OCR
Oxford Cambridge and RSA

Wednesday 24 May 2023 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C341/2306

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. **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. 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.

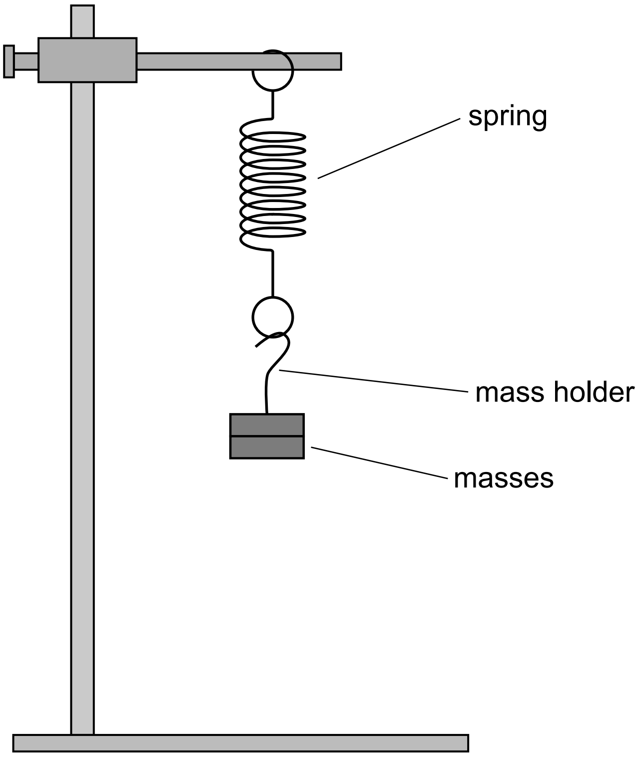
1 Amir is a technician working in a college science laboratory.

He is responsible for making sure that laboratory equipment is working correctly, and he also sets up equipment for practical investigations.

(a) A group of students are studying Hooke's Law.

Hooke's Law states that the extension of an elastic object is directly proportional to the force applied to it.

Amir sets up the equipment as shown below.



The students follow the method outlined below.

1. Record the length of the spring with the empty mass holder attached.
2. Add a 10 g mass to the holder and record the length of the spring.
3. Repeat by adding 10 g masses until 50 g is reached.
4. Calculate the extension of the spring.

(i) Name the other piece of equipment needed for this investigation, not shown above.

.... **[1]**

(ii) State **one** safety precaution that the students should take when completing this investigation.

.... **[1]**

(b) The students prepare a table so that they can record their results during the investigation.

Their table is shown below.

Mass (g)	Length of spring	Extension
0	20	....
10	25	....
20	31	....
30	35	....
40	40	....
50	46	....

(i) State the key piece of information not included in the table.

.... **[1]**

(ii) For each mass, calculate the extension of the spring and add the values to the table.

[1]

(iii) The students analyse the results in the table to determine whether Hooke's Law applies to their investigation.

Suggest the most appropriate way they should do this.

....

....

....

....

.... **[3]**

(iv) The students discuss how to write up their investigation.

List, in order, the **five** headings they should use.

1 ....

2 ....

3 ....

4 ....

5 ....

[3]

(c) Another group of students plan to use electronic balances for a different investigation.

Amir calibrates the electronic balances before they can be used by the students.

(i) Describe the steps Amir should follow to calibrate the balances.

....

....

....

....

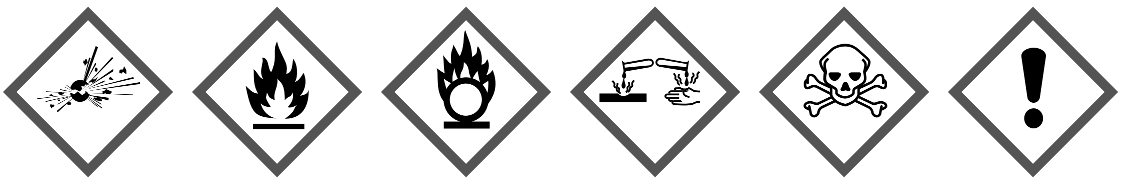
.... **[2]**

(ii) The students are studying the oxidation of ethanol. They begin their experiment by weighing out a known mass of ethanol which they take from a labelled container.

Amir knows that ethanol is a highly flammable liquid which causes eye irritation.

Select the **two** hazard symbols from the images below which Amir must include on the ethanol container label.

