Rewarding Learning

ADVANCED
General Certificate of Education
2019

Life and Health Sciences

Assessment Unit A2 3

assessing

Medical Physics

[AZ031]

FRIDAY 31 MAY, AFTERNOON

MARK SCHEME

Foreword

Introduction

Mark Schemes are published to assist teachers and students in the preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of 16–18-year-old students in schools and colleges. The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes therefore are regarded as a part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

1 **(i)** Used to produce an image of organ [1]

(ii) **Indicative Content**

- It emits gamma radiation (only)
- It has *high penetration* power/can penetrate through body
- Weakly ionising/least ionising radiation
- It can be incorporated into a range of biologically-active substances
- Low risks/similar radiation dose as conventional X-ray/radiation exposure low
- No discomfort to patient (other than injection)/no need for surgery/less invasive
- Shows metabolic activity/organ activity/body function/uptake by organ
- Short radioactive half-life/decays rapidly or half-life 6hrs/equivalent
- Short biological half-life/quickly removed from body
- Will need to avoid (ill) persons/pregnant women/children for a short time after procedure/wait hours before leaving
- cell damage/risk of cancer [8]

Response	**Mark**
Candidate identifies and describes 7 or more of the points shown in the indicative content. There is a widespread and accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are excellent. Candidates use the most appropriate form and style of writing. Relevant material is highly organised with clarity and coherency.	**[7]–[8]**
Candidate identifies and describes between 5 and 6 of the points shown in the indicative content. There is accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar is very good. Candidates use the most appropriate form and style of writing. Relevant material is well organised with clarity and coherency.	**[5]–[6]**
Candidate clearly identifies between 3 and 4 of the points shown in the indicative content. There is some use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are sufficient to make the meaning clear. Candidates use an appropriate form and style of writing. There is some attempt to organise material.	**[3]–[4]**
Candidates clearly identify 2 of the points shown in the indicative content. There is limited reference to scientific terminology. Presentation, spelling, punctuation and grammar may contain some errors. The form and style are of a satisfactory standard. There is only a limited attempt to organise material.	**[1]–[2]**
Response is not worthy of credit	**[0]**

AVAILABLE MARKS

9

						AVAILABLE MARKS
2	**(a)**		Radiation causes ionisation	[1]		
			Leading to cancer/death/kills cells/disrupts DNA	[1]	[2]	
	(b)	**(i)**	$T_{Physical}$ – no effect	[1]		
			Radioactive half-life cannot be changed by external factors	[1]		
			$T_{Biological}$: Remains in body/is not removed/is not excreted	[1]		
			Increases biological half-life	[1]	[4]	
		(ii)	$\left(\frac{1}{T} =\right) \frac{1}{1.1 \times 10^4} + \frac{1}{1.8 \times 10^4}$	[1]		
			$\left(\frac{1}{T} = \right) 1.46 \times 10^{-4}$ (days^{-1}) or $\frac{29}{198000}$	[1]		
			T_{Sr} = 6830 days (to 3sf)	[1]	[3]	
		(iii)	Phosphorus (^{32}P) – threshold	[1]		
			Phosphorus has a shorter biological half-life/effective half-life	[1]		
			So it is removed from the body faster/reduce radiation exposure	[1]	[3]	12
3	**(a)**	**(i)**	37 ± 0.5		[1]	
		(ii)	Upper temperature = 41–45 °C	[1]		
			Lower temperature = 24–28 °C	[1]	[2]	

(b) (i)

Type of Thermometer	Method of use	Limitations
Mercury in glass thermometer	Placed under tongue/ arm/rectal (and temperature read from a scale)	Human error in interpreting scale/ difficult to read/Very long wait – not always possible with children Can't take temperature orally after eating/drinking
Digital thermometer	Sensor under tongue/ under arm/rectal and digital reading	Keep mouth closed – not always possible with children Can't take temperature orally after eating/drinking
Electronic thermometer	Place sensor in ear And digital reading displayed	Ear wax can interfere with accuracy Most expensive Ear swelling/infection can interfere with accuracy

[6]

(ii) Mercury poisoning/glass shattering/breakable/toxic [1] 10

AVAILABLE MARKS

4 (a) (i)
- Identify a pulse (by place fingers) (not thumb) on neck or wrist [1]
- Count (the number of pulses) [1]
- indicate time taken (⩾ 15 seconds) [for accuracy] [1]
- Indicate how to convert to pulses per minute [1]
- Repeat experiment/and average results [for reliability] [1] [5]

(ii) athlete/very fit/healthy/genetic [1]

(b) (i) Damage to heart/atrial or ventricular fibrillation/enlarged heart/angina/if patient is having (or had) a heart attack/fast/slow heart rhythm/monitor effects of medicines/thickening of heart muscle (due to high blood pressure)
(Any **two**) [2]

(ii) Any **two** from:
Heart may not be behaving abnormally during test
Any observed abnormalities may not be genetic/long QT
White coat syndrome/stress during test/drugs/caffeine [2] 10

5 (a) (i)

Properties
Cause ionisation of matter
Can travel in a vacuum
Part of the electromagnetic spectrum

[1] each, [–1] for each extra tick [3]

