OCR
Oxford Cambridge and RSA

Thursday 11 January 2024 – Afternoon

Level 3 Cambridge Technical in Applied Science

05847/05848/05849/05874/05879 Unit 1: Science fundamentals

Time allowed: 2 hours

C340/2401

C340/2401

You must have:
- the Data Sheet
- a ruler (cm/mm)

You can use:
- a scientific or graphical calculator
- an HB pencil

0 5 8 4 7 – 0 1

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- The Periodic Table is on the back page.
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

1

(a) Sulfur is a common element in the Earth's crust. A sample of sulfur produced by a volcano contains two isotopes of sulfur, ^{32}S and ^{34}S.

(i) Explain what **isotopes** means.

.....

.....

..... **[1]**

(ii) Use the Periodic Table to show the number of protons, neutrons and electrons in an atom of ^{34}S.

Isotope	Number of protons	Number of neutrons	Number of electrons
^{34}S	.....	.....	.....

[1]

(iii) Oxygen is in the same group of the Periodic Table as sulfur.

Explain why oxygen and sulfur are placed in the same group.

.....

..... **[2]**

(b) Sodium (atomic number 11) reacts with oxygen (atomic number 8) to form sodium oxide, Na_2O.

(i) Write down the electron configurations of the elements sodium and oxygen.

- sodium .....
- oxygen .....

[2]

(ii) Sodium oxide has ionic bonding.

Using outer shells only, draw a *dot and cross* diagram to show the bonding in sodium oxide.

[3]

Turn over for the next question

(c) Sulfur reacts with oxygen to form a covalent compound called sulfur dioxide, SO_2.

(i) Complete the following sentence using words from the list.

atoms **ions** **molecules** **particles** **shared** **transferred**

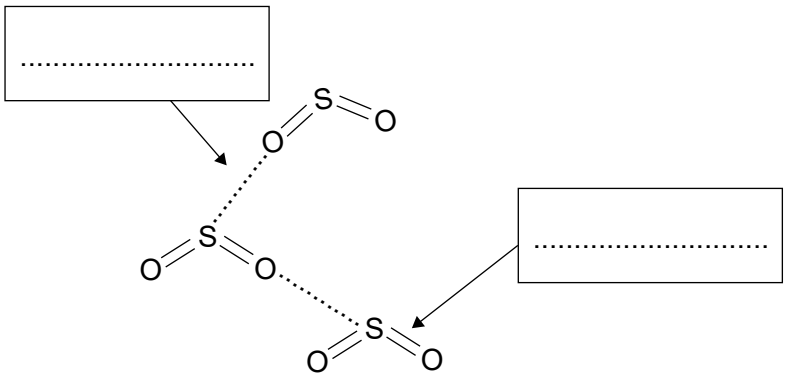
A covalent bond is the attraction between a ..... pair of

electrons and the nuclei of the bonded ..... .

[2]

(ii) Solid SO_2 has a simple molecular lattice structure with a low melting point.

In the diagram below complete the boxes to indicate which is a covalent bond and which is an intermolecular force of attraction (IMF).



[1]

(iii) Explain why solid SO_2 has a low melting point.

.....

.....

.....

..... **[2]**

(iv) Sulfur dioxide molecules are polar.

Explain in terms of electrons why SO_2 is polar.

.....

..... **[1]**

(d) Magnesium, silicon and argon are three elements in Period 3 of the Periodic Table.

They are in the same period because they all have three electron shells.

The table below shows the atomic number and atomic radius of the three elements.

Element	Atomic number	Atomic radius (nm)
Mg	12	0.160
Si	14	0.118
Ar	18	0.095

Describe and explain the change in atomic radius as the atomic number increases.

.....

.....

.....

..... **[2]**

Turn over for the next question

2 Chlorine, Cl_2, can undergo several different types of reaction.

(a) **Equation 2.1** shows the reaction of chlorine with a hydrocarbon, $(CH_3)_3CH$.

Equation 2.1

$Cl_2 + (CH_3)_3CH \rightarrow (CH_3)_3CCl + HCl$

(i) What type of reaction is shown in **Equation 2.1**?

