BTEC

Pearson BTEC Level 3 National in Applied Science

Unit 1: Principles and Applications of Science I

Sample Assessment Materials (SAMs)

For use with Certificate, Extended Certificate, Foundation Diploma, Diploma and Extended Diploma in Applied Science

First teaching from September 2016 **Issue 1**

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BTEC

Pearson BTEC Level 3 Nationals

Write your name here

Surname	**Forename**

Learner Registration Number | **Centre Number** | **Level 3**

Applied Science

Unit 1: Principles and Applications of Science I

Certificate, Extended Certificate, Foundation Diploma, Diploma, Extended Diploma Diploma in Applied Science

Sample assessment material for first teaching September 2016

Time: 1 hour 30 minutes

You must have:
Calculator, ruler

Total marks

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.

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.
  - Section B: Periodicity and Properties of Elements.
  - Section C: Waves in Communication.
- 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.

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.

Turn over ▶

Paper reference
XXXX/XX
S50607A

S 5 0 6 0 7 A 0 1 3 6

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SECTION A: Structures and Functions of Cells and Tissues

Answer ALL questions. Write your answers in the spaces provided.

1 Ciliated cells are found in the human lung.

(a) What is the name of the lung tissue that contains ciliated cells?

1 mark

- ☒ **A** columnar endothelium
- ☒ **B** columnar epithelium
- ☒ **C** squamous endothelium
- ☒ **D** squamous epithelium

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

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Total for Question 1 = 3 marks

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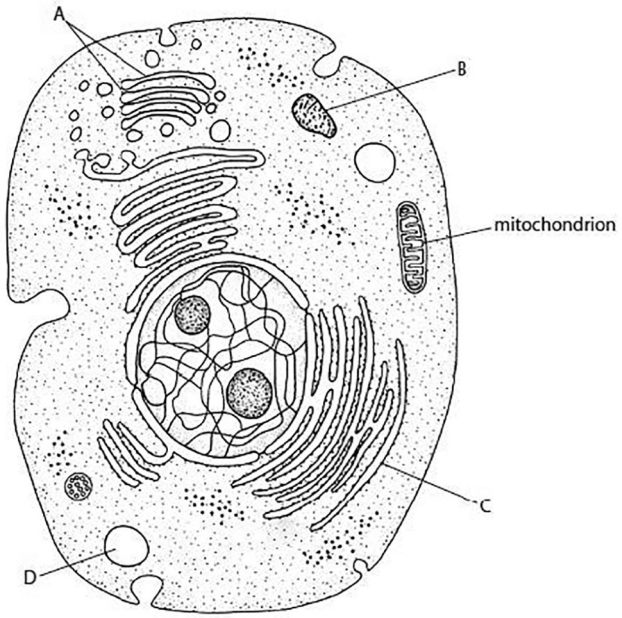
2 The diagram shows the ultrastructure of an animal cell.



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

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

1 mark

- ☒ **A** columnar endothelium
- ☒ **B** columnar epithelium
- ☒ **C** squamous endothelium
- ☒ **D** squamous epithelium

(ii) State **two** functions of the Golgi apparatus.

2 marks

1 .....

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

1 mark

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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.

2 marks

Show your working.

Magnification = ...

