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Write your name here  
Surname  
Forename  
Learner Registration Number  
Centre Number  
Level  

Applied Science  

Unit 1: Principles and Applications of Science I  
Certificate/Extended Certificate/Foundation Diploma/Diploma/Extended Diploma  

Sample assessment material for first teaching June 2016  

Time: 2 hours  

You must have:  
Calculator, ruler  

Instructions  
○ Use black ink or ball-point pen.  
○ Fill in the boxes at the top of this page with your name, centre number and learner registration number.  
○ Answer all questions.  
○ Answer the questions in the spaces provided – there may be more space than you need.  
○ You must attempt all three sections but you may complete them in any order.  

Information  
○ The total mark for this paper is 90.  
○ The paper is comprised of three sections worth 30 marks each.  
○ Section A: Structures and Functions of Cells and Tissues (Biology). Starts on page 2.  
○ Section C: Waves in Communication (Physics). Starts on page 27.  
○ The marks for each question are shown in a box – use this as a guide as to how much time to spend on each question.  
○ The periodic table of elements and formulae sheet can be found at the back of this paper.  
○ You must attempt all three sections but you may complete them in any order.  

Advice  
○ Read each question carefully before you start to answer it.  
○ Try to answer every question.  
○ Check your answers if you have time at the end.
Answer ALL questions. Write your answers in the spaces provided. Some questions must be answered with a cross in a box. If you change your mind about an answer, put a line through the box and then mark your new answer with a cross.

SECTION A: STRUCTURES AND FUNCTIONS OF CELLS AND TISSUES

1. Ciliated cells are found in the human lung.
   (a) What is the name of the lung tissue that contains ciliated cells?
   
   A columnar endothelium  
   B columnar epithelium  
   C squamous endothelium  
   D squamous epithelium
   
   (b) Explain how reducing the movement of these cilia can result in a smoker having to cough.
   
   Chemicals in cigarette smoke reduce the movement of the cilia on ciliated cells in the human lung.

Total for Question 1 = 3 marks
Answer ALL questions. Write your answers in the spaces provided.
Some questions must be answered with a cross in a box ☑. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☑.

SECTION A: STRUCTURES AND FUNCTIONS OF CELLS AND TISSUES

1. Ciliated cells are found in the human lung.

(a) What is the name of the lung tissue that contains ciliated cells?
   - [ ] A columnar endothelium
   - [ ] B columnar epithelium
   - [ ] C squamous endothelium
   - [ ] D squamous epithelium

1 mark

Chemicals in cigarette smoke reduce the movement of the cilia on ciliated cells in the human lung.

(b) Explain how reducing the movement of these cilia can result in a smoker having to cough.

2 marks

Total for Question 1 = 3 marks
2. Figure 1.1 shows the ultrastructure of an animal cell.

(Source: http://m.everythingmaths.co.za/science/lifesciences/grade-10/02-the-basic-units-of-life/images/5aaa292660adc2b15e6153c598f3ff07.jpg)

**Figure 1.1**

(a) (i) Which part of this cell is the Golgi apparatus?

- A
- B
- C
- D

(ii) State two functions of the Golgi apparatus.

1. ....................................................................................................................................................................................................................................................
   ....................................................................................................................................................................................................................................................
2. ....................................................................................................................................................................................................................................................
   ....................................................................................................................................................................................................................................................

(iii) Name an organelle found in a plant cell that is not present in this animal cell.

..........................................................................................................................................................................................................................................................................
   ..........................................................................................................................................................................................................................................................................

(iv) Calculate the magnification of the mitochondrion in the image.

Show your working.

Magnification = ..............................................................
(iii) Name an organelle found in a plant cell that is not present in this animal cell.

..........................................................................................................................................................................................................................

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The actual length of the mitochondrion in the animal cell is 10.0 μm.

(iv) Calculate the magnification of the mitochondrion in the image.

Show your working.

Magnification = ..............................................................
Mitochondria contain DNA. Mutations in the DNA in mitochondria can cause mitochondrial disease. These mutations can be inherited.

In 2015 the UK became the first country in the world to allow ‘three-parent’ babies. Producing a ‘three-parent’ baby removes the risk of the baby inheriting mutated DNA.