Put a (ring) around each correct letter.



A B C D E F

[1]

(iii) Suggest **one** safety precaution which the students need to take when using ethanol in the laboratory.

....

.... **[1]**

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Turn over for the next question

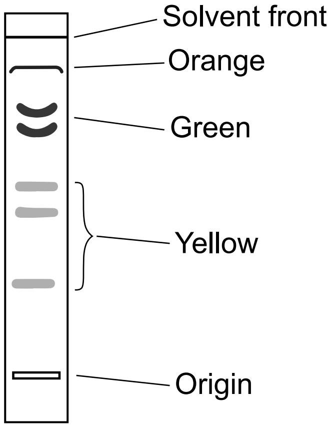
2 Tom is a trainee with a company involved in the extraction and analysis of plant components such as pigments, natural oils and pharmaceuticals.

(a) As part of Tom's induction programme, he analyses the pigments found in different vegetables.

- He chops up some spinach leaves and mixes the fine pieces with an organic solvent to extract the pigments.
- He uses thin layer chromatography (TLC) to separate the pigments extracted from the spinach leaves.

Fig. 2.1 shows the chromatogram Tom obtained for the spinach extract.

Fig. 2.1



(i) Tick (✓) all the advantages that TLC has compared to paper chromatography.

More reproducible results obtained using TLC	☐
TLC is cheaper	☐
TLC is easier to carry out	☐
TLC uses less extract	☐

[2]

(ii) Suggest how Tom can use thin layer chromatography to identify the different pigments extracted from the spinach leaves.

....

....

.... **[2]**

(iii) The table shows the pigments found in the spinach leaf extract.

Name of pigment	Pigment type	Colour
β-carotene	carotene	orange
chlorophyll a	chlorophyll	green
chlorophyll b	chlorophyll	green
lutein	xanthophyll	yellow
cryptoxanthin	xanthophyll	yellow
zeaxanthin	xanthophyll	yellow

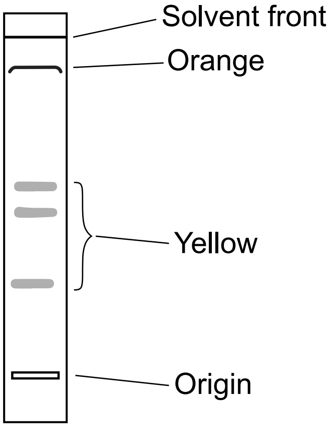
Take appropriate measurements in **Fig. 2.1** to calculate the R_f value of β-carotene.

R_f = ... **[2]**

(iv) Tom then repeats the experiment using carrots instead of spinach.

Fig. 2.2 shows the chromatogram obtained for the carrot extraction.

Fig. 2.2



Identify the differences between the chromatograms in **Fig. 2.1** and **Fig. 2.2** and explain why carrots are orange but spinach leaves are green.

Differences:

....

....

....

Why carrots are orange but spinach is green:

....

....
[3]

(b) The company is researching how active ingredients in plant herbal remedies can be used to develop drugs to treat diseases.

Tom is trained to carry out high performance liquid chromatography (HPLC) and gas chromatography (GC) to separate and identify the components of plants.

HPLC and GC use different stationary and mobile phases.

Use the words below to complete the following sentences.

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

Gaseous **Liquid** **Solid**

HPLC uses a .... stationary phase and a .... mobile phase.

GC uses a .... stationary phase and a .... mobile phase.

[2]

