Surname	Centre Number	Candidate Number
Other Names		0

GCSE

3430UE0-1

S19-3430UE0-1

SCIENCE (Double Award)

Unit 5 – CHEMISTRY 2
HIGHER TIER

THURSDAY, 16 MAY 2019 – MORNING

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**15**	
2.	**7**	
3.	**6**	
4.	**15**	
5.	**11**	
6.	**6**	
Total	**60**	

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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. Do not use correction fluid.

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 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 **6** 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.

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Answer **all** *questions.*

1. Crude oil can be separated into simpler mixtures, called fractions, which contain hydrocarbon compounds with boiling points in a similar range.

(a) The table lists the properties of some fractions obtained from crude oil.

Fraction	Number of carbon atoms in fraction	Boiling point range (°C)	Colour of fraction	Flame when burning	Ease of burning
fuel oil	1-4	–170 to 20	colourless	clean	very easy
petrol	5-10	20 to 70	pale yellow	clean	easy
naphtha	8-12	70 to 120	yellow	some soot	quite easy
kerosene	10-16	120 to 240	dark yellow	smoky	quite difficult
diesel oil	15-30	240 to 350	brown	smoky	difficult

Use the information in the table to describe how the burning of the fractions depends upon the size of the molecules. [2]

....

....

....

(b) The boiling points of hydrocarbons containing 1 to 12 carbon atoms are shown in the table below. The boiling point for the hydrocarbon with 7 carbon atoms is missing.

Number of carbon atoms	Boiling point (°C)
1	–165
2	–90
3	–40
4	10
5	35
6	70
7	
8	125
9	150
10	175
11	195
12	215

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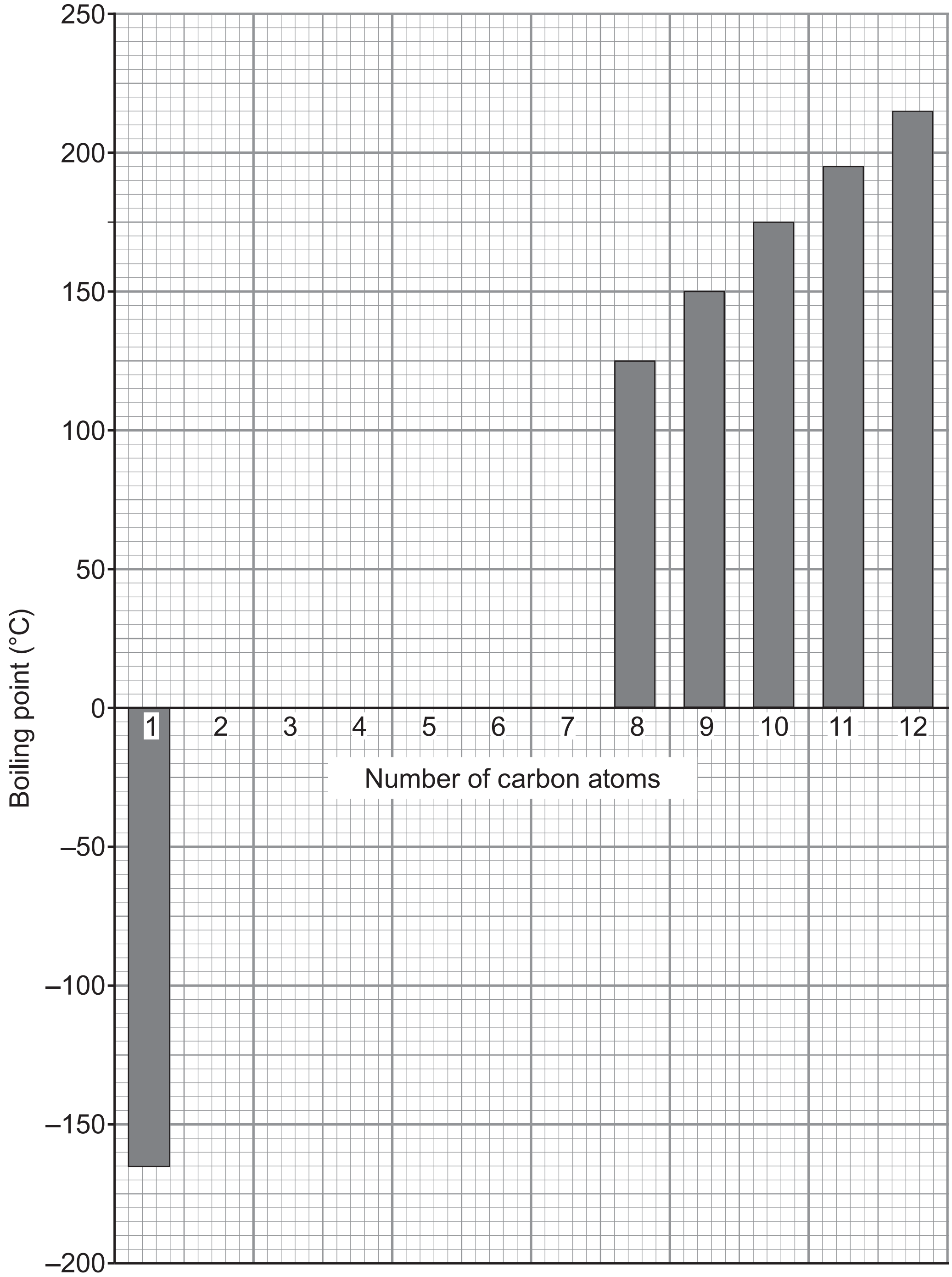
(i) Complete the bar chart below. Some of the bars have already been drawn. [2]



