Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S24-3445UA0-1

3445UA0-1

THURSDAY, 13 JUNE 2024 – MORNING

APPLIED SCIENCE (Double Award)

UNIT 1: Energy, Resources and the Environment

HIGHER TIER

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**19**	
2.	**9**	
3.	**13**	
4.	**16**	
5.	**6**	
6.	**12**	
Total	**75**	

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ADDITIONAL MATERIALS

In addition to this paper you may require 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 **5** is a quality of extended response (QER) question where your writing skills will be assessed.

You are reminded to show all your workings. Credit is given for correct workings even when the final answer given is incorrect.

A Periodic Table is printed on page 20.

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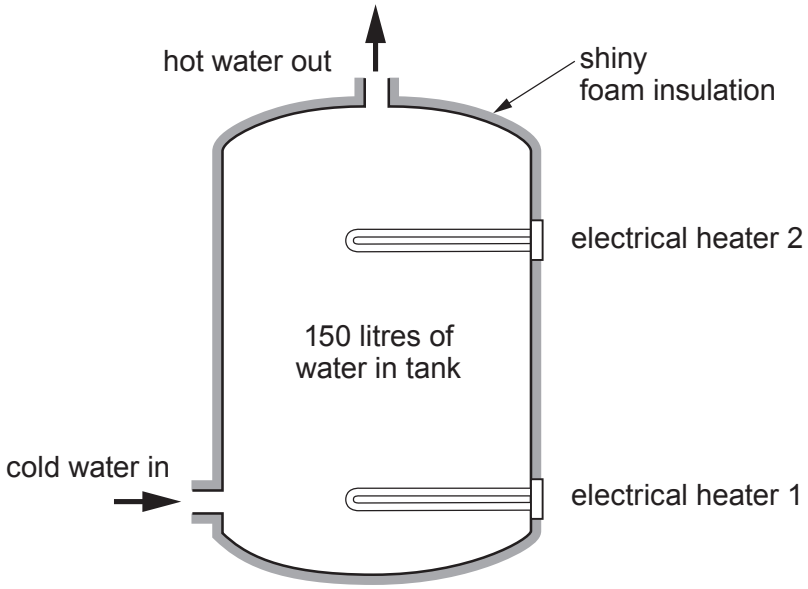
Answer **all** questions.

1. Paul lives in an apartment in central London. His electricity bill is £80 a month. Paul wants to replace his old electric boiler with a new one. A local plumbing company has suggested using a new boiler, the Redstar boiler, which has two electrical heaters. Paul will be able to use either heater to provide hot water after the boiler is installed.

Information about the Redstar boiler



Savings

Cost of boiler	£2500.00
Typical savings	£15.00 per month

Technical information on the two heaters in the Redstar boiler

Information	heater 1	heater 2
maximum volume of water that is heated by heater (litres)	150	50
time to heat this volume of water (hours)	3	0.5
total power supplied (kW)	2	4
power used to heat the water (kW)	1.6	3.6
efficiency (%)	80	
cost to heat the water (p)		44

(a) Use the information given about the boiler to answer the following questions.

(i) Calculate the expected payback time for the boiler in years. [3]

payback time = ... years

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(ii) Use the equation:

$$\% \text{ efficiency} = \frac{\text{power usefully transferred}}{\text{total power supplied}} \times 100$$

to calculate the efficiency of **heater 2**. [2]

% efficiency = ...

(iii) Use the equations:

units used (kWh) = power (kW) × time (h)

total cost = cost of one unit × units used

to calculate the cost of the electricity to heat 150 litres of water using **heater 1**.

Cost per unit of electricity = 22 p [3]

cost = ...

(iv) Paul has estimated that he uses 40 litres of hot water per day.
He thinks that **heater 1** would be the best one to use every day.

Explain whether you agree with Paul. [2]

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(b) The water in London is known to be hard.

Explain how hard water could have affected Paul's old boiler. [2]

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(c) Heat energy can be transferred by conduction, convection and radiation.

