OCR GCSE GATEWAY PHYSICS A · J249

PHYSICS



MARK SCHEME

P5.2 THE ELECTROMAGNETIC SPECTRUM

SCORE	PERCENTAGE
/101	%

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Question			Answer/Indicative content	Marks	Guidance
1	a		Ricco emits IR [1] (and) IR detected by sensor [1]	2	**allow** Ricco emits heat / radiation [1] sensor detects Ricco's body heat scores [2] Examiner's Comments Most candidates attempted this question, but a common misunderstanding was that the sensor detected movement and many thought that it sent out a beam of infra-red radiation which was reflected by the object. Those candidates who understood the working of these detectors found the question straight-forward. Examiners were looking for the idea that Ricco's body emitted IR and the detector sensed this radiation.
	b	i	**any one from** no IR from ball [1] ball same temperature as surroundings [1]	1	**allow** ball not hot / ball does not emit heat / ball does not emit IR / heat radiation [1] **allow** ball not detected / ball too small [1] Examiner's Comments Most candidates explained that the ball did not emit IR, or that the ball was too small to be detected. Both were acceptable answers.
		ii	**any one from** foil reflects IR (back to Ricco) [1] not enough IR (from Ricco) detected [1]	1	**allow** foil reflects heat / foil reflects radiation [1] foil blocks IR / heat from body to sensor [1] allow IR / heat not detected [1] Examiner's Comments In general candidates understood that aluminium foil reflected IR or prevented it from reaching the detector.

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Question			Answer/Indicative content	Marks	Guidance
			Total	4	
2			microwave [1]	1	Examiner's Comments The majority of candidates correctly identified microwaves as the first type of wave used by mobile phones. The most popular wrong answer was gamma.
			Total	1	
3			**transverse** (waves.) [1]	1	if answer line blank **allow** correct answer circled or underlined in the list more than one answer = 0 marks Examiner's Comments As in 2015 this question on electromagnetic waves used for communications was not answered well. Candidates were unfamiliar with how different waves were reflected or scattered by the ionosphere and atmosphere and very few were able to apply ideas of interference to the question. Around half could choose that electromagnetic waves were transverse
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
4	a		any two from same amount of milk [1] same type of milk [1] same thickness / mass / size / volume of beaker [1] same starting temperature (of milk) [1]	2	allow same oven power [1] if no other answers allow 'only change one thing at a time' for [1] Examiner's Comments The majority of candidates gave a general list of how to make experiments fair rather than relating it to the question. An example is the same material for the beaker, when the question had told them that it was made of glass. Some candidates did not give enough detail such as 'same temperature' when the accepted answer was 'same starting temperature.
	b		heat the water (in milk) / AW [1]	1	allow heat the fat (in milk) [1] allow microwaves are absorbed by water / fat [1] allow higher level answers e.g. water molecules vibrate faster / water molecules increase in kinetic energy [1] Examiner's Comments The accepted answer was by being absorbed by the milk or fat (molecules). The incorrect answer "from the inside out" was quite common. The majority of candidates failed to score marks on this question.
	c		microwaves are not absorbed by glass / do not heat the glass / only heat the milk AW [1]	1	allow microwaves penetrate the glass / beaker [1] Examiner's Comments This proved a difficult question for candidates. Few were able to state that microwaves could penetrate glass or were not absorbed by glass.

