T Level Technical Qualification in Healthcare Science

Core knowledge and understanding

Paper B

Elements 11-12

Mark scheme

v1.2: Specimen assessment materials
September 2022
603/7083/X

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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 level-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 Cells can be broadly classified as eukaryotic (eukaryotes) or prokaryotic (prokaryotes).

Give **one** difference between eukaryotic and prokaryotic cells.

[1 mark]

AO1 = 1 mark
AP Ref = B1.6.1, B1.6.2, B1.6.3, B1.6.4

Award **one** mark for any of the following valid differences, up to a maximum of 1 mark.

- Eukaryotic cells are found in complex multicellular organisms, prokaryotic cells are not**.**
- Eukaryotic cells have larger ribosomes than prokaryotic cells.
- Eukaryotic cells have membrane bound organelles prokaryotic cells do not**.**
- Eukaryotic cells of plants have a cell wall composed of cellulose, prokaryotic cells have a cell wall composed of, murein, peptidoglycan and glycoprotein.
- Eukaryotic cells have a true nucleus, prokaryotic cells do not.

Accept any other suitable response.

2 (a) State the number of different types of amino acid commonly found in proteins.

[1 mark]

AO1 = 1 mark
AP Ref = B1.7.3

Award **one** mark only:

- 20.

2 (b) Briefly describe the process by which dipeptides are formed.

[1 mark]

AO1 = 1 mark
AP Ref = B1.7.4

Award **one** mark for a valid process:

- dipeptides are formed by the condensation of two amino acids.

Accept any other suitable response.

3 (a) Radionucleotides emit radiation but behave as normal nucleotides. When cells are grown with radionucleotides, the new DNA synthesised is radioactively labelled.

A bacterium which divides every 20 minutes is added to a media containing radionucleotides. Samples of cells are removed at 0, 20, 40 and 60 minutes, and the radioactivity levels recorded.

As a control, bacteria are also cultured in a media containing radionucleotides for 24 hours. This means that all their DNA consists of radionucleotides. The experiment is repeated for them.

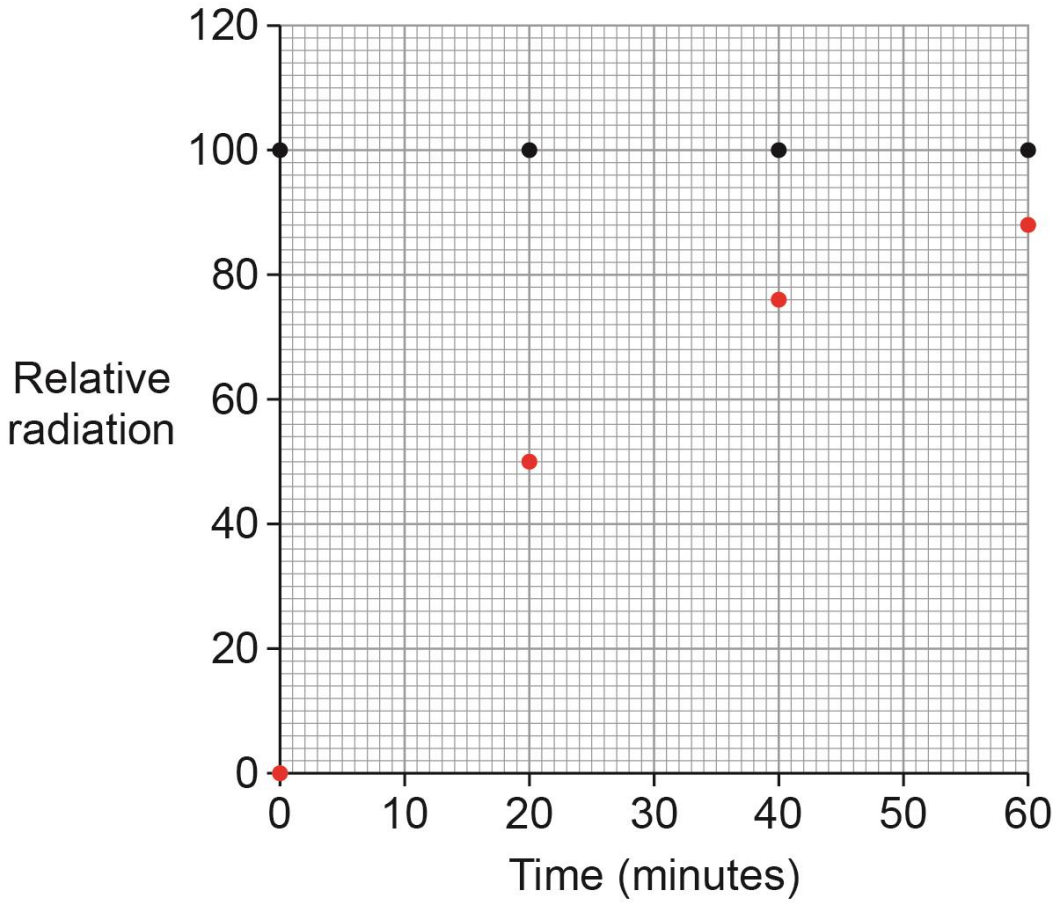
Using the graph below, plot how the detected radioactivity will change over time. No radioactivity is present at t=0, and the control is shown in black.

[3 marks]

AO2 = 3 marks
AP Ref = B1.16

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

- correct plot at 50% (1)
- correct plot at 75% (accept plot point at 76%) (1)
- correct plot at 87.5% (accept plot point at 87% or 88%). (1)



3 (b)	Individual cells are isolated, and the composition of their DNA is determined. At 20 minutes, a single cell from the culture is selected at random. What percentage of its DNA is expected to be radioactively labelled? **[1 mark]**

AO2 = 1 mark
AP Ref = B1.15 and B1.16

Award **one** mark for correctly stating:

- 50%.