(i) Explain how the shiny foam insulation used around the boiler helps to reduce heat loss. [2]

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(ii) Explain how having the foam insulation layer around the boiler benefits the environment. [2]

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(iii) Paul thinks that **heater 2** will not heat all the water in the boiler.

Use the diagram of the boiler to explain whether you agree. [3]

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2. A student, Lisa, is studying how substances are transported into and out of cells.

(a) Oxygen enters the cell by diffusion. Define the process of diffusion. [1]

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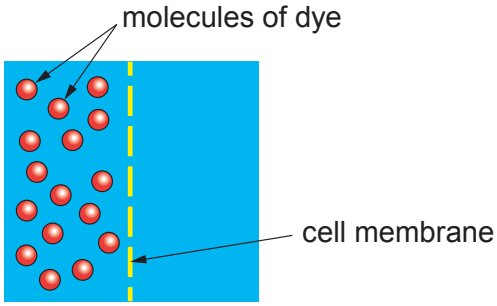
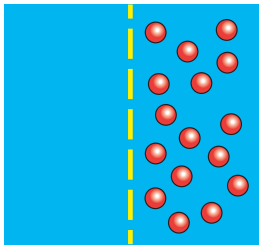
(b) In her schoolbook, Lisa has diagrams of a model to show diffusion of dye into a cell. The dye takes 30 minutes to reach equilibrium.



0 minutes

Lisa thinks the diagram that would show the correct arrangement of dye molecules she would expect to see after 30 minutes is diagram A.

A



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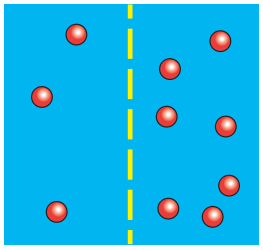
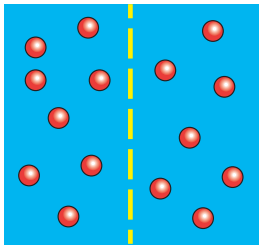
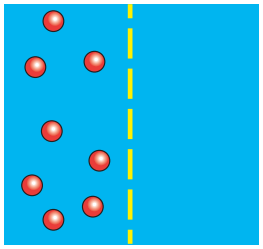


C



D



Explain whether you agree with Lisa. [3]

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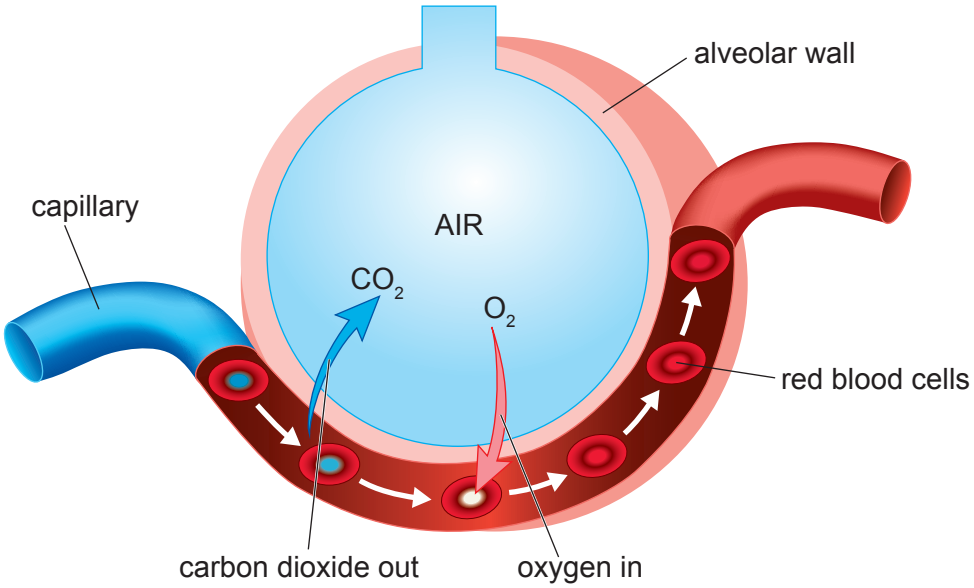
(c) Oxygen and carbon dioxide diffuse into and out of blood surrounding the alveoli.