Figure 1.2 shows some of the steps involved in producing a ‘three-parent’ baby.

Figure 1.2
DNA is found in the mitochondria and in the nucleus of a cell.

(b) Complete the table to show the source of the DNA that contributes to a ‘three-parent’ baby.

<table>
<thead>
<tr>
<th>Parent</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td></td>
</tr>
<tr>
<td>Donor</td>
<td></td>
</tr>
<tr>
<td>Father</td>
<td></td>
</tr>
</tbody>
</table>

Total for Question 2 = 9 marks
(a) State one other lifestyle factor that increases the risk of atherosclerosis.

Heart disease caused by atherosclerosis is a major problem in the UK. Smoking cigarettes and drinking alcohol are lifestyle factors that increase the risk of atherosclerosis.
3 Heart disease caused by atherosclerosis is a major problem in the UK. Smoking cigarettes and drinking alcohol are lifestyle factors that increase the risk of atherosclerosis.

(a) State one other lifestyle factor that increases the risk of atherosclerosis.
Many people in the UK need a heart transplant to replace their diseased heart.

A study of the hearts used in transplant operations from donors of different ages was carried out. The percentage of the donor hearts that showed signs of atherosclerosis was measured.

Figure 1.3 shows the results.

![Bar chart showing percentage of hearts showing signs of atherosclerosis by age range.](chart.png)

Figure 1.3

The number of hearts donated by people between 20 and 29 years of age was 40.

(b) (i) How many hearts showed signs of atherosclerosis for the age range 20–29 years.

- **A** 14
- **B** 26
- **C** 40
- **D** 65
Many people in the UK need a heart transplant to replace their diseased heart. A study of the hearts used in transplant operations from donors of different ages was carried out. The percentage of the donor hearts that showed signs of atherosclerosis was measured. Figure 1.3 shows the results.

Table: Hearts showing signs of atherosclerosis (%)

<table>
<thead>
<tr>
<th>Age range (years)</th>
<th>13–19</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>&gt;50</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>60</td>
<td></td>
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<tr>
<td>40</td>
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<td>20</td>
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</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1.3

The number of hearts donated by people between 20 and 29 years of age was 40.

(ii) Suggest an explanation why young hearts are the best ones to use in transplants.

3 marks

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Total for Question 3 = 5 marks
Nerve impulses are important in the control of many activities in the human body. Figure 1.4 shows changes in the transmembrane potential during the transmission of a nerve impulse along the axon of a motor neurone.

Figure 1.4

(a) State the time period when depolarisation is taking place.

1 mark
Table 1.1 shows the speed of a nerve impulse in different types of axon of the same diameter.

<table>
<thead>
<tr>
<th>Speed of nerve impulse/ms⁻¹</th>
<th>Myelinated axon</th>
<th>Unmyelinated axon</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.1

(b) Explain the difference in the speed of the nerve impulse along these axons.

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3 marks
Nerve impulses are transmitted across synapses by neurotransmitters. The diagram shows what happens to a neurotransmitter called acetylcholine in the synaptic cleft.

\[
\text{cholinesterase enzyme} \quad \text{acetylcholine} \quad \rightarrow \quad \text{acetate + choline}
\]

Organophosphates are chemicals that prevent the cholinesterase enzyme working. When they are used as crop pesticides they can kill the small animals that feed on the crops.

(c) Explain how these pesticides kill small animals.

3 marks

Total for Question 4 = 7 marks
A young athlete is very good at long-distance running but is not good at sprinting.

Discuss how this difference relates to the types of muscle fibre in their legs.

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Total for Question 5 = 6 marks

END OF SECTION

TOTAL FOR SECTION A = 30 MARKS
Nitrogen reacts with oxygen in car exhausts to produce nitrogen(IV) oxide. Nitrogen(IV) oxide is a gas that can cause air pollution. Some of the properties of nitrogen(IV) oxide are dependent on the electronegativity of each of the elements it contains.

(a) (i) State the meaning of the term electronegativity.
Nitrogen reacts with oxygen in car exhausts to produce nitrogen(IV) oxide. Nitrogen(IV) oxide is a gas that can cause air pollution.

