1414	3265	poor	poor
D	−102	−34	poor	
E	10	112	poor	poor
F	−188	−42	poor	
G	660	2470	good	good

(a) Use information from the table to answer parts (i)-(iii).

(i) Give the **letter** of the element that has the greatest difference between its melting point and boiling point. [1]

.....

(ii) Give the **letters** of the **two** elements that are gases at room temperature, 20 °C.

Give a reason for your choice. [2]

Letters ..... and .....

Reason .....

.....

Examiner only

(iii) Give the **letter** of the element that is a metalloid.

Explain your choice. [2]

Letter .....

Explanation .....

.....

.....

(b) One of the elements is aluminium. It reacts spectacularly with iron(III) oxide in the thermit reaction.

Complete and balance the equation for the reaction between aluminium and iron(III) oxide to produce aluminium oxide and iron. [2]

$$\square\ Al + Fe_2O_3 \longrightarrow \text{.....} + 2\,Fe$$

3410UA01
03

7

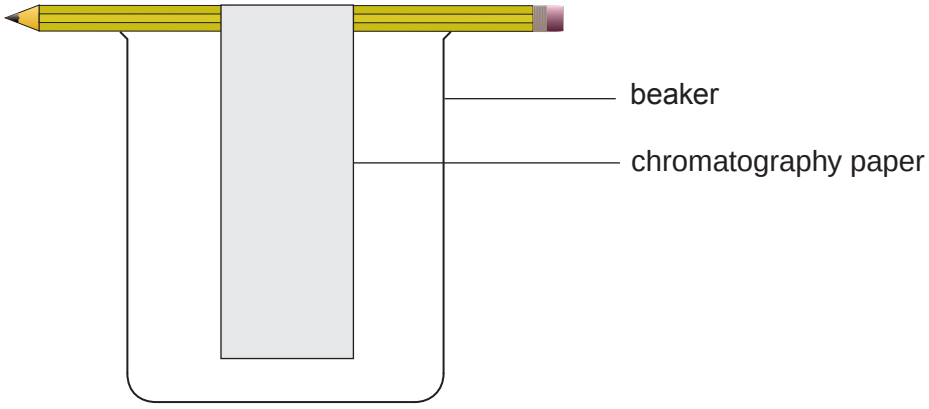
Examiner only

2. (a) Amanda wanted to determine what coloured dyes were present in a sample of orange ink.

The diagram shows a piece of chromatography paper, supported by a pencil, placed in a beaker at the start of her experiment.

Complete the diagram by showing

- the position of the ink sample at the start
- the water level in the beaker [2]



(b) The table shows the R_f values for some coloured dyes that are found in inks.

Dye colour	R_f value
blue	0.40
yellow	0.25
red	0.70
green	0.15

(i) Explain why coloured dyes have different R_f values. [2]

.....

.....

.....

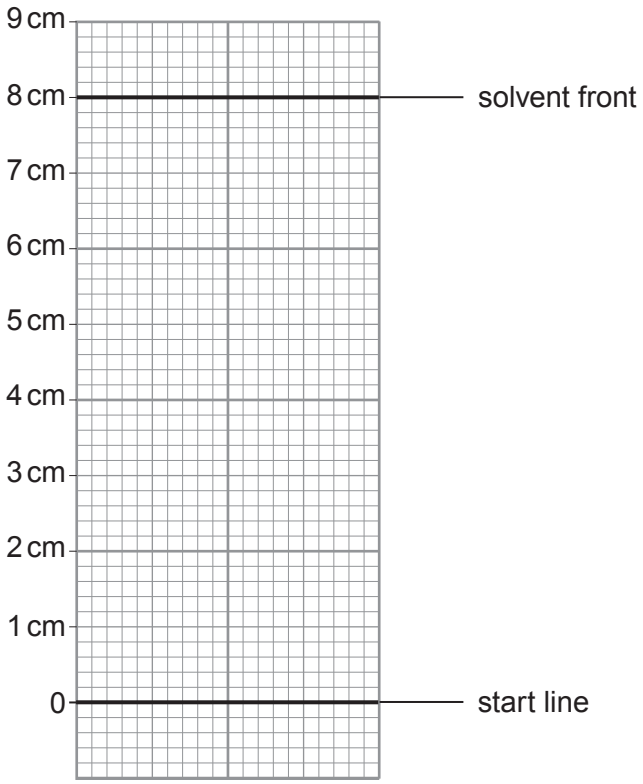
Examiner only

(ii) Orange ink separates into red and yellow dyes.

