T Level Technical Qualification in Healthcare Science

Core knowledge and understanding

Paper B

Elements 11-12

Mark scheme

v1.0 Pre-standardisation
P002397
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This Mark Scheme has been written by the Assessment Writer and refined, alongside the relevant questions, by a panel of subject experts through the external assessment writing process and at standardisation meetings.

The purpose of this Mark Scheme is to give you:

- examples and criteria of the types of response expected from a student
- information on how individual marks are to be awarded
- the allocated assessment objective(s) and total 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 marked 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 levels-based descriptors and indicative content.

Levels-based descriptors. each level is made up of several descriptors across the assessment objective (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 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 assessment objective 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) Figure 1: **A diagram of a prokaryotic microorganism**

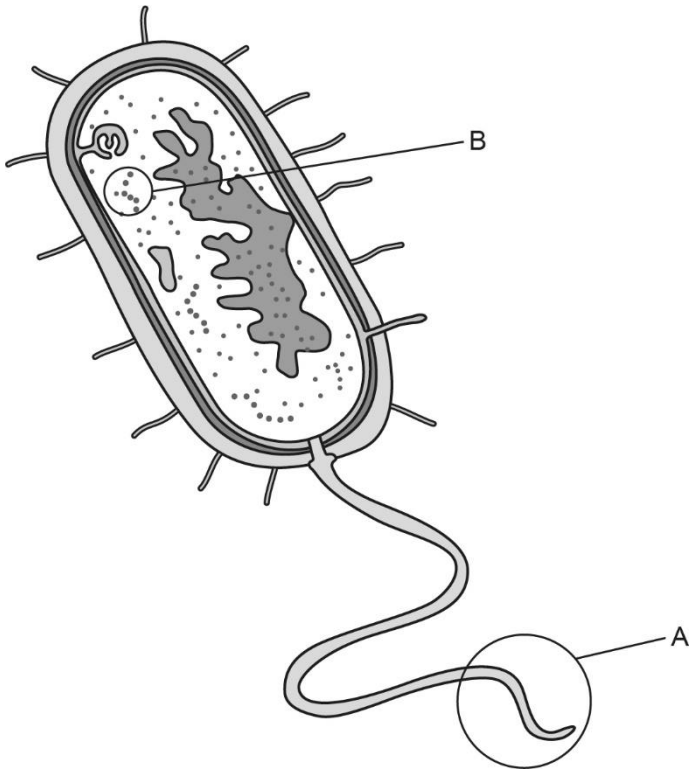


Figure 1 **is a diagram drawn from a photograph taken with an electron microscope and shows some of the features of a prokaryotic microorganism. The organism is capable of carrying out photosynthesis.**

(a)(i) **Give the name of the organelle found in plant cells that carries out photosynthesis.**

[1 mark]

AO1 = 1 mark

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

- chloroplast.

Accept any other suitable response.

1(a)(ii) Structure A **is a flagellum, it is used to enable the cell to move.**

Explain how Structure A **may help this microorganism to photosynthesise.**
[2 marks]

AO2 = 2 marks

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

- move towards a light source/resource (1) to enable photosynthesis (1).

Accept any other suitable response.

1(b) **Identify** one **feature from** Figure 1 that **proves that this microorganism is a bacterium rather than a virus.**
[1 mark]

AO2 = 1 mark

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

- it has some organelles (ribosomes, cell surface membrane), cytoplasm, viruses do not (1)
- it has a cellular structure, viruses do not (1).

Accept any other suitable response.

1(c) **State the name of the structures labelled** B **and give their function.**
[2 marks]

AO1 = 2 marks

Award **one** mark for stating the correct name, and **one** mark for giving the correct function, up to a maximum of **two** marks**:**

Stating name:
- ribosomes (1)

Function:
- protein synthesis/translation (1)

1(d) **The actual length of the microorganism is 2 µm, the length on the photograph was 75 mm. Calculate the magnification used.**

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

1 mm=1000 µm

You must show your working

[4 marks]

AO2 = 4 marks

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

- 75 mm x 1000 (1) =75,000 µm (1)

Or

- 2 µm/1000 (1) = 0.002 mm (1)

Award **one** mark for correct substitutions:

- 75 000/2

Or

- 75/0.002

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

- x37500 (1)

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

2(a) **An accident victim has a chest wound which has pierced the pleural membranes. The lungs have not been pierced.**

(i) **Outline how the intercostal muscles bring about inspiration.**

[4 marks]

AO1 = 4 marks

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

- the intercostal muscles contract pulling the ribs up (and out) (1)
- this intercostal muscle contraction causes the volume of the thorax/chest cavity to increase. (1)
- the increased volume causes the pressure in the thorax/chest cavity to decrease (below atmospheric pressure) (1)
- air moves into the lungs to equalise the pressure (1).

Accept any other suitable response.

(ii) **Explain why this type of chest wound is likely to make inspiration more difficult.**

[2 marks]

AO2 = 2 marks

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

- air will enter the chest cavity through the puncture wound (1) trapped air will prevent the lungs from inflating (1).

Accept any other suitable response.

