

Cambridge TECHNICALS LEVEL 3

Cambridge  
TECHNICALS  
2016

# LABORATORY SKILLS

Feedback on the January 2018 exam paper  
(including selected exemplar candidate answers  
and commentary)

Unit 2 – Laboratory techniques

Version 1

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## INTRODUCTION

This resource brings together the questions from the January 2018 examined unit (Unit 2), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

We have also included exemplar candidate answers with commentary for Questions 1(a), 2(b), 5(b)(i), 5(b)(ii), 5(c) and 5(d).

The marking guidance and the examiner's comments are taken from the Report to Centre for this question paper.

The Question Paper, Mark Scheme and the Report to Centre are available from:

<https://interchange.ocr.org.uk/Modules/PastPapers/Pages/PastPapers.aspx?menuindex=97&menuid=250>

**OCR**  
Oxford Cambridge and RSA

**Level 3 Cambridge Technical in Laboratory Skills**  
05847/05848/05849/05874/05879

**Unit 2: Laboratory techniques**  
**Friday 12 January 2018 – Morning**  
**Time allowed: 2 hours**

You must have:  
• a ruler

You may use:  
• a scientific or graphical calculator

First Name:  Last Name:

Centre Number:

Candidate Number:

Date of Birth:

**INSTRUCTIONS**

- Use black ink.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer all the questions.
- Write your answer to each question in the space provided.
- If additional answer space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- The Periodic Table is printed on the back page.

**INFORMATION**

- The total mark for this paper is 80.
- The marks for each question are shown in brackets [ ].
- This document consists of 24 pages.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/15
2	/15
3	/15
4	/11
5	/15
6	/15
Total	/80

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**Cambridge Technicals**  
**Laboratory Skills**

Unit 2: Laboratory Techniques

Level 3 Cambridge Technical Certificate/Diploma in Laboratory Skills  
05847 – 05848 05874 – 05879

**Mark Scheme for January 2018**

Oxford Cambridge and RSA Examinations

**OCR**  
Oxford Cambridge and RSA

**Cambridge Technicals**  
**Laboratory Skills**

Level 3 Cambridge Technical Certificates in Laboratory Skills  
05879, 05847

Level 3 Cambridge Technical Diplomas in Laboratory Skills  
05848, 05849

**OCR Report to Centres January 2018**

Oxford Cambridge and RSA Examinations

## GENERAL EXAMINER COMMENTS ON THE PAPER

This paper was very different than has probably been seen before by many candidates or Centres. Historically candidates do not sit a paper that contains more than one science discipline in a level 3 paper. This is only the second time this paper has been sat. Some areas were answered well and candidates showed good knowledge of safe working practice and flame tests. They were able to calculate the number of genomes in a sample. Areas that were weaker were some of the more complex laboratory techniques such as gel electrophoresis and ICP-AES.

This is a techniques paper and so the focus is on the techniques they need to know.

### **Resources which might help address the examiner comments:**

From the link below, you'll find 'The OCR guide to examinations' (along with many other skills guides)

<http://www.ocr.org.uk/i-want-to/skills-guides/>

Command verbs definitions

<http://www.ocr.org.uk/Images/273311-command-verbs-definitions.pdf>

## Questions 1(a) and (b)

Answer **all** the questions.

- 1** Middle East Respiratory Syndrome (MERS-CoV) is a disease of the respiratory system. MERS-CoV is caused by a new strain of a virus called a coronavirus.

- (a)** The virus has been transmitted from infected patients to other patients and workers within hospitals.

Suggest **two** ways in which the transmission of the virus could be reduced in hospitals.

1. *Any two from:* .....  
 • Isolate affected patients; .....  
 ... • Hospital staff wear gloves; .....  
 • Hospital staff wear masks; .....  
 2. • Hospital staff wash hands (when caring for patient/when on ward/regularly); .....  
 • Hospital environment cleaned thoroughly/with disinfectant/kept clean; .....  
 ... • Transfer of patients between wards kept to a minimum. [2]

- (b)** In 2014 it emerged that camels in the Middle East were the main source of the virus.

The link to camels was established when scientists analysed blood samples from infected camels.

- (i)** Suggest **two** precautions the scientists should take when they are taking blood samples from camels.

1. *Any two from:* .....  
 • Carry out Risk Assessment; .....  
 2. • Wear gloves/wear mask/avoid contact with blood; ..... [2]  
 • Follow standard procedures strictly; .....  
 • Caution when handling (hypodermic) needles/use sterilised needles; .....  
 • Answers related to keeping the camel restrained.

- (ii)** Suggest **two** precautions the scientists should take when they are analysing blood samples that may be contaminated with microorganisms.

1. *Any two from:* .....  
 • Staff trained in necessary procedures; .....  
 2. • Wear gloves/wear mask/avoid contact with blood; ..... [2]  
 • Follow (organisational) guidance/adhere to (organisational) regulations; .....  
 • Use good laboratory practice/no eating/no drinking/no smoking; .....  
 • Avoid splashes/work in biological safety cabinet if splashes likely to occur; .....  
 • Decontaminate work surfaces after work/sterilise/autoclave wastes.

### Mark scheme guidance

#### Question 1(a):

Ignore anti bacterial.

**Examiner comments**

Questions 1(a), (b)(i) and (b)(ii) – These questions were well answered. There was good understanding of safe working practice. Some candidates confused bacteria and viruses which affected their answers.

## Exemplar Candidate Work

## Question 1(a) – Medium level answer

- 1 Middle East Respiratory Syndrome (MERS-CoV) is a disease of the respiratory system.  
MERS-CoV is caused by a new strain of a virus called a coronavirus.

(a) The virus has been transmitted from infected patients to other patients and workers within hospitals.

Suggest **two** ways in which the transmission of the virus could be reduced in hospitals.

1. Wear suitable clothing which prevents the skin to be touched with someone who has the disease
2. Sterilise the places he infected has been so if someone else goes there they are not affected because they are sitting in sterile, clean place. [2]

## Commentary

This candidate has given the idea of cleaning the hospital environment. They have used the term 'sterilise' which isn't quite what the mark scheme asks for but they also use the phrase 'clean place' so it is clear they mean the environment to be cleaned thoroughly as in the mark scheme.

A better answer would have stated that they clean the area with disinfectant. A high level answer would have given another way to reduce transmission of the virus e.g. isolate patients. There are several correct options on the mark scheme the candidate could have given. Wearing suitable clothing is not specific enough. The candidate should state the specific clothing such as gloves or masks to gain more credit.

## Exemplar Candidate Work

## Question 1(a) – High level answer

- 1 Middle East Respiratory Syndrome (MERS-CoV) is a disease of the respiratory system.  
MERS-CoV is caused by a new strain of a virus called a coronavirus.

(a) The virus has been transmitted from infected patients to other patients and workers within hospitals.

Suggest **two** ways in which the transmission of the virus could be reduced in hospitals.

- 1..... making sure all equipment that is used is  
sterilised.....
- 2..... washing hands or protecting skin exposure  
with gloves, goggles or masks.....

[2]

**Commentary**

Gloves and masks are independent points and so both gain credit even though they are on the same answer line. The point about sterilising equipment isn't quite enough to gain credit but it does not negate any correct answers and so does not affect the final mark.

Washing hands is also creditworthy so overall this is a very good answer.



