



GCSE

3445UA0-1

THURSDAY, 13 JUNE 2024 – MORNING

APPLIED SCIENCE (Double Award)
UNIT 1: Energy, Resources and the Environment

HIGHER TIER

1 hour 30 minutes plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

ADDITIONAL MATERIALS

In addition to this paper you may require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

A separate Data Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional pages 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 in the separate data booklet.

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

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.**
- (a) DIAGRAM 1 in the separate diagram booklet contains information about the Redstar boiler. Use the information given about the boiler to answer the following questions.**
- (i) Calculate the expected payback time for the boiler in years. [3 marks]**

payback time = _____ years

(Turn over)

1 (a)(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 marks]

% efficiency = _____

(iii) Use the equations:

units used (kWh) = power (kW) \times time (h)

total cost = cost of one unit \times 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 marks]

cost = _____

(Turn over)

1 (a)(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 marks]

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

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

1 (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 marks]

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

1 (c)(iii)

Paul thinks that HEATER 2 will not heat all the water in the boiler.

Use the diagram of the boiler in DIAGRAM 1 to explain whether you agree. [3 marks]

19

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 mark]

2 (b) In her schoolbook, Lisa has diagrams of a model to show diffusion of dye into a cell. These are shown in **DIAGRAM 2.1** in the separate diagram booklet. The dye takes 30 minutes to reach equilibrium.

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

Explain whether you agree with Lisa.
[3 marks]

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

Use DIAGRAM 2.2 in the separate diagram booklet to explain how diffusion is always maintained. [3 marks]

2 (d) Describe TWO differences between diffusion and active transport. [2 marks]

1. _____

2. _____

9

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

TABLE 3.1 in the separate diagram booklet shows the composition of stream water supplying a reservoir in Wales. The samples were taken from three different streams.

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 marks]

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

Explain whether you agree. [3 marks]

3 (c) Seawater can be desalinated using the apparatus shown in DIAGRAM 3.2 in the separate diagram booklet.

(i) Describe how pure water is extracted using the apparatus in DIAGRAM 3.2. [4 marks]

3 (c)(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 marks]

13

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

(a) Look at DIAGRAM 4.1 in the separate diagram booklet. Complete the circuit diagram used to measure the resistance of a thermistor. [3 marks]

(b) Jonathon's results are shown in TABLE 4.2 in the separate diagram booklet.

(i) Plot the data on the grid in GRAPH 4.3 in the separate diagram booklet and draw a suitable line. [3 marks]

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

4 (b)(iii)

Use **GRAPH 4.3** 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 marks]

current = _____ mA

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

power = _____ W

(Turn over)

4 (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 marks]

16

6

6 **TABLE 6** in the separate diagram booklet shows the mean carbon footprint for 1 kWh of electricity generated in different ways.

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

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

6 (a)(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.

[4 marks]

1 billion kWh = 1×10^9 kWh

carbon footprint = _____ gCO₂eq/kWh

(Turn over)

6 (a)(iii)

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

Explain why TABLE 6 shows a carbon footprint of 30 gCO₂eq/kWh for power generated by nuclear power. [2 marks]

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

6 (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 mark]

6 (b)(ii)

Use the equation:

$$\text{carbon dioxide equivalent} = \frac{\text{mass of a gas}}{\text{mass of CO}_2} \times \text{global warming potential of the gas}$$

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

global warming potential = _____

12

END OF PAPER

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

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1 hour 30 minutes plus your additional time allowance

DIAGRAM BOOKLET

This Diagram Booklet MUST be handed in to the invigilators and sent for marking.

