GCSE CHEMISTRY

COMPONENT 2

Applications in Chemistry

FOUNDATION TIER

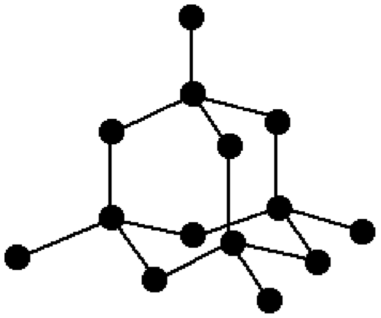
RESOURCE BOOKLET
for use in Section B

Allotropes of carbon

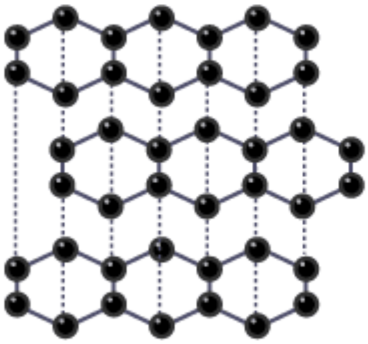
Carbon exists as a number of different allotropes. Some important allotropes of carbon are described in this article.

Diagram 1 Diamond and graphite

Diamond

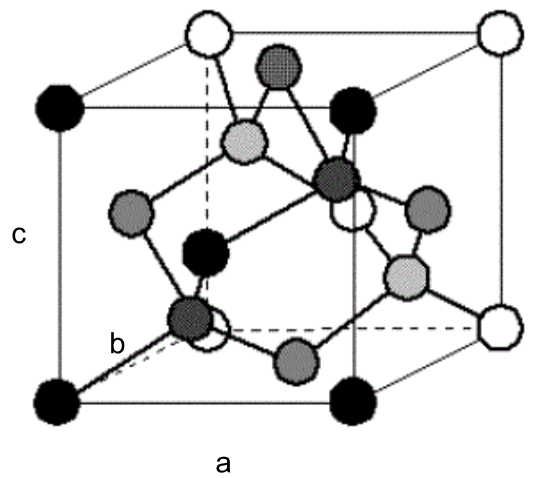


Graphite



The structure of diamond can be related to a cube. The diagram below shows this.

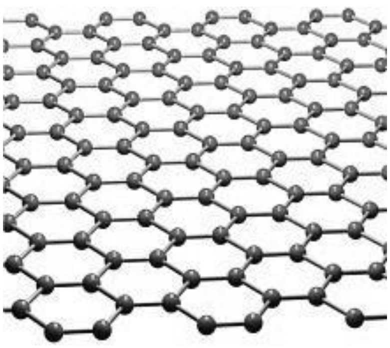
Diagram 2 A unit cubic cell of diamond



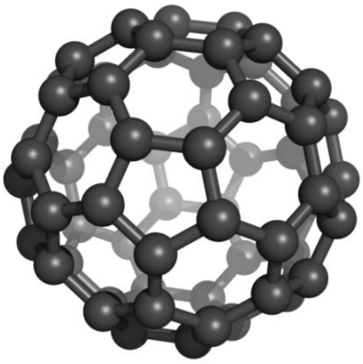
The cell dimension a = b = c = 0.36 nm

Diagram 3 Graphene and fullerene

Graphene



Fullerene



Graphene and fullerenes

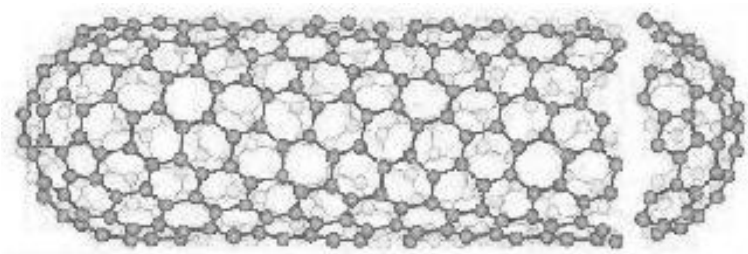
Graphene is a single sheet with the carbon atoms arranged in the layer as they are in graphite.

Fullerenes are cage-like spherical molecules. They were first discovered using a method known as mass spectroscopy. One fullerene identified by mass spectrometry had a relative molecular mass of 720.

Carbon nanotubes

Carbon nanotubes are made of graphene sheets rolled into the shape of a cylinder, often with at least one end closed.

