OCR
Oxford Cambridge and RSA

Monday 13 January 2025 – Morning

Level 3 Cambridge Technical in Applied Science

05847/05848/05849/05874/05879 Unit 2: Laboratory techniques

Time allowed: 2 hours
C341/2501

C341--2501

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

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

05847-02

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. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- Answer **all** the questions.

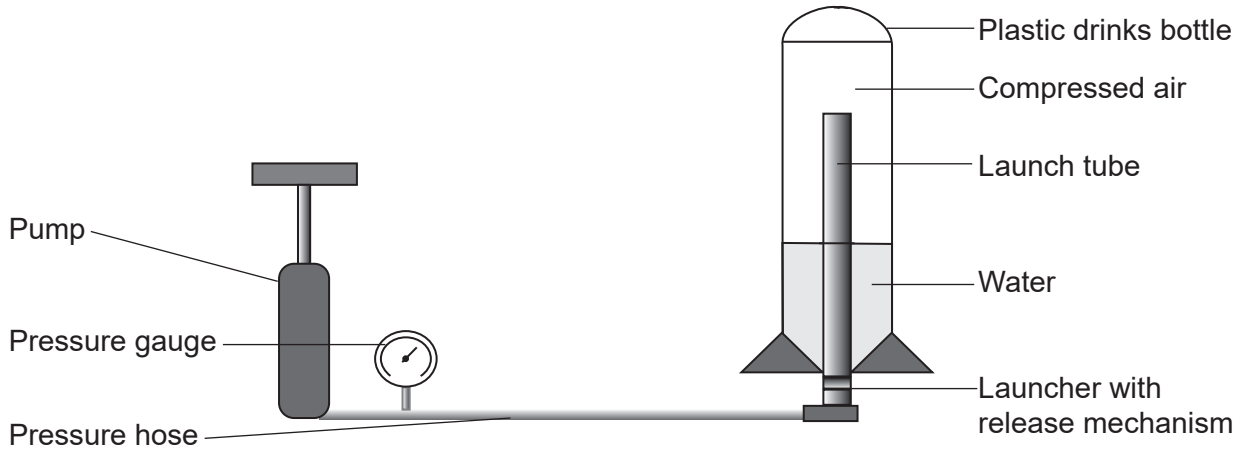
INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- The Periodic Table is on the back page.
- This document has **24** pages.

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

1 A water rocket is a type of model rocket that uses water as its reaction mass, powered by air pressure.

- The rocket body is a plastic drinks bottle.
- Water is forced out of the bottom of the rocket by the pressure of the air inside the bottle, and exerts an upward force on the rocket.
- This upward force causes the rocket to shoot upwards at high speed.
- The length of time the rocket is in the air depends on the air pressure and on the amount of water in the bottle.
- The maximum safe pressure which the bottle can hold is 700 kPa.

Some students are investigating how the pressure inside the bottle affects the length of time the rocket is in the air. They set up the water rocket as shown below.



They use the pump to increase the pressure inside the bottle and open the release mechanism to release the rocket when the air pressure has reached the required value.

(a) The students wrote up the method in their laboratory notebook as shown below.

Method

- We put some water into the bottle.
- We then pumped some air into the bottle and recorded the pressure in kPa.
- We released the bottle and timed how long it took for the bottle to return to the ground.
- Finally, we calculated the average time in the air for each pressure.

(i) Their teacher said that the method outlined in their notebook did not give enough details.

Suggest **three** details that the students should include in their write-up.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(ii) State **two** risks for this investigation.

1 .....

2 .....

[2]

(iii) State **two** safety precautions the students should take.

1 .....

.....

2 .....

.....

[2]

(b) The students use a table to collect and process data. Draw a suitable table for the task in the space below.

You only need to complete the column headings.

[4]

(c) The students plot a scatter graph and a bar chart of their results, as shown below.

