

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

APPLIED SCIENCE

05847–05849, 05879, 05874

Unit 2 January 2025 series

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from [Teach Cambridge](#).

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Unit 2 series overview

In general candidates' performance is improving, even considering the difficulties of the last few years. Most candidates seem prepared for this style of paper. Most candidates attempted all questions.

There is a lot of application and understanding of contexts that some candidates may have found challenging. Centres are encouraged to use sample papers and any previously sat papers available with the candidates to give them practice at the style of paper and the questions within.

Some areas were answered well, and candidates showed good knowledge of Health and Safety. They understood that a method needs specific measurements and were able to draw a table of results. They were able to label basic laboratory glassware. They struggled with mole calculations, but most knew how to calculate an average titre. Most had a basic understanding of how X-Ray and ultrasound are used in medicine. They had good knowledge of microscopy although sometimes confused the type of microscopes being tested. They were able to interpret a graph. Candidates coped better with interpreting spectra than on previous papers. They had good knowledge of standard procedures when using agar plates to grow cultures.

Occasionally, their lack of good scientific terminology prevented them answering questions to the required standard. This was especially seen when describing scientific principles and procedures. There is an improvement in candidates answering in terms of the context of the question and this did impact positively on their ability to score marks.

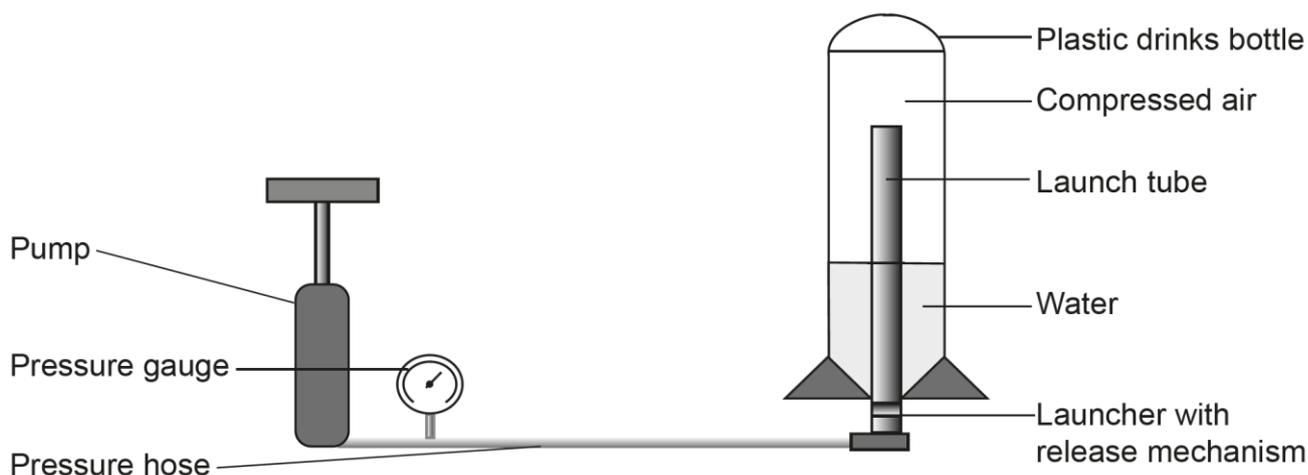
This is a techniques paper and so it is the techniques they need to know how to describe. They also need to explain why a technique is used and the scientific principles behind the technique. Candidates who have had the opportunity to carry out and discuss the techniques are much more able to answer the questions successfully. Good use of demonstrations and video clips is also important.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
<ul style="list-style-type: none"> • attempted all questions and had practised exam technique ensuring they read the question carefully and followed instructions • could interpret graphs (Questions 1 (c), 1 (d) and 5 (e) (ii)) • had experience of gel electrophoresis and chromatography techniques (Question 2) and were able to interpret results from each • had good understanding of titration techniques (Question 3) and were able to calculate concentrations. They were confident in using given equations, choosing and substituting numbers correctly • Could successfully compare different microscopes and interpret microscopy results (Questions 4 (b) and 4 (c)) • used accurate and precise science terminology. (Questions 2 (a) (i), 2 (a) (ii), 2 (d) (i), 2 (d) (ii), 4 (a), 4 (c), 5 (b), 5 (c) (i) and 6 (a) (ii)) 	<ul style="list-style-type: none"> • were not able to attempt all questions and not able to answer questions in the context they are set • struggled to correctly interpret graphs or draw conclusions (Questions 1 (c), 1 (d) and 5 (e) (ii)) • did not seem understand a range of skills and knowledge as outlined in the specification, including gel electrophoresis and chromatography (Question 2) • seemed to struggle with calculating concentrations even where scaffolding was provided and did not show logical working (Question 3 (c)) • were unable to interpret microscopy results (Question 4 (b)), and confused different types of microscopes (Questions 4 (b) and 4 (c)) • struggled to demonstrate the knowledge and skills required to respond effectively to the extended response question, struggling to use accurate and precise terminology (Question 4 (a)) • did not know specific scientific names for processes. (Questions 2 (a) (i) and 5 (c) (i))

Question 1 (a) (i)

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

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



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

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

Method

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

(i) Their teacher said that the method outlined in their notebook did not give enough details. Suggest **three** details that the students should include in their write-up.