Diagram 4 Carbon nanotube



Properties of carbon nanotubes

The **specific strength** is a material's tensile strength divided by its density. It is also known as the **strength-to-weight ratio**.

Another way to describe specific strength is **breaking length** which is the maximum length of a vertical column of the material that could support its own weight when suspended only at the top.

Table 1

Material	Tensile strength (MPa)	Density (g/cm³)	Specific strength (kN m/kg)	Breaking length (km)
stainless steel	505	8.00	63.1	6.4
aluminium	572	2.81	204	20.8
kevlar	3 620	1.44		
carbon nanotube	62 000	1.34	46 268	4 716

Candidate Name	Centre Number					Candidate Number				

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SAMPLE PAPER

(1 hour 15 minutes)

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1**	**5**	
	2	**11**	
	3	**6**	
	4	**6**	
	5	**7**	
	6	**4**	
	7	**6**	
Section B	**8**	**15**	
	Total	**60**	

ADDITIONAL MATERIALS

In addition to this examination paper you will need a resource booklet, 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.

INFORMATION FOR CANDIDATES

This paper is in two Sections, Section **A** and Section **B**.

Section **A**: 45 marks. Answer **all** questions. You are advised to spend about 50 minutes on this section.

Section **B**: 15 marks. Read the article in the resource booklet carefully then answer **all** questions. You are advised to spend about 25 minutes on this section.

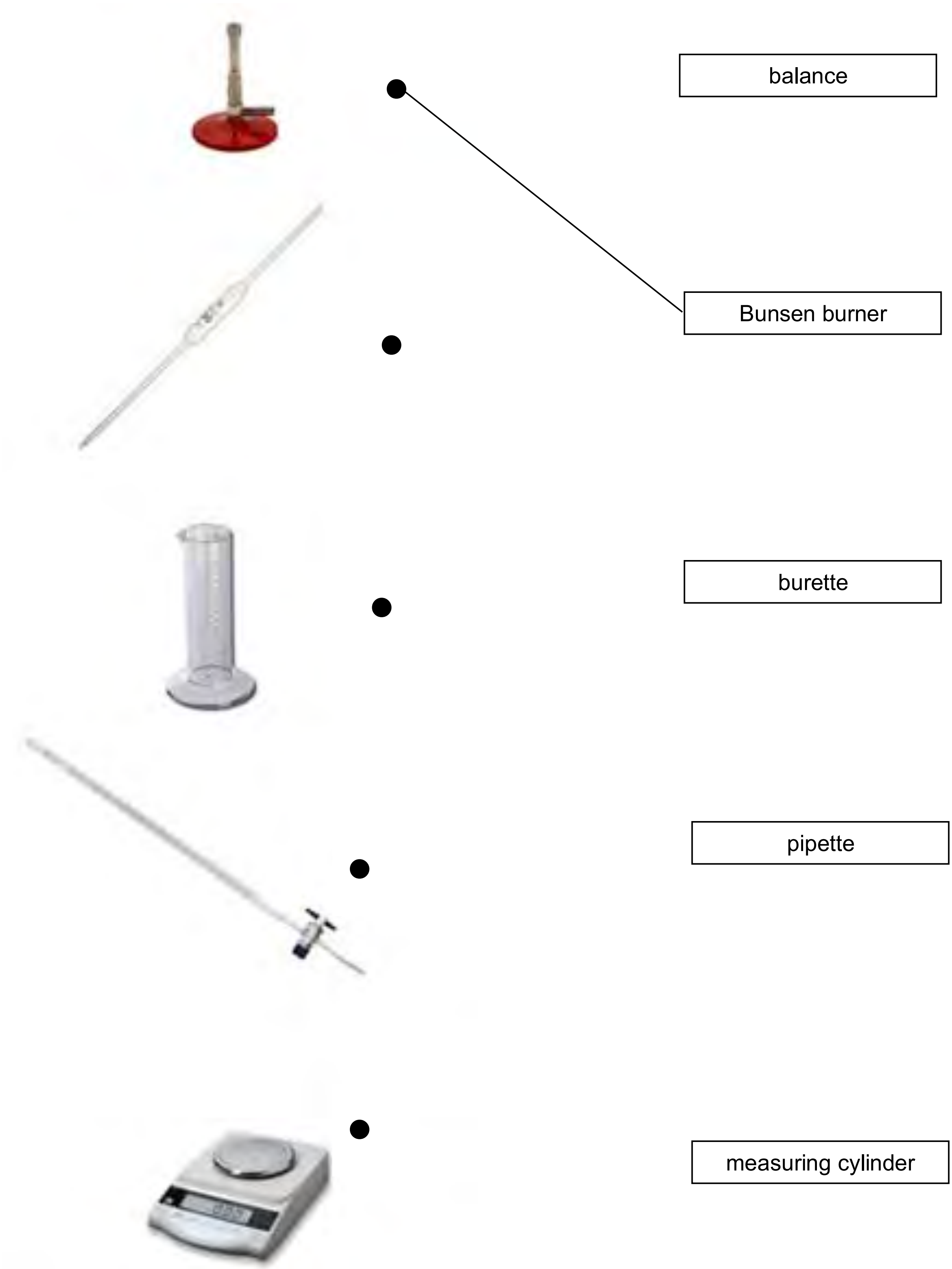
The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **7.**

