T-LEVELS | Institute for Apprenticeships & Technical Education

T Level Technical Qualification in Health

Core knowledge and understanding

Paper B

Mark scheme

V1.3: P001982
Post-standardisation
Summer 2023
603/7066/X

NCFE CACHE

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 marks 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 mark grids have been designed to assess students' work holistically. They consist of band-based descriptors and indicative content.

Each level is made up of several descriptors across the AO range (AO1–AO3) which, when combined, provide the quality of response that a student needs to demonstrate. Each levels-based descriptor is worth varying marks.

The grids are broken down into levels, with each level having an associated descriptor indicating the performance at that level. You should determine the level 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 level, you should use a bottom-up approach. If the response meets all the descriptors in the lowest level, you should move to the next one, and so on, until the response matches the level 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 levels, you should use a best-fit approach at this stage and use the available marks within the level 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.

Assessment objectives

This assessment requires students to:

AO1: Demonstrate knowledge and understanding of contexts, concepts, theories and principles in healthcare
AO2: Apply knowledge and understanding of contexts, concepts, theories and principles in healthcare to different situations and contexts
AO3: Analyse and evaluate information and issues related to contexts, concepts, theories and principles in healthcare 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

Total for this section: 42 marks plus 6 marks for quality of written communication (QWC)

1 Which one **of the following is the gland responsible for the production of glucagon?**

A Adrenal
B Pancreas
C Parathyroid
D Thyroid

[1 mark]

AO1 = 1 mark

Award **one** mark for the following:

Answer

B. Pancreas (1)

2(a) A researcher wishes to study the detailed structure of mitochondria.

Using your knowledge of the properties of transmission electron microscopes, explain one **reason why a transmission electron microscope is likely to be more useful than a scanning electron microscope in this scenario.**

[2 marks]

AO1 = 1 mark
AO2 = 1 mark

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

- transmission electron microscopes can image internal structures (AO1 – 1), scanning electron microscopes cannot and mitochondria are inside the cell. (AO2 – 1)

Or

- transmission electron microscopes have a higher resolution than scanning electron microscopes (AO1 – 1), as mitochondria are organelles a higher resolution will give more detail. (AO2 -1)

Accept any other suitable response.

2(b)	**A technician working in a fertility clinic needs to examine how mobile individual sperm cells are in a semen sample.** **Using your knowledge of the properties of light microscopes, explain** one **reason why a light microscope would be most suitable for this examination.** [2 marks]

AO1 = 1 mark
AO2 = 1 mark

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

- light microscopes can be used to examine living organisms / cells (AO1 – 1) therefore a light microscope is most suitable as the sperm need to be living to observe movement. (AO2 – 1)

Accept any other suitable response.

3	**A patient is admitted to hospital following a car accident, with the following symptoms:** • **severe bruising and swelling of the abdomen** • **initial blood pressure of 88/56 mmHg which is continuing to fall steadily** • **no external bleeding** • **tests showing that liver and kidney function are declining rapidly.** **State whether this would be classed as an injury only or whether it would be considered a trauma and justify your choice.** [4 marks]

AO2 = 1 mark
AO3 = 3 marks

Award **one** AO2 mark for the correct suggestion:

- trauma.

Justification

Award **one** AO3 mark for each appropriate justification up to a maximum of **three** marks:

- one characteristic of trauma is loss of organ function, as there is evidence of loss of liver / kidney function and the liver / kidney is an organ, this indicates trauma (1)
- one characteristic of trauma is multiple organ failure as there is evidence of loss of function of 2 organs, this could be classed as multiple organ failure, this indicates trauma (1)
- one characteristic of trauma is internal bleeding / haemorrhaging, as blood pressure is below 90/60 mmHg and continuing to fall, and there is no external bleeding, this suggests serious internal bleeding/haemorrhaging, this indicates trauma (1)

- one definition of trauma is having the potential to cause disability or death, as organ failure and internal bleeding have the potential to cause death, this indicates trauma. (1)

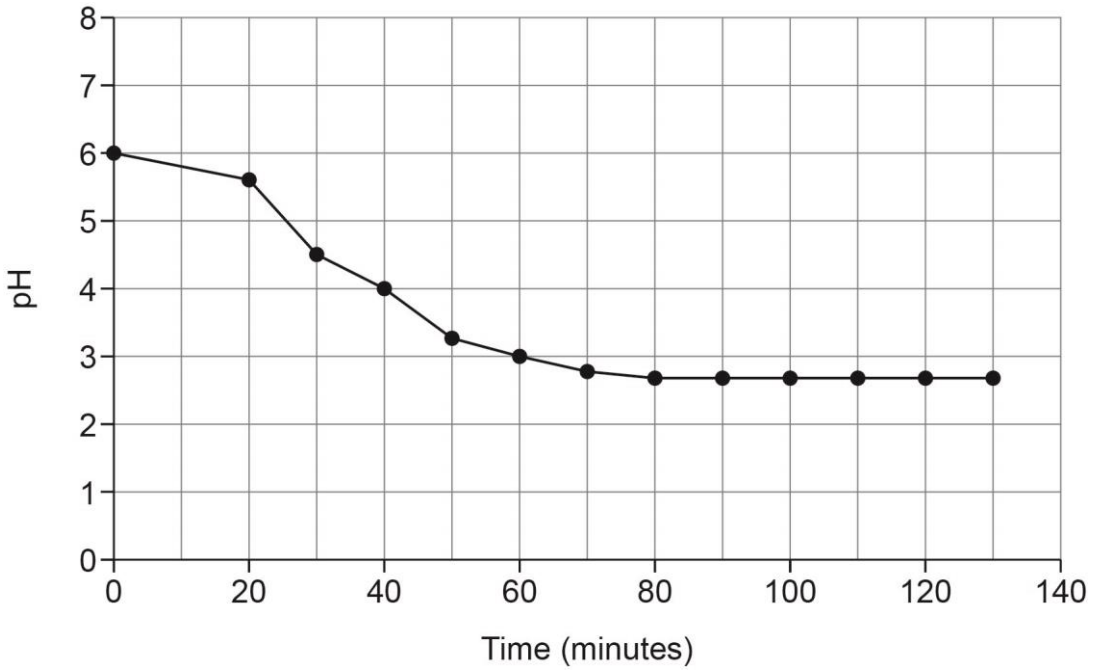
Accept any other suitable response.

4(a) **A student investigated the digestion of lipids in milk by the enzyme lipase, using the following procedure:**

- **100ml of sterilised whole milk was maintained at 30˚C in a water bath**
- **5ml of lipase solution was added to the milk**
- **the pH of the mixture was measured every ten (10) minutes.**

The results are shown in Figure 1**.**

Figure 1: **a graph to show pH change over time**



State the effect of lipase on lipids and explain why the student chose to measure pH changes to investigate lipid digestion.