3 (c)	A student concluded that however many divisions occur, the total bacterial DNA can never become 100% radioactively labelled. Evaluate the accuracy of the student's conclusion. Your response should demonstrate reasoned conclusions. **[2 marks]**

AO3 = 2 marks
AP Ref = B1.15 and B1.16

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

- DNA replication is semi-conservative; therefore, the original strand of non-radiolabelled DNA always remains intact - this supports the conclusion (1)
- as new radioactive DNA is synthesised, the ratio of radiolabelled to non-radiolabelled DNA will increase and approach 100% - this supports the conclusion (1)
- there will always be some cells that are only 50% radiolabelled - this supports the conclusion. (1)

Accept any other suitable response.

4 (a) State **two** ways in which light microscopy and staining can be used to identify the precise causative agent of a disease.

[2 marks]

AO1 = 2 marks
AP Ref = B1.21.1, B1.23.1, B1.23.1.1, B1.23.2, B1.23.2.1

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

- identifying morphological features of the bacteria (size, shape, colonies formed) (1)
- identifying Gram staining to further classify bacteria (as gram-positive or negative) (1)
- identifying Giemsa staining as a means of identifying malaria, spirochetes, etc. (1)

Accept any other suitable response.

4 (b) Give **one** reason why light microscopy and staining would be unlikely to work if an infection is caused by a virus.

[1 mark]

AO2 = 1 mark
AP Ref = B1.21.2.1, B1.20.4

Award **one** mark for any **one** of the following:

- light microscopy only has a limited resolution; therefore, the virus particles are below the maximum resolution of a light microscope (1)

Accept other appropriate responses.

5 (a) A 64 year old male has been experiencing increasing shortness of breath and tiredness over the last 6 months.

He has a persistent cough that is producing thick, green sputum.

He was previously active but has recently been struggling to walk without becoming breathless.

He has smoked 20 cigarettes a day since he was 16 and has a BMI of 36.

Name **one** disease likely to cause his shortness of breath.

[1 mark]

AO2 = 1 mark
AP Ref = B2.16
Award **one** mark for any **one** of the following:

- chronic obstructive pulmonary disease (COPD) (1)
- lung cancer (1)
- heart disease. (1)

Award a mark for any other suitable response, for example, an illness that is likely to present with a similar pattern of symptoms.

5(b)	Suggest **one** routine test that can be used to identify the cause of the symptoms. Describe the potential outcome of this test. **[2 marks]**

AO2 = 2 marks
AP Ref = B2.11, B2.12

Award **one** mark **maximum** for naming a suitable test to investigate the cardiovascular or respiratory systems and **one** mark **maximum** for correctly identifying the potential observations from this test:

- pulse oximetry (1) – reduced oxygen saturations (associated with respiratory illness) (1)
- peak flow (1) – low reading caused by chronic obstructive pulmonary disease (COPD)/asthma (1)
- electrocardiogram (ECG) (1) – increased heart rate (may reveal underlying electrical abnormalities in the heart) (1)
- blood pressure (1) – low blood pressure (may indicate cardiac deficiency) (1)
- sputum test (1) – may contain the causative organism, which can be identified. (1)
- Biopsy. (1)

Accept any other suitable response.

5 (c)	A consultant stated that 'if the patient stopped smoking this would have a significant positive effect on their symptoms.' Evaluate the accuracy of the consultant's statement. **[4 marks]**

AO2 = 2 marks
AO3 = 2 marks
AP Ref = B2.18

Award up to **one** (AO2) mark for each valid point regarding the effect on the patient's symptoms, up to a maximum of **two** marks for example:

- stopping smoking would reduce the risk of smoking related illness (1) AO2
- stopping smoking would reduce breathlessness in the patient (1) AO2
- stopping smoking would reduce the persistent cough. (1) AO2

Accept any other suitable response

Award **one** (AO3) mark for **each** valid evaluative point up to a **maximum** of **two** marks:

- as smoking is a major risk factor for chronic obstructive pulmonary disease (COPD), the likely diagnosis, stopping smoking would remove this risk factor (1) AO3
- as the benefits of smoking cessation can be significant even in elderly/already ill patients, stopping smoking could bring significant improvement (1) AO3
- Stopping smoking would have a greater impact on the underlying illness than other

interventions (weight loss, reducing alcohol intake) (1) AO3
- if the symptoms are being caused by lung cancer, stopping smoking may have very little effect on the symptoms. (1) AO3

Accept any other suitable response.

6 A 34 year old female is admitted to accident and emergency with a blood pressure of 84/52 mmHg following a motorcycle accident.

Suggest the most likely cause of the abnormal blood pressure measurements and an appropriate intervention to correct the blood pressure.

[2 marks]

AO2 = 2 marks
AP Ref = B2.17, B2.12

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

- the likely cause is haemorrhage/bleeding (1)
- intervention to locate and/or stop the bleeding/replace blood/volume loss. (1)

Accept any other suitable response.

7 Infection with HIV may progress to acquired immune deficiency syndrome (AIDS) where the patient's CD4+ T helper cells are destroyed.

HIV is a blood-borne virus (BBV) and is normally transmitted through the exchange of bodily fluid.

The CD4+ cells and viral load of HIV patients are regularly monitored.

One patient's results are shown below:

	6 months ago	Today
Viral load	Undetectable	100 000 copies/ml
CD4+ count	795 cells/mm^3	50 cells/mm^3

Describe **two** suitable procedures to care for the patient whilst in hospital.

Justify your choices taking into account risks to the patient and others.

[4 marks]

AO2 = 2 marks
AO3 = 2 marks
AP Ref = B1.26 B1.30 B2.18

Award **one** mark for suggesting appropriate procedures for delivering care, up to a **maximum** of **two** marks.

These procedures can involve minimising risk to patients using:

- reverse barrier nursing/isolation from other patients (1) AO2
- environmental hygiene (room cleaning/positive pressure) (1) AO2
- minimising visitors/personal items. (1) AO2

And can also consider the risk to staff and other patients, such as:

- use of appropriate PPE when performing exposure prone procedures (for example, taking blood) (1) AO2
- appropriate reporting of needlestick injuries/contamination. (1) AO2

Award **one** mark for identifying the following justifications for these measures, up to a **maximum** of **two** marks:

- due to his low T helper cell counts, the patient is unlikely to be able to effectively fight infection, so steps should be taken to reduce the chance of this occurring (1) AO3
- due to the high viral load in his blood, there is a risk of directly transmitting infection to the professional involved in his care (1) AO3
- due to high viral load in his blood, there is a risk of contamination of objects in the patient's room, leading to potential transmission of the virus, this would be reduced through appropriate environmental hygiene. (1) AO3

8 A scientist investigating the passage of drugs into cells through the cell surface membrane removed **four** identical squares of the small intestine of a rat and placed these in **four** separate beakers: A, B, C and D.