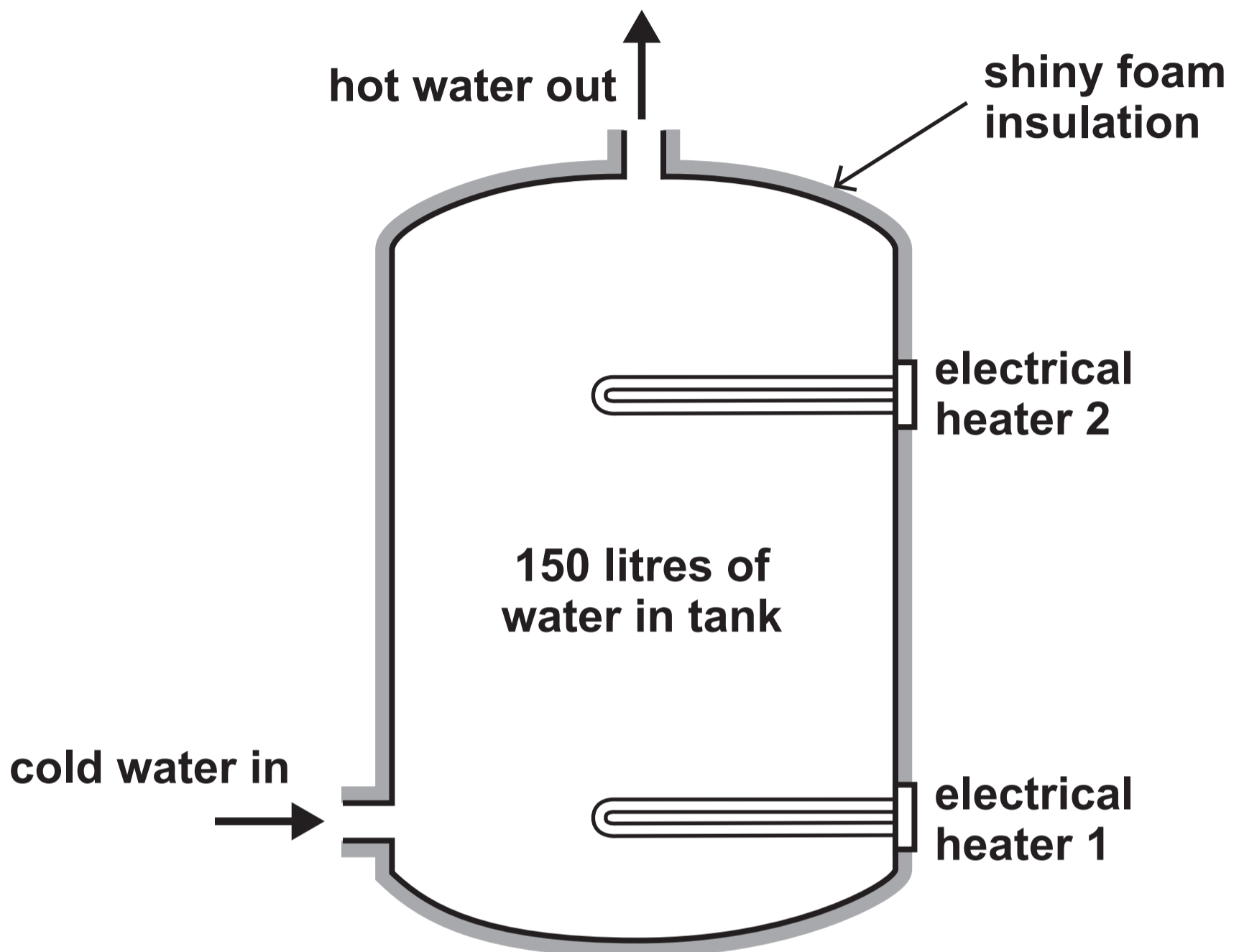
Surname _____

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Candidate Number 0 _____

