OCR
Oxford Cambridge and RSA

Thursday 19 May 2022 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C340/2206

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

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

Please write clearly in black ink.

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 **24** pages.

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

FOR EXAMINER USE ONLY	
Question No	Mark
1	/14
2	/10
3	/10
4	/8
5	/9
6	/12
7	/11
8	/6
9	/10
Total	**/90**

Answer **all** the questions.

1 There are four fundamental forces.

The forces are listed in the box below.

gravitational force

electromagnetic force

strong nuclear force

weak nuclear force

(a) Some of these forces are responsible for attraction or repulsion within the nucleus of an atom.

You should select from the forces in the box to complete **(a)(i)** to **(a)(iv)**.

The name of each force can be used once, more than once or not at all.

State which fundamental force is responsible for:

(i) the attraction between electrons and protons.

.... **[1]**

(ii) keeping the nucleus stable.

.... **[1]**

(iii) radioactive decay.

.... **[1]**

(iv) the repulsion between protons.

.... **[1]**

(b) An isotope of radon has the nuclear notation

$$^{222}_{86}\text{Rn}$$
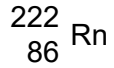
In radioactive decay, the identity of this isotope of radon changes to an isotope of polonium with the loss of 4 atomic mass units.

(i) Use the Periodic Table on the back page to identify the atomic number of polonium.

.... **[1]**

(ii) Complete the nuclear notation of the isotope of polonium formed.

$$^{......}_{......}\text{Po}$$

[1]

(iii) State **one** difference between different isotopes of polonium.

.... **[1]**

(iv) The nuclear radius of an atom, R, can be approximated using the formula:

$$R = r_0 A^{\frac{1}{3}}$$

where   A is the nucleon number

$r_0 = 1.25 \times 10^{-15}\,\text{m}$

Calculate the nuclear radius of the isotope Ra-222.

Show your working.

nuclear radius R = ... m **[2]**

Turn over

(c) Polonium is classed as a metal.

(i) Use the Periodic Table on the back page to identify the group number of polonium.

.... **[1]**

(ii) Polonium reacts with hydrogen to form a compound with the formula PoH_2.

Suggest why it is difficult to predict the type of bonding present in PoH_2.

....

....

....

....

.... **[3]**

(iii) Tellurium is in the same group in the Periodic Table as polonium. It has a relative atomic mass of 127.6.

Explain why the relative atomic mass of tellurium is not a whole number.

....

.... **[1]**

2 A chemistry student is investigating the redox reaction between chlorine and sodium iodide.

(a) A Cl_2 molecule is formed when two Cl atoms join together to form a covalent bond.

(i) The atomic number of Cl is 17.

Give the electron configuration of a Cl atom.

.... **[1]**

(ii) Draw a dot-and-cross diagram to show the bonding in a Cl_2 molecule and label the covalent bond.

Show the outer shells only.

[2]

(b) Sodium iodide, NaI, is an ionic solid with a high melting point.

A model of the structure of NaI is shown below.
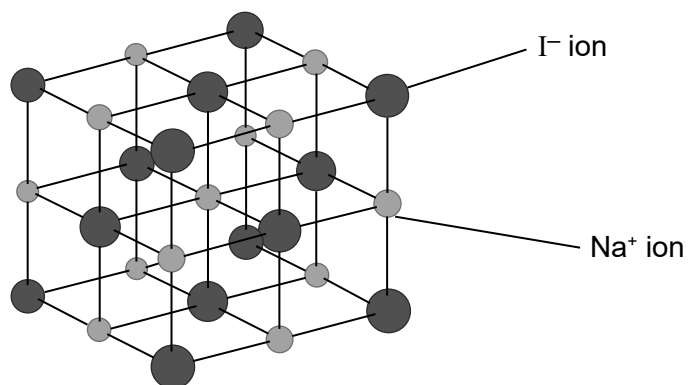
Use the model to explain why sodium iodide has a high melting point.

....

....

....

.... **[2]**

Turn over

(c) When chlorine reacts with sodium iodide, chlorine molecules (Cl_2) react with iodide ions (I^-) to form iodine molecules and chloride ions.

(i) The reaction is normally carried out with water as the solvent.

Describe the colour change the student sees when they add aqueous sodium iodide NaI(aq) to chlorine water, Cl_2(aq).

.... **[1]**

(ii) Complete and balance the ionic equation for this reaction.