The scientist then added **two** different drugs and a respiratory inhibitor as shown in the table.

After 20 minutes, they measured the amount of the drug absorbed in each, in µg per minute.

	Beaker A	**Beaker B**	**Beaker C**	**Beaker D**
Type of drug added	Drug X	Drug X	Drug Y	Drug Y
Respiratory inhibitor added	No	Yes	No	Yes
Amount of drug absorbed µg per minute	21	21	47	5

The scientist made the following conclusions:

- drug X was transported passively by diffusion
- drug Y was mainly transported actively
- drug Y was also transported to a lesser extent passively by diffusion
- drug Y may be a significantly larger molecule than drug X.

Use the results from the table above to evaluate the accuracy of the scientist's conclusions.

[5 marks]

AO1 = 2 marks
AO3 = 3 marks
AP = B.1.11.0.2 and B.1.11.0.3

Award a **maximum** of **one mark** for **the following:**

- a respiratory poison would prevent respiration and therefore prevent the formation of ATP/release of energy (1) AO1, this is required for active transport. (1) AO1

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

- as the respiratory inhibitor has no effect on uptake of drug X, energy/ATP is not required meaning transport must be passive - this supports the scientist's first conclusion (1) AO3
- as the uptake of drug Y was reduced from 47 µg to 5 µg when the respiratory inhibitor was added, energy/ATP is required, and transport is active - this supports the scientist's second conclusion (1) AO3
- as there is a small amount of drug Y transported when the respiratory inhibitor is present this suggests drug Y can be transported passively (but this is a slow process) - this supports the scientist's third conclusion (1) AO3
- as the passive uptake of Y is much slower (5mg/m) than the passive uptake of X (21mg/m), this may be due to Y being a larger molecule than X - this (partially) supports the scientist's fourth conclusion. (1) AO3

9 The table below provides information regarding outbreaks of infectious diseases:

	Disease X	**Disease Y**
Pathogen airborne	Yes	Yes
Transmissibility – R_0*	2.5	2.4
Incubation period – days	4–12	2–7
Interval between symptom onset and maximum infectivity – days	0	5–7
Proportion with only mild symptoms or asymptomatic infection	High	Low
Proportion of patients requiring hospitalisation	Few (20%)	Most (>70%)
Proportion of patients requiring intensive care	1/16 000	40%
Proportion of deaths in people younger than 65 years out of all deaths	0.6–2.8%	Unknown
Total cases	14.7 million (confirmed)	8096 (confirmed)
Total deaths	610 000	774
Risk factors for severe illness	Age, pre-existing health conditions	Age, pre-existing health conditions

Evaluate how the features of disease X and disease Y have contributed to the severity of each epidemic.

Use the data in the table.

Your response should include:

- discussion of the differences between disease X and disease Y
- reasoned judgements of the consequences of failing to limit the spread of infection.

[6 marks]

AO1 = 2 marks
AO2 = 2 marks
AO3 = 2 marks
AP Ref = B2.18

AO1 Knowledge

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

- Masks and similar protective measures may reduce the spread of infection with airborne pathogens.
- Social restrictions may also reduce the spread but may have significant economic impacts.
- Failure to implement restrictions to reduce the spread of a virus can lead to high mortality rates.

AO2 Application

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

- Disease X is more infectious than disease Y, meaning the infection may spread between people more rapidly. There is a longer period between infection and symptom onset for disease X, facilitating transmission and making contact tracing more challenging.
- Patients with disease X are highly infectious as soon as they become symptomatic, reducing the opportunity for quarantine/isolation.
- Patients with disease Y were likely to require hospitalisation, allowing them to be tested and quarantined appropriately.
- Disease Y has a higher fatality rate, leading to more immediate and effective action to contain it.

AO3 Evaluation

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

- Increased spread of the virus is likely to increase mortality (or, conversely, less spread leads to less mortality).
- If the spread of an infective micro-organism is not controlled, the mortality could dramatically exceed that of previous pandemics.
- The relatively high risk of hospitalisation/requiring intensive therapy unit (ITU) with disease Y may place significant pressure on hospital capacity.
- It is the elderly and those with existing medical conditions that are most likely to be severely affected by disease X, thus the economic burden/total quality-adjusted life years (QALYs) lost may be less than in outbreaks affecting predominantly younger demographics.

Accept any other suitable response.

10 Sarah is a healthy 48 year old and is 14 weeks pregnant with non-identical twins. This is her first pregnancy. Prenatal screening tests show that her pregnancy is at 30% risk of at least **one** child having Down's syndrome.

Sarah and her partner are requesting further genetic testing to check for any health problems their children may face. Carrying out this testing may be invasive and pose a risk to the pregnancy.

Evaluate the associated risks and benefits to both parents and children.

