T Level Technical Qualification in Science

Core knowledge and understanding

Paper B

Mark scheme

v1.0: Pre-standardisation
P002411
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This mark scheme has been written by the assessment writer and refined, alongside the relevant questions, by a panel of subject experts through the external assessment writing process and at standardisation meetings.

The purpose of this mark scheme is to give you:

- examples and criteria of the types of response expected from a student
- information on how individual marks are to be awarded
- the allocated assessment objective(s) and total mark for each question.

Marking guidelines

General guidelines

You must apply the following marking guidelines to all marking undertaken throughout the marking period. This is to ensure fairness to all students, who must receive the same treatment. You must mark the first student in exactly the same way as you mark the last.

- The mark scheme must be referred to throughout the marking period and applied consistently; do not change your approach to marking once you have been standardised.
- Reward students positively giving credit for what they have shown, rather than what they might have omitted.
- Utilise the whole mark range and always award full marks when the response merits them.
- Be prepared to award zero marks if the student's response has no creditworthy material.
- Do not credit irrelevant material that does not answer the question, no matter how impressive the response might be.
- The marks awarded for each response should be clearly and legibly recorded in the grid on the front of the question paper.
- If you are in any doubt about the application of the mark scheme, you must consult with your team leader or the chief examiner.

Guidelines for using extended response marking grids

Extended response marking grids have been designed to assess students' work holistically. They consist of bands-based descriptors and indicative content.

Bands-based descriptors: each band is made up of several descriptors for across the AO range, AO1 to AO3, which, when combined, provide the quality of response that a student needs to demonstrate. Each band-based descriptor is worth varying marks.

The grids are broken down into bands, with each band having an associated descriptor indicating the performance at that band. You should determine the band before determining the mark.

Indicative content reflects content-related points that a student may make but is not an exhaustive list. Nor is it a model answer. Students may make all, some or none of the points included in the indicative content as its purpose is as a guide for the relevance and expectation of the responses. Students must be credited for any other appropriate response**.**

Application of extended response marking grids

When determining a band, you should use a bottom-up approach. If the response meets all the descriptors in the lowest band, you should move to the next one, and so on, until the response matches the band descriptor. Remember to look at the overall quality of the response and reward students positively, rather than focussing on small omissions. If the response covers aspects at different bands, you should use a best-fit approach at this stage and use the available marks within the band to credit the response appropriately.

When determining a mark, your decision should be based on the quality of the response in relation to the descriptors. You must also consider the relative weightings of the assessment objectives, so as not to over/under credit a response. Standardisation materials, marked by the chief examiner, will help you with determining a mark. You will be able to use exemplar student responses to compare to live responses, to decide if it is the same, better or worse.

You are reminded that the indicative content provided under the marking grid is there as a guide and therefore you must credit other suitable responses a student may produce. It is not a requirement either that students must cover all the indicative content to be awarded full marks.

Assessment objectives

This assessment requires students to:

AO1: Demonstrate knowledge and understanding of contexts, concepts, theories and principles in science
AO2: Apply knowledge and understanding of contexts, concepts, theories and principles in science to different situations and contexts
AO3: Analyse and evaluate information and issues related to contexts, concepts, theories and principles in science to make informed judgements, draw conclusions and address individual needs

The weightings of each assessment objective can be found in the qualification specification.

Section A: Biology

This section is worth **45** marks, plus **3** marks for the quality of written communication (QWC) and use of specialist terminology.

1 **Which group of pathogens does *Candida auris* belong to?**

A **Bacteria**
B **Fungi**
C **Prions**
D **Viruses**

[1 mark]

AO1 = 1 mark

B Fungi

2 **Which** one **of the following protein molecules is an example of a fibrous protein?**

A **Antibodies**
B **Collagen**
C **Enzymes**
D **Haemoglobin**

[1 mark]

AO1 = 1 mark

B Collagen

3 (a) **Name** one **of the main groups of lipids.**

[1 mark]

AO1 = 1 mark

Award **one** mark for the correct name, up to a maximum **one** mark:

- triglycerides (1)
- phospholipids (1).

Accept any other suitable response.

(b) **State** four **roles of lipids in living organisms.**

[4 marks]

AO1 = 4 marks

Award **one** mark for each role stated, up to a maximum of **four** marks:

- plasma membrane/cell surface membrane flexibility (1)
- plasma membrane/cell surface membrane transport mechanisms (1)
- energy store (1)
- insulation (1)
- protection (1).

Accept any other suitable response.

(c) **Phagocytes are a type of white blood cell that ingest invading microbes into vesicles called phagosomes. Lysosomes containing enzymes, fuse with the phagosomes and the enzymes digest the microbes.**

As well as containing lysosomes, the cytoplasm of phagocytes has increased levels of rough endoplasmic reticulum.

Explain how the cells having increased levels of rough endoplasmic reticulum benefits the process of phagocytosis.

[2 marks]

AO2 = 2 marks

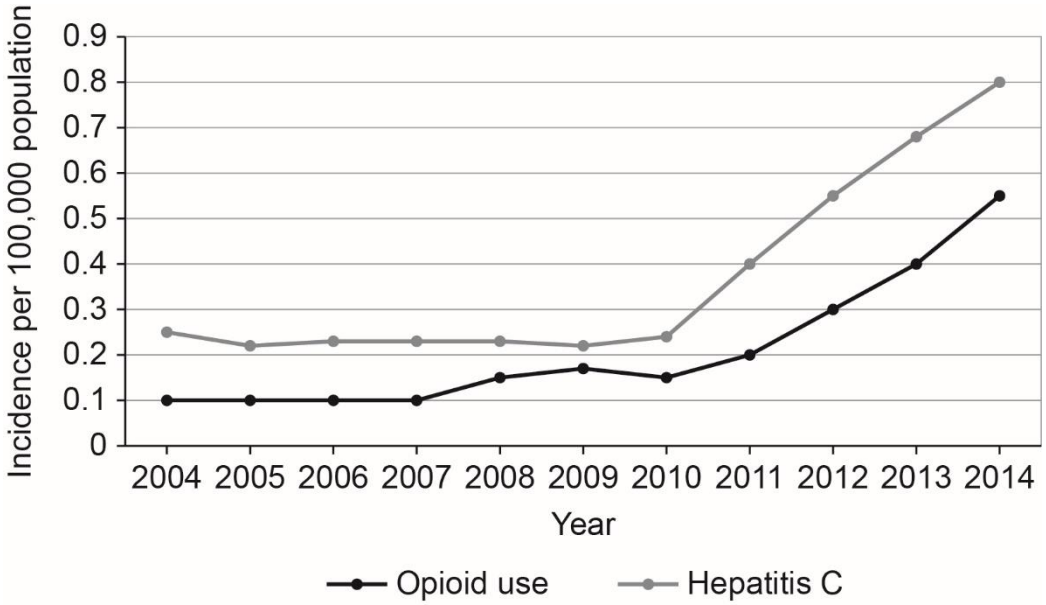
Award **one mark** for each explanation, up to a maximum of **two** marks:

- The increased levels of rough endoplasmic reticulum will produce more proteins (1). This is useful as the phagocytes need a high volume of enzymes for phagocytosis (1).

Accept any other suitable response.