Cl_2(aq) + ……………... $\longrightarrow$ I_2(aq) + ……………... **[1]**

(iii) The reaction is a redox reaction.

State whether chlorine is oxidised or reduced and explain your answer.

....

.... **[1]**

(d) The student repeats the experiment in **2(c)** using solid sodium iodide in place of aqueous sodium iodide.

Explain in terms of particles why the reaction would be slower in **2(d)** than in **2(c)**.

....

....

....

.... **[2]**

3 (a) Photosynthesis takes place in the chloroplast of a plant cell.

Fig. 3.1 shows a labelled diagram of a chloroplast.

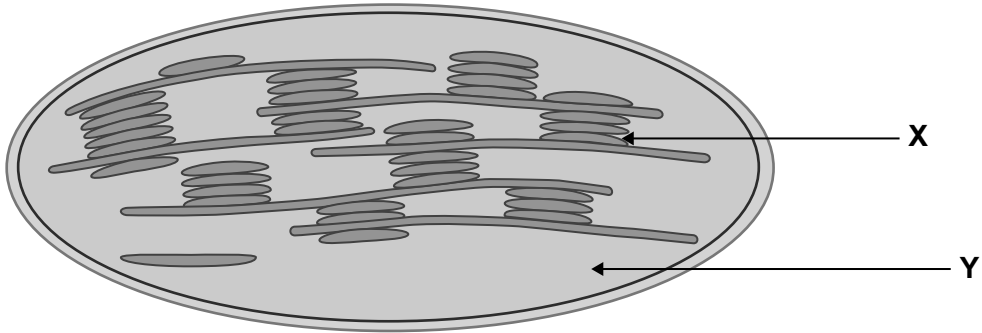**Fig. 3.1**

(i) Draw a **straight line** to link each **Label** to the name of the **Structure**.

Label		Structure
		Cristae
X		Cytoplasm
Y		Cilia
		Stroma
		Thylakoid

[2]

(ii) Plant cells also contain mitochondria.

Mitochondria perform a biological process which differs from photosynthesis.

Identify the process and state **two** ways in which this process differs from photosynthesis.

Process ....

1 ....

....

2 ....

....

[3]

(b) A biology student is studying photosynthesis.

The student carries out an experiment to investigate the effect of light intensity on the rate of photosynthesis of an aquatic plant in water.

They set up the apparatus shown in **Fig. 3.2**.
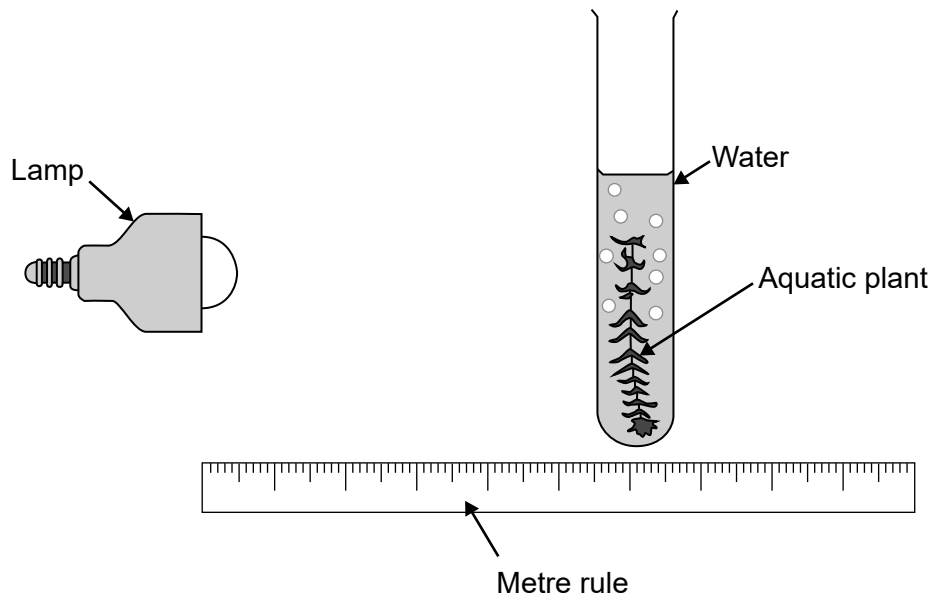
Fig. 3.2

- A light source is supplied by a lamp which is placed 0.1 m away from the test tube containing the aquatic plant.
- The student counts the number of bubbles produced in 1 minute. This is a measure of the rate of photosynthesis.
- The student repeats the experiment with the lamp placed at increasing distances from the aquatic plant.

