OCR
Oxford Cambridge and RSA

Monday 13 January 2020 – Morning

Level 3 Cambridge Technical in Applied Science

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

Time allowed: 2 hours
C341/2001

C341 – 2001

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

You can use:
- a scientific or graphical calculator

Please write clearly in black ink.

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink.
- Answer **all** the questions.
- 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.

INFORMATION
- The Periodic Table is on the back page.
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **28** pages.

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

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/15
2	/12
3	/17
4	/14
5	/17
6	/15
Total	**/90**

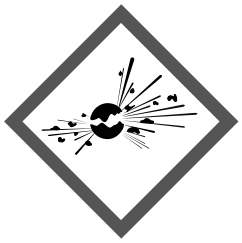
Answer **all** the questions.

1 Alex is a technician working in a college chemistry department.

(a) The chemicals used in the laboratory are labelled with warning symbols to identify the hazards.

Identify the meaning of each hazard warning symbol below.

Write your answer below each symbol.



....

[2]

(b) **Fig. 1.1** shows some typical glassware used in the college chemistry laboratories.

(i) Draw a line to link each piece of **equipment** to its correct **name**.

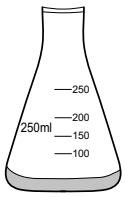
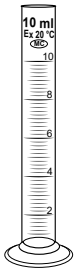
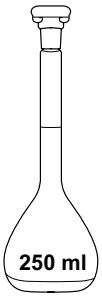
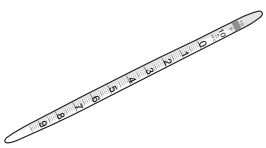
Equipment	Name
	Conical flask
	Graduated pipette
	Measuring cylinder
	Volumetric flask

Fig. 1.1

[3]

(ii) Suggest **one** potential hazard shared by all the pieces of equipment in **Fig. 1.1**.

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

(c) One of the college chemistry teachers is planning a class practical to investigate the oxidation of ethanol.

Fig. 1.2 shows part of the instruction sheet for the practical.

Chemicals required

Ethanol: HIGHLY FLAMMABLE

Acidified sodium dichromate solution: VERY TOXIC, CORROSIVE, OXIDISING

Method

1. Place exactly 3 cm^3 of acidified sodium dichromate solution in a boiling tube.
2. Use a teat pipette to add 5 – 7 drops of ethanol, with shaking.
3. Cool the mixture in the tube under a tap and note the smell.
4. When the reaction has subsided, warm the mixture gently, and again note the smell.

Fig. 1.2

(i) Safe storage of chemicals is an essential part of Health and Safety regulations.

Describe how Alex should store ethanol safely.

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

(ii) Alex decides to make up 250 cm^3 of a 0.2 mol dm^{-3} solution of sodium dichromate solution.

Which piece of equipment in **Fig. 1.1** would be most appropriate to make up the solution?

Tick (✓) **one** box.

Conical flask ☐

Graduated pipette ☐

Measuring cylinder ☐

Volumetric flask ☐

[1]

(iii) Alex then carefully adds approximately 10 cm^3 of concentrated sulfuric acid to the sodium dichromate solution.

Suggest which piece of equipment in **Fig. 1.1** would be most appropriate for measuring out the sulfuric acid.

Tick (✓) **one** box.

Conical flask	☐
Graduated pipette	☐
Measuring cylinder	☐
Volumetric flask	☐

[1]

(iv) Explain your answer to **(c)(iii)**.

.....

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

(v) All the students wear lab coats and safety glasses.

State **two** further precautions that the students should take to ensure that the practical work is carried out safely.

Explain your answers.

1.....

.....

2.....

.....

[2]

(vi) In **step 1** of the practical instructions in **Fig. 1.2**, students are told to 'Place exactly 3 cm^3 of acidified sodium dichromate solution in a boiling tube.'

Suggest which piece of equipment in **Fig. 1.1** would be most appropriate for measuring out the sodium dichromate solution.

Tick (✓) **one** box.

Conical flask	☐
Graduated pipette	☐
Measuring cylinder	☐
Volumetric flask	☐

[1]

(vii) In step 4 of the practical instructions in **Fig. 1.2** students are told to 'warm the mixture gently'.

Describe how the students should carry out **step 4** safely.

.....