## Mark scheme guidance

### Question 1(c)(i):

**ALLOW** specific example of treating in same way.

### Question 1(c)(ii):

One mark is awarded for the explanation.

### Question 1(d)(i):

**ALLOW** appropriate facilities not available in country of origin/other labs are more specialised or have better equipment.

### Question 1(d)(ii):

**ALLOW** references to 'biohazard' labelling.

## Examiner comments

Question 1(c)(i) – This question was about how to produce repeatable results. Many candidates discussed accuracy. They did not consider how the current test should be similar to that carried out in 1992.

Question 1(c)(ii) – Few candidates stated that the components of blood should be separated. Many knew to freeze the blood although some just said keep cool which was not creditworthy. Some were able to explain why the blood should be separated and frozen.

Question 1(d)(i) – This was answered well with an understanding that the lab may not be specialised enough. A few candidates gave an answer relating to traceability or procedures.

Question 1(d)(ii) – Many candidates incorrectly gave modes of transport such as truck or boat when answering this question. They needed to discuss how the sample was packaged/stored/labelled etc.

## Question 1(d)(iii)

(iii) A laboratory receives tissue samples for analysis.

Identify the type of sample to be removed for analysis.

Put a tick (✓) in the box next to the correct answer.

random

representative

whole

[1]

**Mark scheme guidance**

>1 tick = 0 marks

## Questions 2(a) and (b)

2 A DNA-sequencing laboratory in the UK receives tissue samples for analysis.

(a) Suggest **two** features of the DNA sample to be checked before sequencing.

1.
  - Determine/approximate the amount present;
2.
  - Check the quality of DNA present/check that DNA has not been degraded.

[2]

(b) When DNA from tissue samples is analysed the DNA has to first be broken into fragments.

One of the next stages of analysis of DNA from tissue samples is the Polymerase Chain Reaction (PCR).

Describe **two** of the steps carried out during PCR.

1. *Any two from:*
  - Primers added (to copy specific DNA sequence);
  - Nucleotides added;
  - Polymerase added;
  - DNA/mixture heated and cooled in cycles;
2.
  - DNA helix separates;
  - adds complementary nucleotides adjacent to/on locating primer;
  - Cycle repeated many times/specified number (to produce many copies).

[2]

### Mark scheme guidance

#### Question 2(b):

Maximum 1 mark if RNA mentioned.

#### Examiner comments

Question 2(a) – Many candidates answered this in terms of blood samples and not DNA samples, and so discussed disease or contamination. This was not creditworthy. Candidates needed to discuss quantity and quality of DNA to score marks.

Question 2(b) – This was answered very poorly. Candidates did not know this process and many answered in terms of addition polymerisation reactions. They needed to describe the actual steps in the process.

## Exemplar Candidate Work

## Question 2(b) – Low level answer

(b) When DNA from tissue samples is analysed the DNA has to first be broken into fragments.

One of the next stages of analysis of DNA from tissue samples is the Polymerase Chain Reaction (PCR).

Describe **two** of the steps carried out during PCR.

1. The chains of the polymerase are attached together first.

2. The chains all have to be the same length to make it work properly.

[2]

### Commentary

In general this question was not well answered. Many candidates tried to answer in terms of the chemistry of addition polymerisation rather than the actual steps that a laboratory technician would have to do. This is a laboratory skills qualification and so many questions need to be answered in terms of skills, methods or techniques.

There is nothing creditworthy in this answer as the candidate has not described any of the steps necessary. The question should be answered in terms of what is added and the techniques used e.g. heating and cooling.

## Exemplar Candidate Work

## Question 2(b) – High level answer

(b) When DNA from tissue samples is analysed the DNA has to first be broken into fragments.

One of the next stages of analysis of DNA from tissue samples is the Polymerase Chain Reaction (PCR).

Describe **two** of the steps carried out during PCR.

1. A primer attaches at 55°C, it attaches to the selected strands that have been replicated.

2. DNA polymerase then attaches the free nucleotides to the strands. This occurs at 75°C.

[2]

**Commentary**

This answer has the idea that primers and polymerase are added. The candidate has not used the term 'added' and is really trying to describe the reaction rather than the steps. There is enough evidence of understanding the steps to award marks. A better answer for these mark points would be:

1. primer is added
2. polymerase is added.

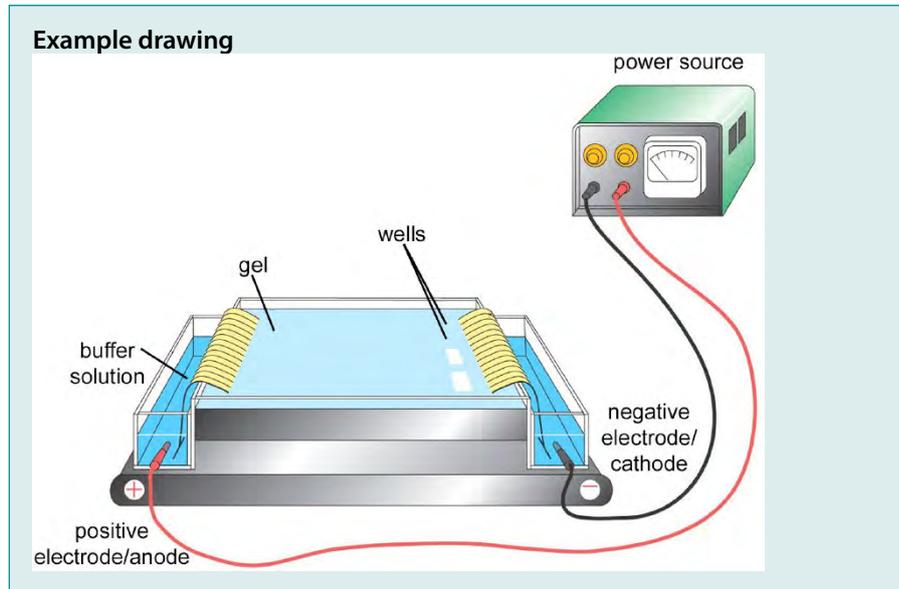
Again, this candidate is describing the reaction and not the steps carried out. However, in doing so has managed to identify the correct things to be added and so has gained marks.

## Question 2(c)

(c) The DNA fragments are then separated by gel electrophoresis.

(i) Describe how gel electrophoresis can be carried out in a school or college laboratory.

You may draw a diagram in the space below to help with your description of the process.



Any four from:

- Add buffer to chamber;
- Place the gel in the (electrophoretic) chamber;
- With wells closest to negative electrode/cathode;
- Load wells of (agarose) gel with (DNA) sample(s);
- Add tracking dye;
- Place the lid on the chamber;
- Connect electrodes to power supply/turn on/run current through;
- Allow to run for requisite period of time/until separation achieved/dye crosses gel.

[4]

(ii) Explain how gel electrophoresis separates the fragments of DNA.

Any three from:

- Electric field applied (to gel with DNA fragments);
- Gel has pores;
- DNA is negatively-charged;
- (DNA fragments) move towards positive electrode/anode;
- Fragments separated according to size/speed at which fragments move is inversely proportional to length/larger fragments can't pass through gel easily.

[3]

## Mark scheme guidance

### Question 2(c)(i):

**ALLOW** differences in learners' sequencing of procedure.

Learners may describe a procedure where the gel is run in the vertical plane; the principles are the same.

