Version 1.0

General Certificate of Education (A-level) Applied
June 2011

Applied Science SC08

(Specification 8771/8773/8776/8777/8779)

Unit 8: Medical Physics

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner 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 examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

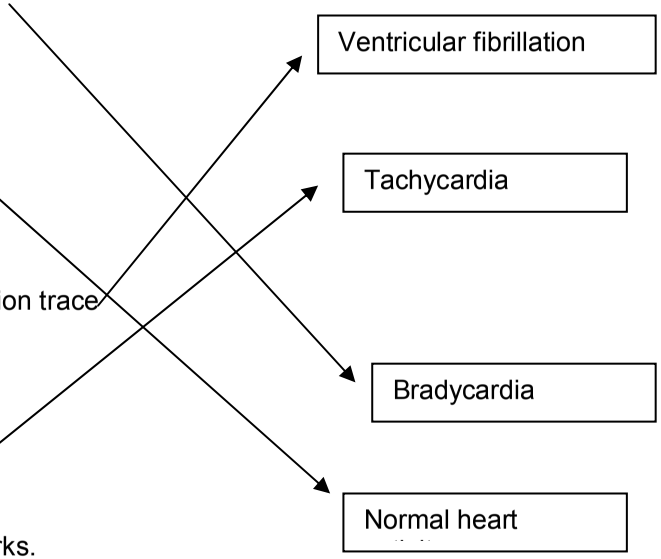
It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment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

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX.

Question 1

1 a	Bradycardia trace Normal trace Ventricular fibrillation trace Tachycardia trace  4 correct for 3 marks. 2 correct for 2 marks 1 correct for 1 mark If only 3 lines drawn and all correct then 2 marks awarded	AO1 x 3	3

1b	• 60-80 (bpm) (allow any single figure within this range or any range within this range). Penalise if wrong unit given e.g. bps.	AO1	1
1c (i)	• Blood pressure	AO1	1
1c (ii)	• Anything to do with breathing/lung function	AO1	1
1c (iii)	• Brain (function)	AO1	1

Total Mark: 7

Question 2

2a	• High frequency/high energy/short wavelength/ionising • Electromagnetic waves/rays/radiation.	AO1 x 2	2
2b(i)	From the top left: • Lead (casing) • Vacuum /evacuated glass tube • Cathode / electron gun / emitter (filament is insufficient)	AO1 x 3	3
2b(ii)	• Electrons (not X-rays) do not keep hitting the same part (of the anode)	AO1	1
2b(iii)	• Radiation / infra-red (rays). • This is the only way that heat can travel through a vacuum / there is a vacuum inside the tube.	AO2	2

Total Mark: 8

Question 3

3a	• To find out what is wrong / what disease the patient has (or wtte).	AO1	1
3b(i)	Any one of: • Using lowest (effective) dose • Shielding parts that are not being photographed • Lowest (effective) time of exposure • Checking whether patient is pregnant (or similar).	AO1	1
3b(ii)	Any one of: • Wearing lead lined apron / shielding clothing (protective clothing is insufficient) • Using a lead lined screen • Leaving the treatment area • Operating the machine remotely. Allow other reasonable precautions e.g. film badge	AO1	1

3b(iii)	Any one of: • Cancer • Radiation burns • Radiation sickness/radiation poisoning • Genetic disorders • Damage to foetus (accept death of foetus) • Cell mutation/ionisation • Damage to reproductive organs / infertility (accept other relevant answers)	AO1	1

3b(iv)	• *Stochastic* – there is no threshold dose for damage to occur / extent of damage does not depend on dose /random / probability of damage depends on dose • *Somatic* – not hereditary / (only) the person exposed suffers the damage	AO1 x 2	2

3c(i)	• Clear picture / large difference between different areas of the image (or wtte).	AO1	1

3c(ii)	• Contrast depends on density difference / difference in attenuation • Bones have high density / soft tissue has low density • Bones/high density tissues attenuate X-rays (much more) strongly than soft / low density tissues)	AO2 x 3	3