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Question			Answer/Indicative content	Marks	Guidance
	d		black absorbs **more** IR / heat (than white) / ORA [1] white reflects **more** IR /heat (away than black) / ORA [1]	2	**allow** black absorbs heat more quickly ORA [1] **allow** SHC is the same [1] If no comparison then allow 1 mark for either black is a good absorber of IR/heat or White reflects IR / heat **Examiner's Comments** In this question, examiners were looking for a comparative answer. Whilst the majority of candidates stated that black absorbed IR radiation and white reflected IR radiation, few said that black absorbs more IR radiation than white and white reflects more IR radiation than black.
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
5	a		any three from skin cancer / skin cells mutate[1] eye damage / cataracts [1] premature aging of skin [1] suntan / sunburn [1]	3	 **ignore** just cancer /mutate **allow** problems with eyes **allow** skin becomes wrinkly **allow** skin damage /harm/ burn if no mention to premature aging of skin / suntan / sunburn [1] Examiner's Comments There were 3 marks for this question and examiners were looking for 3 separate answers. Most candidates gave skin cancer and some form of sunburn as correct answers, but few realised that it also caused eye damage or cataracts.
	b		use sun-cream / sun-block / sun(tan) lotion / sun screen [1] idea of reduced exposure / less sunbathing / wear a sunhat / wear clothing / put on sunglasses / move to the shade / AW [1]	2	Examiner's Comments Asked about how people could protect themselves from UV rays. Sunblock, shade and clothing/hats/sunglasses were all popular answers, but many candidates only gave one answer despite there being 2 marks for the question.
			Total	5	
6			any 2 from short waves penetrate atmosphere / Long waves don't penetrate atmosphere / AW [1] long waves absorbed or refracted or reflected (by atmosphere) [1] (therefore) short waves **reach** the receiver / long waves don't **reach** the receiver [1]	2	Examiner's Comments Even fewer could compare microwaves and radio waves used in satellite communication
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
7			any two from so doctor knows where the problem is [1] so doctor knows what the problem is / to diagnose the problem [1] so the doctor knows how severe / bad the problem is [1] so the doctor knows if an (surgical) operation is needed / AW [1]	2	 **allow** so the doctor know where to make the cut in the skin [1] **allow** so the doctor knows how big to make the cut or if the problem can be treated by keyhole surgery [1] **allow** it is safer than invasive surgery to see the problem [1] Examiner's Comments In general this question on how ultrasound is used in pre-surgical diagnosis wasanswered well across the full range. Most candidates scored at least one mark for either identifying the location or the nature of the problem.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
8			(suggestion) idea of exact alignment with receiver [1] (explanation) to maximise signal received / AW [1] (suggestion) idea of making dish larger [1] (explanation) to reduce diffraction / so wave spreads less / to maximise signal received / to produce a parallel beam / AW [1] (suggestion) position dish high up / sensible place [1] (explanation) avoids obstacles / maximise signal received / avoids signal loss [1]	4	Answers in either order acceptable Eg. line of sight needed [1] Eg. Point in right direction [1] Eg more waves hit receiver / more chance of receiving the signal / stronger signal (received) [1] **Ignore** focussed **Ignore** more curved **Allow** stronger signal received [1] **Ignore** focussed Eg. Ensures line of sight [1] Eg. no obstacles to absorb microwaves [1] Examiner's Comments The suggestions for improving microwave dishes were often correct. The explanations given were usually relevant if not entirely correct. One misconception was that placing the satellite dishes high on hills [1] would improve things as they are closer to space.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
9		i	idea that microwaves heat water (and fat) only / microwaves penetrate food [1] **but** microwaves increase **KE** / movement / vibration of water (or fat) particles [2]	2	**allow** IR heats all particles on surface / IR heats surface only [1] **ignore** microwaves cook from the centre **allow** IR increases KE of all food particles / particles on the surface [2] Examiner's Comments This question about energy transfer in the kitchen offered the candidates an opportunity to show what they knew of particles and cooking with waves. It produces a wide range of marks and discriminated well. Most candidates gained 4 or more marks overall. This question asked about the differences and similarities about microwave and infrared cooking. Most knew that microwaves penetrated the food or just heated water [1]. Better answers referred to the microwaves giving more KE to the water particles. Answers in terms of IR heating (all) particles on the surface giving them more KE were also acceptable.