**ALLOW 2** marks max. for clear and correct use of a drawing.

### Examiner comments

Question 2(c)(i) – This question was answered poorly. Some candidates described TLC. Others knew a little but were not able to give enough detail to gain a mark e.g. having wells was not enough to gain the mark. It must be clear the wells are near the negative electrode. This could have been shown on a diagram.

Question 2(c)(ii) – Many candidates put the same answer for 2ci as 2cii. This was an explanation question and so they should have shown an understanding of how gel electrophoresis works.

## Questions 2(d) and (e)

- (d) DNA samples must contain the optimum amount of DNA for analysis.

The mass of the human genome is 6 picograms.

1000 picograms = 1 nanogram

The DNA-sequencing laboratory prepares samples for fragmentation containing

400 nanograms of DNA / 100  $\mu\text{l}$ .

Calculate the number of complete genomes that are contained in a 1  $\mu\text{l}$  fragmented sample.

Show your working.

**FIRST CHECK THE ANSWER LINE**

**If answer = 666 award 3 marks**

Mass genome = 6pg = 0.006ng

Mass of DNA sample = 400ng  $\div$  100 $\mu\text{l}$  = 4ng  $\mu\text{l}^{-1}$

4  $\div$  0.0006 = 666.66 so .....

(number of complete genomes in sample  $\Rightarrow$ ) 666

number of complete genomes = ..... [3]

- (e) State the name of an alternative technique that can be used to separate components within a mixture of DNA.

(Paper/thin-layer/gas/high-performance liquid) chromatography. [1]

### Examiner comments

Question 2(d) – This question was answered very well. Most candidates could calculate the answer correctly. However, the question asked for complete genomes and so some candidates lost a mark as they did not give a whole number.

Question 2(e) – A well answered question.



## Questions 3(a)(ii) and (iii)

(ii) Complete **Table 3.2** to show the flame test results for the three cations listed.

Cation	Colour in a flame
calcium	brick-red
potassium	lilac
sodium	yellow

**Table 3.2**

[3]

(iii) Explain why a flame test could **not** be used to identify all of the elements in a sample of *Spirulina*.

Any two from:

- Not all the elements in *Spirulina* give flame colours;
- Not suitable for analysing more than one element/cation at once;
- Intensity of sodium flame masks others;
- Concentration of element/cation too low.

[2]

### Mark scheme guidance

#### Question 3(a)(ii):

**AWARD** one mark for each correct row.

**ALLOW** acceptable, alternative descriptions of flame colours.

#### Examiner comments

Question 3(a)(ii) – This was a well answered question in general. It is important that candidates know key information such as flame colours.

Question 3(a)(iii) – This question was also well answered with most candidates getting at least one mark. Some did not express the idea that not all elements give flame colours and so did not gain this mark.

## Question 3(b)

- (b) The scientists use inductively-coupled plasma-atomic emission spectroscopy (ICP-AES) to carry out their analyses.

Explain the principles of this technique and the advantages of using this technique for the analysis of elements in a sample of *Spirulina*.

**Valid points:****Principles of ICP-AES**

- Sample dissolved/liquid sample nebulised
- Plasma source/argon plasma at 7000 K – 10 000 K used to dissociate/split sample into constituent atoms/ions
- Excites electrons to higher energy levels
- On return to ground state, emit photons of wavelength characteristic of element
- Light recorded on optical spectrometer
- Intensity is proportional to concentration of element in sample
- Light emitted compared with calibrated standard to give quantitative analysis of sample

**Improved analysis**

- Very low limits of detection
- Multi-element analysis/Many elements can be analysed using this technique
- Wide analytical range
- High speed/sample throughput
- Can be left unattended/no flammable gases involved

.....[6]

**Mark scheme guidance**

**[Level 3]** Candidate shows a high level of understanding of the principles of ICP-AES and explains the advantages of using this technique.

**(5 – 6 marks)**

**[Level 2]** Candidate shows an understanding of the principles of ICP-AES, with knowledge of some advantages of this technique.

**(3 – 4 marks)**

**[Level 1]** Candidate shows a basic understanding of the principles of ICP-AES and with little or no explanation.

**(1 – 2 marks)**

**[Level 0]** Candidate includes fewer than two valid points.

**(0 marks)**

**Examiner comments**

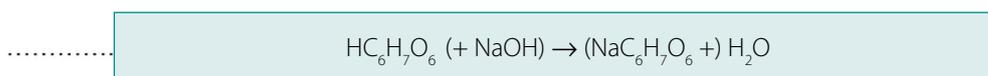
Question 3(b) – Most candidates did not perform well here. It was clear they had not had any experience of this technique. Centres must ensure candidates use or see demonstrations of all the techniques in the specification.

## Question 4(a)

- 4 Helena is a quality control scientist analysing the vitamin C content of a sample of liquid vitamin supplement.
- (a) Vitamin C is a monoprotic acid. One way of estimating the concentration of vitamin C in a sample is by titrating against sodium hydroxide.

- (i) The formula of vitamin C is  $\text{HC}_6\text{H}_7\text{O}_6$ .

Complete the balanced symbol equation for the reaction between vitamin C and sodium hydroxide.



[2]

- (ii) The properties of some indicators are shown in **Table 4.1**.

Indicator	Colour change	pH range
bromophenol blue	yellow – blue	2.8 – 4.6
methyl red	red – yellow	4.2 – 6.3
bromothymol blue	yellow – blue	6.0 – 7.6
phenol red	yellow – red	6.8 – 8.4
thymol blue	yellow – blue	8.0 – 9.6

**Table 4.1**

Vitamin C is a weak acid and sodium hydroxide is a strong base.

Using this information, select the most appropriate indicator from **Table 4.1** for a titration of a sample containing vitamin C against sodium hydroxide solution.

Justify your selection.

Indicator ..... Thymol blue .....

Justification End point/equivalence point lies within colour range of thymol blue. .....

.....

.....

[2]

### Mark scheme guidance

#### Question 4(a)(i):

1 mark for the missing reactant.

1 mark for missing product.

**Question 4(a)(ii):**

If indicator is incorrect no marks awarded.

**Examiner comments**

Question 4(a)(i) – It was nice to see that most candidates could complete this equation. They lost marks where they did not read the question.

Question 4(a)(ii) – Most candidates were not able to answer this question. They did not understand equivalence points and did not know why different indicators are used for different titration reactions.

## Questions 4(b) and (c)(i)

(b) Helena begins to carry out the titration.

(i) She makes up a solution of sodium hydroxide and finds that its concentration is  $0.2445 \text{ mol dm}^{-3}$ .

Suggest how Helena finds the concentration of the sodium hydroxide solution.

Any two from:

- Make up solution of sodium hydroxide solution at approximate concentration required;
- Standardise;
- With potassium hydrogen phthalate of known concentration.

[2]

(ii) She measures out  $5 \text{ cm}^3$  of the liquid vitamin supplement into a conical flask.

Name the piece of equipment Helena would use to measure out the liquid vitamin supplement.

Put a tick (✓) in the box next to the correct answer.

gas syringe

graduated pipette

beaker

dropper

[1]

(c) Helena's titration results are shown in **Table 4.2**.

	titration			
	rough	1	2	3
final reading ( $\text{cm}^3$ )	24.00	23.65	47.35	23.60
initial reading ( $\text{cm}^3$ )	0.00	0.00	23.65	0.00
volume of sodium hydroxide used ( $\text{cm}^3$ )				
average volume of sodium hydroxide used ( $\text{cm}^3$ )				

**Table 4.2**

(i) Complete **Table 4.2** by calculating:

- the volume of sodium hydroxide used for each titration
- the average volume of sodium hydroxide used.