(ii) Use a ruler to draw a trend line **on the chart** and use this to estimate the boiling point of the hydrocarbon with 7 carbon atoms. [2]

Boiling point .... °C

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(c) Many of the fractions obtained from crude oil are used as fuels.

(i) The fire triangle shows the factors necessary to start and maintain a fire.

State **one** method that could be used to safely put out a small amount of spilled petrol burning on the floor. Give the reason why your chosen method would work. [1]

Method ....

Reason ....

....

(ii) One of the hydrocarbons in petrol is pentane, C_5H_{12}.

Complete and balance the symbol equation for the complete combustion of pentane. [2]

C_5H_{12} + $8O_2$ ⟶ ☐ .... + ☐ ....

(iii) Hydrogen fuel cells are now used in many cars instead of petrol. The overall change inside a hydrogen fuel cell is the same as when hydrogen burns.

Explain why using hydrogen fuel cells in cars is better for the environment than petrol. [2]

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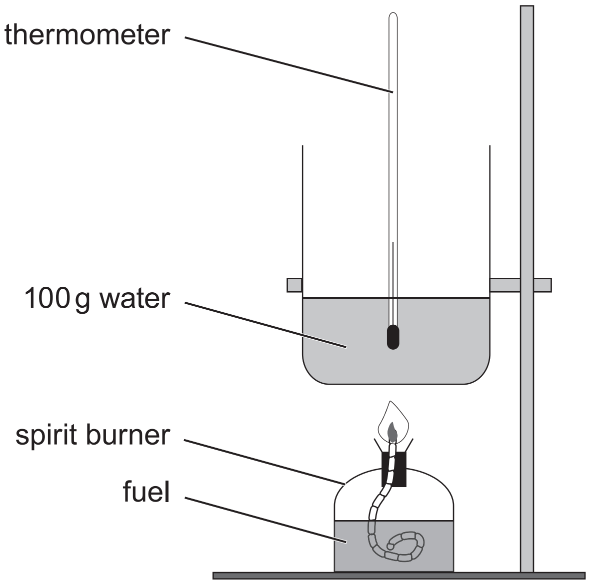
(d) It is possible to compare the energy released when different fuels are burned using the following apparatus.



To calculate the energy released per gram of fuel burned, the following equation is used.

$$\text{energy released per gram of fuel (J/g)} = \frac{\text{mass of water} \times 4.2 \times \text{temperature rise (°C)}}{\text{mass of fuel used (g)}}$$

(i) Apart from measuring the mass of water, describe **all** the measurements that would need to be taken to be able to calculate the energy released per gram of fuel burned. [2]

....

....

....

(ii) When comparing the energy released from different fuels, 100 g of water should be used each time. State **one** other variable that should be controlled. [1]

....