- 1
- 2
- 3

[3]

Most candidates were able to suggest volume of water and pressure of gas for 2 marks. Some also suggested repeats. Very few candidates suggested a type of timer. Many used amounts rather than volume or mass. It is important to use specific terminology throughout the paper.

Question 1 (a) (ii)

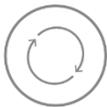
(ii) State **two** risks for this investigation.

- 1
- 2

[2]

Although many candidates gained 2 marks here, for those that didn't it was often because their answers were too vague. Many incorrect responses vaguely defined risk, for example, *(the bottle could) hurt someone/cause injury*. The threat of explosion was sometimes inferred but not made explicit, as in *(the bottle could) exceed maximum pressure*.

Assessment for learning

 It would be useful to spend time on the difference between hazard and risks as these are often confused.

Question 1 (a) (iii)

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

1

.....

2

.....

[2]

This question was often well answered. Most understood the need for safety glasses and keeping a safe distance. Those candidates who did not score both marks often gave vague answers such as use PPE. Candidates need to provide precise answers that are relevant to the context, so not all PPE would be relevant, e.g. no need for a lab coat.

Question 1 (b)

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

You only need to complete the column headings.

[4]

Most candidates gained some marks here. The most common errors were not writing the units or not showing repeats. Some candidates did not put all the headings at the top of the table, so the table did not make sense. Some candidates tried to draw graph axes rather than a table and so misunderstood the question.

Assessment for learning



Practising producing their own tables would help with this question as well as with their scientific skills.

Question 1 (c)

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

Fig. 1.1

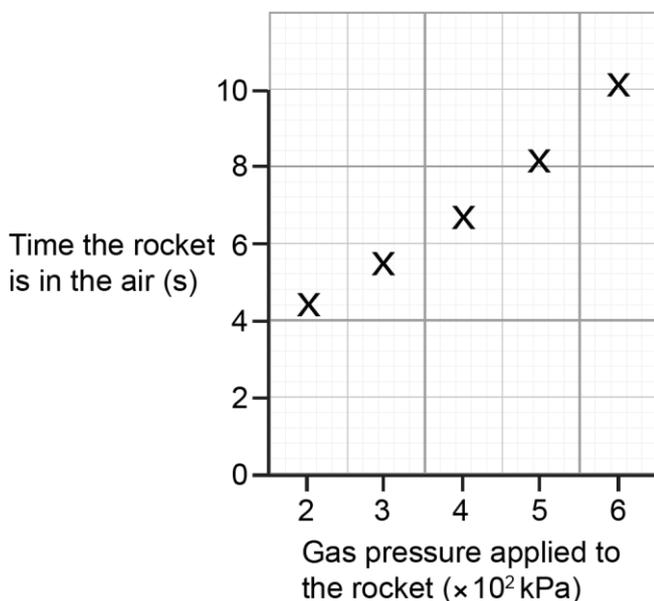
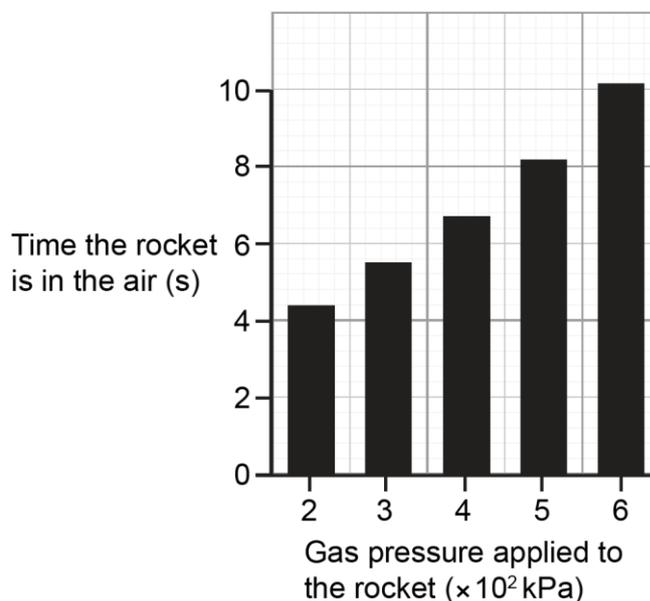


Fig. 1.2



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

.....

..... [1]

Very few candidates understood that a scatter graph is more appropriate because the x axis values are continuous. Some candidates gained the allow mark for understanding you could draw a line of best fit or estimate between points. Although this is not the answer, we would expect it did show some understanding. Candidates should know why different data is displayed in different ways.