[3 marks]

AO1 = 1 mark
AO2 = 2 marks

Award **one** AO1 mark for stating the effect of lipase on lipids:

- lipase digests lipids to produce fatty acids and glycerol. (1)

Award **one** AO2 mark for each stage of the explanation up to a maximum of **two** marks:

- the fatty acid levels would rise as digestion proceeded (1)

- as the fatty acid levels rose, the pH would fall. (1)

4 (b) Give the time period where the rate of lipid digestion was highest.

[1 mark]

AO2 = 1 mark

Award a maximum of **one** mark for the correct time period:

- from 20 – 30 (minutes).

4 (c) Explain why sterilised whole milk was used rather than fresh whole milk.

[2 marks]

AO2 = 2 marks

Award **one** mark for the following explanation:

- fresh / unpasteurised / unsterilised whole milk is likely to contain bacteria (1) and these bacteria could digest the lipids / affect the results resulting in inaccurate results. (1)

Accept any other suitable response.

5 An athlete had been exercising vigorously. At the end of their exercise, their pulse rate was 180bpm. After resting for 20 seconds, their pulse rate had fallen by 18 to 162bpm.

Calculate the percentage reduction in heart rate over the 20 seconds.

Show your working.

[2 marks]

AO2 = 2 marks

Award **one** method mark:

- % reduction in heart rate = (18/180) x 100 (1)

Or

- % reduction in heart rate = (180-162)/180 x 100 (1)

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

- = 10**%** (1)

NB: An answer of 10 with no working, should be awarded **one** mark. % symbol not required to be awarded marks.

6	**The human testes are outside the body cavity, the average temperature of the human testes is around 34˚C.** **'The ovaries need to be maintained at body temperature in order to function efficiently, whereas the testes need to be at a slightly lower temperature.'** **Using the information provided, discuss the validity of this statement.** [4 marks]

AO2 = 1 mark
AO3 = 3 marks

Award **one** AO2 mark for applying knowledge of body temperature to the question, up to a maximum of **one** mark:

- the temperature of the body is 37ºC, the temperature of the testes (34ºC) is therefore slightly lower than body temperature. (1)

Award **one** AO3 mark for each correct discussion point up to a maximum of **three** marks:

- as the testes are outside the body and their temperature is lower, it is reasonable to assume that a lower temperature is required for their efficient functioning (1)
- the testes produce and store sperm which may need to be stored at 34ºC to function correctly (1)
- the testes produce testosterone which may need to be produced at 34ºC to function correctly (1)
- however, both sperm and testosterone act inside the body, at a temperature of 37ºC, so this may not be the reason at all (1)
- as the ovaries are inside the body cavity, their temperature will be 37ºC, therefore they must be able to function at 37ºC (1)
- however, being able to function efficiently at 37ºC body temperature does not mean that the ovaries must be at 37ºC to function efficiently (1)
- the ovaries are positioned next to the uterus/womb, this enables the ova to easily travel to the womb. Being close to the uterus maybe the reason for the position of the ovaries, rather than being at 37ºC (1)

Accept any other suitable response.

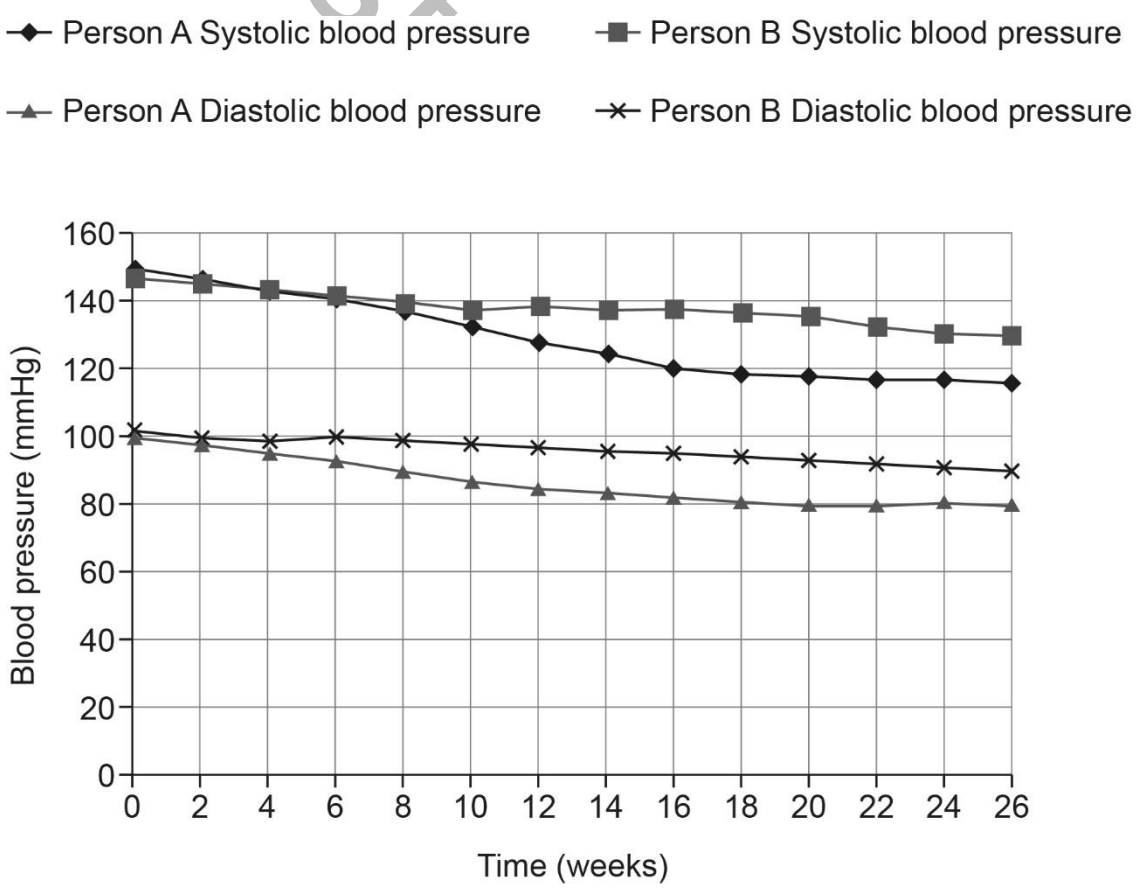
7 **Patient A and Patient B are both significantly overweight and have high blood pressure. Neither patient appears to have any other health issues.**

Figure 2: **table showing details about the patients**

	Patient A	Patient B
Mass (kg)	**110**	**108**
Blood pressure (mmHg)	**150/100**	**147/102**
Age (years)	**45**	**43**

Both patients wish to lower their blood pressure without the use of medication. They are both prescribed the same exercise routine, which they both perform three times per week over 26 weeks.