SECTION A

Answer **all** *questions.*

1 (a) Draw lines to match each diagram below with the correct name of the apparatus. One has been done for you. [2]



(b) Choose a method from the box to answer parts (i) to (iii).

chromatography	**distillation**	**electrolysis**	**filtration**

Name the method you would use to separate:

(i) two liquids (water and ethanol) …………………………… [1]

(ii) the colourings in a food dye ..………………………….. [1]

(iii) a precipitate from water …………………………… [1]

5

2. (a) The following table shows the colours of universal indicator at different pH values.

colour	red	orange	yellow	green	blue	navy blue	purple
pH	0-2	3-4	5-6	7	8-9	10-12	13-14

Use this information to help you complete the table below. [3]

Substance	**Colour with universal indicator**	**pH value**	**Acid, alkali or neutral?**
detergent	purple		
distilled water		7	
soap		8	

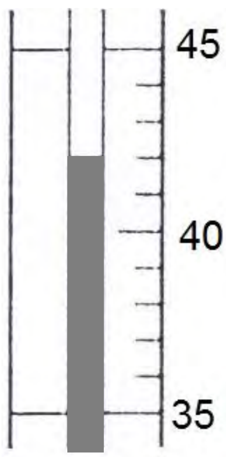
(b) Different lengths of magnesium ribbon were put into separate beakers each containing 25 cm^3 dilute hydrochloric acid and the temperature measured. The initial temperature of the acid in each beaker was 16 ^{o}C.

The results are shown in the table below. Two temperatures are missing.