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

2 Mia works in a laboratory specialising in analysing DNA.

She has been asked to prepare some agarose gel for use in gel electrophoresis.

(a) Mia plans to make 70 cm^3 of a 1.25 % (W/V) agarose solution.

Calculate the mass of agarose she will need to make 70 cm^3 of a 1.25 % (W/V) agarose solution.

Give your answer to **2** significant figures.

Mass of agarose ……..…… g **[1]**

(b) Polymerase chain reaction (PCR) is a technique that can be used on the DNA before it is separated on the agarose gel.

What is the function of the polymerase chain reaction?

Tick (✓) **one** box.

To purify DNA from bacterial cells. ☐

To amplify copies of a specific region of DNA. ☐

To increase the total amount of DNA. ☐

[1]

(c) Gel electrophoresis is a technique used to analyse PCR products.

(i) DNA fragments move during electrophoresis because they are charged.

What is the **charge** of the electrode the DNA moves towards?

Put a (ring) around the correct answer.

Negative **Neutral** **Positive**

[1]

(ii) Outline how gel electrophoresis of DNA is set up.

You may draw a labelled diagram to support your answer.

.....

.....

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.....

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.....

.....

.....**[4]**

(d) **Fig. 2.2** is a gel electrophoresis image produced using PCR.

It shows some marker DNA fragments and DNA fragments present in three samples, **A**, **B** and **C**.

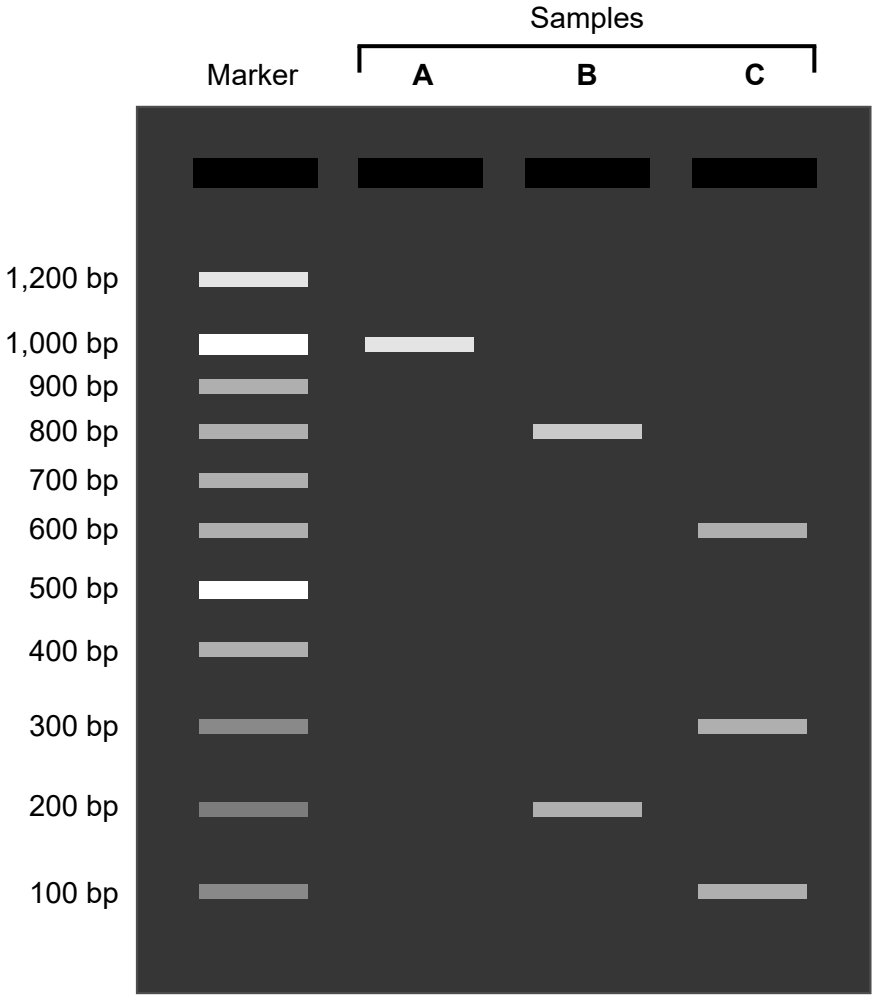

Fig. 2.2

Use **Fig. 2.2** to calculate the difference in size between the two fragments found in **sample B**.