Figure 3: **shows how their blood pressure changes over the 26 weeks.**



A student analyses Figure 3 **and makes the following statement: 'Exercise is not a reliable way of lowering blood pressure, as Person B still has high blood pressure after 26 weeks.'**

	Discuss to what extent the information provided supports the student's statement. **Your response should demonstrate reasoned judgements.** [9 marks plus 3 for QWC]

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

Band	Marks	Descriptor
3	7-9	**AO3:** Discussion of the extent the information provided supports the student's statement 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 blood pressure measurements, factors affecting blood pressure and the scientific method, are applied **effectively** to the given context. **AO1:** A **wide** range of relevant knowledge and understanding of blood pressure measurements, factors affecting blood pressure, and the scientific method is evident. A **wide** range of **appropriate** technical terms are used. The answer demonstrates **comprehensive** breadth and depth of understanding.
2	4-6	**AO3:** Discussion of the extent the information provided supports the student's statement 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 blood pressure measurements, factors affecting blood pressure, and the scientific method are applied mostly **effectively** to the given context, although on occasions there **may** be a lack of clarity. **AO1:** Knowledge and understanding of blood pressure measurements, factors affecting blood pressure, and the scientific method 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:** Discussion of the extent the information provided supports the student's statement 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 blood pressure measurements, factors affecting blood pressure, and the scientific method is **applied** to the given context. **AO1:** Knowledge and understanding of blood pressure measurements, factors affecting blood pressure, and the scientific method, 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

Indicative content:

Examiners are reminded that 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 analysis and reasoned judgements and conclusions that the student provides.

AO1: Demonstration of knowledge regarding blood pressure measurements, factors affecting blood pressure and scientific methodology may include:

- a systolic blood pressure of around 120 is considered to be average
- a diastolic blood pressure of around 80 is considered to be average
- a systolic blood pressure of around 140 is considered to be high
- a diastolic blood pressure of around 90 is considered to be high
- being overweight can be a factor in causing blood pressure to be higher
- age can be a factor in causing blood pressure to be higher
- general health can be a factor in determining blood pressure.

AO2: Application of knowledge of blood pressure measurements, factors affecting blood pressure and scientific methodology may include:

- there is no detail provided about controlling other variables such as diet and lifestyle choices
- both patients have significantly high blood pressure
- both patients have similar systolic and diastolic blood pressures at the start of the prescribed exercise plan
- no detail is provided about gender which can impact the range for blood pressure
- no detail is provided about their blood pressure history prior to their current measurement
- both systolic and diastolic blood pressure falls for each patient over the first 20 weeks
- after 20 weeks both systolic and diastolic blood pressure start to level out for Patient A
- both systolic and diastolic blood pressure fell throughout the 26 weeks for Patient B
- both systolic and diastolic blood pressure fall faster for patient A than Patient B
- both systolic and diastolic blood pressure for Patient A fall to normal levels after 20 weeks
- neither systolic nor diastolic blood pressure fall to normal after 26 weeks for patient B.
- the sample size of 2 is very small.

AO3: Discussion of the extent the information provided supports the student's statement may include:

- as the sample size is only 2, this is too small a sample to produce results which are sufficiently reliable to base conclusions/this statement on
- as there is no detail provided about controlling other variables such as diet and lifestyle choices, this reduces the validity of the results / statement

- as the blood pressure of both patients fell over the exercise period, the student's statement is not supported
- although both patients have a similar weight, no detail is provided of their height. Patient B could be much shorter than Patient A and therefore more overweight. This could affect how quickly their blood pressure fell
- if the exercise period had continued beyond 26 weeks, the blood pressure of Patient B may also have fallen to normal levels
- as no detail is given about their blood pressure history, Patient B could have other causes of high blood pressure not associated with being overweight.

Accept other appropriate responses.

Quality of written communication (QWC) = 3 marks

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.

8 The NHS is currently trialling the use of an artificial pancreas with 1,000 patients who have Type 1 diabetes.

Approximately:

- **8% of UK diabetics have Type 1 diabetes**
- **90% of the UK diabetics have Type 2 diabetes**
- **2% of UK diabetics have other forms of diabetes.**

The artificial pancreas is designed to continuously monitor glucose levels and pump insulin directly into the bloodstream, when needed, in order to balance blood glucose levels. It is hoped that it will enable better glucose control.

The data provided from this trial will be used to assess whether the technology should become routinely available.

Using your knowledge of diabetes and homeostatic control, discuss to what extent this technology could be used to both prevent and treat diabetes.

Your response should demonstrate reasoned judgements.

[12 marks plus 3 for QWC]

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

Band	Marks	Descriptor
4	10 – 12	**AO3**: Discussion of the extent that this technology could be used to treat or prevent diabetes is **comprehensive, effective and relevant,** showing **logical** and **coherent** chains of reasoning throughout. Analysis of the information provided is **fully** supported with **rational and balanced** judgements. **AO2**: Applied all **relevant** knowledge of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body to the given context. **AO1**: A **wide** range of **relevant** knowledge and understanding of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body is evident and **accurate**. A **wide** range of **appropriate** technical terms are used consistently. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
3	7 - 9	**AO3**: Discussion of the extent that this technology could be used to treat or prevent diabetes is in **most** parts **effective** and mostly **relevant**, showing in most parts **logical** and **coherent** chains of reasoning. Analysis of the information presented is in **most** parts **accurate**. **AO2**: Applied **mostly relevant** knowledge of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body in the given context. **AO1**: Knowledge and understanding of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body 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.
2	4 - 6	**AO3**: Discussion of the extent that this technology could be used to treat or prevent diabetes is in **some** parts **effective** but at times may be of **little relevance**. **AO2**: Applied **limited** knowledge of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body to the given context.

		AO1: Knowledge and understanding of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body 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.
1	1 - 3	**AO3**: Discussion of the extent that this technology could be used to treat or prevent diabetes is **minimal** and **very limited** in **effectiveness** and **relevance**. **AO2**: Applied **very limited** knowledge of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body to the given context. **AO1:** Knowledge and understanding of the types of diabetes and their causes and effects, as well as the homeostatic control of blood glucose in the body shows **very minimal accuracy, focus** and **relevance**. The answer has **isolated** points, showing **very minimal** breadth and/or depth of understanding, with **significant** inaccuracies and omissions.
	0	No creditworthy material

Indicative Content

Examiners are reminded that 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 analysis and reasoned judgements and conclusions that the student provides.

AO1: Demonstration of knowledge regarding diabetes and homeostatic control may include:

- type 1 diabetes occurs when the pancreas secretes / produces little or no insulin
- insulin reduces the amount of glucose in the blood
- blood glucose levels must remain between certain levels
- if blood glucose levels rise too high or fall too low, this can cause serious medical problems (including death).
- hypoglycaemia is a condition where the blood glucose levels fall too low
- if too much insulin is in the body, this can cause hypoglycaemia
- type 1 diabetes has a variety of possible causes
- type 1 diabetes is not normally linked to lifestyle / general health
- type 1 diabetes most commonly develops in children and adolescents
- type 2 diabetes usually develops later in life and is usually linked to lifestyle and general health

- type 2 diabetes can involve the pancreas not secreting enough insulin.
- type 2 diabetes can involve insulin resistance, where the body cells do not react to insulin
- type 2 diabetes is the most common form of diabetes
- blood glucose levels tend to fall during the night / sleeping
- the pancreas produces glucagon to prevent blood sugar levels falling too low / hypoglycaemia.