Tick (✓) **one** box.

addition ☐

condensation ☐

polymerisation ☐

substitution ☐

[1]

(ii) Draw a (circle) around the word(s) that complete each sentence.

Chlorine molecules can be split into **ions / radicals** by exposing them to **infrared / ultraviolet** radiation.

If the light **wavelength / intensity** of the radiation is increased, the rate of reaction will increase.

[2]

(iii) The reactants in **Equation 2.1** are gases.

Explain how increasing the pressure affects the rate of this reaction.

.....

.....

.....

.....

.....

..... **[3]**

(b) The elements in Group 17 (group 7) of the Periodic Table are called halogens.

A student is investigating displacement reactions of chlorine, bromine and iodine.

A displacement reaction occurs when a more reactive halogen displaces a less reactive halogen from a solution of one of its salts.

The student adds a solution of chlorine to separate portions of aqueous potassium bromide and aqueous potassium iodide and records the colour of the solutions.

The student repeats the experiment for solutions of:

- bromine with potassium chloride and potassium iodide,
- iodine with potassium chloride and potassium bromide.

The table below shows the results from this experiment.

Halogen	**Colour of aqueous solution**	**Addition of potassium chloride (aq)**	**Addition of potassium bromide(aq)**	**Addition of potassium iodide(aq)**
Chlorine	Pale Green		Orange	Brown
Bromine	Orange	Orange		Brown
Iodine	Brown	Brown	Brown	

If a colour change has occurred, displacement has taken place.

Explain how the student can use the results to determine the order of reactivity of the halogens.

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

(c) When fluorine reacts with aqueous sodium chloride, chlorine and sodium fluoride are produced.

The ionic equation for the reaction is shown in **Equation 2.2**.

Equation 2.2

$F_2(g) + 2Cl^-(aq) \rightarrow 2F^-(aq) + Cl_2(g)$

Complete the sentences using the following words.

gained **lost** **oxidised** **reduced**

Fluorine is ..... because electrons are

..... .

Chloride ions are ..... because electrons are

..... .

[2]

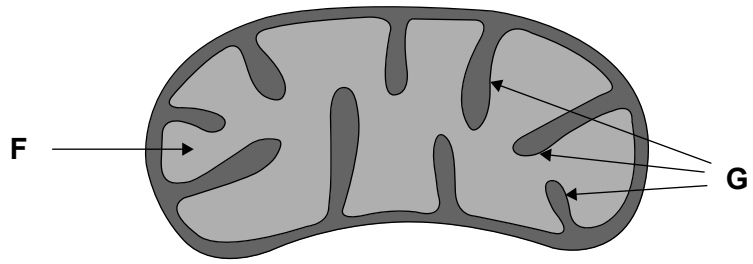
BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

Turn over for the next question

3

(a) A diagram of a mitochondrion is shown below.



Draw a **line** to link each label to its structure.

Label	Structure
	Cristae
	Chromatin
F	
	Matrix
G	
	Stroma
	Thylakoid

[2]

(b) Explain why mitochondria are found in large quantities in muscle cells.

.....

.....

.....

..... **[2]**

(c) Muscle tissue can be striated or unstriated.

What is the function of striated muscle in the human body?

..... **[1]**

(d) The cells in striated muscle are also called fibres.

Muscle fibres contain filaments of actin and myosin.

(i) Describe the arrangement of actin and myosin filaments inside a muscle fibre.

.....

..... **[1]**

(ii) What happens to these filaments when a muscle contracts?

.....

.....

..... **[2]**

(e)

(i) The sarcoplasmic reticulum is an organelle which releases a metal ion to enable muscle contraction.

Which metal ion enables muscle contraction?

Tick (✓) **one** box.

Ca^{2+} ☐

Li^{+} ☐

Na^{+} ☐

Pt^{2+} ☐

[1]

(ii) The sarcoplasmic reticulum is a specialised form of smooth endoplasmic reticulum (SER).

SER is responsible for the production and storage of essential biological molecules.