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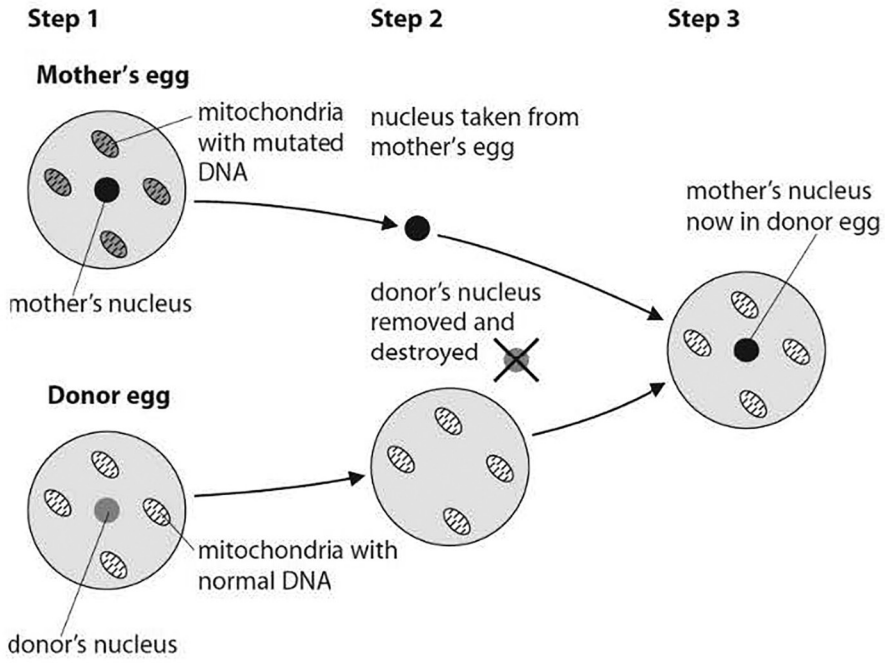
Mitochondria contain DNA. Mutations in the DNA in mitochondria can cause mitochondrial disease. These mutations can be inherited.

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.

The diagram shows some of the steps involved in producing a 'three-parent' baby.



(Source: http://www.hfea.gov.uk)

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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.

3 marks

Parent	Source
Mother	
Donor	
Father	

Total for Question 2 = 9 marks

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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.

1 mark

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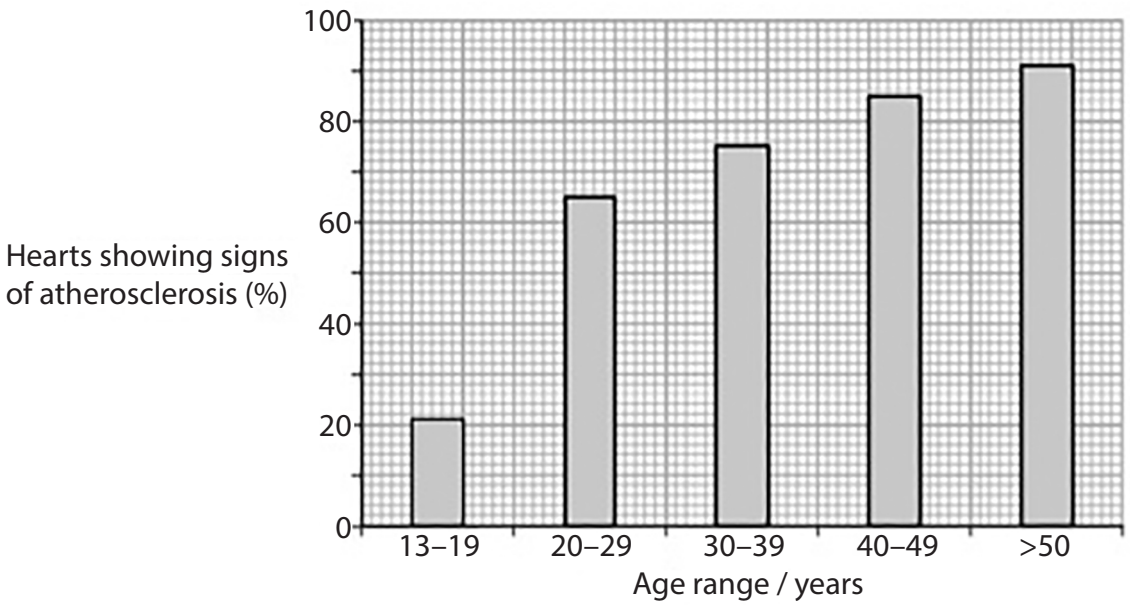
Many people in the UK need a heart transplant to replace their diseased heart.

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.

The graph shows the results.



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.