Misconception

Many thought the scatter graph was 'easier to see' or 'easier to understand' showing a misconception about why data is represented in specific ways.

Question 1 (d)

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

.....

.....

.....

.....

.....

..... [3]

Most candidates gained 2 marks for the higher the pressure, the longer the rocket stays in the air. Very few recognised it was non-linear.

Question 2 (a) (i)

2 Gel Electrophoresis is a method used to separate mixtures of DNA, RNA or proteins. Gel Electrophoresis produces a DNA fingerprint which is unique to each individual. DNA fingerprinting can be used to determine the parentage of a child.

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

..... [1]

It was clear candidates either knew this or they didn't. It was good to see that even if they did not know the answer many attempted to give a response. However, a high number of blank responses were seen. In this question it is important that precise language and spelling is used. Phonetic spellings are usually accepted but if the word is too similar to another scientific term, then it is not always possible to be confident that the candidate knows the correct term. In this case, the correct response was polymerase chain reaction. There were a range of spellings seen, e.g. polymer, polymerise, polymerising etc which have specific and different meanings to polymerase so benefit of the doubt could not be given. This is an example of where precise use of terminology is important.

Question 2 (a) (ii)

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

.....

.....

..... [2]

Most candidates recognised that PCR was involved in the analysis of DNA, but a prevailing misconception is that PCR is used as a method of detection in its own right rather than as part of a more complex assay.

Misconception

 Careless popularisation of the use of the acronym *PCR* during the COVID-19 pandemic has likely contributed to this misunderstanding. Some candidates appeared to revise their response to this question after attempting the next part on electrophoresis, as seen in incorrect responses crossed out and replaced with creditworthy answers.

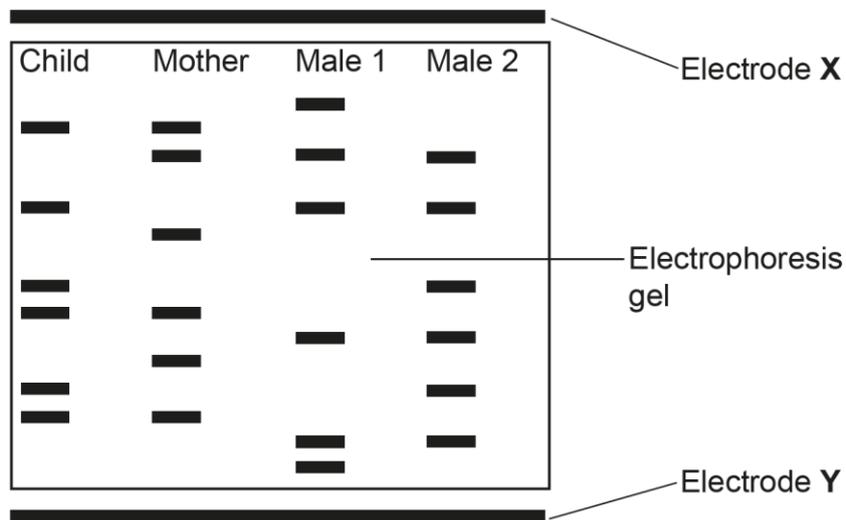
Question 2 (b) (i)

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

Fig. 2.1 shows the electrophoresis gel viewed from above.

The two electrodes are labelled X and Y.

Fig. 2.1



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

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

[1]

Very few candidates gave the correct response. There was no real pattern in the incorrect responses.

Question 2 (b) (ii)

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

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

Tick (✓) the box.

Base pair

- Adenine – adenine
- Adenine – cytosine
- Adenine – guanine
- Adenine – thymine

[1]

Very few candidates got this question correct. There was no real pattern in the incorrect responses.

Question 2 (b) (iii)

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

Explain your answer.

.....

[2]

Candidates gave a range of incorrect responses. The most common mistake was circling the first band of male 1 near to the x electrode, although several circled more than one band or all the bands for one person.

Misconception



Many thought that the fragment was shortest because it was closest to another fragment or thought all the fragments of one person was the shortest fragment as the 'lines' were closest together.

It is important for candidates to experience interpreting the results of this process.

Question 2 (b) (iv)

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

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

Explain how you reached your conclusion.

Most likely father

Explanation

.....
.....
.....
.....
.....

[3]

Most candidates gained the first mark for choosing male 2. However, they were unable to explain why. They were told that **half** of the DNA fingerprint of a child is likely to overlap with that of their mother and **half** is likely to overlap with that of their father. This means that stating **half** the fragments were the same would not gain a mark. They needed to be clear that it was 3 for male 2 and 3 for mother that overlapped to gain the explanation marks.

Question 2 (c)

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

.....
.....

[1]

Many vague answers were given here, e.g. to find a criminal or investigate a crime and these were not credited as it was unclear the candidates understood DNA fingerprinting. Precise responses such as forensics/at a crime scene would have gained the mark.