DIAGRAM 1 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

DIAGRAM 2.1

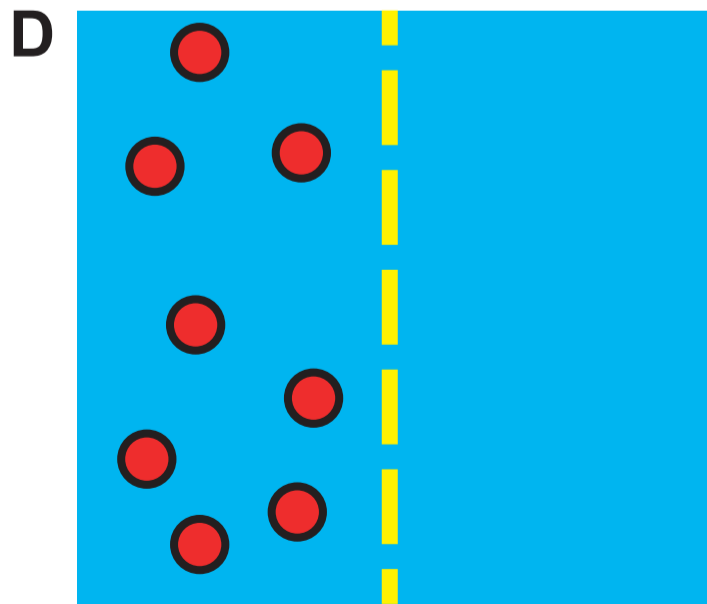
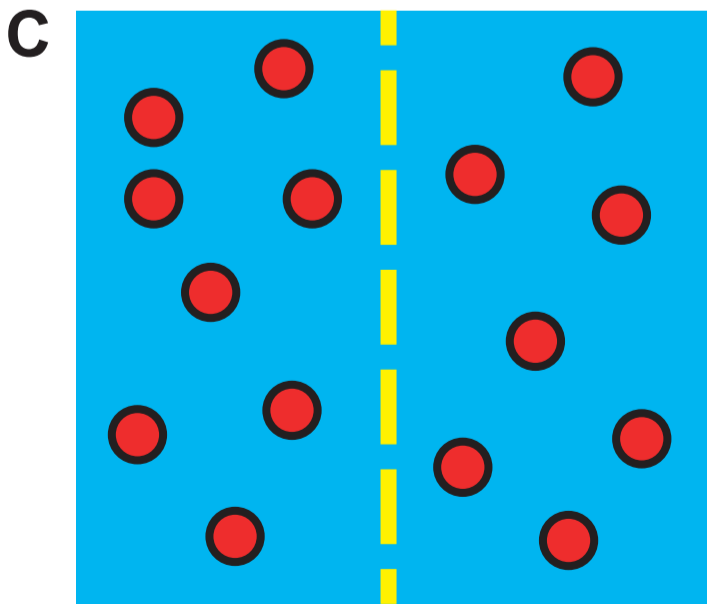