(ii)
- Electrons produced by heating wire/filament/cathode
- Electrons accelerated (by high PD)/attracted by positive charge or anode
- Travel at high speeds
- In a vacuum
- Strike the target/tungsten/anode
- X-rays produced at anode or X-rays produced when e^- strike anode/target **or** X-rays produced when e^- decelerate
- Anode/target rotates/oil cooled to dissipate heat
- Aluminium shielding to remove soft X-rays **or** Lead shielding

([1] each, Any **six** for full marks) [6]

(b) (i) Similarity
Both form *shadow* image [1]
Difference
Conventional X-ray is 2D image whereas CT scan is 3D (series of 2D slices to form 3D) image
CT scans give more detailed image [1] [2]

(ii) Conventional X-ray emitter and detector are stationary [1]
CT scan emitter and/or detector rotate around patient [1]
CT bigger dose than X-ray [2]

(iii) Reduce the risk of damage to ((reproductive) organs)
Reduced exposure
Prevent ionisation [1] 14

						AVAILABLE MARKS
6	**(a)**	**(i)**	1 decay **or** disintegration per second		[1]	
		(ii)	295 [1] 295/120 [1] **or** 295/2 = 1475 or 148 [1] 2.46 [1]		[3]	
		(iii)	Counts observed when no source is present		[1]	
		(iv)	2.09 Bq ecf from **(ii)**		[1]	
	(b)	**(i)**	$T_{\frac{1}{2}} = 0.693/\lambda$	[1]		
			$T_{\frac{1}{2}} = 6678720$ s	[1]		
			$\lambda = 0.693/6678720$ or $\lambda = 1.038 \times 10^{-7}$ $T_{\frac{1}{2}} = 0.693/1.04 \times 10^{-8}$	[1]	[3]	
			= 6663462s = 6663462/86400 = 77.3 days			
		(ii)	$A = A_o e^{-\lambda t}$	[1]		
			Sub $A_o = 85.4$ and $\lambda = 1.038 \times 10^{-7}$ or 1.4×10^{-7}	[1]		
			Sub t = 8640000 [$\lambda t = 0.899$]	[1]		
			A = 34.8 Bq	[1]	[4]	13
			Allow ecf with their subs			
7	**(a)**	**(i)**	Sounds (with frequencies) *greater* ⩾ **or** > than 20 **kHz** **or** 20 000 Hz		[1]	
		(ii)	Ultrasound (pulse) transmitted into body and	[1]		
			Reflected at the boundaries between different densities or organs	[1]	[2]	
	(b)	**(i)**	7–18 MHz (both limits required, unit required)		[1]	
		(ii)	Any **two** from: Provides more detail/clearer image Change in density between tissues is small Deep penetration not required/tissues on the surface		[2]	
		(iii)	Too much absorption (of energy)/poor penetration **or** low frequencies for greater penetration		[1]	
		(iv)	Prevent (large amounts of energy) reflection (at skin surface) Allows sound waves to penetrate skin/improves transmission		[1]	
	(c)	**(i)**	Magnetic Resonance Imaging		[1]	
		(ii)	Radio (waves)		[1]	
		(iii)	**Large** magnetic field or **strong** magnet or strong B-field may	[1]		
			disrupt/break/damage the pacemaker	[1]	[2]	
		(iv)	They move too much/cannot stay still/takes a long time		[1]	13

				AVAILABLE MARKS
8 **(a)** $z = \rho v$		[1]		
$v = 1500\ m\ s^{-1}$		[1]		
$\rho = 1630 \times 10^3/1500$	[10^n error deduct [1]]	[1]		
$\rho = 1087\ kg\ m^{-3}$ Accept 1050–1100		[1]	[4]	
(b) **(i)** $(R =)\left(\frac{z_2 - z_1}{z_2 + z_1}\right)^2$	**or** $\frac{(z_1 - z_2)^2}{(z_2 + z_1)^2}$	[1]		
$(R =)\left(\frac{1.70 \times 10^6 - 1.38 \times 10^6}{1.70 \times 10^6 + 1.38 \times 10^6}\right)^2$		[1]		
(R =) 0.0108 **or** 0.01079 **or** 0.011		[1]	[3]	
(ii) Bone } threshold for 3rd point		[1]		
Fat		[1]		
This produces the largest intensity reflection coefficient or biggest value of R		[1]	[3]	
(iii) Heat			[1]	
(c) **(i)** A-scan (1-dimensional scan) – amplitude vs time trace/amplitude scan		[1]		
B-scan (2-dimensional scan) – brightness scan/image observed/brightness scan		[1]	[2]	
(ii) B-scan			[1]	
(iii) Either:				
$d = \frac{vt}{2}$		[2]		
$60\ \mu s = 60 \times 10^{-6}$ (credit if seen anywhere)		[1]		
$= \frac{1500 \times 60 \times 10^{-6}}{2}$		[1]		
= 0.045 10^n error – deduct [1]		[1]		
or				
$d = vt$		[1]		
$= 1500 \times 60 \times 10^{-6}$		[2]		
= 0.09		[1]		
$\therefore$ diameter $= \frac{0.09}{2} = 0.045$ – 10^n error deduct [1]		[1]	[5]	19
			Total	**100**