4 Figure 1 **shows the incidence of hepatitis C and opioid drug use in a state in the USA. The most common method of taking the drug was via intravenous injection.**

Figure 1**: Incidence of hepatitis C and opioid drug use in a state in the USA**



(a) **Using** Figure 1**, describe** two **trends showing the relationship between hepatitis C and opioid drug use.**

[2 marks]

AO2 = 2 marks

Award **one** mark for each description point, up to a maximum of **two** marks:

- both follow the same trend staying fairly steady from 2004 to 2010 (1) and both rise rapidly after 2010 (1)
- the rise in the incidence of hepatitis C is higher/greater than the rise in the incidence of opioid use from 2010 (1) **or** the incidence of hepatis C rises/increases by 0.55 after 2010 and the incidence of opioid use rises/increases by 0.4 after 2010 (1) although the trends are the same, the opioid use trend is lower than the hepatitis C trend (1).

Accept any other suitable response.

(b) **Using your knowledge of transmission of disease, suggest** one **reason for the relationship shown in** Figure 1**.**

[1 mark]

AO2 = 1 mark

Award **one** mark for each suggestion, up to a maximum of **one** mark:

- the most common method for taking opioid drugs was via intravenous injection, injecting drug users may have shared needles (1)
- incidence of hepatitis C may be higher than opioid use as people can contract hepatitis C in other ways not related to drug use, for example, when someone comes into contact with blood from an infected person (1).

Accept any other suitable response.

5 **A lecturer in infection control made the statement,**

'The spread of infectious pathogens can always be reduced by avoiding physical contact with an infected person and increasing social distancing.'

(a) **Define the term 'infection'.**

[1 mark]

AO1 = 1 mark

Award **one** mark for the correct definition, up to a maximum of **one** mark:

- an organism replicating inside the body, resulting in disease (1).

Accept any other suitable response.

(b) Discuss the validity of the lecturer's statement.

Your response should include reasoned judgements and a conclusion.

[3 marks]

AO3 = 3 marks

Award **one** mark for each discussion point, up to a maximum of **three** marks:

- physical contact with an infected person can be a route of direct transmission, so avoiding physical contact may help reduce the chance of infection spreading (1), but routes of transmission, such as, airborne, do not depend on physical contact/depends upon social distancing (1) therefore, the lecturer is correct that both avoiding physical contact and social distancing are important (1).
- contact with surfaces contaminated by the pathogen would be a route of transmission (1), avoiding physical contact with an infected individual and increasing social distancing would not prevent transmission via this route (1) therefore, the lecturer is correct that infection could be reduced but it would not be prevented altogether (1).

Accept any other suitable response.

(c) A strain of antibiotic resistant bacteria that has caused numerous hospital-acquired infections is being investigated.

Initially scientists isolate and sequence the complete genetic material. They then go on to investigate the role of each gene within the genetic material to try and identify genes responsible for the resistance.

A student reading a report on the investigation states,

'This is an example of genomics rather than genetics.'

Discuss the validity of the student's statement.

Your response should include reasoned judgements and a conclusion.

[3 marks]

AO3 = 3 marks

Award **one** mark for each discussion point, up to a maximum of **three** marks:

- The student is partially correct as genomics focuses on the entire genetic material and in this case the entire genetic material is isolated and sequenced (1). However, genetics focuses on the function and composition of individual genes composition and individual genes are being investigated (1). In this case as the initial stage is genomics and the next stage is genetics, the student statement cannot be fully supported (1).

Accept any other suitable response.

6 **A laboratory technician uses a differential staining technique to prepare a slide of bacteria. Microscopic examination of the slide shows a mixture of bacteria; some are stained pink, and some are stained purple.**

(a) **Suggest which differential staining technique the technician used to prepare this slide.**

[1 mark]

AO2 = 1 mark

Award **one** mark for the correct suggestion, up to a maximum of **one** mark:

- Gram stain (1).

(b) **Name** two **other differential staining techniques.**

[2 marks]

AO1 = 2 marks

Award **one** mark for each correct technique, up to a maximum of **two** marks:

- Giemsa (1)
- haematoxylin and eosin (accept H and E) (1).

Allow Gram stain here if it has not been given for 6a.

7 ***Helicobacter pylori*** **is a bacterial species that is carried in the stomach of many people. About 10% of carriers will go on to develop stomach ulcers caused by the bacteria.**

Bacteria that can move independently in their environment are described as being motile. ***Helicobacter pylori*** **is highly motile. A research student is investigating whether motility of the bacteria is linked to their ability to cause ulcers and needs to observe the motility of the bacterium.**

Helicobacter pylori **cells are typically 3 µm long and 0.5 µm wide.**

Resolution is the shortest distance between two points on a specimen that can still be seen as two different points.

Table 1**: shows the maximum resolution of two different types of microscopes.**

Type of microscope	Maximum resolution
Light microscope	**200 nm**
Scanning electron microscope (SEM)	**1–20 nm**

1 µm = 1000 nm

(a) **Using the information provided and your knowledge of different types of microscopes, assess which type of microscope would be the most appropriate for this investigation.**

[3 marks]

AO3 = 3 marks

Award **one** mark for each assessment point, up to a maximum of **three** marks:

- this specific bacterium is highly motile, if the research student needs to observe the bacterium moving then the light microscope must be used as it can observe living specimen (1), the SEM cannot be used to observe living specimen but can offer a higher resolution, and therefore, more detail (1), the overall choice of microscope would depend on whether the research student would prefer higher resolution or to observe a living specimen (1)
- factors other than resolution might need to be considered by the research student, for example, SEMs are much more expensive than light microscopes (1) SEMs also require more in depth/specific training which may not be available to the research student (1), the resolution of the light microscope is sufficient to provide a clear image of the bacterium as the resolution is 200nm and the bacterium is 0.5µm/500nm at it's smallest point therefore a light microscope will likely be sufficient for the investigation (1).

Accept any other suitable response.

(b) **On a photograph of *Helicobacter pylori*, taken from a microscope, each bacterial cell is 18 mm long.**

***Helicobacter pylori* cells are typically 3 µm long and 0.5 µm wide.**

You can use the following equation to calculate magnification:

$$\textbf{magnification} = \frac{\textbf{size of image}}{\textbf{size of object}}$$

Calculate the magnification used to create the photograph.

1 mm = 1000 µm

You must show your working.

[4 marks]

AO2 = 4 marks

Award **one** mark for conversion of values to make the units match.
Award **one** additional mark for the conversions being correct:

- 18 x 1000 (1) = 18,000 µm (1)

or

- 3/1000 (1) = 0.003 mm (1).

Award **one** mark for correctly substituting values into equation:

- 18,000/3 (1)

or

- 18/0.003 (1).

Award **one** mark for the correct answer:

- x6000 (1).

Note: do not penalise if an error is carried forward.

(c) ***Helicobacter pylori*** **is a prokaryote.**

Give two **features of a prokaryotic cell that would** not **be found in a eukaryotic cell.**

[2 marks]

AO1 = 2 marks

Award **one** mark for giving a correct feature, up to a maximum of **two** marks:

- prokaryotes have cytoplasm that lacks membrane-bound organelles (1)
- prokaryotes have smaller ribosomes (1)
- prokaryotes have no nucleus/have a single circular DNA molecule that is free in the cytoplasm and is not associated with proteins (1)
- prokaryotes have a cell wall that contains murein/peptidoglycan/glycoprotein (1)
- prokaryotes may have one or more plasmids (1)
- prokaryotes may have a (slime) capsule surrounding the cell (1)
- prokaryotes may have one or more simple flagella (1).

