Question Number	Answer	Acceptable answers	Mark
1(a)	**A** longitudinal : yes		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(b)	An explanation linking any two of: 1. A cause or description of earthquakes (1) 2. why timing of earthquake is uncertain / complex (1) 3. we cannot see {what is happening deep inside the Earth / where the plates are rubbing} (1)	The release of {energy / pressure/friction force} (in Earth's surface) (caused when tectonic) plates slide past each other any idea of relative movement of plates e.g. move over each other, collide (movement of plates is) {sudden / random / jerky} it is too difficult to {work out / measure} when release of energy will happen "it is difficult to measure when the plates will collide" = 2 marks	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(c)		award full marks for correct answer (6.5) **with no working** (since 13 small squares = 6.5 mins)	**(3)**
	P-wave = 8 (minutes) (1)	7.5 – 8.5 (minutes) inclusive	
	S-wave = 14.5 (minutes) (1)	14.0 - 15.0 (minutes) inclusive	
	time difference = 6.5 (minutes) (1)	**ecf** for difference of wrong readings from graph **accept** time shown as m:ss (e.g. 6:30) if correct construction lines are shown on graph but no values written, the score is maximum of 1 of the three	

Question Number		Indicative Content	Mark
QWC	***1 (d)**	A description including some of the following points **Data collection** • S and P arrival times found • Use or collect data from more than one station **Manipulation / Calculation for one station** • Circle drawn on map with station at centre • Circle drawn on map at appropriate distance from station • Earthquake on that circle • (Distance found from) S minus P time **Triangulation** • Repeat calculation / drawing with at least three stations • Epicentre / earthquake at point of intersection of all three (or more) circles • Triangulation • Meaning of triangulation **If no other marks scored** • Strength greatest nearer earthquake = Level 1 • Time shortest nearest the earthquake = Level 1	**(6)**

Level	0	No rewardable content
1	**1 - 2**	• a limited description of process involving isolated fact(s) from one section. e.g. Circle drawn on map with station at centre OR "triangulation" • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• a simple description of process involving linked facts from two sections e.g. the S and P arrival time is recorded, and the difference noted. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• a detailed description of process involving elements from all three sections e.g. showing how three stations can identify the epicentre of an earthquake using a calculation and intersecting circles. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Total for Question 6 = 12 marks

Question Number	Answer	Acceptable answers	Mark
2(a)(i)	**C** The Earth is radiating heat to space		**(1)**

Question Number	Answer	Acceptable answers	Mark
2(a)(ii)	An explanation linking any 2 of: • Hot material rises/cold material falls (1) • (causes) material under the plate to move sideways (1) • (because of) uneven heating (1)	convection current in the {mantle/magma/under plates} heat from core warms mantle near core IGNORE temperature difference (in stem)	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(i)	an explanation linking: • change in wave speed (1) • (with) change in {density/state of the rock/media/material} (1)	Refraction S-waves reflected Accept change from solid to liquid or vice versa IGNORE reference to gas	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(ii)	suggestion to include: • the time difference (1) • of S and P waves {arriving/reaching /detected/recorded} (same place) (1)	Allow P-waves travel faster ORA for 1 mark, if no other mark scored	**(2)**

Question Number	Answer	Acceptable answers	Mark
2(b)(iii)	• Identifies two points on the graph • Evidence of calculation or comparison to the equation • Draws a suitable conclusion	May be scored by points marked on graph Accept appropriate comment shape of graph e.g. Graph not straight at short distances or Graph nearly straight at long distances works better for long distances than short distances	**(3)**