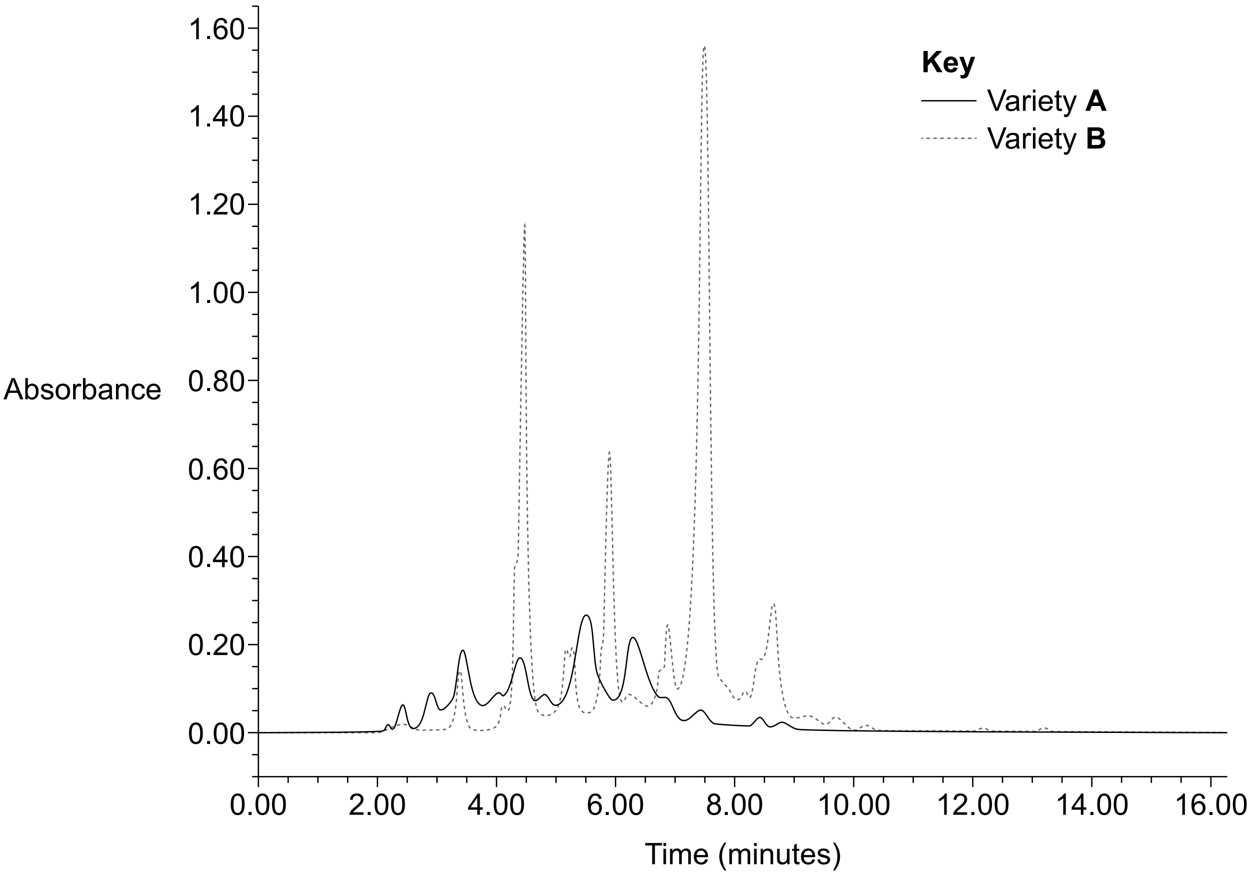
(c) *Artemisia annua* is a plant used in herbal remedies to limit the development of some forms of cancer.

- There are two varieties of *Artemisia annua*, **A** and **B**, which contain an active ingredient.
- The company plans to separate the active ingredient from other components found in the plant.

Tom uses HPLC to separate the components in the two varieties.

Fig. 2.3 shows the chromatogram of the two different varieties of *Artemisia annua*.

Fig. 2.3



(i) The compound with a retention time of 4.5 minutes is the active ingredient.

Write the letter **X** on the peak in **Fig. 2.3** which corresponds to this compound. **[1]**

(ii) Which variety (**A** or **B**) contains more of this compound assuming that equal amounts of the two varieties were analysed?

Tick (✓) the correct box.

Variety **A** ☐

Variety **B** ☐

[1]

(iii) Use **Fig. 2.3** to estimate how much more of the active ingredient is found in the variety identified in **(a)(ii)** compared to the other variety.

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

(iv) The active ingredient can be positively identified by linking up the HPLC equipment to a mass spectrometer (MS).

Assume that the active ingredient is **not** on the database of known compounds.

Explain how the mass spectrum can be analysed to identify the compound.

....

....

.... **[2]**

3 Yoghurt is produced by bacterial fermentation of milk.

During the fermentation process, the lactose in milk is converted into lactic acid which is a weak acid.

Jack works at a dairy farm producing plain and fruit yoghurts. One of his jobs is to determine if fermentation in plain yoghurt is complete. He does this by titrating samples against sodium hydroxide.

(a) Jack first prepares a standard solution of sodium hydroxide.

(i) Use the Periodic Table to determine the relative formula mass of sodium hydroxide, NaOH.