Accept the converse in terms of eukaryotes.

8 **Mitosis always produces two daughter cells that are genetically identical to the parent cell.**

(a) **State the role of the centrioles in mitosis.**

[1 mark]

AO1 = 1 mark

Award a maximum of **one** mark for the correct statement, up to a maximum of **one** mark:

- they are organelle/structures (at both ends of the parent cell) that the spindle fibres anchor/attach to (1)
- they are involved with the separation of chromosomes during cell division (1).

(b) **Identify the stage in which the nuclear envelope reforms to produce two daughter cells.**

[1 mark]

AO1 = 1 mark

Award a maximum of **one** mark for the correct identification, up to a maximum of **one** mark:

- telophase (1).

9	**The genetic code in DNA and RNA consists of 4 different bases arranged in groups of 3 called triplets. In total this arrangement leads to 64 different triplets. These 64 triplets have to code for 20 amino acids.** **To promote discussion, a lecturer delivering a lesson on DNA made the following statement:** **'If there were only 3 different bases, and these were still arranged in combinations of 3, this arrangement would lead to 27 different triplets. This suggests that the structure of DNA is unnecessarily complicated.'** **With reference to the structure, function and mechanism of action of DNA and RNA, evaluate the accuracy of this statement.** **Your response should include reasoned judgements and conclusions.** **Calculations are not required.** [12 marks, plus 3 marks for QWC]

AO1 = 4 marks
AO2 = 4 marks
AO3 = 4 marks
QWC = 3 marks

Band	Mark	Descriptor
4	10–12	**AO3** - Evaluation of the statement in relation to the structure, function and mechanism of action of DNA and RNA is **comprehensive**, **effective** and **relevant**, showing **detailed** understanding and **logical** and **coherent** chains of reasoning **throughout**. Makes **informed** conclusions that are **fully** supported with **rational** and **balanced** reasoned judgements. **AO2** - Applied **all relevant** knowledge of structure, function and mechanism of action of DNA and RNA **effectively** showing a **detailed** functional understanding. This is **effectively** linked to the context provided. **AO1** - A **wide** range of relevant knowledge and understanding of structure, function and mechanism of action of DNA and RNA is demonstrated, which is **accurate** and **detailed**. A **wide** range of **appropriate** technical terms are used.

3	7–9	**AO3** - Evaluation of the statement in relation to structure, function and mechanism of action of DNA and RNA, is in **most** parts effective and **mostly** relevant, showing **mostly** logical and coherent chains of reasoning. Makes conclusions **mostly** supported by reasoned judgements that consider **most** of the relevant arguments. **AO2** - Applied **mostly** relevant knowledge of structure, function and mechanism of action of DNA and RNA showing functional understanding. This linked **mostly** effectively to the context provided. **AO1** - Knowledge and understanding of structure, function and mechanism of action of DNA and RNA is in **most** parts clear and **mostly** accurate, although on **occasion** may lose focus.
2	4–6	**AO3** - Evaluation of the statement in relation to structure, function and mechanism of action of DNA and RNA, is in **some** parts effective and of **some** relevance, with **some** understanding and reasoning taking the form of generic statements with **some** development. Judgements are **basic** and **brief**; conclusions will have **limited** rationality and balance. **AO2** - Applied **little** but some **knowledge** of structure, function and mechanism of action of DNA and RNA, which is **limited** and **may** show a **lack** of functional understanding. Linking to the context is **attempted** but **not** always clear. **AO1** - Knowledge and understanding of structure, function and mechanism of action of DNA and RNA shows **some** but **limited** accuracy, focus and relevance.
1	1–3	**AO3** - Evaluation of the statement in relation to structure, function and mechanism of action of DNA and RNA is **minimal** and **very limited** in effectiveness and relevance. Given **brief** conclusions supported by judgements that consider only **basic** arguments and show **little** relevance to the question aims. **AO2** - Applied **limited** knowledge of structure, function and mechanism of action of DNA and RNA, showing a **very limited** functional understanding. Linking to the context is **not** attempted or **inappropriate**. **AO1** - Knowledge and understanding structure, function and mechanism of action of DNA and RNA, shows **very minimal** accuracy, focus and relevance.
	0	No creditworthy material.

Indicative content

Examiners are reminded that the indicative content reflects content-related points that a student may make but is not an exhaustive list, nor is it a model answer. Students may make all, some or none of the points included in the indicative content, as its purpose is as a guide for the relevance and expectation of the responses. Students must be credited for any other appropriate response.

AO1 and **AO2** will be implicit through the level of evaluation and reasoned judgements and/or conclusions that the student provides.

AO1: Demonstration of relevant knowledge and understanding of the structure, function and mechanism of action of DNA and RNA may include:

- the genetic code is degenerate
- a degenerate code has more codons than there are amino acids to code for
- DNA is double stranded
- each base on 1 strand, forms a complementary pair with a base on the other strand
- adenine (A) always pairs with thymine (T)
- cytosine (C) always pairs with guanine (G)
- the specific pairing of bases is called complementary base pairing
- DNA must be replicated accurately during cell division
- the genetic code in DNA is used to determine the amino acid sequence of all proteins
- during protein synthesis an mRNA copy of a sequence of DNA must be created
- formation of complementary base pairs is involved in DNA replication
- formation of complementary base pairs is involved in transcription/mRNA formation
- formation of complementary base pairs is involved in translation/attachment of tRNA to mRNA.

AO2: Application of knowledge and understanding of the structure, function and mechanism of action of DNA and RNA may include:

- a code consisting of 27 triplets would still be a degenerate code
- a degenerate code reduces the chances of a spontaneous change in the sequence of bases having an effect, as the sequence may change but still code for the same amino acid
- 27 triplets are considerably less than 64 triplets
- having 4 different bases enables complementary base pairing
- having 3 bases would prevent complementary base pairing
- DNA replication would not be possible without complementary base pairing
- transcription would not be possible without complementary base pairing
- translation would not be possible without complementary base pairing.

AO3: Evaluation of the statement in relation to the structure, function and mechanism of action of DNA and RNA may include:

- as an arrangement of 3 bases would still produce more triplets than are required, it would still be sufficient to code for all the amino acids required to produce proteins
- as 27 triplets is 7 more than required, there would still be the possibility of reduction of the effect of spontaneous changes in the DNA
- however, the more triplets that can code for each amino acid, the more reduction in the chances of a spontaneous change in the DNA having an effect, therefore there could be more problems with only 3 different bases
- as DNA replication cannot occur without complementary base pairing, there could be no mitosis and therefore no growth or replacement of cells
- as DNA replication could not occur without complementary base pairing, there could be no meiosis, therefore no gametes/sexual reproduction
- as transcription and translation are required for protein synthesis, there could be no protein synthesis.

Accept any other suitable response.

QWC mark scheme

Mark	Descriptor
3	The answer is clearly expressed and well-structured. The rules of grammar are used with effective control of meaning overall. A wide range of appropriate technical terms are used effectively.
2	The answer is generally clearly expressed and sufficiently structured. The rules of grammar are used with general control of meaning overall. A good range of appropriate technical terms are used effectively.
1	The answer lacks some clarity and is generally poorly structured. The rules of grammar are used with some control of meaning and any errors do not significantly hinder the overall meaning. A limited range of appropriate technical terms are used effectively.
0	There is no answer written or none of the material presented is creditworthy. or The answer does not reach the threshold performance level. The answer is fragmented and unstructured, with inappropriate use of technical terms. The errors in grammar severely hinder the overall meaning.