Total for Question 3 = 10 marks

Question Number	Answer	Acceptable answers	Mark
3(a)	**D** an ultraviolet wave		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(b)	Ultraviolet (from lamp) <u>absorbed</u> (by fluorescent substance/bank note) (1) (which) emits {visible/light} (into eye) (1)	Allow UV for ultraviolet Allow 'taken in' for absorbed Allow 'given out'/releases/fluoresces for emits 'Fluoresces' on its own is insufficient Mention of both ultraviolet AND visible/light only, scores 1 mark only	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(c)	Substitution (1) (Speed =) $6.67 \times 10^{14} \times 4.5 \times 10^{-7}$ Transposition AND substitution (1) (time =) $\frac{4 \times 10^{16}}{(6.67 \times 10^{14} \times 4.5 \times 10^{-7})}$ Evaluation (1) 1.33×10^{8} (s)	Award full marks for correct answer with no working 3×10^{8} (m/s) seen anywhere $\frac{4 \times 10^{16}}{3 \times 10^{8}}$ ECF candidate's speed maximum 2 marks Allow answers which round to 130 000 000 IGNORE Power of Ten error until evaluation	**(3)**

Question Number		Indicative Content	Mark
QWC	***3(d)**	An explanation including some of the following points • Longitudinal {vibrations/oscillations} are {along/parallel to/in the same direction as} the direction of {travel/energy transfer} • Transverse {vibrations/oscillations} are {across/perpendicular to/90° to/right angles to} the direction of {travel/energy transfer} • Ultraviolet waves are transverse • Ultrasound waves are longitudinal (ignore sound – not on list) • Some seismic waves are longitudinal and some are transverse • P waves are longitudinal • S waves are transverse • Longitudinal waves need a material for the vibrations whereas electromagnetic waves can pass through a vacuum **IGNORE** irrelevant material	**(6)**

Level	0	No rewardable content
1	1 - 2	• a limited explanation of: EITHER the {vibration/movement} direction and direction of {travel/movement} for transverse or longitudinal wave OR correctly identifying the wave type for at least one example from the list, e.g. o Longitudinal waves move in the same direction as the wave moves o Ultraviolet waves are transverse • the answer communicates ideas using simple language and uses limited scientific terminology
2	3 - 4	• a simple explanation linking: EITHER directions of {vibration/oscillation} and wave travel for both types of wave OR direction of {vibration/oscillation} and wave travel of one type of wave with at least one example of a wave from the list OR the direction of 'movement' and direction of {travel/movement} for transverse AND longitudinal waves AND correctly identifying the wave type for at least one example from the list e.g. o In longitudinal waves the vibrations are in the same direction as the wave travels. In transverse waves the vibrations are at right angles to the direction the wave travels. o In longitudinal waves the vibrations are in the same direction as the wave travels. Ultraviolet waves are transverse. o Longitudinal waves move in the same direction as the wave moves. Transverse waves move at right angles to the direction the wave moves. Ultrasound waves are longitudinal. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	5 - 6	• a detailed explanation clearly differentiating between the directions of {vibration/oscillation} for longitudinal AND transverse waves AND at least one example of each type of wave from the list, e.g. o In longitudinal waves the vibrations are in the same direction as the wave travels. In transverse waves the vibrations are at right angles to the direction the wave travels. Ultrasound waves are longitudinal and ultraviolet waves are transverse. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Total for Question 5 = 12 marks

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	an explanation linking: • frequency / Hz (1) • above 20 000 (1)	Pitch too high to be heard by the man "it is above 20kHz" 2 marks "The frequency is too loud" gets 1st mark	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	substitution: (1) 140/0.42 evaluation: (1) 330 m/s (1)	award full marks for correct answer with no working allow 333(.333) independent mark allow ms^{-1}	**(3)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	A infrasound wave (1)		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	• arrows to show vibration in opposite directions (1) • parallel to arrow on diagram (1)	arrows do not have to go through R horizontal and vertical – no marks multiple directions – no marks	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(c)	Explanation linking: • convection (currents) (1) • in mantle (1)	Accept answers in form of a labelled diagram in molten rock in magma below plates in the hot rock coming from the core under Earth's crust under surface ignore lava clear unlabelled diagram scores maximum 1 mark clear labelled diagram scores maximum 2 marks	**(2)**

(Total for Question 4 = 10 marks)