The results of the experiment are shown in the table below.

Distance/metres	Rate (bubbles per minute)
0.1	49
0.2	49
0.3	49
0.4	36
0.5	25
0.6	
0.7	9
0.8	4
0.9	1
1.0	0

(i) Identify the gas found in the bubbles produced by the aquatic plant.

.... **[1]**

(ii) Predict the rate of photosynthesis when the lamp is 0.6 m away from the plant.

Write your answer in the blank space in the table.

[1]

(iii) Use the data shown in the table to describe the effect of light intensity on the rate of photosynthesis.

....

....

....

.... **[3]**

Turn over

4 Tissues are a group of specialised cells which work together to provide a specific function.

(a) One type of tissue found in humans contains a collection of cells and fibres held in a gelatinous matrix.

Identify this type of tissue.

Put a tick (✓) in the correct box.

Ciliated epethelial ☐

Connective ☐

Nerve ☐

Squamous epethelial ☐

[1]

(b) Muscle tissue has a range of functions in the human body.

This type of tissue is important for the movement of the skeleton and for blood flow along blood vessels.

- Muscle tissue contains bundles of myofibrils.
- Each myofibril is formed from protein filaments called actin and myosin.

(i) The action of the filaments is triggered by the release of an ion by the sarcoplasmic reticulum.

Identify the ion that is released.

Draw a circle around the correct ion.

Ca^{2+} Fe^{2+} Mn^{2+} Ni^{2+}

[1]

(ii) The arrangement of the actin and myosin filaments in a **relaxed** muscle is shown below.

Thin (actin) filament   Thick (myosin) filament

Z line   Z line
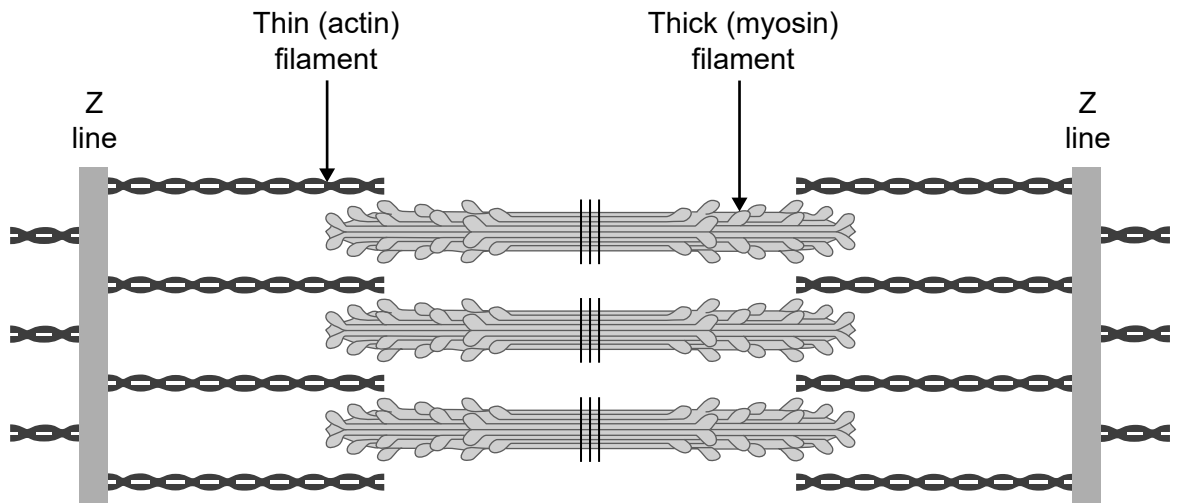
Explain how the action of the filaments in the figure can bring about muscle contraction and movement of the skeleton.

....

....

....

....

.... **[3]**

(iii) Vasodilation is an important process involved in the regulation of body temperature.

Complete the sentences describing the process of vasodilation in the skin.

Use words or phrases from the list below.

contracts	**decreases**	**increases**	**less**
more	**no**	**relaxes**	**stays the same**

Nitric oxide is released into the smooth muscle tissue in the wall of blood vessels supplying blood to the capillaries in the skin.

As a result, the muscle tissue ………………………..…….............. .

This allows ……………………..……............. blood to flow into the capillaries.

As a result, the temperature of the blood ………………………..……............. .