Volumes:            24.00    23.65;    23.70;    23.60  
Average:            23.65

[1]

**Mark scheme guidance****Question 4(b)(i):**

**ALLOW** standardisation with hydrochloric acid.

**Question 4(b)(ii):**

>1 tick = 0 marks

**Question 4(c)(i):**

All answers must be correct for one mark.

**DO NOT ALLOW** average volume based on the inclusion of rough titration.

**Examiner comments**

Question 4(b) – Again a description of the technique was required here. Most candidates tried to give a calculation and so did not score marks.

Question 4(c)(i) – Candidates lost this mark because they included the rough titre in their average calculation.

## Questions 4(c)(ii) and (iii)

- (ii) Calculate the average number of moles of sodium hydroxide that reacted with the vitamin C in the liquid vitamin supplement.

Use the formula:

$$n = c \times V$$

$c$  = concentration in  $\text{mol dm}^{-3}$

$n$  = number of moles

$V$  = volume in  $\text{dm}^{-3}$

Show your working.

**FIRST CHECK THE ANSWER LINE**  
**If answer = 0.005782 (moles), award 3 marks**

Conversion of  $23.65 \text{ cm}^3$  to  $0.02365 \text{ dm}^3$

Substitution into formula and calculation:

$$c = 0.2445 \times 0.02365$$

$$= 0.005782 \text{ (moles)}$$

average = ..... moles  
**[3]**

- (iii) The molar mass of vitamin C is  $176.12 \text{ g mol}^{-1}$ .

Calculate the concentration of vitamin C in the liquid vitamin supplement.

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

Show your working.

**FIRST CHECK THE ANSWER LINE**  
**If answer = 203.67 ( $\text{mg cm}^{-3}$ ), award 3 marks**

Any three from:

1 mole vitamin C  $\equiv$  1 mole NaOH

$\therefore$  0.005782 moles of vitamin C (in conical flask)

0.005782 moles of vitamin C =  $(0.005782 \times 176.12) \text{ g} = 1.0183 \text{ g}$

= 1.0183 mg (in  $5 \text{ cm}^3$ )

=  $1.0183 \div 5 \text{ mg (in } 1 \text{ cm}^3)$

= 203.67 ( $\text{mg cm}^{-3}$ );

concentration = .....  $\text{mg cm}^{-3}$   
**[3]**

### Mark scheme guidance

#### Question 4(c)(ii):

**ALLOW** ecf stemming from an incorrect average value shown in the table at 4(c)(i).

#### Question 4(c)(iii):

**ALLOW** ecf from 4(c)(ii).

**Examiner comments**

Question 4(c)(ii) – Error was carried forward from 4(c) in order to not penalise candidates. Many lost marks because they did not convert  $\text{cm}^3$  to  $\text{dm}^3$ .

Question 4(c)(iii) – Again error was carried forward from 4(c)(ii). Candidates divided 176.12 by their answer for 4(c)(iii) rather than multiply it and so lost marks. Most did not divide by 5.

## Question 5(a)(i)

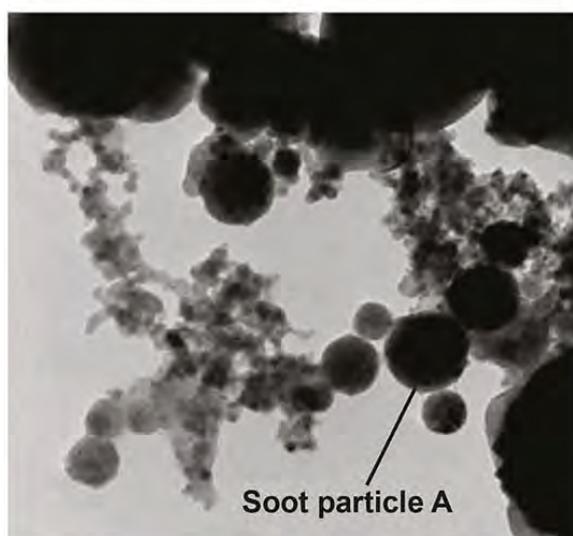
- 5 Forensic microscopy is often used in cases of industrial hygiene, environmental monitoring and forensic investigations.

(a) Steve is an industrial forensic technician.

He analyses the fumes produced during welding.

Steve examines deposits from the fumes with a transmission electron microscope. A number of soot particles are visible in the transmission electron micrographs.

- (i) One of the transmission electron micrographs he produces is shown in **Fig. 5.1**.



**Fig. 5.1**

The magnification of the micrograph shown in **Fig. 5.1** is  $\times 120\,000$ .

Calculate the diameter of **Soot particle A**.

Use the formula:

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

Show your working.

**FIRST CHECK THE ANSWER LINE**

**If answer = 100 (nm), award 3 marks**

Width of soot particle = 12 mm on micrograph

= 12 000 000 nm

(magnification =  $\times 120\,000$ )

$$\therefore \text{actual size} = \left( \frac{12\,000\,000}{120\,000} \right) \text{ nm}$$

= 100 (nm)

**OR** (working in millimetres)

(Width of soot particle = 12 mm on micrograph)

(magnification =  $\times 120\,000$ )

$$\therefore \text{actual size} = \left( \frac{12}{120\,000} \right) \text{ mm}$$

= 0.0001 mm

= 100 (nm)

diameter = ..... nm  
[3]

**Mark scheme guidance**

**Allow** measurement between 12 and 13mm.

**Examiner comments**

Many candidates did not know how to work out the diameter. It is important to practice these types of calculations as although they are in different contexts the maths is quite simple.

## Questions 5(a)(ii) and (b)(i)

- (ii) Suggest **two** reasons why Steve uses a transmission electron microscopy (TEM), rather than other forms of microscopy.

1. Any two from

- Better resolution (than light microscopy or scanning electron microscopy);
- Higher magnification possible (than light microscopy or scanning electron microscopy);

2. • No requirement to see surface of structures (as provided by scanning electron microscopy).

[2]

- (b) A team of firefighters was exposed to dust clouds when tackling an industrial fire. They were asked to provide sputum samples from their lower airways for analysis. The samples were examined by Steve using scanning electron microscopy.

Fig. 5.2 shows a micrograph of a particle removed from one of the firefighter's lungs.



Fig. 5.2

- (i) The length of the particle is 125  $\mu\text{m}$ .

Draw a scale bar of appropriate length next to Fig. 5.2.

Show your working.

Length of particle represented by 62.5 mm on micrograph.

Choice of suitable length of scale bar, e.g. equivalent to 50  $\mu\text{m}$ .

Correct calculation of length of this scale bar:

$$\text{represented by } \left( \frac{50}{125} \times 62.5 \right) \text{ mm}$$

$$= 25 \text{ mm}$$

Accurately drawn and labelled scale bar.

[4]

**Mark scheme guidance****Question 5(a)(ii):**

Comparison of magnification needed.