Section B: Chemistry

Total for this section: **27** marks plus **3** marks for quality of written communication (QWC) and use of specialist terminology

10 (a) Which one **of the following describes empirical formula?**

A **The largest ratio of atoms of each element in a compound**
B **The simplest ratio of atoms of each element in a compound**
C **The total mass of all atoms of each element in a compound**
D **The total number of atoms of each element in a compound**

[1 mark]

AO1 = 1 mark

B The simplest ratio of atoms of each element in a compound

(b) Give one **use of mass spectrometry.**

[1 mark]

AO1 = 1 mark

Award **one** mark for a valid use, up to a maximum of **one** mark:

- to separate substances due to their mass to charge ratio (1)
- to identify molecular ions and ion fragments (1)
- to identify the components of an unknown sample due to their molecular weights (1)
- to quantify components in a mixture (1).

Accept any other suitable response.

(c) **Scientists are investigating a new compound they have synthesised in the laboratory. They understand the empirical formula of this compound to be $C_{10}H_7O$ and the mass of the atoms in the empirical formula to be 143.**

Upon further analysis, scientists determine the relative molecular mass to be 286.

Work out the molecular formula of this compound.

You must show your working.

[2 marks]

AO2 = 2 marks

Award **one** mark for each valid calculation, up to a maximum of **two** marks:

- ratio between empirical mass and molecular mass = 286/143 = 2 (1)
- molecular formula is therefore $C_{10x2}H_{7x2}O_{1x2} = C_{20}H_{14}O_2$. (1).

Award 2 marks for $C_{20}H_{14}O_2$ without any working out shown.

11 **A team of scientists is comparing isotopes of carbon-12 (^{12}C) and carbon-13 (^{13}C). They have recorded their findings in** Table 2**.**

Table 2: **Isotopic data for carbon**

Isotope	Atomic mass	Atomic number	Number of neutrons
^{12}C	**12**	**6**	**6**

(a) **Using** Table 2, **which details the isotopic data for ^{12}C, suggest** two **similarities the scientists would expect to see in the structure of ^{12}C and ^{13}C.**

[2 marks]

AO2 = 2 marks

Award **one** mark for each similarity, up to a maximum of **two** marks:

- both isotopes have the same atomic number of 6 (1)
- both isotopes have 6 protons (1)
- both isotopes have 6 electrons (1).

(b) **Using** Table 2**, describe** two **differences between ^{12}C and ^{13}C.**

[2 marks]

AO2 = 2 marks

Award **one** mark for each difference, up to a maximum of **two** marks:

- ^{12}C has 6 neutrons in the nucleus and ^{13}C has 7 neutrons in the nucleus (1)
- ^{12}C has an atomic mass of 12 whereas ^{13}C has an atomic mass of 13 (1).

12 **Titanium is a transition metal often used in surgical implants, such as hip replacements.**

(a) **Describe** one **property of titanium which makes it a good choice for a hip replacement.**

[2 marks]

AO2 = 2 marks

Award **one** mark for each description point, up to a maximum of **two** marks:

- titanium is unreactive (1), this means it will not react in the body with bodily fluids/will not cause an immune response (1)
- titanium is strong (1), this means it will not need to be replaced/a person can do everyday activities without fear of it being broken/it can withstand a person's weight without breaking/bending (1).

Accept any other suitable response.

(b) **Laboratory technicians are developing a new material to use in electrical wiring. They combine titanium with copper, silver or gold. They also use a wire made of pure copper as a control as this is a common component in traditional electrical wiring. Wire options C, D and E use the same ratio of titanium to other metal.**

A technician states that the combination of silver and titanium would be the most appropriate option to use in wiring.

Table 3**: Initial results**

Wire option	Combination of elements in the wire	Electrical conductivity	% Elongation (ductility)
A	**Copper only**	**9.22×10^{3}**	**13**
B	**Titanium only**	**2.4×10^{-6}**	**20–40**
C	**Titanium and copper**	**3.11×10^{3}**	**11**
D	**Titanium and silver**	**4.21×10^{4}**	**12**
E	**Titanium and gold**	**3.21×10^{-1}**	**5**

Using Table 3**, assess the technician's statement.**

[3 marks]

AO3 = 3 marks

Award **one** mark for each assessment point, up to a maximum of **three** marks:

- The technician is likely to be correct based upon the results as, the titanium and silver combination shows the highest conductivity (1) however, it has relatively low ductility (12%) compared to titanium only (20-40%) and copper only (13%) (1) depending on the length of the wire required, it may be better to use copper only as this still has a high conductivity and is already widely used (1).
- titanium only has the highest ductility/percentage elongation, so this would be the best option for producing long wires (1). However, it has the lowest electrical conductivity, that means it is not suitable for use as an electrical wire (1). The titanium and silver is a combination of reasonable ductility and high conductivity, which makes the technicians' statement correct (1).

Accept any other suitable response.

13 **A technician dropped a small piece of potassium into some water contained within a glass beaker.**

Below is the unbalanced symbol equation for the reaction that subsequently took place:

$$\mathbf{K(s) + H_2O(l) \rightarrow KOH(aq) + H_2(g)}$$

Work out the balanced symbol equation for the reaction described above.

[2 marks]

AO2 = 2 marks

Award **one** mark for each side of the balanced equation, up to a maximum of **two** marks:

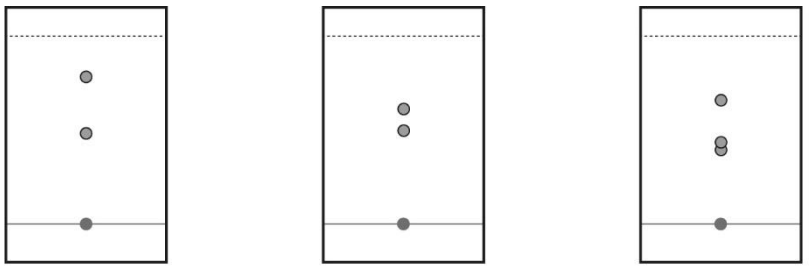
$$\mathbf{2K + 2H_2O \rightarrow 2KOH + H_2}$$

- identifying the first half of the balanced equation $2K + 2H_2O$ (1)
- identifying the second half of the balanced equation as $2KOH + H_2$ (1).

Accept any ratio of the elements that provide the correct balanced equation.