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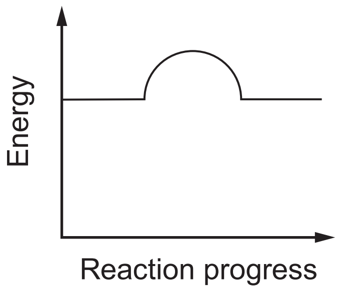
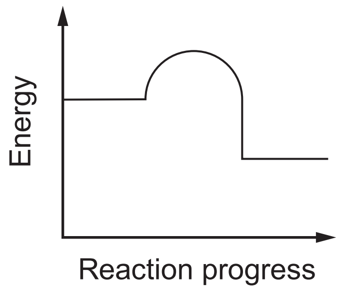
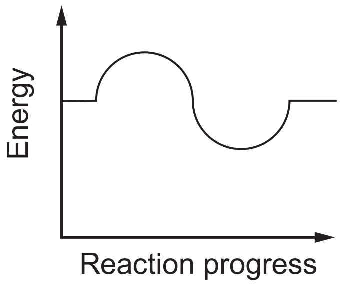
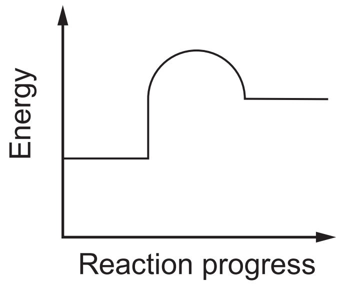
(iii) Tick (✓) the energy profile diagram that represents the combustion of fuels. [1]









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2. *(a)* Magnesium reacts with oxygen to form magnesium oxide.

Using the electronic structures below, draw dot and cross diagrams to show how bonding takes place during the formation of magnesium oxide. Include the electronic structures of the ions formed. [3]

magnesium = 2,8,2 oxygen = 2,6

(b) The melting points of magnesium oxide and sodium chloride are given below.

Substance	Melting point (°C)
sodium chloride	801
magnesium oxide	2852

Explain why there is a difference in their melting points even though they are both ionic substances. [2]

....

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(c) Using the electronic structures below, draw a dot and cross diagram to show the bonding in a molecule of carbon dioxide, CO_2. [2]

carbon = 2,4 oxygen = 2,6

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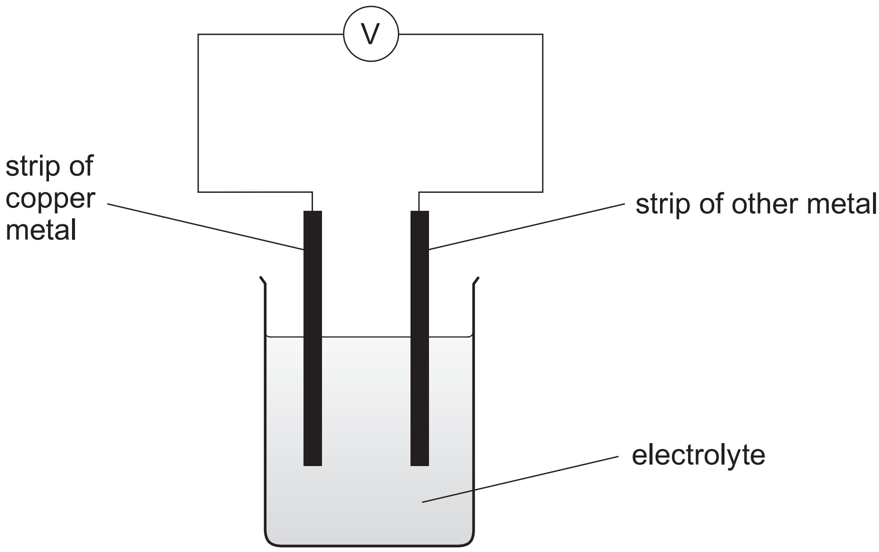
3. When two different metals are connected in a cell, **the metal with the higher reactivity transfers its electrons to the other metal.**

The potential difference produced between pairs of metals can be used to place them in order of reactivity. **The bigger the potential difference, the bigger the difference in reactivity.**

(a) The following apparatus was used to investigate the reactivity of four different metals, **A**, **B**, **C** and **D**, compared with copper.



Each metal was placed separately into a cell with a copper strip. The potential difference was recorded for each metal and the results are shown below.

Metal	Potential difference (V)	Direction of electron flow
A	0.3	copper → metal **A**
B	0.6	metal **B** → copper
C	1.1	metal **C** → copper
D	0.8	copper → metal **D**

Use the information to place metals **A**, **B**, **C** and **D** in order of their reactivity in relation to copper. [2]

most reactive

1. ....

