A-LEVEL
Applied Science
SC08 Medical Physics
Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Question	Answers	Additional Comments/Guidance	Mark	
1 (a)	• (The) heart	c.a.o.	1	
1 (b) (i)	Any one of: • It is used to improve electrical connectivity/conductivity • There are no sound waves /ultrasound (waves) involved • Acoustic impedance refers to sound waves/ ultrasound (waves)	• The point is the student understands that acoustic impedance is related to sound wave transmission and/or EEGs do not use sound, they use electrical signals • Coupling agent / conductivity both insufficient.	1	
1 (b) (ii)	• EEGs detect electrical signals produced within the body (No electricity is sent into the body)	• Accept correct specific parts of the body e.g. brain/nervous system Looking for understanding of how EEGs work in terms of what they detect. 'non-invasive' is insufficient	1	
1 (b) (iii)	Any one of: • sleep researchers study delta waves • delta waves occur in deep sleep • beta waves occur when awake	• The point is beta waves are not associated with sleep Do not award mark if wrong type of wave (e.g. theta) specified.	1	
1 (c)	• Delta • Theta • Beta • Alpha	• all 4 correct gains 3 marks • 2 or 3 correct gains 2 marks • 1 correct gains 1 mark	3	
Total			**7**	

2 (a)	Fast heartbeat	c.a.o	1	
2 (b) (i)	• (it is likely to be correct because) the temperature is below that needed to diagnose hypothermia • hypothermia is diagnosed at a temperature of 32 °C (or below) (in the mouth)	For MP1 we are looking for a comparison between the person's temperature and that at which hypothermia is diagnosed. Can award even if an incorrect temperature is stated but 'below normal' is insufficient. For MP2 we are looking for the knowledge that hypothermia is diagnosed when body temperature drops to 32^0 C. A statement such as 'hypothermia is diagnosed at 32 °C and the patient has a temperature of 31 °C 'is sufficient for both marks.	2	
2 (b) (ii)	**(**No**)** because the temperature of the mouth will be affected by external factors.	Reason required for mark to be awarded Accept reasons to do with the temperature of food/drink affecting the mouth's temperature. "Mouth will be colder" is insufficient	1	

2 (c) (i)	(thermal) radiation/ infra-red (radiation)	Any other type of named radiation negates. Ignore reference to conduction and/or convection.	1	
2 (c) (ii)	To <u>reflect</u> heat from the patient's body back to the patient	The focus is on the patient not losing heat to the blanket 'Bounce back' etc. are insufficient for 'reflect'. Any indication that conduction or convection are involved negates. Just 'to reflect heat' is insufficient – need to know where it's reflected to – whereas 'reflect heat back to the patient' is OK as it implies that's where it came from in the first place. Similarly 'to reflect the heat from the patient back' is OK as it implies that it is going back to the patient. If the explanation is accompanied by incorrect statement about the silver surface, e.g. silver is a good emitter/absorber of radiation, this will negate the mark.	1	
2 (c) (iii)	To prevent heat being radiated/emitted to the surroundings (from the warmer blanket)	The focus here is on the blanket not emitting heat to the cooler surroundings Need a reference to the blanket/surroundings/colour silver/shiny material. Accept 'to prevent heat escaping to the surroundings as long as there is no indication that any mechanism other than radiation is involved.	1	
Total			**7**	

3 (a) (i)	To prevent light being refracted out of the sides of the fibre / to achieve total internal reflection.	Accept to reduce the amount of light lost/escaping. 'leaving' is insufficient(as it may refer to the light leaving the end of the fibre after being transmitted down it). Ignore comments relating to protecting the core/fibre or the effect on refractive index. 'to reduce the amount of light refracted' is insufficient but 'to reduce the amount of light refracted out of the fibre' is just sufficient.	1	
3 (a) (ii)	(The refractive index of the cladding needs to be)(slightly) lower	'low' is insufficient – comparison needed.	1	
3 (b)	Any one of: • To check for / remove anomalies	Accept reliable/repeatable. 'more accurate' is insufficient.	1	

	• To take an average.			