AO2: Application of knowledge of diabetes and homeostatic control to the information and data provided may include:

- a trial containing 1,000 patients is a large sample
- the artificial pancreas is only being trialled with Type 1 diabetics.
- the artificial pancreas treats the effects of diabetes not the causes
- the artificial pancreas does not cure diabetes
- Insulin resistance is less likely to be reduced by injecting more insulin
- conventional blood testing and injection of insulin by the patient can lead to human error
- conventional testing and injection may place a significant mental strain on the patient
- patients are less likely to carry out tests during the night and therefore are more likely to become hypoglycaemic
- long term regulation of dietary glucose sources may be difficult for some patients
- 9 times as many people have type 2 diabetes compared to those with type 1
- the artificial pancreas does not inject glucagon if blood glucose levels fall too low.

AO3: Discussion of the extent that this technology could be used to treat and prevent diabetes may include:

- if the trial shows that medical complications have been reduced, as it is a large sample, this should be statistically valid
- as the artificial pancreas only treats type 1 diabetes it will have no effect on Type 2 diabetes
- as Type 1 diabetes tends to be more serious; the artificial pancreas will be treating the most serious forms of the condition
- as the artificial pancreas only treats the effects and not the causes, it will not prevent/reduce the overall incidence of Type 1 diabetes
- as the artificial pancreas continuously monitors and balances blood glucose levels, this will reduce hypoglycaemia during the night which can be a cause of medical complications
- as the artificial pancreas does not inject glucagon, it cannot actually prevent glucose levels falling too low
- as the artificial pancreas removes the need for patient self-testing and insulin injection, this will reduce the chance of human error and therefore medical complications
- as the artificial pancreas removes the need for patent self-testing and insulin injection, this will reduce the mental strain on the patient
- as the artificial pancreas removes the need for patient self-testing and insulin injection, this will benefit children who may find this difficult
- this form of treatment is likely to be expensive and may only become available in the developed world this treatment should reduce the incidence of these complications

- patients will still need the back up of being 'trained' / able to revert back to finger prick and manual injection of insulin in the event of a malfunction.

Accept other suitable responses.

Quality of written communication (QWC) = 3 marks

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: 20 marks plus 3 marks for quality of written communication (QWC)**

9 **Boron supplements can be used in our body to aid with healing wounds.**

Boron has 5 electrons in total: two in the inner shell and three in the outer shell.

Which one **of the following is the group that Boron belongs to in the periodic table?**

A: 2
B: 3
C: 4
D: 5

[1 mark]

AO2 = 1 mark
Award up to a maximum of **one** mark:

B: 3 (1)

10	**Atoms are made up of sub-atomic particles.** **Which** one **of the following is the name(s) of the particle(s) you would find in the nucleus of an atom?** **A: Electrons only** **B: Neutrons only** **C: Protons and neutrons** **D: Protons and electrons** [1 mark]

AO2 = 1 mark

Award up to a maximum of **one** mark:

C: Protons and neutrons (1)

11(a) **Magnesium hydroxide is commonly used as a remedy for indigestion as it neutralises excess stomach acid.**

Complete both two-word equations for the two neutralisation reactions below:

(i) **Acid + Base → ____ + Water**

(ii) **Hydrochloric acid + Magnesium hydroxide → ____ + Water**

[2 marks]

AO1 = 1 mark
AO2 = 1 mark
Award **one** AO1 mark for the completed equation, up to a maximum of **one** mark:

Acid + Base → Salt +Water. (1)

Award **one** AO2 mark for the completed equation, up to a maximum of **one** mark:

Hydrochloric acid + Magnesium hydroxide → Magnesium chloride +Water. (1)

11(b) **Acetic acid is the main component in vinegar. Citric acid is found in citrus fruits.**

State two **properties of these acids.**

[2 marks]

AO1 = 2 marks
Award **one** AO1 mark for **each** description, up to a maximum of **two** marks:

- corrosive (1)
- irritant (1)
- neutralise bases (1)
- react with metal to produce hydrogen gas (1)
- pH less than 7 (1)

Accept any other suitable response.

11(c) **Whilst developing a new toothpaste in the laboratory, scientists reported the following pH values of some common household products:**

- **Acetic acid (vinegar): pH 2.5**
- **Citric acid (lemon juice): pH 4.5**
- **Sodium bicarbonate (baking soda): pH 8.0**

With reference to the hydrogen ion concentration, compare the difference in pH between lemon juice and vinegar.

[2 marks]

AO2 = 2 marks

Award **one** AO2 mark for **each** description, up to a maximum of **two** marks:

In the context of the pH scale, vinegar is more acidic than lemon juice with a pH difference of 2 (1) meaning vinegar has 100 times (10^2) more hydrogen ions than lemon juice (1)

Accept any other suitable response.

12 **A pharmaceutical industry has been asked to purify a crude mixture of two components. A scientific team working for this industry has performed thin layer chromatography (TLC) using ether as a solvent. They noted that the spots on the chromatogram were very close together, with Spot 2 moving slightly further up the coated plate than Spot 1.**

One scientist decides column chromatography should be the next step in the purification process.

Evaluate the accuracy of this statement and give a reason for your answer.

[3 marks]

AO3 = 3 marks
Award **one** AO3 mark for **each** evaluation point, up to a maximum of **three** mark:

- the scientist may be correct as spot 1 has a slightly lower affinity for the solvent than spot 2, however, this is principally based on the distance moved by the two spots in the question. There is missing information which could clarify the accuracy of the scientist's statement (1)
- there is some degree of separation and column chromatography may work, however, other methods of purification maybe possible, this depends on the nature of the crude mixture. For example, the number of components present or their material state (solid, liquid, gas). This information is not provided in the question scenario (1)

- Mass spectrometry could be used to analyse the crude mixtures purity and identify the components. This would provide further information or clues as to which purification method maybe the best to use (1)
- further TLC analysis should be made using different solvents to try and get a better separation. This would involve using different solvent combinations, or different stationary phases to obtain potentially better separations. This information is not provided in the scenario and should be explored. (1)

13 **You are working within a laboratory conducting drug test trials on a urine sample from an athlete. After drying the sample, you obtain the following results:**

Figure 4: **Percentage composition of dried urine sample from athlete**

	% Composition
Calcium	**4**
Carbon	**11**
Nitrogen	**15**
Organic matter	**65**
Phosphorus	**2**
Potassium	**3**

Scientists are now interested in isolating the organic matter from this sample. This organic matter contains many different types of compounds. Given that a quick turnaround time is required, your team conclude that high performance liquid chromatography (HPLC) is the best course of action.

