



GCSE

3445UC0-1

TUESDAY, 17 MAY 2022 – MORNING

APPLIED SCIENCE (DOUBLE AWARD)

UNIT 3: FOOD, MATERIALS AND PROCESSES

HIGHER TIER

1 hour 30 minutes plus your additional time allowance

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: **0** _____

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	19	
2.	8	
3.	8	
4.	16	
5.	13	
6.	11	
Total	75	

(Turn over)

ADDITIONAL MATERIALS

A calculator.

ITEMS INCLUDED WITH QUESTION PAPER

Periodic Table (provided separately)

A separate Diagram 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, black felt tip or your usual method.

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

Answer ALL questions.

Write your answers in the spaces provided.

INFORMATION FOR CANDIDATES

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

Question 5 (c) is a quality of extended response (QER) question where your writing skills will be assessed.

The Periodic Table is provided separately.

ANSWER ALL QUESTIONS.

1. Criminals will try to hide their activities but forensic scientists, using biological and chemical testing, are able to find evidence that reveals what happened.

(a) DNA profiling is commonly used to identify criminals.

(i) State where DNA is found in the cell.

[1 mark]

continued on the next page . . .

(Turn over)

Question 1 (a) continued

1. (a) (ii) There were three suspects in a crime. Suspect 1 did not have an alibi but suspects 2 and 3 did. Initially it was thought that suspect 1 was the criminal. DNA samples were collected from the crime scene.

Look at the diagram for Question 1 (a) (ii) in the separate Diagram Booklet.

The diagram shows the DNA samples that were collected at the crime scene.

Compare the DNA samples shown to explain whether having an alibi or not is sufficient to decide on guilt.

[2 marks]

1. (a) (iii) State ONE OTHER use of DNA profiling.

[1 mark]

continued on the next page . . .

(Turn over)

Question 1 continued

1. (b) It is suspected that supplies of vinegar have been tampered with by adding a strong acid. White vinegar usually contains ethanoic acid at a concentration of **0.01 mol/dm³**

Samples of the vinegar are taken and tested by titrating against **0.5 mol/dm³** sodium hydroxide solution.

Look at the diagram for Question 1 (b) in the separate Diagram Booklet.

The diagram shows the equipment used for the titration.

continued on the next page . . .

Question 1 (b) continued

A pH meter is used to monitor the pH of the solution in the flask.

The results are shown in the table below.

Volume of sodium hydroxide solution (cm ³)	pH
0	1.5
5	1.6
10	1.7
15	1.9
20	2.2
25	3.0
30	13.7
35	14.0
40	14.0

continued on the next page . . .

(Turn over)

Question 1 (b) continued

1. (b) (i) Use the data in the table to complete the graph on the grid provided for Question 1 (b) (i) in the separate Diagram Booklet.

[3 marks]

- (ii) Use the graph to find the volume of sodium hydroxide solution required to neutralise the white vinegar.

volume = _____ cm^3

[1 mark]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

1. (b) (iii) Look at the equation for Question 1 (b) (iii) in the separate Diagram Booklet.

Use the information given in this question and the equation given to determine whether or not the samples had been tampered with.

SPACE FOR WORKING:

[3 marks]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

1. (b) (iv) Complete the word equation for the reaction between an acid and a base.

acid + base → _____

[2 marks]

- (v) Explain why taking multiple readings will increase the accuracy of the result.

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

1. (c) Powders **A** and **B** are collected at a crime scene.

The tests used to identify them are shown in the table below.

Test	Action
1	Flame test
2	Add silver nitrate solution
3	Add sodium hydroxide solution
4	Add dilute hydrochloric acid and bubble gas through limewater

Look at the diagram for Question 1 (c) in the separate Diagram Booklet.

The diagram shows the results of the tests.

continued on the next page . . .

(Turn over)

Question 1 (c) continued

Identify powders **A** and **B**.

Powder **A**: _____

Powder **B**: _____

[4 marks]

(Total for Question 1 = 19 marks)

(Turn over)

2. Microorganisms are regularly used in food production. However, unless precautions are taken, microorganisms can also cause food poisoning.

(a) (i) Describe the process of making cheese from milk.

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 (a) continued

2. (a) (ii) State the optimum conditions required in this process.

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

2. (b) Look at the diagram for Question 2 (b) in the separate Diagram Booklet.

The diagram is a graph.

Pasteurisation is a process that allows milk to be stored for longer.

The graph shows how bacterial growth varies with temperature.

Use the information in the graph to explain why milk is pasteurised at temperatures of about 70°C .

[2 marks]

(Total for Question 2 = 8 marks)

(Turn over)

3. Metals are good conductors of heat and electricity.

(a) Look at the diagram for Question 3 (a) in the separate Diagram Booklet.

Three students investigated the thermal conductivity of four metal rods as shown in the diagram.

State TWO ways in which the students will make the experimental method valid.

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (b) Look at the table for Question 3 (b) in the separate Diagram Booklet.**

The table shows results from the students' investigation together with theoretical values of thermal conductivity.

Use the data to explain whether the students' results are as expected.

[3 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (c) Explain, in terms of structure and bonding, why the electrical conductivity of sodium chloride is dependent upon its state.**

[3 marks]

(Total for Question 3 = 8 marks)

(Turn over)

Question 4 continued

- 4. (b) Students investigated the effect of one type of NPK fertiliser.**

Rice plants were treated with solutions of different concentrations of this NPK fertiliser.

They were treated each day for five weeks.

Look at the table for Question 4 (b) in the separate Diagram Booklet.

The growth of each plant was recorded and the results are shown in the table.

continued on the next page . . .

Question 4 (b) continued

4. (b) (i) Calculate the difference in mean plant growth PER WEEK for the plants treated with 0.2 and 0.6 units of NPK fertiliser.

SPACE FOR WORKING:

difference = _____ mm / week

[3 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

4. (b) (ii) John suggests that mean growth **ALWAYS** doubles if the concentration of fertiliser is doubled. Use data from the table to explain whether you agree with him.

SPACE FOR WORKING:

[3 marks]

continued on the next page . . .

