T Level Technical Qualification in Healthcare Science

Core knowledge and understanding

Paper B

Elements 11–12

Mark scheme

v1.1: Specimen assessment materials
20 November 2023
603/0783/X

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) (AOs) 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.
- When allocating marks across assessment objectives (AOs) within an individual response these should logically link and should not be from disparate points of indicative content provided in the mark scheme.
- 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 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 AOs, 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 (AOs)

This assessment requires students to:

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

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

Section A: Biology **Total for this section: 45 marks plus 3 marks for quality of written communication (QWC)**

1 (a) A student wishes to examine the internal structures of a sample of cells.

State one **advantage of using a transmission electron microscope over a light microscope for this examination.**

[1 mark]

AO1 = 1 mark

Award **one** mark for a correct advantage:

- transmission electron microscope (TEM) has a higher resolution than a light microscope
- TEM can visualise / reveal internal structures.

Accept any other suitable response.

1 (b) The student decides to use a transmission electron microscope for the examination.

Identify two **features the student could observe in this examination that would indicate that these cells were prokaryotic.**

[2 marks]

AO1 = 2 mark

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

- no nucleus
- no membrane-bound organelles
- presence of a capsule
- presence of flagella / flagellum
- presence of plasmids.

Accept any other suitable response.

1 (c) Prokaryotic ribosomes are smaller than eukaryotic ribosomes.

Explain how the student could use the size of the ribosomes in the sample of cells, to determine whether these cells were prokaryotic or eukaryotic.

[2 marks]

AO2 = 2 mark

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

- measure / calculate / workout the size of the ribosomes they could see in their sample of cells (1) and compare this with the data on ribosome size in prokaryotes and eukaryotes (1).

Accept any other suitable response.

2 Figure 1 **gives information about cells taken from two different types of human tissue.**

Figure 1

	Average number of mitochondria per cell	**Relative surface area to volume**
Tissue A	100,000	Smaller surface area compared to volume
Tissue B	500,000	Larger surface area compared to volume.

The duodenum is involved with the transport of nutrients into the blood, including glucose, which is transported actively.

State why tissue B is more likely to be from the duodenum of the digestive system than tissue A and explain why you have made this conclusion.

[3 marks]

AO1 = 1 mark
AO2 = 2 marks

Award **one** mark for each correct stage of the explanation, up to a maximum of **three** marks:

- active transport requires energy from respiration (AO1)
- tissue B has a larger surface area compared to volume than tissue A, which is required for absorption of materials (AO2)
- tissue B has a much higher number of mitochondria (500,000) than tissue A (100,000), which could supply the energy required for active transport (AO2).

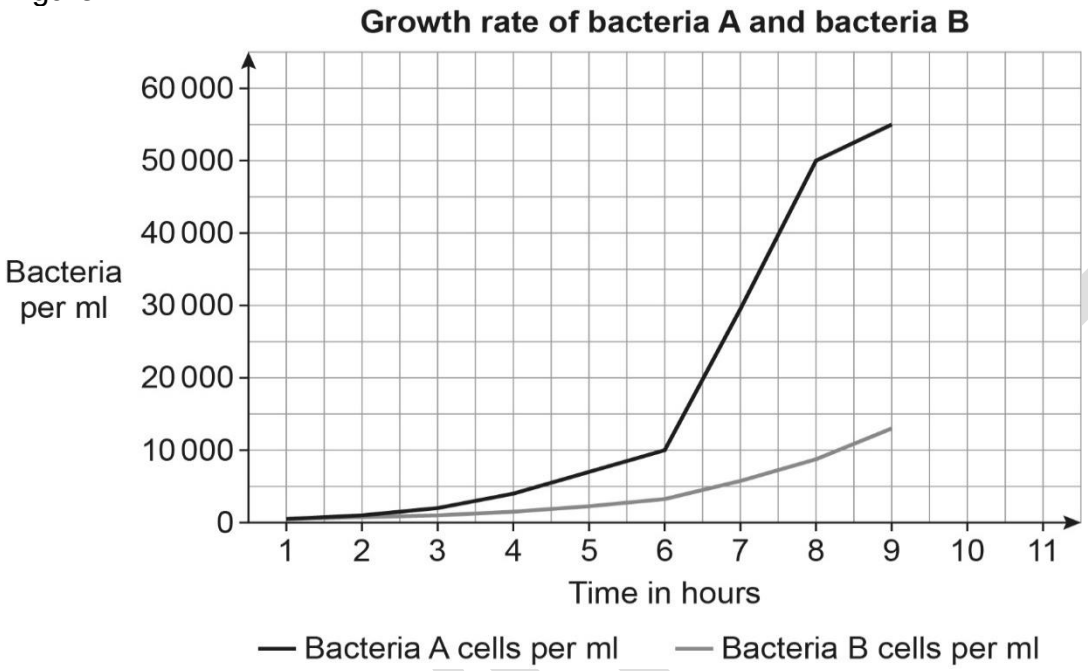
Note: Do not accept 'create energy'.

Accept any other suitable response.

3 **Two different pathogenic bacteria, A and B, were grown in laboratory conditions and their rate of growth was measured.**

Both bacteria can cause diseases of the respiratory system. The results are represented in Figure 2.

Figure 2



3 (a) **Calculate the rate of growth of bacteria A in cells produced per minute, between 6 hours and 8 hours.**

Show your working and express your answer to the nearest whole number.

[2 marks]

AO2 = 2 marks

Award **one** mark maximum for the correct method:

- 40,000/120.

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

- 333 (cells per minute).

NB: Award both marks if only the correct answer is given as we can assume the correct method has been correctly applied.

3 (b) A student stated that bacteria A was more dangerous than bacteria B as it has a faster growth rate in laboratory conditions.

Evaluate the student's statement.