Using your knowledge of purification techniques, evaluate the suitability of the team's decision to use HPLC.

Your answer should include reasoned judgements and conclusions.

[9 plus 3 marks for QWC]

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

Band	Marks	Descriptor
3	7-9	**AO3:** Evaluation of the scientist's conclusions in relation to purification techniques 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 how purification techniques work. Shows a detailed functional understanding of the scientific mechanics involved. **AO1**: Demonstrates a wide range of relevant knowledge and understanding of purification which is accurate and detailed. The answer demonstrates comprehensive breadth and/or depth of understanding.
2	4-6	**AO3:** Evaluation of the scientist's conclusions 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 how purification works in most parts appropriate, showing some functional understanding of the scientific mechanics involved. **AO1:** Knowledge and understanding purification in this context are in most parts clear and mostly accurate, although on occasion may lose focus.
1	1-3	**AO3:** Evaluation of the scientist's conclusions 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 how purification can be used and may show a lack of functional understanding of the scientific mechanics involved. **AO1**: Knowledge and understanding of purification in this context show some but limited accuracy, focus and relevance.
	0	No creditworthy material

Indicative content

AO1 (Recall of knowledge regarding purification technique):

- HPLC is used to separate substances based on their affinity for a mobile (pressurised solvent) or stationary phase (in a capillary or packed column)
- other examples of purification techniques are: thin layer chromatography, column chromatography, and gas chromatography.
- thin layer chromatography (TLC) is used to separate substances based on their affinity for a mobile (solvent) or stationary phase (on a coated plate)
- column chromatography is used to separate a single chemical compound from a mixture
- column chromatography involves the use of gravity/pressure to achieve separation
- gas chromatography is used to separate and analyse compounds that can be vaporised (in a capillary or packed column)
- purification involves the separation of a multi component mixture
- there are several types of purification methods that could be used
- some methods are better suited for simple mixtures of one or two compounds / where the number of impurities is small or trace
- chromatography involves exploiting the affinity a mobile phase has for the stationary phase
- The mobile phase is passed through a stationary phase.

AO2 (application of knowledge to the scenario outlined in the question):

- HPLC uses high pressure to achieve separation which is useful for complex mixtures such as this one and is highly efficient.
- column chromatography is typically used for small / non-complex samples consisting of 2 or 3 compounds, or where the amount of impurity is larger, so potentially would not apply to the organic matter
- gas chromatography would only be appropriate if the organic matter can be vaporised, which is unlikely
- thin layer chromatography would not be appropriate due to there being multiple different compounds present in the organic matter which would be difficult to separate.

AO3 (conclusion and evaluations relating to the scenario as outlined in the question):

- as HPLC uses pressurised solvent to achieve separation, it is the most appropriate method to use as it will successfully separate out the multiple compounds found within the organic matter. This means each compound can be successfully isolated and further characterised.
- upon extraction of the organic matter a mass spectrometry analysis may become viable to identify the components based on the molecular weights and mass to charge ratio
- as the organic matter contains multiple compounds, this means that column chromatography and thin layer chromatography will not be appropriate. This is because all the different compounds may not separate out sufficiently on the coated plate in TLC and it would be difficult to isolate the specific components via column chromatography
- it is unclear on whether or not the organic matter can be vaporised and therefore gas chromatography may or may not be suitable.
- based on the reasoning above, HPLC seems the most suitable purification technique to use.

Accept other appropriate responses.

Quality of written communication (QWC) = 3 marks

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 C: Physics

Total for this section: 20 marks plus 3 marks for quality of written communication (QWC)

14 Which one **of the following is the correct definition of an electrical current?**

A The energy of the charged particles that are moving
B The rate at which charged particles flow
C The strength of the force that is driving the charged particles
D The total number of charged particles that move

[1 mark]

AO1 = 1 mark
Award **one** mark for:

B The rate at which charged particles flow

15 A radioactive nucleus decays by ejecting a helium nucleus, consisting of 2 protons and 2 neutrons.

Name the type of radiation being ejected from the radioactive nucleus.

[1 mark]

AO1 = 1 mark
Award **one** mark for naming:

- alpha (particle / radiation)

16 **Electromagnets are used in MRI machines.**

An experiment is set up in which a current of 2A is passed through a wire wrapped around a 10cm iron nail. An iron ball bearing is then placed at varying distances away from the electromagnet.

As the iron ball bearing gets further away from the electromagnet, the magnetic force it experiences, decreases. The scientist therefore concludes that healthcare staff should not be concerned about any magnetic materials on their person, providing they keep a suitable distance away from the MRI machine.

Evaluate the strength of the scientist's conclusion.

[3 marks]

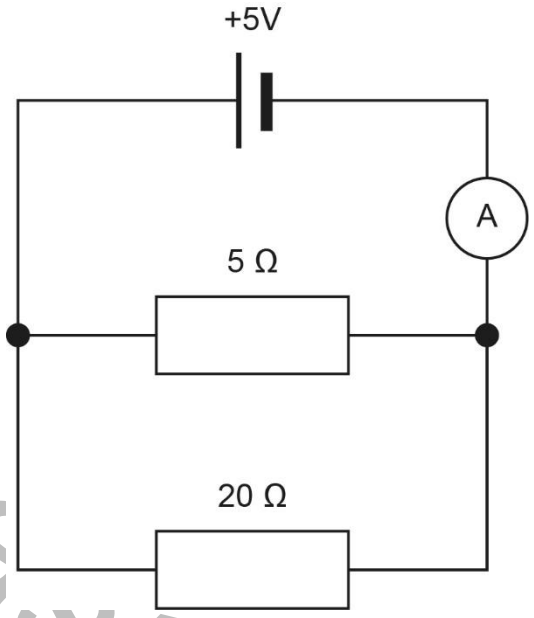
AO3 = 3 marks
Award **one** mark for each of the following points, up to a maximum of **three** marks:

- the electromagnet used in the experiment is much smaller than an MRI machine and therefore is not a suitable model for making a conclusion in terms of how appropriate it is to have magnetic materials in the same room (1)
- the model used in the experiment has a relatively low current meaning it is not a suitable model for making this conclusion as size of the current determines the strength of the magnetic field (1)
- a specific distance from the MRI machine where the magnetic force is no longer experienced needs to be adhered to when carrying magnetic materials, not what is deemed suitable by healthcare staff (1)
- the electromagnet used in an MRI will be much stronger than the model used in the experiment, meaning there will be strict guidelines as to which materials can be used within proximity to the machine. (1)

Accept any other suitable response.