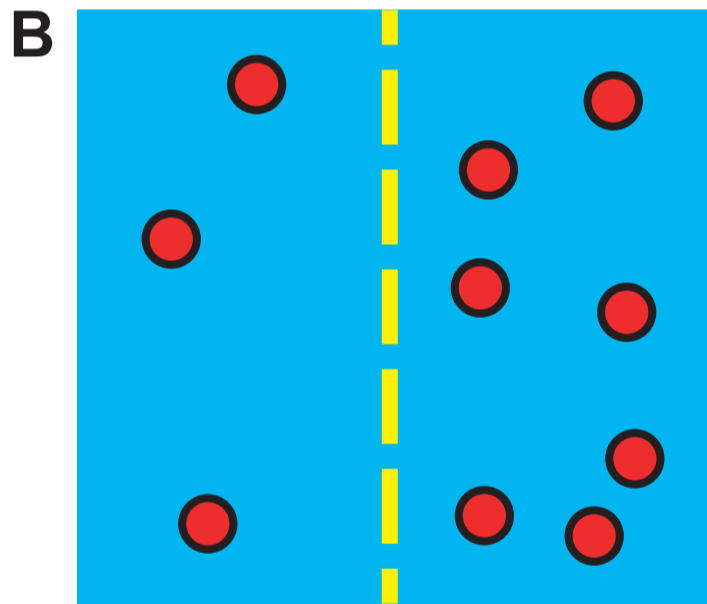
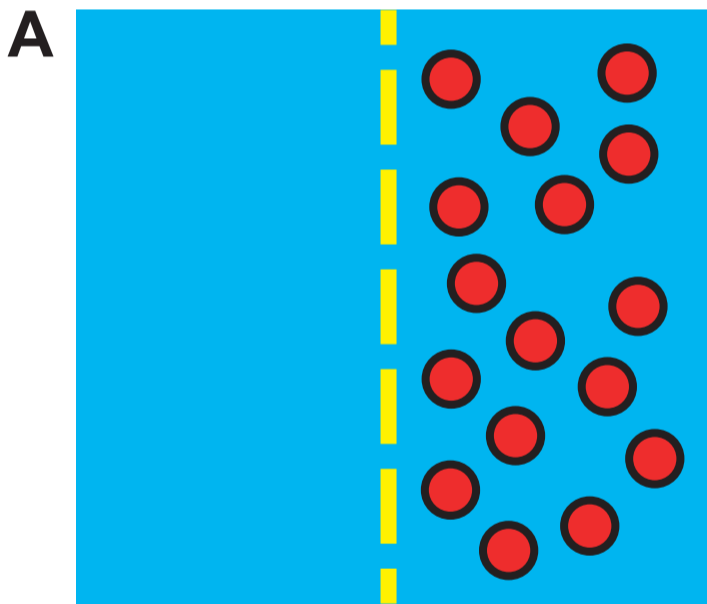
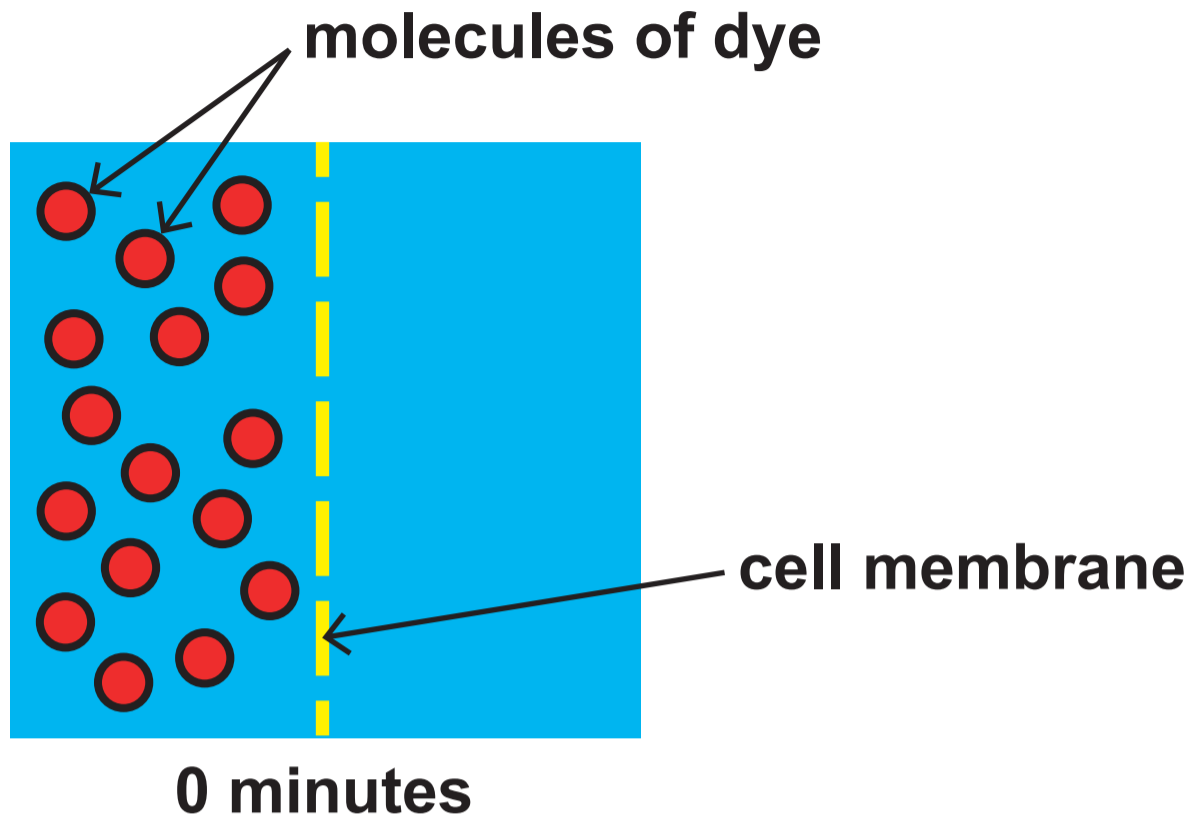