1 mark

- ☒ **A** 14
- ☒ **B** 26
- ☒ **C** 40
- ☒ **D** 65

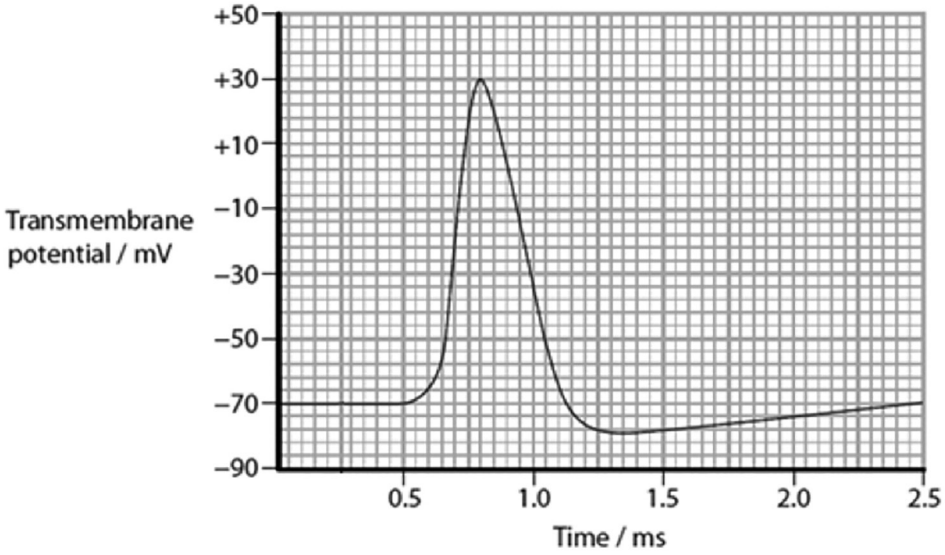
(ii) Suggest an explanation why young hearts are the best ones to use in transplants.

3 marks

Total for Question 3 = 5 marks

4 Nerve impulses are important in the control of many activities in the human body.

The graph shows changes in the transmembrane potential during the transmission of a nerve impulse along the axon of a motor neurone.



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

1 mark

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.....

The table shows the speed of a nerve impulse in different types of axon of the same diameter.

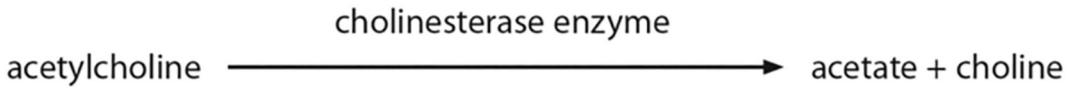
Speed of nerve impulse/ms^{-1}	
Myelinated axon	Unmyelinated axon
25	5

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

3 marks

Nerve impulses are transmitted across synapses by neurotransmitters.

The diagram shows what happens to a neurotransmitter called acetylcholine in the synaptic cleft.



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

5 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 his legs.

Total for Question 5 = 6 marks

END OF SECTION

TOTAL FOR SECTION A = 30 MARKS

SECTION B: Periodicity and Properties of Elements

Answer ALL questions. Write your answers in the spaces provided.