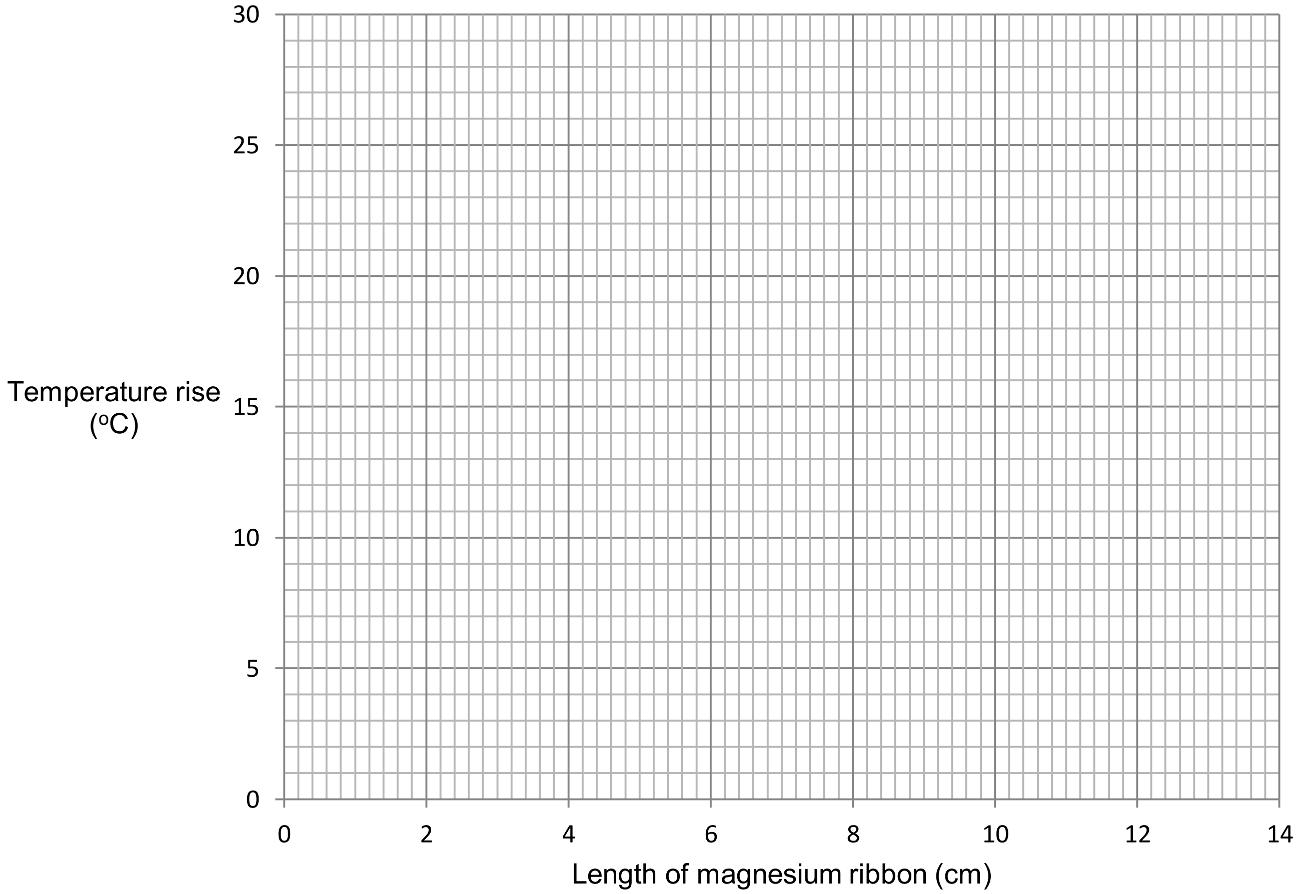
Length of magnesium ribbon (cm)	2	4	6	8	10	12
Final temperature (°C)	20	23	28	33	35	....
Initial temperature (°C)	16	16	16	16	16	16
Temperature rise (°C)	4	7	12	17	19	....

(i) Complete the table by using the thermometer reading shown below.[2]

Thermometer reading when 12 cm of magnesium was used.



(ii) Plot the length of magnesium ribbon against the temperature rise and draw a suitable line. [3]



(iii) Use your graph to find the temperature rise if 5 cm of magnesium was added to 25 cm^3 dilute hydrochloric acid. [1]

temperature rise ………… °C

(iv) Put a tick (✓) next to the statement which describes the temperature rise you would expect if the hydrochloric acid was replaced with vinegar. Give a reason for your choice. [2]

temperature rise will be higher with vinegar than with hydrochloric acid ☐

temperature rise will be lower with vinegar than with hydrochloric acid ☐

temperature rise will be the same with vinegar as with hydrochloric acid ☐

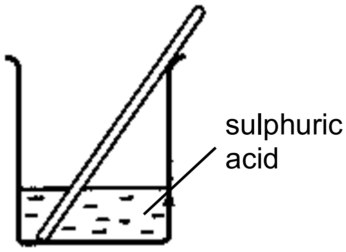
Reason for choice

…………………………………………………………………………………

11

3. The diagrams below show the stages in making the compound zinc sulfate by reacting zinc carbonate with dilute sulfuric acid. The diagram showing the apparatus for **Stage 2** is missing.

Stage 1

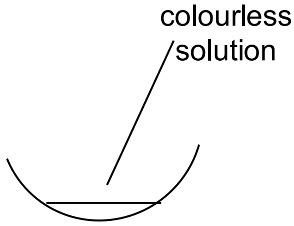


Excess zinc carbonate is added to dilute sulfuric acid, the mixture being continuously stirred

Stage 2

Excess zinc carbonate is removed

Stage 3



Colourless solution is left in an evaporating basin at room temperature to obtain white crystals of zinc sulfate

(a) State what you would **see** when excess zinc carbonate is added. [1]

………………………………………………………………………………………………………

(b) State why **excess** zinc carbonate is added. [1]

………………………………………………………………………………………………………..