**Question 5(b)(i):**

**If scale bar = 25 mm in length, and labelled, 50  $\mu\text{m}$  (or suitable alternative), award max. 2 marks if working is not shown.**

**If scale bar drawn = 62.5 mm in length and labelled 125  $\mu\text{m}$  award max 1 mark if working is not shown.**

**ALLOW** measurement =  $27.5 \pm 1$  mm.

**Accept** measurement =  $62.5 \pm 1$  mm.

**Examiner comments**

Question 5(a)(ii) – There needed to be a comparison e.g. higher resolution to gain these marks.

Question 5(b)(i) – Candidates struggled with this question. Most drew a line with no real scale or units. It was unclear why the length of the scale bar had been chosen.

## Exemplar Candidate Work

## Question 5(b)(i) – Low level answer

- (b) A team of firefighters was exposed to dust clouds when tackling an industrial fire. They were asked to provide sputum samples from their lower airways for analysis. The samples were examined by Steve using scanning electron microscopy. Fig. 5.2 shows a micrograph of a particle removed from one of the firefighter's lungs.



Fig. 5.2

- (i) The length of the particle is  $125\ \mu\text{m}$ .  
 Draw a scale bar of appropriate length next to Fig. 5.2.  
 Show your working.

$$L = 125\ \mu\text{m}$$

6.3

125

[4]

## Commentary

This question asks the candidates to draw a scale bar of appropriate length. In a laboratory setting this should be a scale that would be useful to use whatever was being measured. This candidate has drawn a scale along the length of the particle and labelled it  $125\ \mu\text{m}$ . Technically this is correct and gains compensatory credit. However, a scale of  $125\ \mu\text{m}$  is not an appropriate scale and there is no working shown. A suitable length would be  $50\ \mu\text{m}$  or possibly  $10\ \mu\text{m}$ . The candidate should also show some working. The scale bar should then be drawn accurately based on the working.

Exemplar Candidate Work

Question 5(b)(i) – Medium level answer

(b) A team of firefighters was exposed to dust clouds when tackling an industrial fire. They were asked to provide sputum samples from their lower airways for analysis. The samples were examined by Steve using scanning electron microscopy. Fig. 5.2 shows a micrograph of a particle removed from one of the firefighter's lungs.



Fig. 5.2

X ~~2011.3~~  
magnification  
X 49600  
—

(i) The length of the particle is 125 μm.  
Draw a scale bar of appropriate length next to Fig. 5.2.  
Show your working.

6.2 cm

6.2      1000    1010  
20.16129      125 000 = 62

$$\frac{6.2}{125}$$

$$2016.13$$

$$0.0004.96$$

$$\frac{62}{125,000} = 4$$

[4]

Commentary

This candidate has also drawn a scale bar for 125 μm. In this case they have shown some working. They have measured the length of the particle in the diagram and recorded this. They have also attempted to divide this length by 125. This evidences some understanding of how to calculate the scale.

The candidate could improve this answer by trying to calculate a suitable scale e.g. for 50 μm.

## Exemplar Candidate Work

## Question 5(b)(i) – High level answer

(b) A team of firefighters was exposed to dust clouds when tackling an industrial fire.

They were asked to provide sputum samples from their lower airways for analysis.

The samples were examined by Steve using scanning electron microscopy.

Fig. 5.2 shows a micrograph of a particle removed from one of the firefighter's lungs.

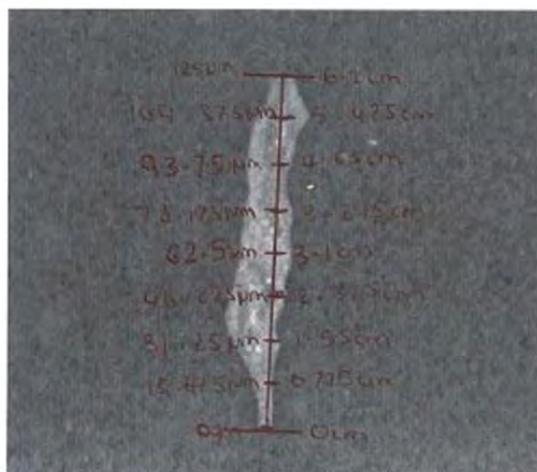


Fig. 5.2

(i) The length of the particle is  $125\ \mu\text{m}$ .

Draw a scale bar of appropriate length next to Fig. 5.2.

Show your working.

6.2 cm length

$$3.1 \div 2 = 1.55$$

$$62.5 \div 2 = 31.25$$

$$62.5 + 31.25 = 93.75$$

$$31.25 \div 2 = 15.625$$

$$\frac{125}{2} = 62.5$$

$$\frac{6.2}{2} = 3.1$$

So 3.1 on  
scale bar  
would be  
half of full  
length which  
would be  
 $62.5\ \mu\text{m}$

[4]

$$31.25 + 15.625$$

$$62.5 + 15.625$$

$$93.75 + 15.625$$

$$2.1 + 1.55 = 4.65$$

$$1.55 + 0.775 = 2.325$$

$$3.1 + 0.775 = 3.875$$

$$4.65 + 0.775 =$$

$$1.55 \div 2 = 0.775$$

### Commentary

This candidate has shown their working to show how they decided on a suitable scale. They have worked in cm rather than mm. A better answer would use mm. The scale they have drawn is usable but is not the most appropriate. This could be improved by working backwards from a suitable length e.g.  $50\ \mu\text{m}$  and then drawing a scale to match this.

Questions 5(b)(ii) and (c)

(ii) Some of the particles discovered were larger, metallic particles.

Explain how a different type of microscopical technique could be used to view these.

• Light (microscopy);  
• Use of incident light.

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

(c) Healthcare professionals monitored the health of the firefighters' nine months after the industrial fire.

Figure 5.3 is a stained light micrograph of white blood cells in the sputum of a firefighter. One of the white blood cells contains particles of dust.

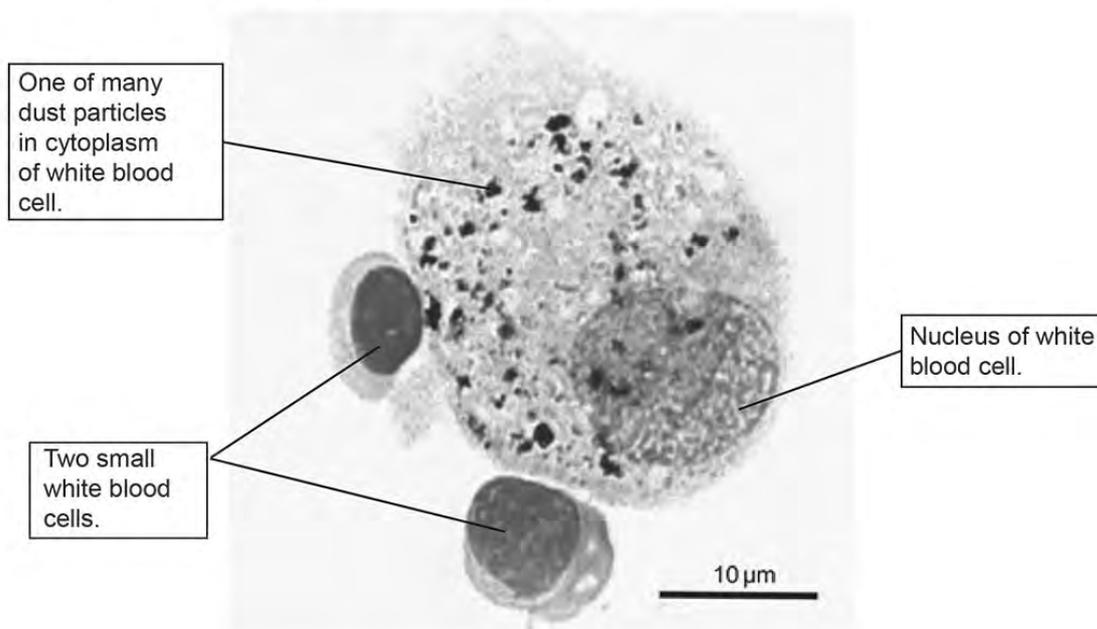


Figure 5.3

Explain why, in this instance, light microscopy was preferred to other forms of microscopy.