6 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

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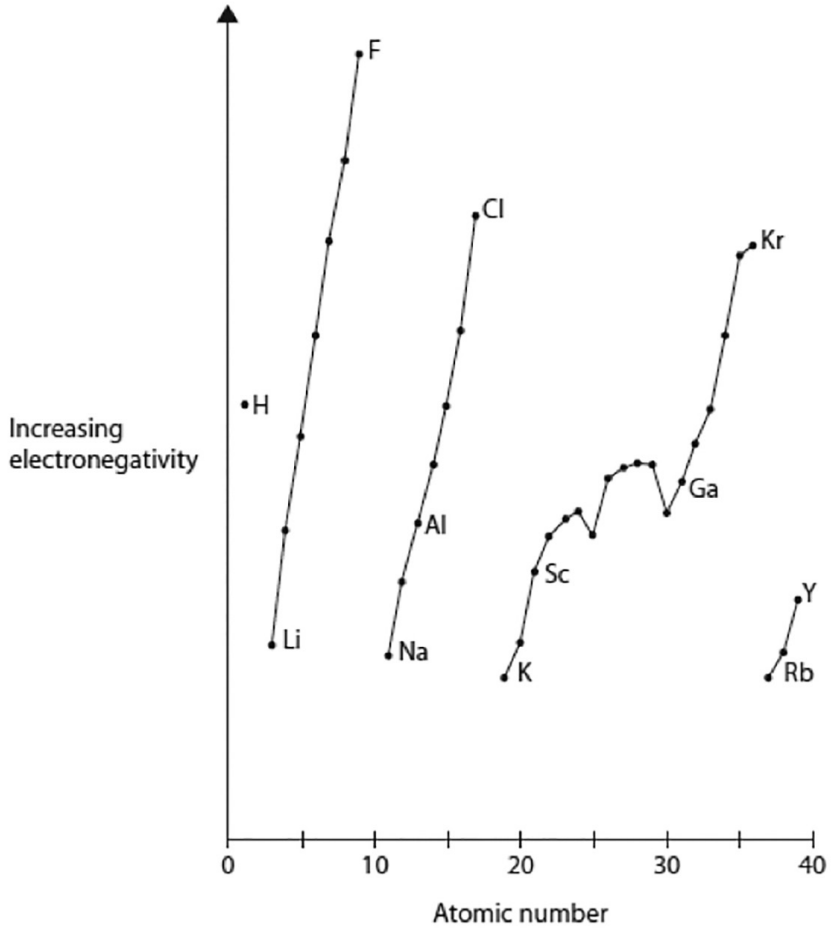
The graph shows the variation of electronegativity with atomic number for some of the first 40 elements.



(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.

3 marks

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2 .....

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3 .....

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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.

4 marks

1 .....

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.....

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2 .....

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.....

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Total for Question 6 = 10 marks

7 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?

$1s^2\ 2s^2\ 2p^2$

1 mark

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

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}).

2 marks

Total for Question 7 = 6 marks

8 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.

1 mark

.....

.....

(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, $CaCl_2$.

2 marks

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.

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$$

(c) Calculate the maximum mass of calcium chloride, $CaCl_2$, that can be produced when 500 kg of calcium carbonate, $CaCO_3$, reacts with excess dilute hydrochloric acid.

3 marks

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.

2 marks

Most metals have high melting and boiling points.

The table shows the melting and boiling points of three metals: sodium, magnesium and potassium.

Metal	Group	Melting points/°C	Boiling points/°C
Sodium	1	97.72	883
Magnesium	2	650	1090
Potassium	1	63.38	759

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

6 marks

Total for Question 9 = 8 marks

END OF SECTION

TOTAL FOR SECTION B = 30 MARKS

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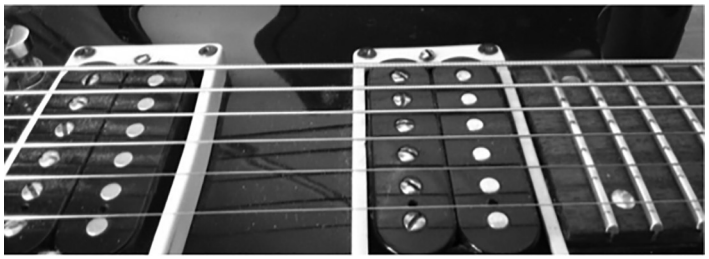
SECTION C: Waves in Communication

Answer ALL questions. Write your answers in the spaces provided.

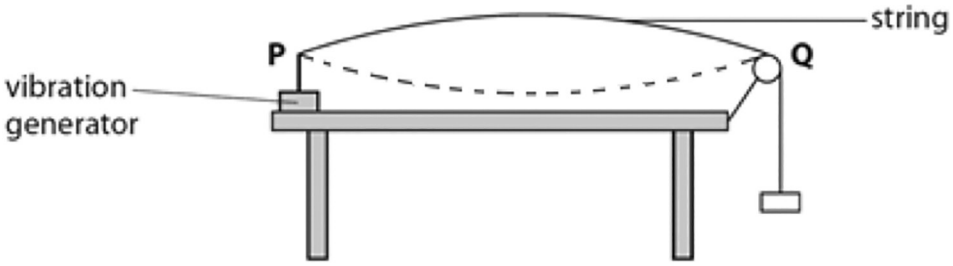
10 The photograph shows a guitar.