(Turn over)

Question 4 continued

- 4. (d) Hydroponics is used to grow plants under controlled conditions. Describe how hydroponics differs from traditional methods of growing plants.**

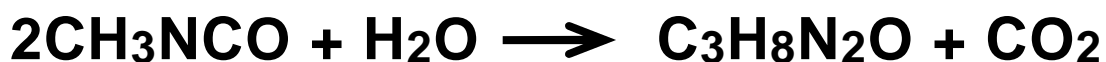
[2 marks]

(Total for Question 4 = 16 marks)

5. The release of a cloud of highly toxic methyl isocyanate (**MIC**) gas from a pesticide plant in Bhopal led to the deaths of thousands of people.

On the night of the disaster **MIC** reacted with water that leaked into a storage tank, causing an explosion. As a result, **MIC** was released into the atmosphere.

The chemical formula of **MIC** is **CH₃NCO** and the equation for the reaction of **MIC** with water is shown below.



continued on the next page . . .

Question 5 continued

5. (a) Calculate the relative molecular mass (M_r) of MIC using information from the Periodic Table (provided separately). Show your workings, starting with the relative atomic mass (A_r) of each element found in MIC.

SPACE FOR WORKING:

$M_r =$ _____

[4 marks]

continued on the next page . . .

(Turn over)

Question 5 continued

5. (b) Approximately **30 000 kg** of MIC gas was released. Calculate the number of moles released to three significant figures using your answer in part (a).

SPACE FOR WORKING:

number of moles = _____

[3 marks]

continued on the next page . . .

(Turn over)

Question 5 continued

5. (c) Look at the diagram for Question 5 (c) in the separate Diagram Booklet.

The diagram shows the structural equation and reaction pathway for the reaction causing the explosion in the Bhopal plant.

Use ALL the information to explain why the reaction between MIC and water resulted in an explosion in terms of reaction pathway, bond energies and thermal runaway.

(Turn over)

6. Modern javelins are made of aluminium alloys or aluminium composite materials.

(a) Describe what is meant by the term 'composite material'.

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (b) Look at the diagram for Question 6 (b) in the separate Diagram Booklet.**

The diagram shows the arrangement of atoms in aluminium and a copper and aluminium alloy.

Pure aluminium is too flexible to make javelins. Copper can be mixed with aluminium to produce an alloy.

Use the diagrams and your own knowledge of alloys to explain how the presence of copper atoms in the aluminium results in the alloy being more rigid than pure aluminium.

[3 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

6. (c) Look at the diagram for Question 6 (c) in the separate Diagram Booklet.

The diagram shows the plan view and front view of an aluminium bar.

The bar is in the shape of a cuboid.

An engineer was asked to determine the force required to break a pure aluminium rectangular bar.

The tensile strength of pure aluminium is 90 MN/m^2

Use the information above and the equation

$$\text{tensile strength} = \frac{\text{force}}{\text{cross-sectional area}}$$

to calculate the force (F) required to break this bar.

$$(1 \text{ MN} = 10^6 \text{ N and } 1 \text{ cm}^2 = 10^{-4} \text{ m}^2)$$

continued on the next page . . .

(Turn over)

Question 6 (c) continued

SPACE FOR WORKING:

force (**F**) = _____ **N**

[6 marks]