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Question			Answer/Indicative content	Marks	Guidance
		ii	(Both are) electromagnetic waves / reflected by shiny surfaces or metal walls / conduction or convection (heat) to centre of food [1] both transfer KE to particles [1]	2	**maximum two marks** **ignore** references to heat **eg** (both) conduct to the rest of the food [1] **allow** both cause particles to vibrate more / vibrate faster [1] eg 'KE passed on to other particles in the rest of the food scores' [2] Examiner's Comments This question about energy transfer in the kitchen offered the candidates an opportunity to show what they knew of particles and cooking with waves. It produces a wide range of marks and discriminated well. Most candidates gained 4 or more marks overall. In part (ii), the similarities were based around the rest of the food being heated by conduction or convection and the KE being passed on between particles. Other acceptable similarities were less often seen but covered by the mark scheme. For example both waves are from the electromagnetic spectrum [1].
			Total	4	
10			**any two from** less chance of infection (1) does not damage the patient (1) so the patient does not need an operation (to see if anything is wrong) (1) idea of non-ionising (1)	2	 **ignore** safer **ignore** harmless
			Total	2	

Question			Answer/Indicative content	Marks	Guidance
11			any **three** from geostationary satellites use **C** (1) low orbit satellites use **B or C** (1) low orbit satellites use low frequency waves / radio waves (1) geostationary satellites use high(er) frequency waves / geostationary satellites use microwaves or radio waves that can **pass straight through the atmosphere** (1) no satellites use A / high frequency microwaves / radiowaves as they are **absorbed** by rain and dust (1)	3	**allow** if type of satellite is not given then one mark can be awarded for satellites use C(1)
			Total	3	
12			(ultra-low) LEO satellites use **B because:** they are reflected by ionosphere (1) (higher) LEO satellites use **C because:** they can pass through the atmosphere (1) geostationary satellites use **C because:** they need to pass through the atmosphere (1)	2	**Ignore** references to ionosphere for satellite C **Ignore** references to ionosphere for satellite C Reward compound answers: **Eg.** (they) would use C so they pass through atmosphere scores (2)
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
13			**Level 3: 5–6 marks** **Three correct uses identified AND at least two advantages of wireless communication suggested.** Quality of written communication does not impede communication of science at this level. **Level 2: 3–4 marks** **Two correct uses identified AND at least one advantage of wireless communication suggested.** Quality of written communication partly impedes communication of science at this level. **Level 1: 1–2 marks** **At least one correct communication use identified** Quality of written communication impedes the communication of science at this level **Level 0: 0 marks** Insufficient or irrelevant science. Not worthy of credit. **Look** for links in the table. If only the table completed max level 1.	6	This question is targeted up to C **Indicative scientific points may include (but are not limited to) the following:** <u>Uses</u> radio waves – TV signals microwaves – mobile phones infrared – TV remote control **allow** visible light – Morse code <u>Advantages</u> allows tracking portable convenient allows access when on the move no trailing wires no connection to a landline required works in remote locations
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
14	a		**any two from:** suntan (1) sunburn (1) skin cancer (1) cataracts (1) premature skin aging/AW (1)	2	**Allow** burns skin **ignore** just cancer **ignore** just eye damage
	b		**any one from:** keep out of the sun (1) cover up / wear clothing (1) use sunscreen / suncream / sun lotion / sun protection / sun block (1)	1	**allow** stay inside
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
15	a	i	(Wave speed =) frequency x wavelength ✓	2 (AO1.1)	**ALLOW** correct symbol equation eg (v =) f × λ **ALLOW** equation in any form **ALLOW** any frequency and corresponding wavelength from the table substituted into this equation **IGNORE** units for this marking point only
			$30 \times 10^9 \times 0.01$ or $30 \times 10^9 \times 1 \times 10^{-2}$ ✓	(AO3.2b)	**ALLOW** 30 000 000 000 × 0.01 or 30 000 000 000 × 1 × 10^{-2} **ALLOW** reverse arguments using speed and wavelength or speed and frequency <u>Examiner's Comments</u> This question assessed AO1 and AO3 and required candidates to recall and use the equation: *wave speed = frequency x wavelength* as well as convert 30 GHz into Hertz and 1 cm into metres. Most candidates struggled with the meaning of the prefixes and converting the units. Because many of these candidates did not write down the equation or their workings they could not be credited for any of the compensatory marks available in the mark scheme. A number of candidates used data from the table for radio or infra-red waves. Although they could not gain full marks they were credited with 1 mark for correct use of the equation.