[9 marks, plus 3 for QWC]

AO1 = 3 marks
AO2 = 3 marks
AO3 = 3 marks
AP Ref = B2.23.1

Band	Mark	Descriptor
3	7–9	Evaluation and conclusions drawn of the risks and benefits in terms of health and social outcomes are complex and show awareness of inter-relationships. Sustained chains of reasoning show detailed understanding of the effects of the parents and foetus, acknowledging ethical challenges. **Accurate judgements** of the information obtained through testing and the options available once it is performed are **rational** and **balanced**, and conclusions are evident and link to the brief. Factual information obtained through testing and the options available once it is performed and the broader context are used to support accurate and rational judgements. Conclusions are evident and link to the brief. Knowledge and understanding of the importance of the issues surrounding prenatal genetic testing is **clear** and **fully accurate** with **sustained** focus. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	4–6	Evaluation and conclusions drawn of the risks and benefits in terms of health and social outcomes are **in most parts effective** and **mostly relevant**, showing **mostly logical and coherent** chains of reasoning. **Mostly accurate judgements** and **mostly rational** and **balanced** conclusions are evident of the information obtained through testing and the options available once it is performed. Factual information obtained through testing and the options available once it is performed are used to support mostly accurate and rational judgements. Conclusions are evident. Knowledge and understanding of the issues surrounding prenatal genetic testing is **mostly clear** and **generally accurate**, although on occasion

Band	Mark	Descriptor
		may lose focus. The answer demonstrates **reasonable** breadth and/or depth of understanding, with **occasional** inaccuracies and/or omissions.
1	1–3	Evaluation and conclusions drawn of the risks and benefits in terms of health and social outcomes are simple and straightforward, with some understanding and reasoning taking the form of **generic statements** with some development. Judgements of information obtained through testing and the options available once it is performed are **basic** and **brief**, and conclusions or addressed needs will have **limited rationality**. Knowledge and understanding of the issues surrounding prenatal genetic testing 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

- Genetic testing would allow the confirmation of the presence or absence of Down's syndrome in the pregnancy.
- The parents would then be able to decide whether they want to proceed with the pregnancy or not (for example, termination).
- People may have strong views regarding termination.
- These tests are likely to be accurate and reliable.

AO2 Application

- Raising a child with Down's syndrome can be challenging and have negative consequences for the parents and unaffected twin.
- Raising a child with Down's syndrome can be a positive and rewarding experience.
- Advances in medicine mean the life expectancy of Down's syndrome individuals is increasing.
- Individuals with Down's syndrome are increasingly being integrated into society.
- There is a wide range of cognitive delays with Down's syndrome individuals, not all are severe.
- If Sarah is considering a termination, she needs to consider how likely she is to be able to have another child at her age.
- If the parents would not consider termination of the pregnancy, then there is little reason to do the test.
- If only one twin or both had Down's syndrome, this may dramatically affect the decision.
- A potential future risk of heart disease should not be considered when deciding.

AO3 Conclusion

- The decision to perform the genetic tests would need to carefully weigh the risks and benefits, namely the risk of losing a healthy pregnancy against gaining information that may help with a challenging decision.
- Parents need to weigh the positive and negative aspects of raising a Down's syndrome child to help them reach their decision.
- Due to Sarah's age, she may struggle to raise a child with learning disabilities later in life. It is important to consider the implications of the decisions on the future.
- Parents should ultimately make this decision themselves, whilst being provided with as much information as possible. There are medical grounds to offer the test, but the decision to take it or not must be theirs.

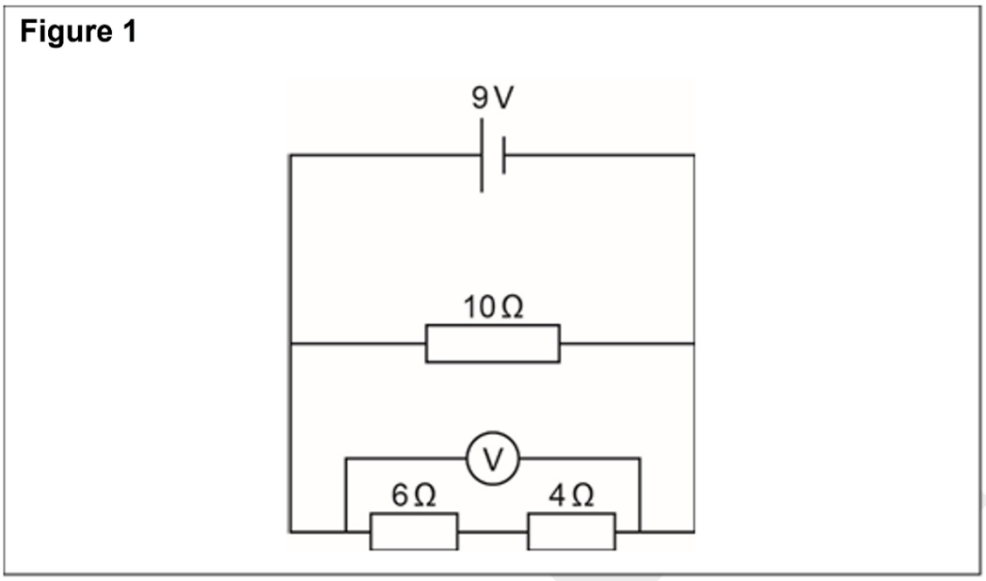
Quality of written communication (QWC) = 3 marks

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

Section B: Physics **Total for this section: [26 marks] plus 3 marks for QWC**

11 **Figure 1** shows an electronic circuit. The battery has negligible internal resistance.

Figure 1



Calculate the total resistance of the circuit.

[4 marks]

AO2 = 4 marks
AP Ref = B1.47

Award **one** mark for each correct process/calculation of the **two** circuits up to a maximum of **three** marks and **one** further mark for the correct total resistance with correct units.

Working shown below:

- TR = 1/10 + 1/(4+6) (1) = 1/5 (1) conversion to reciprocal = 5/1 (1) = 5 Ω or 5 Ohms (1).

Award final mark with correct units only.

12 (a)

The most common form of colour vision deficiency results in a difficulty in distinguishing between red, yellow and green. These colours appear much duller and reds are often confused with blacks. This is known as red green colour deficiency.

A student states:

'The effect of red green colour vision deficiency in SCUBA divers is reduced as the diver travels deeper into the water'.

The chart below shows how far different wavelengths of light can penetrate water.

Colour	**Red**	**Orange**	**Yellow**	**Green**	**Blue**	**Violet**
Wavelength nm	620-750	590-620	570-590	495-570	450-495	380-450
How deep the light penetrates in metres	10	20	35	45	100	80

Use the information above to evaluate the student's statement.