17 **An electrical circuit is constructed containing 2 resistors. The resistors are arranged in parallel and connected to a 5V battery as shown in** Figure 6**.**

Figure 6: **A parallel circuit**



Use the following equation:

$$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Calculate the total resistance.

Show your working.

[3 marks]

AO2 = 3 marks

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

$$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{5} + \frac{1}{20}$$

Award **one** mark for calculating $\frac{1}{R_{Total}}$:

$$\frac{1}{R_{Total}} = \frac{1}{4}$$

Award **one** mark for the correct answer for R_{Total}:

$$R_{Total} = 4 (\Omega)$$

18	**A soundwave travels through human tissue with a frequency of 1,000,000Hz, and a wavelength of 1.5mm.** **Use the following equation:** **$v = f\lambda$** **Calculate the velocity at which the wave travels through the tissue.** **Show your working and give your answer in m / s.** [3 marks]

AO2 = 3 marks

Award **one** method mark for converting wavelength from millimetres to metres:

1.5 mm = 0.0015 m (1) **or**
1.5 mm = 1.5×10^{-3} m (1)

Award **one** method mark for substituting numbers into the formula:

v = $1 \times 10^{6} \times 1.5 \times 10^{-3}$ (1) **or**
v = 1000000×0.0015 (1)

Award **one** mark for solving to calculate the correct answer of

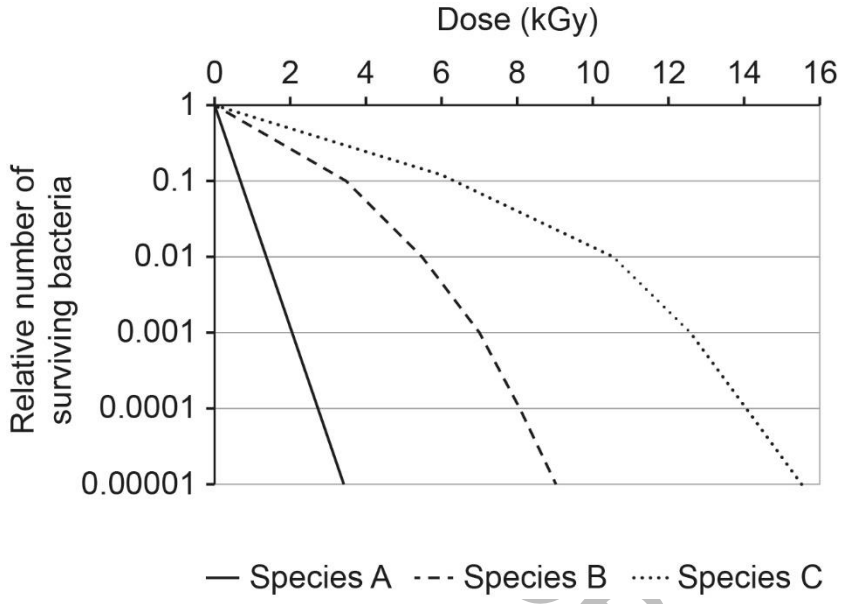
v = 1500 m/s (1) **or**
v = 1.5×10^{3} m/s (1)

19 A scientist is developing new methods of preserving food that eliminates contaminating bacteria with radiation. This preservation method will allow hospitals to store food in case of emergency for long periods of time without the food expiring due to contaminating bacteria.

To investigate the effect of radiation on the survival of bacteria, samples of food are treated with gamma rays (irradiated).

The number of surviving bacteria of different, potentially dangerous species is recorded following irradiation treatment. The results of this experiment are shown in Figure 7.

Figure 7: **A graph to show the effect of gamma radiation on different species of bacteria.**



Gray (Gy) is the unit of ionising radiation dose.

Based on this experiment, the scientist concludes that all food should be treated with 6kGy of radiation, as it kills most bacteria that might be present in the food, and that higher levels of irradiation could make the food become radioactive.

Using your knowledge of radiation and its application to food preservation, evaluate this conclusion. Your response must include your own reasoned judgements and conclusions.

[9 marks plus 3 for QWC]

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

Band	Mark	Descriptor
3	7-9	**AO3:** Evaluation of the presented data, and the recommendation of radiation dose to use for food preservation, 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. Balanced evaluations are evident. **AO2:** Application of knowledge of food preservation by irradiation in order to evaluate the statement is highly appropriate and shows a detailed functional understanding. **AO1:** There is a wide range of relevant knowledge and understanding of the properties of gamma radiation, that is accurate and detailed. The answer demonstrates comprehensive breadth and depth of understanding of radiation and its application to food processing,
2	4-6	**AO3:** Evaluation of the presented data, and the recommendation of radiation dose to use for food preservation, 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 food preservation by irradiation in order to evaluate the statement is in most parts appropriate, showing some functional understanding. **AO1:** Knowledge and understanding of the properties of gamma radiation is in most part clear and mostly accurate, although on occasion may lose focus. The answer demonstrates reasonable breadth and depth of understanding of radiation and its application to food processing, with occasional inaccuracies and/or omissions.
1	1-3	**AO3:** Evaluation of the presented data, and the recommendation of radiation dose to use for food preservation, 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 food preservation by irradiation in order to evaluate the statement is limited and may show a lock of functional understanding. **AO1:** Knowledge and understanding of the properties of gamma radiation shows some but limited accuracy, focus and relevance. The answer is basic and shows limited breadth and/or depth of understanding radiation and its application to food processing, with inaccuracies and omissions.
0	0	No credit worthy material

Indicative Content
AO1 Properties of gamma radiation and its application to food preservation:

- gamma radiation has low ionising and high penetrating power
- gamma radiation has a range of many kilometres in air
- gamma radiation is ionising, and so is able to damage and kill cells
- gamma irradiation does not contaminate the food itself with radiation
- increasing the dose of radiation will do more damage and kill more bacteria
- not all bacteria are pathogenic and therefore not all bacteria need to be destroyed

- some bacteria are pathogenic and are the causative agents of infection.

AO2 discussion of effect of dose on bacteria:

- gamma radiation kills all species of bacteria in a dose dependent fashion
- 6kGy of radiation is sufficient to reduce the relative number of bacteria for species A and B to 0.01 (99% decrease) whereas Species C has only reduced to 0.1 (90% decrease)
- higher doses may be needed to kill all species effectively, as some are more resistant than others
- the factor that should be focussed on is the dose needed to kill pathogenic bacteria - if the bacteria only killed at high doses are non-pathogenic then there's no need to destroy them
- very high doses (16kGy+) are sufficient to kill nearly all potentially pathogenic bacteria.

AO3 reasoning and conclusions:

- higher doses of radiation than 6kGy should be used in order to ensure that a greater proportion of the bacteria are destroyed
- very high doses may lead to degradation of the food, so this should be avoided by using as low a dose as is safe
- the cost of irradiating foods excessively should be considered, as there will be reduced benefit from much higher doses
- the optimal dose to use may require further experiments to determine, looking at degradation and cost/benefit factors
- the bacteria that are still alive above a 6kGy dose of irradiation might be the most harmful to humans (pathogenic) meaning that people still get poorly even when the company has paid for the treatment of the food
- issues with food contamination will reduce profits, so it is in the company's best interest to ensure all pathogenic bacteria are destroyed despite cost.