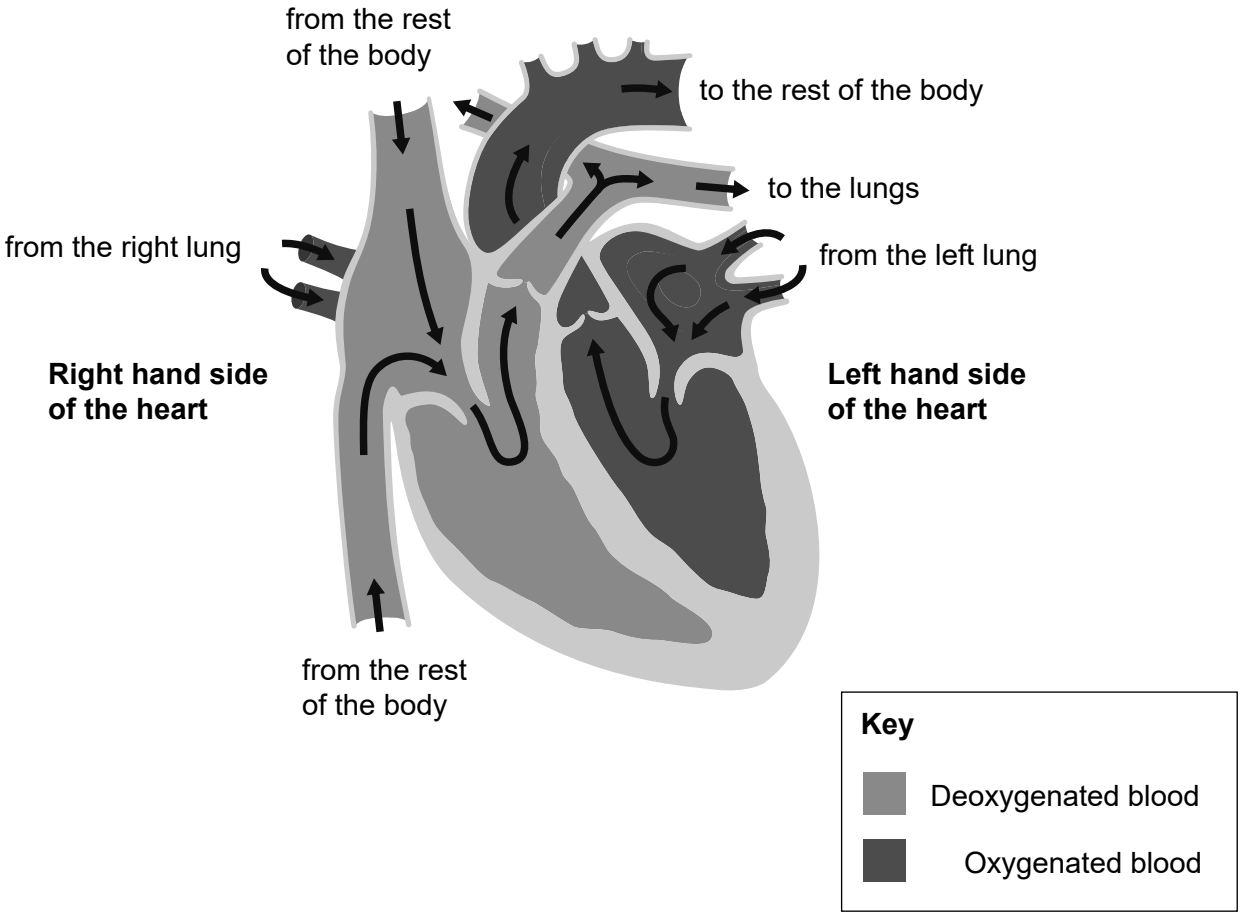
Draw a (circle) around **two** types of biological molecules that are produced and stored by SER.

carbohydrate **DNA** **lipid**

protein **RNA**

[2]

(f) The figure shows how blood flows through the heart.



(i) Which metal ion is responsible for carrying oxygen in the blood?

Tick (✓) **one** box.

Cu^{2+} ☐

Fe^{2+} ☐

K^{+} ☐

[1]

(ii) The wall of the heart contains muscle tissue.

Name the type of muscle tissue found.

..... **[1]**

(iii) Suggest why the muscle tissue in the wall on the left hand side of the heart in the figure is thicker than on the right hand side.