Fig. 1.1

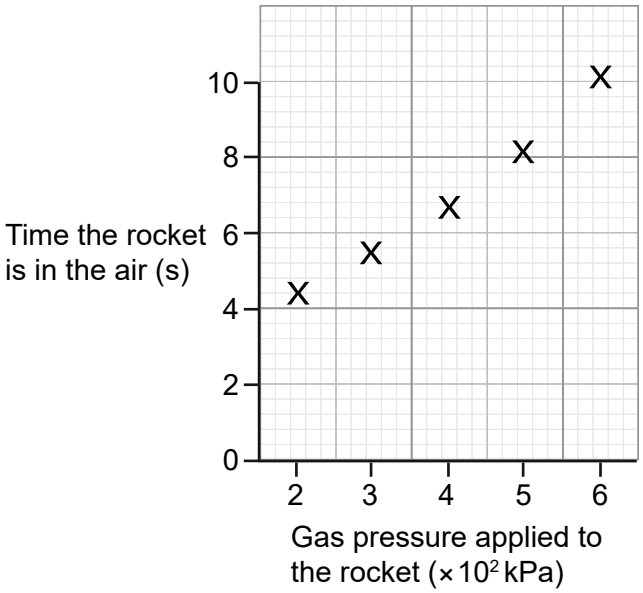
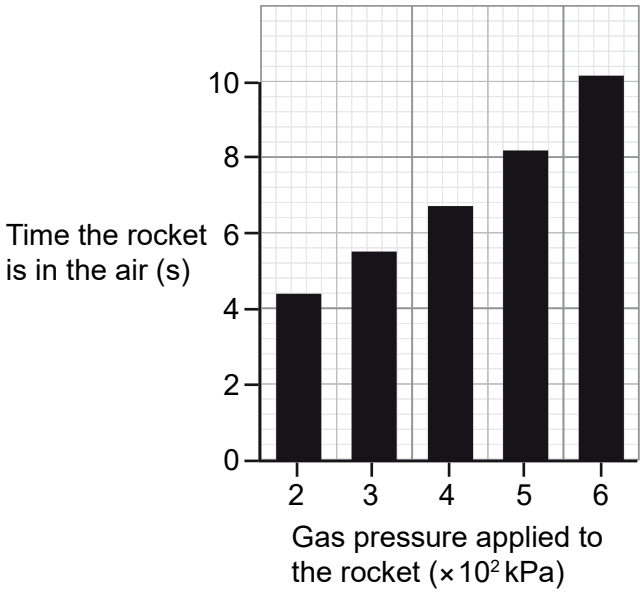


Fig. 1.2



Explain why **Fig. 1.1** is more suitable than **Fig. 1.2** for displaying the results the students obtained.

.....

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

(d) Use the data shown in **Fig.1.1** to write a conclusion.

.....

.....

.....

.....

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

BLANK PAGE

DO NOT WRITE ON THIS PAGE

Turn over for the next question

2 Gel Electrophoresis is a method used to separate mixtures of DNA, RNA or proteins. Gel Electrophoresis produces a DNA fingerprint which is unique to each individual.

DNA fingerprinting can be used to determine the parentage of a child.

(a)

(i) A technician swabs cheek cells from the mother, the child and two possible fathers, and processes the swabs using a technique called PCR.

State what PCR stands for.

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

(ii) Explain why PCR is used for this type of investigation.

.....

.....

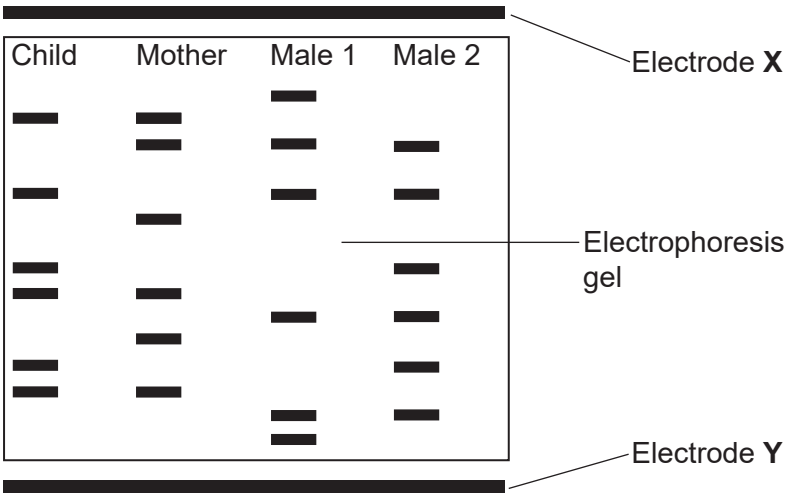
..... **[2]**

(b) After the PCR is completed, the technician uses gel electrophoresis to separate the fragments of DNA.