Accept other appropriate responses.

Quality of written communication (QWC) = 3 marks

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 D: Biology, Chemistry, and Physics

Total for this section: 18 marks plus 6 marks for quality of written communication (QWC)

20 Viruses enter living cells and cause damage. They are often specific to certain types of cells in the body; for example, viruses which cause respiratory tract infections will enter the cells of the respiratory tract and become concentrated there.

Antiviral drugs must be designed to be able to pass through the cell surface membrane, so that they can destroy or neutralise the virus.

A pharmaceutical research scientist used a gamma emitting radioactive tracer to investigate the ability of three different drugs, A, B and C to enter cells. All three drugs are new and still in development.

They used the following method:

- **each of the three drugs was chemically attached to the same type of radioactive tracer**
- **equal sized samples of live tissue from the respiratory tract of rats were isolated and placed in each of three Petri dishes**
- **each of the three Petri dishes was filled with a fluid designed to keep the cells within the tissue alive**
- 1ml **of a** 1% **solution of drug A was added to the first Petri dish**
- **the process was repeated with drugs B and C and the remaining Petri dishes**
- **the Petri dishes were maintained at** 37˚C **for** 30 **minutes**
- **after** 30 **minutes, the fluid was poured away and the concentration of the radioactive tracer in the tissue was measured.**

Figure 8: **shows the results and information regarding the chemical make-up of each drug.**

	Drug A	Drug B	Drug C
Chemical features of the drug	**Lipid based**	**Not lipid based**	**Not lipid based but encapsulated in a lipid membrane**
Relative concentration of the radioactive tracer in the tissue	**15**	**3**	**14**

A student studying the results stated that drug A would be the most effective antiviral drug as it appeared to be the best at entering the cells.

Using your knowledge of radioactive tracers and transport into cells, evaluate the validity of the student's statement in this context.

Your response should demonstrate reasoned judgements and conclusions.
[9 marks plus 3 for QWC]

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

Band	Marks	Descriptor
3	7-9	**AO3:** Evaluation of the student's statement 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 radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific method, are applied **effectively** to the given context. **AO1:** A **wide** range of relevant knowledge and understanding of radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific method 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 student's statement, 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 radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific method are applied mostly **effectively** to the given context, although on occasions there **may** be a lack of clarity. **AO1:** Knowledge and understanding of radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific method 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 student's statement 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 radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific method is **applied** to the given context. **AO1:** Knowledge and understanding radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific, 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 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 analysis and reasoned judgements and conclusions that the student provides.

AO1: Demonstration of knowledge of radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific method may include:

- radioactive tracers emit radiation which can be detected
- gamma radiation has high penetration
- gamma radiation is low ionising
- the drugs have to be able to pass across the cell surface membrane to enter the cells
- the cell surface membrane consists mainly of phospholipids
- phospholipids are a type of lipid
- lipid based substances can pass across cell surface membranes easily
- ionising radiation can break (chemical) bonds in molecules.

AO2: Application of knowledge of radioactive tracers, the factors affecting the ability of substances to enter living cells and the scientific method may include:

- gamma radiation would easily be able to pass through the cell surface membrane and leave the tissue
- gamma radiation would easily be able to pass through the air above the tissue and be detected and measured
- ionising radiation could alter the properties of the drugs
- both drugs A and C appear to be in a much higher concentration in the tissue than drug B
- the difference in the relative concentration of drug A and C in the tissue is minimal
- being lipid based/coated in lipid, does appear to help the drug pass across the cell surface membrane
- the investigation only compared the relative uptake of each drug by the cells
- the investigation did not measure the relative effectiveness of each drug
- it is likely that some of the radioactively labelled drug is remaining among the tissue without being absorbed into the cells
- no information is provided on how each of the drugs is tolerated by the body.

AO3: Evaluation of the student's statement may include:

- as anti-viral drugs need to enter the cells to destroy/neutralise the virus, and drug A did have the highest concentration in the cells, it may be the most effective of the 3 drugs

- however, as the investigation did not try to measure the actual effectiveness of the drug on the virus, this statement cannot be supported
- as some of the radioactively labelled drug is likely to still be present among the tissue, without entering the cells, this could make the results less valid
- as the radioactive tracer is emitting ionising radiation, this could have changed the nature of the drug, this could alter its ability to pass across the cell surface membrane this could make the results less valid
- as the difference in relative concentration of drug A and C in the tissue is minimal, drug C may be just as effective at passing across the membrane as drug A, this makes the statement less valid
- the student stated that drug A would be the most effective antiviral drug, the investigation only looked at viruses infecting the respiratory tract, so the statement cannot be supported
- although drugs A and C appeared to have the greatest ability to cross the cell surface membrane in these conditions (in vitro), this does not mean that the same would apply in the human body (in vivo)
- as no information is provided on how the drugs are tolerated by the body, it is possible that some or none of the drugs could be used safely.

Accept other appropriate responses.

Quality of written communication (QWC) = 3 marks

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.

21 **Lactose intolerance is caused by an inability of the small intestine to produce the enzyme lactase.**

Lactose intolerance can be managed by avoiding the consumption of dairy products. However, there is evidence that consuming a quantity of lactase supplement before eating dairy products can prevent the symptoms developing.

The enzyme lactase will break down the disaccharide lactose into the monosaccharide's glucose and galactose. Glucose and galactose both have the same molecular formula.

If lactase is consumed it will be exposed to the acidic conditions of the stomach.

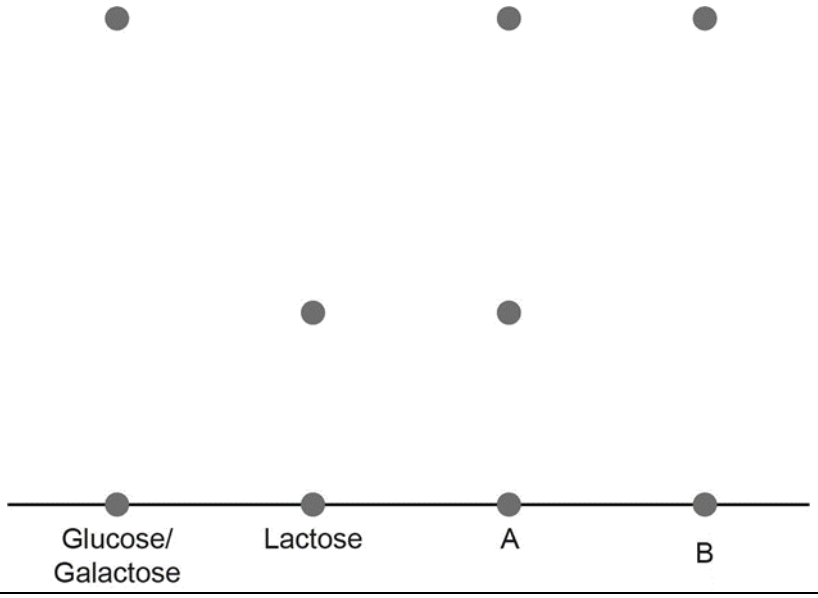
A student investigated the relative activity of two different commercially available forms of lactase supplements, A and B, after exposure to hydrochloric acid.