14 **A mixture of product A and product B needs to be purified. The lab manager asks for a thin layer chromatography (TLC) analysis using two different solvents.**

Figure 2**: Chromatograms after carrying out a TLC analysis**



A colleague suggests that solvent 1 **should be used when carrying out future analysis as it shows the best separation.**

Using Figure 2**, assess the colleague's suggestion.**

[3 marks]

AO3 = 3 marks

Award **one** mark for each assessment point, up to a maximum of **three** marks:

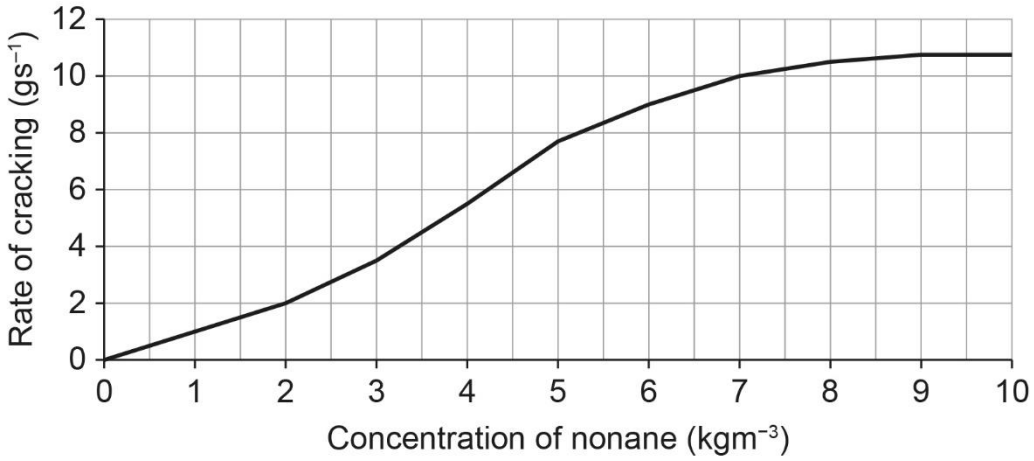
- the colleague is partially correct as solvent 1 does show clear separation of products A and B as it shows two very clear spots (1). The spots are more clearly separated using solvent 1 alone over solvent 2 alone/the spots in the solvent 2 chromatogram are closer together (1) however, a mixture of solvents 1 and 2 shows an additional component appearing which demonstrates that using both solvents together may be a better option, depending on the level of separation needed in the investigation (1)
- the colleague could be correct, however, there is no information regarding the ratio of solvents 1 and 2 within this chromatogram (1) there is also no information on other available solvents/other combinations of solvents 1 and 2 (1). Therefore, it is difficult to say whether the colleague is correct as it may be worth experimenting further to try and improve separation before moving on (1).

Accept any other suitable response.

15 A team of industrial scientists is studying a process that splits a very long molecule, called nonane, into shorter molecules using a catalyst.

The team started its investigation by using one type of catalyst at a fixed temperature and pressure. They changed the concentration of nonane and recorded the rate of reaction. Their results are shown in Figure 3**.**

Figure 3**: Graph of nonane concentration against rate of reaction**



One of the scientists suggests that if the temperature or pressure were increased, the rate of reaction would not level off at higher concentrations of nonane.

Using Figure 3**, your knowledge of collision theory and factors affecting rate of reaction, evaluate the scientist's suggestion.**

Your response should include reasoned judgements and conclusions.

[9 marks, plus 3 marks for QWC]

AO1 = 3 marks
AO2 = 3 marks
AO3 = 3 marks
QWC = 3 marks

Band	Mark	Descriptor
3	7–9	**AO3** – Evaluation of the scientist's suggestion **is comprehensive**, **effective and relevant**, showing **detailed understanding** and **logical and coherent** chains of **reasoning** throughout. Makes **informed conclusions** that are fully **supported** with rational and **balanced reasoned judgements.** **AO2** – **Applied** relevant **knowledge of collision theory** and factors affecting rate of reaction to the data provided. Shows a **detailed functional understanding of the scientific methodology** involved. **AO1** – Demonstrates a **wide range of relevant knowledge** and **understanding** of collision theory and factors affecting rate of reaction, which is **accurate and detailed**. The answer demonstrates **comprehensive breadth and/or depth of understanding**.
2	4–6	**AO3** – Evaluation of the scientist's suggestion is **in most parts effective** and **mostly relevant**, showing **mostly logical and coherent** chains of **reasoning**. Given **conclusions supported by reasoned judgements** that consider **most of the relevant arguments**. **AO2** – Applied **relevant knowledge** of collision theory and factors affecting rate of reaction to the data provided is in **most parts appropriate**, showing **some functional understanding** of the scientific methodology involved. **AO1** – **Knowledge and understanding** of collision theory and factors affecting rate of reaction is in **most parts clear and mostly accurate**, although on occasion may lose focus.
1	1–3	**AO3** – Evaluation of the scientist's suggestion is **in some parts effective** and of **some relevance**, with **some understanding** and reasoning taking the form of **generic statements** with **some development**. Judgements are **basic and brief**; conclusions will have **limited rationality** and **balance**. **AO2** – Applied **limited knowledge** of collision theory and factors affecting rate of reaction to the data provided and may show a **lack of functional understanding of the scientific methodology** involved. **AO1** – **Knowledge and understanding** of collision theory and factors affecting rate of reaction shows **some but limited accuracy**, focus and relevance.
	0	No creditworthy material.

Indicative content

Examiners are reminded that the indicative content reflects content-related points that a student may make but is not an exhaustive list, nor is it a model answer. Students may make all, some or none of the points included in the indicative content, as its purpose is as a guide for the relevance and expectation of the responses. Students must be credited for any other appropriate response.

AO1 and **AO2** will be implicit through the level of evaluation and reasoned judgements and/or conclusions that the student provides.

AO1: Demonstration of knowledge regarding collision theory and factors affecting rate of reaction may include:

- collision theory states that for a reaction to occur molecules must:
  - collide
  - collide with enough energy to break and reform bonds
  - be in the correct spatial orientation
- an increase in temperature makes molecules move faster, resulting in increased collisions and rate of reaction
- catalysts are substances that increase the rate of a chemical reaction without themselves being permanently chemically changed
- a range of factors affect the rates of chemical reactions:
  - surface area
  - temperature
  - concentration
  - pressure
- activation energy is the minimum amount of energy required to start a reaction
- a catalyst provides an alternative pathway with a lower activation energy
- using a catalyst in industrial reactions can increase the rate of reaction/give a faster turnaround time and so reduces costs.

AO2: Application of knowledge of collision theory and factors affecting rate of reaction using the data may include:

- at nonane concentrations between 0 and 3 kgm^{-3} on the graph the rate of reaction increases from 0 to 3.5 gs^{-1}
- at a nonane concentration of 8 kgm^{-3} the rate of reaction reaches a limit of 10.75 gs^{-1}
- the rate of reaction between nonane concentrations of 9 and 10 kgm^{-3} does not decrease and only maintains a value of 10.75 gs^{-1}
- in this scenario, the concentration of catalyst is fixed, and the pressure and temperature are also fixed, meaning that the concentration of nonane is the limiting factor in this reaction
- the experiment has not been repeated
- the scientists only investigated concentration and no other factors, such as, temperature or pressure
- the scientists have only investigated one catalyst
- there is no information given on rate of reaction without a catalyst.

AO3: Evaluation of the scientist's suggestion may include:

- the scientist's suggestion may be correct, however, there is no way of knowing without performing further experimentation as the data does not give information on changing temperature or pressure
- the scientist could conduct further investigations, for example, a control where no catalyst is used/fixed temperature and varying pressure (including catalyst)/fixed pressures and varying temperatures (including catalyst)
- the data presented in **Figure 3**, may show that the catalyst has a limiting turnover rate/capacity, potentially observed at nonane concentrations between 8 and 10 kgm^{-3}, increasing temperatures and pressures may achieve this limit at lower concentrations of nonane
- different types of catalyst could be investigated to see if a higher limit is achieved, or whether this affects the speed at which this limit is reached upon varying nonane concentration
- the scientist should consider repeating the investigation at least three times so they can identify any anomalous results and ensure the results are valid.