The strings on a guitar are different thicknesses.



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

The diagram shows how a stationary wave on a stretched string might be studied.



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

.....

.....

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

1 mark

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

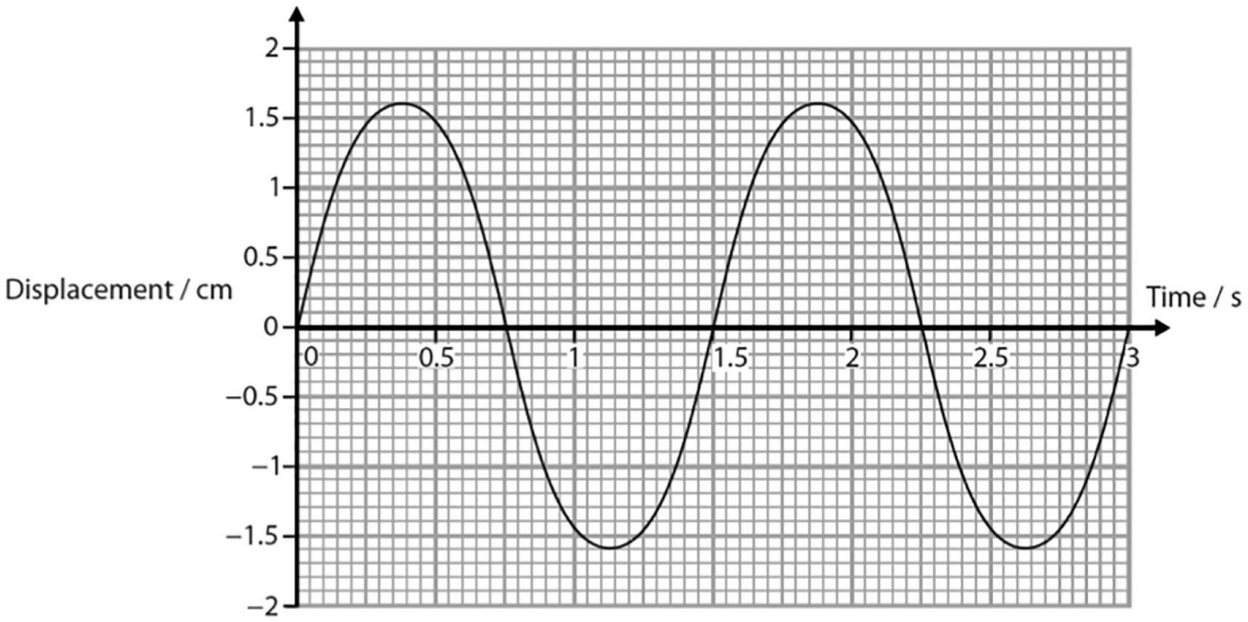
(d) Explain why stationary waves are seen only at certain frequencies.

3 marks

Total for Question 10 = 7 marks

11 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.



Use the graph to:

(a) Give the amplitude of the wave.

1 mark

Amplitude = ... cm

(b) Give the wavelength of the wave.

1 mark

Wavelength = ... cm

(c) Calculate the frequency of the wave.

3 marks

Show your working.

Frequency = ... Hz

Total for Question 11 = 5 marks

12 Fibre optic cables are used in some broadband networks.

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

1 mark

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

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

3 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.

