Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2017

Physics

Assessment Unit AS 2
assessing
Module 2: Waves, Photons and Medical Physics

[AY121]

THURSDAY 8 JUNE, AFTERNOON

MARK SCHEME

Subject-specific Instructions

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer. A correct answer and unit, if obtained from a valid starting-point, gets full credit, even if all the intermediate steps are not shown. It is not necessary to quote correct units for intermediate numerical quantities.

Note that this “correct answer” rule does not apply for formal proofs and derivations, which must be valid in all stages to obtain full credit.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, **in a physically incorrect equation**. However, answers to subsequent stages of questions that are consistent with an earlier incorrect numerical answer, and are based on a physically correct equation, must gain full credit. Designate this by writing **ECF** (Error Carried Forward) by your text marks.

The normal penalty for an arithmetical and/or unit error is to lose the mark(s) for the answer/unit line. Substitution errors lose both the substitution and answer marks, but 10^n errors (e.g. writing 550 nm as 550×10^{-6} m) count only as arithmetical slips and lose the answer mark.

					AVAILABLE MARKS
1	**(a)**	**(i)**	$v = f\lambda$	[1]	
			6 m – 0.03 m	[1] [2]	
		(ii)	Microwaves	[1]	
	(b)	**(i)**	$T = 5 \times 10^{-9}$ s	[1]	
			f = 200 MHz which is within range of detection (ecf T)	[1] [2]	
		(ii)	I = 3.0 or 3.1	[1]	
			75%–78% (ecf from incorrect reading of graph)	[1] [2]	7
2	**(a)**		Get series of i and r values ⩾ 4 more sets	[1]	
			Sin i and sin r plotted/calculated	[1]	
			Gradient of sin i against sin r or 1/gradient of sin r against sin i	[1] [3]	
			n determined by calculation, max [2]		
			(penalty –1 if A = i)		
	(b)		n = sin i/sin r	[1]	
			correct subs: 1.36 = sin 30/sin r	[1]	
			22° (allow e.c.f. for angle of incidence)	[1] [3]	6
			(SE 39.6 2/3)		
3	**(a)**		Convex or converging	[1]	
	(b)	**(i)**	Measures height or width of each once correctly	[1]	
			Repeats measurement with different height/width	[1]	
			Magnification 2.9–3.1	[1] [3]	
		(ii)	Calculates v from v = M × 0.080 (or 8)	[1]	
			Subs into lens equation (v negative)	[1]	
			P = 8.3 (D) e.c.f. **(b)(i)**	[1] [3]	
			(SE 16.7 D 2/3)		
	(c)		Object between f and lens	[1]	
			Rays drawn correctly (with at least one arrow + virtual rays dotted)	[1]	
			Image marked	[1]	
			Position of eye	[1] [4]	11
			S.E. Max [2] for wrong lens or object position Marking parts 2 and 3 available		
4	**(a)**	**(i)**	Young's (double) slits	[1]	
		(ii)	Single slit	[1]	
			Laser light is coherent/in phase	[1] [2]	
	(b)	**(i)**	Measure multiple fringe widths and divide by number of fringes	[1]	
		(ii)	Correct subs into $\lambda = \frac{ay}{D}$	[1]	
			6.72×10^{-7}	[1]	
			Conversion to nanometres	[1] [3]	
		(iii)	Increase D to 3.75 m or decrease a to 0.4 mm	[1]	8

						AVAILABLE MARKS
5	(a)		Spreading out of waves	[1]		
			when they pass through a gap or around an obstacle (accept through a slit)	[1]	[2]	
	(b)	(i)	e.g. sound diffracting around corners/through doorways/ loudspeaker openings		[1]	
		(ii)	e.g. water waves diffracting at a jetty/obstacle, radio waves diffracting around hills etc.		[1]	
	(c)		Width of shaded region approximately equal to the wavelength	[1]		
			Wavefronts correct shape	[1]		
			Wavelength same as before gap	[1]	[3]	7
6	(a)		2 to any power	[1]		
			Unit match their answer, e.g. 2 ms cm^{-1}	[1]	[2]	
	(b)	(i)	Won't be heard because it is outside curve or similar reason	[1]		
			Lines drawn up from 100 Hz and across from 20 dB to show	[1]	[2]	
		(ii)	Recall $I_0 = 1 \times 10^{-12}$ W m^{-2}	[1]		
			$20 = 10\log_{10} \frac{I}{1 \times 10^{-12}}$ (ecf I_0)	[1]		
			1×10^{-10}	[1]	[3]	7
7	(a)	(i)	**Rapid** deceleration of electrons passing the **nucleus** results (in photon emission)	[1]		
			Tightly bound/inner/low level electrons being knocked out of the atom by the incident (high-energy) electrons	[1]		
			Subsequent photon emission when electrons in upper states drop down into vacated lower states	[1]	[3]	
		(ii)	e.g. images of any cross section/slices X-ray source/detector move Analysis by computers Higher dose/longer time		[1]	
	(b)	(i)	Other methods give more detailed soft tissue images		[1]	
		(ii)	**Ionizing** radiation could harm the foetus		[1]	6

					AVAILABLE MARKS
8	**(a)**	(**Metal)** illuminated by **electromagnetic** radiation	[1]		
		Electrons emitted (from surface)	[1]		
		Electrons are emitted if the frequency is above threshold/the **photons** of light have more energy than the work function	[1]		
		Increasing the intensity increases the rate of emission	[1]		
		because there are more photons to cause more emissions	[1]		
		freq increased, electrons are released with more (kinetic) energy	[1]	[6]	

Quality of written communication

2 marks
The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling.

1 mark
The candidate expresses ideas clearly, if not always fluently. There are some errors in grammar, punctuation and spelling, but not such as to suggest weakness in these areas.

0 marks
The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2]

	(b)	Evidence of gradient being used or states h = gradient	[1]		
		Realising x-intercept = 6.7×10^{14} Hz	[1]		
		7×10^{-34}	[1]	[3]	11
9	**(a)**	Each frequency corresponds to transition between energy levels	[1]		
		Set of energy levels is unique to each element	[1]	[2]	
	(b)	**(i)** 6		[1]	
		(ii) Chooses correct energy change diff = 0.43 eV	[1]		
		Conversion from eV to J (6.88×10^{-20}J)	[1]		
		Subs into E = hf	[1]		
		2.9×10^{-6} m (ecf from their energy change)	[1]	[4]	7

10 (a)

	Can be explained using wave model	Can be explained using particle model
Diffraction	✓ (given)	
Interference	✓	
Polarization	✓	
Reflection	✓	✓

Wave models all ticked [1]
Particle models, only reflection ticked [1] [2]

(b) (i) (Associated) wavelength is similar to atomic spacing [1]

(ii) $E = hc/\lambda$ and $\lambda = h/mc$ (either c or v) [1]
Evidence of correct rearranging to $E = mc^2$ [1] [2]

AVAILABLE MARKS: 5

Total **75**