Any two from:

- Staining aids identification of different types of cells;
- Technique reveals internal structure showing dust particles;
- No magnification higher than that obtained by LM required;
- Resolution by LM is adequate.

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

**Examiner comments**

Question 5(b)(ii) – Many got one mark for light microscope but then did not get the second mark. Almost no candidates mentioned use of incident light.

Question 5(c) – Most candidates only got one mark for being able to see the dust particle. Some understood that you did not need higher resolution. No candidates understood that staining aids identification of different types of cells.

## Exemplar Candidate Work

## Question 5(b)(ii) – Low level answer

- (ii) Some of the particles discovered were larger, metallic particles.

Explain how a different type of **microscopical technique** could be used to view these.

X-Ray or ultrasound could be used to look inside the site sighters body easier to identify gold ~~and~~ the solid components metallic particles. [2]

## Commentary

This candidate has not engaged with the question properly. They need to give a different type of microscopical technique. They have suggested two non microscopical techniques. These are not creditworthy and it also means they will be unable to explain correctly so will have difficulty accessing the second mark point. They need to suggest the use of a light microscope. If they had done this they would have found accessing the second mark easier.

## Question 5(b)(ii) – Medium level answer

- (ii) Some of the particles discovered were larger, metallic particles.

Explain how a different type of microscopical technique could be used to view these.

for the larger particles light microscopy could be used to identify the larger particles and measure. [2]

## Commentary

The command word 'explain' means a candidate should give a statement with an explanation of that statement. This candidate has given the correct statement, that a light microscope can be used, but has not explained how the light microscope works. They needed to add that incident light is used.

## Exemplar Candidate Work

## Question 5(c) – Low level answer

(c) Healthcare professionals monitored the health of the firefighters' nine months after the industrial fire.

Figure 5.3 is a stained light micrograph of white blood cells in the sputum of a firefighter.

One of the white blood cells contains particles of dust.

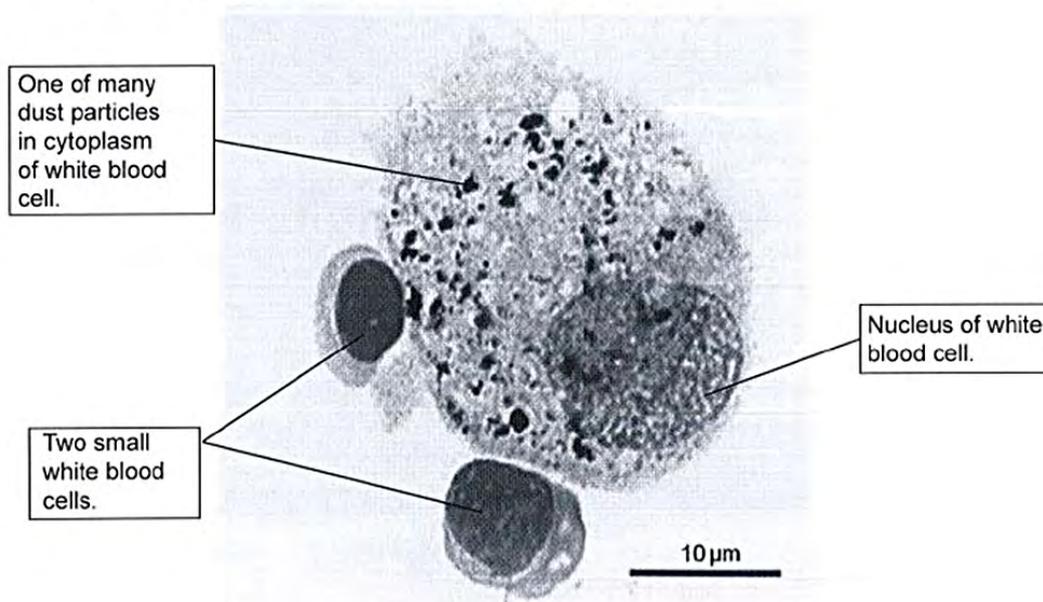


Figure 5.3

Explain why, in this instance, light microscopy was preferred to other forms of microscopy.

They are a easier to use, so if a small  
large sample has to be viewed.

[2]

### Commentary

The candidates need to answer in terms of why a light microscope is better than other microscopes for this investigation. They can also answer in terms of why using a light microscope is good enough. They could have mentioned that staining aids identification of cells that the technique shows the dust particles, or that the resolution and magnification possible by a light microscope is sufficient for the task.

'Easier to use' is not an appropriate answer as it is very subjective. Also, even if this is true, it does not mean it will be the most suitable giving the results needed and so cannot be credited.

## Exemplar Candidate Work

## Question 5(c) – Medium level answer

(c) Healthcare professionals monitored the health of the firefighters' nine months after the industrial fire.

Figure 5.3 is a stained light micrograph of white blood cells in the sputum of a firefighter.

One of the white blood cells contains particles of dust.

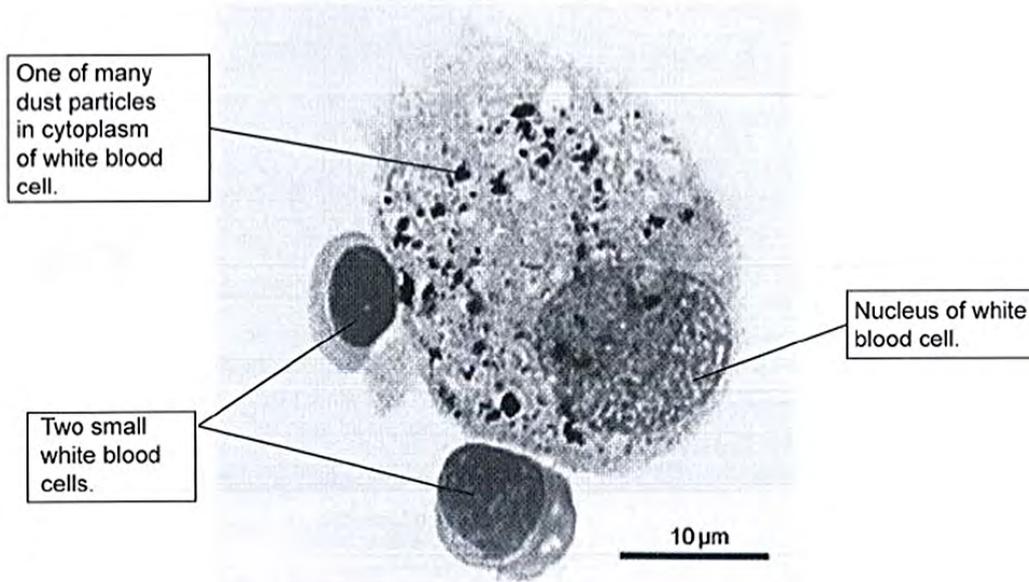


Figure 5.3

Explain why, in this instance, light microscopy was preferred to other forms of microscopy.