.....

.....

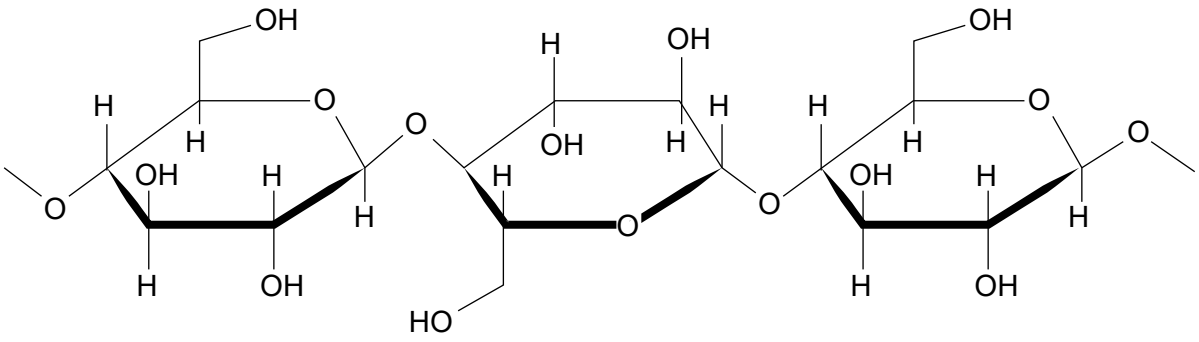
.....

..... **[2]**

Turn over for the next question

4 Polymers are long chain molecules made of small monomer molecules.

(a) The figure below shows part of the structure of the naturally occurring polymer, cellulose.



(i) What type of polymer is shown in the figure?

Tick (✓) **one** box.

polyglyceride ☐

polypeptide ☐

polysaccharide ☐

[1]

(ii) Name the type of link that holds the monomers together in this polymer.

..... **[1]**

(iii) Which type of reaction forms the polymer shown in the figure?

Tick (✓) **one** box.

addition ☐

condensation ☐

reduction ☐

substitution ☐

[1]

(iv) Suggest **three** reasons why cellulose is suitable as a material in plant cell walls.

1 .....

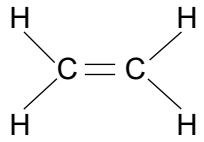
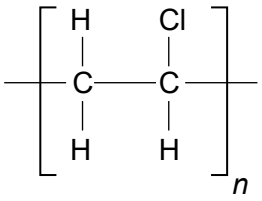
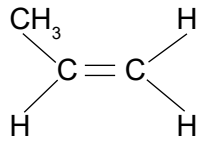
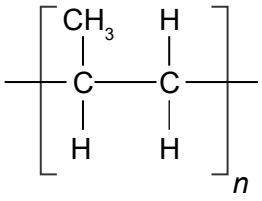
2 .....

3 .....

[3]

(b) Alkenes are used extensively in industry to make polymers.

The table shows the names and structures of some polymers and the structures of their monomers.

Monomer	**Polymer**	
Structural formula	**Name**	**Structural formula**
	Polyethene	
	Polyvinyl chloride (PVC)	
		

(i) Complete the table to show the missing structures and the missing name.

[3]

(ii) Draw a section of PVC showing **three** repeat units.

[1]

(c) But-2-ene, $CH_3CH=CHCH_3$, is an alkene which shows geometric isomerism.

(i) Draw the structure of the **two** geometric isomers of but-2-ene in the boxes below.

Clearly show the shape of each isomer.

[1]

(ii) Explain why but-2-ene shows geometric isomerism.

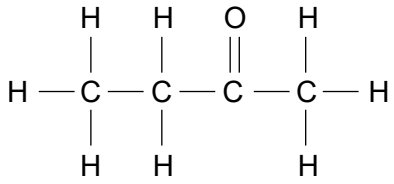
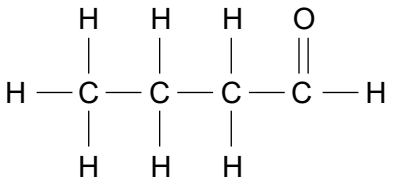
.....

.....

.....

