A-LEVEL
APPLIED SCIENCE

SC08 Medical Physics
Mark scheme

8770
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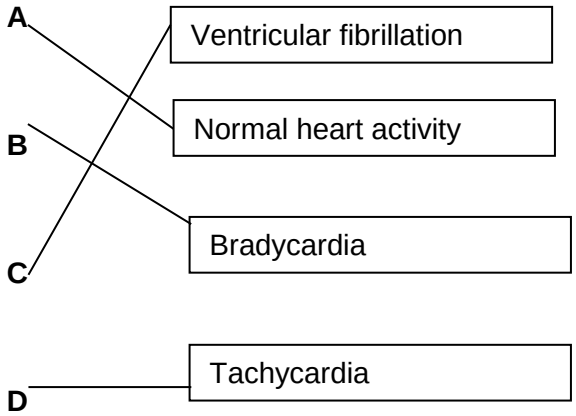
Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this 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	Part	Sub-part	Marking guidance	AO	Mark	Comment
1	(a)		To improve contact / conductivity Electrical conductivity	AO1 AO1	2	Mention of reducing reflections negates both marks. Ignore references to interference.
1	(b)	(i)	Theta	AO1	1	c.a.o
1	(b)	(ii)	Normal consciousness / mental activity	AO1	1	Accept 'awake' or 'conscious'. Ignore 'relaxed'.
1	(b)	(iii)	(Deep) sleep	AO1	1	Relaxation is insufficient.
1	(c)	(i)		AO1 × 3	3	All correct = 3 2 or 3 correct = 2 1 correct = 1
1	(c)	(ii)	**B** Slower than normal heartbeat (is a symptom of hypothermia) / hypothermia reduces heart rate.	AO2 AO2	2	For first point, do not accept bradycardia if identified wrongly on above otherwise accept.
1	(c)	(iii)	32	AO1	1	c.a.o.

Total 11 marks

2	(a)		The time taken for half the sample to decay / activity to halve / count-rate to halve (or w.t.t.e)	AO1	1	Accept 'Time taken for isotope to halve'. Do not accept 'Time taken for an atom. a nucleus (or 'a nuclei' , as some candidates write) to halve.

2	(b)	(i)	The marking scheme for this part of the question includes an assessment of the Quality of Written Communication (QWC). There are no discrete marks for the assessment of written communication but QWC will be one of the criteria used to assign the answer to an appropriate level below.	AO3 x5	5	Basic spelling, punctuation and grammar checks – full stops and capital letters used appropriately are expected for high marks to be awarded, as is a logical structure to the answer. Diagrams may be used to aid communication.

Level	**Marks**	**Descriptor** An answer will be expected to meet most of the criteria in the level descriptor
3	4-5	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 minimal repetition or irrelevant points - accurate and clear expression of ideas with only minor errors in the use of technical terms, spelling, punctuation and grammar
2	2-3	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			
			1	0-1	Answer is largely incomplete. It may contain some 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			
					A typical answer would include: *I would need a radiation detector, such as a Geiger counter, a timer and a sample of the radioisotope.* *I would set the Geiger counter up a fixed distance from the sample. I would ensure it was close enough for all the radiation emitted to reach it.* *I would use the Geiger counter for a set period of time, say 1 minute, to measure the initial count–rate emitted from the sample. I would then repeat this at set times.* *I would plot my readings on a graph and use the graph to find out how long it had taken the count-rate to halve.* *I would repeat the whole experiment several times as a check.* *I would also measure the background*			

					radiation and subtract this from my readings.			

2	(b)	(ii)	Any two from: • put the source in a lead lined box when not in use • point the source away from myself and other people • handle the source with tongs • stand behind a lead screen • warning signs / warning others • Use the source for as short a time as possible.	AO3 × 2	2	Ignore: • lead-lined clothing/gloves • working in a lead lined room • wearing a film badge • monitoring the time exposed to the source (insufficient)

2	(b)	(iii)	• Accept any answer between 10 minutes and 1 hour • This will allow enough readings to be taken (within one half-life) (but not so many readings that they become unmanageable) / if longer intervals the source may decay too much (accept decay completely)	AO3 × 2	2	Accept a range within these values

2	(c)	(i)	• The time it takes for half the radioisotope to be removed from the body • Through biological processes / named appropriate biological process (e.g. excretion).	AO1 AO1	2	N.B. this is related to physical movement of the radioisotope out of the body and not decay. Ignore: 'pass through the body' (insufficiently clear).

2	(c)	(ii)	$T_{e=}$ 1.3 days (or 1.33 or 4/3 days) Correct answer alone gains both marks 1 mark compensation for correct equation • $1 / T_e = 1 / T_p + 1 / T_b$ Either of the steps below gains a total of 2 compensation marks • $1 / T_e = 1 / 4 + 1 / 2$ (or decimal equivalent)	AO2 AO2 AO2	3	Accept 1.33 or 4/3 days

			. 1 / T_e = ¾ (or decimal equivalent)			

2	(d)		Gamma Gamma has the greatest penetration	AO2 AO2	2	Must be clear gamma has higher penetration than alpha and beta.