(c) Draw the apparatus you would use to carry out stage **2**. Label the excess zinc carbonate on your diagram. [3]

(d) Put a tick (✓) next to the box that shows the estimated time it would take for **all** the water to evaporate from 25 cm^3 of zinc sulfate solution in stage **3**. [1]

1 hour ☐ 1 week ☐ 1 school term ☐ 1 year ☐

6

4. Hydrogen peroxide solution decomposes very slowly at room temperature.

$$H_2O_2(aq) \quad + \quad 2H_2O(l) \longrightarrow O_2(g)$$

This reaction can be catalysed using manganese(IV) oxide.

The statement below shows the definition of a catalyst.

*"A **catalyst** will change the speed of a chemical reaction but will not be used up during the reaction."*

A student carried out an investigation to find out if it is true that a catalyst is not used up in a reaction.

1.50 g of manganese(IV) oxide powder was accurately weighed and put into 20 cm^3 of hydrogen peroxide solution. After the reaction had stopped, the reaction mixture was filtered into a pre-weighed filter paper. The filtered manganese(IV) oxide and filter paper was dried in an oven.

The mass readings are shown below.

	Mass (g)
filter paper	1.26
manganese(IV) oxide and filter paper **after** drying	2.74
recovered manganese(IV) oxide	1.48

(a) Calculate the percentage (%) mass of manganese(IV) oxide recovered to one decimal place. [3]

% mass of manganese(IV) oxide recovered = ……….. %

(b) Do you agree with the statement that *'a catalyst is not used up in a reaction'* Give the reason for your decision. [1]

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(c) Suggest why not all of the manganese(IV) oxide was recovered and how this problem could be overcome. [2]

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5. (a) A compound was dissolved in water and tested as described below.
Use the information to complete the table and name the compound. [3]

Solution of unknown compound	Observation	Conclusion
dilute hydrochloric acid was added, the gas produced was passed through limewater	limewater turned milky	....
a flame test was carried out	an orange flame	....

The compound is ....

(b) A solution contains barium ions. It may also contain magnesium ions.

Use the information below to decide how to remove the barium ions and then test to find if magnesium ions are present. [4]

You are also given a solution of sodium sulfate and a solution of sodium carbonate which you can use.

Compound	Soluble or insoluble?
barium sulfate	insoluble
barium carbonate	insoluble
magnesium sulfate	soluble
magnesium carbonate	insoluble
sodium sulfate	soluble
sodium carbonate	soluble

Method to remove barium ions

....

....

Test for magnesium ions

....

....

7

6. A student measured out 25 cm^3 of a sodium carbonate solution. The sodium carbonate solution had a concentration of 1.06 g / dm^3.
Calculate the mass of sodium carbonate (Na_2CO_3) that was in 25 cm^3 of this solution.
Give your answer in units of g and mg. [4]

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……………………………………………………………………………………………….

4

7. Describe and explain an investigation you would carry out to find the relative positions of copper, iron and magnesium in the reactivity series. Include equations where appropriate.

You are provided with:
- solid samples of copper, iron and magnesium
- solid samples of copper(II) sulfate, iron(II) sulfate and magnesium sulfate.

[6 QER]

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6

SECTION B

*Read the article in the resource booklet and answer **all** the questions that follow.*

8. (a) Describe the bonding between carbon atoms in diamond. Include a dot and cross diagram in your answer. [3]
Details of the structure of diamond are not required.

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(b) (i) Explain why graphene is a good conductor of electricity. [2]

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(ii) Explain why graphite is soft and slippery and can act as a lubricant. [2]

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(iii) Diamond is a very dense allotrope of carbon because the carbon atoms are tightly packed. Calculate the volume of the cube containing carbon atoms in **Diagram 2**. Give the unit. [1]

volume = …………..

(c) Determine the molecular formula of the fullerene identified using mass spectroscopy in the article.
Show your working. [2]

molecular formula = ………….

(d) (i) Calculate the specific strength of Kevlar **(Table 1)** and use this value to **estimate** the breaking length. [3]

specific strength ………… kN m/kg

breaking length …………… km

(ii) Explain why carbon nanotubes may eventually replace materials like steel and aluminium in the manufacture of power lines. [2]

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15

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

Key: A_r = relative atomic mass; Symbol; Name; Z = atomic number

s Block: Groups 1–2; d Block: transition metals; p Block: Groups 3–0

Period	1	2											3	4	5	6	7	0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 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
3	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	40.0 Ar Argon 18
4	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
5	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	98.9 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
6	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
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

f Block

▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) 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
▸▸ Actinoid elements	232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103