[3 marks]

AO3 = 3 marks
AP Ref = B1.54

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

- All wavelengths and therefore colours of light can penetrate to 10 metres depth. Therefore, the effects of red green colour vision deficiency/colour blindness would still be fully present. (1)
- Red light cannot penetrate below 10 metres, therefore any red materials/objects would appear as black, so the effect of red green colour vision deficiency is diminished because someone with normal vision would also be unable to distinguish red from black materials/objects. (1) AO3
- At a depth of 45 to 100 metres, only blue and violet light can penetrate, therefore the effects of red green colour blindness should not be present. (1)
- Below 100 metres no light can penetrate therefore there would be no vision at all, therefore the effects of red green colour blindness would be irrelevant. (1)

12 (b) An ultrasound probe uses sound waves at a frequency of 6 MHz.

The speed of sound in human tissue is approximately 1500 ms^{-1}.

Calculate the wavelength of the sound waves in human tissue in mm.

[2 marks]

AO2 = 2 marks
AP Ref = B1.54, B1.56 and B2.25

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

- application of equation for wave speed, v = f λ rearranged for λ (1)
- correct answer (including correction of units): λ = 1500/(6 x 106) = 2.5 x 10 - 4 m = 0.25 mm (1).

12 (c) A patient undergoing an ultrasound scan has a small cyst at an unknown depth in their tissue.

A sound wave is sent and the signal from the cyst is received 0.03ms later, this means that the time taken for the sound wave to reach the cyst itself is 0.015ms.

Calculate the depth of the cyst in cm.

[2 marks]

AO2 = 2 marks
AP Ref = B1.54, B1.56 and B2.25

Award **one** mark for correct use of the equation speed = distance/time rearranged for distance (depth):

- depth = 1500 × (0.015 × 10^{-3}) = 0.0225 m (1).

Award **one** mark for correct unit conversion and answer:

- = 2.25 cm (accept 2.3 cm) (1).

13 (a) Describe how an image is formed when carrying out an X-ray on the human body.

[3 marks]

AO1 = 3 marks
AP Ref = B2.25.1.4

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

- X-rays pass through the body (with some being attenuated (accept 'absorbed') (1)
- different materials/tissues attenuate (or, conversely, transmit) by different amounts (1)
- differences in attenuation cause a variation in X-ray intensity exiting the patient, which forms the image (1).

13 (b) A patient requires a scan of a suspected soft tissue lesion on their liver.

The patient has an artificial knee implant made of titanium.

The patient's consultant states:

Although magnetic resonance imaging (MRI) produces strong magnetic fields, it is medically more appropriate than using X-ray in this situation.

Evaluate the consultant's statement.

[3 marks]

AO2 = 1 mark
AO3 = 2 marks
AP Ref = B1.52.4 and B2.25.3

Award a maximum of **one** AO2 mark **maximum** for a valid point.

- The strong magnetic field may dislodge the metal knee plant. (1) AO2
- Titanium is not a permanently magnetic material, so should not be affected by the magnetic field. (1) AO2
- The lesion is in soft tissue; MRI gives superior soft tissue contrast than X-ray. (1) AO2

Award **one** AO3 mark for each valid judgement/reasoned conclusion, up to a **maximum** of **two** marks.

- As the magnetic field is unlikely to have any effect on the knee implant, and the MRI image will be superior image to the X ray, this supports the statement. (1) AO3
- As X rays are a form of (ionising) radiation, they can be damaging to the body and should be avoided if possible, this supports the statement. (1) AO3
- As the titanium implant is not affected by the magnetic field, and is outside the area the MRI is imaging, it will not interfere with the image being formed, this supports the statement. (1) AO3

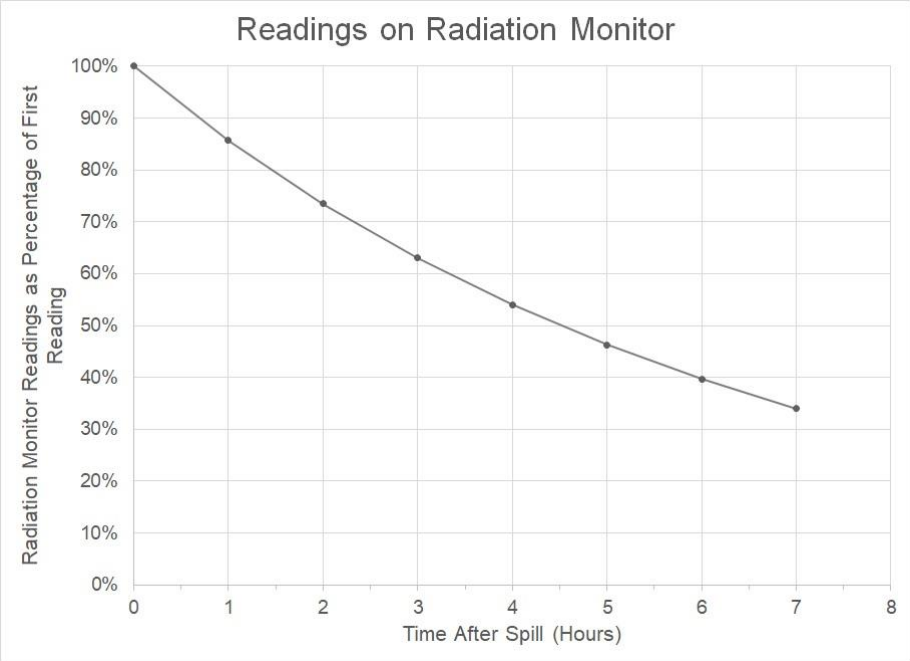
Accept any other suitable response

14 A workbench has become contaminated by a radioactive material which is emitting both gamma and alpha radiation. Monitor readings were taken throughout the day. The results are shown on the graph below:

The lab is closed at weekends, so the manager is considering **two** options to deal with the spill:

- have staff manually decontaminate the workbench now
- temporarily seal the lab and resume work on Monday.

Using your knowledge of radiation and half-life, evaluate the best option.