QWC mark scheme

Mark	Descriptor
3	The answer is clearly expressed and well-structured. The rules of grammar are used with effective control of meaning overall. A wide range of appropriate technical terms are used effectively.
2	The answer is generally clearly expressed and sufficiently structured. The rules of grammar are used with general control of meaning overall. A good range of appropriate technical terms are used effectively.
1	The answer lacks some clarity and is generally poorly structured. The rules of grammar are used with some control of meaning and any errors do not significantly hinder the overall meaning. A limited range of appropriate technical terms are used effectively.
0	There is no answer written or none of the material presented is creditworthy. Or The answer does not reach the threshold performance level. The answer is fragmented and unstructured, with inappropriate use of technical terms. The errors in grammar severely hinder the overall meaning.

Accept any other suitable response.

Section C: Physics

This section is worth **18** marks.

16 (a) **Which** one **of the following states the area of a magnet where the magnetic forces are strongest?**

A **The centre**
B **The north and south poles**
C **The north pole only**
D **The south pole only**

[1 mark]

AO1 = 1 mark

B The north and south poles.

(b) **State** one **difference between permanent and induced magnets.**

[1 mark]

AO1 = 1 mark

Award **one** mark for a valid statement, up to a maximum of **one** mark:

- a permanent magnet produces its own magnetic field (1)
- an induced magnet is an object that becomes a magnet when placed in a magnetic field (1).

Accept any other suitable response.

(c) **An experiment is prepared in which an iron bar is placed inside a coil of wire. A current is passed through the wire for 10 seconds, and then turned off. The magnetic field around the iron bar is measured before, during and after the current is passed through.**

Before the current is passed through the wire, the magnetic field strength measures zero.

State how the measurements for magnetic field strength would change as the current is passed through the wire and as the current is switched off again.

[2 marks]

AO1 = 2 marks

Award **one** mark for each statement, up to a maximum of **two** marks:

- when the current is passed through the wire, a magnetic field around the bar will be created/magnetic field strength will increase (1)
- once the current is switched off, the magnetic field will dissipate/decrease/disappear (1).

Accept any other suitable response.

17 **A charge of 200 coulombs flows through a circuit for 10 seconds.**

The following equation can be used to calculate charge:

$$\boldsymbol{Q = It}$$

Using this equation, calculate the average current.

You must show your working and provide the correct units.

[4 marks]

AO2 = 4 marks

Award **one** mark for each of the following, up to a maximum of **four** marks:

- the rearrangement of the equation:

$$I = \frac{Q}{t}$$

- substituting the values into the equation:

$$I = \frac{200}{10}$$

- the calculation of the correct value:

$$I = 20$$

- the correct units:

A or Amps.

18 **State** one **difference between alternating current and direct current.**

[1 mark]

AO1 = 1 mark

Award **one** mark for a valid statement, up to a maximum of **one** mark:

- in direct current the voltage is always constant, whereas, in alternating current, the voltage changes periodically between negative and positive (1)
- in direct current the current flows in a specific direction, whereas, in alternating current, the current flows in both directions periodically (1).

Accept any other suitable response.

19 **A physicist is investigating hydrostatic pressure by carrying out an experiment similar to the one carried out by the scientist Blaise Pascal in the 17th century.**

The experiment involves filling a large glass jar with water, sealing the neck of the jar with a bung and a rubber tube extending from this. The physicist extends the tube from the glass jar on the ground floor up the outside of the building, to the 50th floor.

The physicist hypothesises that as they fill the tube with water, the glass jar will shatter.

Using your knowledge of hydrostatic pressure, justify the physicist's hypothesis.

Your response should include reasoned judgements and a conclusion.

[3 marks]

AO3 = 3 marks

Award **one** mark for each justification point, up to a maximum of **three** marks:

- An increase in depth of water increases the hydrostatic pressure (due to gravity in the jar) (1). It can be assumed that the same will happen with height so the higher the tube, the greater the hydrostatic pressure (1). Eventually the hydrostatic pressure will be so great that the glass jar will break (1).

Accept any other suitable response.

20 Nuclear scientists are investigating four synthetic isotopes of iodine:

- **iodine-123 (^{123}I)**
- **iodine-129 (^{129}I)**
- **iodine-131 (^{131}I)**
- **iodine-135 (^{135}I).**

They hope to find an isotope that allows a relatively safe way to study beta radiation.

Table 4 **shows the data the scientists are provided with relating to the synthetic isotopes of iodine.**

Table 4**: Data relating to the four synthetic isotopes of iodine**

Isotope	Half-life	Main type of ionising radiation emitted
^{123}I	**13.2 hours**	**Gamma**
^{129}I	**15 700 000 years**	**Beta**
^{131}I	**8 days**	**Beta**
^{135}I	**6.6 hours**	**Beta**

One nuclear scientist suggests that researching ^{129}I would be the safest isotope to use as its half-life is the longest and therefore it is the most stable. They reason that less specialised personal protective equipment (PPE) will be required due to the stability of the isotope.

With reference to radioactive decay, general laboratory safety and the data provided in Table 4**, assess the scientist's suggestion.**

Your response should include reasoned judgements and conclusions.

[6 marks]

AO1 = 2 marks
AO2 = 2 marks
AO3 = 2 marks

Band	Mark	Descriptor
3	5–6	**AO3** – Assessment of the suggestion in relation to radioactive decay and the data provided is **comprehensive**, **effective** and **relevant**, showing **detailed** understanding and **logical** and **coherent** chains of reasoning throughout. There are **effectively** informed judgements that are **fully** supported and **rational**. **AO2** – Application of knowledge of radioactive decay and general laboratory safety linked to the data provided is **highly appropriate** and shows a **detailed** functional understanding. **AO1** – There is a **wide** range of relevant knowledge and understanding of radioactive decay and general laboratory safety, that is **accurate** and **detailed**. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	3–4	**AO3** – Assessment of the suggestion in relation to radioactive decay and the data provided is in **most** parts **effective** and **mostly relevant**, showing **mostly logical** and **coherent** chains of reasoning throughout. There are **mostly accurate** judgements and **mostly rational** and balanced conclusions are evident. **AO2** – Application of knowledge of radioactive decay and general laboratory safety linked to the data provided is in **most** parts appropriate, showing **some** functional understanding. **AO1** – Knowledge and understanding of radioactive decay and general laboratory safety is in **most** parts **clear** and **mostly accurate**, although on occasion may lose focus. The answer demonstrates **reasonable** breadth and/or depth of understanding, with occasional inaccuracies and/or omissions.
1	1–2	**AO3** – Assessment of the suggestion in relation to radioactive decay and the data provided is in **some** parts effective and of **some** relevance, with **some** understanding and reasoning taking the form of generic statements with some development. Judgements are **basic** and **brief**, and conclusions will have **limited** rationality and balance. **AO2** – Application of knowledge of radioactive decay and general laboratory safety linked to the data provided is **limited** and may show a lack of functional understanding. **AO1** – Knowledge and understanding of radioactive decay and general laboratory safety shows some but **limited accuracy**, **focus** and **relevance**. The answer is **basic** and shows **limited** breadth and/or depth of understanding, with inaccuracies and omissions.
0	0	No creditworthy material.

Indicative content

Examiners are reminded that the indicative content reflects content-related points that a student may make but is not an exhaustive list, nor is it a model answer. Students may make all, some or none of the points included in the indicative content, as its purpose is as a guide for the relevance and expectation of the responses. Students must be credited for any other appropriate response.