END OF PAPER

TOTAL 75 MARKS



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Diagram Booklet

Surname: _____

First name(s): _____

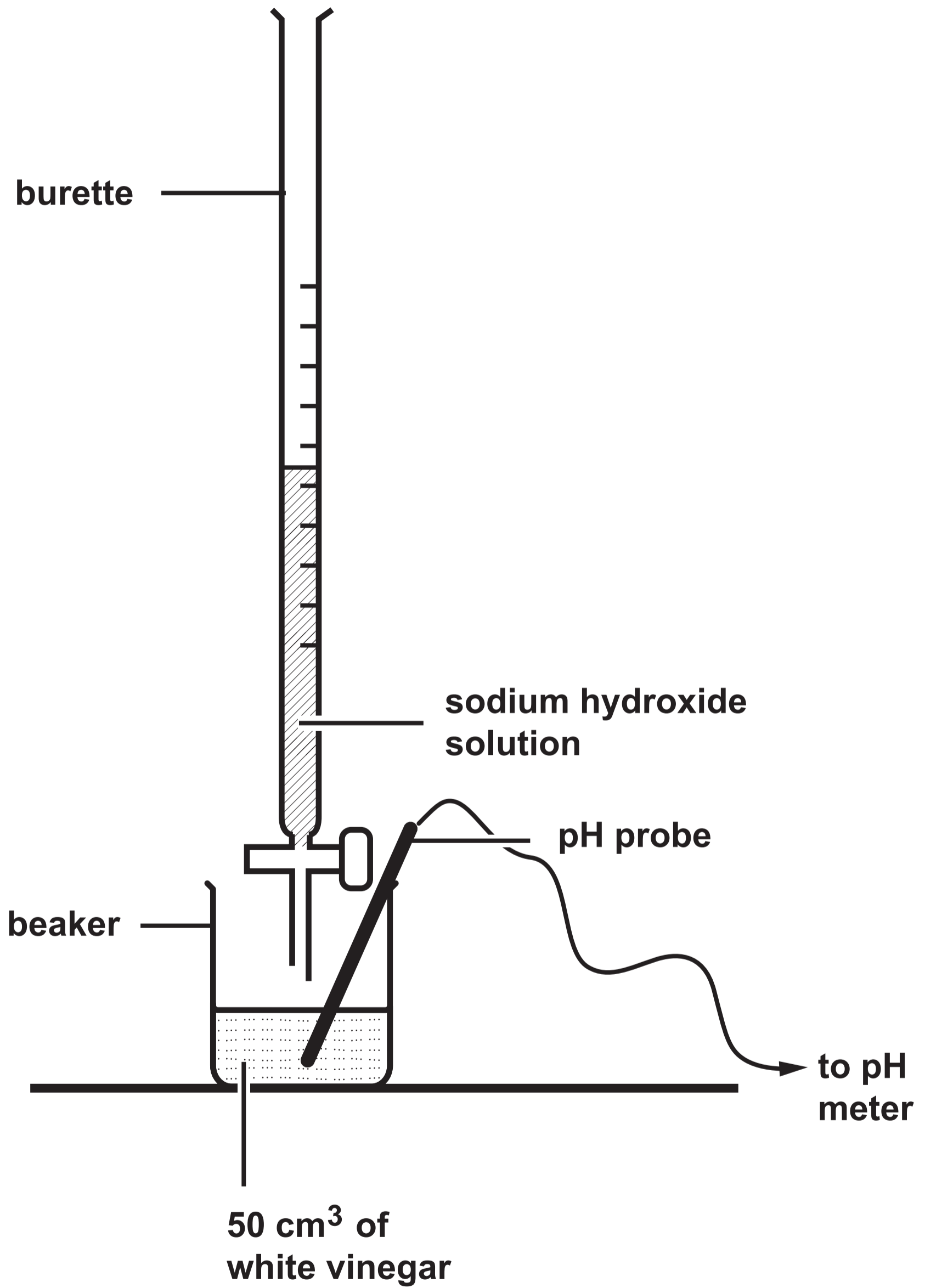
Centre Number: _____

Candidate Number: 0 _____

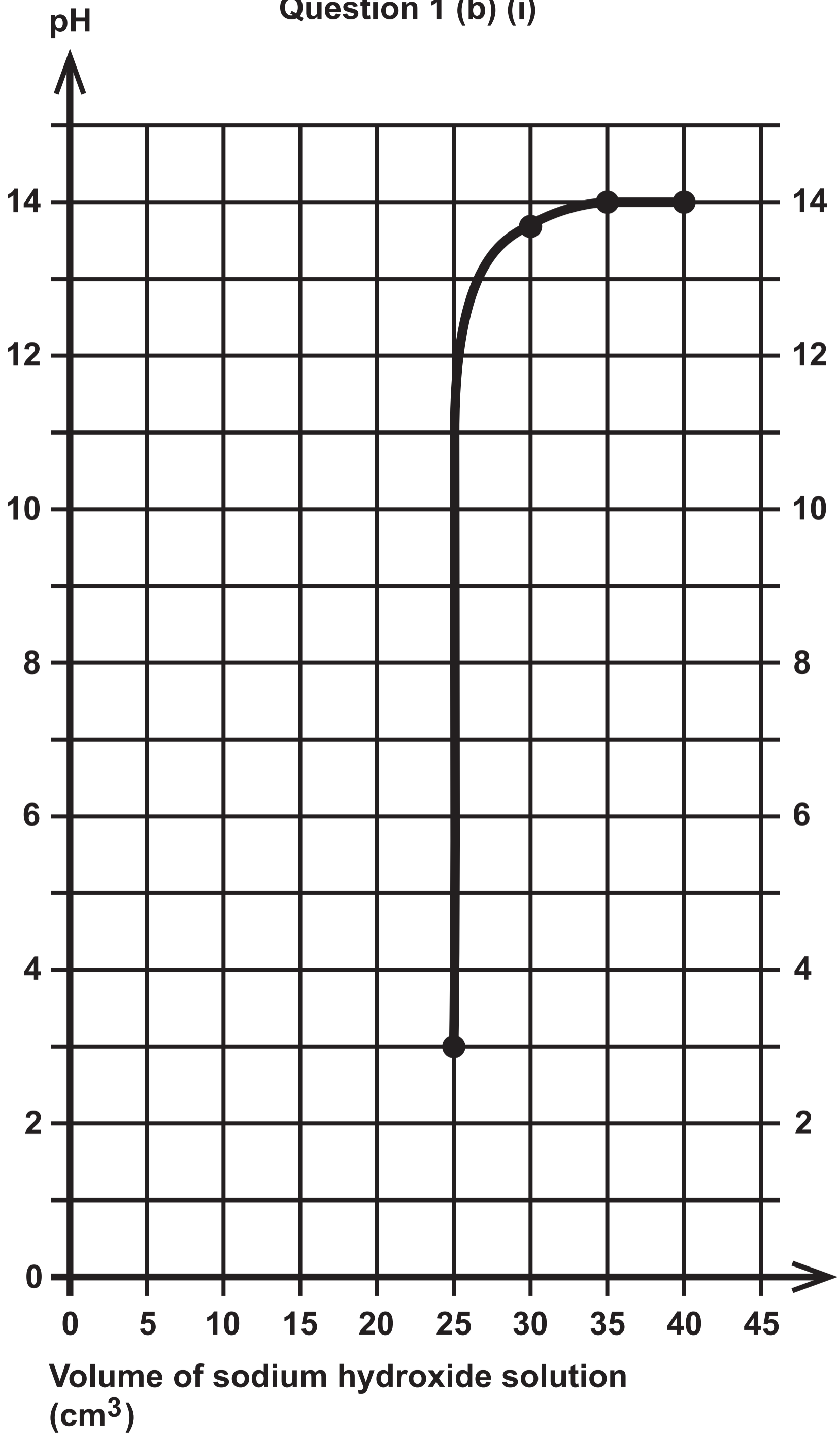
Question 1 (a) (ii)



Question 1 (b)



Question 1 (b) (i)