On the chromatogram, draw the positions of the spots you would expect to see after a sample of orange ink has been analysed by chromatography. [2]

Use the formula

distance travelled by dye = R_f value × distance travelled by solvent



3410UA01
05

6

Examiner only

3. (a) Wegener's theory of continental drift was not accepted by other scientists during his lifetime because he had no explanation of how the continents moved.

We now know that the continents sit on tectonic plates which move very slowly.

State why these plates move. [1]

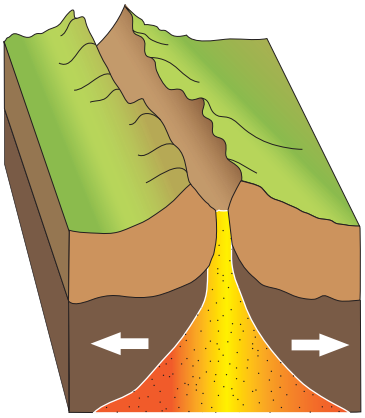
.....

.....

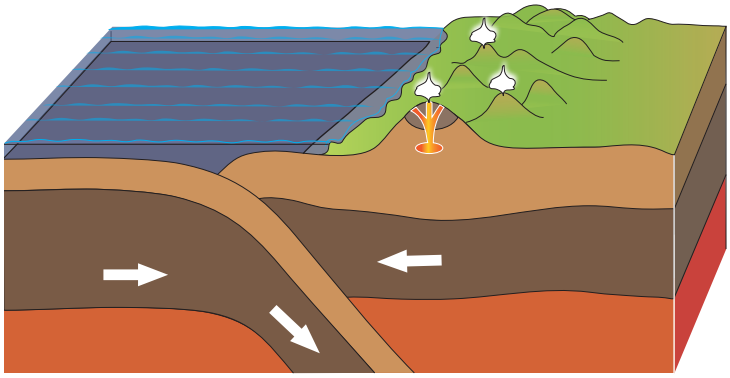
(b) The diagrams below show two different types of plate boundary.

At a constructive plate boundary, the plates move away from each other.

At a destructive plate boundary, the plates move towards each other.



Constructive



Destructive

Describe what happens at each type of boundary. [4]

Constructive

.....

.....

.....

Destructive

.....

.....

.....

Examiner only

(c) The cities of Los Angeles and San Francisco are on opposite sides of a conservative plate boundary at a distance of 600 km apart.

They are moving closer together as the plates slide past one another at a relative speed of about 40 mm per year.

Use the formula below to calculate the amount of time before the cities are next to one another. [2]

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

1 km = 1 000 m 1 m = 1 000 mm

Time = ... years

7

Examiner only

4. The table shows the composition of four particles, **W**, **X**, **Y** and **Z**.

Particle	Number of protons	Number of electrons	Number of neutrons
W	12	12	12
X	12	12	14
Y	12	10	12
Z	11	11	12

(a) Use information from the table to answer parts (i)-(iii).

(i) State how the information shows that particle **X** is an atom. [1]

.....

(ii) State how the information shows that particle **Y** is a positive ion. [1]

.....

(iii) State how the information shows that particles **W** and **X** are isotopes of the same element. [1]

.....

.....

(b) (i) Give the electronic structure of element **Z**. [1]

.....

(ii) State the group and period number of element **Z** in the Periodic Table. [1]

Group .....

Period .....

5

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

Examiner only

5. Zinc reacts with sulfuric acid, H_2SO_4, to produce zinc sulfate and hydrogen gas.

(a) Write the formula of zinc sulfate to complete the equation for this reaction. [1]

$$Zn + H_2SO_4 \longrightarrow \text{.....} + H_2$$

(b) Some Year 10 students decided to investigate the rate of this reaction at 20 °C.