As an electron microscope would be too refined and magnified, you may get a clearer picture in which you are not able to see the dust particles. [2]

### Commentary

This candidate has answered in terms of why you would not use a different type of microscope. This is acceptable and as long as it matches the mark scheme it can be credited. So an answer that states that an electron microscope will not see the dust particle is creditworthy against the point that the (light microscope) technique shows dust particles.

The candidate could also have stated that staining allows different cells to be identified, or that you do not need the high magnification or resolution of an electron microscope.

## Question 5(d)

(d) The level of detail in an image depends on the resolving power of the microscope.

The theoretical resolving power of an objective lens of a light microscope can be calculated using the following equation:

$$\epsilon = 0.61 \times \frac{\lambda}{N.A.}$$

$\epsilon$  = resolving power, in micrometres ( $\mu\text{m}$ )

$\lambda$  = the wavelength of light, in  $\mu\text{m}$ . Assume this to be  $0.55 \mu\text{m}$

$N.A.$  = the Numerical Aperture of the lens

For a lens with a  $N.A.$  of 0.90, calculate its theoretical resolving power.

**FIRST CHECK THE ANSWER**

**If answer = 0.37 ( $\mu\text{m}$ ), award 2 marks**

Substitution into formula:

$$\epsilon = 0.61 \times \frac{\lambda}{N.A.} = 0.61 \times \frac{0.55}{0.90} = 0.37 \mu\text{m}$$

$$= 0.37 (\mu\text{m})$$

resolving power = .....  $\mu\text{m}$   
[2]

### Mark scheme guidance

Allow upto four decimal places.

### Examiner comments

This question was really well answered. Most candidates were awarded 2 marks.

## Exemplar Candidate Work

## Question 5(d) – Low level answer

(d) The level of detail in an image depends on the resolving power of the microscope.

The theoretical resolving power of an objective lens of a light microscope can be calculated using the following equation:

$$\epsilon = 0.61 \times \frac{\lambda}{N.A.}$$

$\epsilon$  = resolving power, in micrometres ( $\mu\text{m}$ )

$\lambda$  = the wavelength of light, in  $\mu\text{m}$ . Assume this to be  $0.55 \mu\text{m}$

$N.A.$  = the Numerical Aperture of the lens

For a lens with a  $N.A.$  of 0.90, calculate its theoretical resolving power.



$$0.55 \mu\text{m} \times 0.90 = 0.495$$

$$\lambda \times N.A. = ?$$

$$\text{resolving power} = 0.495 \dots \mu\text{m}$$

[2]

### Commentary

The candidate has to substitute the correct numbers into the equation given. The equation did not need re arranging. The equation does not fit into the 'formula triangle'. This candidate has incorrectly used a 'formula triangle' to rearrange the equations. They have not used all the terms and so could not get the correct answer.

The candidate should have inserted all the terms into the equations and then carried out the simple calculation and written the answer on the answer line.

## Exemplar Candidate Work

## Question 5(d) – High level answer

(d) The level of detail in an image depends on the resolving power of the microscope.

The theoretical resolving power of an objective lens of a light microscope can be calculated using the following equation:

$$\epsilon = 0.61 \times \frac{\lambda}{N.A.}$$

$\epsilon$  = resolving power, in micrometres ( $\mu\text{m}$ )

$\lambda$  = the wavelength of light, in  $\mu\text{m}$ . Assume this to be  $0.55 \mu\text{m}$

$N.A.$  = the Numerical Aperture of the lens

For a lens with a  $N.A.$  of 0.90, calculate its theoretical resolving power.

$$\epsilon = 0.61 \times \frac{0.55}{0.90} = 0.3727$$

resolving power =  $0.3727 \mu\text{m}$   
[2]

## Commentary

The answer on the answer line is correct. An examiner would not look at the working if they could award all marks from the answer line. This question has not asked for significant figures or decimal places. However, it is good practice to give an answer to the same level of accuracy as the numbers in the question. In this case the mark scheme shows 0.37. This candidate has given an answer of 0.3727. This is not penalised as they have rounded correctly and they have not been asked for specific accuracy.

## Question 6

- 6 Polyethylene terephthalate (PET) is a plastic often described by polymer chemists as indestructible. PET is very slow to biodegrade.

In 2016, scientists discovered a soil bacterium, called *Ideonella sakaiensis*. This bacterium is able to live on the surface of, and biodegrade, PET.

The bacterium, along with other soil-living bacteria, is shown on the surface of a waste PET bottle in Fig. 6.1.

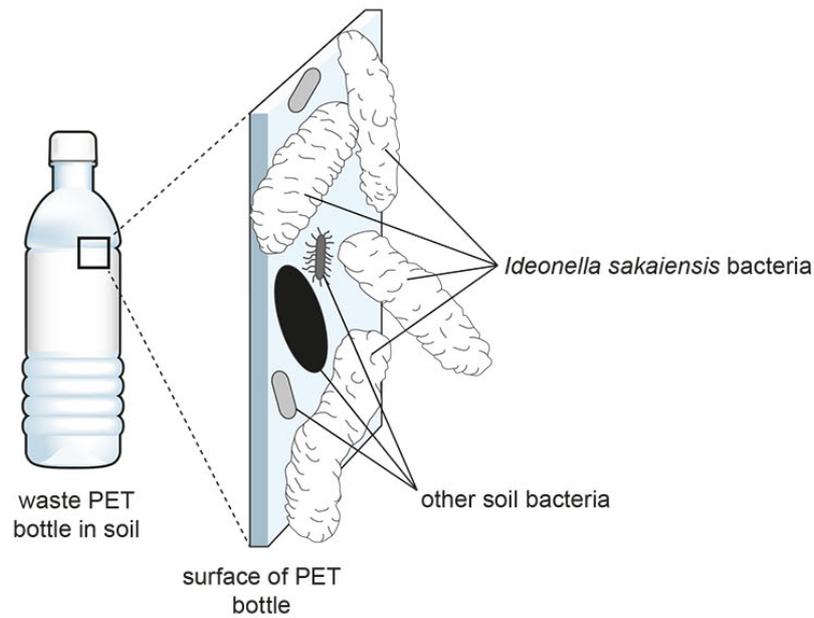


Fig. 6.1

## Question 6(a)

(a) You are given a waste PET bottle known to have *Ideonella sakaiensis* on its surface.

Describe in detail how aseptic techniques could be used to prepare a pure culture of the bacterium *Ideonella sakaiensis* in the laboratory.

Assume that *Ideonella sakaiensis* is the bacterium likely to be in the highest concentration on the bottle.