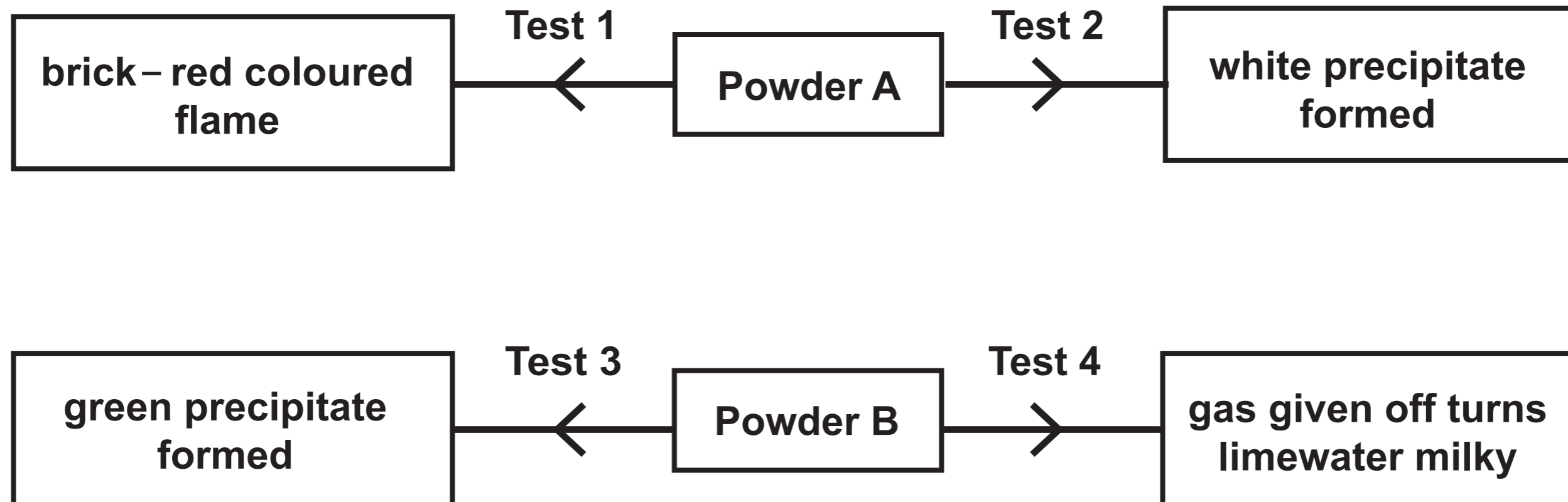


Question 1 (b) (iii)

Equation

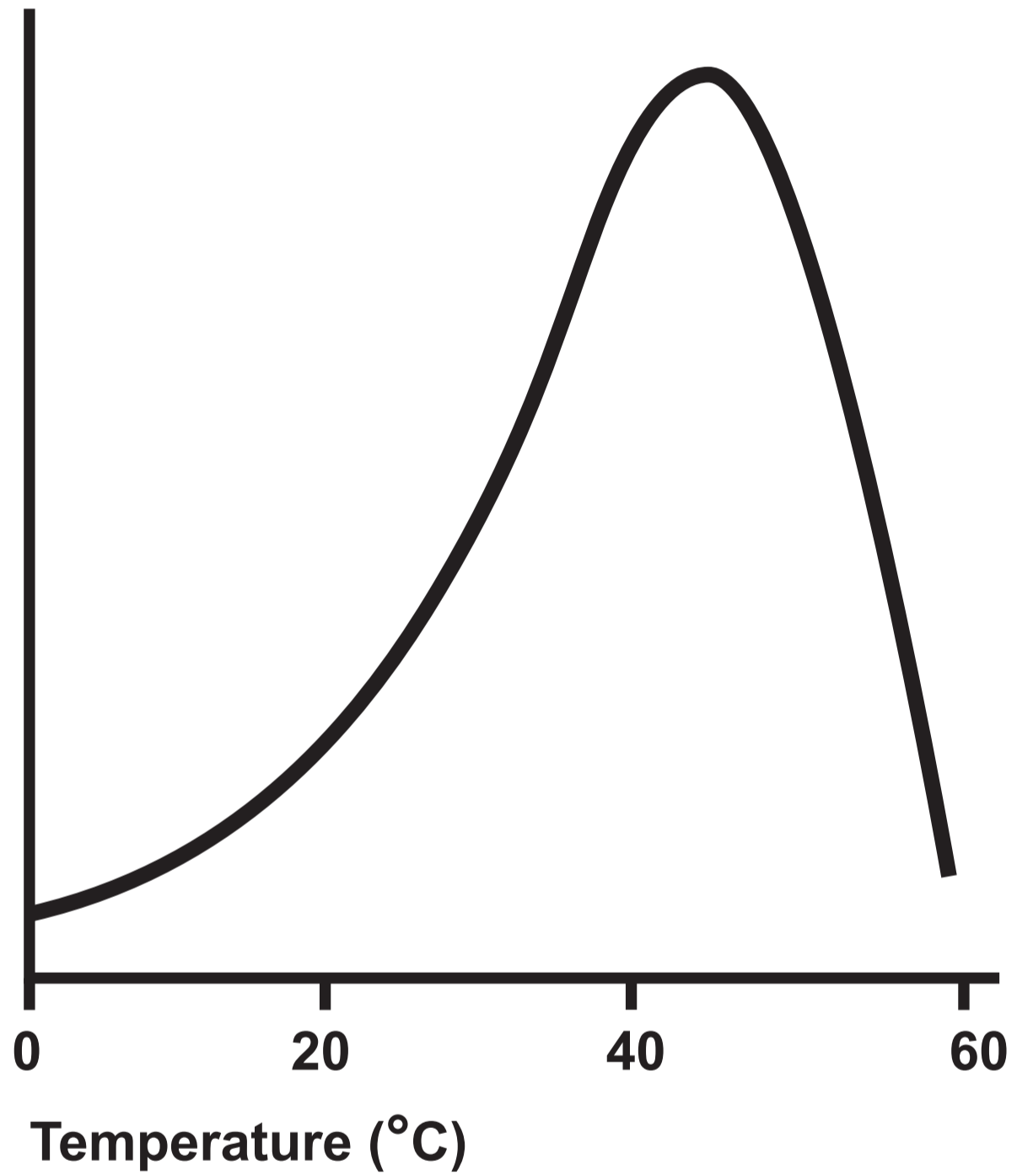
$$\text{concentration of white vinegar} = \frac{\text{concentration of sodium hydroxide} \times \text{volume of sodium hydroxide}}{\text{volume of white vinegar}}$$

Question 1 (c)