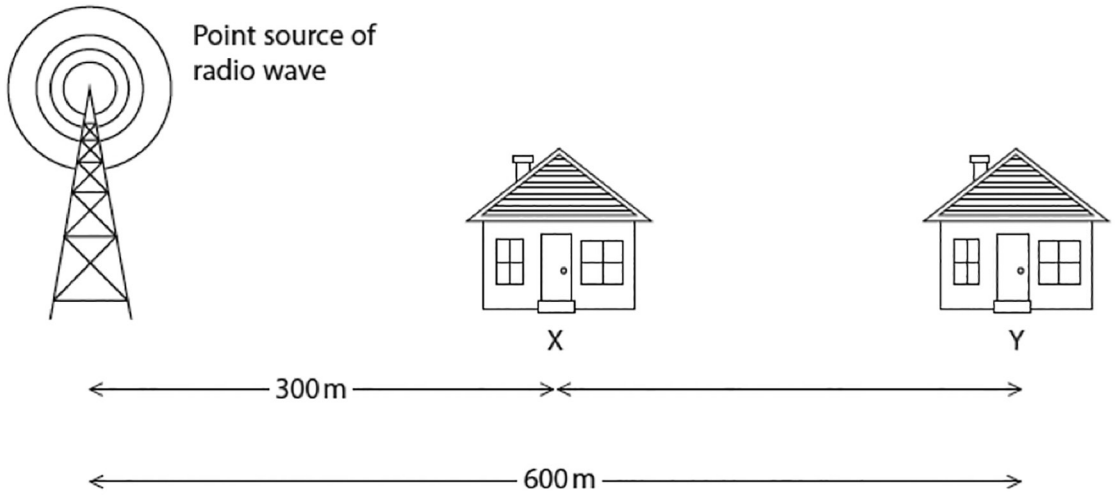
3 marks

Show your working.

Refractive index = ...

Total for Question 12 = 7 marks

13 The diagram shows a point source of radio waves and two detectors at houses X and Y.



(a) Determine how the intensity at Y, I_Y, compares with the intensity at X, I_X.

1 mark

.....

.....

(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

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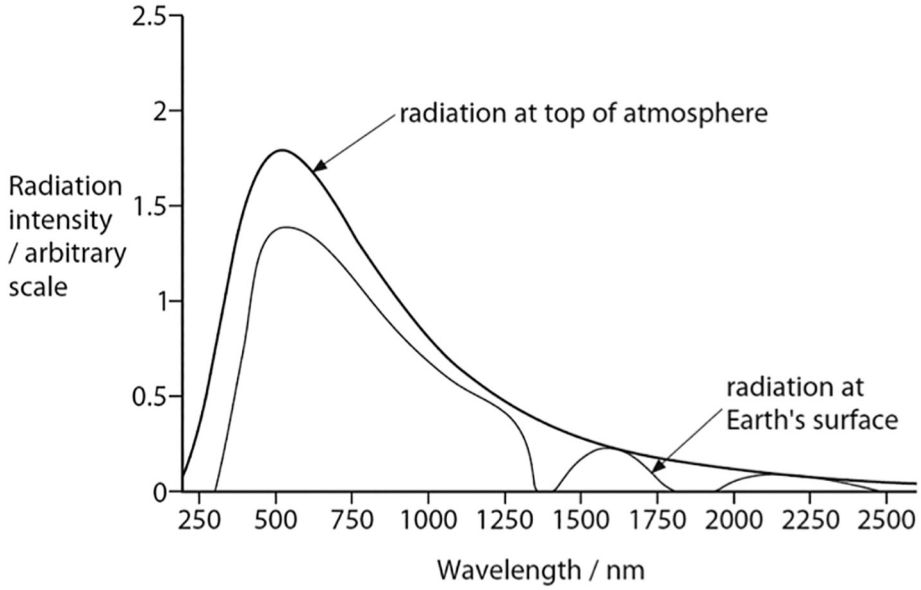
The diagram shows the solar radiation spectrum at the top of the atmosphere and at sea level.



(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

Total for Question 13 = 11 marks

END OF EXAM

TOTAL FOR SECTION C = 30 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

Formulae sheet

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.