Misconception



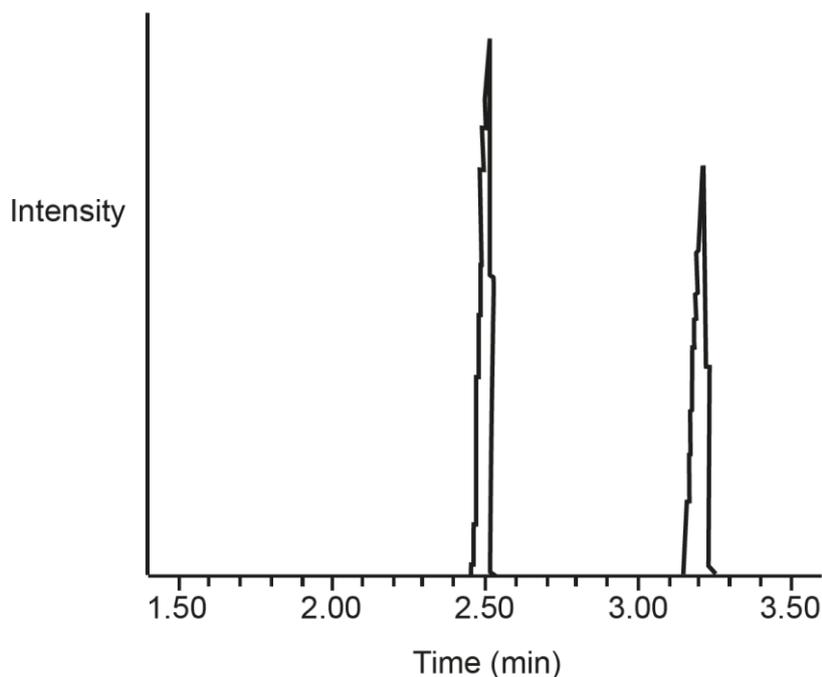
Many were clearly confused between fingerprints from fingers and DNA fingerprinting. E.g. stating the police could find the criminal from their fingerprints. This was a common misconception that showed the candidates did not understand the question.

Question 2 (d) (i)

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

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

The chromatogram is shown below.



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

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

.....

.....

..... [2]

Few candidates appeared aware that pure samples are routinely analysed in HPLC alongside mixtures of unknown composition. Many candidates appeared to think HPLC data, in a similar way to MS data, can be drawn from a database for a comparison to be made.

Misconception

In practice, retention times in HPLC are highly dependent upon column conditions, therefore valid comparisons with published data are unlikely. Where candidates gained a mark here it was for understanding that the alcohols should be run separately.

Question 2 (d) (ii)

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

.....

.....

..... [1]

Few candidates achieved credit here. Some attempts correctly made reference to peak area or peak height, but they often did not explain that a comparison is made. Many attempts made impractical suggestions, such as *run through MS*.

Question 3 (a) (i)

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

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

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

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

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

(a) First, a technician prepares 250 cm³ of a 0.0250 mol dm⁻³ standard solution of NaOH.

(i) Show that the molar mass of sodium hydroxide is 40.0 g mol⁻¹.

[1]

Many candidates misunderstood what they needed to do here and used one of the equations given in the question, manipulating it to get an answer of 40.

Assessment for learning



Candidates who have clearly practised calculation questions from past papers and homework etc tend to do well in the calculation questions as the skills are similar even if the contexts are different.

Question 3 (a) (ii)

(ii) Calculate the number of moles of NaOH needed to make 250 cm³ of a 0.0250 mol dm⁻³ solution.

Moles = mol [1]

Candidates generally did well on this question, although some did not gain the mark because they transferred their answer from their calculator to the paper incorrectly and so had an incorrect number of zeros.

Question 3 (a) (iii)

(iii) Calculate the mass of NaOH required.

Mass = g [2]

Candidates generally did well on this question. Those that did not gain the marks had usually chosen the incorrect numbers to multiply. Another common error was to divide rather than multiply.

Question 3 (a) (iv)

(iv) The technician dissolves the calculated mass of NaOH in water and makes up the solution to 250 cm³.