[9 marks, plus 3 for QWC]

AO1 = 3 marks
AO2 = 3 marks
AO3 = 3 marks
AP Ref = B1.57 and B1.58

Band	Mark	Descriptor
3	**7-9**	**AO3** Evaluation of the two options is comprehensive, effective, and relevant, showing detailed understanding and logical and coherent chains of reasoning throughout. Effectively informed reasoned judgements that are fully supported and rational and balanced conclusions are evident. **AO2** Application of knowledge regarding the properties of the two types of radiation and the risk they pose in this context is highly appropriate and shows a detailed functional understanding of how these can be applied in this specific situation. **AO1** A wide range of relevant knowledge and understanding of the types, properties and risks from the two types of radiation, is demonstrated. A wide

		range of appropriate technical terms are used. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	**4-6**	**AO3** Evaluation of the two options is **in most parts effective** and **mostly relevant**, showing **mostly logical and coherent** chains of reasoning. **Mostly accurate** reasoned judgements and **mostly rational** and **balanced** conclusions are evident. **AO2** Application of knowledge regarding of the properties of the two types of radiation and the risk they pose in this context, is **in most parts appropriate**, showing **some** functional understanding of how these can be applied in this specific situation. **AO1** Knowledge and understanding of the types, properties and risks from the two types of radiation, is demonstrated **and 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 two options is, in **some parts effective** and of **some relevance,** with some understanding and reasoning taking the form of **generic statements** with some development. Reasoned judgements are **basic** and **brief;** conclusions will have **limited** rationality and balance. **AO2** Application of knowledge regarding the properties of the two types of radiation and the risk they pose in this context is **limited** and may show a lack of functional understanding of how these can be applied in this specific situation. **AO1** Knowledge and understanding the types, properties and risks from the two 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 credit worthy material

Answer

(AO1) Half-life

- The half-life of a radioactive material is the time taken for the radioactive activity to decrease by 50% or half.
- The half-life can be used to calculate when the amount of radiation reaches safe levels.
- Gamma radiation has very high penetration power.
- Gamma radiation is electromagnetic radiation.
- Gamma radiation is low ionising but can cause indirect ionisation.
- Alpha radiation has low penetrating power.
- Alpha radiation has low range, 1–2 centimetres.
- Alpha radiation is high ionising.
- Alpha radiation is in the form of a particle.

(AO2) Discussion of options

- The half-life of the material is 4.5 hours.
- Within 48 hours the amount of radiation would have (effectively) reached zero.
- The gamma radiation being emitted can easily enter the body and cause damage.
- It would be very difficult for the staff to shield themselves while decontaminating, due to its high penetration.
- Alpha radiation would be easy for the staff to shield themselves from while decontamination, due to its low penetration.

(AO3) Reasoning and conclusions

- Option 2 would be better as a negligible amount of radioactivity will remain by Monday morning (due to radioactive decay with a short half-life). (1)
- Option 2 would be better as, Gamma radiation (is ionising radiation which) poses a risk to those decontaminating the workbench and exposure is not necessarily due to the short half-life. (1)
- Option 2 would be better as although alpha radiation has a low penetrating power, it is highly ionising and would cause severe damage if it got into the body, (eg through inhalation). (1)
- Option 2 would be better as decontamination could lead to alpha particles attaching to clothing etc, which could enter the body later (eg through ingestion). (1)

Accept any other suitable response.

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**

15 (a) State what the following **two** types of chromatography are used for:

- column chromatography
- gas chromatography.

[2 marks]

AO1 = 2 marks
AP Ref = B1.42.2.1 and B1.42.3.1

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

- column chromatography is used to separate a single chemical compound from a mixture (in a vertical column) (1)
- gas chromatography is used to separate and analyse compounds that can be vaporised (in a packed column) (1).

15 (b) A solution containing a mixture of **three** amino acids (X) is analysed by thin layer chromatography (TLC). The procedure includes the following two points:

- plastic gloves must be worn when drawing a pencil line 2cm from the bottom of the TLC plate
- when solvent is added to the developing tank, that the TLC plate is placed into, it must **not** be more than 1.5cm deep.

Explain why each of the highlighted aspects of the procedure are essential.

[2 marks]

AO2 = 2 marks
AP Ref = B1.42.1

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

- plastic gloves prevent contamination from the hands (1)
- solvent that is too deep will dissolve the mixture from the plate (1)
- a depth of no more than 1.5 cm would prevent the mixture from the plate dissolving. (1)

Accept any other suitable response.

15 (c) **Two** students follow the procedure carefully. One student's TLC shows **three** amino acids and the other student's TLC shows **two** amino acids.

Explain why there is a difference in the student's results.

[1 mark]

AO3 = 1 mark
AP Ref = B1.42.1

Award **one** mark for correct judgement:

- The TLC showing two amino acids may have been removed from the solvent earlier, therefore the **three** amino acids have not had time to completely separate (1)
- The TLC showing two amino acids may have been left in the solvent longer, resulting in two of the amino acids reaching the top and merging. (1)

16 (a) Which unit of the International System of Units is used to measure an amount of substance?

[1 mark]

AO1 = 1 mark
AP Ref = B1.62

Award **one** mark for stating the name of the unit:

- mole (mol).

16 (b) The equation for the reaction between ethanoic acid and sodium hydroxide is $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$.

$25.00cm^3$ of ethanoic acid was placed in a conical flask. This was neutralised by titrating $24.60cm^3$ of sodium hydroxide, with a concentration of $0.100moldm^{-3}$.

The equation to calculate concentration is 'conc = mol / vol'. Use the information above to calculate the concentration of the ethanoic acid, in mol dm^{-3}.

You do not need to show your working.

AO2 = 2 marks
AP Ref = B1.44

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

- Correct values are selected for the equation (0.1 x 24.6)/25 (1)
- concentration of CH_3COOH = 0.098 mol·dm-3.

Working out is not required.

17 A student is investigating the reaction rate between **two** equal amounts of gas A and B at different temperatures.

The student repeated the experiment **three** times.