..... **[2]**

5 The figure shows the structures of two organic compounds, **Q** and **R**.

	
Q	**R**

Compare and contrast the two organic compounds in terms of:

- the name and type of compound
- the molecular and skeletal formulae
- how they are formed from alcohols

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[6]**

6 Enzymes containing nickel, such as hydrogenase and hydrolase, are important biological molecules.

(a) What is the definition of an enzyme?

..... **[1]**

(b) Hydrogenase promotes the formation and utilisation of hydrogen in living organisms as shown in **Equation 6.1**.

Equation 6.1

$H_2 \leftrightarrows 2H^+ + 2e^-$

Identify whether the statements about **Equation 6.1** are true or false.

Put a tick (✓) in the correct boxes.

	True	**False**
Hydrogenase is a reactant		
The reaction is reversible		
H_2 is oxidised to H^+		
Electrons are gained by H_2		

[3]

(c) Hydrolase is a type of enzyme which promotes hydrolysis reactions in living organisms.

(i) Explain what **hydrolysis** means.

.....

..... **[1]**

(ii) In the human body hydrolase is needed in the breakdown of waste products such as urea (H_2NCONH_2).

Complete **Equation 6.2** to show the breakdown of urea.

Equation 6.2

H_2NCONH_2 + ….…..... → CO_2 + 2 ….…..…....

[2]

(d) Nickel ions are required in very small amounts by the human body.

The table shows two food types that contain nickel.

Food type	**Mass of nickel in μg per 100 g of food type**
Cashew nuts	510
Kidney beans	45

(i) A person's average daily intake of nickel from food and drink should be between 200 and 300 μg.

Calculate the mass of cashew nuts a person would need to eat to have an intake of 250 μg of nickel.

..... g **[2]**

(ii) The percentage of nickel absorbed by the human body from food is no more than 15%.

Calculate the maximum amount of nickel the human body will absorb from eating 150 g of kidney beans.

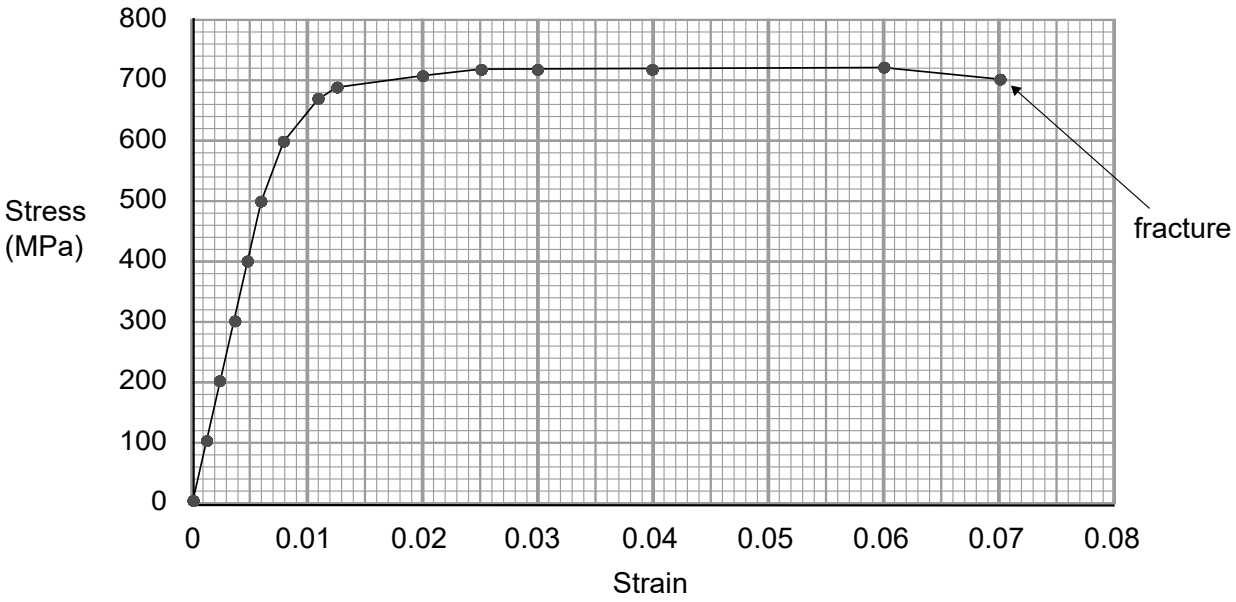
..... μg **[2]**

7 Alloys of aluminium are commonly used in making parts for aircraft engines.

(a) An aerospace engineer tests the strain of a sample of an aluminium alloy (alloy **X**) by applying different levels of stress.