Use the diagram to explain how diffusion is always maintained. [3]

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(d) Describe **two** differences between diffusion and active transport. [2]

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3. Welsh Water is responsible for supplying and maintaining safe water supplies in Wales. It monitors the composition of our drinking water.

The table below shows the composition of stream water supplying a reservoir in Wales. The samples were taken from three different streams.

Component	Concentration (units)		
	stream 1	stream 2	stream 3
sodium ions (Na^+)	5.0	5.0	5.0
potassium ions (K^+)	6.3	6.2	6.2
magnesium ions (Mg^{2+})	15.3	50.4	60.5
calcium ions (Ca^{2+})	50.4	50.1	101.1
chloride ions (Cl^-)	30.1	30.0	30.2
hydrogen carbonate ions (HCO_3^-)	10.1	50.1	40.0
dissolved sulfur dioxide	9.9	12.3	15.0
dissolved carbon dioxide	0.6	0.9	1.6
pH	5.7	5.5	5.4

Use the information in the table and your knowledge to answer the following questions.

(a) Explain how human activity has affected the acidity of the streams. [3]

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(b) A technician thinks the water in stream 1 is the softest and in stream 3 is the hardest.

Explain whether you agree. [3]

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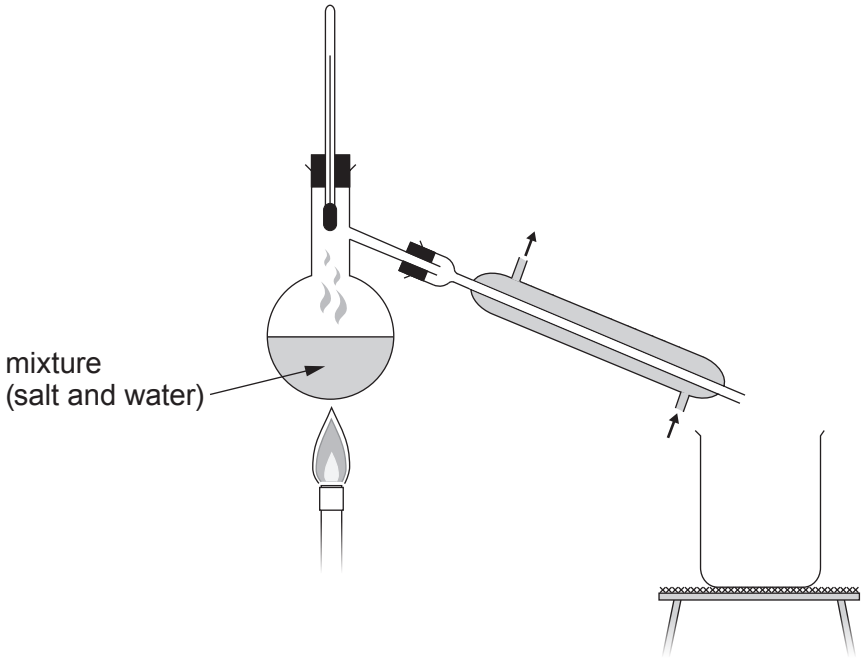
(c) Seawater can be desalinated using the apparatus below.



(i) Describe how pure water is extracted using the apparatus above. [4]

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(ii) Desalination can be used to increase the water supply for the public in parts of the world where water is scarce.

Describe the factors a government must consider when investing in industrial-sized desalination plants. [3]

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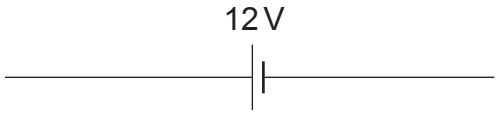
4. Jonathon is investigating how the resistance of a thermistor varies with temperature.

(a) Complete the circuit diagram used to measure the resistance of a thermistor. [3]



(b) Jonathon's results are shown in the table below.