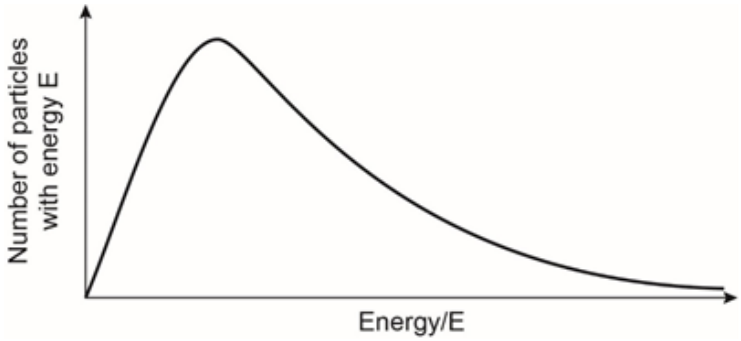
The table below shows the results and their calculated average reaction rates:

Temperature/K	Run 1 rate	Run 2 rate	Run 3 rate	Average rate
275	0	0	0	0
285	0	0	0	0
295	2	3	2	2
305	4	4	5	4
315	8	7	10	8
325	15	16	14	15
335	30	31	32	31
345	62	60	98	73
355	126	132	128	129
365	256	252	260	256
375	200	200	202	200

The student studied the results shown in the table and a copy of the distribution graph in **Figure 2** to form the following conclusions:

- the higher the temperature, the faster the reaction because the number of collisions increases (conclusion 1)
- for every 10 K rise in temperature, the reaction rate doubles due to the number of collisions doubling (conclusion 2).

Figure 2



Evaluate the accuracy of the student's conclusions using the information in the table and the graph in **Figure 2** to support your answer.

Your response should include reasoned judgements and conclusions.

[9 marks, plus 3 for QWC]

AO1 = 3 marks
AO2 = 3 marks
AO3 = 3 marks
AP Ref = B1.39.1, B1.39.2, B1.39.3, B1.40,1, B1.40.2

Band	Marks	Descriptor
3	7–9	Evaluation of the student's conclusion in relation to the temperature/rate data in the table and the distribution graph 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** conclusions are evident. Application of knowledge of how to interpret the results in order to evaluate the student's conclusions is **highly appropriate** and shows a **detailed** functional understanding. There is a **wide range** of relevant knowledge and understanding of the collision theory of reaction rates and how two species may react when they collide, which is **accurate** and **detailed**. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	4–6	Evaluation of the student's conclusion in relation to the temperature/rate data in the table and the distribution graph is **in most parts effective** and **mostly relevant**, showing **mostly logical and coherent** chains of reasoning. There are **mostly accurate** judgements, and **mostly rational** and **balanced** conclusions are evident. Application of knowledge of how to interpret the results in order to evaluate the student's conclusions is **in most parts appropriate**, showing **some** functional understanding Knowledge and understanding of the collision theory of reaction rates and how two species may react when they collide 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	Evaluation of the student's conclusion in relation to the temperature/rate data in the table and the distribution graph 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. Application of knowledge of how to interpret the results in order to evaluate the student's conclusions is **limited** and may show a lack of functional understanding. Knowledge and understanding of the collision theory of reaction rates and how two species may react when they collide 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 and AO2 will be implicit through the level of evaluation and reasoned judgements that the student provides.

AO1 Collision theory.

- Molecules must collide in order for reaction to take place.
- Molecules must collide with enough energy to break and reform bonds.
- Activation energy is the minimum amount of energy required for a reaction to occur.
- Molecules must be in the correct spatial orientation to react.
- The collision theory explains the relationship between temperature and rate of reaction.

AO2 Application of knowledge.

- There was no reaction below 295 K.
- The reaction rate increased with increasing temperature between the temperatures of 295 K and 365 K.
- The rate of reaction at the highest temperature investigated, 375 K, led to a decrease in the reaction rate (going against the trend observed at temperatures between 295 K and 365 K).
- At 345 K, run 3 yielded a result that is an outlier (rate of 98).
- The reaction rate approximately doubled with every 10 K rise in temperature between the temperatures of 295 K and 335 K.
- The reaction rate approximately doubled with every 10 K rise in temperature between the temperatures of 355 K and 365 K.
- The average rate calculated for 345 K is calculated using the outlier result and yields an average result that is higher than the expected result, using the trend observed at lower temperatures.
- If the outlier result for 345 K is not used to calculate the average rate, then the average rate for 345 K is 61, which fits the trend observed both above and below that temperature.

AO3 Reasoned judgements.

- Only **one** type of reaction was investigated so the conclusion may not be applicable to other reactions.
- The doubling of rate for every 10 K rise in temperature needs to be investigated at temperatures above 375 K to assess if the 375 K result is an outlier.
- There is no investigation of the effects of changing pressure on the rate.
- Due to the limitations of this investigation, the conclusions drawn may not be valid.
- The explanation for conclusion 1 would be supported by the explanation that at a higher temperature, the average energy for the molecules will increase so their velocity will increase, and the frequency of collisions must increase.
- However, this will not be a linear relationship, but rate doubles because a higher proportion of the collisions are successful.
- No statistical analysis has been carried out to see if the number of repeats is sufficient to be certain of the validity of (conclusions about the) reaction rates.

Accept other appropriate responses.

Quality of written communication (QWC) = 3 marks

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

Section D: Biology, Chemistry and Physics **Total for this section: [12 marks] plus 3 marks for QWC**

18 Discuss the usefulness of an electrocardiogram (ECG) in assessing cardiac activity.

Your response should demonstrate:

- knowledge and understanding of cardiac anatomy and physiology
- how the ECG deciphers cardiac activity
- a reasoned analysis of the types of conditions that can be diagnosed and the limitations of an ECG.