AO1 and **AO2** will be implicit through the level of evaluation and reasoned judgements and/or conclusions that the student provides.

AO1: Demonstration of knowledge regarding radioactive decay may include:

- beta radiation is medium penetrating
- beta radiation is medium ionising
- beta radiation can cause damage to cells and tissues that it comes into contact with
- certain equipment, such as radioactive sources, may need more specialised safety equipment
- half-life is the time taken for half the unstable nuclei in a sample to decay
- count-rate is the number of decays recorded each second
- the longer the half-life, the fewer decays recorded per second.

AO2: Application of knowledge of the implications of radioactive decay, laboratory safety and linked to the data may include:

- iodine-129 is unlikely to emit a measurable level of beta radiation
- iodine-135 is the isotope likely to emit the most beta radiation in a given time
- iodine-123 would not be of use to the scientists as it emits gamma radiation
- lab coat and goggles will provide minimal protection against radiation risks, alternative PPE is required when working with radioactive sources, such as gloves, mask and/or apron, regardless of the type of radiation emitted
- a radiation monitor will be useful to alert the scientist if the cumulative dose reaches too high levels during the experiment.

AO3: Assessment of the suggestion in relation to radioactive decay, laboratory safety and the data provided may include:

- If the purpose of the investigation is to study beta radiation, then the scientists will need to use an isotope with a shorter half-life than iodine-129 as this is unlikely to emit enough beta radiation to be useful to the scientists. It would, therefore, be more appropriate to use iodine-131 or iodine-135 as they both have a much shorter half-life.
- The scientist is incorrect that the level of beta radiation emitted should be a deciding factor when considering safety. Any use of radioactive materials can be dangerous and needs to be treated as such. Additional safety measures, such as lined aprons and use of a cabinet with shielding, should therefore be included in the risk assessment.
- Regardless of the type of radiation being emitted, shielding (or lead shielding), or doing the experiment from another room entirely, would be much safer than using only a lab coat and gloves.

- The experiment duration, or at least the time spent using the radioactive sample, should be kept to a minimum to reduce the exposure to ionising radiation.
- Additional workflow changes could also be considered, such as working with colleagues to reduce individual exposure.

Accept any other suitable response.

Section D: Scientific concepts

This section is worth 20 marks plus 3 marks for quality of written communication (QWC) and use of specialist terminology.

21 **Copper is ductile, an excellent electrical conductor and is used in electrical cabling. However, if the current rate of use continues, we may eventually run out of copper.**

Explain two **other properties a metal would need, to be able to replace copper in electrical cables.**

[4 marks]

AO2 = 4 marks

Award up to **two** marks for each explanation, up to a maximum of **four** marks:

- the metal would need to be strong (1); electrical cables need to be long; this creates weight therefore strength is required to prevent breaking (1)
- the metal would need to be relatively unreactive with oxygen and water (1); electrical cables are exposed to air and rain, if the metal reacted easily with either, the metal would no longer exist as an element/free metal and could not do its job (1).

Accept any other suitable response.

22 **Scrap metal yards often use powerful magnets suspended from cranes to move scrap iron and steel around.**

Explain two **reasons why an electromagnet would be more useful than a permanent magnet in this situation.**

[4 marks]

AO2 = 4 marks

Award **one** mark for each explanation, up to a maximum of **four** marks:

- the crane needs to be able to lift the scrap metal and put it down again (1); an electromagnet can be switched on and off, therefore it can pick up the scrap metal and put it down again (1).
- a permanent magnet cannot be switched on and off (1); therefore, it could pick up the scrap metal but could not put it down again (1).

or:

- the scrap metal being moved is likely to be heavy (1); an electromagnet can be very powerful and therefore could lift the scrap metal (1).
- the scrap metal is likely to be too heavy for a permanent magnet to lift (1) as permanent magnets are less powerful (than electromagnets) (1).

Accept any other suitable response.

23 **You are part of a team designing an electric motorbike to be used for racing. You are working on the outer casing for the battery pack to power the bike.**

You are interested in investigating the use of a polymer. However, one of your colleagues states that the casing should be stainless steel, as stainless steel is strong, unreactive and can easily be moulded into the appropriate shape.

Assess the use of a polymer over stainless steel for the battery casing.

[3 marks]

AO3 = 3 marks

Award **one** mark for each assessment point, up to a maximum of **three** marks:

- The colleague is correct that stainless steel has many useful properties, however, polymers are usually lower density than stainless steel (1), which will make the battery pack/bike lighter and therefore easier to ride/change parts (1) polymers are also electrical insulators which will reduce the risk of electric shock and make the bike safer for the rider (1).
- The colleague is correct that stainless steel has many useful properties, however, polymers can also be easily moulded and are also unreactive (1) this means that other factors could be considered, such as, cost and availability (1) depending on the outcome of these other factors being considered it may be more beneficial to the team to use polymers over stainless steel, which makes the colleague incorrect (1).

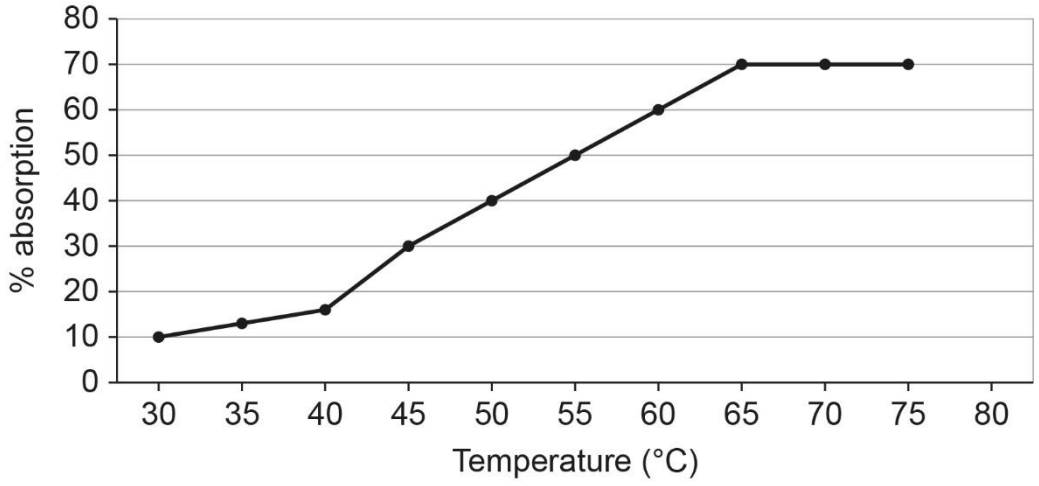
Accept any other suitable response.

24 **An investigation was carried out into the relationship between membrane permeability and temperature using spinach leaves.**

1 g of chopped spinach was placed into several boiling tubes with 10 ml of alcohol. The tubes were placed in water baths at different temperatures. After 15 minutes, the spinach was removed and the amount of chlorophyll released was obtained by measuring the amount of light absorbed by the chlorophyll: the higher the absorption, the higher the chlorophyll.

The results are shown in Figure 4.

Figure 4**: A graph to show the effect of temperature on absorption**



A student studying the results concludes:

‘Cell surface membrane permeability in plants does increase as the temperature increases. This happens because the higher temperatures cause the cell surface membrane structure to break down.’

Considering the structure and properties of the cell surface membrane, and the processes used in the investigation, evaluate the validity of the student's conclusion.