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Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 100 (nm) award 3 marks	3	
			(Wavelength =) velocity ÷ frequency ✓	(AO1.2)	**ALLOW** (λ =) v ÷ f **IGNORE** v = f × λ and f = v / λ or words **ALLOW** 3×10^8 divided by any frequency from the table
			$\frac{3 \times 10^8}{3000 \times 10^{12}}$ or 1×10^{-7} ✓	(AO2.1)	**IGNORE** units for this marking point only
			= 100 (nm) ✓	(AO2.1)	Examiner's Comments This question required candidates to convert the prefix Tera into a power of ten, recall and rearrange the equation: *wave speed = frequency x wavelength* to calculate the wavelength of ultra-violet, and then convert their answer into nanometres. Only the higher ability candidates gained full credit. The majority of candidates did not score any marks. Those candidates, who did gain credit, were credited with a one mark for correctly rearranged equation or for the correct application of the equation (i.e. 3×10^8 divided by any frequency from the table). OCR support Candidates would benefit from greater familiarity with the standard metric prefixes (WS1.4d). The Mathematical Skills Handbook provides additional support on the use of prefixes and powers of ten for orders of magnitude: http://www.ocr.org.uk/Images/310651-mathematical-skills-handbook.pdf

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Question			Answer/Indicative content	Marks	Guidance
	b		(skin) cancer / (skin) aging ✓	1 (AO1.1)	ALLOW sunburn / blisters / wrinkles / mutates cells / ionises cells IGNORE kills cells / damages cells / just burns Examiner's Comments The majority of candidates achieved 1 mark. Of those candidates who did not gain credit, most had stated that ultra-violet waves cause 'burns' rather than cause sunburn.
	c	i	120 (minutes) ✓	1 (AO2.2)	Examiner's Comments Almost every candidate answered this question correctly.
		ii	Any two from: children have (more) sensitive skins ✓ children have cells / skins that are more at risk from skin cancers ✓ children lack awareness of the time they spend in the sunshine ✓ the idea that they advise a higher SPF than they (really) need just to be sure they are safe ✓	2 (AO1.1) (AO2.1)	IGNORE just to reduce risk of burning ALLOW skin is vulnerable / more easily damaged / more affected by UV / delicate / has less melanin / AW ALLOW idea that damage to cells builds up over time ALLOW children are outside for longer / spend more time in the sun Examiner's Comments Most candidates were credited with one mark for the idea that children have more sensitive skins. Around a quarter of candidates were credited with both marks, frequently because they recognised that children spend more time in the sun.