Some of the properties of nitrogen(IV) oxide are dependent on the electronegativity of each of the elements it contains.

(a) (i) State the meaning of the term electronegativity.

1 mark
Figure 2.1 shows the variation of electronegativity with atomic number for some of the first 40 elements.

(ii) Describe the trends in electronegativity in the periods and groups of the periodic table.

2 marks

(iii) State the three factors that affect the electronegativity of an element.

1. ....................................................................................................................................................................................................................................................
2. ....................................................................................................................................................................................................................................................
3. ....................................................................................................................................................................................................................................................
(iii) State the **three** factors that affect the electronegativity of an element.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Nitrogen(IV) oxide is a gas which dissolves in water in the atmosphere to form acid rain.

Electronegativity of nitrogen 3.006
Electronegativity of oxygen 3.610

(b) Explain the **two** types of intermolecular force that exist in nitrogen(IV) oxide.

Total for Question 6 = 10 marks
Understanding the electronic structure of chemical elements allows scientists to predict how they will react.

(a) Which of the following elements has this electronic structure?

\[ 1s^2 \ 2s^2 \ 2p^2 \]

- A  Boron
- B  Carbon
- C  Oxygen
- D  Sulfur

1 mark

Silicon has four electrons in the third energy level.

(b) (i) Explain the arrangement of the electrons in the third energy level of silicon.

3 marks
(ii) Explain why the first ionisation energy of silicon (789 kJ mol\(^{-1}\)) is greater than that of germanium (762 kJ mol\(^{-1}\)).
The production of the ionic compound calcium chloride is an important industrial process.

Calcium chloride has a large range of uses, for example in the pharmaceutical industry and in the food industry.

(a) State the name of the force between the calcium and chloride ions.

(b) Draw dot-and-cross diagrams to show the arrangement of the outer electrons in the calcium ion and the two chloride ions in calcium chloride, CaCl₂.

Show outer electrons only.
The reaction between calcium carbonate and hydrochloric acid can produce extremely pure calcium chloride, which is suitable for use in the food industry.

\[
\text{CaCO}_3(s) + 2\text{HCl}_{(aq)} \rightarrow \text{CaCl}_2_{(aq)} + \text{CO}_2(g) + \text{H}_2\text{O}_{(l)}
\]

(c) Calculate the maximum mass of calcium chloride, \(\text{CaCl}_2\), that can be produced when 500 kg of calcium carbonate, \(\text{CaCO}_3\), reacts with excess dilute hydrochloric acid.

Show your working.

Maximum mass = ............................................................. kg

Total for Question 8 = 6 marks
9. Aluminium corrodes quickly in air to form a thin protective aluminium oxide layer that prevents further oxidation. This protective layer makes it suitable for use in drink cans.

(a) Write the balanced equation for the reaction of aluminium in air to form aluminium oxide.

Most metals have high melting and boiling points.

Table 2.1 shows the melting and boiling points of three metals: sodium, magnesium and potassium.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Group</th>
<th>Melting points/°C</th>
<th>Boiling points/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>1</td>
<td>97.72</td>
<td>883</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2</td>
<td>650</td>
<td>1090</td>
</tr>
<tr>
<td>Potassium</td>
<td>1</td>
<td>63.38</td>
<td>759</td>
</tr>
</tbody>
</table>

Table 2.1
(b) Discuss the different melting and boiling points of the three metals and the trends they show.

Total for Question 9 = 8 marks
Discuss the different melting and boiling points of the three metals and the trends they show.

Total for Question 9 = 8 marks
10. Figure 3.1 shows a guitar.

The strings on a guitar are different thicknesses.

Figure 3.1

When a string on a guitar is plucked a stationary wave is set up and a sound is produced.

Figure 3.2 shows how a stationary wave on a stretched string might be studied.

Figure 3.2

The diagram shows the first mode of vibration of the string.

(a) On the diagram, label a node and an antinode.

2 marks

(b) State the relationship between the distance PQ and the wavelength of the wave.

1 mark

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(c) Draw the second mode of vibration of the string in the space below.

![Diagram of a string with labeled nodes P and Q]

Stationary waves are seen on the string only when the vibration generator is set to certain frequencies.