Fig. 2.1 shows the electrophoresis gel viewed from above.

The two electrodes are labelled **X** and **Y**.

Fig. 2.1



(i) Tick (✓) the box which indicates the correct charge on Electrode **X** and on the DNA fragments.

Charge on Electrode X	Charge on DNA fragments	
negative	positive	
positive	negative	
negative	negative	
positive	positive	

[1]

(ii) The fragments range in length from 200 bp to 1000 bp, where bp stands for base pair.

Identify the correct example of a base pair found in DNA.

Tick (✓) the box.

Base pair

Adenine – adenine ☐

Adenine – cytosine ☐

Adenine – guanine ☐

Adenine – thymine ☐

[1]

(iii) Label the shortest fragment on the diagram in **Fig. 2.1**.

Explain your answer.

.....

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

(iv) Children inherit half of their genetic material from their father and half from their mother. This means that half of the DNA fingerprint of a child is likely to overlap with that of their mother and half is likely to overlap with that of their father.

Use the DNA fingerprints in **Fig. 2.1** to determine which male (1 or 2) is most likely to be the father of the child.

Explain how you reached your conclusion.

Most likely father .....

Explanation .....

.....

.....

.....

.....

.....

[3]

(c) Give **one** other application for the use of gel electrophoresis in DNA fingerprinting.

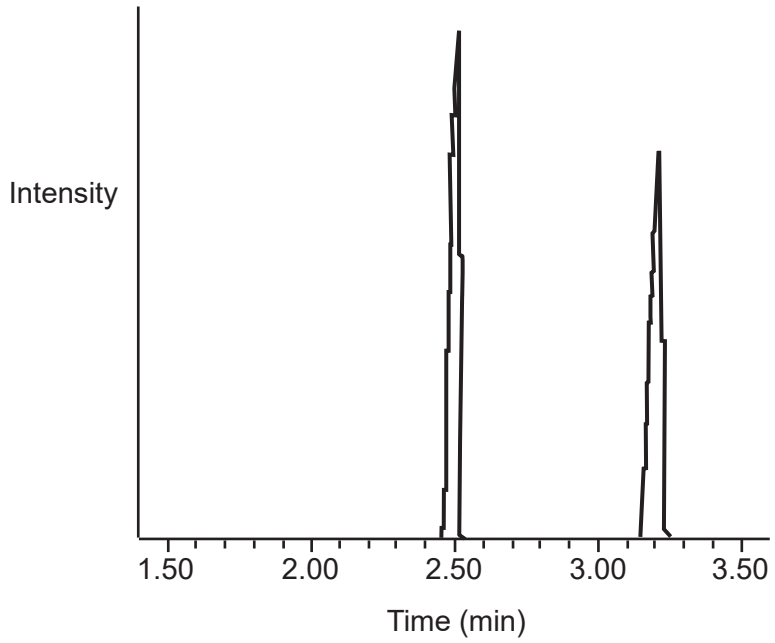
.....

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

(d) Chromatography is another important technique used by scientists to separate and identify substances in a mixture.

A technician analyses a mixture of two alcohols, pentan-1-ol and pentan-3-ol, by gas chromatography (GC).

The chromatogram is shown below.



(i) The technician does not know which peak corresponds to which alcohol.

Outline how the technician could use GC to determine which peak is pentan-1-ol.

.....

.....

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

(ii) Explain how the technician would determine the proportions of each alcohol in the mixture.

.....

.....

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

3 A transport company plans to reduce their carbon footprint by using biodiesel in their vehicles.

- Biodiesel can be made from waste cooking oil obtained from fast food restaurants.
- Waste cooking oil contains weak acids which must be neutralised before processing, by adding sodium hydroxide, NaOH.
- To determine how much NaOH is needed to neutralise the acids in the cooking oil, a small sample of waste cooking oil is dissolved in a solvent such as propan-2-ol and titrated against a standard solution of NaOH.
- The mass of NaOH required to neutralise the acids in a whole batch of waste cooking oil can be calculated from the result of the titration.