They added 0.2 g of zinc to 50 cm^3 of sulfuric acid and measured the volume of hydrogen gas produced every 20 seconds for 160 seconds using a gas syringe.

Their results are shown in the table.

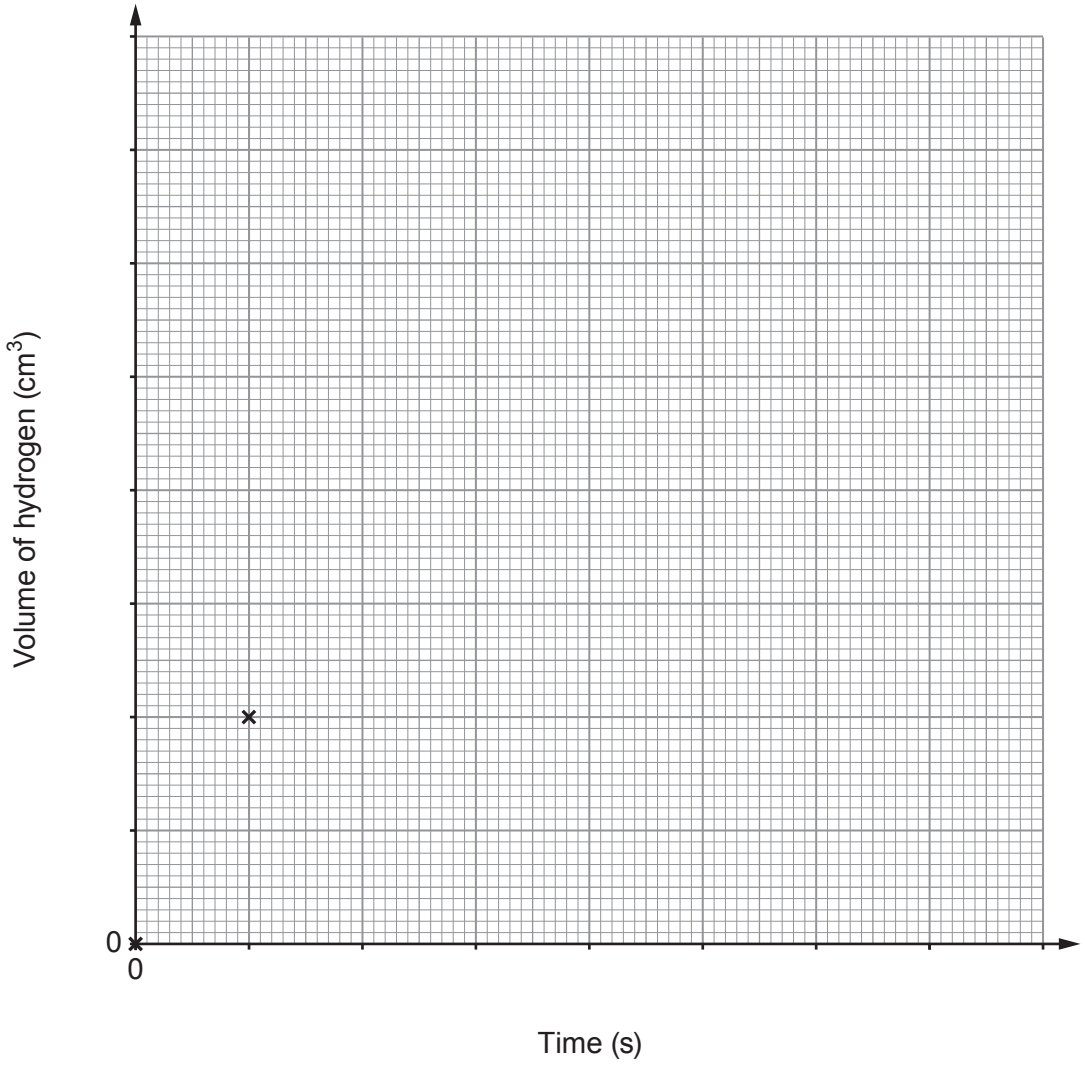
Time (s)	Volume of hydrogen (cm^3)
0	0
20	20
40	37
60	50
80	60
100	66
120	69
140	70
160	70

Examiner only

Draw appropriate scales on both axes on the grid.