Total 17 marks

3	(a)	(i)	A material that emits radioactivity Accept a material that emits alpha, beta or gamma radiation OR a material that emits alpha, beta and gamma radiation.	AO1	1	'Emits radiation' is insufficient.as is 'emits α' or 'emits β' or 'emits γ' or emits any two of these

3	(a)	(ii)	Something that is put inside the body and left there for a period of time	AO1	1	Something placed inside the body alone is insufficient, there must be the implication that it is staying there for a significant length of time therefore stating a specific time that is less than one week means the mark is not awarded. Accept appropriate specific item, such as 'radioisotope' as an alternative to the more general 'something'. Also accept answers detailing replacement of damaged/missing tissues.

3	(a)	(iii)	Something put inside the body to have its path followed/traced	AO1	1	Accept appropriate specific item, such as 'radioisotope' as an alternative to the more general 'something'. Ignore references to how the tracer is followed and/or detected.

3	(b)	(i)	Any 2 of: • short half-life / half-life is 4 hours • can complete the trace before becoming too weak • person will not remain radioactive for too long Any 2 of: • emits only gamma radiation • can be detected outside the body/ penetrates body / high penetration • will not damage local cells significantly / is least ionising/ is non-ionising	AO2 × 2 AO2 × 2	4	2 marks related to half-life 'active for only 4 hours' / 'will have gone in 8 hours' are not sufficiently correct for MP1 – ignore. 2 marks related to type of radiation emitted Ignore: 'passes through body' / penetrates skin for

						MP 5 Ignore any reference to daughter products for MP 6.
3	(b)	(ii)	• Organ affinity means that the material will accumulate in/ be absorbed by one specific organ / the material will accumulate in the liver. • Therefore may not travel to the organ is being investigated / won't travel around the body/ may accumulate in the wrong area/ may damage the organ it accumulates in.	AO1 AO2	2	Accept 'attracted to' or 'pool in' for accumulation idea. For MP 2, accept 'it may damage the organ it accumulates in' (ie the liver). 'May cause (more) harm' is insufficient unless related to organ in which the material accumulates.
3	(b)	(iii)	Any 2 of: • long half-life/ half-life of 4 years • will remain at high activity level for a long time • patient will not need to have the implant replaced frequently Any 2 of: • emits no gamma / <u>only</u> α and β • will act at site • will be most ionising/ <u>most</u> damaging to cancer cells/ <u>more</u> damaging to cancer cells than gamma would be. • patient will not irradiate others/ can't penetrate out of the body	AO2 × 2 AO2 × 2	4	2 marks related to half-life Ignore (as insufficient) : 'will kill cells for longer' 'gives enough time to treat' 2 marks related to type of radiation emitted For MP 4 Accept: 'can't penetrate the skin' Ignore any reference to daughter products. Reference to 'passing through the body' is insufficiently correct – ignore.
3	(b)	(iv)	Poisonous	AO1	1	'Harmful' is insufficient – the idea of poison/poisoning needed.
3	(b)	(v)	**A**	AO2	1	cao

Total 15 marks

4	(a)	(i)	• Fewer tissues/ less tissue between the probe and the heart • Fewer changes of density • Fewer reflections from other tissues/ less attenuation	AO2 AO2 AO2	3	For MP1 accept: 'closer to the heart' 'don't have to penetrate skin' For MP3 'transmit better' and 'signals will be stronger' are insufficient – ignore.

4	(a)	(ii)	The marking scheme for this part of the question includes an assessment of the Quality of Written Communication (QWC). There are no discrete marks for the assessment of written communication but QWC will be one of the criteria used to assign the answer to an appropriate level below.			AO2 × 5	5
			Level	**Marks**	**Descriptor** An answer will be expected to meet most of the criteria in the level descriptor		
			3	4-5	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 minimal repetition or irrelevant points - accurate and clear expression of ideas with only minor errors in the use of technical terms, spelling, punctuation and grammar		
			2	2-3	Answer has some omissions but is generally supported by some of the relevant points below - the argument shows some attempt at structure		

Basic spelling, punctuation and grammar checks – full stops and capital letters used appropriately are expected for high marks to be awarded, as is a logical structure to the answer.
Diagrams may be used to aid communication.

					- the ideas are expressed with reasonable clarity - but with a few errors in the use of technical terms spelling, punctuation and grammar			
			1	0-1	Answer is largely incomplete, it may contain some 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			
					A typical answer might include: The disadvantages of transoesophageal echocardiogram include: • more invasive therefore more chance of infection or scarring • more uncomfortable as tube has to be inserted into oesophagus • more anxiety created as tube has to be swallowed • increased risk due to use of sedative and local anaesthetic. ***If the patient is a young child, they are likely to find it difficult to remain still for a long time so it may be more difficult to use the internal echocardiogram method***			

					with them than with adults. On the other hand, they may need to be sedated anyway even if the basic external method were used.			