(d) Explain why stationary waves are seen only at certain frequencies.

Total for Question 10 = 7 marks
Oceanographers can understand the effects of coastal erosion by studying water waves in tanks. They collect information about the behaviour of a wave.

The graphs show two sets of information about the same water wave.

**Figure 3.3**

**Figure 3.4**

Use the graphs to:

(a) Give the amplitude of the wave.

Amplitude = .............................................................. cm

(b) Give the wavelength of the wave.

Wavelength = .............................................................. cm

(c) Calculate the frequency of the wave.

Show your working.

Frequency = .............................................................. Hz

Total for Question 11 = 5 marks
Use the graphs to:

(a) Give the amplitude of the wave.

\[ \text{Amplitude} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_cm \]

(b) Give the wavelength of the wave.

\[ \text{Wavelength} = \_\_\_\_\_\_\_\_\_\_\_\_\_cm \]

(c) Calculate the frequency of the wave.

\[ \text{Frequency} = \_\_\_\_\_\_\_\_\_\_\_\_\_Hz \]
Fibre optic cables are used in some broadband networks.

(a) Give one use of fibre optics in medicine.

1 mark

(b) Explain why there is total internal reflection in an optical fibre.

3 marks

The use of fibre optic cables relies on total internal reflection.

(c) Calculate the refractive index for this material.

Show your working.

Refractive index = ..............................................................

Total for Question 12 = 7 marks
A fibre optic cable is made from a material that has a critical angle of 43.8 °.

(c) Calculate the refractive index for this material.

Show your working.

Refractive index = ..............................................................

Total for Question 12 = 7 marks
Figure 3.5 shows a point source of radio waves and two detectors at houses X and Y.

Figure 3.5

(a) Determine how the intensity at Y, \( I_y \), compares with the intensity at X, \( I_x \).

(b) Compare the use of mobile phones, Bluetooth® and Wi-Fi in communications. Your answer should include reference to their uses, frequencies and range.
(b) Compare the use of mobile phones, Bluetooth® and Wi-Fi in communications.

Your answer should include reference to their uses, frequencies and range.

6 marks
Figure 3.6 shows the solar radiation spectrum at the top of the atmosphere and at sea level.

(c) Describe what the regions of the graph show about the effect of the atmosphere on the amount of radiation that reaches the Earth.

4 marks
Figure 3.6 shows the solar radiation spectrum at the top of the atmosphere and at sea level.

(c) Describe what the regions of the graph show about the effect of the atmosphere on the amount of radiation that reaches the Earth.

Figure 3.6

- The regions of the graph illustrate the variation in solar radiation at different altitudes, with the atmosphere significantly absorbing certain wavelengths.
- The curve indicates that the atmosphere filters out higher-energy radiation, allowing only a specific range to reach the Earth's surface.
- The dip at certain wavelengths suggests the presence of atmospheric absorption bands, possibly due to water vapor or carbon dioxide.

Total for Question 13 = 11 marks
Wave speed
\[ v = f\lambda \]

Speed of a transverse wave on a string
\[ v = \sqrt{\frac{T}{\mu}} \]

Refractive index
\[ n = \frac{c}{v} = \frac{\sin i}{\sin r} \]

Critical angle
\[ \sin C = \frac{1}{n} \]

Inverse square law in relation to the intensity of a wave
\[ I = \frac{k}{r^2} \]
Unit 1: Principles and Applications of Science I – sample mark scheme

General marking guidance

- All learners must receive the same treatment. Examiners must mark the first learner in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Learners must be rewarded for what they have shown they can do, rather than be penalised for omissions.
- Examiners should mark according to the mark scheme, not according to their perception of where the grade boundaries may lie.
- All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks, if the learner’s response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a learner’s response, the team leader must be consulted.
- Crossed-out work should be marked, UNLESS the learner has replaced it with an alternative response.
- You will not see ‘or words to that effect’ (OWTTE). Alternative correct wording should be credited in every answer, unless the mark scheme has specified specific wording that must be present.
- Round brackets () indicate words that are not essential, e.g. ‘(hence) distance is increased’.
- Error carried forward (ECF), means that a wrong answer given in an earlier part of a question is used correctly in a later part of a question.
- / indicates that the responses are alternatives and either answer should receive full credit.
Levels-based mark schemes (LBMS) have been designed to assess learners’ work holistically. They consist of two parts: indicative content and levels-based descriptors. Indicative content reflects specific content-related points that a learner might make. Levels-based descriptors articulate the skills that a learner is likely to demonstrate, in relation to the assessment outcomes being targeted by the question. Different rows in the levels, represent the progression of these skills.