[3 marks]

AO3 = 3 marks

Award **one** mark for each correct evaluative point, up to a maximum of **two** marks: Award **one** mark for a related judgement / conclusion:

- bacteria A does have a faster growth rate (in these conditions) than bacteria B, this may make it a more dangerous pathogen which supports the student's statement (1)
- although bacteria A has a faster growth rate (in the laboratory conditions), this may not be the case inside the body as they are untested conditions, which does not support the student's statement (1)
- although bacteria A has a faster growth rate (in the laboratory conditions), there is no information provided about how each disease progresses in the body which contradicts the student's statement (1)
- although bacteria A has a faster growth rate (in the laboratory conditions), there is no information provided on how transmissible each bacterium is which contradicts the student's statement (1)
- although bacteria A has a faster growth rate (in the laboratory conditions), there is no information provided about how treatable each disease is which contradicts the student's statement (1)
- As bacteria A has only been tested in laboratory conditions it is unclear as to whether its growth rate is dangerous as no human testing has been conducted. Therefore, the statement suggesting that bacteria A is more dangerous cannot be confirmed (1).

Accept any other suitable response.

4 (a) Emphysema is a lung condition that causes:

- **the bronchioles to collapse preventing ventilation of the alveoli**
- **the individual air sacs of the alveoli to rupture. This creates larger spaces instead of many smaller ones.**

Explain the effect of emphysema on the available alveolar surface area.

[2 marks]

AO2 = 2 marks

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

- the many smaller air sacs had a larger surface area than the larger space (created) (1), therefore the air cannot reach the alveoli due to the collapsed bronchioles, therefore there is less available surface area (1).

Accept any other suitable response.

4 (b) **Give** four **functions of the respiratory process.**

[4 marks]

AO1 = 4 marks

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

- gaseous exchange occurs by the process of ventilation (inspiration and expiration)
- delivers oxygen to cells in the body
- removes waste gases
- increases or decreases breathing rate.

Accept any other suitable response.

4 (c) **Polio is a virus that infects and weakens muscles. This disease can weaken or paralyse the diaphragm and intercostal muscles.**

Give three **reasons why the polio virus can make breathing difficult.**

[3 marks]

AO2 = 3 marks

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

- the intercostal muscles cannot contract (1)
- if the diaphragm and intercostal muscles do not contract, then the volume cannot increase (1)
- air cannot move into the lungs due to the lack of expansion and contraction of both the intercostal muscles (1).

Accept any other suitable response.

5 **A 57-year-old woman visits her GP stating that she has recently developed the following symptoms:**

- **dark urine**
- **recent weight loss**
- **loss of appetite**
- **constant tiredness.**

Discussion with the woman reveals she has a history of alcoholism and has frequent migraines, for which she has taken paracetamol for many years.

The GP makes an initial diagnosis of liver damage caused by alcohol consumption.

Assess to what extent can this diagnosis be justified.

Your response should include reasoned judgements and / or conclusions.

[4 marks]

AO3 = 4 marks

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

- as all of the symptoms described are symptoms of liver damage this supports the diagnosis (1), as excessive alcohol consumption can lead to liver damage, this supports the diagnosis of damage due to excessive alcohol consumption (1)
- if she is treating the migraines with frequent paracetamol use, this could also cause liver damage (1), this does not support the diagnosis as paracetamol misuse could lead to these symptoms (1)
- as the symptoms have developed recently and there is no information to show if she is still drinking alcohol (1), this does not support the diagnosis and therefore future investigation is warranted (1).

Accept any other suitable response.

6 **The human genome makes up our genes, approximately 2% of the human genome includes the coding genes. Some genetic disorders result from changes in the base sequence within these coding regions.**

The remaining 98% of the genome is non-coding deoxyribonucleic acid (DNA), this contains many regions which control the expression of our genes.

Other genetic disorders can be caused by a change in the base sequence of a region of non-coding DNA which controls the expression of a particular gene.

i) Explain how either **a change in the base sequence of the DNA in a gene or a change in the base sequence in a region of non-coding DNA, could lead to a genetic disorder.**

ii). A genomics lecturer states that an understanding of epigenetics is as important as an understanding of functional genomics, in understanding genetic conditions.

Evaluate this statement.

[5 marks]

AO2 = 2 marks
AO3 = 3 marks

AO2

i) Award **one** mark for each correct explanatory point, up to a maximum of **two** marks:

- a change in the DNA of a gene can make the gene code for an altered protein (1) but this may not function / function correctly leading to problems / genetic disorders (1)
- a change in the DNA of a region which controls gene expression may affect how a gene is expressed (1) if the control of expression of a gene is altered, this may lead to problems / a genetic disorder (1).

ii) AO3

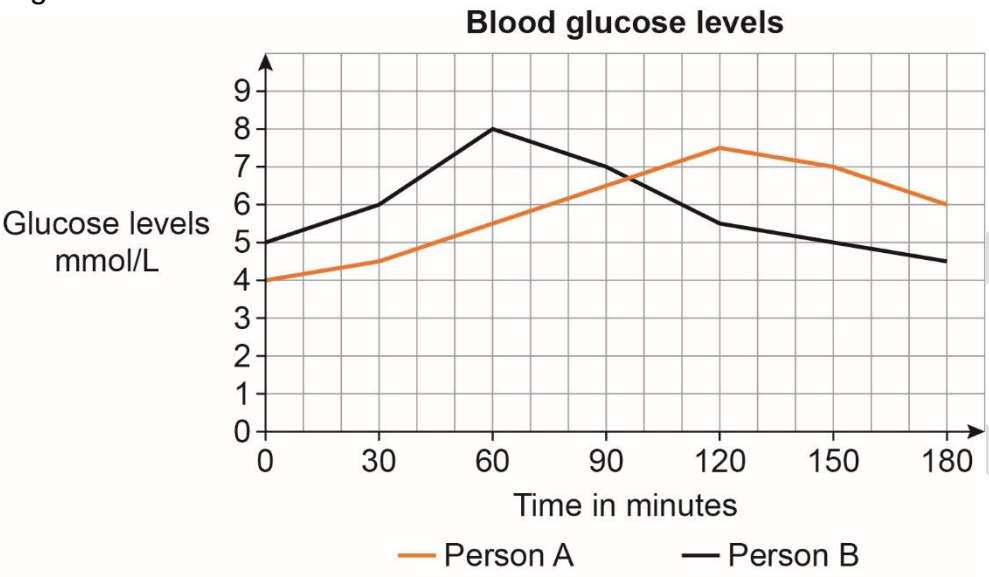
Award **one** mark for each correct evaluative point, up to a maximum of **three** marks:

- epigenetics is the study of DNA modifications that can affect gene activity which could lead to genetic conditions (1). Functional genomics is the study of the functions and interactions of all genes (and therefore proteins), so is important in understanding how the change to gene activity affects the interaction with other genes (1). Therefore, functional genomics can be considered most important, as it will result in understanding the overall effect of a change to a gene's expression (1)
- epigenetics is the study of DNA modifications which can affect gene activity which could lead to genetic conditions (1). Functional genomics is the study of the functions and interactions of all genes (and therefore proteins), so is important in understanding how the change to gene activity affects the interaction with other genes (1). Therefore, both can be considered as important as each other in genetic conditions that have been caused by DNA modifications (1).

Accept any other suitable response.

7 (a) Figure 3 **shows the blood glucose levels over a 3-hour period for two different people.**

Figure 3



Both people had fasted for 6 hours before eating a snack at time 0 on the graph.

One of the people ate a starch-rich snack at time 0.

One of the people ate a glucose-rich snack at time 0.

Suggest which person ate the glucose-rich snack and **explain your choice.**

[2 marks]

AO2 = 2 marks

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

- person B.

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

- glucose will be absorbed much more quickly from the glucose-rich snack than from the starch-rich snack as the starch needs to be broken down to glucose.

Accept any other suitable response.

7 (b) **A clinician examining the graph states that it is unlikely either person has diabetes.**

Evaluate their statement.

Your response should include a reasoned judgement and / or conclusion.

[3 marks]

AO3 = 3 marks

Award **one** mark for each suitable evaluative point, up to a maximum of **two** marks. Award **one** further mark for an accurate conclusion:

- as there is no evidence provided whether either person was taking any diabetic medication / insulin this makes the statement less reliable (1). However, people undertaking fasting tests may not have taken medication (1). Therefore, the clinician's conclusions cannot be substantiated (1)
- as both persons A and B had a low fasting blood glucose level that suggests that neither are diabetic (1) however person B's level rose more rapidly than person A (1) and therefore the clinician is possibly correct, but a formal diagnosis cannot be confidently confirmed (1)
- as both person A's and person B's blood glucose levels peak after eating the snack was within normal levels this suggests that neither are diabetic (1) however, the peaks were at different times but this may be due to the type of snack (1) and therefore the clinician is likely to have made a correct diagnosis (1).

Accept any other suitable response.

8 **Tanzania is a country in the equatorial area of East Africa.**

In 2011, 20 people died and thousands were left homeless in Tanzania after excessive rainfall led to severe flooding. Many of the homeless were housed in temporary camps, which were overcrowded and with minimal facilities. After the incident, the mortality rate from disease rose significantly in the area.

A student studying epidemiology suggested that:

- **the increase in mortality may be due to increased cases of malaria**
- **poorer people are likely to be affected more than the wealthy.**

Evaluate the epidemiology student's suggestions.

Your response should demonstrate:

- **an understanding of transmission routes for disease-causing organisms**

- **an understanding of how health promotion can affect malaria transmission**
- **reasoned judgements and / or conclusions.**

[9 marks plus 3 marks for QWC]

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

Band	Mark	Descriptor
3	7–9	**AO3:** evaluation of the suggestions is **comprehensive, effective, and relevant**, showing **detailed** understanding and **logical and coherent** chains of reasoning t**hroughout**. **Informed** judgements that are **fully supported** with rational and balanced reasoned judgements are included. **AO2:** application of **all relevant** knowledge of transmission routes, malaria and role of health promotion related to wealth is **effective, highly appropriate** and shows a **detailed** functional understanding of the issues. **AO1:** a **wide** range of relevant knowledge and understanding of transmission routes, malaria and role of health promotion related to wealth in this context is demonstrated, which is **accurate and detailed**. A **wide** range of **appropriate** scientific terms is used.
2	4–6	**AO3:** evaluation of the suggestions is in **most** parts **effective** and **mostly relevant**, showing **mostly logical and coherent** chains of reasoning. Conclusions supported by reasoned judgements that consider **most** of the relevant arguments are presented. **AO2:** applied mostly relevant knowledge of transmission routes, malaria and role of health promotion related to wealth, which is in **most parts appropriate**, showing **some** functional understanding of the issues. **AO1:** knowledge and understanding of transmission routes, malaria and role of health promotion related to wealth respiration, in this context is in **most** parts clear and **mostly** accurate, although on **occasion may lose focus**. A range of **mostly appropriate** scientific terms is used.
1	1–3	**AO3:** evaluation of the suggestions is in **some** parts **effective** and of **some relevance**, with some **understanding and reasoning** taking the form of **generic** statements with **some** development. Conclusions are **basic and brief**; and will have **limited** rationality and balance. **AO2:** applied **limited** knowledge of transmission routes, malaria and role of health promotion related to wealth respiration and may show a **lack** of functional understanding of the issues.

		AO1: knowledge and understanding of transmission routes, malaria and role of health promotion related to wealth show some but limited accuracy, focus and relevance. A **limited** range of scientific terms is used, which may **often** be inappropriate
	0	No creditworthy material.

Indicative content

AO1: transmission routes for disease-causing organisms

- Malaria is caused by a protoctist / Plasmodium.
- Malaria is spread by an insect vector / mosquito bite.
- Malaria can be fatal / cause deaths.
- Mosquitos need standing water to breed.
- Malaria is common in warmer climates.
- Many diseases can be transmitted through standing water.
- Many diseases can be transmitted through direct physical contact with an infected person.
- Many diseases can be transmitted through physical contact with a contaminated surface.
- Many diseases can be transmitted through airborne particles or droplets.