Specific marking guidance for levels-based mark schemes*

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

Question number	Answer	Additional guidance	Mark
1(a)	• B (columnar epithelium)		**(1)**

Question number	Answer	Additional guidance	Mark
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)**

Question number	Answer	Additional guidance	Mark
2(a)(i)	• A		**(1)**

Question number	Answer	Additional guidance	Mark
2(a)(ii)	Any two from the following points: • modifying/sorting/packaging proteins **(1)** • lipid transport in cells **(1)** • formation of lysosomes **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
2(a)(iii)	Any one from the following points: • cell wall **(1)** • chloroplast **(1)** • tonoplast **(1)** • amyloplast **(1)**		**(1)**

Question number	Answer	Additional guidance	Mark
2(a)(iv)	• substitution **(1)** 12 000 ÷ 10 • answer **(1)** × 1200	Allow answer based on ± 1 mm.	**(2)**

Question number	Answer	Additional guidance	Mark
2(b)	<table><tr><th>Parent</th><th>Source</th></tr><tr><td>Mother</td><td>Nucleus **(1)**</td></tr><tr><td>Donor</td><td>Mitochondria **(1)**</td></tr><tr><td>Father</td><td>Nucleus/sperm **(1)**</td></tr></table>		**(3)**

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

Question number	Answer	Additional guidance	Mark
3(b)(i)	• B (26)		**(1)**

Question number	Answer	Additional guidance	Mark
3(b)(ii)	An explanation that makes reference to the following points: • (graph shows) young hearts have less atherosclerosis **(1)** • (so young hearts give) better supply of blood/glucose/oxygen to heart muscle cells **(1)** • (therefore) a young heart will last longer **(1)**	Allow converse, if older hearts discussed.	**(3)**

Question number	Answer	Additional guidance	Mark
4(a)	• 0.5 to 0.8 (ms)	Allow any two values in this range.	**(1)**

Question number	Answer	Additional guidance	Mark
4(b)	An explanation that makes reference to the following points: • myelinated axons have Schwann cells/nodes of Ranvier **(1)** • therefore impulse/action potential jumps from one node to the next/ saltatory conduction **(1)** • therefore depolarisation only at nodes (therefore greater speed of nerve impulse) **(1)**		**(3)**

Question number	Answer	Additional guidance	Mark
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)**		**(3)**

Question number	Indicative content
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 anerobic 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*	

Level	Mark	Descriptor

	0	no rewardable content
Level 1	1–2	• demonstrates adequate knowledge of scientific facts/concepts, with generalised comments 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	**Mark**	**Descriptor**
Level 2	3–4	• demonstrates good knowledge and understanding, by selecting and applying some relevant scientific knowledge facts/concepts, to provide the discussion being presented • 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	• demonstrates comprehensive knowledge and understanding, by selecting and applying relevant knowledge of scientific facts/concepts, to provide the discussion being presented • 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 B – Periodicity and properties of elements

Question number	Answer	Additional guidance	Mark
6(a)(i)	• The ability of an element/atom in a molecule, to attract a bonding pair of electrons		**(1)**

Question number	Answer	Additional guidance	Mark
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)**

Question number	Answer	Additional guidance	Mark
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)**

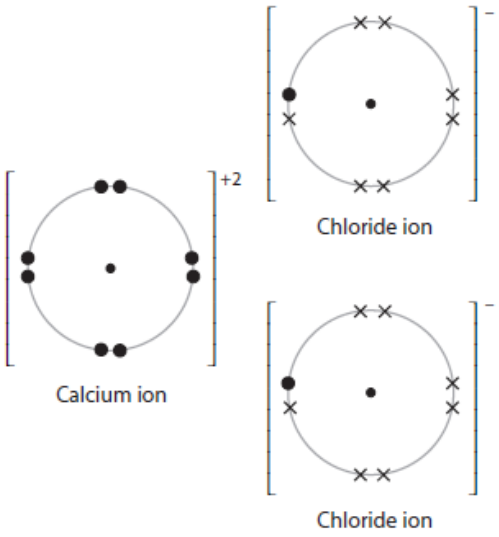
Question number	Answer	Additional guidance	Mark
6(b)	An explanation that makes reference to the following points: • induced dipole-dipole/London force/ dispersion force **(1)** • fluctuation in electron density, creates an instantaneous dipole in one molecule and this induces a dipole in a neighbouring molecule **(1)** • permanent dipole-dipole force **(1)** • due to a difference in electro-negativities **(1)**	Accept the nitrogen-oxygen bond is polar.	**(4)**