DIAGRAM 2.2

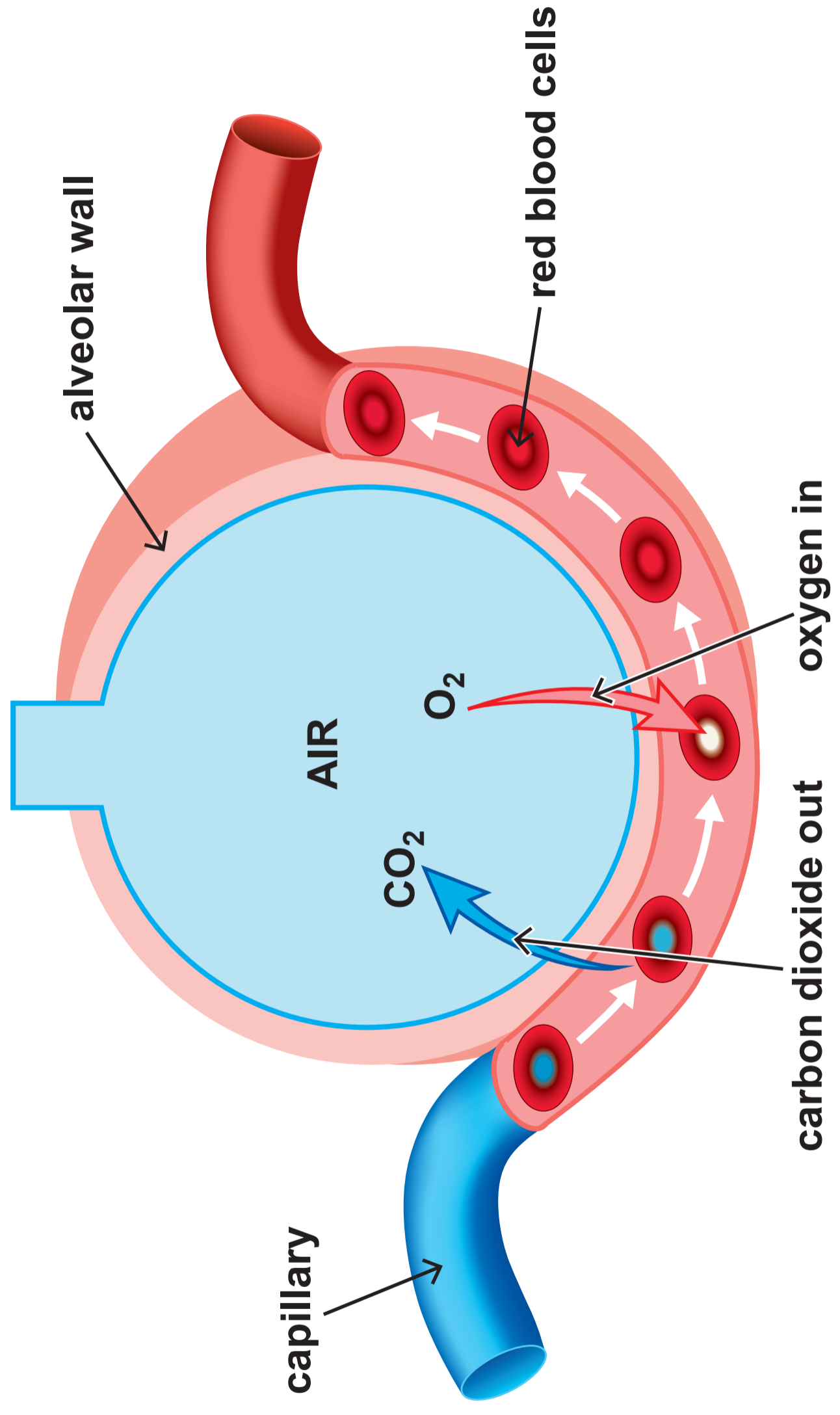


TABLE 3.1

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 (Mg²⁺)	15.3	50.4	60.5
calcium ions (Ca²⁺)	50.4	50.1	101.1
chloride ions (Cl⁻)	30.1	30.0	30.2