3 (c) (i)	Light source, protractor, (rectangular glass sample, white paper, pencil, ruler)	Ignore any additional equipment unless clearly wrong (e.g. GM tube). Ignore reference to prism/ semi-circular blocks as long as candidate has also mentioned the sample block/rectangular block/block. If the prism/semi-circle is the only glass block mentioned this is insufficient for the mark.	1	

3 (c) (ii)	

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

Level 1 (0—1 marks)

Answer is largely incomplete. It may contain valid points which are not clearly linked to an argument structure.
Unstructured answer
Errors in the use of technical terms, spelling, punctuation and grammar or lack of fluency

Level 2 (2—3 marks)

Answer has some omissions but is generally supported by some of the relevant points below:
- the argument shows some attempt at structure
- the ideas are expressed with reasonable clarity but with a few errors in the use of technical terms, spelling, punctuation and grammar

Level 3 (4—5 marks)

Answer is full and detailed and is supported by an appropriate range of relevant points such as those given below:
- argument is well structured with minimum repetition or irrelevant points
- accurate and clear expression of ideas with only minor errors in the use of technical terms, spelling and punctuation and grammar.

examples of the points made in the response	**extra information**
• The block is placed on white paper and its position is marked. • A narrow ray of light is sent into the side of the block (and emerges at the opposite side of the block). • The normal is drawn at the point of entry and at the point of exit. • The path of the ray is marked with a pencil and the points of entry and exit are using a ruler.	A diagram can be used to communicate much of this information. To gain full marks, there must be some mention of what is measured and how the measurements are used to calculate *n*. Watch out for answers where they think the ray that emerges from the block is the one at the angle of refraction from the normal. You will be unlikely to find enough credit in such an answer to award more than 3

• The angles of incidence and refraction are measured – both angles being measured between the ray and the normal. • This is repeated several times for the same angle of incidence and for several different angles of incidence. • Results are tabulated, averages taken and *n* calculated using the formula: $n = \frac{\sin i}{\sin r}$ Alternatively a graph can be drawn of sin *i* against sin *r* and, in this case, the gradient gives *n*.		marks. Answers where the candidate is trying to get TIR are very unlikely to get more than 2 marks as they can only gain credit in relation to the first 4 example points.		
3 (c) (iii)	To make the ray more clearly visible	To stop other light sources interfering is insufficient Accept 'so you can see the ray'.	1	
3 (c) (iv)	To reduce the percentage error / to increase precision	to reduce errors/ more accurate are insufficient	1	
3 (d) (i)	the (incident) angle for which the angle of refraction is 90°	Accept: The smallest (incident) angle at which total internal reflection will occur (or wtte) / the (incident) angle for which light refracts along the edge of the block/ the largest angle at which refraction (out of the block) will occur/ the angle at which TIR first happens/ the angle above which TIR happens. The angle at which TIR happens is insufficient. Answers that just state an equation are insufficient. The key point is that at this angle refraction out of the material stops and TIR starts to occur	1	
3 (d) (ii)	*c* = 38.7°	Correct answer alone gains all 3 marks Accept: 38.6^0 , 38.682°, 38.68°, 39° for full marks. 1 compensation mark for each of the below up to a **maximum of 2** • correct equation sin c = 1/*n* • correct substitution sin c = 1/1.6 • correct use of sines	3	

		answer of 0.625 gains 2 marks		
3 (e) (i)	**C**	c.a.o	1	
3 (e) (ii)	Any appropriate use, other than supplying heat to burn away ulcers, tumours etc, eg cutting through tissue/laser scalpel/ cauterising/ remove cataracts/ eye surgery/ reshaping cornea/ treatment for gallstones/ treatment for kidney stones/ tattoo removal	Need to ensure candidate is not just repeating use given in (f)(i). 'prevent bleeding' is insufficient – need a context	1	
3 (e) (iii)	• Any relevant example of an advantage of traditional open surgery named. e.g. only one incision needs to be made/ • Advantage explained (must match named example). e.g. keyhole surgery usually needs two incisions (one for the tools and one for an endoscope) • Any relevant example of a disadvantage of traditional open surgery named. e.g. larger incision needed • Disadvantage explained (must match named example). e.g. so a longer recovery time/ greater chance of bleeding	Advantages include (but are not necessarily limited to): • one incision needed • surgeon has a larger space to work in • surgeon can see more clearly. • Less risk of error Note some of the points above (and others you may come across) can work as both the example and the explanation e.g. 'the surgeon can see more clearly so there is less risk of error' is worth 2 marks. Disadvantages include (but are not necessarily limited to): • larger incision needed (accept 'more invasive') Explanations could be discussing why this is different from keyhole surgery or could be explaining the relevance to the patient.	4	
Total			**21**	