Question number	Answer	Additional guidance	Mark
7(a)	• B (carbon)		**(1)**

Question number	Answer	Additional guidance	Mark
7(b)(i)	Any explanation that makes reference to the following points: • (arrangement should be) ($1s^2$ $2s^2$ $2p_x^2$ $2p_y^2$ $2p_z^2$) $3s^2$ $3p_x^1$ $3p_y^1$ **(1)** • $3s^2$ fills first because it is lower energy **(1)** • then the p orbitals fill singularly before doubly **(1)**	Accept $1s^2$ $2s^2$ $2p_x^2$ $2p_y^2$ $2p_z^2$ $3s^2$ $3p^2$	**(3)**

Question number	Answer	Additional guidance	Mark
7(b)(ii)	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)**	Reject ionic radius/ molecules ignore just 'fewer electrons'. Accept reverse argument for germanium.	**(2)**

Question number	Answer	Additional guidance	Mark
8(a)	• electrostatic force		**(1)**

Question number	Answer	Additional guidance	Mark
8(b)	 • correct charges on each ion Ca^{2+} Cl^{-} **(1)** • correct number of electrons from each ion on the outer shell **(1)**	Ignore inner shells. Reject covalent bonding. Ignore whether dots or crosses.	**(2)**

Question Number	Answer	Additional guidance	Mark
8(c)	• calcium carbonate to calcium chloride 1:1 ratio **(1)** • (111 × 500) ÷ 100 **(1)** • answer = 555 (kg) **(1)**		**(3)**

Question number	Answer	Additional guidance	Mark
9(a)	$4Al + 3O_2 \rightarrow 2Al_2O_3$ • correct formula **(1)** • correct balancing **(1)**	Allow multiples.	**(2)**

Question number	Indicative content
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

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*.		
Level	**Mark**	**Descriptor**
	0	no rewardable content
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

Question number	Answer	Additional guidance	Mark
10(a)	• node/N labelled at either P or Q **(1)** • antinode/A labelled at mid-point of PQ **(1)**		**(2)**

Question number	Answer	Additional guidance	Mark
10(b)	• PQ = $\frac{1}{2}$ × wavelength **(1)**	Accept wavelength = 2 × PQ	**(1)**

Question number	Answer	Additional guidance	Mark
10(c)	**P**  **Q**		**(1)**

Question number	Answer	Additional guidance	Mark
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)**

Question number	Answer	Additional guidance	Mark
11(a)	• 1.6 (cm)	Allow $\pm\frac{1}{2}$ square	**(1)**

Question number	Answer	Additional guidance	Mark
11(b)	• 4.8 (cm)	Allow $\pm\frac{1}{2}$ square	**(1)**

Question number	Answer	Additional guidance	Mark
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)**

Question number	Answer	Additional guidance	Mark
12(a)	• any one valid use **(1)** For example endoscopy/endoscopes/keyhole surgery		**(1)**

Question number	Answer	Additional guidance	Mark
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)**	Accept reference to refractive index being greater in fibre optic cable. Accept rays are reflected back, inside the fibre.	**(3)**

Question number	Answer	Additional guidance	Mark
12(c)	• substitution **(1)** $\sin 43.8 = \frac{1}{n}$ • transposition **(1)** $n = \frac{1}{0.692}$ • evaluation **(1)** 1.44		**(3)**

Question number	Answer	Additional guidance	Mark
13(a)	• (intensity at Y =) $\frac{1}{4}$ (of intensity at X)		**(1)**

Question number	Indicative content
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) refer to the guidance on the cover of this document for how to apply levels-based mark schemes*.		
Level	**Mark**	**Descriptor**
	0	no rewardable content
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

Question number	Answer	Additional guidance	Mark
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)**

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