Plot the volume of hydrogen produced against time and draw a suitable line. [3]

The first two points have been plotted for you.



(c) **On the same grid**, sketch the graph you would expect to obtain if the experiment were repeated at 40 °C using the same mass of zinc and the same volume and concentration of sulfuric acid. [1]

Examiner only

(d) Use the particle theory to explain what you would expect to happen to the rate of the reaction if the experiment were repeated at 20 °C using sulfuric acid of **lower concentration**. [3]

.....

.....

.....

.....

(e) Copper is a useful catalyst in the reaction between zinc and sulfuric acid.

State how a catalyst increases the rate of a reaction. [1]

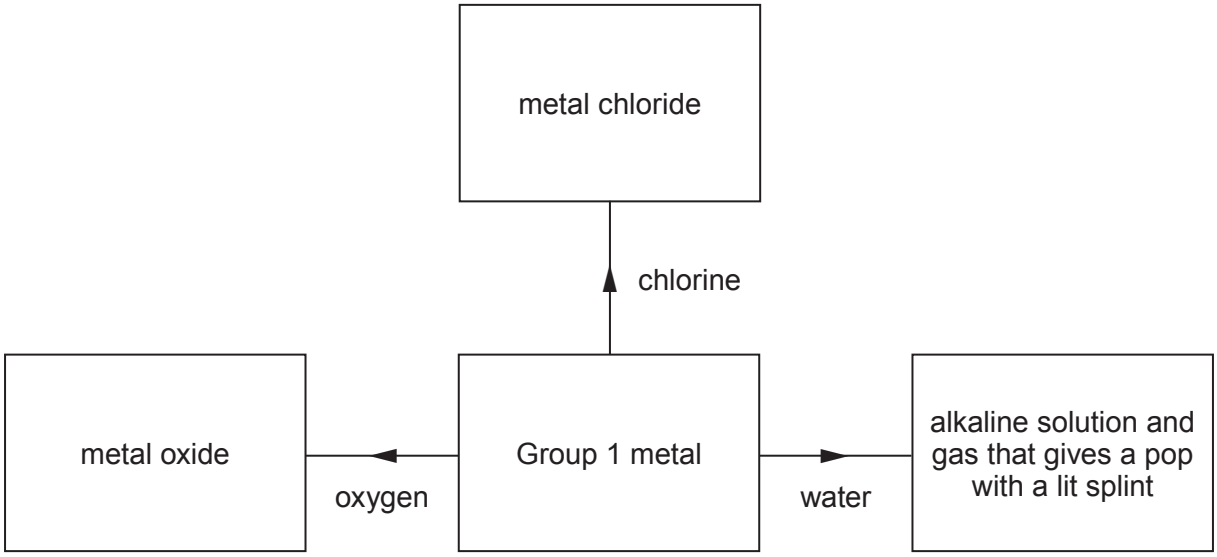
.....

.....

9

Examiner only

6. The flow diagram shows some of the reactions of Group 1 metals.



(a) Identify the Group 1 metal chloride that would give a red flame test. [1]

.....

(b) Give the **formula** of the alkaline compound formed when sodium is added to water. [1]

.....

(c) Complete the balanced equation for the reaction of lithium and oxygen to form lithium oxide. [3]

$$\square\,Li + \ldots\ldots\ldots\ldots \longrightarrow 2\,\ldots\ldots\ldots\ldots$$

5

Examiner only

7. Although the Group 0 gases are unreactive elements, some Group 0 compounds have been made.

The heavier Group 0 gases have more electron shells than the lighter ones. Their outermost electrons are shielded from the attraction of the nucleus by the inner electrons. These atoms can therefore form bonds with very reactive atoms under certain conditions.

As a rule, Group 0 gases having an atomic radius greater than 80 picometres (pm) can form compounds. The atomic radii of Group 0 elements are shown in **Table 1**.