You will need to use the following equations in your answers to the numerical questions.

$$\text{Number of moles} = \frac{\text{mass in g}}{\text{molar mass (g mol}^{-1}\text{)}}$$

$$\text{Number of moles} = \frac{\text{concentration in mol dm}^{-3} \times \text{volume in cm}^3}{1000}$$

(a) First, a technician prepares 250 cm^3 of a 0.0250 mol dm^{-3} standard solution of NaOH.

(i) Show that the molar mass of sodium hydroxide is 40.0 g mol^{-1}.

[1]

(ii) Calculate the number of moles of NaOH needed to make 250 cm^3 of a 0.0250 mol dm^{-3} solution.

Moles = ... mol **[1]**

(iii) Calculate the mass of NaOH required.

Mass = ... g **[2]**

(iv) The technician dissolves the calculated mass of NaOH in water and makes up the solution to 250 cm^3.

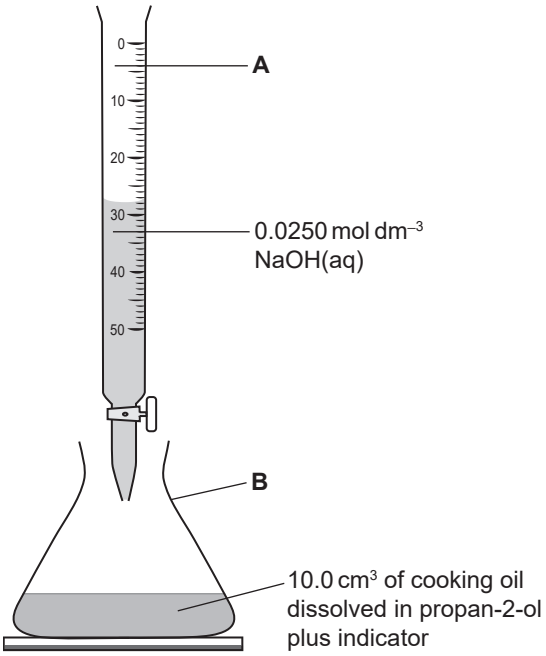
Name the piece of laboratory equipment the technician should use to make up the solution.

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

(b) The technician then does a titration to determine how much NaOH is required to neutralise the acids in a sample of the cooking oil.

The technician measures out 10.0 cm^3 of the cooking oil into a conical flask and adds an equal volume of propan-2-ol. The technician titrates this against 0.0250 mol dm^{-3} NaOH using phenolphthalein as the indicator.

(i) The diagram below shows the titration set-up that the technician uses.



Identify equipment **A** and **B**.

A .....

B .....

[2]

(ii) State the colour change of the phenolphthalein indicator at the end point of this titration.

From ..... to ..... **[1]**

(iii) Methyl orange is **not** a suitable indicator for this titration.

Suggest why it is not suitable.

.....

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

(iv) The table shows the results of four titrations completed by the technician.

Titre / cm^3			
20.30	20.15	20.10	20.15

Put (rings) around the results that are concordant.

[1]

(v) Calculate the mean titre that the technician should use in the calculation.

Give your answer to **two** decimal places.

Mean titre = ... cm^3 **[2]**

(vi) Use the mean titre to calculate the number of moles of NaOH required to neutralise the acids in 10.0 cm^3 of oil.

Number of moles NaOH = ... mol **[1]**

(c) The transport company has six containers of this waste cooking oil.

Each container holds 20 dm^3 of oil.

Calculate the mass of NaOH required to neutralise the acids in 20 dm^3 of oil.

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

Mass of NaOH = ... g **[4]**

4 Ultrasound and X-ray scanners can be used to create an image of structures hidden inside the body of a patient.

(a) Describe the differences between ultrasound and X-ray scanners.

In your answer refer to:

- how they work
- which structures can be seen in the image created
- potential hazards which pose a risk to the patient.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

(b) Electron microscopy can also be used to image difficult to view structures.

Fig. 4.1 shows a scanning electron micrograph of the eye of a fly.

Fig. 4.2 shows a light micrograph of the head of the same fly.

The distance from **A** to **B** is shown on the electron micrograph and the light micrograph. This distance can be used to determine the width of the fly's eye.