3(d)	Any 4 points BUT to get full marks both advantages and disadvantages of CAT scans must be considered i.e. max 3 for advantages, max 3 for disadvantages, max 4 in total: Advantages of CAT scans: • CAT scans would show up soft tissue damage • CAT scans can give 3D views Disadvantages of CAT scans • Much higher doses of X-rays used • CAT scans take much longer • Fewer patients can be diagnosed in a given time • CAT scans are <u>much</u> more expensive/very expensive • Fewer CAT scanners available c.f. X-ray machine Summary point: • No benefit in using CAT scans if injury is to bones / using CAT scans would be beneficial if injury was to soft tissue • Other valid advantages, disadvantages and summary points accepted Ignore any reference to claustrophobia	AO2 x 4	4

Total Mark: 14

Question 4

4a(i)	• The time it takes for half the radioactive nuclei present to decay / time it takes for activity to halve (or wtte).	AO1	1

4a(ii)	0.25 (g) gains the full 2 marks. One mark penalty if incorrect unit stated. Compensation mark – correct iterative method OR recognition of 4 half lives gains a maximum of 1 compensation mark.	AO2 x 2	2

4a(iii)	• Reason E.g. short half-life / no need for storage space / less hazardous. Matching explanation. E.g. activity drops quickly / would become too 'weak to use' quickly / as would need protection when stored. Reference to cost or waste accepted only if linked to decay	AO2 x 2	2

4b	Tracer (no mark) • Long enough half-life to carry out the trace / not long enough for implant to work • Would reach a safe level of activity quickly / implants need a long time to kill cancer cells/ if used as an implant it would have to be changed frequently.	AO2 x 2	2

4c	• Only gamma radiation can penetrate out of the body • Has to penetrate out of the body to be detected • Gamma is less damaging to cells/ gamma is less ionising/ alpha and beta are more damaging to cells/ alpha and beta are more ionising. (accept 'alpha' or 'beta' instead of 'alpha and beta')	AO2 x 3	3

4d	• Sensible reason (x2) e.g. organ affinity toxicity physical state/phase (accept cost or availability). • Matching explanation (x2) e.g. may be absorbed by an organ other than that to be investigated may poison the patient may not be easy to administer to patient (accept far more expensive than alternatives / very difficult to obtain so not likely to be available when needed). Other sensible reasons with matching explanations accepted.	AO2 x 4	4

Total Mark: 14

Question 5

5a(i)	• More closely targeted to tumour / radiation does not have to pass through healthy tissue to reach tumour / no radioactivity involved. • More chance of damaging cancer cells / less chance of damaging healthy tissue / radiation used is thought to be safe unlike radioactivity.	AO2 x 2	2

5a(ii)	• No radioactivity involved / treatment completed more quickly • radiation used is thought to be safe unlike radioactivity / implants need to be in place for several weeks/months • (Explanation must match reason. Do not award marks twice for the same answers in both parts (i) and (ii))	AO2 x 2	2

5a(iii)	• No need for surgery / just an injection / less invasive • Less chance of scarring / bleeding / infection / needing a long recovery time.	AO2 x 2	2

5b	• Nothing is physically inserted into the body (or wtte).	AO2	1

Total Mark: 7

Question 6

<table>
<tr>
<td>6a</td>
<td>
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.
<table>
<tr><th>Level</th><th>Mark</th><th>Descriptor

An answer will be expected to meet most of the criteria in the level descriptor.</th></tr>
<tr><td>3</td><td>4-5</td><td>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.</td></tr>
<tr><td>2</td><td>2-3</td><td>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</td></tr>
<tr><td>1</td><td>0-1</td><td>- answer is largely incomplete and 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.</td></tr>
<tr><td></td><td></td><td>An example of the type of answer that may be produced would be:

I would need to have the following equipment available:
• Geiger–Muller tube and counter / radiation detector
• Selection of metal and plastic shields and a shield holder
• Tongs
• Radioisotope (source) to be tested housed in a safe container.</td></tr>
</table>
</td>
<td></td>
<td>AO3 x 5</td>
<td>5</td>
</tr>
</table>

	To carry out the experiment I would place the radioisotope in a set position. I would then place the radiation detector 1 or 2 cm away from the radioisotope and measure the count rate. To test if it emitted alpha radiation I would then move the detector to 5 cm away from the source and see if the count rate changed. If the count rate dropped I would know that some alpha radiation was being emitted. I would then place the detector about 30 cm away from the source and take a reading of the count rate. Next I would place a thin aluminium shield between the source and the detector. If the count rate dropped further then I would know that beta radiation was emitted. If the drop was small I would repeat this with slightly thicker aluminium and if the count rate now dropped I would be quite sure that some beta radiation was being emitted. To check if any gamma radiation was emitted I would place a lead shield between the source and the detector. If any radiation got through the lead shield then I would know that some gamma radiation was being emitted. By looking at the results of all these tests I would know which types of radiation were being emitted.		