hydrogen carbonate ions (HCO₃⁻)	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

DIAGRAM 3.2

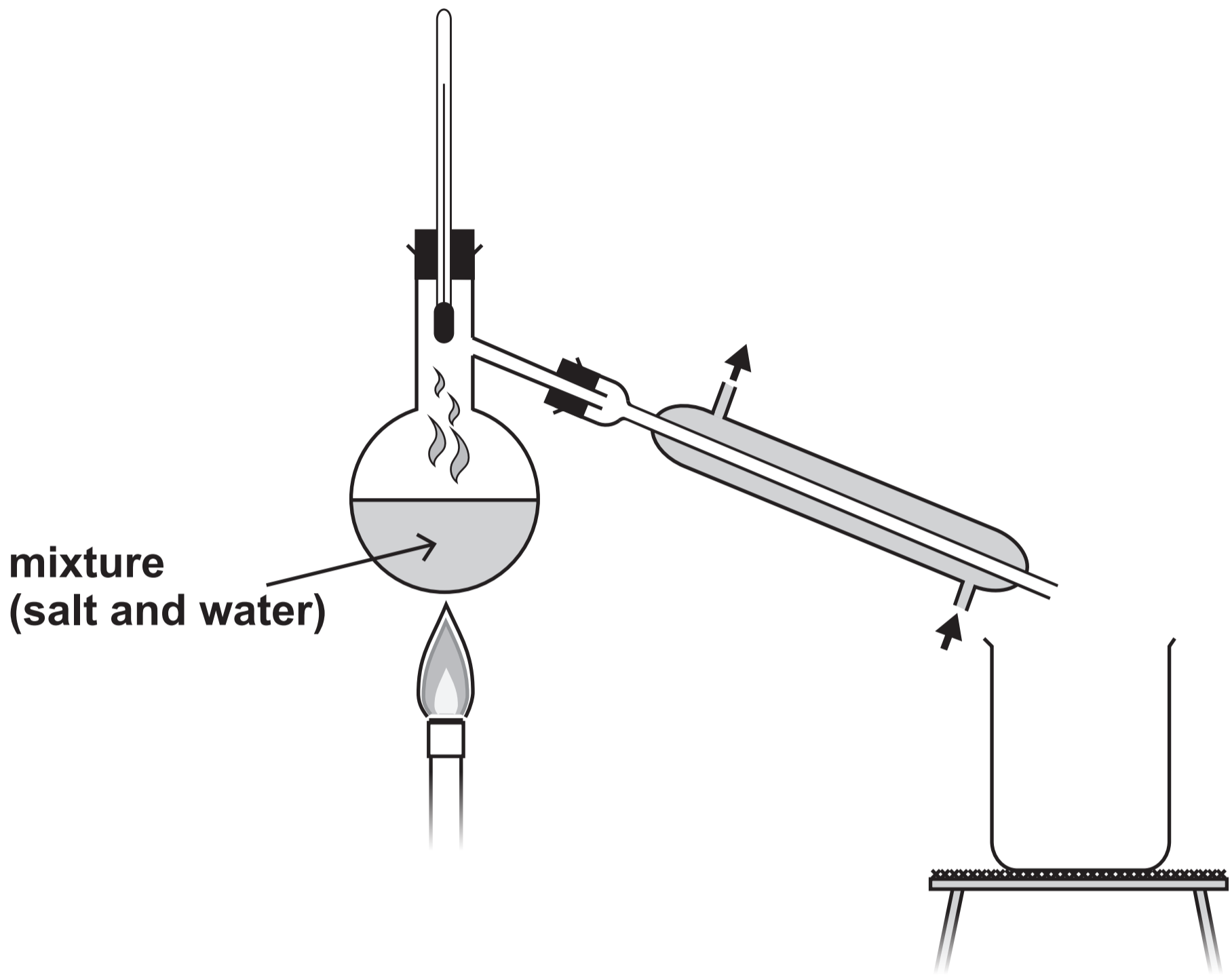
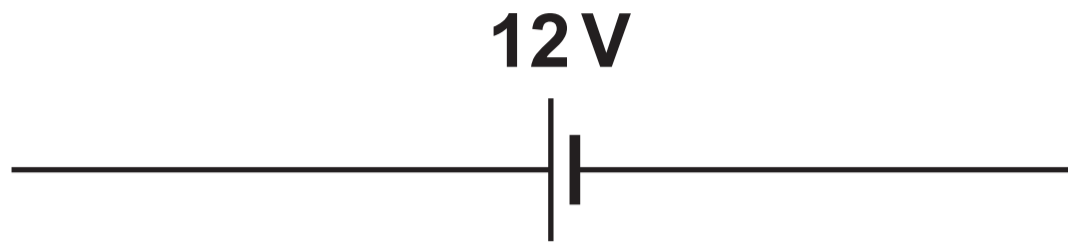