Fig. 4.1

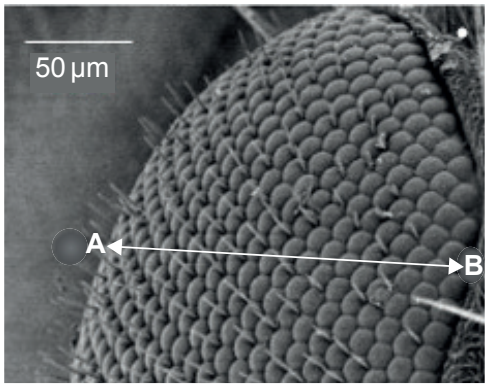
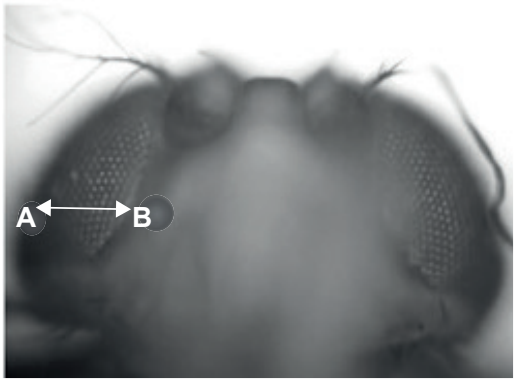


Fig. 4.2



(i) State **two** disadvantages of using electron microscopy, rather than light microscopy, for this type of study.

.....

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

(ii) Measure the distance, in mm, between points **A** and **B** in **Fig. 4.1** and **Fig. 4.2**.

- Distance between **A** and **B** in **Fig. 4.1**.

..... mm

- Distance between **A** and **B** in **Fig. 4.2**.

..... mm
[1]

(iii) Calculate how many times greater the magnification of the electron microscope is than the light microscope.

Magnification = ... times **[1]**

(iv) Use the line showing 50 µm in **Fig. 4.1** to calculate the actual width of the eye.

Give your answer in metres and in standard form.

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

(c) Describe **two** differences between scanning electron microscopy and transmission electron microscopy.

.....

.....

.....

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

BLANK PAGE

DO NOT WRITE ON THIS PAGE

Turn over for the next question

5 The sparks seen in a firework display are different colours because the fireworks contain different cations.

(a) State the colour of the sparks produced by each of the following cations.

Ba^{2+} .....

Ca^{2+} .....

Li^{+} .....

[3]

(b) Some students are investigating the flame colours emitted by different cations.

Describe how the students would do a flame test on a solid sample of potassium nitrate.

.....

.....

.....

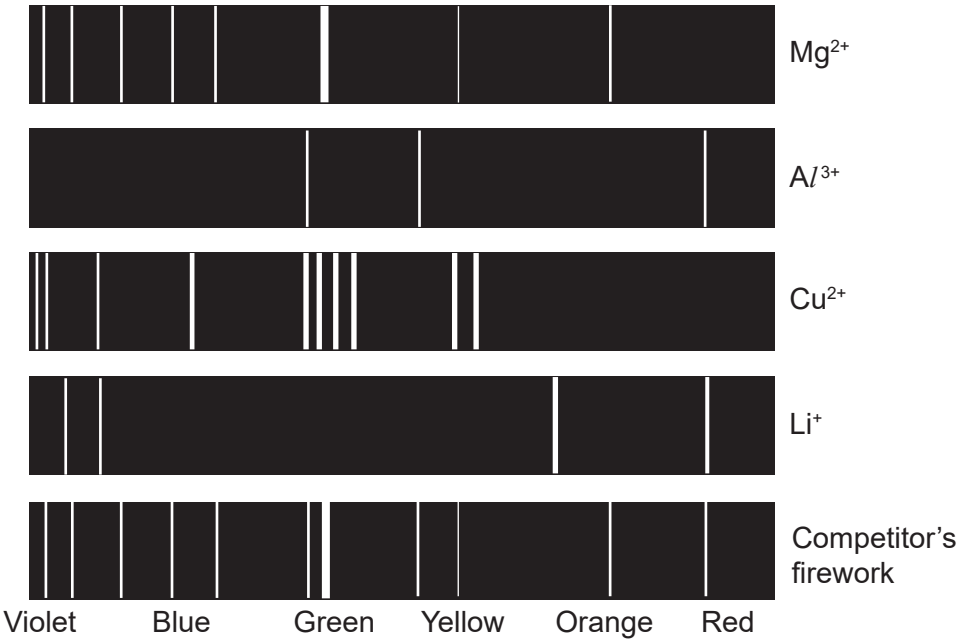
..... **[2]**

(c) A firework manufacturer is using AES to find the cations used in fireworks produced by a competitor.