When using a levels-based mark scheme, the ‘best fit’ approach should be used.

- Examiners should first make a holistic judgement on which band most closely matches the learner’s response, and place it within that band. Learners will be placed in the band that best describes their answer.
- The mark awarded within the band will be decided based on the quality of the answer, in response to the assessment focus/objective and will be modified according to how securely all bullet points are displayed at that band.
- Marks will be awarded towards the top or bottom of that band, depending on how they have evidenced each of the descriptor bullet points.
### Section A – Structures and functions of cells and tissues

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Additional guidance</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>B (columnar epithelium)</td>
<td></td>
<td>(1)</td>
</tr>
</tbody>
</table>

1(b)  
An explanation that makes reference to the following points:  
- cilia no longer moves mucus (1)  
- therefore coughing needed to unblock airways (1) (2)

2(a)(i)  
- A (1)

2(a)(ii)  
Any two from the following points:  
- modifying/sorting/packaging proteins (1)  
- lipid transport in cells (1)  
- formation of lysosomes (1) (2)

2(a)(iii)  
Any one from the following points:  
- cell wall (1)  
- chloroplast (1)  
- tonoplast (1)  
- amyloplast (1) (1)
<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
</tr>
</thead>
</table>
| 2(a)(iv)        | • substitution (1) 12 000 ÷ 10  
• answer (1) × 1200 |
| Additional guidance | Allow answer based on ± 1 mm. |
| Mark | (2) |

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2(b)</td>
<td>Parent</td>
</tr>
<tr>
<td></td>
<td>Mother</td>
</tr>
<tr>
<td></td>
<td>Donor</td>
</tr>
<tr>
<td></td>
<td>Father</td>
</tr>
<tr>
<td>Mark</td>
<td>(3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
</tr>
</thead>
</table>
| 3(a)            | Any one from the following points:  
• lack of exercise (1)  
• diet with too much fat/cholesterol/carbohydrate/salt (1)  
• stress (1) |
| Additional guidance | Ignore poor diet, unless qualified. |
| Mark | (1) |

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>3(b)(i)</td>
<td>• B (26)</td>
</tr>
<tr>
<td>Additional guidance</td>
<td></td>
</tr>
<tr>
<td>Mark</td>
<td>(1)</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3(b)(ii)</td>
<td>An explanation that makes reference to the following points:</td>
</tr>
<tr>
<td></td>
<td>• (graph shows) young hearts have less atherosclerosis (1)</td>
</tr>
<tr>
<td></td>
<td>• (so young hearts give) better supply of blood/glucose/oxygen to heart muscle cells (1)</td>
</tr>
<tr>
<td></td>
<td>• (therefore) a young heart will last longer (1)</td>
</tr>
<tr>
<td>4(a)</td>
<td>• 0.5 to 0.8 (ms)</td>
</tr>
<tr>
<td>4(b)</td>
<td>An explanation that makes reference to the following points:</td>
</tr>
<tr>
<td></td>
<td>• myelinated axons have Schwann cells/nodes of Ranvier (1)</td>
</tr>
<tr>
<td></td>
<td>• therefore impulse/action potential jumps from one node to the next/saltatory conduction (1)</td>
</tr>
<tr>
<td></td>
<td>• therefore depolarisation only at nodes (therefore greater speed of nerve impulse) (1)</td>
</tr>
</tbody>
</table>
### Question 4(c)

An explanation that makes reference to the following points:
- acetylcholine {remains/builds up} in cleft (1)

Plus any two from:
- (therefore) constant depolarisation of post synaptic membrane (1)
- (and) constant action potentials/impulses to muscles (1)
- (so) muscles permanently contracted (1)

**Mark:** (3)

### Question 5

Answers will be credited according to the learner’s demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content but learners should be rewarded for other relevant answers.