(b) **Name the** other **component in the respiratory system that helps bring about inspiration.**

[1 mark]

AO1 = 1 mark

Award **one** mark for naming the structure, up to a maximum of **one** mark:

- the diaphragm (1)

3 **A glucose meter shows that a patient's blood sugar level, before eating a meal with a high starch content, is 5 mmol/L. This rises to 7.5 mmol/L after the meal.**

(a) **Give the name of the digestive enzyme responsible for breaking down starch.**

[1 mark]

AO1 = 1 mark

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

- salivary amylase (1)
- pancreatic amylase (1)
- carbohydrase (1)

(b)	**Calculate the percentage rise in blood sugar level after the meal.** **You must show your working.** [2 marks]

AO2 = 2 marks

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

- 7.5 - 5/5 x 100 (1)
- = 50(%) (1)

Note: Award two marks for an answer of 50% with no working out.

4	**A student suggests that in order to provide better targeted healthcare all newborn babies should undergo genome mapping and gene screening.** **To what extent do you agree with the student's suggestion?** **Your response must include reasoned judgements and conclusions.** [6 marks]

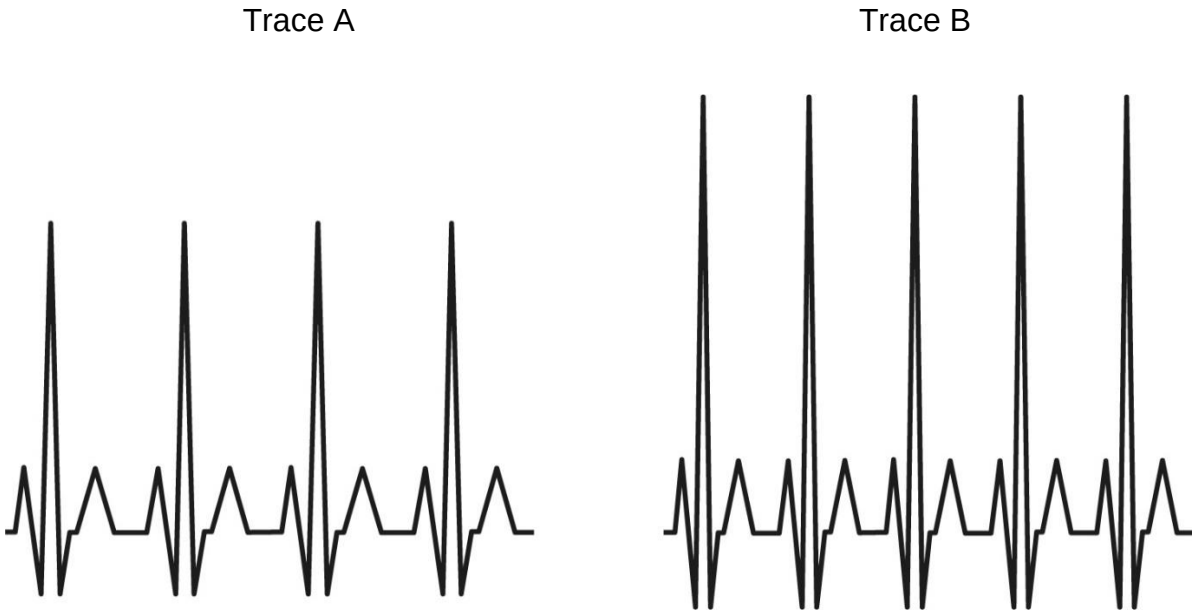
AO3 = 6 marks

Award **one** mark for each judgment and conclusion in response to the suggestion, up to a maximum of **six** marks:

- agree because genome mapping will help to identify any specific chromosomal abnormalities (1) gene sequencing will help to identify abnormalities in specific genes which may prevent the production of enzymes required for metabolic reactions (1) both mechanisms will enable the identification of any genetic disorders/diseases the baby may have (1).
- agree because if an individual knows they are susceptible to a particular disorder; this would enable them to take steps to reduce their risk of developing the disorder (1) taking these precautions may be better for their health than waiting for the disease to develop (1) preventative measures are often cheaper/more cost effective (1).
- disagree because some disorders/do not have a genetic cause, so other tests may be needed (1) having an increased susceptibility does not mean an individual will develop a disorder (1) worrying about developing the disorder could cause the individual problems (1).
- disagree because there will be some newborn babies who are more likely to have genetic/chromosomal disorders due to hereditary factors (1) if genome mapping and gene screening are carried out with newborn babies, it will be too late to intervene via gene editing (1). both genome mapping and gene sequencing can provide useful information which may help in the treatment of genetic/chromosomal disorders, however due to the high cost of this testing it may be better to target this for newborns who are at risk due to hereditary factors (1).

Accept any other suitable response.

5(a) Figure 2**: ECG traces from the same person at different times**



(i) **Give the letters associated with the trace shown in** figure 2**.**

[1 mark]

AO1 = 1 mark

Award **one** mark for giving the correct letters of the wave, up to a maximum of **one** mark:

- PQRST (wave) (1)

(ii)	**Explain** one **piece of evidence from** figure 2 **which shows the person's physical activity has increased in** Trace B**.** [2 marks]

AO2 = 2 marks

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

- **trace B** shows more beats in the same period of time than **trace A** (1) indicating a faster heart rate, which would be expected with an increase in physical activity (1)
  Or
- **trace B** shows the peak of each contraction is higher in each of the beats (1) indicating a stronger contraction (which would be associated with an increase in physical activity) (1).