(i) State what AES stands for.

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

(ii) The image shows spectra for **Mg**, **A*l***, **Cu** and **Li** and the competitor's firework.



State which **two** cations are in the competitor's firework.

1 ..... 2 ..... **[2]**

(iii) Justify your answer to **(ii)**.

.....

.....

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

(d) The firework manufacturer also uses ICP-AES to identify cations.

Put a (ring) around **two** cations that ICP-AES can identify but AES cannot.

Ca^{2+} **Fe^{2+}** **Mg^{2+}** **Na^{+}** **Pb^{2+}**

[2]

(e) AES can be used to find the concentration of lithium ions in a solution of unknown concentration (solution **T**).

A technician uses the following steps to obtain a calibration graph.

Step 1 The technician prepares 100 cm^3 of a solution containing 0.010 mol dm^{-3} of lithium ions. This is the stock solution **S**.

Step 2 The technician calculates the volume of solution **S** and the volume of water required to make 10 cm^3 of four more solutions to complete the calibration.

Step 3 The technician prepares the five solutions and places each one in turn (including the stock solution), in the AES instrument.

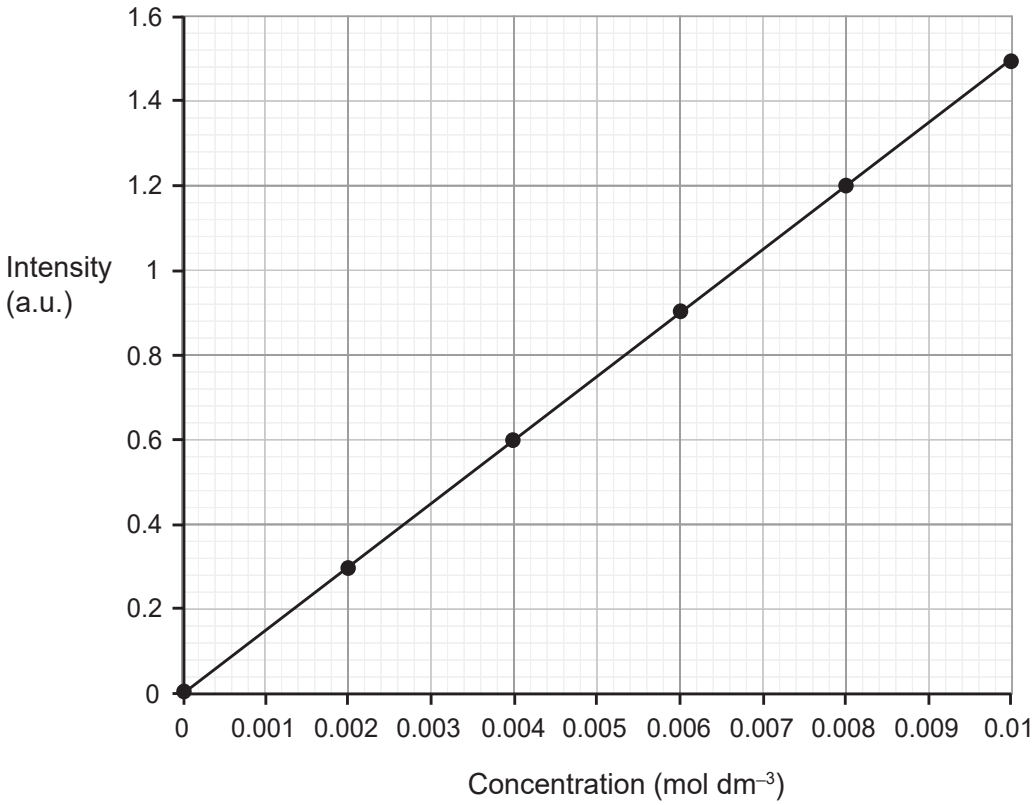
Step 4 The intensity of light emitted by each solution is then measured.

(i) Complete the table below to show the volume of solution **S** and the volume of water needed to prepare 10 cm^3 of each solution.

Concentration of Li+ (mol dm^{-3})	**Volume of solution S (cm^3)**	**Volume of water (cm^3)**
0.01	10	0
0.008		
0.006		
0.004		
0.002		

[2]

(ii) The technician plots a graph of intensity (a.u) against concentration (mol dm^{-3}) as shown below.