Your response should include reasoned judgements and conclusions.

[9 marks, plus 3 marks for QWC]

AO1 = 3 marks
AO2 = 3 marks
AO3 = 3 marks
QWC = 3 marks

Band	Mark	Descriptor
3	7–9	**AO3** – Evaluation of the validity of the student's conclusion is **comprehensive**, **effective** and **relevant**, showing **logical** and **coherent** chains of reasoning throughout that are **fully** supported with **rational** and **balanced** judgements. **AO2** – **All relevant** knowledge of the structure and properties of cell surface membranes is applied **effectively** to the given context. **AO1** – A **wide** range of relevant knowledge and understanding of the structure and properties of cell surface membranes is evident. A **wide** range of **appropriate** technical terms are used. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	4–6	**AO3** – Evaluation of the validity of the student's conclusion is in **most** parts **effective** and **mostly relevant**, showing in **most** parts **logical** and **coherent** chains of reasoning, which are **mostly** supported with rational and balanced judgements. **AO2** – **Most of the** relevant knowledge of the structure and properties of cell surface membranes is applied **mostly effectively** to the given context, although on occasions there **may** be a lack of clarity. **AO1** – Knowledge and understanding of the structure and properties of cell surface membranes is in **most** parts **clear** and in **most** parts **accurate**, although on **occasion** may lose focus. The answer demonstrates **reasonable** breadth and/or depth of understanding, with occasional inaccuracies and/or omissions.
1	1–3	**AO3** – Evaluation of the validity of the student's conclusion is in **some** parts **effective** but may **at times** have **little relevance**. **Brief** conclusions supported by judgements that consider only **basic** arguments and show **tenuous** relevance to the question aims are evident. **AO2** – **Limited** knowledge of the structure and properties of cell surface membranes is **applied** to the given context. **AO1** – Knowledge and understanding of the structure and properties of cell surface membranes shows **some** but **limited accuracy, focus** and **relevance.** The answer is **basic** and shows **limited** breadth and/or depth of understanding, with inaccuracies and omissions.
	0	No creditworthy material.

Indicative content

Examiners are reminded that the indicative content reflects content-related points that a student may make but is not an exhaustive list, nor is it a model answer. Students may make all, some or none of the points included in the indicative content, as its purpose is as a guide for the relevance and expectation of the responses. Students must be credited for any other appropriate response.

AO1 and **AO2** will be implicit through the level of evaluation and reasoned judgements and/or conclusions that the student provides.

AO1: Demonstration of knowledge regarding the structure and properties of cell surface membranes may include:

- the bulk of the cell surface membrane consists of a phospholipid bilayer
- the bilayer consists of 2 layers of phospholipids with their fatty acid tails facing inwards
- within the phospholipids in the bilayer are protein channels and carrier proteins
- the phospholipid bilayer is maintained by the hydrophobic nature of the fatty acid tails and the hydrophilic nature of the phosphate group
- the cell surface membrane controls what can enter and leave the cell
- as the temperature rises the movement of molecules increases.

AO2: Application of knowledge of the structure and properties of cell surface membranes using the data may include:

- there is no evidence that the chopped spinach samples were washed
- there is no evidence that all the samples were taken from the same batch of spinach
- there is no evidence that all the samples were chopped in the same way
- the procedure was not repeated to increase validity
- the % absorption did rise over the duration of the investigation from 10% to 70%
- the increase in the amount of absorption was not linear
- as the temperature increased from 30 to 40 ˚C the absorption increased relatively slowly from (10% to about 15%)
- between 40 and 65 ˚C the absorption increased more rapidly from (15% to about 66%)
- above 70 ˚C the amount of absorption levelled out
- the hydrophobic nature of the fatty acid tails would resist the movement of chlorophyll pigment out of the cells
- the investigation was only carried out on spinach.

AO3: Evaluation of the validity of the student's conclusion may include:

- as the chopped spinach samples had not been washed, the chlorophyll on their surfaces would increase absorption without any increase in temperature, this may reduce the validity of the conclusion
- as there is no indication that the spinach samples were taken from the same batch of spinach this could make the conclusion less valid, as different batches may have different amounts of chlorophyll

- as the investigation was not repeated, there is no evidence that the results were repeatable, this reduces the validity of the conclusion
- as the phospholipids in the bilayer are in a fluid mosaic structure, increased movement of the phospholipids may affect the structure of the bilayer and therefore increasing the permeability of the cell surface membrane
- the student concluded that as temperature increases so does membrane permeability, although this is not wrong it is too simple as the relationship is not linear
- as the investigation was only carried out in spinach, there is no proof that this would be repeated in other types of plants.

Accept any other suitable response.

QWC mark scheme

Mark	Descriptor
3	The answer is clearly expressed and well-structured. The rules of grammar are used with effective control of meaning overall. A wide range of appropriate technical terms are used effectively.
2	The answer is generally clearly expressed and sufficiently structured. The rules of grammar are used with general control of meaning overall. A good range of appropriate technical terms are used effectively.
1	The answer lacks some clarity and is generally poorly structured. The rules of grammar are used with some control of meaning and any errors do not significantly hinder the overall meaning. A limited range of appropriate technical terms are used effectively.
0	There is no answer written or none of the material presented is creditworthy. or The answer does not reach the threshold performance level. The answer is fragmented and unstructured, with inappropriate use of technical terms. The errors in grammar severely hinder the overall meaning.

Assessment objective grid

Section A
Biology

Question Number	AO1	AO2	AO3	Maths	QWC	Total
1	1					1
2	1					1
3 (a)	1					1
3 (b)	4					4
3 (c)		2				2
4 (a)		2				2
4 (b)		1				1
5 (a)	1					1
5 (b)			3			3
5 (c)			3			3
6 (a)		1				1
6 (b)	2					2
7 (a)			3			3
7 (b)		4		(4)		4
7 (c)	2					2
8 (a)	1					1
8 (b)	1					1
9	4	4	4		3	15
Total	**18**	**14**	**13**	**(4)**	**3**	**48**
Totals required	**17–22 marks**	**11–16 marks**	**11–16 marks**	**4**		
Kil	**x**					

Section B
Chemistry

Question Number	AO1	AO2	AO3	Maths	QWC	Total
10 (a)	1					1
10 (b)	1					1
10 (c)		2		(2)		2
11 (a)		2				2
11 (b)		2				2

12 (a)		2				2
12 (b)			3			3
13		2				2
14			3			3
15	3	3	3		3	12
Total	**5**	**13**	**9**	**(2)**	**3**	**30**
Totals required	**3–7 marks**	**11–16 marks**	**6–11 marks**	**2**		
Kil						

Section C
Physics

Question Number	AO1	AO2	AO3	Maths	QWC	Total
16 (a)	1					1
16 (b)	1					1
16 (c)	2					2
17		4		(4)		4
18	1					1
19			3			3
20	2	2	2			6
Total	**7**	**6**	**5**	**(4)**		**18**
Totals required	**3–7 marks**	**3–7 marks**	**3–7 marks**	**4**		
Kil						

Section D
Scientific concepts

Question Number	AO1	AO2	AO3	Maths	QWC	Total
21		4				4
22		4				4
23			3			3
24	3	3	3		3	12
Total	**3**	**11**	**6**		**3**	**23**
Totals required	**3–7 marks**	**6–11 marks**	**6–11 marks**			
Kil	**X**					

Document information

Owner: Head of Assessment Design