Relative formula mass = ...g mol^{-1} **[1]**

(ii) Calculate the mass of NaOH required to make 250 cm^3 of 0.05 mol dm^{-3} NaOH(aq).

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

(iii) Name **two** pieces of **measuring** equipment required to make an accurate standard solution.

Put a tick (✓) in the boxes next to the measuring equipment.

2 decimal place balance	☐
25 cm^3 graduated pipette	☐
25 cm^3 one-mark pipette	☐
50 cm^3 burette	☐
250 cm^3 conical flask	☐
250 cm^3 volumetric flask	☐

[2]

(b) Jack then fills up a burette with the sodium hydroxide solution.

Describe how Jack should wash out his burette before using it in the titration.

....

....

....

.... **[2]**

(c) Fermentation is complete when the lactic acid concentration is between 85 and 90 mmol dm^{-3}.

Jack uses the following method to determine whether fermentation is complete.

- Weigh out 10.30 g of plain yoghurt into a conical flask.
- Add a few drops of indicator.
- Titrate against 0.05 mol dm^{-3} sodium hydroxide.
- Repeat the titration until concordant titres are obtained.

(i) The indicator that Jack uses turns from colourless to pink at the end point.

Put a tick (✓) in the box next to the name of this indicator.

bromothymol blue	☐
litmus	☐
methyl orange	☐
phenolphthalein	☐
universal indicator	☐

[1]

(ii) Explain what **concordant titres** means.

.... **[1]**

(iii) The mean volume of 0.05 mol dm^{-3} NaOH used in the titration was 17.50 cm^3.

Calculate the concentration of lactic acid, in mol dm^{-3}, in the yoghurt.

Assume that:

- all the acid present in the yoghurt is lactic acid
- 10.30 g of yoghurt has a volume of 10.0 cm^3
- 1 mole of lactic acid is neutralised by 1 mole of NaOH.

Concentration of lactic acid = ... mol dm^{-3} **[3]**

(iv) Use the value obtained for **(c)(iii)** to explain how Jack knows that fermentation is complete.

....

.... **[1]**

(v) Jack is asked to determine the lactic acid concentration in a pot of strawberry flavoured yoghurt.

Suggest **two** reasons why Jack's method would **not** be suitable.

1 ....

....

2 ....

....

[2]

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Turn over for the next question

4 Mei is a researcher studying different blood disorders, which cause abnormalities of blood cells.

The magnification of blood samples is essential to examine the cells in blood.

Mei can use different pieces of equipment, ranging from electron microscopes and light microscopes to hand lenses when carrying out his research.

(a) The first column of the table lists features of the three pieces of equipment used for magnification.

Put a tick or ticks (✓) in each of the four rows to show the piece or pieces of equipment that have each feature.

Feature	**Electron microscope**	**Light microscope**	**Hand lens**
Easiest to use outside the laboratory			
Highest magnification			
Cheapest			
Can be used to view living blood cells			

[4]

(b) Sickle cell disease is a disorder of red blood cells and one of the symptoms of this disease is pain.

Mei uses a light microscope to take the images of blood cells shown in **Fig. 4.1** and **Fig. 4.2**.

Fig. 4.1 is sickle cell blood and **Fig. 4.2** is normal blood.

Fig. 4.1

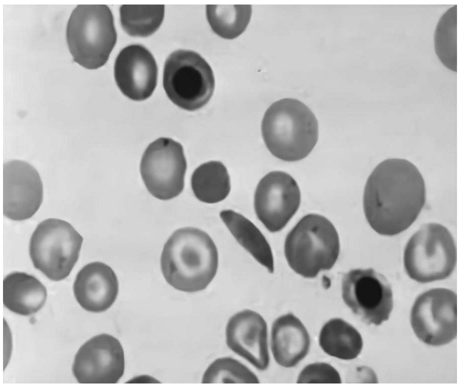
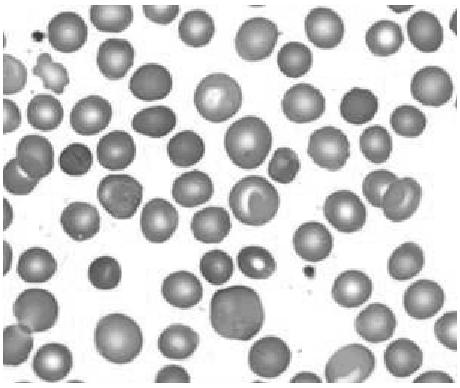


Fig. 4.2



(i) Light microscopes use an eye-piece lens and an objective lens to achieve the magnification required.