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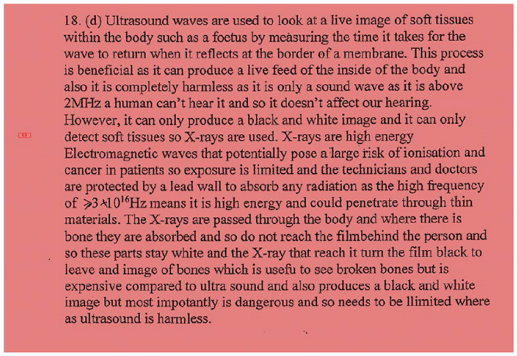
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Question			Answer/Indicative content	Marks	Guidance
	d		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) A detailed explanation of how ultrasound and X-rays are used. AND A detailed evaluation of the risks / benefits of using the two different waves to scan patients in hospital, which may include use of information from the table. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* Level 2 (3–4 marks) An explanation of how ultrasound and X-rays are used. AND An evaluation of the risks / benefits of using the two different waves to scan patients in hospital. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* Level 1 (1–2 marks) EITHER An explanation of how ultrasound and X-rays are used. OR An evaluation of the risks / benefits of using the two different waves to scan patients in hospital. OR An explanation of ultrasound or X-rays AND an evaluation of the risks / benefits of ultrasound or X-rays. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* 0 marks - *No response worthy of credit.*	6 (AO2 × 1.2) (AO1 × 2.2) (AO1 × 3.1b) (AO2 × 3.2a)	AO1.2 Demonstrate knowledge and understanding of X-rays and ultrasound • X-rays show bone • Ultrasound shows eg soft tissue / kidneys/ blood flow / prenatal scan AO2.2 Applies knowledge and understanding of X-rays and ultrasounds • X-rays damage / ionise living cells / causes cancer / damage foetus • Ultrasound is harmless AO3.1b Analyses information to evaluate the differences in X-rays and ultrasound • X-rays are absorbed by bone but do not show up soft tissues • Ultrasound is (partially) reflected for soft tissues only AO3.2a Analyses information to make judgements about the risks and benefits: • Ultrasound always safe **and** useful for soft tissue scanning • X-rays can cause cancer **but** save lives with identifying bone problems • X-rays have a frequency greater than 3 × 10^{16} Hz / (very small) wavelengths less than 10 nm to penetrate the body <u>Examiner's Comments</u> This Level of Response question assessed all three Assessment Objectives and provided an opportunity for candidates to demonstrate Grade 9 performance. Most candidates gained some credit for their written responses. The majority demonstrated a good knowledge of X-rays in particular and two thirds of the candidates demonstrated Level 2 or Level 3 performance. Many excellent responses at Level 3 included detailed explanations of absorption of X-rays by bones, reflection of ultrasound for soft tissues, and a detailed

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Question			Answer/Indicative content	Marks	Guidance
					evaluation of the risks and benefits of the two different waves. Most responses successfully identified the risks / benefits of X-rays but a common misconception was that ultrasound could also cause cell mutations or harm (to the baby). **Misconception** Most candidates successfully identified the risks and benefits of X-rays but a significant number of candidates mistakenly believed that ultrasound could also cause cell mutations or harm to the baby. **Exemplar 4**  18. (d) Ultrasound waves are used to look at a live image of soft tissues within the body such as a foetus by measuring the time it takes for the wave to return when it reflects at the border of a membrane. This process is beneficial as it can produce a live feed of the inside of the body and also it is completely harmless as it is only a sound wave as it is above 2MHz a human can't hear it and so it doesn't affect our hearing. However, it can only produce a black and white image and it can only detect soft tissues so X-rays are used. X-rays are high energy Electromagnetic waves that potentially pose a large risk of ionisation and cancer in patients so exposure is limited and the technicians and doctors are protected by a lead wall to absorb any radiation as the high frequency of $\geqslant 3\times10^{16}$Hz means it is high energy and could penetrate through thin materials. The X-rays are passed through the body and where there is bone they are absorbed and so do not reach the filmbehind the person and so these parts stay white and the X-ray that reach it turn the film black to leave and image of bones which is usefu to see broken bones but is expensive compared to ultra sound and also produces a black and white image but most impotantly is dangerous and so needs to be llimited where as ultrasound is harmless. This is a six mark, Level 3 answer. The candidate included a detailed explanation of how both X-rays and ultrasound are used to scan patients. There is also a detailed evaluation of risks / benefits of both waves, which includes the use of some data from the table.
			Total	15	