Difference in size = ……..…..... bp **[1]**

(e) Mia suggests some changes to the electrophoresis set-up.

These changes will have an effect on the outcome of the electrophoresis.

Draw a line to connect the **change** to the correct **effect**.

Change	**Effect**
Increase the potential difference of the power supply.	No separation of DNA fragments.
Use alternating current instead of direct current.	Better separation of small fragments of DNA, poorer separation of larger fragments.
Use a non-mutagenic dye to visualise the DNA.	Reduces the risk associated with gel electrophoresis.
Use a higher percentage of agarose in the gel.	Reduces the time it takes to separate the DNA fragments.

[4]

3 Titration is a laboratory technique which is used to determine the concentration of a solution.

(a) Indicators can be used to show the end point of an acid-base titration.

Some indicators are listed below:

- Bromothymol blue
- Litmus
- Methyl orange
- Phenolphthalein.

(i) Which indicator can be used for a strong acid-weak base titration?

Tick (✓) **one** box.

Bromothymol blue ☐

Litmus ☐

Methyl orange ☐

Phenolphthalein ☐

[1]

(ii) Which indicator can be used for a weak acid-strong base titration?

Tick (✓) **one** box.

Bromothymol blue ☐

Litmus ☐

Methyl orange ☐

Phenolphthalein ☐

[1]

(b) **(i)** State the colour of bromothymol blue in acidic conditions.

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

(ii) Suggest why universal indicator is not a suitable indicator for an acid-base titration.

.....

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

(c) Anhydrous sodium carbonate has the formula Na_2CO_3.

(i) Use the Periodic Table to calculate the relative formula mass (Mr) of sodium carbonate.

Relative formula mass = ……..…..... g/mol **[1]**

(ii) Calculate the mass of sodium carbonate required to make 250.0 cm^3 of a 0.0600 mol dm^{-3} standard solution.

Mass of sodium carbonate = ... g **[3]**

(d) James is a science student.

He uses the standard sodium carbonate solution to find the concentration of some hydrochloric acid, HC*l*(aq).

He titrates the 0.060 mol dm^{-3} sodium carbonate solution against 10.0 cm^3 of the hydrochloric acid.

(i) Give the name of the apparatus used to measure the 10.0 cm^3 of hydrochloric acid.

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

Table 3.1 shows the results of the titration

	Titration 1	**Titration 2**	**Titration 3**
Final reading (cm^3)	32.80	31.45	31.50
Initial reading (cm^3)	1.10	0.10	0.05
Titre (cm^3)	31.70	31.35	.....

Table 3.1

(ii) Calculate the titre for **Titration 3** and write your answer in **Table 3.1**.

[1]

(iii) Calculate the mean titre of 0.060 mol dm^{-3} Na_2CO_3 that James should use for analysing his results.

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

(iv) Calculate the number of moles of sodium carbonate used in the titration.

Use the equation: number of moles = $\frac{\text{concentration (mol dm}^{-3}\text{) x mean titre (cm}^3\text{)}}{1000}$

Number of moles of sodium carbonate …..…… mol **[1]**

(v) In the reaction between sodium carbonate and hydrochloric acid, **1 mole** of Na_2CO_3 reacts with **2 moles** of HC*l*.

Use the reacting ratio to calculate the number of moles of HC*l* in 10.0 cm^3 of the hydrochloric acid.

Number of moles of HC*l* = ……..……..…..…… mol **[1]**

(vi) Calculate the concentration, in mol dm^{-3}, of the hydrochloric acid.

Give your answer to **3** significant figures.

Concentration of HC*l* = ……..…….. mol dm^{-3} **[2]**

4 Sundip is studying microscopy.

Her biology teacher asks her to investigate the different features of microscopes.

(a) Sundip first compares light and electron microscopes.

Some of the advantages and disadvantages of light and electron microscopy are shown in **Table 4.1**.

Put a tick (✓) in the correct column of **Table 4.1** to show if the advantage or disadvantage applies to a light microscope or an electron microscope.

Advantages or disadvantages	**Light microscope**	**Electron microscope**
Cheaper equipment cost		
Highest magnification is up to x 2000		
More skill required to prepare samples		
Produces colour images		
Smaller equipment size and easier to use		
Can view live specimens		
Image cannot be viewed directly by human eye		

Table 4.1 **[7]**

(b) Sundip starts to consider different types of electron microscope in more detail.