The most common compounds of Group 0 gases are those formed with Group 7 elements. For example, krypton difluoride (KrF_2) and xenon dichloride ($XeCl_2$).

The stability of these compounds increases with increasing atomic number of the Group 0 gas and decreasing atomic number of the Group 7 element.

The oxidation state of the Group 0 gas in these compounds varies. Oxidation state is linked to the number of bonds formed. The melting points of these compounds decrease as the oxidation state of the Group 0 gas increases. An example of this is shown in **Table 2**.

Table 1

Group 0 gas	Atomic radius (pm)
He	31
Ne	38
Ar	71
Kr	88
Xe	108
Rn	120

Table 2

Xenon compound	Oxidation state of xenon	Melting point (°C)
XeF_2	+2	129
XeF_4	+4	117
XeF_6	+6	49

(a) (i) Tick (✓) the box next to the three Group 0 gases that are most likely to form compounds. [1]

helium, argon, xenon ☐

helium, neon, argon ☐

argon, krypton, xenon ☐

krypton, xenon, radon ☐

Examiner only

(ii) Tick (✓) the box next to the most stable Group 0 compound. [1]

XeF_2 ☐

KrF_2 ☐

$XeCl_2$ ☐

$KrCl_2$ ☐

(iii) Use the trend shown in **Table 2** and the information below to suggest the most likely melting point for $KrCl_6$.

Krypton compound	Oxidation state of krypton	Melting point (°C)
$KrCl_2$	+2	98
$KrCl_4$	+4	80
$KrCl_6$	+6	

Tick (✓) the box next to your answer. [1]

23 °C ☐ 71 °C ☐ 110 °C ☐

(iv) Explain why neon does not form compounds. [2]

.....

.....

.....

.....

(b) Give **one** use of helium and explain this use in terms of its properties. [2]

.....

.....

7

Examiner only

8. The reactivity of the halogens changes on going down the group.

You are provided with samples of the halogens and solutions of the halides shown below.

Halogen	Halide solution
chlorine	sodium chloride
bromine	sodium bromide
iodine	sodium iodide

State how you would carry out an investigation to determine the order of reactivity of the halogens using these chemicals.

Describe the observations made and explain how these are used to draw your conclusion.

Include an equation in your answer. [6 QER]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

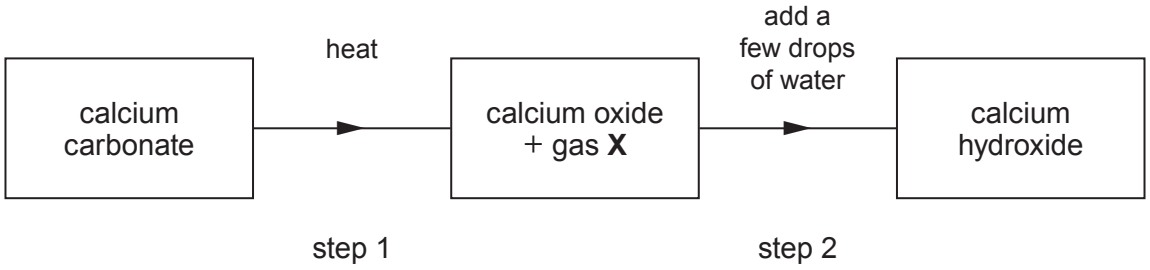
.....

.....

6

Examiner only

9. (a) The flow diagram shows the reactions carried out to prepare calcium hydroxide from calcium carbonate, $CaCO_3$.



(i) Name the type of reaction taking place in step 1. [1]

.....

(ii) Give the name of gas **X**. [1]

.....

(iii) Give **one** observation that shows that step 2 is exothermic. [1]

.....

(iv) Write a balanced equation for the reaction of calcium oxide and water to form calcium hydroxide. [2]

.....

(b) Give a reason why no reaction occurs when sodium carbonate is heated with a Bunsen burner. [1]

.....

.....

(c) Barium hydroxide is another Group 2 hydroxide.

Solutions of calcium hydroxide and barium hydroxide are both alkalis and turn pH paper purple.