**Slow twitch fibre:**
- young athlete’s muscle mainly composed of slow twitch fibres
- these contain more myoglobin which stores oxygen
- more mitochondria so more Adenosine triphosphate (ATP) made
- more capillaries to deliver oxygen
- therefore, more aerobic respiration takes place
- so less lactic acid made
- so less muscle fatigue/can run for longer

**Fast twitch fibre:**
- these contain less myoglobin, which stores oxygen
- less mitochondria, so less ATP made
- less capillaries to deliver oxygen
- therefore, more anaerobic respiration takes place
- so more lactic acid made
- so more muscle fatigue/cannot run for longer

**Mark scheme (award up to 6 marks)** refer to the guidance on the cover of this document for how to apply levels-based mark schemes*

<table>
<thead>
<tr>
<th>Level</th>
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</tr>
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</table>

*Mark scheme (award up to 6 marks)*

Refer to the guidance on the cover of this document for how to apply levels-based mark schemes*
Question number
Answer
Additional guidance
Mark
4(c)
An explanation that makes reference to the following points:
- acetylcholine {remains/builds up} in cleft (1)
- (therefore) constant depolarisation of post synaptic membrane (1)
- (and) constant action potentials/impulses to muscles (1)
- (so) muscles permanently contracted (1)

Mark scheme (award up to 6 marks)
refer to the guidance on the cover of this document for how to apply levels-based mark schemes*.
### Section B – Periodicity and properties of elements

<table>
<thead>
<tr>
<th>Question number</th>
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<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>6(a)(i)</td>
<td>• The ability of an element/atom in a molecule, to attract a bonding pair of electrons</td>
<td></td>
<td>(1)</td>
</tr>
</tbody>
</table>

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</table>
| 6(a)(ii)        | A description that makes reference to the following points:  
• decrease in electronegativity down a group (1)  
• increase in electronegativity across a period left to right (1) | | (2) |

<table>
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<tr>
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</table>
| 6(a)(iii)       | • atomic radius (1)  
• nuclear charge (1)  
• screening (by electron shells/orbitals) (1) | Accept number of protons in nucleus  
Accept shielding as an alternative to screening | (3) |
<table>
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<tr>
<th>Question number</th>
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</thead>
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<tr>
<td>6(a)(i)</td>
<td>The ability of an element/atom in a molecule, to attract a bonding pair of electrons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 6(a)(ii)        | A description that makes reference to the following points:  
- decrease in electronegativity down a group (1)  
- increase in electronegativity across a period left to right (1) | Accept the nitrogen-oxygen bond is polar. | (2) |
| 6(a)(iii)       |  
- atomic radius (1)  
- nuclear charge (1)  
- screening (by electron shells/orbitals) (1) | Accept number of protons in nucleus  
Accept shielding as an alternative to screening | (3) |
| 6(b)            | An explanation that makes reference to the following points:  
- induced dipole-dipole/London force/dispersion force (1)  
- fluctuation in electron density, creates an instantaneous dipole in one molecule and this induces a dipole in a neighbouring molecule (1)  
- permanent dipole-dipole force (1)  
- due to a difference in electronegativities (1) | | (4) |
| 7(a)            | B (carbon) | | (1) |
| 7(b)(i)         | Any explanation that makes reference to the following points:  
- (arrangement should be) (1s² 2s² 2px² 2py² 2pz²) 3s² 3px¹ 3py¹ (1)  
- 3s² fills first because it is lower energy (1)  
- then the p orbitals fill singularly before doubly (1) | Accept 1s² 2s² 2px² 2py² 2pz² 3s² 3p² | (3) |
<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>7(b)(ii)</td>
<td>Any explanation that makes reference to the following points: • stronger attraction between (positive charge of) protons in the nucleus and the (negative charge of) outer electrons (in silicon) (1) and • because the outer electrons are closer to the nucleus/smaller atomic radius/ fewer electron shells (in silicon) (1) or • because of less shielding (in silicon) (1)</td>
<td>Reject ionic radius/ molecules ignore just ‘fewer electrons’. Accept reverse argument for germanium.</td>
<td>(2)</td>
</tr>
<tr>
<td>8(a)</td>
<td>• electrostatic force</td>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Question number</td>
<td>Answer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8(b)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8(c)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Question Number 8(b)