AO2: an understanding of how health promotion can affect transmission of disease

- The flooding would lead to increased amounts of standing water in the area. The increased amounts of standing water would provide breeding grounds for mosquitos therefore, local people should be advised to avoid these areas.
- Sewage polluted water could contain pathogens therefore, the population should be advised to avoid using this water for any purpose to minimise transmission.
- In overcrowded conditions, pathogens can pass from person to person through the air more easily. The local population should be advised of this and keep person to person contact to a minimum during the outbreak.
- Poorer people are more likely to need to use the camps than wealthier people and need to be made aware of effective hygiene practices.
- Poorer people are less likely to have access to social media / television / radio than wealthier people therefore, local educational schemes should be put in place to provide information relating to the specifics of health and hygiene during these circumstances.
- Poorer people are less likely to have access to a balanced / nutritious diet than wealthier people and therefore would be more likely to recover more quickly.
- Poorer people are less likely to have access to mosquito nets / sprays than wealthier people – local and national charities could provide these.
- Poorer people are less likely to have access to medical care than wealthier people – this could be provided by local and national charities.

AO3: reasoning and conclusions

- Although the presence of standing water could increase the number of mosquitoes leading to more malaria, there are many other diseases that can be spread through standing water, which could increase mortality.
- As the polluted water could contaminate drinking water, this could increase mortality with malaria not necessarily being the primary cause of mortality.
- As the camps are overcrowded, increasing the population density, this would increase the rate of transmissions of pathogens / disease.
- As poorer people are more likely to be in the camps, this will increase transmission among poorer people and therefore increase the mortality.
- As access to clean water is more difficult in the camps, this will increase the transmission among poorer people and therefore the mortality as they have limited water sources and all residents have access.
- As poorer people will have less access to social media / television / radio, they will have less access to information explaining how to avoid becoming ill, leading to more transmission and higher mortality.
- As poorer people are less likely to have access to education, they will be less able to read any leaflets / posters explaining how to avoid becoming ill, leading to more transmission and a higher mortality.
- As poorer people are likely to have less access to a balanced / nutritious diet, their immune systems may be less able to combat pathogens, leading to more disease and higher mortality.
- As poorer people are less likely to have access to mosquito nets / sprays, this will lead to a higher rate of malaria and therefore higher mortality.
- Poorer people are less likely to have access to medical care than wealthier people, therefore they are less likely to get appropriate treatment, and this will lead to more disease and higher mortality.

QWC

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 is 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 is 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 is used effectively.
0	There is no answer written or none of the material presented is creditworthy.

Section B: Physics

Total for this section: 26 marks,
plus 3 marks for quality of written communication (QWC)

9 Define a longitudinal wave.

[1 mark]

AO1 = 1 mark

Award **one** mark for:

- a wave that moves in the same direction in which the particles are vibrating.

Accept any other suitable response.

10 Figure 4 **Shows radiation activity recordings from samples for carbon dating per day above background level.**

Figure 4

	Sample	Control
Activity (counts per day)	42	168

The use of radioactivity when dating deceased organisms is used to estimate the age of organic material. The technique works by detecting levels of the radioisotope Carbon-14 (^{14}C), which is found in trace amounts in organic compounds and emits radiation via beta decay.

^{14}C has a half-life of 5730 years.

Archaeologists are excavating an ancient burial site and identify human remains. They analyse a piece of tissue and use this dating method to age the organic material. Levels of radioactive activity from ^{14}C in the specimen are compared to a control sample of fresh tissue.

10 (a) The results of these measurements are shown in Figure 4.

Using this information and your knowledge of the use of radioactivity when dating deceased organisms, calculate the estimated age of the sample.

[3 marks]

AO2 = 3 marks

Award **one** mark for giving an estimated age of 11460 years.

Award **one** mark for determining the relative amount of ^{14}C in the sample:

- =42/168 = 0.25.

Award **one** mark for determining that this is equivalent to 2 half-lives of decay, such as by using:

- $\log_{0.5} 0.25 = 2$.

Or equivalent workings such as:

- (42/168) x 100 = 25%
- 100% - 50% - 25% = 2 half-lives
- 5730 years x 2 half-lives = 11460 years old.

Award **three** marks if student gives correct answer without showing working.

10 (b)	**A team of forensic scientists is investigating a death known to have occurred within the last year.** **The team has decided to use radiocarbon dating to determine the exact date of death. They plan to take a tissue sample from the body and determine levels of ^{14}C. These results will be compared to those from a similar sample taken from a living donor.** **Evaluate the team's plan and the suitability of radioactivity when dating deceased organisms to determine the date of death.** [3 marks]

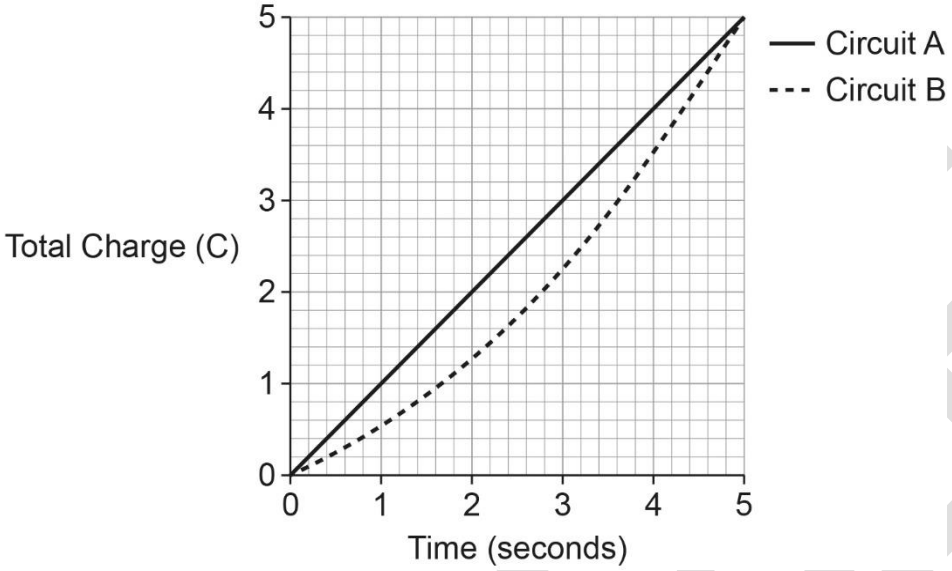
AO3 = 3 marks

Award **one** mark for the following points, up to a maximum of **two** marks. Award **one** mark for a related conclusion:

- the half-life of ^{14}C is much greater than a year, therefore there will be very little decay occurring during this time (1) there will be very little change in the ^{14}C content / emitted radiation from the sample (1)
- there is a lot of variation in the ^{14}C composition of different organisms / tissues (1) depending on the control sample used, the variability in carbon content could be greater than that due to radioactive decay (1)
- it would be very difficult to detect a difference between the sample and control, so the technique is not appropriate (1).

Accept any other suitable response.

11 Figure 5 **Plots of cumulative charge transfer in both circuits (A and B)**



An electrician is measuring the charge that passes through circuit A and circuit B. The total charge that is transferred is measured in each circuit and recorded once every second for 5 seconds.

The measurements are plotted in a graph that is shown in Figure 5.

The electrician concludes that, as the total charge transferred over 5 seconds is 10 C for each circuit, the current is the same at the 5 second time point.

Evaluate this conclusion.

[3 marks]

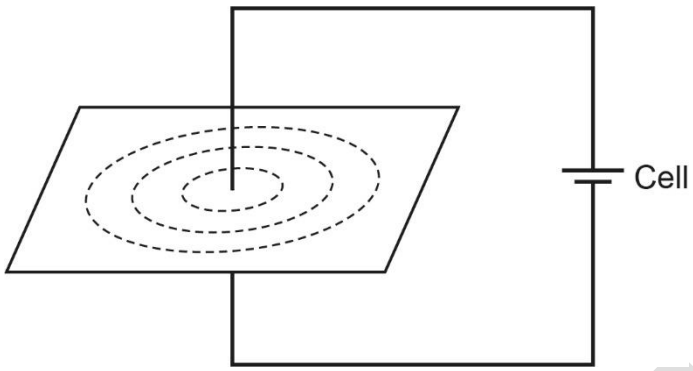
AO3 = 3 marks

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

- over the 5 second period, the total charge transferred is the same, and so the average current over this period will be the same. This is consistent with the electrician's conclusion (1)
- the charge is transferred at different rates in each circuit, so the current will be different at different time points. This does not support the electrician's conclusion (1)
- the current in circuit A is constant, while the current in circuit B increases with time. This is inconclusive (1)
- the gradient of the line is steeper in circuit B at 5 seconds, and so the current will be greater. This does not support the electrician's conclusion (1).

Accept any other suitable response.

12 **Figure 6** Electrical circuit passing through a piece of card holding iron filings. The dotted line indicates the alignment of iron filings on the piece of card.



A wire is passed through a sheet of card and connected to a cell, as shown in Figure 6.

Iron filings are placed on the card and are observed to form circles around the wire.

Explain what will happen if the positive and negative terminals of the cell are reversed.

[3 marks]

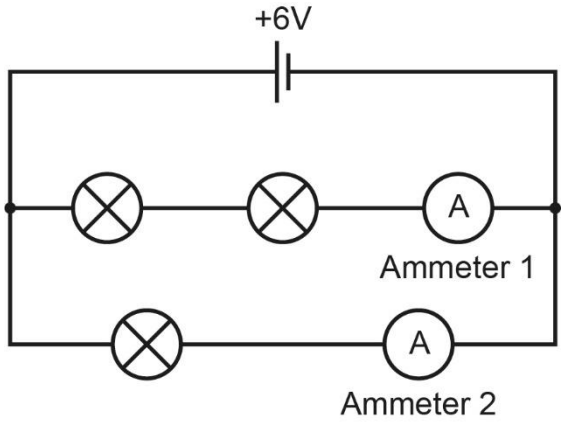
AO2 = 3 marks

Award **one** mark for each part of the explanation, up to a maximum of **three** marks:

- the current passing through the wire induces a magnetic field that circles the wire, which attracts and aligns the magnetic filings (1) adjusting the positive and negative terminals will reverse the direction of the current (1). However, this will have no effect on the observed pattern of the iron filings, as the magnetic field will still be in a circular pattern around the wire (1).

Accept any other suitable response.

13 **Figure 7** Circuit diagram showing bulbs in parallel



The circuit in Figure 7 **is constructed.**

Each bulb has a resistance of 4Ω.

Calculate the reading on each ammeter. Show your working.

[3 marks]

AO2 = 3 marks

Award **one** mark for using the correct equation:

- V=IR, I=V/R.

Award **one** mark for each of the correct answers:

Ammeter 1:
- I=6/(4+4)=0.75A.

Ammeter 2:
- I=6/4=1.5A.

14 **A wavemeter is a device that can measure the wavelength of light.**

Give the other measurement that is needed to calculate the speed of light.

[1 mark]

AO1 = 1 mark

Award **one** mark for:

- frequency.

15 External beam radiotherapy is often used to kill or reduce malignant tumours in patients suffering from cancer.

A research scientist is developing a new method of administering radiotherapy, by injecting a radioisotope that emits alpha radiation close to the tumour site.