DIAGRAM 4.1

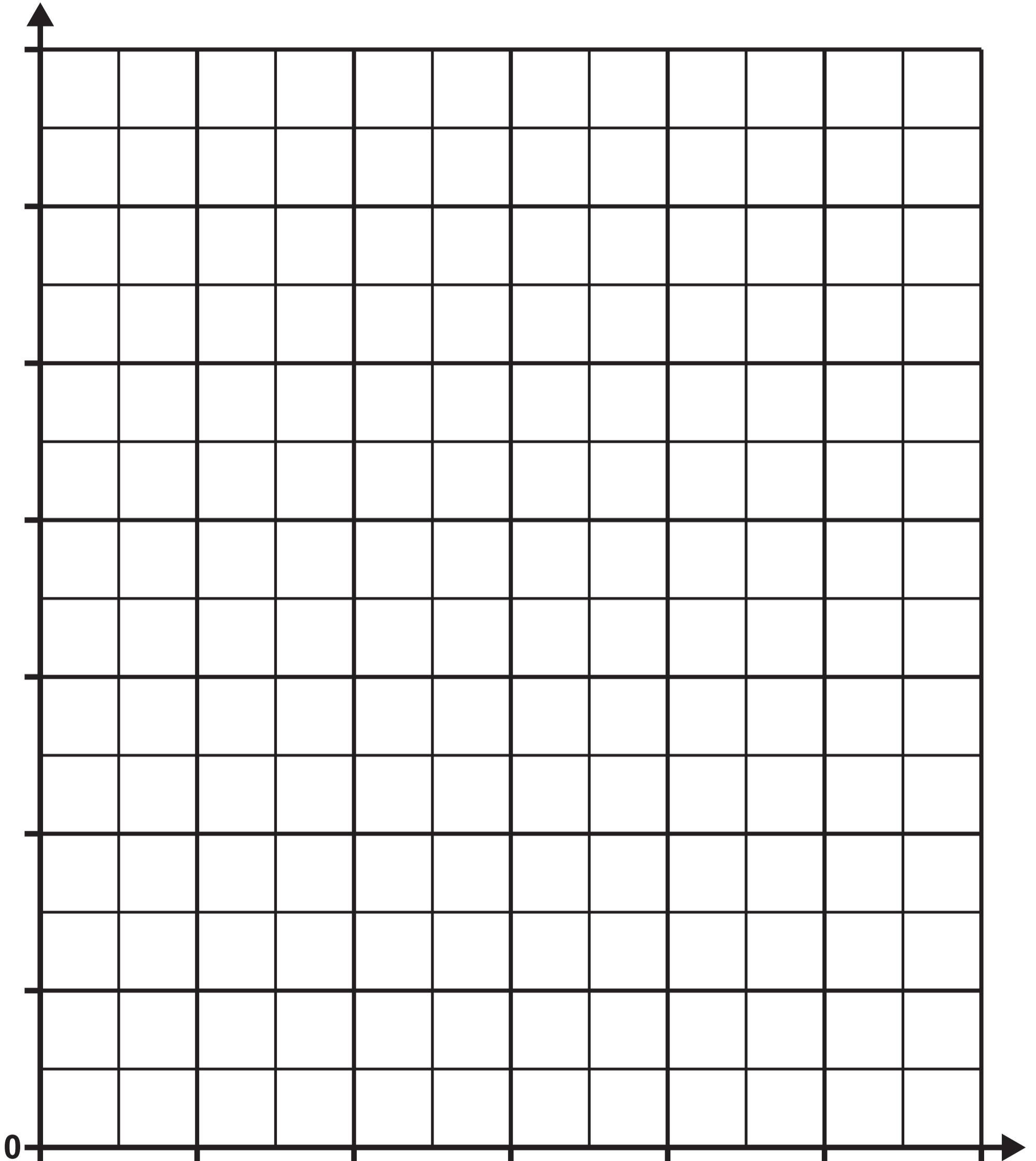
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TABLE 4.2