Fig. 7.1 shows the stress−strain graph that the engineer obtains for alloy **X**.

Fig. 7.1



(i) Use the graph to deduce the breaking stress of alloy **X**.

..... MPa **[1]**

(ii) Use the graph to determine the Young's modulus of alloy **X**.

Show your working on the graph and in the space below.

Young's modulus = ... MPa **[2]**

(b) Alloy **X** contains 95% aluminium and 5% magnesium by mass.

(i) Alloy **X** has a density of 2.71×10^3 kg m^{-3}.

Calculate the volume of 25.0 kg of alloy **X**.

volume = ... m^3 **[1]**

(ii) Calculate the mass of magnesium needed to make 25.0 kg of alloy **X**.

mass = ... kg **[1]**

(iii) Suggest two benefits of using alloy **X** for aircraft parts rather than pure aluminium.

.....

.....

.....

.....

..... **[2]**

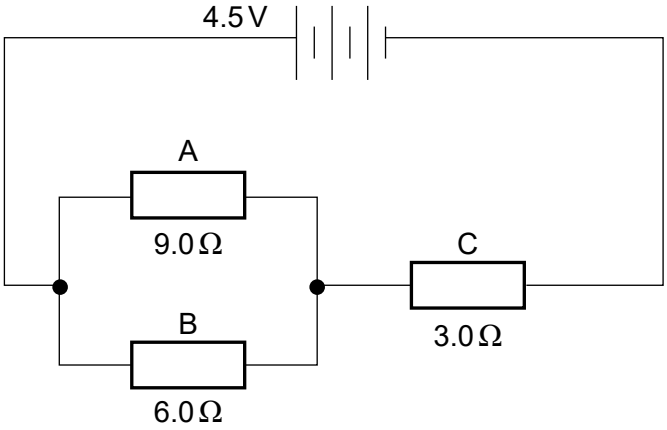
(c) Alloy **Y** is also an alloy of aluminium. It has a Young's modulus less than alloy **X**. It undergoes brittle fracture at a stress of 640 MPa.

On **Fig. 7.1** draw a line to show the possible stress–strain graph for this material.

Label this line **Y**.

[2]

8 A battery of electromotive force (e.m.f.) 4.5 V is connected to three resistors **A**, **B** and **C** as shown in the circuit diagram.



(a) Use the following steps to determine the power dissipated in the circuit:

(i) **Step 1** Calculate the combined resistance R_D of resistors **A** and **B**.

Use the equation: $\frac{1}{R_D} = \frac{1}{R_A} + \frac{1}{R_B}$

R_D = ... Ω **[1]**

(ii) **Step 2** Calculate the total resistance R_t of the circuit.

Use the equation: $R_t = R_D + R_C$

R_t = ... Ω **[1]**

(iii) **Step 3** Use Ohm's Law ($V = I \times R_t$) to calculate the current I, in the circuit.

I = ... A **[1]**

(iv) **Step 4** Calculate the power dissipated in the circuit and give the units.

Use the equation: Power = potential difference × current (P = V × I)

P = ... Units ..... **[1]**

(b) The resistors **A**, **B** and **C** are wires of the same material and have the same length.

(i) Suggest why resistors **A**, **B** and **C** have different resistances.

.....

..... **[1]**

(ii) The voltage across the parallel combination of resistors **A** and **B** is 2.45 V.

Explain why the current in resistor **B** is 1.5 times more than the current in resistor **A**.

.....

.....

.....

..... **[2]**

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

1 (1)	2 (2)	3	4	5	6	7	8	9	10	11	12	13 (3)	14 (4)	15 (5)	16 (6)	17 (7)	18 (0)
1 **H** hydrogen 1.0																	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											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		

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