Figure 8 **A comparison of properties of alpha and gamma radiation**

	Alpha radiation	**Gamma radiation**
Percentage of radiation that penetrates 10 cm of tissue	0.01%	99.8%
Relative ionising strength of radiation	20	1

Using the information in Figure 8**, evaluate the use of injecting alpha-emitting radioisotopes over external beam radiotherapy in the treatment of cancer. Your response should include reasoned judgements and / or conclusions.**

[9 marks plus 3 marks for QWC]

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

Band	**Mark**	**Descriptor**
3	7–9	**AO3:** evaluation of the effect of different sources of radiation on tissue 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 the effect of radiation on tissue is **highly appropriate** and shows a **detailed** functional understanding. **AO1:** there is a **wide** range of relevant knowledge and understanding of the properties of different types of radiation that is **accurate and detailed.** The answer demonstrates comprehensive breadth and / or depth of understanding.
2	4–6	**AO3:** evaluation of the effect of different sources of radiation on tissue 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 the effect of different sources of radiation on tissue is in **most parts appropriate**, showing **some** functional understanding.

		AO1: knowledge and understanding of the properties of different types of radiation 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	1–3	**AO3:** evaluation of the effect of different sources of radiation on tissue 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 the effect of different sources of radiation on tissue is **limited** and may show a **lack** of functional understanding. **AO1:** knowledge and understanding of the properties of different types of radiation 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

AO1: properties of types of radiation

- Radiation ionises and excites molecules, leading to them to break apart.
- Radiation can cause damage to cells that may lead to cell death.
- By targeting malignant / unwanted cells with this radiation, these cells can be destroyed.
- Radiation can be used to effectively treat diseases, such as various cancers.
- External beam radiotherapy uses gamma rays to target the tumours.
- Gamma rays are emitted from radioisotopes outside of the body and can penetrate through the tissue towards the tumour.
- Other types of radiation (alpha and beta) cannot normally penetrate the skin sufficiently to effectively destroy the malignant cells.
- Alpha and beta particles are also ionising, and so can destroy cells.

AO2: application of knowledge of the effect of both methods of radiation treatment

- External beam radiation is aimed at the tumour based upon imaging, and so may not target the tumour completely accurately.
- External beam radiotherapy may cause damage to structures / tissue overlying the site of the tumour as 99.8% of gamma radiation penetrates 10cm of tissue.
- Alpha particles are highly ionising, and so have the potential for causing more damage to healthy cells.
- Alpha particles have little penetrating power compared to gamma rays, and so would only damage cells near the injection / implantation site as demonstrated by the fact that the relative strength of alpha radiation is 20 compared to 1 of gamma radiation.

- Gamma rays will have no effect on the body once therapy has finished, alpha therapy will have a persistent effect as the radioisotope decays.
- Alpha particles need to be injected to be effective, which is a more invasive procedure, that would need to be performed by a trained clinical professional.

AO3: reasoning and conclusions

- Alpha therapy may be a more effective treatment than external beam radiotherapy, as the radiation is more powerful, and has a more local effect, and so may cause fewer side effects.
- Alpha radiation is more ionising, so there is a potentially greater risk of causing additional cancers. Therefore, there is a greater long-term risk.
- Alpha therapy may require a longer period of hospitalisation, as there may be persistent radiation risk.
- Alpha therapy is unlikely to affect people other than the patient due to the poor penetrating power of the radiation.
- External beam radiotherapy is more likely to cause damage to surrounding healthy tissues, whilst the effect will be localised almost entirely to the malignant cells, and so alpha therapy may be safer.

Accept any other suitable response.

QWC:

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 is 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 is 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 is used effectively.
0	There is no answer written or none of the material presented is creditworthy.

Section C: Chemistry

Total for this section: 17 marks, plus 3 marks for quality of written communication (QWC)

16(a) A team of chemists is conducting experiments in the laboratory to generate hydrocarbons. They are producing butane (C_4H_{10}) from decane ($C_{10}H_{22}$). The process is represented by the following chemical reaction:

$$C_{10}H_{22} + H_2 \xrightarrow{\mathbf{B}} C_4H_{10} + C_6H_{14}$$

Identify the role of reagent B.

[1 mark]

AO1 = 1 mark

Award **one** mark for correct identification:

- B is a catalyst, or accelerator.

Note: do not accept enzyme

16(b) With reference to the process depicted in question 16 (a), explain how reagent B affects the rate of this reaction.

[2 marks]

AO2 = 2 mark

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

- B lowers the activation energy for this reaction (1) B increases the rate of reaction (1).

Accept any other suitable response.

16 (c) **The chemists are curious how changes in temperature affect the chemical reaction used to produce butane. They carry out the experiment at a range of different temperatures without reagent B.**

The starting quantity of decane ($C_{10}H_{22}$) for each experiment is 5 kilograms (kg). All reactions proceed for 2 hours, after which the quantity of butane ($C_{10}H_{22}$) is measured.

The results are shown in Figure 9.

Figure 9 **Results from initial experiment**

Reaction conditions (K)	Amount of $C_{10}H_{22}$ (after 2 hours) (kg)	Reaction rate (gs^{-1})	% yield of butane
100 K	4.5	0.069	60
200 K	4.25	0.104	50
300 K	3.98		46

- **gs^{-1} = grams per second**
- **1kg = 1000g.**

Calculate the rate of reaction for 300 K. Show your working and your final calculation to three **decimal places. Ensure to include units.**

[3 marks]

AO2 = 3 marks

Award **one** mark for each correct stage of the working, up to a maximum of **three** marks:

- conversion of mass to grams: (5 – 3.98) x 1000 = 1020 g
- conversion of time to seconds: (120 minutes x 60 seconds) = 7200 s
- calculating 300 K as: (1020 g)/7200 s = 0.142 gs^{-1}.

If correct answer given with no working award 3 marks.

16(d) **The chemists repeat the experiment at 100 K but this time include reagent B. They record the following results:**

- **rate of reaction (after 2 hours): 0.157 gs^{-1}**
- **percentage yield of butane (C_4H_{10}): 72%.**

Analyse the effect that the change in temperature and the addition of reagent B has on the production of butane (C_4H_{10}).