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

..... [1]

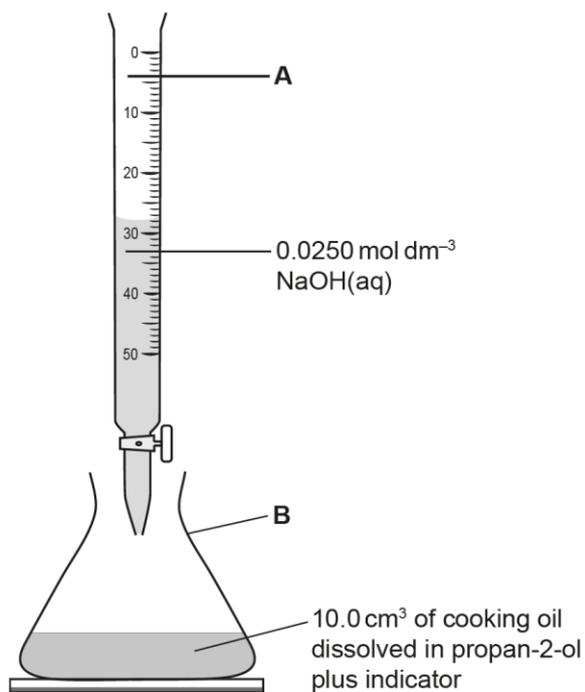
Common errors here included beakers or conical flasks. It is important that candidates know the procedure to make up a solution including the relevant equipment needed.

Question 3 (b) (i)

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

The technician measures out 10.0 cm³ of the cooking oil into a conical flask and adds an equal volume of propan-2-ol. The technician titrates this against 0.0250 mol dm⁻³ NaOH using phenolphthalein as the indicator.

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



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

A

B

[2]

Most candidates got at least 1 mark here. Common errors were pipette instead of burette and volumetric flask rather than conical flask.

Question 3 (b) (ii)

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

From to [1]

It was good to see this was well known. Common errors were the colours the wrong way round or the use of clear instead of colourless. Clear does not gain the mark and it is an example of where imprecise language prevents candidates accessing the mark.

Question 3 (b) (iii)

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

Suggest why it is not suitable.

.....
 [1]

Many candidates suggested that the colour of the oil would prevent you seeing the colour change. This was not credited, and it is likely the candidates have practised on a past paper where a blue dye affected the colour change. It is important that the candidates answer the question set rather than what they think the question is about.

Question 3 (b) (iv)

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

Titre / cm ³			
20.30	20.15	20.10	20.15

Put rings around the results that are concordant.

[1]

It was clear that many candidates did not understand the term concordant. Many circled all the titres and several only circled the ones that were exactly the same.

Question 3 (b) (v)

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

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

Mean titre = cm³ [2]

Most candidates knew how to calculate an average. A common error was using all four titres in the average. Many did not give their answer to two decimal places. Good exam technique would be to tick off each instruction in the question to ensure they have not missed anything.

Question 3 (b) (vi)

(vi) Use the mean titre to calculate the number of moles of NaOH required to neutralise the acids in 10.0 cm³ of oil.

Number of moles NaOH = mol [1]

Many candidates incorrectly multiplied or divided by 10. This is probably due to the 10 cm³ of oil in the question. It showed a misunderstanding of the question. Practice of these types of calculations will help candidates as the skills are similar even if the context is different.

Question 3 (c)

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

Each container holds 20 dm^3 of oil.

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

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

Mass of NaOH = g [4]

Candidates found this a difficult question. A lot of responses were left blank. Very few that attempted the question gained full marks. Common errors included not converting for number of moles to neutralise 1 dm^3 and not giving answer to 3 significant figures. Marks were sometimes gained for multiplying by 20 or for multiplying by 120.

Question 4 (a)

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

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

In your answer refer to:

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

.....

.....

.....

.....

.....

.....

..... [6]

Most candidates demonstrated general knowledge of what parts of the body could be imaged with ultrasound and X-rays, mostly *foetuses/babies* and *bones* respectively, and the hazards to the patient of both methods. Explanations of how the methods work were often restricted to identifying (*high frequency*) *sound waves* and *radiation* as the principles of function. Higher scoring responses correctly described waves being *deflected* in ultrasound and *passing through* in X-rays, but few showed understanding of the effect of body tissue density on the waves or how the images were generated. Frequently occurring misuse of technical language included *gamma rays* being confused with X-rays and the word *stomach* used where *uterus/abdomen* would be more appropriate.

It was good to see most candidates attempt to address each of the bullet points within the question.

Exemplar 1

- X-rays: electromagnetic waves are shot at the patient, and there is photographic film on the other side of the patient. The electromagnetic waves are absorbed by hard structures in the patient, i.e. bones, and pass through soft structures, such as soft tissue. The structures you can see in the film when the x-ray is complete are hard structures, i.e. bones. These show up as white, and soft structures such as tissues are shown as black. Frequent exposure to x-rays can increase radiation for the patient, and could potentially affect/alter the structure of the DNA. ultrasounds: a transducer is used to reflect sound rays in a patient, that is then reflected back to the transducer to produce an image. You can see soft, moving structures in a live ultrasound, such as a fetus. Features of the organism can be seen, but not in large detail, as harder structures, such as bone and teeth, are difficult to see. Ultrasounds pose no risks to patients, but the gel used may cause allergies or irritation, but compared to x-rays, they are less harmful.

The candidate has described with good detail how both X-Rays and ultrasound work. They have given examples of how each are used to image and have given the potential hazards for both. The work shows high level of understanding and so holistically is worth 6 marks at Level 3.