The two **traces allow a comparison of heart rate.**

(b) **Identify** one additional **piece of information which should be added to the traces to enable the individual's actual heart rate to be determined.**

[1 mark]

AO2 = 1 mark

Award a maximum of **one** mark for correctly identifying the additional information required, up to a maximum of **one** mark:

- a time scale should be added (1)

6 **A lecturer states that the endocrine function of the ovaries in reproduction is as important as the egg production function of the ovaries.**

To what extent do you agree with the lecturer's statement?

Your response must include reasoned judgements and conclusions.

[6 marks]

AO3 = 6 marks

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

- Agree because the ovaries produce oestrogen that is essential for puberty, without puberty egg cells cannot be produced (1) and they regulate the menstrual cycle/prepare the womb/uterus to receive the fertilised ovum/egg, without this regulation pregnancy cannot occur (1). Therefore, the endocrine role of the ovaries is essential for reproduction (1)
- Agree because the ovaries produce egg cells, without egg cells fertilisation cannot occur therefore without production of egg cells, reproduction cannot occur (1), therefore both the endocrine role and the egg cell producing role are essential for reproduction to occur (1), however as production of egg cells cannot occur without the endocrine role, it could be argued that the endocrine role is more important (1)
- Agree because the ovaries produce other hormones that are vital for preparing the uterus for pregnancy and for maintaining the pregnancy (1) without these hormones pregnancy could not occur (1). If pregnancy cannot occur the ability of the ovaries to produce egg cells is irrelevant, therefore it could be argued that the endocrine role is more important (1).

Accept any other suitable response.

7	**A student studying the immune system stated that the T and B cell responses were more important in preventing and responding to infection than the physical and chemical barriers and phagocytosis.** **Discuss the validity of the student's statement.** **Your response must include reasoned judgements and conclusions**. [9 marks plus 3 marks for QWC]

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

Band	Mark	Descriptor
3	7-9	**AO3:** Discussion of the mechanisms involved in preventing and responding to infection is **comprehensive**, **effective and relevant**, showing **detailed understanding** and **logical and coherent** chains of reasoning throughout. Informed conclusions are fully supported with **rational, balanced**, and reasoned judgements, with most of the relevant arguments evident. **AO2:** Applied **all** relevant knowledge of the mechanisms involved in preventing and responding to infection, showing a **detailed, functional understanding** of the given context. **AO1:** Demonstrates a **wide** range of understanding of the mechanisms involved in preventing and responding to infection which is **accurate and detailed.** The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	4-6	**AO3:** Discussion of the mechanisms involved in preventing and responding to infection are in **most parts effective** and **mostly relevant**, showing in **mostly logical** and **coherent** chains of reasoning. Conclusions supported by reasoned judgements that consider **most** of the relevant arguments are evident. **AO2:** Applied **some relevant knowledge** of the mechanisms involved in preventing and responding to infection, showing **some functional understanding** of the given context. **AO1:** Demonstrates a **sufficient** of understanding of the mechanisms involved in preventing and responding to infection, is **mostly accurate and detailed.** The answer demonstrates **r**easonable breadth and/or depth of understanding, with **occasional inaccuracies** and/or **omissions**

1	1-3	**AO3** Discussion of the mechanisms involved in preventing and responding to infection is in **some parts effective** and of **some relevance** with some understanding and reasoning taking the form of **generic** statements with **some** development. **Brief** conclusions supported by reasoned judgements that consider only **basic arguments** and show **little** relevance to the question aims are evident. **AO2** Applies limited knowledge of the mechanisms involved in preventing and responding to infection, which shows a **lack of functional understanding** of the given context. **AO1** Demonstrates a **limited** range of understanding of the mechanisms involved in preventing and responding to infection which is **limited** in **accuracy and detail**. The answer is **basic** and shows **limited** breadth and/or depth of understanding, with **inaccuracies** and **omissions.**
	0	No creditworthy material

Indicative content

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

AO1: Knowledge and understanding of the mechanisms involved in preventing and responding to infection may include:

- an infection occurs when an organism replicates inside the body causing disease
- physical barriers:
  - the skin forms a physical barrier to prevent causative agents entering the body
  - hairs in the nostrils form a physical barrier to prevent causative agents entering the body
  - the cough and sneeze reflexes prevent causative agents entering the body
- chemical barriers:
  - (hydrochloric) acid in the stomach form a chemical barrier to prevent causative agents entering the body
  - lactic acid in the genitals forms a chemical barrier to prevent causative agents entering the body
  - enzymes in tears form a chemical barrier preventing causative agents entering the body
- involuntary inflammatory response:
  - **i**ncreased blood flow to the area
  - redness
  - pain
  - swelling
  - white cell response

- phagocytosis: phagocytes recognise foreign antigen on causative agents and engulf and digest them/destroy them
- T and B cell responses:
  - T cells and B cells are stimulated by the presence of a foreign antigen
  - cell mediated immunity involved T cells (T lymphocytes)
  - T cells destroy causative agents without producing antibodies
  - antibody mediated immunity involves B cells (B lymphocytes)
  - B cells destroy causative agents by the production of antibodies

AO2: Application of knowledge and understanding of the mechanisms involved in preventing and responding to infection may include:

- physical and chemical barriers are non-specific and are effective against any causative agent
- physical and chemical barriers are effective immediately against causative agents, (there is no time lag)
- the skin can be cut/damaged allowing causative agents to get past the barrier
- some causative agents have a capsule that may help prevent them being destroyed by chemical barriers/protect them against chemical barriers
- phagocytes can react immediately to foreign antigen on the causative agent and therefore can there is no time lag
- some types of phagocytes can present antigen from the causative agent on their surface, this speeds up activation of T and B cells
- T and B cells need to be activated by antigen from the causative agent before they can respond, this takes time
- T and B cells are specific to particular antigens and therefore particular causative agents, this takes time
- T and B cells produce memory cells which are responsible for providing immunity
- phagocytes do not produce memory cells and therefore do not provide immunity.