[2 marks]

AO3 = 2 marks

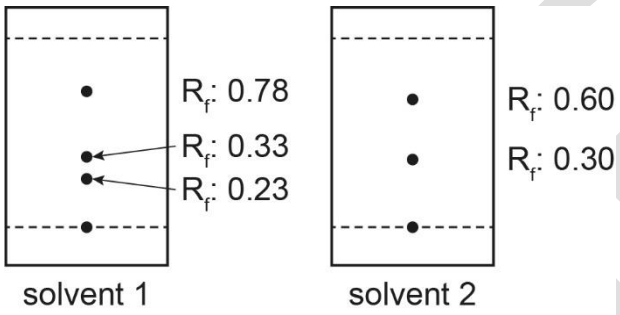
Award **one** mark, up to a maximum of **two** marks, for any of the following points:

- although increasing the temperature, increases the rate of reaction, it decreases the percentage yields of butane (1) and therefore decreases the production of butane (1)
- the addition of reagent B increases the rate of reaction and % yield of butane at a lower temperature (1) and therefore increases the production of butane using the reaction (1).

Accept any other suitable response.

17 **A research scientist has synthesised a compound in the laboratory. The compound now requires purification from a mixture. The scientist conducts a thin layer chromatography (TLC) analysis of the mixture in two different solvents and obtains the following results as shown in** Figure 10.

Figure 10 TLC analysis plates of the mixture



The scientist now plans to perform column chromatography on this mixture.

Using your knowledge of purification techniques, evaluate the use of thin layer chromatography and the suitability of the scientist's next steps.

Your answer should include reasoned judgements and / or conclusions.

[9 marks plus 3 marks for QWC]

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

Band	Mark	Descriptor
3	7–9	**AO3:** evaluation of the potential 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 each purification technique can be used. Shows a detailed functional understanding of the scientific methodology involved. **AO1**: demonstrates a **wide** range of relevant knowledge and understanding of purification techniques that is **accurate and detailed.** The answer demonstrates comprehensive breadth and / or depth of understanding.
2	4–6	**AO3:** evaluation of the potential purification techniques is in **most** parts **effective** and **mostly relevant**, showing mostly logical and coherent chains of reasoning. Makes conclusions supported by reasoned judgements that consider most of the relevant arguments. **AO2**: applied relevant knowledge of how each purification technique can be used is in **most parts** appropriate, showing **some** functional understanding of the scientific methodology involved. **AO1:** knowledge and understanding of purification techniques in this context are in **most parts** clear and mostly accurate, although on **occasion may lose focus.**
1	1–3	**AO3:** evaluation of the potential purification techniques available 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 each purification technique can be used and may show a **lack** of functional understanding of the scientific methodology involved. **AO1**: knowledge and understanding of purification techniques in this context show some but limited accuracy, focus and relevance.
	0	No creditworthy material.

Indicative content

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

AO1: knowledge of types of chromatography

- Thin layer chromatography is used to identify the compounds and their purity.
- Thin layer chromatography used to separate non-volatile mixtures based on their affinity for a mobile (solvent) or stationary phase (on a coated plate).
- Column chromatography can be used to separate a single chemical compound from a mixture (in a vertical column).
- There are other purification techniques including gas chromatography, and high-performance liquid chromatography (HPLC).

- Gas chromatography is used to separate and analyse compounds that can be vaporised (in a packed column).
- High-performance liquid chromatography (HPLC). is used to separate substances based on their affinity for a mobile (pressurised solvent) or stationary phase (in a capillary or packed column).

AO2: application of knowledge of chromatography in two different solvents

- Based on thin layer chromatography, there are 3 different compounds in the mixture (using solvent A).
- Column chromatography can be used for separating the synthesised compound from the mixture.
- Gas chromatography can only be used if the mixture / compounds can be vaporised.
- High-performance liquid chromatography (HPLC) could be used as the compounds have varying affinity for the mobile and stationary phase, as shown by the thin layer chromatography.

AO3: evaluation of potential next steps

- Analysis of the results suggests solvent 1 obtained the best separation due to the greater separation between each spot. Therefore, solvent 1 is more polar than solvent 2.
- More tests need to be carried out – column chromatography could be a logical next step as it can separate out the synthesised compound from the mixture containing three compounds in total.
- The scientists could test other solvents for better separation and possibly more spots before attempting other techniques.
- High-performance liquid chromatography (HPLC) may be appropriate as a next step as two of the compounds moved similar distances during thin layer chromatography using solvent 1.
- More information is needed on whether the compounds can be vaporised before deciding whether or not gas chromatography could potentially be an appropriate next step.

Accept any other suitable responses.

QWC

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 is 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 is 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 is used effectively.
0	There is no answer written or none of the material presented is creditworthy.

Section D: Biology, Chemistry and Physics

Total for this section: 12 marks,
plus 3 marks for quality of written communication (QWC)

18 **A rock climber is brought into an accident and emergency department. The paramedics explains that the patient has fallen several metres, but has no obvious external injuries, however they are unable to move or feel their legs.**

The doctor suspects damage to the vertebrae which could have subsequently damaged the soft tissue of the spinal cord.

They have access to both X-rays and MRI scans to assist in the diagnoses of the internal injuries the patient may have sustained.

Evaluate the relative risks and benefits to patients of using these methods.