[12 marks, plus 3 marks for QWC]

AO1 = 4 marks
AO2 = 4 marks
AO3 = 4 marks
AP Ref = B2.11.1.1, B1.2.2.2 and B2.25.1.1

Band	Mark	Descriptor
3	9–12	Discussion of the importance of the ECG is **comprehensive**, **effective** and **relevant**, showing **detailed** understanding and **logical** and coherent chains of reasoning throughout. **Effectively** informed analyses related to how the ECG can be altered through biochemical changes and therefore be used to diagnose cardiac conditions are fully supported. Potential limitations are analysed and rational and balanced conclusions are evident. Application of knowledge is **fully** appropriate and shows a **detailed** functional understanding of the cellular level of the mechanisms of the ECG. There is a **wide range** of relevant knowledge and understanding of the anatomy, physiology and biochemistry of the electrocardiogram, which is **accurate** and **detailed**. The answer demonstrates **comprehensive** breadth and/or depth of understanding.
2	5–8	Discussion of the importance of the ECG is limited and is **in most parts effective** and **mostly relevant**, showing **mostly logical and coherent** chains of reasoning. **Mostly accurate** analyses related to biochemical changes giving rise to the diagnosis of cardiac conditions are evident. The most significant potential limitations are analysed and **mostly rational** and **balanced** conclusions are evident. Application of knowledge of the cellular level that can alter ECG mechanics is **limited** and may show a lack of functional understanding of the diagnostic tools.

Band	Mark	Descriptor
		Knowledge and understanding of the anatomy, physiology and biochemistry of the electrocardiogram 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	1–4	Discussion of the importance of the ECG is **in some parts effective** and of **some relevance**, with some understanding and reasoning taking the form of **generic statements** with some development. Analyses of biochemical changes and the link to the diagnosis of cardiac conditions are **basic** and **brief**. Potential weaknesses are **not** recognised, and conclusions will have **limited** rationality and balance. Application of knowledge of the cellular changes is **limited** and may show a lack of functional understanding. Knowledge and understanding of the aspects of the anatomy, physiology or biochemistry **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 Cardiac anatomy and physiology.

- P wave shows activity in the left and right atria.
- P-R interval indicates the time taken between sinoatrial node (SAN) and ventricles contracting.
- QRS complex indicates ventricular contraction.
- T wave shows ventricular rest.

AO2 ECG deciphering cellular activity.

- Conduction pathway identified as SAN, atria, atrioventricular node (AVN), bundle of His, L&R branches, Purkinje fibres, ventricles.
- P wave = atrial systole, QRS complex = ventricular systole/atrial diastole, T wave = ventricular diastole.
- L&R chambers effectively contract at same time.
- Cardiac conduction is organised, and systematic/tissue acts as a syncytium.
- Depolarisation on membrane causes influx of calcium for contraction and stimulates connecting myocardial cells.
- Depolarisation due to rapid loss of intracellular sodium and slower influx of potassium.
- Rest is reversal orchestrated by NA+/K+ ATPase pump.
- SAN starts a regular action potential.
- SAN fires/initiates at rate of about 60–70 bpm.

- This causes depolarisation of atria.
- Pause at AVN (has own pace of around 30–40 bpm, not seen).

AO3 Analysis.

ECG very important because:

- of the range of diagnosable conditions:
  - the ECG can be used to show the heart rate. It will show if there is a slowing of the heart (bradycardia) or a speeding up of the heart (tachycardia)
  - additional electrical activity can indicate ectopic activity
  - altered wave morphology can be considered as to cardiac cell anomalies; this may include bundle branch block, supra ventricular tachycardia
  - changes to the shape of the waves can show an anomaly to the relevant tissues
  - changes to the T wave can indicate damaged tissue
  - missing P waves can show that the sinoatrial node is not working
  - pulseless electrical activity would not be detectable on the ECG.

Chaotic electrical activity can show heart fibrillation. If this is during the P wave, then it indicates atrial fibrillation and if whole ECG is chaotic with no pattern, then it can indicate ventricular fibrillation.

- The practicality of their use:
  - safe and painless procedure which is usually quick
  - requires only very small voltages across the body
  - modern machines highly portable with screens and printers
  - even smaller devices are being developed
  - include automated interpretation of algorithms – increased consistency/reliability
- But ECG does have limitations:
  - cannot be used as method of prevention in people with no symptoms/at low risk
  - longer tests needed for those with intermittent symptoms
  - can give false positives leading to over medication/unnecessary surgery
  - some people develop a rash from the electrode patches/feel some discomfort when the patches are removed
  - additional tests might be needed to confirm any diagnosis.

Accept other appropriate responses.

Quality of written communication (QWC) = 3 marks

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

Section A

Question Number	AO1	AO2	AO3	Maths	QWC	Total
1	1					1
2(a)	1					1
2(b)	1					1
3(a)		3		(3)		3
3(b)		1		(1)		1
3(c)			2			2
4(a)	2					2
4(b)		1				1
5(a)		1				1
5(b)		2				2
5(c)		2	2			4
6		2				2
7		2	2			4
8	2		3			5
9	2	2	2			6
10	3	3	3		3	12
Total	**12**	**19**	**14**	**(4)**	**3**	**48**
Totals required	**11–13 marks**	**17–19 marks**	**14–16 marks**		**3**	**48**
Kil	**5**					

Section B

Question Number	AO1	AO2	AO3	Maths	QWC	Total
11		4		(4)		4
12(a)			3	(3)		3
12(b)		2		(2)		2
12(c)		2		(2)		2
13(a)	3					3
13(b)		1	2			3
14	3	3	3		3	12
Total	**6**	**12**	**8**	**(11)**	**3**	**29**
Totals required	**5–7 marks**	**10–12 marks**	**8–10 marks**		**3**	**29**
Kil	**3**					

Section C

Question Number	AO1	AO2	AO3	Maths	QWC	Total
15(a)	2					2
15(b)		2				2
15(c)			1			1
16(a)	1					1
16(b)		2		(2)		2
17	3	3	3		3	12
Total	**6**	**7**	**4**	**(2)**	**3**	**20**
Totals required	**3–6 marks**	**6–8 marks**	**4–9 marks**		**3**	**20**
Kil	**3**					

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	**28**	**42**	**30**		**12**	
Total Kil	**11**					
Paper total marks						

Document information

Owner: Head of Assessment Design

Change History Record

Version	Description of change	Approval	Date of Issue
v1.0	Published.		2020
v1.1	NCFE rebrand.		September 2021
v1.2	Amends to Q16b p26. ODSR_HS_070		September 2022