**Valid points:**

**Taking sample of bacteria from bottle and plating**

- Prepare suitable medium for growth of bacterium/*Ideonella sakaiensis*
- Plausible suggestion for growth medium, e.g. sterile sheet/film of PET in Petri dish/use scientific literature to find suitable medium suitable/use a range of media with different metabolic substrates
- Sterilise work surface
- Sterilise medium
- Pour sterile agar plates
- Sterilise inoculating loop
- Use inoculating loop to remove sample from bottle
- Streak Petri dish/agar plate in appropriate manner to obtain single, isolate colonies
- Seal culture appropriately
- Incubate at appropriate temperature/at temperature of environment where bacterium found

DO NOT ALLOW specified temperature

**Isolation of bacterium/*Ideonella sakaiensis***

- Sterilise inoculating loop
- Pick up loopful of bacterium
- From one of single/isolated 'dominant' colonies
- Streak Petri dish
- With fresh, sterile PET/agar plate
- Seal culture appropriately
- Incubate at appropriate temperature/at temperature of environment where bacterium found

**Checking for purity of colonies**

- Suitable method, e.g. check colony morphology/examine microscopically (with oil immersion)

.....

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.....

.....

.....[6]

## Mark scheme guidance

**[Level 3]** Candidate shows a high level of understanding and gives a good description of necessary components of aseptic technique to isolate the bacterium and check for the purity of the colonies in the culture produced.

*(5 – 6 marks)*

**[Level 2]** Candidate shows an understanding of how to use aseptic technique to isolate the bacterium.

*(3 – 4 marks)*

**[Level 1]** Candidate shows a basic understanding of how to use aseptic technique to isolate the bacterium and with little or no detail in the description.

*(1 – 2 marks)*

**[Level 0]** Candidate includes **fewer than two** valid points.

*(0 marks)*

## Examiner comments

Many candidates produced level 1 or level 2 responses to this question. However, they did not understand that once the culture was grown they would need to isolate the bacterium. This meant they could not gain credit for a level 3 response. This is a technique they should be familiar with and candidates should be able to describe both stages.

## Questions 6(b) and (c)

**(b)** Aseptic technique is essential in all microbiological work.

**(i)** Give **two** reasons for the importance of aseptic technique.

1. *Any two from:* .....  
 • Prevent contamination of culture;  
 2. • Prevent contamination of environment; .....  
 • Prevent contamination/illness of operator. [2]

**(ii)** Give **two** other examples of laboratory work, other than culturing bacteria, in which the use of aseptic technique is essential.

1. *Any two examples from:* .....  
 • Cell/tissue culture/growth of plant explants;  
 2. • Blood samples; .....  
 • Production of pharmaceuticals; [2]  
 • Medical/surgical procedures.

**(c)** Describe how the waste PET bottle, along with other waste, is treated after isolating the bacterium from its surface.

- Any two from:* .....  
 • Follow standard procedures for disposal; .....  
 • Wrapped in aluminium foil/placed in autoclaving bag; .....  
 • Autoclaved; .....  
 • Disposed of by appropriate agency/procedure in organisation; [2]  
 • Keep/maintain disposal records.

### Mark scheme guidance

#### Question 6(b)(i):

Allow 1 mark maximum for unqualified contamination.

#### Question 6(c):

**IGNORE** responses indicating that the PET bottle is burned.

### Examiner comments

Question 6(b)(i) – Candidates lost marks because they just said to prevent contamination. They needed to give specific examples of what would be contaminated to get full marks.

Question 6(b)(ii) – Candidates were unable to answer this question. This is knowledge from the specification that should be covered.

Question 6(c) – Candidates needed to be specific in order to gain marks here e.g. it is not enough to say it should be placed in a bag, the candidates needed to state it was an autoclaving bag.

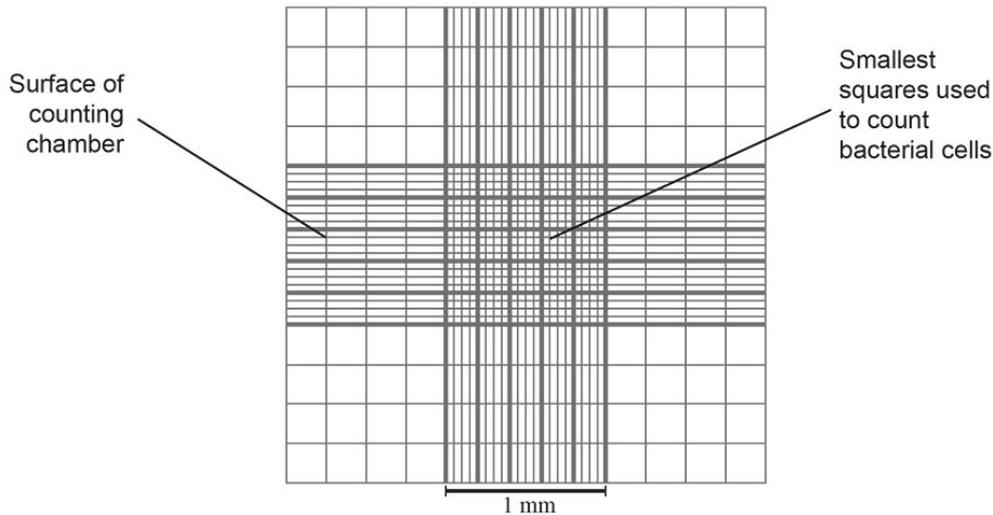
## Question 6(d)

(d) Scientists in another lab prepare a liquid culture of the bacterium.

They use a counting chamber and a microscope to estimate the concentration of the bacterial cells in the liquid culture.

The surface of the counting chamber is shown in **Fig. 6.2**.

The chamber has a (0.05mm × 0.05mm × 0.10 mm) volume of liquid culture beneath each of the smallest squares.



**Fig. 6.2**

The results of the cell counts for 10 of the smallest squares are shown in **Table 6.1**.

Cell count (0.05 mm × 0.05 mm × 0.10 mm square)											
Replicate	1	3	3	4	5	6	7	8	9	10	Mean cell count
Cell count recorded	50	48	48	52	49	53	52	50	49	51	

**Table 6.1**

(i) Calculate the mean cell count and complete **Table 6.1**.

50

[1]

(ii) Calculate the concentration of bacterial cells in the liquid culture.

Show your working and include the units.

**FIRST CHECK THE ANSWER**

**If answer = 200 000 mm<sup>-3</sup>, award 3 marks**

**If answer is 200 000 but unit is incorrect award 2 marks**

Volume of cell = 0.05 mm × 0.05 mm × 0.10 mm = 0.00025 mm<sup>3</sup>

(Mean cell count = 50 cells in 0.00025 mm<sup>3</sup>)

∴ concentration =  $\left(\frac{50}{0.00025}\right)$  cells mm<sup>-3</sup>  
= 200 000 mm<sup>-3</sup>

concentration = ..... (units) .....

[3]

**Mark scheme guidance****Question 6(d)(i):**

**DO NOT CREDIT** unless it is to TWO significant figures.

**Question 6(d)(ii):**

**ALLOW** one mark for correct units, even with the incorrect concentration.

**ECF** from (d)(i).

**Examiner comments**

Question 6(d)(i) – Candidates could calculate the average, however they lost the mark as they did not give a whole number. This question was about number of cells so should be a whole number.

Question 6(d)(ii) – There was an error carried forward from 6(c)(ii). Many candidates got the division upside down and so lost marks. Most candidates gained marks for correctly calculating the volume of the cell.



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Q5(b), Fig. 5.2 (Image) [www.ncbi.nlm.nih.gov](http://www.ncbi.nlm.nih.gov), *Environmental Health Perspectives* (EHP); 2004; 112(15): 1564–1569.

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