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Question			Answer/Indicative content	Marks	Guidance
16			D ✓	1 (AO 1.1)	Examiner's Comments This question was generally answered well. The common incorrect answer was B, where candidates thought that ultrasound was an electromagnetic wave.
			Total	1	
17			D ✓	1 (AO 2.2)	Examiner's Comments Candidates found this question difficult with only about a third of the candidates choosing the correct answer D. Candidates should know that electromagnetic waves are transverse and travel through space with the same velocity. The other three options were regularly chosen by the candidates. Candidates should practice answering this type of questions which often test basic knowledge and understanding. One way of answering these questions is to look at one of the column headings for example transmission and rule out with small crosses A and B, then look at the next column and rule out A and C, which then means the correct answer should be D. In this question the third column could be used to check that D would still work again by placing a cross next to A and B.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
18			A ✓	1 (AO 2.2)	Examiner's Comments This was the most challenging question in Section A. The most common response was distractor D, where candidates multiplied the numbers together rather than dividing wave speed by wavelength. AfL For these type of questions candidates should be encouraged to insert the numbers into the equation. When they do this they will see that the equation needs to be rearranged. Alternatively, candidates could rearrange the equation so that the unknown quantity is on the left-hand side of the equal sign.
			Total	1	
19			A ✓	1 (AO 1.2)	Examiner's Comments Most candidates successfully applied their knowledge of electromagnetic waves to identify that the energy transfer for row A was correct.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
20		i	Radio / infra-red / microwave ✓	1 (AO 1.1)	
		ii	Ultra-violet / X-rays / gamma-rays ✓	1 (AO 1.1)	
		iii	**Any two from:** Radiotherapy / killing cancer cells ✓ Irradiating food / sterilisation of instruments✓ Tracer / medical imaging✓ Scanning metals / non-destructive testing (NDT) ✓	4 (AO2.1)	**ALLOW** tumours / treatment of cancer **ALLOW** killing bacteria / (harmful) microorganisms / sterilising food Examiner's Comments Candidates had a sounder understanding of the trend in frequency in the electromagnetic spectrum (part ii) than that for wavelength (part i). The most common misconception was by candidates who gave visible light as their response to both part i and part ii. Around half of the candidates knew that gamma-rays are used in the treatment of cancer but other uses, such as the irradiation of food or medical equipment, were known by far fewer. To gain credit, candidates need to ensure that their answers are specific. A number of candidates stated that gamma-rays were used in chemotherapy. Some candidates stated that gamma-rays were used in scans, often with an implication of unborn babies. It was hoped that candidates would understand the use of gamma radiation as a tracer and for sterilising instruments.
			Total	4	
21			**D** ✓	1 (AO 1.1)	
			Total	1	
22			**A** ✓	1 (AO 1.1)	
			Total	1	

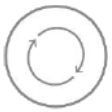
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Question			Answer/Indicative content	Marks	Guidance
23	a		A.C. (transmitted in power lines) / (electrical/electron/particle) oscillations / AW ✓ **BUT** Alternating currents/(electrical/electron/particle) oscillations produce (radio) waves/electromagnetic radiation ✓✓	2 (AO2×1.1)	<u>Examiner's Comments</u> This Assessment Objective 1 question assessed candidates' knowledge and understanding of how radio waves are produced. This proved to be one of the most difficult questions on the paper but also discriminated well. Only the most able candidates gained marks for relating the production of radio waves to the oscillations of electrons in the transmission lines. **Misconception** Common misconceptions included radio waves being produced by something in the house or because the transmission lines produced heat.

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Question			Answer/Indicative content	Marks	Guidance
	b		(High voltage means) lower current ✓ Less heating/heat loss/power loss/energy wasted or more useful energy transmitted / ORA ✓	2 (AO2×1.1)	IGNORE no energy losses / prevent energy loss / AW ALLOW more efficient / (wires at) lower temperature <u>Examiner's Comments</u> Although this question has been asked often in past GCSE Physics papers, over one quarter of candidates did not gain credit. Many gained 1 mark for the idea of less energy lost (as heat) but only the more able candidates were able to link this to higher voltages resulting in a lower current.  AfL Candidates had many misconceptions about why energy should be transferred at high voltages. The responses often referred to incorrect ideas e.g. 'to make the energy move faster/further' or 'to transfer enough power to the home' or 'to reduce the resistance'. Candidates should also be aware that the idea of NO energy losses will not gain credit.