Exemplar 2

- X-ray uses ionising radiation
to penetrate to the body.
- Ultrasound uses sound waves, to
find soft tissue.
- X-ray uses to determine the
fractures on the bones.
- Ultrasound uses to determine
the blood vessels, pregnancy.
- X-ray is exposure to radiation.
- Ultrasound is not using
ionising radiation so,
safe for the patients.
- Ultrasound is expensive.

The candidate has a basic understanding of how both X-Rays and ultrasound work. They have given examples of how each are used to image. They have stated that ultrasound is safe for patients and have recognised that X-rays lead to exposure to radiation but have not taken that any further. The candidate has attempted to cover each of the bullet points in the question, but it is all quite basic. However, there is enough here for Level 2, 4 marks.

Question 4 (b) (i)

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

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

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

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

Fig. 4.1

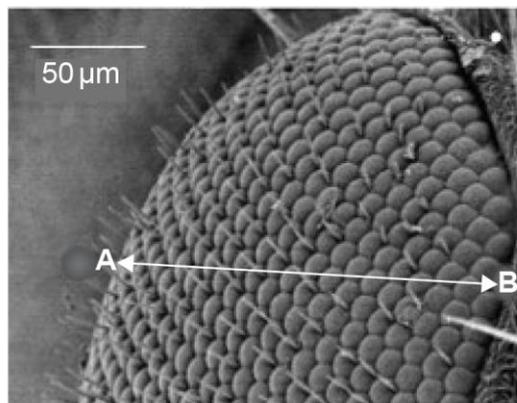
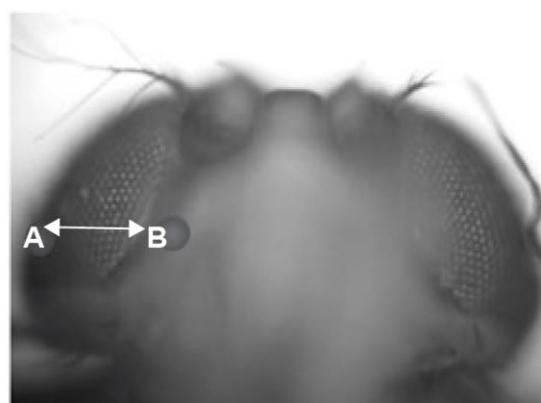


Fig. 4.2



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

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

This was well known, and candidates did well here. Common answers included that the specimen had to be dead and that you needed more training. Some candidates misread the question and answered in terms of advantages of electron microscopy and so did not gain credit.

Question 4 (b) (ii)

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

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

..... mm

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

..... mm

[1]

There was a tolerance for the response given in the mark scheme, however, few candidates answered correctly. There was no common pattern to incorrect responses.

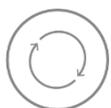
Question 4 (b) (iii)

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

Magnification = times **[1]**

Many candidates were unable to carry out this simple calculation and so did not gain marks. Some tried to multiply by lens power. Others used the incorrect numbers.

Assessment for learning



This is an essential skill so it would be worth revisiting this calculation with candidates.

Question 4 (b) (iv)

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

Give your answer in metres and in standard form.

..... m [2]

Candidates struggled with this calculation. Most did not seem to realise they had to work out how many times the scale line fitted into the width of the eye before calculating the width of the eye.

Question 4 (c)

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

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

Many candidates gained at least 1 mark here, usually for understanding SEM equipment produce three-dimensional images and TEM equipment only produce 2D images. Candidates that did not gain marks usually did so because they gave answers comparing electron microscopes with light microscopes. It is important to answer the question set. Many candidates discussed resolution or magnification.

Most did not seem to know how the two microscopes worked or struggled to explain the difference. Again, scientific terminology and precision of language was important here.

Question 5 (a)

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

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

Ba²⁺

Ca²⁺

Li⁺

[3]

Although many candidates did gain some marks here it was also clear that many were just guessing the colours. There was no pattern to incorrect responses.

Question 5 (b)

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

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

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

Many candidates described cleaning the wire loop, this was not creditworthy as it is preparation for the procedure rather than the procedure but did not cause any marks to be lost. Where marks were not credited it was either for not stating use a blue flame or the candidate did not mention observing the colour.