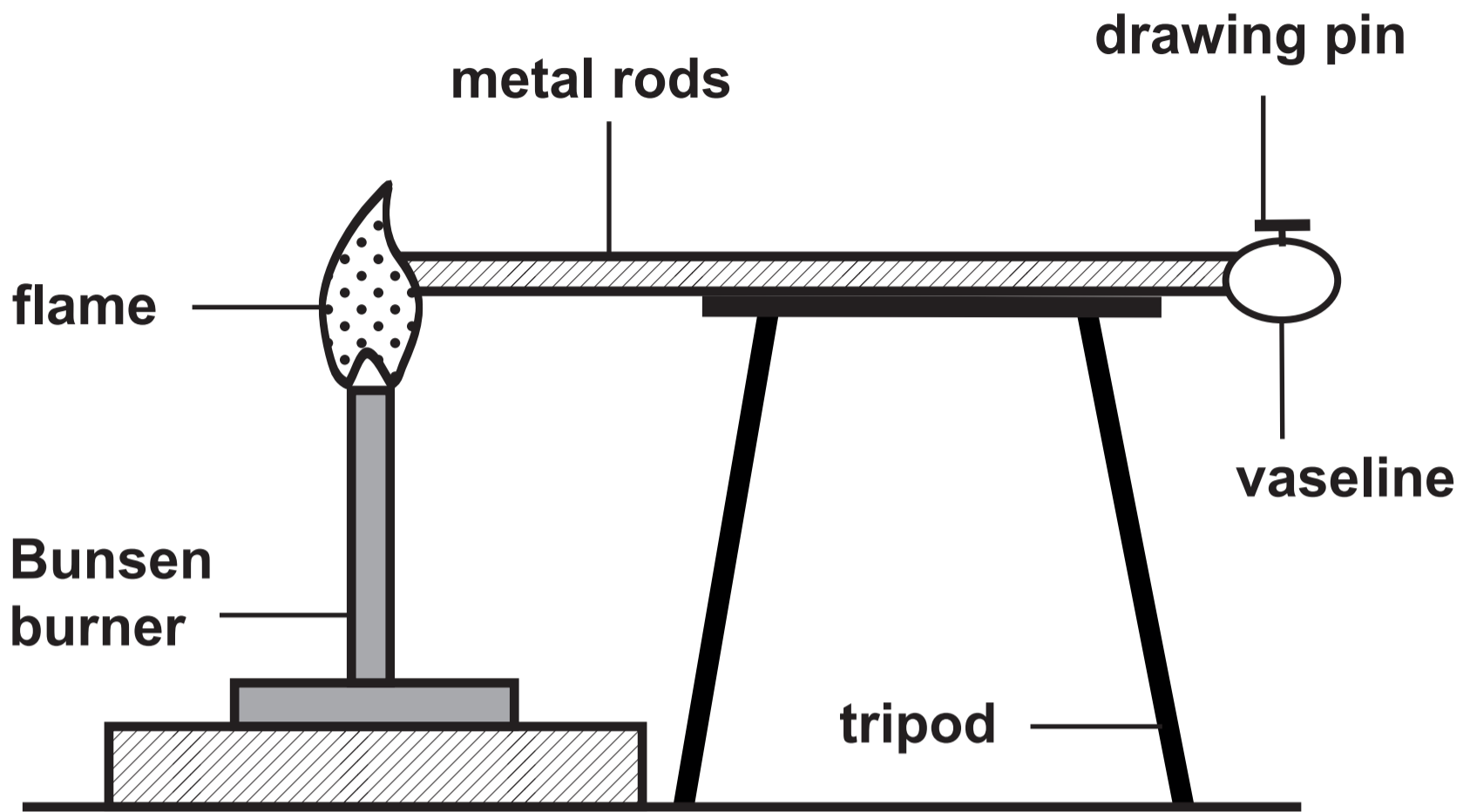


Question 2 (b)