[3]

5 **(a)** A protein is a long-chain molecule which is synthesised from amino acids.

Give the name of the bond formed when amino acids join together to form a protein molecule.

.... **[1]**

(b) The amino acids in this molecule are joined together in a specific order.

The order of amino acids involves the activity of DNA and RNA molecules.

Identify the role of the DNA and RNA molecules.

Draw a **straight line** to link the name of each **Molecule** to its **Role**.

Molecule	**Role**

DNA	Brings the amino acids to the site of protein synthesis at the ribosome
Messenger RNA	Copies the genetic code and carries this to the ribosome
Transfer RNA	Holds the genetic code in the nucleus

[2]

(c) Vesicles are organelles which transport the proteins that have been made at the ribosomes.

One specific type of vesicle is a lysosome.

(i) Identify **two** structural features of a lysosome.

Put a tick (✓) in **two** boxes.

It has a membrane ☐

It has no membrane ☐

It has a star-like shape ☐

It has a spherical shape ☐

It has a rectangular shape ☐

[2]

(ii) Identify the cell organelle that produces lysosomes.

Choose from the following list:

golgi apparatus   **plasma membrane**

rough endoplasmic reticulum   **smooth endoplasmic reticulum**

.... **[1]**

(iii) The type of protein that a lysosome contains is an enzyme.

Describe the specific functions of the enzyme contained within a lysosome.

....

....

....

....

....

....

....

.... **[3]**

Turn over

6 Organic compounds can be classified according to which family they belong to.

Fig. 6.1 shows the first member of a family of hydrocarbons.

H——C≡≡C——H
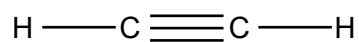
Fig. 6.1

(a) (i) State whether the hydrocarbon in **Fig. 6.1** is saturated or unsaturated.

Explain your answer.

....

....

....

.... **[2]**

(ii) Identify the type of hydrocarbon shown in **Fig. 6.1**.

Put a tick (✓) in the correct box.

Aldehyde ☐

Alkane ☐

Alkene ☐

Alkyne ☐

[1]

(iii) Draw the structural formula of the second member in the family of hydrocarbons.

[1]

(b) The compound in **Fig. 6.1** can be used as a monomer to make a polymer.

The skeletal formula of the polymer that is formed from the monomer is shown in **Fig. 6.2**, where n is the number of repeat units.
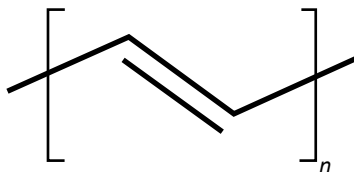
Fig. 6.2

(i) Identify the type of reaction taking place when the polymer shown in **Fig. 6.2** is formed.

Put a tick (✓) in the correct box.

Addition ☐

Condensation ☐

Substitution ☐

[1]

(ii) Explain this reaction in terms of bond-breaking and bond-forming.

....

.... **[1]**

(iii) The polymer shown in **Fig. 6.2** shows stereoisomerism.

Identify the type of stereoisomerism.

Draw a (circle) around the correct type.

geometric   **optical**   **structural**

[1]

(iv) Explain how the section of the polymer shown in **Fig. 6.2** is able to exist as two stereoisomers.

....

....

....

....

.... **[3]**

(c) A polymer that is formed from a different hydrocarbon monomer is shown in **Fig. 6.3**, where *n* is the number of repeat units.
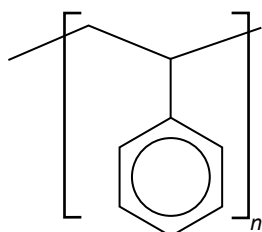
Fig. 6.3

(i) Identify the polymer shown in **Fig 6.3**.

Draw a (circle) around the correct name.

polyethene   **polylactate**   **polypropene**   **polystyrene**

[1]

(ii) The compounds in **Figs 6.1**, **6.2** and **6.3** all have the same empirical formula.

Write down the empirical formula of these compounds.

.... **[1]**

7 Lithium, sodium and potassium are metals in the same group of the Periodic Table.

They form ions that have important biological functions.

(a) Identify the charge on the ion that these metals form.

Put a tick (✓) in the correct box.

2− ☐

− ☐

+ ☐

2+ ☐

[1]

(b) Identify the role that sodium and potassium ions have during nerve impulse transmission.