Question 5 (c) (i)

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

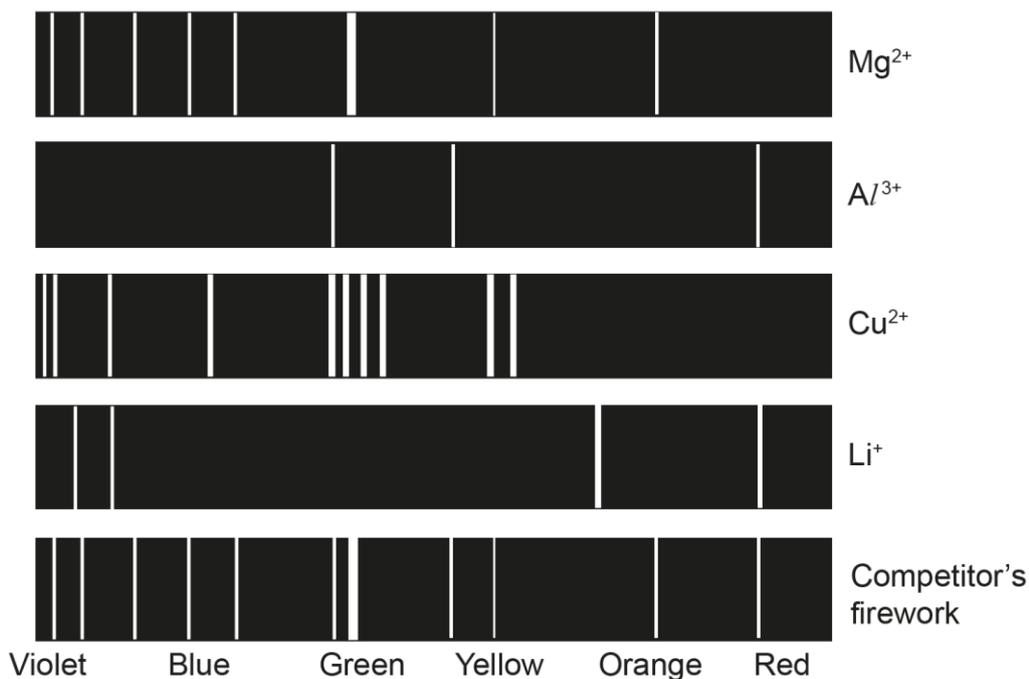
(i) State what AES stands for.

..... [1]

This was answered better than in previous series. However, many candidates still did not answer this correctly. They used incorrect terms such as spectrometry which was not allowed for a mark.

Question 5 (c) (ii)

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



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

1 2 [2]

This was generally well answered. Copper ion was a common incorrect answer.

Question 5 (c) (iii)

(iii) Justify your answer to (ii).

.....

.....

..... [2]

Candidates clearly had a good understanding of how to use the spectra to decide which ions were present. In some cases, marks were not gained because they did not explain clearly that ALL the lines matched for both ions.

Question 5 (d)

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

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

Ca²⁺

Fe²⁺

Mg²⁺

Na⁺

Pb²⁺

[2]

This was generally answered well. There was no pattern to the incorrect responses. Candidates are required to recall and be confident with this knowledge.

Question 5 (e) (i)

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

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

- Step 1** The technician prepares 100 cm³ of a solution containing 0.010 mol dm⁻³ of lithium ions. This is the stock solution **S**.
- Step 2** The technician calculates the volume of solution **S** and the volume of water required to make 10 cm³ of four more solutions to complete the calibration.
- Step 3** The technician prepares the five solutions and places each one in turn (including the stock solution), in the AES instrument.
- Step 4** The intensity of light emitted by each solution is then measured.

- (i) Complete the table below to show the volume of solution **S** and the volume of water needed to prepare 10 cm³ of each solution.

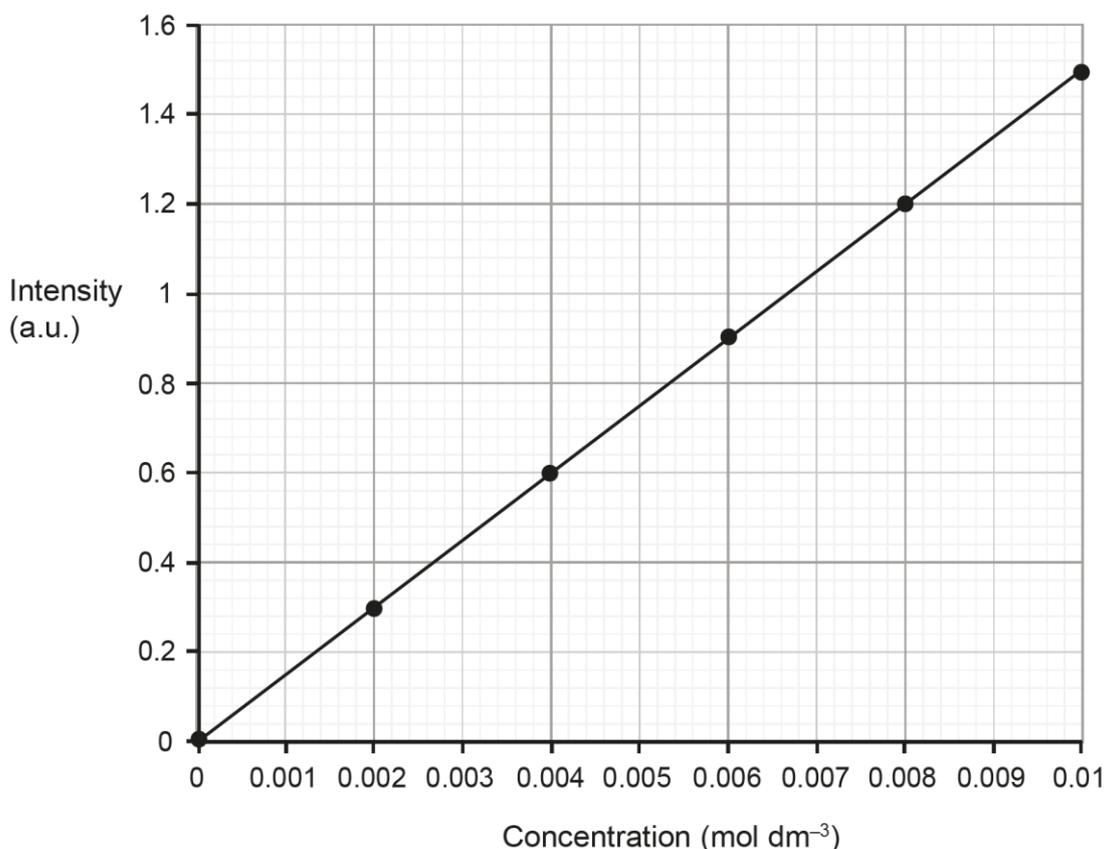
Concentration of Li ⁺ (mol dm ⁻³)	Volume of solution S (cm ³)	Volume of water (cm ³)
0.01	10	0
0.008		
0.006		
0.004		
0.002		