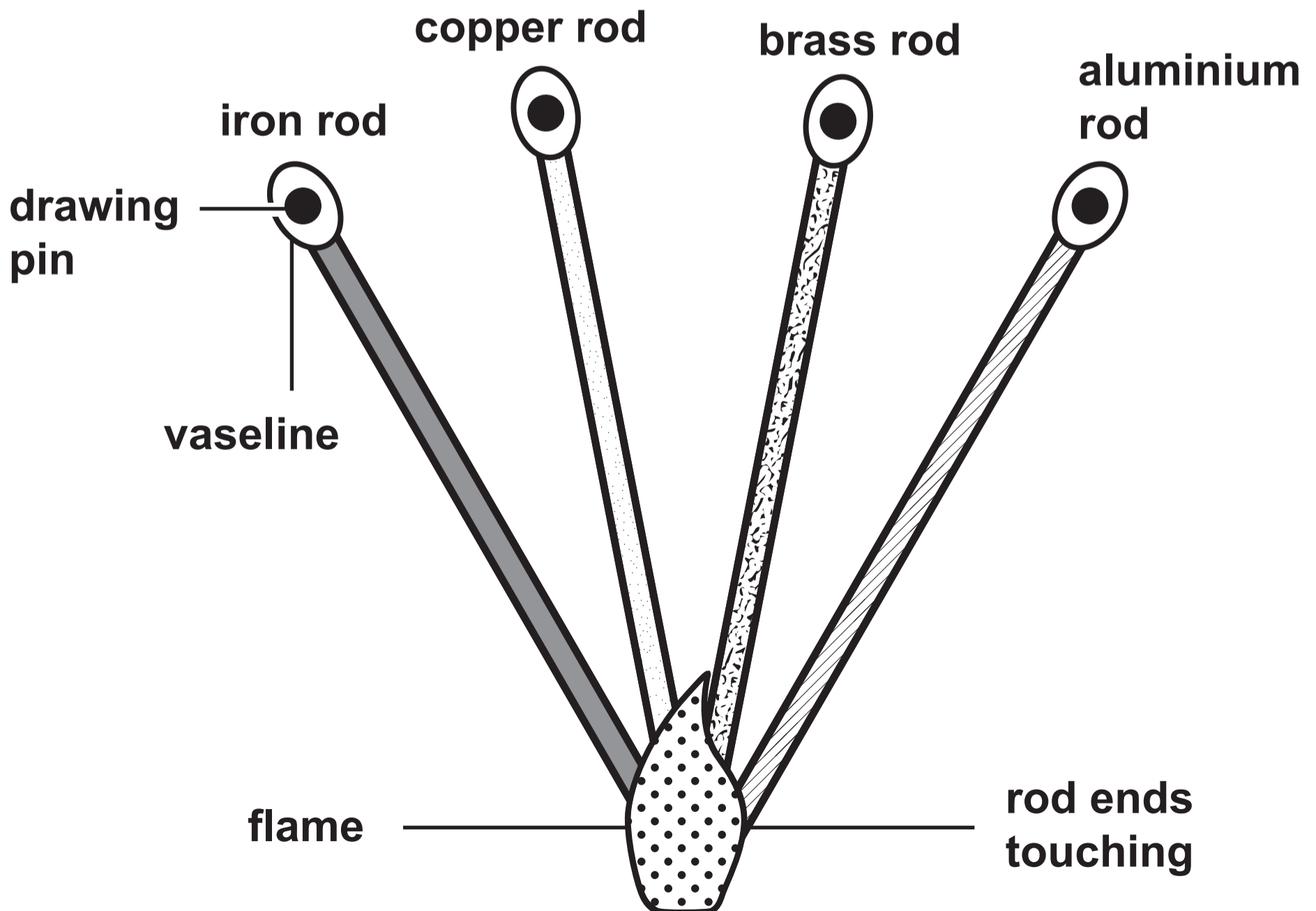
Number of bacteria



Question 3 (a)



Metal rods arrangement on the tripod



Question 3 (b)

Table

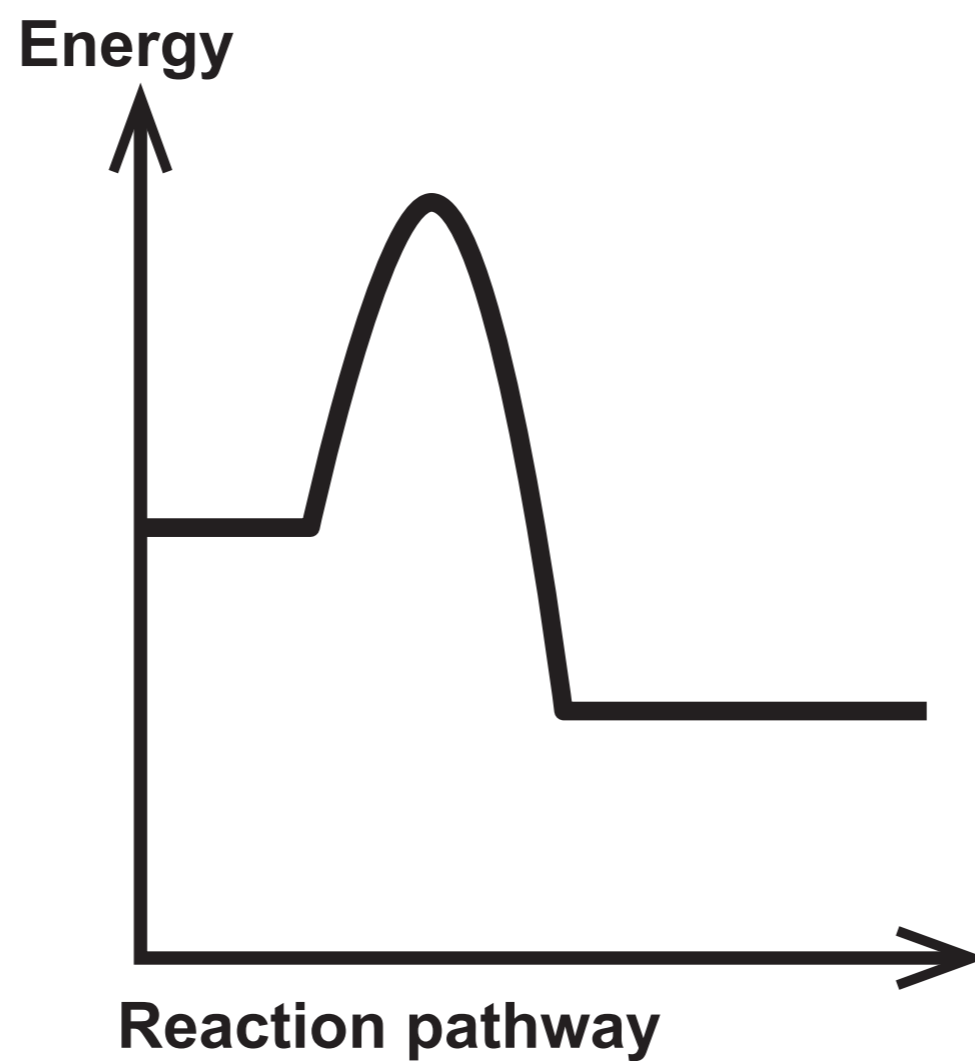
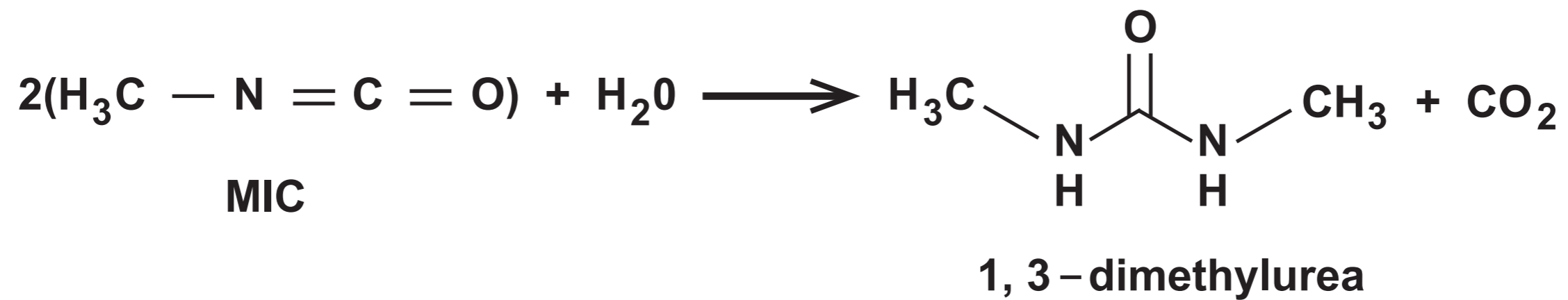
Metal	Time taken for pin to drop (s)	Thermal conductivity (W/m K)
iron	17	80.4
copper	7	401
brass	12	109
aluminium	5	210