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) have different uses. These are shown in **Table 4.2**.

Put a tick (✓) in the correct column for each use.

Use	**SEM**	**TEM**
Viewing below-surface features		
Forming images from reflected electrons		
Showing the internal composition of a structure		
Showing the overall form or shape of a structure		

Table 4.2 **[4]**

(c) Sundip is shown an image produced by an electron microscope. This type of image is called an electron micrograph.

Fig. 4.1 shows an electron micrograph of a virus.

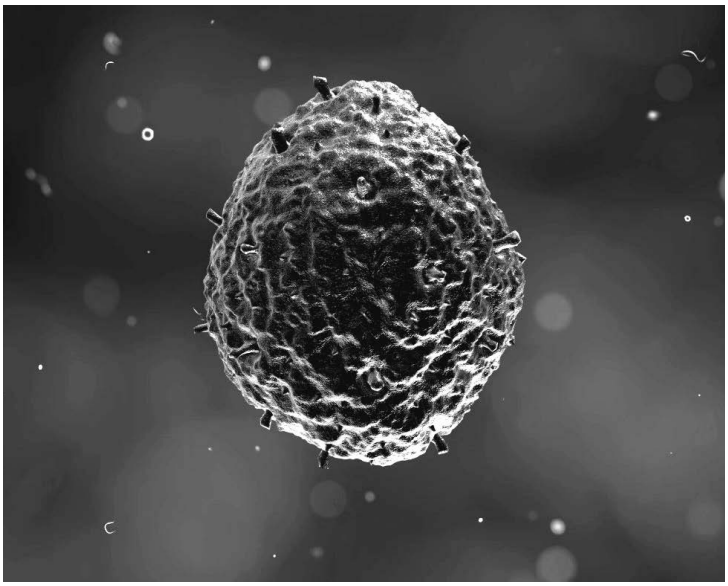

Fig. 4.1

(i) Use a ruler to measure the diameter of the image of the virus in **Fig. 4.1** at the widest part, to the nearest mm.

This is called the image diameter.

Widest diameter of virus (image diameter) = …… mm **[1]**

(ii) The actual diameter of the virus is 200 nanometres (nm).

Convert this value into millimetres (mm).

Actual diameter of virus = ...…..……..... mm **[1]**

(iii) Calculate the magnification of the electron micrograph.

Use the formula: magnification = measured size ÷ actual size

Show your working.

Magnification = x …….....……. **[1]**

5 **(a)** Kai is a laboratory technician. He carries out tests on various chemical samples.

(i) Kai often uses flame tests to identify cations in unknown samples.

He has three bottles, each containing a white solid. One is sodium chloride, another is lithium chloride and the other is barium chloride.

He uses a flame test to identify the cation in each sample.

State the flame colour for each of the white solids in **Table 5.1**.

White solid	Flame colour
Lithium chloride	
Barium chloride	
Sodium chloride	

Table 5.1 **[3]**

(ii) Describe how a flame test is carried out.

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.....

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.....

.....

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

(b) Cations can also be identified using precipitation reactions with aqueous sodium hydroxide.

Draw a line to connect each **cation** to the correct **colour of precipitate with sodium hydroxide**.

Cation	**Colour of precipitate with sodium hydroxide**
Iron (III) (Fe^{3+})	White
Iron (II) (Fe^{2+})	Light blue
Copper (II) (Cu^{2+})	Pale green
Aluminium (Al^{3+})	Orange-brown

[4]

(c) Kai also carries out tests using ion chromatography to determine the concentration of caffeine in energy drinks.

The presence of caffeine is shown as a peak in the chromatogram, and the peak area is a measure of its concentration.