Your response should demonstrate:

- **an understanding of the principles of X-ray and MRI scans**
- **reasoned judgements and / or conclusions.**

[12 marks plus 3 marks for QWC]

AO1 = 4 marks
AO2 = 4 marks
AO3 = 4 marks

Band	Mark	Descriptor
3	9–12	**AO3:** evaluation of the risks and benefits 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 principles of X-rays and MRI scans are applied **effectively** to the given context. **AO1** a **wide** range of relevant knowledge and understanding of the principles of X -rays and MRI scans is evident. A **wide** range of **appropriate** technical terms is used. The answer demonstrates **comprehensive** breadth and / or depth of understanding.
2	5–8	**AO3:** evaluation of the risks and benefits, 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 principles of X-rays and MRI scans are applied **mostly** effectively, although there **may** be lack of clarity. **AO1:** knowledge and understanding of the principles of X-rays and MRI scans 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	1–4	**AO3:** evaluation of the risks and benefits 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 principles of X-rays and MRI scans is **applied** to the given context. **AO1:** knowledge and understanding of X-rays and MRI scans, 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

AO1: Knowledge of X-Ray and MRI risks and benefits

- X-rays are a form of high energy radiation that can pass through the body.
- Ionising (electromagnetic) radiation is the basis for X-ray imaging.
- X-rays are absorbed by different tissues at different rates.
- Bones absorb X-rays more than any other tissue.
- X-ray machines are relatively cheap.
- MRI scans use a powerful magnetic field to create an image.
- MRI scans do not use (ionising) radiation.
- MRI scans can clearly image soft tissue and bones.
- MRI scanners are expensive.
- MRI scans can produce a 3D image within the body.
- MRI scans can image a cross-section of the body.
- Some MRI scans involve the body being placed into a tube.

AO2: Application of knowledge of X-Ray and MRI risks and benefits

- The high energy radiation of X rays can cause damage to cells.
- As X-rays are readily absorbed by bone tissue, they are very useful for imaging bones and identifying bone damage which could be causing the symptoms.

- As X-rays are less well absorbed by soft tissues, they are less useful for imaging the spinal cord.
- As X-ray machines are relatively cheap, they are readily available.
- As X-ray machines are readily available, they can be accessed quickly when diagnosing an injury.
- As MRI scans do not use (ionising) radiation, they do not cause damage to cells.
- As MRI scanners are expensive, they are not readily available.
- As MRI scanners are not readily available, there may be a waiting list to access a scan.
- The strong magnetic field produced by an MRI scanner will attract magnetic implants in the body, the doctor will need to find out if the patient has any metallic implants.
- As X-rays do not use a magnetic field, they will have no effect on magnetic implants in the body.

AO3: Evaluation of risks and benefits of X-Ray and MRI use to patients

- As X-rays can cause damage to cells, frequent X-rays can be dangerous to the body, however as most people do not get frequent X-rays, this is unlikely to be a problem.
- As X-rays are readily available with minimal waiting time, they can be used to support a rapid diagnosis of an injury; this rapid diagnosis could be extremely important in successfully treating a patient.
- As X-rays are relatively cheap and are very useful for imaging bones, there is no need to use an MRI scan for many routine injuries; this can save money and enable more rapid treatment.
- As X-rays are not as useful for imaging soft tissues, they are less likely to be useful in imaging tissue damage or tumours than MRI scans.
- As X-rays do not have an effect on magnetic implants within the body, they can be used when patients have such implants (without causing damage).
- As MRI scans do not damage tissue they can be used repeatedly, however this will be very expensive and is likely to involve long waiting times.
- As MRI scans can clearly image soft tissue and bone, they can be used for a much wider range of diagnoses than X-rays.
- As MRI scans can produce a 3D image of an area of the body / cross-sectional image, they can be used to help diagnose how an injury / condition is affecting another region of the body.
- As MRI scans create a very strong magnetic field that could dislodge magnetic implants, this could be dangerous and may prevent their use in areas of the body with such implants.
- As some MRI scans involve placing the body inside a tube, this can cause fear / claustrophobia, which may affect the clarity of the scan; X-rays do not cause this problem.
- Both X-rays and MRI scans are extremely useful, which is most appropriate will be determined by the injury / condition being investigated.
- In most cases the risks from either form of scan are very minimal, as they are used to diagnose serious injuries / conditions, the benefits far outweigh the risks.

Accept any other suitable response.

QWC

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 is 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 is 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 is effectively.
0	There is no answer written or none of the material presented is creditworthy.

Assessment objective grid

Section A

Question number	AO1	AO2	AO3	Maths	QWC	Total
1 (a)	1					1
1 (b)	2					2
1 (c)		2				2
2	1	2				3
3 (a)		2		(2)		2
3 (b)			3			3
4 (a)		2				2
4 (b)	4					4
4 (c)		3				3
5			4			4
6		2	3			5
7 (a)		2				2
7 (b)			3			3
8	3	3	3		3	12
Total	**12**	**17**	**16**	**(2)**	**3**	**48**
Totals required	**11–13 marks**	**17–19 marks**	**14–16 marks**		**3**	**48**
Kil	**6**					

Section B

Question number	AO1	AO2	AO3	Maths	QWC	Total
9	1					1
10 (a)		3		(3)		3
10 (b)			3			3
11			3			3
12		3				3
13		3		(3)		3
14	1					1
15	3	3	3		3	12
Total	**5**	**12**	**9**	**(6)**	**3**	**29**
Totals required	**5–7 marks**	**10–12 marks**	**8–10 marks**			**29**
Kil	**2**					

Section C

Question number	AO1	AO2	AO3	Maths	QWC	Total
16 (a)	1					1
16 (b)		2				2
16 (c)		3		(3)		3
16 (d)			2			2
17	3	3	3		3	12
Total	**4**	**8**	**5**	**(3)**		**20**
Totals required	**3–6 marks**	**6–8 marks**	**4–9 marks**			
Kil	**1**					

Section D

Question number	AO1	AO2	AO3	Maths	QWC	Total
18	4	4	4		3	15
Total	**4**	**4**	**4**		**3**	**15**
Totals required	**3–4 marks**	**4–6 marks**	**3–4 marks**		**3**	**15**
Whole paper totals	**25**	**42**	**33**		**12**	
Kil paper total	**9**					

Document information

Owner: Head of Assessment Design

Change History Record

Version	Description of change	Approval	Date of Issue
v1.0	Additional specimen assessment materials		November 2022
v1.1	Sample added as a watermark	November 2023	20 November 2023