[2]

This question was found challenging by candidates. Even where candidates gained a mark for volume of solution, they often did not gain it for volume of water. It is important that candidates are allowed to make up solutions for their practical work, so they understand how to do as well as why the solutions are different concentrations.

Question 5 (e) (ii)

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



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

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

Show your working on the graph.

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

This was well answered. Some candidates drew their line from 0.7 on the y axis and so did not gain some marks. Other candidates lost marks because they drew second lines that were not perpendicular to the x axis.

Question 6 (a) (i)

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

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

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

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

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



The scientists are discussing the appearance of the agar plate.

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

Draw **two** lines only.

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

[2]

Candidates did well here. There was no pattern to the incorrect responses although where only 1 mark was gained it was usually for a correct line from the second box.

Question 6 (a) (ii)

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

- 1
-
- 2
-
- 3
-
- 4
-

[4]

Candidates generally demonstrated an understanding of the use of inoculating loops, the method of sterilisation and how the inoculum is transferred and were able to achieve full marks on the basis of this explanation alone. Where candidates attempted to describe the process of streaking, few attempts showed an understanding that the purpose of the streak plate was to obtain isolated colonies of bacteria. Some incorrect responses described plates prepared using spreaders or swabs. Other candidates incorrectly suggested flaming the agar.

Question 6 (a) (iii)

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

Complete the sentences.

Use the words from the list.

autoclaved dried flamed washed

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

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

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

.....

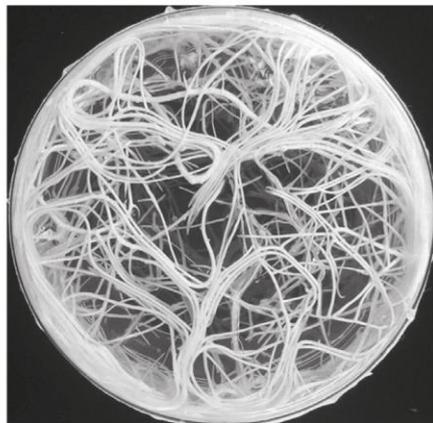
[2]

This question was generally well answered. There was no pattern to incorrect responses.

Question 6 (b) (i)

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

The image shows transformed roots growing on an agar plate.



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

Complete the sentences, using words from the list below.

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

autoclaving cooling drying flaming wiping

- 1 Sterilise the surfaces inside a controlled air flow hood by with ethanol.
- 2 Sterilise scissors by dipping into ethanol and then
- 3 Cut a 5 cm length of transformed root with the sterile scissors.
- 4 Sterilise the forceps by dipping into ethanol and then
- 5 Use the sterile forceps to transfer the length of root to a fresh agar plate.

[3]

This question was generally well answered with most candidates scoring at least 1 mark. There was no pattern to incorrect responses.

Question 6 (b) (ii)

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

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

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

[3]

Many candidates scored all 3 marks. It was clear that they were familiar with the procedure and understood the conclusions made.

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Question 4: Photographs of a drosophila, OCR is aware that third party material appeared in this exam but it has not been possible to identify and acknowledge the source.

Question 6 (b): Transformed roots, © 2022 Nguyen and Searle, An Efficient Root Transformation System for Recalcitrant *Vicia sativa*. Reproduced under the terms of the Creative Commons Attribution License (CC-BY 4.0).

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