4 (a)	• Suitable advantage of thermography e.g. no possibility of any damage • Matching explanation e.g. (completely) non-invasive • Suitable disadvantage of thermography e.g. more difficult to interpret • Matching explanation e.g. differences in temperature may be small	Accept any reasonable advantage and disadvantage Explanations must match the advantage/disadvantage given Some points may work as both advantages/ disadvantages are explanations e.g. 'lower contrast image so more difficult to interpret/ diagnosis is difficult/ more prone to human error' is worth 2 marks 'More limited access to thermography' is insufficient. However, 'doctors are less skilled in interpreting thermographs/ more chance of human error' (disadvantage) 'because they use them less frequently' (explanation) is an acceptable response. Reference to equipment used for thermography being more expensive is incorrect but should be ignored. Ignore any advantages/ disadvantages that also apply to ultrasound (e.g. non-ionising). Accept less detailed/lower contrast but 'less clear/ less precise/ less accurate' are insufficient.	4	
4 (b)	• 1.1×10^{-4} (2 marks) • m	Correct answer alone gains both calculation marks and all 3 marks if the correct unit is also given. Answers expressed in cm or mm are also acceptable for all 3 marks as long as the correct unit is stated. Without the unit, these answers can score a maximum of 1 compensation mark (see below) For the calculation, one compensation mark is available for: Either: correct equation $v = f\lambda$ (in any arrangement) or correct figures but incorrect power of 10	3	

4 (c) (i)	When one doubles the other doesn't halve (or wtte)		1	
4 (c) (ii)	• Plotted the right way round with suitable large, even scale and correct labels and units on axes • All points correctly plotted • Acceptable line–of-best-fit (curve)	If the graph does not have even scales then neither of the other 2 points can be awarded Points 2 and 3 can still be awarded if the graph is small and/or plotted the wrong way round Cannot award point 2 if the axes have neither labels nor units.	3	
4 (c) (iii)	As read from graph (approx.10 cm)	Cannot be awarded if the graph drawn does not have even scales. Can award if axes have missing labels and/or units as long as it has been plotted the right way round. The focus is on correct interpolation of the graph.	1	
4 (c) (iv)	1/penetration		1	
4 (d)	• (To obtain an image of the stomach) the ultrasound would have to have high penetration • High penetration would mean a low quality image	Accept converse or similar arguments e.g. 'to get a clear image you need a high frequency', 'high frequency means low penetration so may not reach the stomach' etc. The focus is on the links between frequency, penetration and clarity and its application to a situation where high penetration is needed.	2	

4 (e) (i)	0.9990	Accept 0.99898/0.9989/0.999/0.99 or any other numerical answer where the first three figs. Are 0.99 AS LONG AS THE INITIAL EQUATION IS NOT INCORRECT. If there is evidence that an incorrect equation has been used then award 0. (candidates often forget to square) Ignore 1 Correct answer alone gains all 3 marks One compensation mark for each of the below to a maximum of 2 marks: • correct equation $\alpha = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$ or $\left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$ • correct substitution • correct answer with wrong power of 10 $(1.5796 / 1.5804)^2$ gains 2 marks	3	
4 (e) (ii)	Air and bone	Either order	1	
Total			**19**	

5 (a) (i)	• High frequency/ high energy/short wavelength • Electromagnetic waves	Any suggestion that they are gamma rays negates second mark.	2	

5 (a) (ii)	
Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.	
Level 1 (0—1 marks)	
Answer is largely incomplete. It may contain valid points which are not clearly linked to an argument structure Unstructured answer Errors in the use of technical terms, spelling, punctuation and grammar or lack of fluency	
Level 2 (2—3 marks)	
Answer has some omissions but is generally supported by some of the relevant points below: • the argument shows some attempt at structure • the ideas are expressed with reasonable clarity but with a few errors in the use of technical terms, spelling, punctuation and grammar	
Level 3 (4—5 marks)	
Answer is full and detailed and is supported by an appropriate range of relevant points such as those given below: • argument is well structured with minimum repetition or irrelevant points • accurate and clear expression of ideas with only minor errors in the use of technical • terms, spelling and punctuation and grammar	
examples of the points made in the response In an X-ray machine, X-rays are produced when electrons from a heated cathode hit a tungsten anode. To produce an image, X-rays are sent into the body. They are absorbed by some tissues but transmitted through others. The amount of attenuation and the proportion of X-rays absorbed depends on the density of the tissue they pass through. The denser the tissue, the higher the proportion of X-rays absorbed. This means that X-rays travel through soft tissue but are absorbed by bone. The X-rays that are transmitted continue until they reach a photographic plate. The plate is exposed where the X-rays hit it. A shadow of the bone is formed on the plate because the X-rays absorbed by the bone cannot reach it.	**extra information** Beware of any suggestion that X-rays are reflected by dense tissue or that they are gamma rays. Key points to look for: • production of X-rays in an X-ray tube • differential absorption/attenuation • absorption/attenuation depends on density • correct relationships between absorption/attenuation, density and type of tissue • transmitted X-rays reach photographic film / electronic detector • appearance of final image related to transmission/ absorption/shadow effect. Full marks may still be given if not all points are covered.