AO3: Discussion of the mechanisms involved in preventing and responding to infection may include:

- Without the presence of physical and chemical barriers, large numbers of causative agents could enter the body and multiply, this would be likely to overwhelm the T and B cells therefore the physical and chemical barriers are essential
- As the phagocytes are not specific and can act immediately, they can start to destroy causative agents straight away, this gives the T and B cells the time to become activated and start their responses. Without the phagocytes the T and B cells could be overwhelmed therefore they are essential
- Without the presence of antigen presenting phagocytes, the T and B cell responses may be too slow to prevent the causative agents multiplying and causing serious illness. Therefore, the phagocytes are essential
- As causative agents can sometimes get past the physical and chemical barriers phagocytosis, and the T and B cell responses are essential to destroy the causative agents
- As the T and B cells both produce memory cells leading to immunity and the phagocytes and physical/chemical barriers do not, there would be no immunity without the T and B cell responses, this would therefore lead to a higher number of infections.

Possible overall conclusion

Each of the mechanisms mentioned have a vital part to play in preventing and responding to infection. If any of the mechanisms were absent, then this would lead to more frequent and more serious infections, (throughout the life of an organism).

Accept any other suitable response.

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 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 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 is 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: physics **Total for this section: [26 marks] plus 3 marks for QWC**

8(a) **Outline the process that occurs in an unstable nucleus to emit a beta particle.** [2 marks]

AO1 = 2 marks

Award **one** mark for each outlined point, up to a maximum of **two** marks.

- a neutron converts into a proton (1)
- a high energy/speed electron is emitted (1)

8(b) **State the range of a beta particle in air.** [1 mark]

AO1 = 1 mark

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

- (approximately) 15 cm (1).

Accept any response within 10 to 20cm.

9 **A student constructs a circuit with a 10 volt battery and two bulbs. The circuit has a total resistance of 2 Ohms.**

Calculate the current in amps. Use the following equation to help you.

$$I = \frac{V}{R}$$

[2 marks]

AO2 = 2 marks

Award **one** mark for inputting the values correctly into the equation, up to a maximum of **one** mark:

$$I = \frac{V}{R} = \frac{10}{2}$$

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

$$I = 5(A)$$

Note: award two marks for an answer of 5 with no working out.

10 **Microwave therapy can be used alongside other radiotherapy techniques to kill cancer cells.**

A microwave has a wavelength of 1×10^{-3} m.

Microwaves travel at a speed of 3×10^{8} m/s.

Using the equation $v = f\lambda$, calculate the frequency of the wave.

You must show your working and provide appropriate units.

[4 marks]

AO2 = 4 marks

Award **one** mark for correctly rearranging the equation, up to a maximum of **one** mark:

$$f = \frac{v}{\lambda}$$

Award **one** mark for correctly substituting the values into the rearranged equation, up to a maximum of **one** mark:

$$f = \frac{3 \times 10^{8}}{1 \times 10^{-3}}$$

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

$$f = 3 \times 10^{11}$$

Award **one** mark for using the appropriate units, up to a maximum of **one** mark:

Hz or Hertz

11(a) **Electromagnets are often used in locking mechanisms for healthcare science laboratories' access doors. This is to ensure security and give access only to authorised people.**

A team of scientists is investigating the use of electromagnets for this purpose.

They begin by investigating the relationship between voltage and magnetic field strength. Their results are shown in Table 1.

Table 1: **Results from scientists' initial experiment**

Voltage (V)	Magnetic field strength (T)
0	**0.00**
2	**0.02**
4	**0.04**
6	**0.05**
8	**0.06**
10	**0.07**

(T) – Tesler, the unit of measurement for the strength of magnetic fields.

Describe the trend shown in the data in Table 1.

[2 marks]

AO2 = 2 marks

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

- Between 0 and 4 volts, as the voltage increases, so does the magnetic field strength (1)
- At 6 volts onwards the magnetic field strength increases at a lower rate (1).

Accept any other suitable response.

(b) **The same team of scientists then perform a similar experiment using two different metals in the electromagnet and measure how fast each one loses its magnetic field after the current is switched off.**

They measure the magnetic field strength every two seconds for ten seconds after the current is switched off. Results are shown in Table 2.

Table 2**: Results from scientists' experiments**

	Magnetic field strength (T)	
Time elapsed (s)	Metal 1	Metal 2
0	**0.09**	**0.11**
2	**0.05**	**0.09**
4	**0.02**	**0.07**
6	**0.00**	**0.05**
8	**0.00**	**0.03**
10	**0.00**	**0.02**

One of the scientists suggests using metal 2 as this metal has a stronger magnetic field than metal 1 and therefore is more secure.