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

GRAPH 4.3

Resistance ($k\Omega$)



Temperature ($^{\circ}C$)

DIAGRAM 5

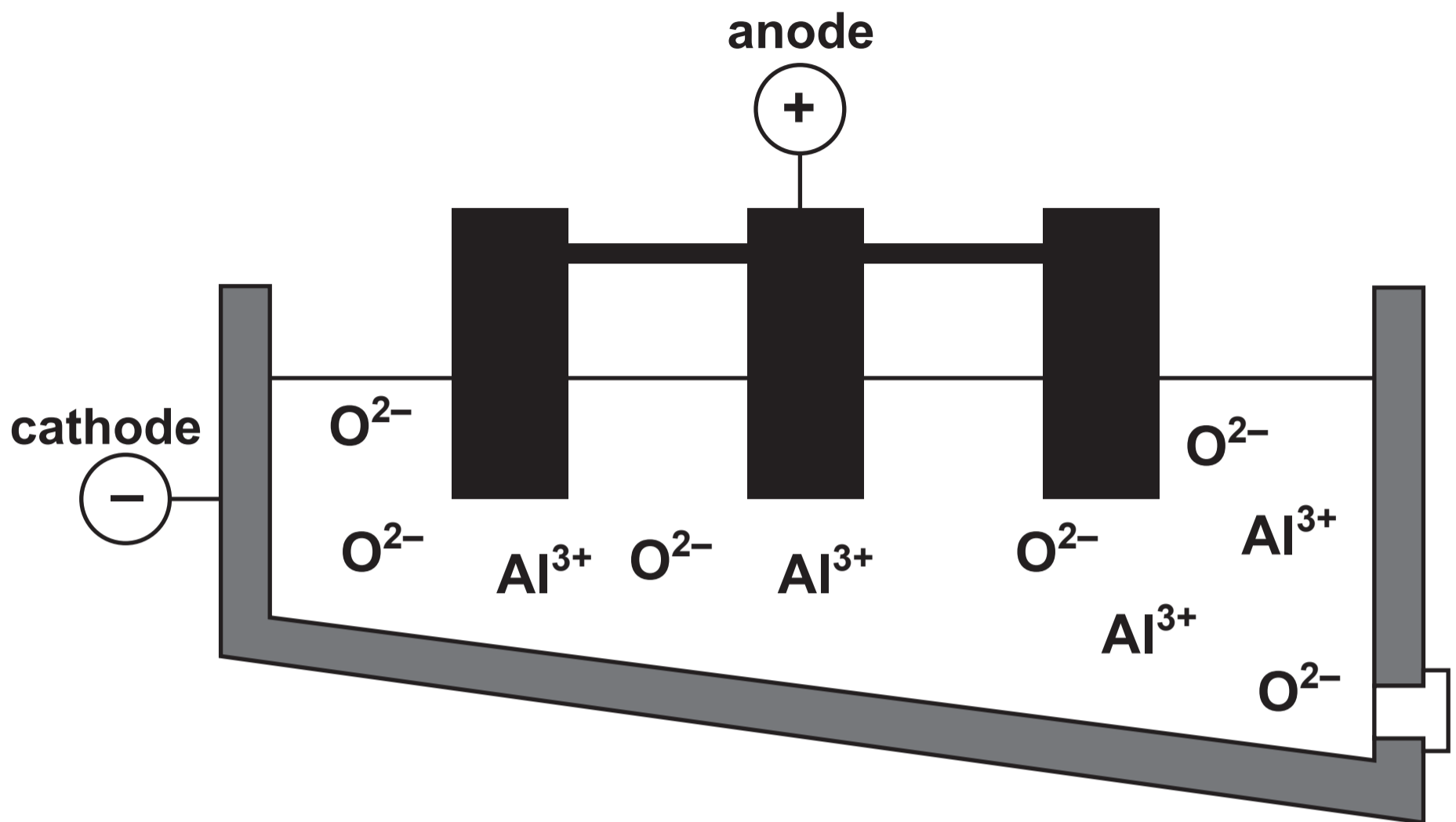


TABLE 6

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



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HIGHER TIER

Data Booklet

THE PERIODIC TABLE

KEY

Ar	relative atomic mass
Sym	symbol
Z	atomic number

GROUP

1 2 3 4 5 6 7 0

1	H	1
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7	Li	3	9	Be	4	11	Na	11	23	Na	11	24	Mg	12	27	Al	13	28	Si	14	31	P	15	32	S	16	35.5	Cl	17	39	K	19	40	Ca	20	45	Sc	21	48	Ti	22	51	V	23	52	Cr	24	55	Mn	25	56	Fe	26	59	Co	27	59	Ni	28	63.5	Cu	29	65	Zn	30	70	Ga	31	73	Ge	32	75	As	33	77	Se	34	79	Br	35	84	Kr	36	86	Rb	37	88	Sr	38	89	Y	39	91	Zr	40	93	Nb	41	96	Mo	42	99	Tc	43	101	Ru	44	103	Rh	45	106	Pd	46	108	Ag	47	112	Cd	48	115	In	49	119	Sn	50	122	Sb	51	127	I	53	131	Xe	54	133	Cs	55	137	Ba	56	139	La	57	179	Hf	72	181	Ta	73	184	W	74	186	Re	75	190	Os	76	192	Ir	77	195	Pt	78	197	Au	79	201	Hg	80	204	Tl	81	207	Pb	82	209	Bi	83	210	Po	84	210	At	85	223	Fr	87	226	Ra	88	227	Ac	89	222	Rn	86
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THE PERIODIC TABLE

PERIODIC TABLE – KEY ATOMIC NUMBER – SYMBOL – NAME

1	H – Hydrogen
2	He – Helium
3	Li – Lithium
4	Be – Beryllium
5	B – Boron
6	C – Carbon
7	N – Nitrogen
8	O – Oxygen
9	F – Fluorine
10	Ne – Neon
11	Na – Sodium
12	Mg – Magnesium
13	Al – Aluminium
14	Si – Silicon
15	P – Phosphorus
16	S – Sulfur
17	Cl – Chlorine
18	Ar – Argon
19	K – Potassium
20	Ca – Calcium
21	Sc – Scandium
22	Ti – Titanium
23	V – Vanadium
24	Cr – Chromium
25	Mn – Manganese
26	Fe – Iron
27	Co – Cobalt
28	Ni – Nickel
29	Cu – Copper
30	Zn – Zinc
31	Ga – Gallium
32	Ge – Germanium
33	As – Arsenic

34	Se – Selenium
35	Br – Bromine
36	Kr – Krypton
37	Rb – Rubidium
38	Sr – Strontium
39	Y – Yttrium
40	Zr – Zirconium
41	Nb – Niobium
42	Mo – Molybdenum
43	Tc – Technetium
44	Ru – Ruthenium
45	Rh – Rhodium
46	Pd – Palladium
47	Ag – Silver
48	Cd – Cadmium
49	In – Indium
50	Sn – Tin
51	Sb – Antimony
52	Te – Tellurium
53	I – Iodine
54	Xe – Xenon
55	Cs – Caesium
56	Ba – Barium
57	La – Lanthanum
72	Hf – Hafnium
73	Ta – Tantalum
74	W – Tungsten
75	Re – Rhenium
76	Os – Osmium
77	Ir – Iridium
78	Pt – Platinum
79	Au – Gold
80	Hg – Mercury

81	Tl – Thallium
82	Pb – Lead
83	Bi – Bismuth
84	Po – Polonium
85	At – Astatine
86	Rn – Radon
87	Fr – Francium
88	Ra – Radium
89	Ac – Actinium