2. ....

3. copper

4. ....

5. ....

(b) The reactivity of four other metals, **W**, **X**, **Y** and **Z**, was also investigated using the same apparatus. Some of the results are shown in the following table.

Pair of metals in the cell	Potential difference (V)	Direction of electron flow
W and **X**	1.2	**W** → **X**
W and **Y**	0.9	**Y** → **W**
W and **Z**	0.8	
Y and **Z**		**Y** → **Z**

The order of reactivity of these four metals is as follows.

most reactive ↑

Y

Z

W

X

Use this information to give

(i) the direction of the electron flow when **W** and **Z** are placed in the cell, [1]

....

(ii) the potential difference for the cell with metals **Y** and **Z**. [1]

.... V

(c) When copper and zinc are placed into the cell, the following reaction takes place.

$$Cu^{2+} + Zn \longrightarrow Zn^{2+} + Cu$$

Explain how **this** reaction shows both oxidation and reduction. [2]

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4. In a class experiment, Dylan and Joel were given a solution of sodium carbonate containing 5.23 g of sodium carbonate powder dissolved in 500 cm^3 of water.

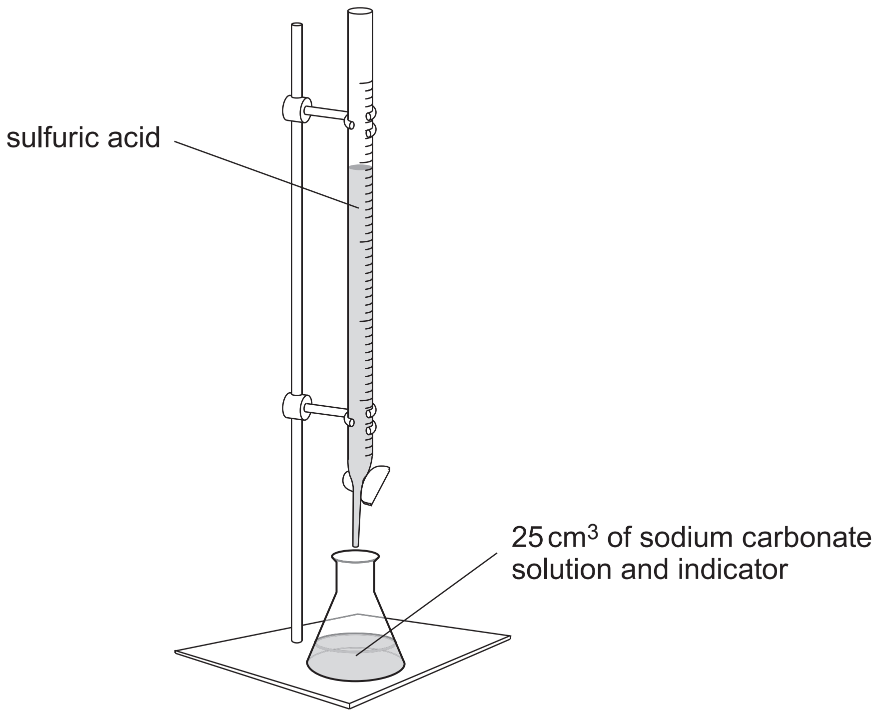
The relative formula mass (M_r) of sodium carbonate is 106.

(a) Use this information to calculate the number of moles of sodium carbonate in the 5.23 g of the powder. Give your answer correct to **two** decimal places. [2]

Number of moles = ... mol

(b) Dylan and Joel were asked to use the sodium carbonate solution to prepare a sample of sodium sulfate crystals in a three-stage process.

In the first stage of their preparation, they used the following apparatus to carry out a titration.



The equation for the reaction taking place is as follows.

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2$$

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(i) A trial run was carried out and the titration repeated three times. The volume of acid added each time was recorded.

	Trial	1	2	3
Volume of sulfuric acid added (cm^3)	30.20	27.55	27.75	27.65

I. State the purpose of carrying out a trial run. [1]

....

....

II. State whether the sulfuric acid or the sodium carbonate solution is the more concentrated. Give the reason for your answer. [1]

....

....

(ii) Use **all** of the information provided to describe **in detail** the other two stages Dylan and Joel carried out to obtain pure sodium sulfate crystals. [4]

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(c) Sodium sulfate solution is also formed when sodium hydroxide solution reacts with copper(II) sulfate solution.