Using the data provided in Table 2, assess this suggestion.

[3 marks]

AO3 = 3 marks

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

- (the suggestion may be incorrect as) metal 2 does have a stronger magnetic field but does not discharge as quickly as metal 1 (1); it might be more useful for the medical staff if the door opened more quickly (1) as they could move between rooms faster (1)
- (the suggestion may be correct as) metal 2 does have a stronger magnetic field than metal 1 (1); this could mean that the door lock is more secure (1), this could minimise risk of unauthorised access (1)
- the scientist would need to carry out further investigations with other variables to be certain of which metal would be most appropriate to use in door locks (1); it may be possible to open the door before the electromagnet has fully lost magnetism (1), this could pose a risk to staff safety if the door could be unexpectedly hard to open when rushing (1).

Accept any other suitable response.

12 **A consultant needs to image the digestive system of a patient. To achieve this the consultant is going to use a radioactive tracer, a pill that can be swallowed and gives off a small amount of radiation. The radiation will then be measured using a detector that surrounds the patient, producing an image.**

The consultant says:

'The isotope we will use needs to have a suitable level of radioactivity and be able to pass through the soft tissues of the patient to reach the detector.'

Table 3 shows the details of some radioactive isotopes.

Table 3**: Radioactive isotopes**

Isotope	Half-life	Radiation
Americium-241	**432 years**	**Alpha**
Technetium-99	**6 hours**	**Gamma**

Analyse the suitability of the radioactive isotopes for the procedure.

[3 marks]

AO3 = 3 marks

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

- The half-life of americium is 432 years; this is too long (1); very little/no radiation would be detected as the count rate would be very low (1), therefore americium should not be used for this purpose (1)
- Alpha radiation has the lowest penetration (1), therefore it would not be detectable outside the body as it cannot pass through all the tissue (1), therefore americium should not be used for this purpose (1)
- The half-life of technetium is short enough to observe over the course of a procedure as a suitably considerable proportion will have decayed over the course of a digestion (1); gamma radiation has highest penetration and will be able to pass through the body to the detector (1), therefore technetium should be used/is most suitable (1).

Accept any other suitable response.

13 **Scientists are investigating the use of a preservative spray as an alternative to using gamma radiation for the preservation of a dietary supplement.**

They take 4 samples, place each one in an identical environment and give each treatment once per day, as shown in Table 4. Over six days they observe the number of bacterial colonies that develop on the surface of the samples. Their results are displayed in Table 4.

Table 4**: Scientists' observations after six days of experimentation**

Treatment given (once per day)	Bacterial colonies observed			
	Day 0	**Day 2**	**Day 4**	**Day 6**
No treatment (control)	**0**	**1**	**3**	**4**
Preservative spray	**0**	**0**	**1**	**2**
Gamma radiation	**0**	**0**	**0**	**0**

A scientist suggests that one option for further research could be to use the preservative spray twice per day as this may prevent bacterial colonies from forming on the sample and also avoid using gamma radiation.

Using your knowledge of gamma radiation and food preservation, evaluate the scientist's suggestion.

Your answer should include reasoned judgements and conclusions.

[9 marks plus 3 marks for QWC]

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

Band	Mark	Descriptor
3	7-9	AO3: Evaluation of scientist's suggestion 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** and **balanced** conclusions are evident. AO2: Application of knowledge in using gamma radiation to preserve food using the data provided 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/or depth of understanding.
2	4-6	AO3: Evaluation of the scientist's suggestion is in most parts effective and mostly relevant, showing mostly logical and coherent chains of reasoning throughout. There are mostly accurate judgements. Mostly **rational** and **balanced** conclusions are evident.

		AO2: Application of knowledge in using gamma radiation to preserve food using the data provided 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/or depth of **understanding**, with **occasional** inaccuracies and/or omissions.
1	1-3	AO3: Evaluation of the scientist's suggestion is in some parts effective and of some relevance, with some understanding and reasoning taking the form of generic statements with some development. Judgements are **basic** and **brief**, and conclusions will have limited rationality and balance. AO2: Application of knowledge in using gamma radiation to preserve food using the data provided is limited and may show a lack 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**, with **inaccuracies** and omissions.
0	0	No credit worthy 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 gamma radiation may include:

- gamma radiation is low ionising and has a high penetrating power
- the range of gamma radiation is many kilometres of air
- gamma radiation is electromagnetic radiation from the nucleus of an unstable atom
- gamma radiation can cause electrons to break apart from atoms or molecules
- gamma radiation can transfer energy to atoms or molecules
- gamma radiation can be harmful to people if they do not use the correct level of protection
- foods preserved using gamma radiation should be safe to consume

AO2: Application of knowledge of using gamma radiation in food preservation using the data may include:

- the results from table 4 suggest that the gamma radiation only experiment worked the best in terms of food preservation across the six days as there were no bacterial colonies observed.
- the control test appears to be a good point of comparison as the natural degradation process occurred over the six day period.
- the chemical spray alone worked as well as the gamma radiation until day 4, when bacterial colonies start to form.
- observations could be made more frequently as the colonies may have started forming on days 1, 3 or 5.
- the investigation was not repeated.
- there is no information about how strong/the concentration of the preservative spray.