Temperature (°C)	Current (mA)	Voltage (V)	Resistance (kΩ)
20	1.01	12.0	11.9
40	2.21	12.0	5.4
60	4.78	12.0	2.5
80	8.51	12.0	1.4
100	19.95	12.0	0.6

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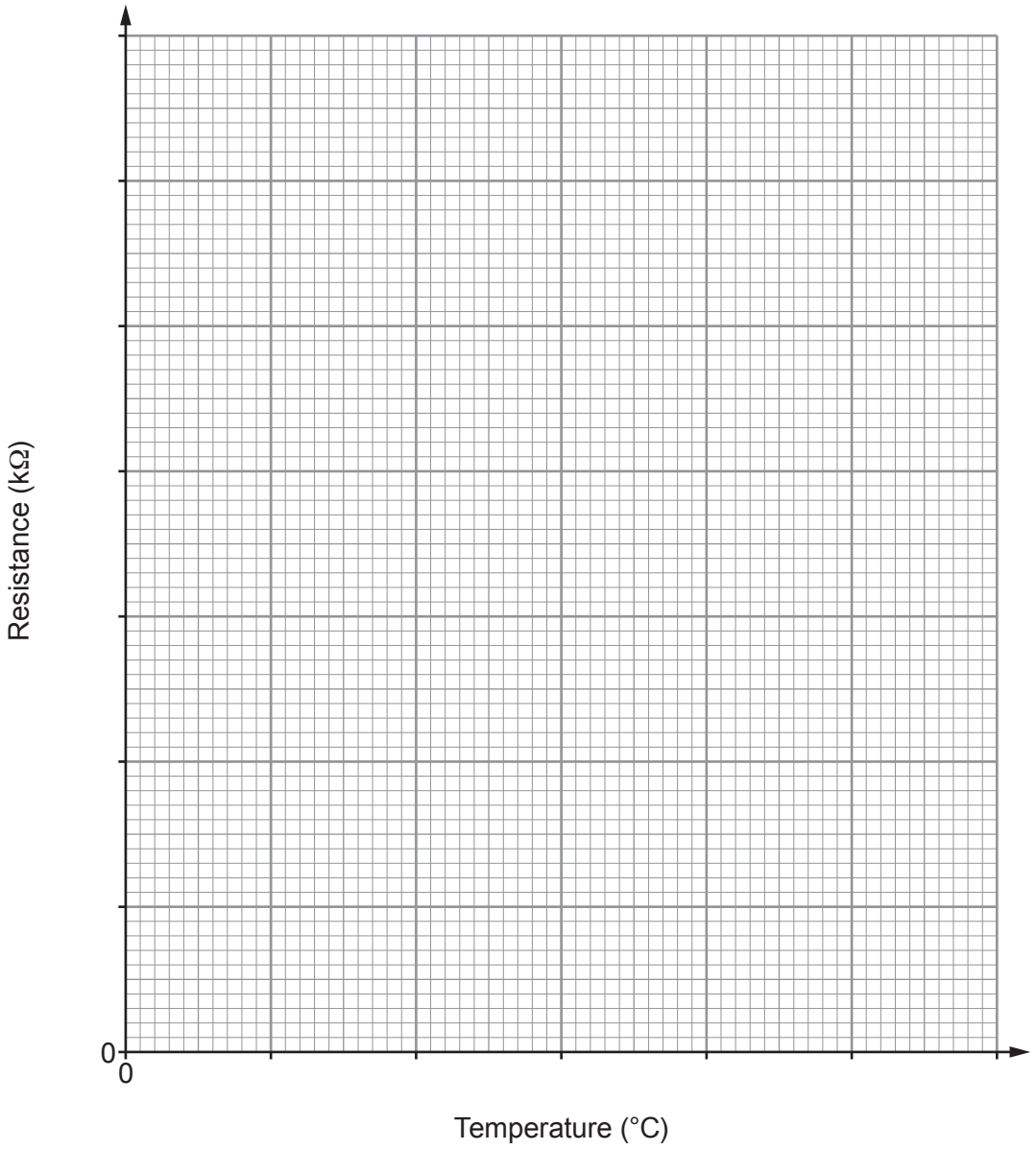
(i) Plot the data on the grid and draw a suitable line. [3]