<table>
<thead>
<tr>
<th>Answer</th>
</tr>
</thead>
</table>
| Any explanation that makes reference to the following points:  
- stronger attraction between (positive charge of) protons in the nucleus and the (negative charge of) outer electrons (in silicon) (1)  
- because the outer electrons are closer to the nucleus/smaller atomic radius/fewer electron shells (in silicon) (1)  
- because of less shielding (in silicon) (1) |

**Additional guidance**
- Ignore ionic radius/molecules ignore just 'fewer electrons'.
- Accept reverse argument for germanium.

**Mark**

### Question Number 8(c)

<table>
<thead>
<tr>
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</tr>
</thead>
</table>
| calcium carbonate to calcium chloride 1:1 ratio (1)  
- $(111 \times 500) \div 100$ (1)  
- answer = 555 (kg) (1) |

**Additional guidance**

**Mark**
<table>
<thead>
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</table>
| 9(a)            | $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$  
  • correct formula (1)  
  • correct balancing (1) | Allow multiples. | (2) |

<table>
<thead>
<tr>
<th>Question number</th>
<th>Indicative content</th>
</tr>
</thead>
</table>
| 9(b)            | Answers will be credited according to the learner’s demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content, but learners should be rewarded for other relevant answers.  
  • melting and boiling point increases across the period/decreases down a group  
  • sodium and potassium have different physical properties from magnesium because they are in a different group  
  • potassium has more electron shells than sodium, therefore potassium has more shielding between electron shells and the nucleus than sodium, thus has lower melting and boiling points  
  • sodium and potassium atoms has one free electron/one electron on outer shell  
  • magnesium atom has two free electrons/two electrons on outer shell  
  • higher electron density in magnesium metallic bond means strong bond, therefore higher melting and boiling point than group 1 metals  
  • stronger attraction between magnesium nucleus and delocalised electrons than in group 1 metals ORA  
  • one more proton in nucleus of magnesium than sodium ORA, means a stronger attraction in the metallic bond, therefore magnesium has a higher melting and boiling point than sodium  
  • bond harder to break in group 2 metal ORA  
  • more energy needed to boil/melt magnesium ORA |
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<tbody>
<tr>
<td>0</td>
<td></td>
<td>no rewardable content</td>
</tr>
</tbody>
</table>
| Level 1 | 1–2  | • adequate interpretation, analysis and/or evaluation of the scientific information, with generalised comments being made  
• generic statements may be presented rather than linkages being made, so that lines of reasoning are unsupported or partially supported  
• the discussion shows some structure and coherence |
| Level 2 | 3–4  | • good analysis, interpretation and/or evaluation of the scientific information, leading to lines of argument that are occasionally supported through the application of relevant evidence  
• lines of argument mostly supported through the application of relevant evidence  
• the discussion shows a structure that is mostly clear, coherent and logical |
| Level 3 | 5–6  | • comprehensive analysis, interpretation and/or evaluation of all pieces of scientific information  
• line(s) of argument consistently supported throughout by sustained application of relevant evidence  
• the discussion shows a well-developed structure that is clear, coherent and logical |
### Section C – Waves in communication

<table>
<thead>
<tr>
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</table>
| 10(a)           | • node/N labelled at either P or Q (1)  
• antinode/A labelled at mid-point of PQ (1) |                      | (2)  |
| 10(b)           | • PQ = \( \frac{1}{2} \times \text{wavelength} \) (1)  
Accept wavelength = 2 × PQ |                      | (1)  |
| 10(c)           | P Q                           |                      | (1)  |
| 10(d)           | An explanation that makes reference to the following points:  
• a string has a series of natural frequencies (1)  
• corresponding to a number of half wavelengths (1)  
• a stationary wave is produced only when the frequency of the vibration generator produces waves of those wavelengths (1) | Forced frequency = natural frequency. Without reference to this situation award 2 marks. | (3)  |
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</tr>
</thead>
<tbody>
<tr>
<td>11(a)</td>
<td>• 1.6 (cm)</td>
<td>Allow ± 1/2 square</td>
<td>(1)</td>
</tr>
<tr>
<td>11(b)</td>
<td>• 4.8 (cm)</td>
<td>Allow ± 1/2 square</td>
<td>(1)</td>
</tr>
</tbody>
</table>
| 11(c)           | • Use of formula $f = \frac{1}{T}$ (1)  
• Substitution $f = \frac{1}{1.5}$ (1)  
• Answer 0.67 (Hz) (1) | Maximum 2 marks for incorrect value of $T$ taken as 0.75 | (3)  |
<table>
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<tr>
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| **12(a)**       | any one valid use *(1)*  
For example  
endoscopy/endoscopes/keyhole  
surgery |