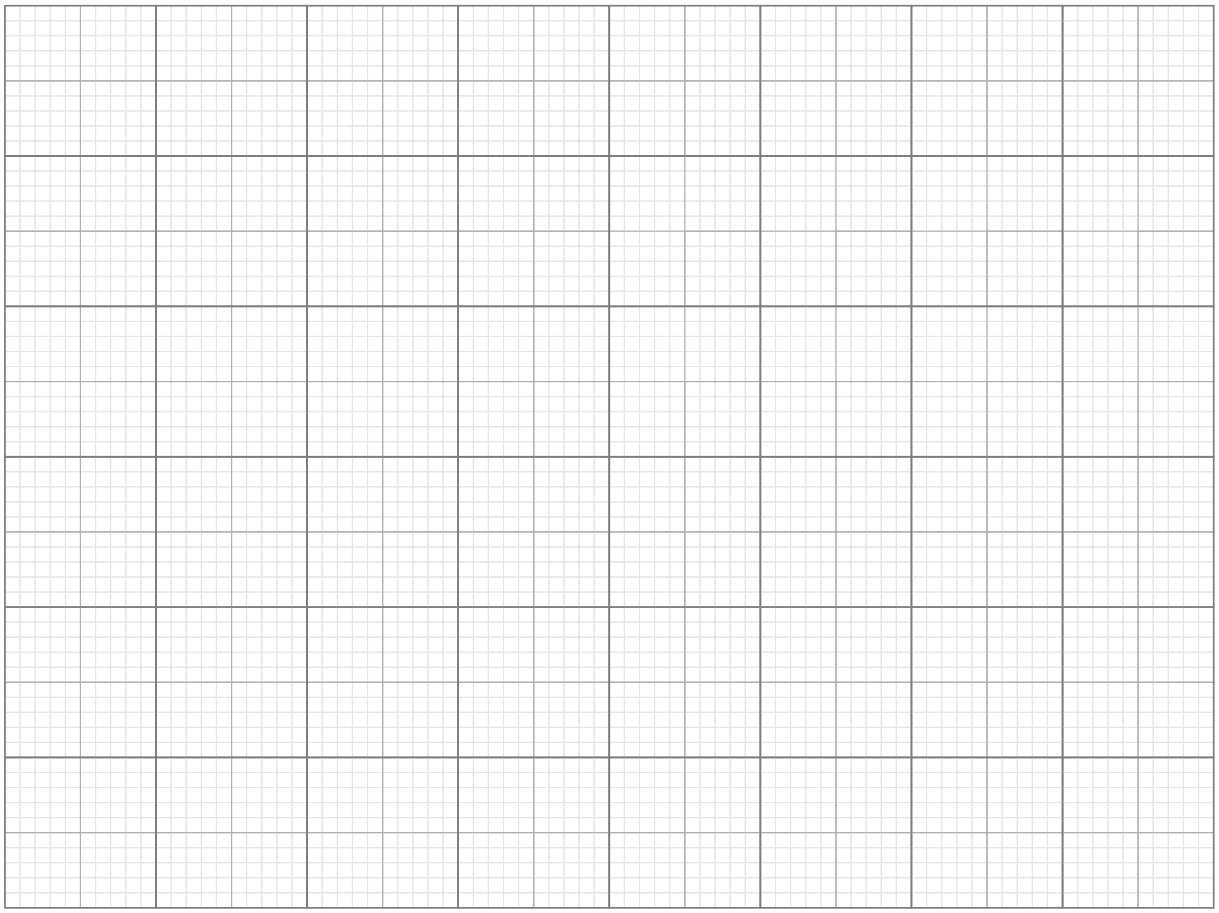
Kai constructs a calibration graph using known concentrations of caffeine.

Table 5.2 shows the relative peak areas of known concentrations of caffeine.

Concentration of Caffeine (mg dm^{-3})	**Relative peak area**
10.0	35
25.0	70
50.0	140
100.0	280
150.0	420

Table 5.2

(i) Plot a graph of the calibration data in **Table 5.2**.



[5]

(ii) A sample of an energy drink has a caffeine peak with a relative peak area of 340.

Use the calibration graph you have drawn to determine the concentration of caffeine in the energy drink.

Show on your graph how you obtained your answer.

Concentration of caffeine drink = …..…..… mg dm^{-3} **[2]**

6 Aseptic techniques are an essential feature of biology laboratories.

(a) Different scientific equipment is sterilised in different ways.

Draw a line to connect each type of **equipment and/or material** to the correct **sterilisation method**.

Equipment and/or material	Sterilisation method
Many flasks of bacterial growth medium	Autoclaving
Antibiotic solutions	Dry heat
Inside of controlled air flow cabinets	Filtering
Plastics for medical applications	Gamma irradiation
Glass graduated pipettes	Spray with disinfectant

[5]

(b) **Fig. 6.1** shows bacterial colonies growing on an agar plate after bacteria were streaked on to the plate.