(ii) Describe the relationship shown by the graph. [2]

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(iii) Use the graph and a suitable equation from the list below to answer each of the following questions.

$$\text{resistance } (\Omega) = \frac{\text{voltage (V)}}{\text{current (A)}}$$

$$\text{power} = \text{voltage} \times \text{current}$$

$$\text{power} = \text{current}^2 \times \text{resistance}$$

I. Calculate the current through the thermistor at 30 °C. [4]

current = ...mA

II. Calculate the power developed in the thermistor at 30 °C. [2]

power = ...W

(c) Thermistors are found in refrigerators to control the temperature.

Describe how the experiment needs to be modified to test if this thermistor would be suitable for a refrigerator. [2]

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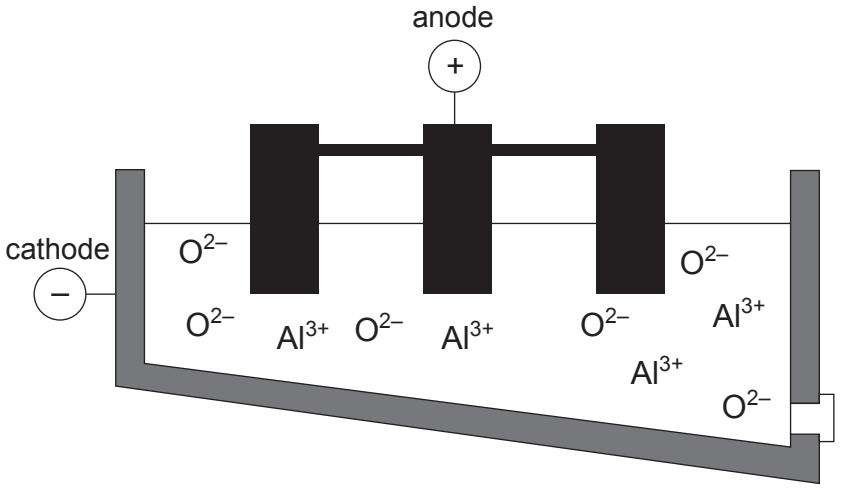
5. Aluminium is extracted from its ore by electrolysis.



Use the diagram above to describe how aluminium is extracted from its ore. [6 QER]

6

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6. The table below shows the mean carbon footprint for 1 kWh of electricity generated in different ways.

Type of power station	Carbon footprint (gCO2eq / kWh)
coal	921
oil	750
gas	500
solar	100
biomass	52
nuclear	30
hydroelectric	27
wind	30

Use the information in the table and your knowledge to answer the following questions.

(a) (i) Define the term carbon footprint. [2]

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(ii) A typical 500 MW **coal**-fired power station produces 3.5 billion kWh of electricity per year.
Calculate the carbon footprint of this power station in gCO2eq / kWh per year.
Give your answer to 2 significant figures.

1 billion kWh = 1×10^9 kWh [4]

carbon footprint = ... gCO2eq / kWh

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(iii) The carbon footprint of a nuclear power station is close to zero whilst generating electricity.

Explain why the table shows a carbon footprint of 30 gCO2eq / kWh for power generated by nuclear power. [2]

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(iv) A biomass power station burns wood chips as its energy source.
State why a biomass generator is considered as being 'carbon neutral'. [1]

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(b) The Antarctic ice sheet traps methane. It is estimated that the mass of trapped methane is about 2.8×10^{17} kg which has a carbon dioxide equivalent of 7×10^{18} kgCO2eq.

(i) Explain what is meant by the term global warming potential. [1]

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(ii) Use the equation:

carbon dioxide equivalent = mass of a gas × global warming potential of the gas

to calculate the global warming potential of methane. [2]

global warming potential = ...

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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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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															

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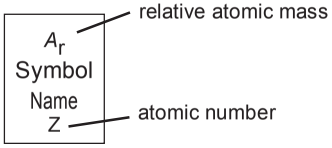

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