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<tr>
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</table>
| **12(b)**       | An explanation that makes reference to the following points:  
- fibre optic cable denser than outside/air *(1)*  
- (therefore) incidence at boundary/reflection *(1)*  
- at greater than the critical angle *(1)* |

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</table>
| **12(c)**       | substitution *(1)*  
\[
\sin 43.8 = \frac{1}{n}
\]  
- transposition *(1)*  
\[
n = \frac{1}{0.692}
\]  
- evaluation *(1)*  
\[
1.44
\] |

**Additional guidance**

**Mark**

(1)

(3)

(3)
### Question 12

12(a)
- (intensity at Y =) \( \frac{1}{4} \) (of intensity at X)

### Question 12

12(b)
- An explanation that makes reference to the following points:
  - fibre optic cable denser than outside/air
  - (therefore) incidence at boundary/reflection
  - at greater than the critical angle
- Accept reference to refractive index being greater in fibre optic cable.
- Accept rays are reflected back, inside the fibre.

### Question 13

13(a)
- (intensity at Y =) \( \frac{1}{4} \) (of intensity at X)

### Question 13

13(b)
- Answers will be credited according to the learner’s demonstration of knowledge and understanding of the material, using the indicative content and levels descriptors below. The indicative content that follows is not prescriptive. Answers may cover some or all of the indicative content, but learners should be rewarded for other relevant answers.

**Similarities:**
- frequencies for all in same range (2 GHz)
- frequencies are all microwave
- Wi-Fi and mobile phones networked
- Wi-Fi and mobile phone signals can go through walls
- Bluetooth® and Wi-Fi over short range

**Differences:**
- mobile phones communicate over larger distances
- mobile phone transmitters are high powered
- Bluetooth® low power, Wi-Fi mid power
- Wi-Fi allows wider communication
- Wi-Fi range is average house/small office
- Bluetooth® is only device to device
- mobile phones communicate with each other, via a base station
- mobile phones use the lowest of the frequencies bands
### Mark scheme (award up to 6 marks)

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</tbody>
</table>
| Level 1 | 1–2 | • demonstrates adequate knowledge and understanding of scientific facts/concepts to the given context with generalised comments made  
• generic statements may be presented rather than linkages to the context being made, so that lines of reasoning are unsupported or partially supported  
• the comparison will contain some similarities and differences, showing some structure and coherence |
| Level 2 | 3–4 | • demonstrates good knowledge and understanding by selecting and applying some relevant scientific facts/concepts to provide the comparison being presented  
• lines of argument mostly supported through the application of relevant evidence drawn from the context  
• demonstrate an awareness of both similarities and differences, leading to a comparison that has a structure that is mostly clear, coherent and logical |
| Level 3 | 5–6 | • demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of scientific facts/concepts to provide the comparison being presented  
• line(s) of argument consistently supported throughout by sustained application of relevant evidence drawn from the context  
• the comparison shows a logical chain of reasoning that is supported throughout by sustained application of relevant evidence |
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</table>
| 13(c)           | A description that makes reference to any four of the following points:  
• some long wavelength UV reaches the Earth \( (1) \)  
• IR absorbed (by atmosphere) \( (1) \)  
• but mainly long wavelength IR \( (1) \)  
• quantitative reference to UV wavelength \( (1) \)  
• quantitative reference to IR wavelength \( (1) \) | Accept UV absorbed (by atmosphere) \( (1) \) | \( (4) \) |