Question 4 (b)

Table

Concentrations of NPK fertiliser (units)	Plant growth after 5 weeks (mm)				
	plant 1	plant 2	plant 3	plant 4	mean
0.2	27	29	32	28	29
0.4	55	57	58	62	58
0.6	65	67	68	72	68
0.8	70	72	73	77	73

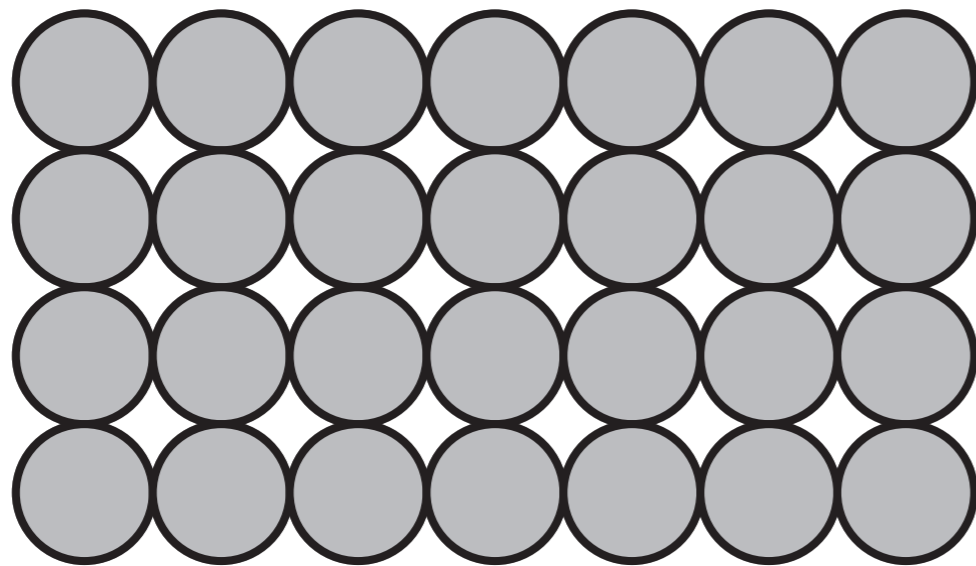
Question 5 (c)



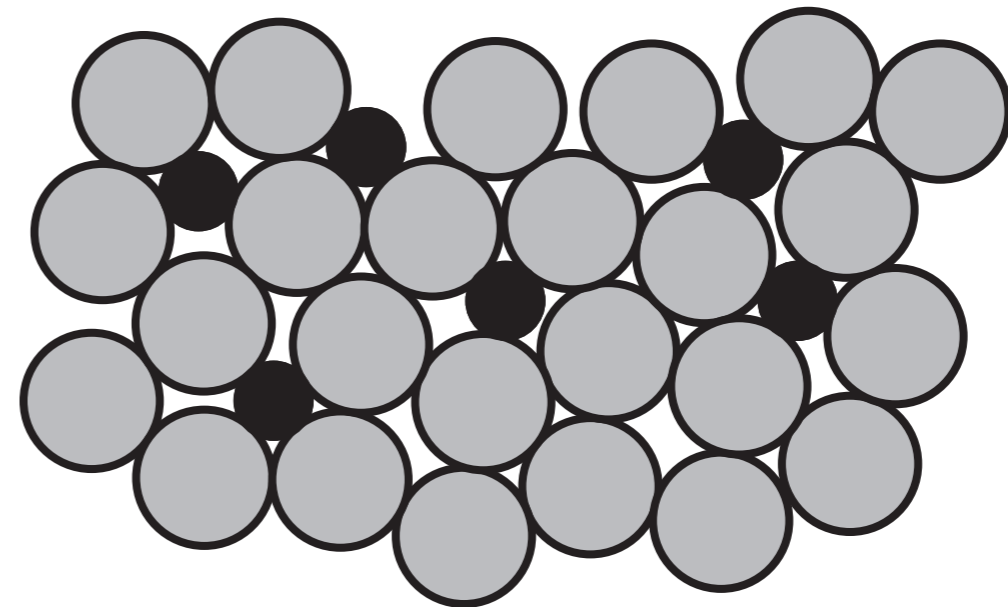
Question 6 (b)