They use the following method:

- **10ml of 1M HCl was placed into each of two test tubes A and B**
- **tubes A and B were placed in a water bath at 37˚C**
- **the amount of each form of lactase recommended by the supplier was added to each test tube**
- **after ten minutes, bile salts, which neutralise the acid, and one gram of lactose was then added to each tube**
- **after a further ten minutes a sample was removed from each tube and analysed using paper chromatography**
- **the chromatograms were developed using reagents which would highlight only glucose, galactose, and lactose.**

The results are shown in Figure 9**.**

Figure 9: **chromatogram of lactose digestion products**



The student made the following conclusions:

- **there was a small amount of lactose digestion in tube A**
- **lactose digestion was complete in tube B**
- **lactase supplement B is a better supplement than lactase supplement A.**

Using your knowledge of thin layer chromatography and the information provided, discuss to what extent the student's conclusion can be supported.

Your response should demonstrate reasoned judgements and conclusions.

[9 marks plus 3 for QWC]

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

Level	Marks	Descriptor
Level 3	7-9	**AO3:** Discussion of the extent to which the student's conclusions can be supported 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 thin layer chromatography and the effect of pH on enzymes, are applied **effectively** to the given context. **AO1:** A **wide** range of relevant knowledge and understanding of thin layer chromatography and the effect of pH on enzymes, is evident. A **wide** range of **appropriate** technical terms are used. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
Level 2	4-6	**AO3:** Discussion of the extent to which the student's conclusions can be supported is , 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 thin layer chromatography and the effect of pH on enzymes, are applied mostly **effectively** to the given context, although on occasions there **may** be a lack of clarity. **AO1:** Knowledge and understanding of thin layer chromatography and the effect of pH on enzymes, 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
Level 1	1-3	**AO3:** Discussion of the extent to which the student's conclusions can be supported 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 thin layer chromatography and the effect of pH on enzymes, is **applied** to the given context. **AO1:** Knowledge and understanding of thin layer chromatography and the effect of pH on enzymes, 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 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 analysis and reasoned judgements and conclusions that the student provides.

AO1: Demonstration of knowledge of thin layer chromatography and the effect of pH on enzymes may include:

- paper chromatography - TLC can separate solutes dependent on their relative molecular weights
- the molecular weight of lactose is almost twice the molecular weight of glucose or galactose
- monosaccharides of the same molecular weight will not be separated by this type of chromatography
- lactase is an enzyme secreted in the small intestine
- hydrochloric acid is a strong acid; therefore, it will be completely ionised
- completely ionised acids have high concentrations of H^+ ions
- lactase is a protein

AO2: Application of knowledge of thin layer chromatography and the effect of pH on enzymes may include:

- chromatogram A shows 2 separate spots
- chromatogram B shows 1 spot
- complete digestion of lactose to glucose and galactose would produce 1 spot
- partial digestion of lactose to glucose and galactose would produce 2 spots
- glucose and galactose must have the same affinity for the mobile phase as they have moved the same distance up the chromatogram
- 10 minutes may not be sufficient for complete digestion of lactose
- the amount of bile salts added is not specified
- a specific amount of bile salts will be required to neutralise the hydrochloric acid
- no details are provided regarding the length of time the chromatogram is left to run.

AO3: Discussion of the extent to which the student's conclusion can be supported may include:

- as A has 2 spots, there must have been partial digestion of lactose, this supports the students first statement
- as only 1 spot was present in B, and this spot was at the same height as the higher spot in A, this suggest that it is glucose and galactose. This supports the students second statement
- as digestion of lactose appears to be complete in B but not in A, this suggests that the lactase in B remains more active in the hydrochloric acid than the lactase in A. This supports the students third statement
- as there are 2 separate spots in A, this does suggest that the chromatogram was left for a sufficient time to separate the solutes present
- although digestion in tube B does seem to have been completed in the 10 minutes allowed, this does not mean that digestion in tube A would not have been completed if more time had been allowed
- as the concentration of bile salts added after 10 minutes is not given, this may not be sufficient to neutralise the acid, this could make the results less valid
- as no indication is given that the amount of bile salts added to each tube were the same, this could make the results less valid
- although the results suggest that supplement B remains more active than supplement A in this situation (in vitro) this may not be the case in the human gut / stomach (in vivo) where there will be many more factors to consider other than the acidic conditions.

Accept other appropriate responses.

Quality of written communication (QWC) = 3 marks

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 A

Question	AO1	AO2	AO3	Maths	QWC	Total
1	1*					1
2 (a)	1*	1				2
2 (b)	1*	1				2
3		1	3			4
4 (a)	1	2				3
4 (b)		1				1
4 (c)		2				2
5		2		2		2
6		1	3			4
7	3	3	3		3	12
8	4	4	4		3	15
	11	**18**	**13**	**2**	**6**	**48**
Totals required	**10–13**	**16–19**	**12–15**	**2**	**6**	**48**
Kil	**3**					

Section B

Question Number	AO1	AO2	AO3	Maths	QWC	Total
9		1				1
10		1				1
11 (a)	1	1				2
11 (b)	2*					2
11 (c)		2				2
12			3			3
13	3	3	3		3	12
	6	**8**	**6**	**0**	**3**	**23**
Totals required	**5–6**	**8–9**	**6–7**	**0**	**3**	**23**
Kil	**2**					

Section C

Question Number	AO1	AO2	AO3	Maths	QWC	Total
14	1*					1
15	1*					1
16			3			3
17		3		3		3
18		3		3		3
19	3	3	3		3	12
	5	**9**	**6**	**6**	**3**	**23**
Target required	**5-6**	**8-9**	**6-7**		**3**	**23**
Kil	**2**					

Section D

Question Number	AO1	AO2	AO3	Maths	QWC	Total
20	3	3	3		3	12
21	3	3	3		3	12
	6	**6**	**6**		**6**	**24**
Totals required	**4–6**	**6-8**	**5-7**		**6**	**24**
Kil						
Total AO weighting	**25−30 %**	**40−45 %**	**30−35 %**			**100%**
Total marks	**25-30**	**40-45**	**30-35**			**100**
Total marks				**(8) Target 6-10**	**18**	**118**

Document information

Owner: Head of Assessment Design