State how you could distinguish between calcium hydroxide and barium hydroxide using a flame test. [1]

.....

.....

7

Examiner only

10. Some students carried out an experiment to investigate the relative hardness of four water samples, **A**, **B**, **C** and **D**.

The students measured 20 cm^3 of sample **A** into a measuring cylinder. They added soap solution, 1 cm^3 at a time. After each addition the mixture was shaken. The volume of soap solution needed to produce 1 cm of lather was recorded.

Samples **B**, **C** and **D** were tested in the same way.

They then repeated each experiment with samples that had been boiled and others that had been treated with washing soda.

Their results are shown in the table.

Water sample	Volume of soap solution needed (cm^3)		
	Before boiling	After boiling	After washing soda
A	8	2	2
B	12	12	2
C	2	2	2
D	9	6	2

(a) Use the results in the table to answer parts (i) and (ii).

(i) Identify the type of hardness found in sample **A**.

Give a reason for your answer. [2]

.....

.....

.....

(ii) Identify the sample containing both temporary and permanent hardness.

Give a reason for your answer. [2]

.....

.....

.....

Examiner only

(b) Another group of students carried out the same experiment on the same four water samples.

However, this group measured smaller volumes of each sample into the measuring cylinder. Their results are shown in the table.

Water sample	Volume of soap solution needed (cm^3)		
	Before boiling	After boiling	After washing soda
A	5	1	1
B	8	6	1
C	1	1	1
D	7	4	1

Compare the conclusions that can be drawn by the two groups. [2]

.....

.....

.....

.....

(c) Permanent hardness is removed by ion exchange.

Explain how ion exchange works. [2]

.....

.....

.....

Examiner only

(d) Magnesium ions cause hardness in water.

(i) 1.00 dm^3 of a hard water sample contains 0.384 g of dissolved magnesium sulfate.

Calculate the number of moles of magnesium sulfate present.

Give your answer in **standard form**. [2]

$M_r(MgSO_4) = 120$

$$\text{number of moles} = \frac{\text{mass}}{M_r}$$

Number of moles = ... mol

(ii) 1.00 dm^3 of another hard water sample contains the same mass (0.384 g) of dissolved magnesium chloride.

$M_r(MgCl_2) = 95$

State which water sample has more hardness.

Give your reasoning. [2]

.....

.....

.....

12

Examiner only

11. (a) Iron reacts with halogens forming iron halides.

(i) Write a balanced equation for the formation of iron(III) bromide. [3]

.....

(ii) You are provided with solutions of iron(III) bromide and iron(II) iodide.

Describe a test to identify which is which.

Your answer should include the expected observation for both compounds. [3]

.....

.....

.....

(b) Bromine and fluorine react to produce a compound called bromine fluoride.

In a reaction 16.3 g of bromine reacted with 19.4 g of fluorine. Calculate the simplest formula for the bromine fluoride produced.

You **must** show your working. [3]

$A_r(Br) = 80$ $A_r(F) = 19$

Simplest formula .....

9

END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

Examiner only

FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	**Formula**	**Name**	**Formula**
aluminium	Al^{3+}	bromide	Br^{-}
ammonium	NH_4^{+}	carbonate	CO_3^{2-}
barium	Ba^{2+}	chloride	Cl^{-}
calcium	Ca^{2+}	fluoride	F^{-}
copper(II)	Cu^{2+}	hydroxide	OH^{-}
hydrogen	H^{+}	iodide	I^{-}
iron(II)	Fe^{2+}	nitrate	NO_3^{-}
iron(III)	Fe^{3+}	oxide	O^{2-}
lithium	Li^{+}	sulfate	SO_4^{2-}
magnesium	Mg^{2+}		
nickel	Ni^{2+}		
potassium	K^{+}		
silver	Ag^{+}		
sodium	Na^{+}		
zinc	Zn^{2+}		

THE PERIODIC TABLE

Group	1	2										3	4	5	6	7	0
							1 H Hydrogen 1										4 He Helium 2
	7 Li Lithium 3	9 Be Beryllium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
	23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
	39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
	86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 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	179 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	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
	223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key