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Question			Answer/Indicative content	Marks	Guidance
	c		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 20 (A) award 5 marks Recall $I^2 = P / R$ ✓ 6.156 kW = 6156 W ✓ (I^2 =) 6156 / 15.39 **OR** (I^2=) 400 ✓ (I =) √400 ✓ (I =) 20 (A) ✓	2 (AO 1.2) (AO 2.1) (AO 2.1) (AO 2.1)	**ALLOW** correct equation in any form **DO NOT ALLOW** marks to be awarded from incorrect equation e.g. I = P / R Award marks if 6.156kW has not been correctly converted to W E.g. (I^2 =) 0.4 or 6.156/15.39 ✓✓ (I=) √0.4 ✓✓✓ I = 0.63 ✓✓✓✓ <u>Examiner's Comments</u> The majority of candidates scored either zero marks or 5 marks for this question. Over a quarter of candidates did not know the correct equation: power = (current)^2 x resistance. It was common to see an incorrect version of the equation (power = current x resistance) used instead. Some candidates did show their calculations and could therefore score 1 mark for converting kW into W.
			Total	9	

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Question			Answer/Indicative content	Marks	Guidance
24			Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Detailed description of the structure of the Earth **AND** Detailed explanation of the trends in **Table 22.1.** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Description of the structure of the Earth. **AND** Explanation of the trends in **Table 22.1.** **OR** Detailed description of the structure of the Earth. **OR** Detailed explanation of the trends in **Table 22.1.** *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** **A basic description of the structure of the Earth.** **OR** A basic description of the trends in **Table 22.1.** *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO 2×3.1a) (AO 2×3.2a) (AO 2×2.1)	**AO3.1a Analyse information and ideas to interpret some basic trends in data** • density increases as depth increases • speed (of P/S waves) increases as density increases • speed (of P/S waves) increases as depth increases **AO2.1 Apply knowledge and understanding of scientific ideas to explain trends in the data** • Earth contains layers • velocity changes at a boundary • as density changes at a boundary • particles more tightly packed • P is longitudinal, S is transverse **AO3.2a Analyse information and ideas to make judgements about the structure of the Earth** • core has highest density • core has highest speed for P waves • S waves do not travel through the core • so the outer core is a liquid • pressure highest in core / P = ρgh • pressure and so density increase with depth • large change in density between mantle and outer core Examiner's Comments This was the Level of Response question, targeted up to Grade 9, and assessed AO2 and AO3. There was a wide range of marks achieved and the question discriminated well. Very few candidates did not achieve any credit. The majority of candidates were able to describe some basic trends in the table for density and speed of P and S waves. More detailed responses also included a description of the structure of the Earth for Level 2.