.... **[1]**

(c) Sodium and potassium ions also create an isotonic balance between the cytoplasm and surrounding tissue fluid of cells.

This has an effect on the process of osmosis in the cell.

Explain what happens to a cell when the overall concentration of these ions in the surrounding tissue fluid decreases.

....

....

....

....

.... **[4]**

(d) Two different lithium compounds that can be used to stabilise a person's mood are lithium carbonate and lithium citrate.

The mass of lithium in a compound can be found using the equation:

$$\text{mass of lithium (mg)} = \frac{\text{mass of compound (mg)} \times \text{number of ions of Li in formula} \times A_r \text{ of Li}}{M_r \text{ of compound}}$$

where A_r of Li = 6.9 and M_r = relative formula mass of a lithium compound.

Fig. 7.1

(i) Name **one** disorder that lithium compounds can be effective in treating.

.... **[1]**

(ii) A tablet contains 300 mg of lithium carbonate.

The formula of lithium carbonate is Li_2CO_3 and its M_r is 73.8.

Use the equation in **Fig. 7.1** to calculate the mass in mg of lithium that the tablet contains.

Give your answer to **3** significant figures.

Mass of lithium = ... mg **[2]**

(iii) A syrup contains 466 mg of lithium citrate of which 46 mg is lithium.

The M_r of lithium citrate is 209.7.

Use the equation in **Fig. 7.1** to calculate the number of lithium ions in the formula of lithium citrate.

Number of lithium ions = ... **[2]**

8 Lead–tin solder is an alloy that is used to join metallic components in electronic circuits.

- When molten, solder is applied to the joint between the two surfaces; the metallic components do not melt because solder has a low melting point.
- As it cools down, the solder solidifies forming a strong bond between the two metallic surfaces.

The phase diagram below shows how the melting point of the alloy changes as the percentages of lead (Pb) and tin (Sn) change.

The phase diagram has four different regions (**A**, **B**, **C** and **D**) indicating the phases present at different temperatures. For example, in region **A**, solid lead (Pb) begins to separate out as the temperature decreases, but the mixture stays molten.

Use the phase diagram to deduce the melting points of lead and tin and describe the different phases present in regions **B**, **C** and **D**.

Explain why the composition of lead–tin solder is 62% tin (Sn) and 38% lead (Pb).

....

....

....

....

....

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....

....

.... **[6]**

Turn over

9 The circuit shown contains three resistors R_x, R_y and R_z.
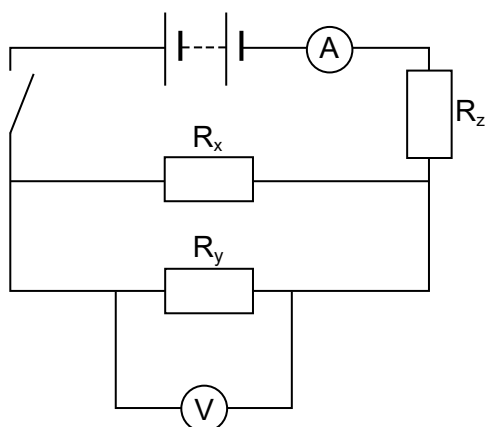
Resistor R_x has a resistance of $22\,\Omega$.
Resistor R_y has a resistance of $47\,\Omega$.
Resistor R_z has a resistance of $10\,\Omega$.

You will need to use the following equations to answer the questions below.

- Potential difference (V) = current (A) × resistance (Ω) $(V = I \times R)$
- Charge (C) = current (A) × time (s) $(Q = I \times t)$
- Power (W) = potential difference (V) × current (A) $(P = V \times I)$
- Resistors in series $R_t = R_1 + R_2 + R_3$
- Resistors in parallel $\dfrac{1}{R_t} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

(a) Calculate the combined resistance of the resistors in the circuit.

Combined resistance = ... Ω **[2]**

When the switch is closed the reading on the voltmeter is 12 V.

(b) Calculate the current in R_y.

Current in R_y = ... A **[2]**

(c) Calculate:

(i) the current in R_x.

Current in R_x = ... A **[1]**

(ii) the charge transferred in the ammeter in one minute.

Charge = ... C **[2]**

(d) Calculate:

(i) the voltage across R_z.

Voltage across R_z = ... V **[1]**

(ii) the total power dissipated in the circuit.

Power dissipated = ... W **[2]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown in the margins – for example, 1(b)(i) or 1(c)(ii).

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

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

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