(i) Give the balanced symbol equation for this reaction. [3]

....

(ii) Describe tests that can be carried out to identify both of the ions in sodium sulfate solution. Give the expected observation for both tests. [2]

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(d) The reaction occurring between solutions of sodium carbonate and magnesium sulfate forms a precipitate of magnesium carbonate.

Write the **ionic** equation for the formation of magnesium carbonate. [2]

.... + ... $\longrightarrow$ ....

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5. In 1985, a new allotrope of carbon was discovered and named buckminsterfullerene. This allotrope consists of sixty carbon atoms joined together to resemble a shape similar to that of a football (**Figure 1**), only ten septillion (10,000,000,000,000,000,000,000,000) times smaller.

This form of carbon was named after the architect Buckminster Fuller, famous for designing geodesic domes, as shown in **Figure 2**.

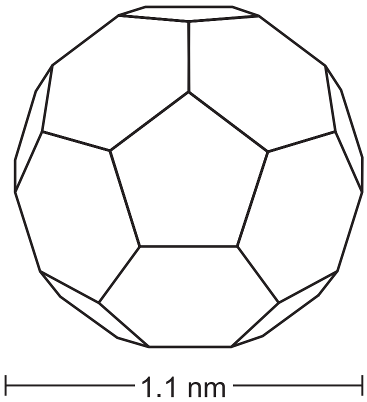

Figure 1

Figure 2

The structure of buckminsterfullerene is a truncated icosahedron, consisting of 20 hexagons and 12 pentagons that intersperse to form a spherical structure. Within the structure, each carbon atom is bonded to three other carbon atoms and no pentagon has a joining edge with another pentagon.

Other spherical allotropes of carbon, called fullerenes, have since been made. These include balls consisting of seventy, seventy-six and eighty-four carbon atoms. Together, they have become known as ‘Buckyballs’.

Fullerenes have high melting points and boiling points. They also have a high density and a large surface area for their size.

Today, fullerenes are at the heart of nanotechnology – the study of atomic scale structures and devices. This provides many exciting new research possibilities for scientists including their potential uses in catalysts, lubricants and in nano-tubes for strengthening materials and as a way of delivering drugs into the body.

Nano-tubes are fullerenes that are used to reinforce graphite in tennis rackets because they are very strong. They are also used as semiconductors in electrical circuits.

The nano-tube’s structure also allows it to be used as a container for transporting a drug in the body. A molecule of the drug can be placed inside the nano-tube cage. This keeps the drug ‘wrapped up’ until it reaches the site where it is needed. In this way, a dose that might be damaging to other parts of the body can be delivered safely to, for example, a tumour.

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(a) Tick (✓) **all** the statements that correctly describe buckminsterfullerene. [2]

its structure has 32 faces	☐
it has a relative molecular mass of 60	☐
it is an allotrope of carbon	☐
it has a giant ionic structure	☐
it is a hydrocarbon compound	☐
it is a smart material	☐
it is 1×10^{25} times smaller than a football	☐

(b) (i) Use the following formula to calculate the number of edges that a molecule of buckminsterfullerene has. [2]

$$\text{number of edges} = \frac{\text{total number of sides of all pentagons and hexagons}}{2}$$

Number of edges = ...

Examiner only

(ii) Calculate, in m^3, the approximate volume of a buckminsterfullerene molecule. Write your answer to **three** significant figures and in standard form. [3]

$$\text{volume} = \frac{4}{3}\pi r^3$$

$\pi = 3.14$ r = radius

$$1\,\text{nm} = 1 \times 10^{-9}\,\text{m}$$

Volume = ... m^3

(c) Give the **main** reason why the structure of fullerenes has resulted in there being an interest in developing their use as catalysts. [1]

....

(d) State why some people might oppose the use of fullerenes in drug delivery systems in the body. [1]

....

....

(e) One student said that Buckyballs should be good electrical conductors but her friend disagreed.

Use your knowledge of bonding and structure to give **one** reason that **each** student could use to support their argument. [2]

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11

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6. Discuss what is meant by isomerism in alkanes and alkenes using compounds with the molecular formulae C_4H_{10} and C_4H_8 to illustrate your answer. [6 QER]

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END OF PAPER

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

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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

1	2					Group						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

A_r	relative atomic mass
Symbol	
Name	
Z	atomic number