The technician then places the test solution **T** in the AES machine and notes that the intensity of light emitted is 0.7 a.u.

Use the calibration graph to determine the concentration in mol dm^{-3} of lithium ions in the test solution **T**.

Show your working on the graph.

Concentration of lithium ions = ... mol dm^{-3} **[2]**

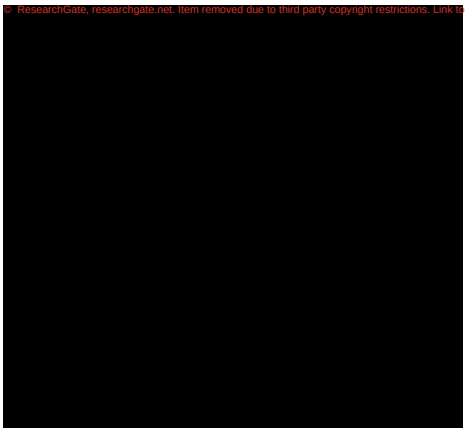
6 Some scientists are studying transformed roots to produce compounds that can be used as medicines.

Making transformed roots starts with injecting plant material with a bacterium that infects plants and causes them to produce only roots.

(a) The bacteria are firstly grown on an agar plate.

They are inoculated onto the agar surface by using a bacterial streaking technique.

Below is a photograph of an agar plate with the bacteria growing on it.



The scientists are discussing the appearance of the agar plate.

(i) Join each of the scientists' statements with the correct explanation for it.

Draw **two** lines only.

Statement	Explanation
The plate is not contaminated.	There is only one kind of colony.
We can get clones from this plate.	There are single colonies.
	There is a patch of agar with no colonies on it.

[2]

(ii) Describe the **four** steps followed by a scientist to streak bacteria onto an agar plate.

1 .....

.....

2 .....

.....

3 .....

.....

4 .....

.....

[4]

(iii) The agar and agar plate must be sterilised correctly before and after use.

Complete the sentences.

Use the words from the list.

autoclaved **dried** **flamed** **washed**

The words may be used once, more than once or not at all.

The agar must be ..... before it is poured into the agar plate.

Following their use in the experiment, the agar and agar plate must be

..... .

[2]

(b) After the bacteria have transformed the roots, the roots can be grown by tissue culture.

The image shows transformed roots growing on an agar plate.

(i) The sentences below summarise the method to create a tissue culture of transformed roots onto an agar plate.

Complete the sentences, using words from the list below.

The words may be used once, more than once or not at all.

autoclaving **cooling** **drying** **flaming** **wiping**

1 Sterilise the surfaces inside a controlled air flow hood by ..... with ethanol.

2 Sterilise scissors by dipping into ethanol and then ..... .

3 Cut a 5 cm length of transformed root with the sterile scissors.

4 Sterilise the forceps by dipping into ethanol and then ..... .

5 Use the sterile forceps to transfer the length of root to a fresh agar plate.

[3]

(ii) The scientists are discussing the appearance of the transformed roots growing on the agar plate and planning future investigations. They draw three conclusions.

Draw a line to connect each conclusion with a correct explanation.

Conclusion	**Explanation**
	...work in a controlled air flow cabinet.
We know the agar dish is not contaminated because...	...the agar surface does not contain any bacterial colonies.
To prevent us contaminating the agar dish containing the transformed roots we should...	...grow the culture in a large room.
To transfer samples of the roots onto other agar plates we should...	...autoclave the roots.
	... use the aseptic technique to surface-sterile the roots.

[3]

END OF QUESTION PAPER

The Periodic Table of the Elements

(1)	(2)												(3)	(4)	(5)	(6)	(7)	(0)
1													**13**	**14**	**15**	**16**	**17**	**18**
1 **H** hydrogen 1.0	**2**																	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	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	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	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	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	111 **Rg** roentgenium	112 **Cn** copernicium	113	114 **Fl** flerovium	115	116 **Lv** livermorium	117	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** darmstadium	111 **Rg** roentgenium	112 **Cn** copernicium	113	114 **Fl** flerovium	115	116 **Lv** livermorium	117	118	

Key
atomic number
Symbol
name
relative atomic mass

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