4	(b)	(i)	Any 2 of: • ionising (radiation) • high frequency / high energy(electromagnetic) (radiation) • damages / mutates cells / DNA	AO1 × 2	2	For MP3 ‘tissue’ is insufficient - ignore

4	(b)	(ii)	Any of: • Suitable precaution relating to avoiding exposure to unnecessary parts of the body (e.g. cover with lead lined blanket) • Suitable precaution related to minimising exposure dosage (e.g. using for as short a time as possible, monitoring cumulative exposure, using as low a dose as possible) • Checking for possible pregnancy Related reason, e.g: • Avoiding areas being exposed unnecessarily / X-rays cannot penetrate lead • Reducing the dose received/ damage (may be) related to the dose received • X-rays are known to harm a foetus	AO1 AO2	2	Note, this refers to risk to the patient not the radiographer Ignore: ‘lead lined clothes’ ‘cover areas that don’t need to be exposed’ (unless a suitable covering material, i.e.lead, is stated).

4	(b)	(iii)	• Heart is soft tissue / low density/ not dense enough • Unable to absorb X-rays well/ X-rays penetrate the heart/ X-rays penetrate soft tissue • Density difference between heart and surrounding tissue too low to differentiate/ X-rays use differential	AO2 × 3	3	‘tissue’ is not sufficient for ‘soft tissue’ Any indication that X-rays reflect from dense materials or that X-ray images are produced through reflection

			absorption.			negates MP2.

4	(c)	(i)	6.6×10^4 / 66000 (Hz) gains **both** marks 1 compensation mark for **any one** of: • correct equation • correct substitution • 6.6 with wrong power of 10	AO2 × 2	2	Allow MP1 if equation originally correctly stated but then re-arranged incorrectly.

4	(c)	(ii)	No (no mark) <u>Frequency</u> is below that required for ultrasound Accept ultrasound waves have a minimum frequency of 20 kHz	AO2	1	Accept: Ultrasound is above 20 kHz Ignore 'Ultrasound is 20 kHz' Ignore 'Above normal hearing' unless frequency or 20 kHz is specified.

Total 18 marks

5	(a)		Any 4 of: • High refractive index means light will change direction through a bigger angle / the light will refract more • Optical fibres rely on total internal reflection. • High refractive index gives small critical angle • Rays have to hit the boundary at an angle greater than the critical angle to (totally) internally reflect • The lower the critical angle, the more rays will hit the boundary at an angle greater than the critical angle/ the greater the range of angles that will reflect. • The lower the critical angle/ the higher the refractive index, the more rays will reflect • Lower critical angle/ higher refractive index means more light is transmitted/less light escapes.	AO2 × 4	4	MP1 – ignore 'more light will refract' MP2 – need the idea that TIR is essential so just mentioning TIR is insufficient.

5	(b)		Any 2 reasonable precautions with matching explanations e.g. • Use large angles of incidence • which lowers the (percentage) error • Work in dark surroundings • which makes rays easier to see • Repeat readings and take an average/ at **many** different angles/ and check results are all in agreement • avoids problems with anomalous results • Use narrow rays of light • less chance of inaccurate marking of the ray's path/ easier to mark the centre of the beam.	AO3 × 4	4	Explanations must match precautions Precautions: 'Ensure the glass is clean' is insufficient – ignore Explanations: 'avoids human error' is insufficient – ignore

			• Use more precise scales • Don't have to estimate between scale divisions • Use (more) precise scales			
5	(c)	(i)	• Large, even scales with graph plotted the right way round • All points plotted correctly • Correct straight line of best fit through the origin	AO2 AO2 AO2	3	MP3 – needs to be straight by eye – use of ruler expected. Needs to pass through the origin correct to within one small square. MP3 can still be awarded if MP1 and/or MP2 are not – as long as the scales are even.
5	(c)	(ii)	(Directly) **proportional** 'positive correlation', 'as one increases so does the other' or similar imprecise answers are insufficient.	AO2	1	
5	(c)	(iii)	sin *i* = 0.6 and/or sin *r* = 0.44 because it is not on the line of best fit.	AO3	1	Both the correct point identified and the reason are required for the mark No e.c.f as can also be identified from the table.
5	(c)	(iv)	1.5 gains both marks Allow **1** mark compensation for correct equation or correct substitution	AO2 × 2	2	
5	(c)	(v)	Work out the gradient	AO2	1	Idea of gradient of line needed – accept 'slope'.
5	(d)		38.7 (º) gains all 3 marks (allow 39 or 38.68)	AO2	3	

			If 3 marks not achieved then 2 marks can be gained for: • sin c = 0.625 • $c = \sin^{-1} 0.625$ • 38.6 If 2 marks not achieved then1 mark can be gained for: • sin c = 1 / n • sin c = 1 / 1.6	× 3		

Total 19 marks

Question	AO1	AO2	AO3	Total
1	9	2		**11**
2	3	5	9	**17**
3	5	10		**15**
4	3	15		**18**
5		14	5	**19**
Total	**20**	**46**	**14**	**80**