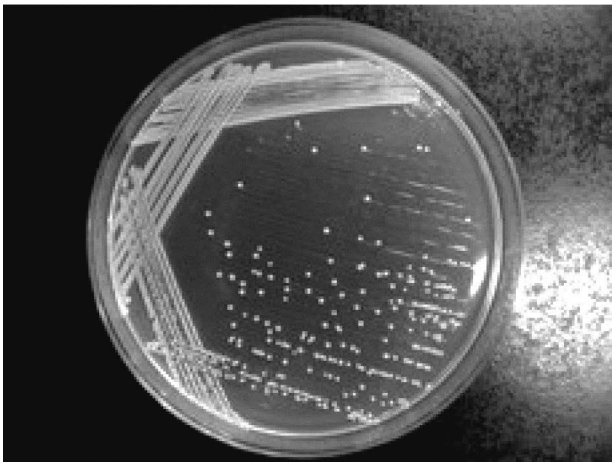


Fig. 6.1

Explain how bacteria can be streaked onto a plate to obtain individual colonies.

You may draw a labelled diagram to support your answer.

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

(c) Suggest why it is important to obtain single colonies on the plate.

.....

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

(d) Teams of science technicians often share tasks in biology laboratories. One of the technicians streaked a plate of bacteria obtained from a pure culture. However, she did not use the correct aseptic technique.

Fig. 6.2 shows a magnified view of the plate.

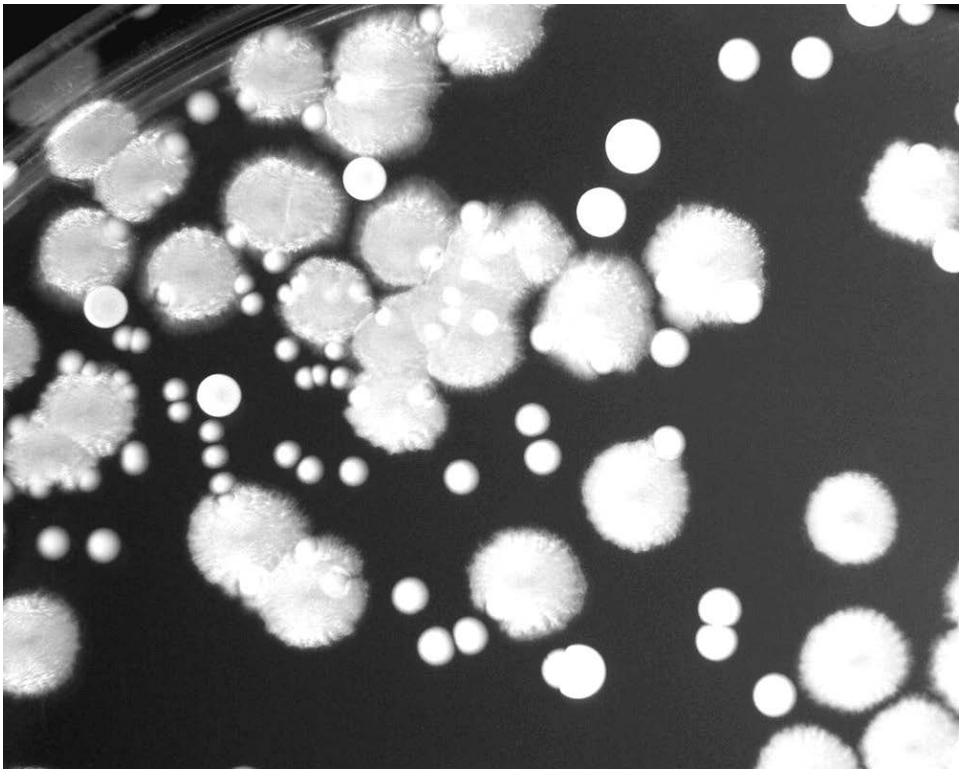

Fig. 6.2

(i) State how you can tell that the plate is contaminated.

.....

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

(ii) Estimate the number of different microorganisms present on the plate.

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

(iii) Explain why the contaminated plate should be autoclaved as soon as is possible.

.....

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

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown in the margins – for example, 2 (c)(ii) or 6(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

Oxford Cambridge and RSA