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

- the scientist's suggestion may be correct, with one treatment using the preservative spray per day, the samples lasted 2 days without bacterial colonies forming. It is reasonable to assume that more treatments with the spray might prevent further bacterial growth.
- the scientist did not repeat the investigation, so we cannot be sure of the validity of the results. Some results in table 4 could be anomalous but we cannot be sure unless repeats are carried out.
- the scientist only tested one type of sample. Other types of dietary supplement might react to the spray differently so adding more spray may not help at all.
- the concentration of the spray might be as strong as it is allowed to be for use with food, therefore adding more treatments could mean that the food is not allowed to be eaten. In this situation, gamma radiation would be the better choice.

Conclusion
It might be worth testing the scientist's suggestion to see if the preservative spray being applied twice per day would preserve the sample for longer but there are also other improvements to the method that could be considered as well.
Accept any other suitable response.

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: chemistry **Total for this section: [17 marks] plus 3 marks for QWC**

14 **Name** one **type of sub-atomic particle located in the nucleus of an atom.** [1 mark]

AO1 = 1 mark

Award **one** mark for correctly naming one type, up to a maximum of **one** mark:

- proton(s) (1)
- neutron(s) (1).

Accept any other suitable response.

15 **State** one **property of an acid.** [1 mark]

AO1 = 1 mark

Award **one** mark for **one** of the following statements, up to a maximum of **one** mark:

- corrosive (1)
- irritant (1)
- have a pH value of less than 7(1)
- can neutralise bases (1)

Accept any other suitable response.

16 **Scientists are interested in developing a new type of lightweight and durable container for a detergent. They are considering two types of material: a polymer named high density polyethene and a ceramic named silicon carbide.**

You are provided with some basic data comparing these materials in Table 5.

Table 5: **Data comparing both materials to be investigated**

Material	High density polyethene	Silicon carbide
Melting point (°C)	**131**	**2830**
Density (g/cm^3)	**0.94**	**3.22**

(a) **Explain why high density polyethene might be more appropriate to use as a container.** [2 marks]

AO2 = 2 marks

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

- high density polyethene has a lower density than silicon carbide (1) this means the container would be lighter and easier for a customer to carry (1)
- high density polyethene has a melting point of 131 °C (1) this would still be high enough to store at room temperature and stay solid (1).

Accept any other suitable response.

(b) **Suggest** one other **property of polymers that would make them a good choice for a container.**

[1 mark]

AO2 = 1 mark

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

- strong so the content does not spill/split (1)
- chemically unreactive so it does not react with the contents (1)

Accept any other suitable response.

17 **Scientists are producing aspirin. The method that is currently used is slow, but they have developed a new method that is faster.**

They carried out their new method at different temperatures to find out if they could make it even faster and still produce at least 55% aspirin. They measure the rates of reaction and percentage of aspirin produced and record their results in Table 6.

Table 6: **Initial results from scientist's experiment**

Temperature (°C)	Rate of Reaction (mg/s^1)	Percentage of the final product that is aspirin (%)
20	**5.23**	**60**
30	**6.67**	**56**
40	**8.96**	**53**
50	**10.04**	**50**

One of the scientists predicts that temperatures higher than 50°C will produce larger percentages of aspirin as well as an increased rate of reaction.

Using your knowledge of collision theory, evaluate the scientist's prediction.

[3 marks]

AO3 = 3 marks

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

- Increasing temperature should increase the number of collisions and therefore the rate of reaction (1) Table 6 shows that as temperature increases, so does the rate of reaction (1) the scientist could, therefore, be correct that increasing the temperature further could increase the rate of reaction (1)
- Increasing the rate of reaction should increase the percentage of aspirin produced as there will be more collisions and therefore more product produced (1) however, the data does not suggest that increasing temperatures above 50°C would increase the percentage of aspirin produced as Table 6 shows that the percentage of aspirin produced at 30°C is lower than 20°C (1) the scientist could, therefore, be incorrect as increasing the temperature does not increase the percentage of aspirin produced (1).

Accept any other suitable response.

18 **A healthcare scientist is assisting with a chemotherapy drug trial. Their laboratory has been sent a urine sample from a cancer patient taking part in the trial. The first round of analysis of this sample shows four unknown products.**

The composition of the urine sample is shown in Table 7.

Table 7: **Composition data of sample taken from patient**

Component	% by weight
Water	**90.1**
Sugars	**5.6**
Product A	**1.2**
Product B	**0.3**
Product C	**1.4**
Product D	**1.4**

The laboratory manager would like the healthcare scientist to find out what the unknown products (products A, B, C and D) are.

The healthcare assistant decides to use mass spectrometry.

Evaluate the use of mass spectrometry in this situation, comparing and contrasting it to other separation techniques.

Your answer should include reasoned judgements and conclusions.