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Question			Answer/Indicative content	Marks	Guidance
					Many excellent responses from the more able candidates at Level 3 included: • trends in the data identified and explained • linking facts about P and S waves to an explanation of why the outer core is liquid. Poor quality of communication, including contradictions or the same facts repeated a number of times, prevented some candidates from achieving a higher mark. **Exemplar 2** Describe what information the data in **Table 22.1** gives about the structure of the Earth. In your answer you should explain any trends in the data in **Table 22.1**. P waves are longitudinal and travel through both solid and liquids but S waves are transverse and only travel through solids. There is no data for the wave speed of S waves through the top of the outer core and the bottom so the core must be made of liquid, however both waves can travel through the crust and the mantle as there is data for it so these must be made of solid. the density of the layers at the earth decreases down the table so the density of the earth must decrease from the surface of the crust to the centre of the inner core. The speed of both P waves and S waves increase down the table as well, P waves travel faster in more dense [6] 22 material as the particles are close together so they carry the wave to each other faster, which the data therefore backs up that the density of the earth increases towards the centre. This response achieved Level 3, 6 marks. The candidates included a detailed description of the structure of the Earth, including ideas about density and the liquid outer core. There is also a detailed explanation of the trends shown in the table.
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
25			idea of 3 echoes/reflections/returning pulses (from each pulse) / AW✓ takes different times to travel (there and back) through different layers/distances/thicknesses / time (interval) between echoes is different/not regular / AW ✓✓ **BUT** the thicker the layer/the longer the distance, the bigger the time interval/takes longer to travel (there and back) / AW ✓✓	3 (AO 3×2.1)	**ALLOW** (idea of measuring) the time taken for the wave to be reflected back (for different layers) Examiner's Comments This question assessed candidates' ability to apply their knowledge of ultrasound. It proved challenging to a number of candidates and about one third did not gain any credit. Candidates used their knowledge of ultrasound but often did not relate this to the question asked, or their answers were not specific enough e.g. the number of pulses shows that there are 3 layers of tissue.
			Total	3	
26			D ✓	1 (AO1.1)	Examiner's Comments This question was not answered well. It was hoped that candidates would know that light is a type of electromagnetic wave and that all electromagnetic waves are transverse. This was a straightforward recall question from the specification.
			Total	1	
27			C ✓	1 (AO1.1)	Examiner's Comments This question was also based on the electromagnetic spectrum section of the specification. Candidates had a better understanding of the main groupings of the electromagnetic spectrum from long to short wavelengths and from low to high frequencies. An alternative way of answering this question is to apply the wave equation realising that the speed of electromagnetic waves in a vacuum is constant.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
28			B ✓	1 (AO1.1)	Examiner's Comments There was evidence that a large number of candidates were unaware of the practical uses of electromagnetic waves. A common incorrect answer was C.
			Total	1	
29			A ✓	1 (AO1.1)	Examiner's Comments This question required candidates to read the options carefully. Many candidates did not realise the direction was important.
			Total	1	
30	a		spoon A AND (More radiation emitted) at higher temperature / hotter objects (emit more radiation) / spoon A is hotter / AW / ORA✓	1 (AO1.1)	ALLOW spoon A is heated (more) Examiner's Comments Many candidates correctly ticked Spoon A but did not explain their answer correctly. It was expected that they would state that objects at higher temperatures would emit more radiation.
	b		Any one from: Eye can only detect visible light / eye cannot detect IR ✓	1 (AO1.1)	ALLOW see for detect ALLOW spoon is not hot enough for a change in colour AW Examiner's Comments The common incorrect answer to this question was to refer to the spoons not melting rather than stating that infrared radiation cannot be detected by the eye.
			Total	2	

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Question			Answer/Indicative content	Marks	Guidance
31	a		**Any one from:** Similarity Both transverse waves ✓ Both electromagnetic waves ✓ Both travel at the same speed/speed of light (in a vacuum) ✓ Both can travel through space / vacuum ✓ **Any one from:** Difference X-ray has higher frequency / shorter wavelength / ORA ✓ X-rays have higher energy / ORA ✓ X-rays are more penetrating / ORA ✓	2 (AO2 × 1.1) 1	**DO NOT ALLOW** we can see visible light/we cannot see X-rays
	b	i	86 (%) ✓	1 (AO2.2)	**ALLOW** 85-87 %
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 14 (%) award 2 marks** 100 – 86 ✓ = 14 (%) ✓	2 (AO 2×2.2)	**ALLOW ECF** from **(i)**
			Total	**5**	
32			**D** ✓	1 (AO1.1)	
			Total	**1**	
33			**A** ✓	1 (AO1.1)	
			Total	**1**	

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