The images of blood cells in **Fig. 4.1** and **Fig. 4.2** are 400× magnification.

Tick (✓) the box next to the correct combination of lenses used to obtain the 400× magnification.

Eye-piece lens	Objective lens	
×40	×10	
×100	×4	
×10	×40	

[1]

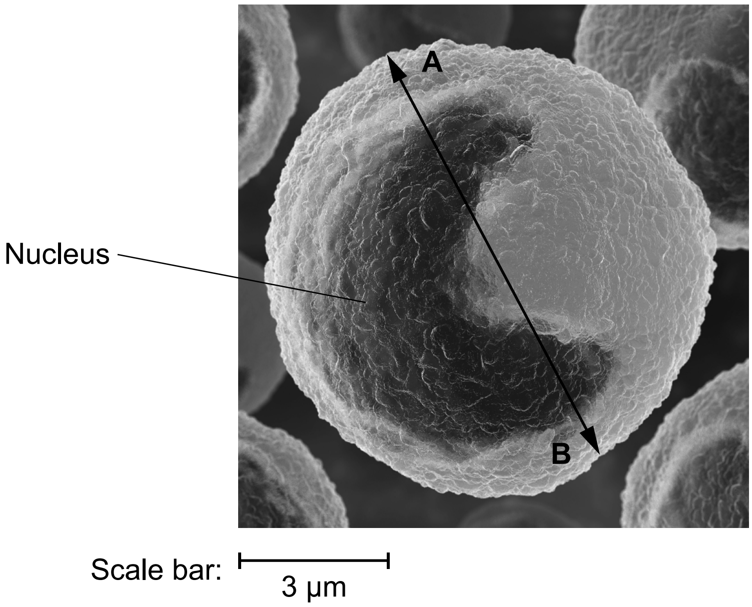
(ii) State **one** feature of cells visible when using a light microscope but **not** visible when using an electron microscope.

.... **[1]**

(iii) Suggest why the red blood cells in **Fig. 4.1** may get stuck and cause painful blockages in narrow blood vessels.

.... **[1]**

(c) Mei takes an image of a white blood cell using an electron microscope, shown below.



(i) Determine the measured and actual diameter of the white blood cell (**A** to **B**).

Firstly, use a ruler to measure the diameter (**A** to **B**).

Give your answer in mm.

Measured diameter of white blood cell = ... mm

Secondly, use the scale bar under the image and your measurement to calculate the actual diameter (**A** to **B**) of the white blood cell.

Give your answer in μm.

Actual diameter of white blood cell = ... μm
[1]

(ii) Calculate the magnification of the image.

Use the values obtained in **(c)(i)** and the equation

$$\text{Magnification} = \frac{\text{measured size}}{\text{actual size}}$$

Give your answer to **1** decimal place.

Magnification = ... × **[2]**

(iii) Suggest why it is more reliable to estimate the diameter of the white blood cell than to estimate the length of the nucleus.

....

....

.... **[2]**

(iv) State the type of electron microscope used to create the image.

Explain your answer.

....

....

.... **[2]**

5 Beth is a technician working in an analytical chemistry laboratory.

(a) One of Beth's tasks is to detect metal ions in food using AES and ICP-AES.

(i) What does AES stand for?

.... **[1]**

(ii) Put a (ring) around each element from the list whose cations can be tested using ICP-AES but **not** AES.

iridium **platinum** **potassium** **rubidium** **sodium**

[1]

(iii) Beth investigates the quantity of arsenic in rice using ICP-AES.

She prepares a series of arsenic standard solutions to produce a calibration graph.

The table shows the absorbance of the arsenic standards.

Concentration of arsenic ($\mu g\,dm^{-3}$)	**Absorbance (AU)**
0.0	0.00
1.0	0.08
2.0	0.13
3.0	0.20
4.0	0.27
5.0	0.33

Use the values in the table to plot a calibration graph on the grid below.

[4]

(iv) Beth carries out the method below to prepare rice for analysis.

- Weigh out 2.0 g of rice.
- Extract the arsenic from the rice using 100 cm^3 of solvent.
- Measure the absorbance of a sample of this solution using ICP-AES.

She measures the absorbance of this sample as 0.23 AU.

Use your calibration graph to determine the concentration of arsenic in the sample, showing clearly on the graph how you obtain your answer.