[9 marks plus 3 marks for QWC]

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

Band	Marks	Descriptor
3	7-9	**AO3:** Evaluation of the healthcare scientists' decision to use mass spectrometry is **comprehensive**, **effective**, and **relevant**, showing **detailed understanding** and **logical and coherent** chains of reasoning throughout. Informed conclusions are fully supported with **rational, balanced,** and reasoned judgements, with most of the relevant arguments evident. **AO2:** Applied **all** relevant knowledge of how separation techniques can be used to purify the products in the sample given, showing a **detailed, functional understanding** of the scientific methodology involved. **AO1**: A **wide** range of relevant knowledge and understanding of separation techniques which are **accurate and detailed.** The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	4-6	**AO3:** Evaluation of the healthcare scientists' decision to use mass spectrometry 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 evident. **AO2**: Applied **some relevant relevant knowledge** of how separation techniques can be used to purify the products in the sample given, showing **some functional understanding** of the scientific methodology involved. **AO1:** Demonstrates a **sufficient** range of knowledge and understanding of separation techniques which are **mostly accurate and detailed.** The answer demonstrates reasonable breadth and/or depth of understanding, with **occasional inaccuracies** and/or **omissions**.
1	1-3	**AO3:** Evaluation of the healthcare scientists' decision to use mass spectrometry is in **some parts effective** and of **some relevance**, with some understanding and reasoning taking the form of **generic** statements with **some** development. **Brief** conclusions supported by reasoned judgements that consider only **basic arguments** and show **little** relevance to the question aims, are evident. **AO2:** Applies some relevant knowledge and understanding of how separation techniques can be used to purify the products in the sample given which shows a **lack of functional understanding** of the scientific methodology involved. **AO1**: Demonstrates a **limited** range of understanding of relevant knowledge and understanding of separation techniques which are **limited** in **accuracy and detail.** The answer is **basic** and shows **limited** breadth and/or depth of understanding, with **inaccuracies** and **omissions**.

	0	No creditworthy material

Indicative content

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

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

AO1: Demonstration of knowledge regarding separation techniques may include:

- to separate or analyse mixtures scientists could use the following separation techniques:
  - thin layer chromatography (TLC):
    - TLC can be used to separate non-volatile mixtures based on their affinity for a mobile (solvent phase)
    - TLC can be used to detect the number of components in a mixture
    - TLC can be used to identify the compounds and their purity
  - column chromatography:
    - column chromatography can be used to separate a single compound from a mixture in a vertical column
  - gas chromatography:
    - gas chromatography can be used to separate a single chemical compound that can be vaporised in a pack column
  - high performance liquid chromatography (HPLC):
    - HPLC can used to separate substances based on their affinity for a mobile phase under pressure
  - mass spectrometry (MS):
    - mass spectrometry can be used to separate substances due to their mass to charge ratio
    - mass spectrometry can also be used to detect molecular ions and ion fragments
    - mass spectrometry can be used to determine molecular weights
- similarities between HPLC and column chromatography are using a mobile phase which is the mixture dissolved into a solvent.
- chromatography often relies upon a mobile phase transported through a stationary phase which separates the components based on solvent affinity.
- HPLC uses high pressure to pass the solvent mixture through the stationary phase. whereas, column chromatography uses gravity.
- this means HPLC has better resolving power than that of column chromatography.

AO2: Application of knowledge of using mass spectrometry or other separation techniques based on the data given may include:

- mass spectrometry would separate the unknown products A to D based upon their molecular weight but would not tell the scientist what the products are
- 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 this sample
- gas chromatography would only be appropriate if products A to D can be vaporised, there is no data provided on this in the scenario
- thin layer chromatography may not be appropriate due to there being multiple different compounds present that would be difficult to separate

AO3: Evaluation of the healthcare scientists' decision to use mass spectrometry may include:

- Mass spectrometry may be a useful means of separation. However, given the composition of the mixture and the potential similarity of the unknown products A to D this may be difficult, this is because the masses associated with the unknown compounds maybe similar and thus separation will be difficult.
- Mass spectrometry is also a destructive method of separation as ionisation of the mixture would be required. This could lead to destruction of the unknown products A to D and potentially unwanted reactions
- Preliminary tests should be performed prior to making a decision, this could include thin layer chromatography (TLC) to separate the mixture based on varying polarity and isolate each unknown product. Mass spectrometry could then be attempted with each product individually.
- HPLC has a high resolving power thus the similar unknown compounds could isolated under pressure quickly before attempting mass spectrometry on each product individually.

Conclusion
Overall, mass spectrometry could be a suitable decision but may be better if combined with TLC, GC or HPLC to separate the unknown products A to D first. GC can only be used if it can be vaporised.

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: [12 marks] plus 3 marks for QWC**

19 **A new clinic is being set up to deal with sports injuries, and they are considering purchasing X-ray machines and MRI machines.**

One of the healthcare scientists states:

'More X-ray machines should be provided as most injuries will be to the musculoskeletal system, and X-ray is sufficient for the diagnosis of these injuries, MRI machines are too expensive and slow.'

Using your knowledge of the musculoskeletal system, X-ray and MRI scans, evaluate the validity of this statement.

Your response should include reasoned judgements and conclusions.

[12 marks, plus 3 marks for QWC]

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

Band	Mark	Descriptor
3	9-12	**AO3:** Evaluation of the board member'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 the musculoskeletal system, X-ray and MRI scans is applied **effectively** to the given context. **AO1** A **wide** range of relevant knowledge of the musculoskeletal system, X-ray and MRI scans is evident. A **wide** range of **appropriate** technical terms are used. The answer demonstrates **comprehensive** breadth and/or depth of understanding.