6b	• Background radiation • Take a reading of background radiation before starting (and subtract this from all other readings taken). (allow removal of other sources) OR • Very short half life / source decays too quickly • Recording the intervals between readings and calculating the count rate expected at the time of each reading if not reduced by air or the presence of the shield.	AO3 x 2	2

6c	Any two of: • Return source to box when not in use • Handle source with tongs • Do not point the source towards anyone Sensible alternatives accepted. Do not accept any unrealistic suggestion e.g. carrying out the experiment in a lead lined room, wearing lead clothing -apart from apron- or wearing a film badge.	AO3 x 2	2

Total Mark: 9

Question 7

7a	• The angle of incidence for which the angle of refraction is 90° (accept the smallest angle of incidence for which total internal reflection will occur – or wtte)	AO1	1

7b	53.13° / 53° /53.1° gains full 3 marks (no unit penalty). One compensation mark for : Correct equation sin c = 1/n Correct substitution e.g. sin c = 1/1.25 Correct calculation sin c = 0.8 (gains 2 marks) Correct re-arrangement e.g. $\sin^{-1}c = n$ To a maximum of 2 compensation marks.	AO2 x 3	3

7c	• All rays at an angle greater than the critical angle will be (totally internally) reflected • (small critical angle means) rays at a greater range of angles will be totally internally reflected/ more chance of TIR/ more angles reflected • More light will travel along the endoscope / less light lost / more light reflected / less of a problem if the endoscope is bent sharply/ low c means high n/ total internal reflection is required.	AO2 x 3	3

7d(i)	• To prevent light leaving through the sides of the fibre/entering other fibres/ to reduce c/ to help TIR occur.	AO1	1

7d(ii)	• (slightly) lower.	AO1	1

7e(i)	• Through the mouth and swallowed / keyhole surgery (allow via the rectum) Reference to trachea negates.	AO1	1

7e(ii)	• Sensible method chosen e.g. thermography CAT scan MRI scan Ultrasound (do not accept X-ray or radioactive tracer) (Allow surgery but not keyhole surgery) • Matching reason why endoscopy would be preferred e.g. direct view – not interpreting an image that doesn't look like the real thing thermography may be affected by heat produced whilst digesting can view from all angles more easily than any other method. Other sensible reasons accepted.	AO2 x 2	2

Total Mark: 12

Question 8

8a	• (Longitudinal) wave/sound • Frequency above 20 kHz / frequency above human hearing range.	AO1 x 2	2

8b(i)	• Material / gel used between the body and electrodes OR material / gel with an acoustic impedance similar to that of skin. Allow gel applied to skin or material used to improve contact.	AO1	1

8b(ii)	• To reduce reflections at the skin / to improve transmission of sound/ to reduce the difference in acoustic impedance/ to remove air • Any implication of electrical conductivity negates.	AO1	1

<table>
<tr>
<td>8c</td>
<td>
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.
<table>
<tr><th>Level</th><th>Mark</th><th>Descriptor

An answer will be expected to meet most of the criteria in the level descriptor.</th></tr>
<tr><td>3</td><td>4-5</td><td>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.</td></tr>
<tr><td>2</td><td>2-3</td><td>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.</td></tr>
<tr><td>1</td><td>0-1</td><td>- 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.</td></tr>
</table>
</td>
<td>AO2 x 5</td>
<td>5</td>
</tr>
</table>

			An example of the type of answer that may be produced would be: When the sound waves hit boundaries between tissues with different densities (or different acoustic impedances) the sound waves are reflected. The intensity of the reflections depends on the differences in density or acoustic impedance. The greater the difference, the greater the proportion of ultrasound waves that are reflected. This means that different strength reflections are received from different types of tissues. The time it takes for the waves to reflect depends on how far they have had to travel so this indicates where in the body the sound waves have hit a boundary. The reflected waves travel back to a receiver and onto a computer which then interprets the signals it receives, taking into account the time it has taken to receive the reflection and the intensity of the reflections. The signals are converted into an image that can be viewed on a screen.		

Total Mark: 9

UMS conversion calculator: www.aqa.org.uk/umsconversion