Concentration of arsenic = ... $\mu g\, dm^{-3}$ **[2]**

(v) The maximum permitted level of arsenic in rice is 0.20 $\mu g\, g^{-1}$.

Calculate the mass in µg of arsenic in 1.0 g of the rice and determine whether the rice is safe to eat.

Mass of arsenic in 1.0 g of rice = ... $\mu g\, g^{-1}$

Is the rice safe to eat? ....

[2]

(b) Beth is learning how to analyse ionic compounds using flame tests and chemical tests.

She has access to the equipment needed for flame tests and she can use a selection of the following solutions for the chemical tests.

- Barium chloride
- Hydrochloric acid
- Nitric acid
- Silver nitrate
- Sodium carbonate
- Sodium chloride
- Sodium hydroxide
- Sulfuric acid

Beth's supervisor gives her two white solids **X** and **Y**.

The supervisor tells Beth that **X** is aluminium sulfate, $Al_2(SO_4)_3$, and that **Y** is lithium bromide, LiBr.

Describe how Beth should test the two samples to check whether her supervisor is correct.

Include details of how you would carry out the tests.

....

....

....

....

....

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....

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....

....

.... **[6]**

6 The maintenance of sterile conditions and the use of aseptic techniques is essential for many areas of medicine and scientific research such as surgical operations, cloning plant tissues and space exploration.

(a) The conditions in a hospital operating theatre must be as sterile as possible.

(i) Draw lines to connect the features of the operating theatre to the most appropriate sterilisation method.

Feature of the operating theatre	**Sterilisation method**
Walls and floors	Irradiation with ultraviolet light
Metal surgical instruments	Autoclave
The air	Wipe down with disinfectant or pesticide

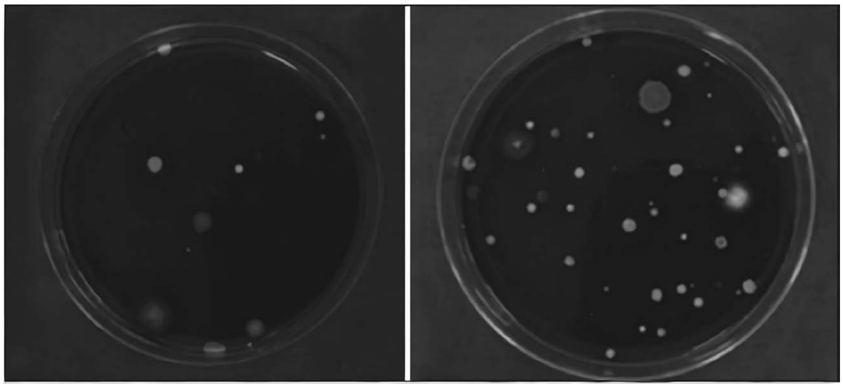
[2]

(ii) **Fig. 6.1** and **Fig. 6.2** show two settle plates used to monitor air quality.

Blood agar (settle) plates are left open in the operating theatre for 30 minutes.

Microorganisms in the air settle on the plates and grow to form colonies.

Fig. 6.1 **Fig. 6.2**



Describe and explain **two** differences that can be seen between the settle plates in **Fig. 6.1** and **Fig. 6.2**.

Difference 1 ....

Explanation ....

....

Difference 2 ....

Explanation ....

....

[4]

(iii) Suggest why it is important that all surgical instruments are sterilised before and after use.

Before use ....

....

After use ....

.... **[2]**

(b) Many different types of plants can be grown to form tissue cultures.

Aseptic conditions must be followed when creating and maintaining the tissue cultures.

Banana plant tissue cultures can be used to form clones.

Gros Michel is a variety of banana. All *Gros Michel* banana plants are clones.

(i) Explain what **clone** means.

.... **[1]**

(ii) Suggest **two** advantages of cloning bananas.

1 ....

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

(iii) Suggest **two** disadvantages that cloning bananas could have for banana growers.

1 ....

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

(iv) The banana plants can be cloned without using aseptic conditions.

Suggest **one** advantage this would have for banana plant breeders.

.... **[1]**

(c) Azmi is an engineer working for the European Space Agency.

Azmi is working alongside a team of scientists to build a rover to land on the surface of a planet to search for life.

The construction of the rover vehicle is carried out in a clean room environment.

Suggest why it is important that the rover is not contaminated with microorganisms.

....

.... **[1]**

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page. The question numbers must be clearly shown in the margins – for example, 3(b) or 5(b).

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

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