5 (b)	• Increases the density (of the soft tissue) • (so) increases the absorption	Accept (Contrast medium has) higher density/higher atomic number for	2	

	of X-rays	1st mark. (so) X-rays are absorbed for 2nd point		
5 (c) (i)	One of: • occur by chance/ random • no threshold level before damage occurs • probability is proportional to the dose • severity of effect does not depend on the dose •	Apply list rule for incorrect statements. Ignore irrelevant answers e.g. cancer, burns, reference to reproductive organs etc. 'Depends on the dose' is insufficient (what depends on the dose? Likelihood or severity?) 'Not predictable' is insufficient	1	
5 (c) (ii)	One of: • not hereditary • only the person exposed is affected	Apply list rule Typical definition is: radiation **effects** that occur in the individual exposed, as opposed to genetic **effects**, which occur in the individual's offspring Answers accepted should reflect this. Accept "as a direct result of the X-rays (e.g. burns)".	1	
5 (c) (iii)	(the) sievert/ Sv	Phonetic spelling accepted Accept mSv / millisievert	1	
Total			**12**	

6 (a) (i)	They remain at a high level of activity for longer	Accept they remain active for longer Ignore references to 'person' so 'patient stays radioactive for longer' is insufficient.	1	
6 (a) (ii)	They emit their radiation quickly so are likely to have higher levels of activity to start with	Accept 'they emit their radiation quickly'/'emitted radiation likely to be more intense' Ignore reference to effectiveness in doing its job	1	
6 (a) (iii)	0.25 (g)	Correct answer alone gains both marks One compensation mark for: • recognition of 4 half-lives • correct iterative method (0,6,12,18,24 not 0,6,12,24)	2	
6 (a) (iv)	Tracer (no mark) because it will remain active long enough for a trace / will lose activity too quickly to be effective for an implant/ patient will not stay radioactive for too long	Accept 'loses activity quickly' / 'short half-life so won't stay radioactive for long'/ 'half-life is long enough to trace its path through the body'/ 'implant would need longer half-life or would have to be changed too often'. 'Has a short half-life' is insufficient 'Will not last long in the body' is insufficient. (linked to biological half-life) Focus is on how long it remains at a reasonable level of activity Wrong choice negates the mark and must be clear as to which application the candidate has selected.	1	
6 (b) (i)	More ionising	Must have comparison Ignore reference to penetration but answers which suggest that different types of radiation have different half-lives are incorrect.	1	
6 (b) (ii)	More penetrating / harder to stop	Accept higher energy. Must have comparison. Ignore reference to ionisation but answers which suggest that different	1	

		types of radiation have different half-lives are incorrect.		
6 (c) (i)	One of: • location of treatment in body • organ affinity • toxicity • intensity • availability. • Daughter product produced	Accept physical factors such as whether solid, liquid or gas. Ignore cost, penetration and personal factors related to the patient.	1	
6 (c) (ii)	Appropriate reason for importance of factor chosen in 6(c)(i) e.g. • chose radioisotope with appropriate organ affinity • to ensure radioisotope accumulates in the right place • so patient is not poisoned • so minimum dose can be given • so there is no delay in administering it. • To ensure daughter product is not toxic	If toxicity is considered then needs to be specific that poisoning is the issue. Any indication that they mean radiation poisoning would be insufficient	1	
6 (d) (i)	Any 4 points Preferred for tumours close to the surface because: • it spreads out less / can be accurately targeted at the required depth. • is less likely to come in contact with surrounding tissue • proton beams are very/more ionising so cause a lot of damage/more damage to cancerous tissue. Not preferred for tumours deep inside the body because: • they are easily stopped so may not penetrate as far as the tumour • because the beam is very focused/ more ionising it could cause more	To gain full marks reference needs to be made to: • penetration • how much beams spread out and both advantages and disadvantages need to be covered.	4	

	damage to the tissue it passes through than X-rays would (even though most energy is deposited at the required depth).			
6 (d) (ii)	The fetus can be damaged by ionising radiation/ X-rays/ proton beams.	'could harm the fetus' is insufficient – need some reference to the use of ionising radiation/X-rays/proton beams.	1	
Total			**14**	