Key:  aluminium atom
 copper atom

Pure aluminium

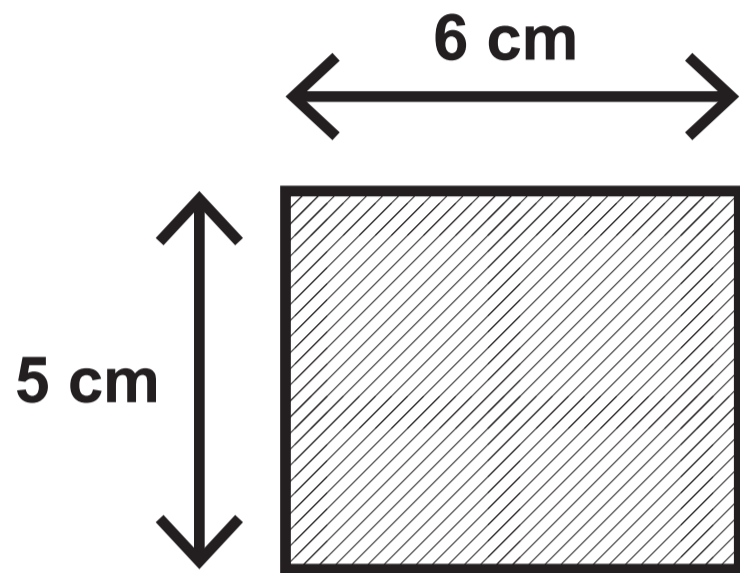


Copper and aluminium alloy

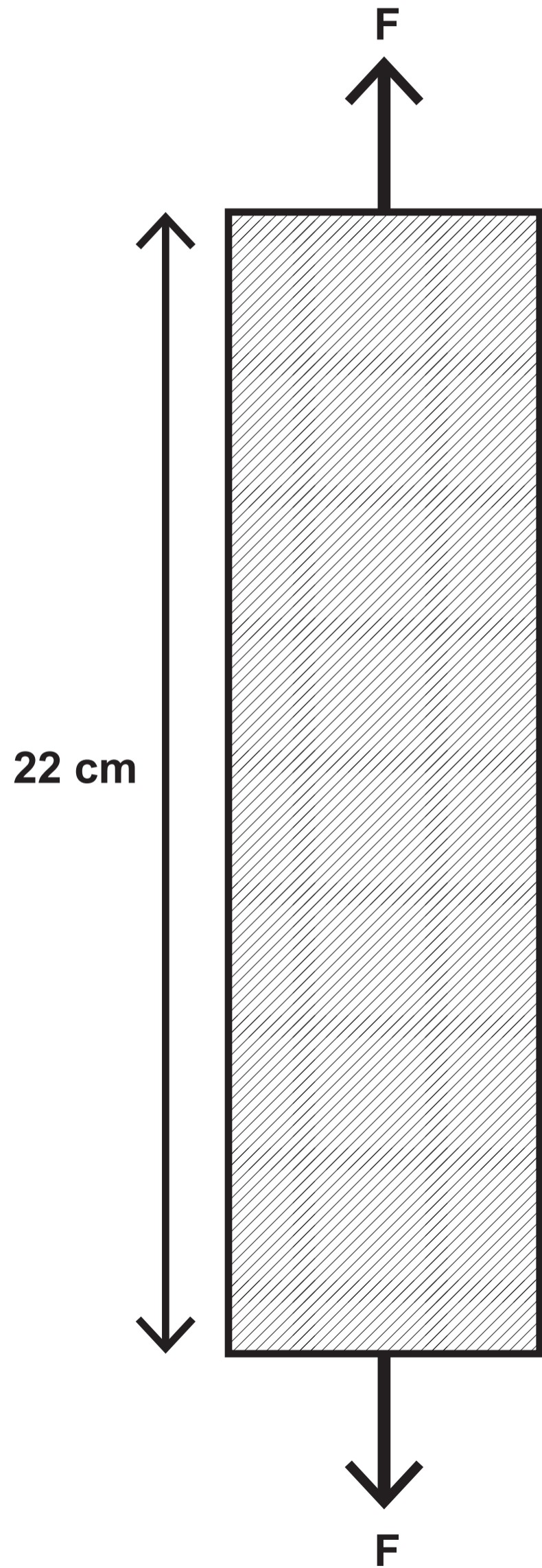


Question 6 (c)

VIEW FROM ABOVE



FRONT VIEW



Periodic Table

Key:

A_r
Symbol
Z

A_r : Relative atomic mass
 Symbol : Chemical symbol
 Z : Atomic number

█ represents where elements 58-71 (lanthanides) are omitted

1 H 1

1

2

7 Li 3

9 Be 4

23 Na 11

24 Mg 12

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

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

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

223 Fr 87

226 Ra 88

227 Ac 89

					0
					4 He 2
3	4	5	6	7	
11 B 5	12 C 6	14 N 7	16 O 8	19 F 9	20 Ne 10
27 Al 13	28 Si 14	31 P 15	32 S 16	35.5 Cl 17	40 Ar 18
70 Ga 31	73 Ge 32	75 As 33	79 Se 34	80 Br 35	84 Kr 36
115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
204 Tl 81	207 Pb 82	209 Bi 83	210 Po 84	210 At 85	222 Rn 86

List of elements in the Periodic table in order of atomic number

KEY: atomic number – chemical symbol – element

1 – Hydrogen – H

2 – Helium – He

3 – Lithium – Li

4 – Beryllium – Be

5 – Boron – B

6 – Carbon – C

7 – Nitrogen – N

8 – Oxygen – O

9 – Fluorine – F

10 – Neon – Ne

11 – Sodium – Na

12 – Magnesium – Mg

13 – Aluminium – Al

14 – Silicon – Si

15 – Phosphorous – P

16 – Sulphur – S

17 – Chlorine – Cl

18 – Argon – Ar

- 19 – Potassium – K**
- 20 – Calcium – Ca**
- 21 – Scandium – Sc**
- 22 – Titanium – Ti**
- 23 – Vanadium – V**
- 24 – Chromium – Cr**
- 25 – Manganese – Mn**
- 26 – Iron – Fe**
- 27 – Cobalt – Co**
- 28 – Nickel – Ni**
- 29 – Copper – Cu**
- 30 – Zinc – Zn**
- 31 – Gallium – Ga**
- 32 – Germanium – Ge**
- 33 – Arsenic – As**
- 34 – Selenium – Se**
- 35 – Bromine – Br**
- 36 – Krypton – Kr**
- 37 – Rubidium – Rb**
- 38 – Strontium – Sr**
- 39 – Yttrium – Y**
- 40 – Zirconium – Zr**
- 41 – Niobium – Nb**

42 – Molybdenum – Mo

43 – Technetium – Tc

44 – Ruthenium – Ru

45 – Rhodium – Rh

46 – Palladium – Pd

47 – Silver – Ag

48 – Cadmium – Cd

49 – Indium – In

50 – Tin – Sn

51 – Antimony – Sb

52 – Tellurium – Te

53 – Iodine – I

54 – Xenon – Xe

55 – Caesium – Cs

56 – Barium – Ba

57 – Lanthanum – La

(The lanthanides, elements 58-71, are omitted)

72 – Hafnium – Hf

73 – Tantalum – Ta

74 – Tungsten – W

75 – Rhenium – Re

76 – Osmium – Os

77 – Iridium – Ir

78 – Platinum – Pt

79 – Gold – Au

80 – Mercury – Hg

81 – Thallium – Tl

82 – Lead – Pb

83 – Bismuth – Bi

84 – Polonium – Po

85 – Astatine – At

86 – Radon – Rn

87 – Francium – Fr

88 – Radium – Ra

89 – Actinium – Ac