2	5-8	**AO3:** Evaluation of the board member'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 the musculoskeletal system, X-ray and MRI scans are applied **mostly** effectively, although there **may** be lack of clarity. **AO1:** Knowledge and understanding of the musculoskeletal system, X-ray 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 board member'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 the musculoskeletal system, X-ray and MRI scans is **applied** to the given context. **AO1:** Knowledge and understanding of the musculoskeletal system, X-ray 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

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

AO1: Demonstration of knowledge regarding the musculoskeletal system, X-ray and MRI scans may include:

- the musculoskeletal system is made up of the bones, and the muscles and tendons
- the joints of the musculoskeletal system contain ligaments, cartilage and associated membranes
- MRI scans involve the use of a powerful magnetic field
- MRI scans can clearly image soft tissue and bone
- X-ray is a form of ionising radiation
- ionising radiation can damage living tissues

- X-ray can clearly image bones

AO2: Application of knowledge regarding the musculoskeletal system, X-ray and MRI scans may include:

- if a sports injury is musculoskeletal, it could include damage to both bones and to soft tissues
- sports injuries could result in damage to tissues other than the musculoskeletal system
- an X-ray is likely to provide a sufficiently clear image to diagnose an injury to a bone
- an X-ray is not likely to provide a sufficiently clear image to diagnose an injury to the soft tissues of the musculoskeletal system
- an MRI scan is likely to provide a sufficiently clear image to diagnose an injury to a bone
- an MRI scan is likely to provide a sufficiently clear image to diagnose an injury to the soft tissues of the musculoskeletal system
- there are other ways of diagnosing sports injuries without using X-ray or MRI scans
- the strong magnetic field of an MRI scanner can affect any metallic implants if they are made of steel
- X-ray will not affect steel implants
- X-ray can be carried out more quickly than MRI scans which may be useful in a sports clinic

AO3: Evaluation of the statement may include:

- as X-ray machines are cheaper than MRI scanners it may be possible to have more X-ray machines in the clinic and therefore diagnose more injuries, providing they were bone related
- as MRI scanners are more expensive, the clinic may not be able to afford a scanner and will have to rely on X-ray machines and other methods, but this will only diagnose bone related injuries
- as X-ray machines are quicker than MRI scanners this may lead to faster diagnoses and therefore faster treatment and recovery, but only if the injuries are bone related
- as many injuries to the musculoskeletal system will involve damage to soft tissues, an X-ray machine is unlikely to be sufficient for diagnosis and an MRI scan will be required
- as X-ray machines emit a form of ionising radiation which can damage tissues, they cannot be used on the same person too often without risk, there is no risk from MRI scanners
- as MRI scanners can affect steel implants it could cause them to move which will damage the patient, therefore they cannot be used on a patient with steel implants if they are in the area which is being scanned
- as X-ray machines do not affect steel implants, they can safely be used on a patient with steel implants, in the area of the implants

Possible overall conclusions may include:

- as X-ray machines are likely to be sufficient for the diagnosis of many of the injuries, the statement made may be valid however there will be many injuries involving soft tissues which cannot be diagnosed with an X-ray machine and therefore both X-ray machines and MRI scanners will be required, therefore the statement is not valid
- as MRI scanners are expensive it is possible that the clinic will not be able to afford them, and the patient will need to go elsewhere for the scan but could then return to the clinic for treatment. However, this could be slow and may limit the business's ability to support the patient, therefore the statement is not valid

- ideally both X ray machines and MRI scanners are required therefore the statement is not valid

Accept any other suitable response.

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.
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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 number	AO1	AO2	AO3	Maths	QWC	Total
1(a)(i)	1					1
1(a)(ii)		2				2
1(b)		1				1
1(c)	2					2
1(d)		4		4		4
2(a)(i)	4					4
2(a)(ii)		2				2
2(b)	1					1
3(a)	1					1
3(b)		2		2		2
4			6			6
5(a)(i)	1					1
5(a)(ii)		2				2
5(b)		1				1
6			6			6
7	3	3	3		3	12
Total	**13**	**17**	**15**	**6**	**3**	**48**
Totals required	**11–13 marks**	**17–19 marks**	**14–16 marks**	**6**	**3**	**48**
Kil	**3**					

Section B

Question number	AO1	AO2	AO3	Maths	QWC	Total
8(a)	2					2
8(b)	1					1
9		2		2		2
10		4		4		4
11(a)		2				2
11(b)			3			3
12			3			3
13	3	3	3		3	12
Total	**6**	**11**	**9**	**6**	**3**	**29**
Totals required	**5–7 marks**	**10–12 marks**	**8–10 marks**	**6**	**3**	**29**
Kil	**3**					

Section C

Question number	AO1	AO2	AO3	Maths	QWC	Total
14	1					1
15	1					1
16(a)		2				2
16(b)		1				1
17			3			3
18	3	3	3		3	12
Total	**5**	**6**	**6**		**3**	**20**
Totals required	**3–6 marks**	**6–8 marks**	**4–9 marks**		**3**	**20**
Kil	**2**					

Section D

Question number	AO1	AO2	AO3	Maths	QWC	Total
19	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	**28**	**38**	**34**	**12**	**12**	**112**
Total Kil Whole paper	**8**					

Document information