Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
January 2014

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

WEDNESDAY 22 JANUARY, 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)	Single or one wavelength/colour/frequency		[1]	
		(ii)	sin i/sin r = n or sin i/sin 26.9 = 1.5 eqn or subs	[1]		
			incident angle, i = 44.2°	[1]		
			σ = 45.8°	[1]	[3]	
	(b)	(i)	The angle of incidence that results in a refraction angle of 90°		[1]	
		(ii)	sin c = 1/n eqn	[1]		
			c = 40.5° ans	[1]		
			θ = 67.4° ans	[1]	[3]	8
2	(a)	(i)	Illuminated object, lens and screen in order (allow plane mirror method)	[1]		
			Metre rule	[1]	[2]	
		(ii)	Any **two** • Adjustment to find sharp image • Measure object and image distance • Change object distance and repeat measurements (not available for plane mirror method)		[2]	
	(b)		m = 2.4/0.4 = 6	[1]		
			v = 6 u	[1]		
			1/6.7 + 1/–40 = 1/f subs e.c.f. (v)	[1]		
			f = 8.0 cm	[1]	[4]	8
3			Polarisation	[1]		
			In **Fig. 3.1** (light from the LCD is transmitted through the lenses) parallel polarising planes	[1]		
			In **Fig. 3.2** (there is complete cancellation) perpendicular planes	[1]		
			Light from the LCD is plane polarised	[1]		
			The lenses are polarising filters	[1]		
			Light behaves as a transverse wave form	[1]	[6]	

Quality of written communication

[2]
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]
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]
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] 8

						AVAILABLE MARKS
4	**(a)**	**(i)**	Constant phase difference		[1]	
		(ii)	Compression/rarefaction emitted from both speakers at the same time **or** suitable alternative (crest or trough gets [0])		[1]	
	(b)	**(i)**	Loud<u>**est**</u>/louder/very loud	[1]		
			Zero path difference/constructive interference/in phase	[1]	[2]	
		(ii)	Volume is (periodically) rising and falling		[1]	
		(iii)	$v = f\lambda$ Eqn	[1]		
			$\lambda = 0.380$ m ans	[1]		
			path diff $= \frac{1}{2}\lambda$	[1]		
			path diff $= 0.190$ m e.c.f. λ ans	[1]	[4]	9
5	**(a)**		Lowest (threshold) **intensity** that a human can detect		[1]	
	(b)	**(i)**	$140 = 10 \lg \left(\frac{I}{1.0 \times 10^{-12}}\right)$ subs	[1]		
			$I = 100$ (W m^{-2})	[1]	[2]	
		(ii)	$I = \left(\frac{100}{4 \times 10^{4}}\right) = 2.5 \times 10^{-3}$	[1]		
			SIL = 94 dB	[1]	[2]	
			SE: 74 dB [1]/[2]			5
6	**(a)**		(For each frequency) resonance tube fully immersed and gradually removed/or moved up and down to get shortest tube length	[1]		
			Until a loud sound is heard	[1]		
			Distance from water surface to top of resonance tube is measured	[1]	[3]	
	(b)	**(i)**	Max uncertainty in frequency is 0.5% (min = 0.2%) or any percentage uncertainty calculated	[1]		
			Metre rule accurate to ± 1 mm hence max uncertainty in length is 7.1% (min = 2.4%) or longer length more accurate	[1]		
			Frequency range better, smaller than that used	[1]	[3]	
		(ii)	Correct description using $v = 4fl$	[1]		
			calculation and average **or** graph and gradient	[1]	[2]	8
7	**(a)**		Nuclei (some) immersed in a (static) magnetic field (allow atoms)	[1]		
			Are polarised/line up/spin/precess	[1]		
			Exposed to radio waves	[1]	[3]	
	(b)		Scanner magnet (allow main)		[1]	
			Superconducting (coils)	[1]	[2]	
	(c)	**(i)**	Strong B-field wipes data on card's magnetic strip		[1]	
		(ii)	Strong B-field and movement causes non-ferrous metal to heat up/eddy currents/it distorts (**not** blocks) the image		[1]	7

					AVAILABLE MARKS
8	**(a)** A particle/packet	[1]			
	of electromagnetic/light energy	[1]	[2]		

(b) The one near the surface has greater KE [1]
(Both electrons receive the same amount of energy AND) deeper one has to use more energy or do more work to escape to the surface [1] [2]

(c) **(i)** 4.2 eV = 6.72×10^{-19} J [1]
E = hf $6.72 \times 10^{-19} = 6.63 \times 10^{-34}$ f Eqn or subs [1]
f = 1.01×10^{15} (Hz) [1] [3]
(SE = 6.33×10^{33} [1] out of [3])

(ii) $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1.01 \times 10^{15}} = 2.97 \times 10^{-7}$ m e.c.f. (f) [1]

297 (nm) [1] [2]

(iii) UV e.c.f. [1] 10

9 **(a)** More electrons/atoms [1]
in the excited state (than in the ground state) [1] [2]

(b) Using the phrase ‘stimulated emission’ or describing it [1]

(c) e.g. CD/DVD players, shop checkouts, laser printers, laser pointers, car parking assist etc [1] 4

10 **(a)** **(i)**

Phenomenon	Wave theory	Particle theory
Diffraction	✓	✗
Photoelectric effect	✗	✓
Polarisation	✓	✗
Reflection	✓	✓

[−1] for each error; assume blank = ✗ [2]

(ii) It contains wavelength, a wave theory term, [1]
and momentum, a particle theory term. [1] [2]

(b) Converts 68 V to 4.9×10^6 m s^{-1} or 5.0×10^6 m s^{-1} [1]

$\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 4.9 \times 10^6}$ subs [1]

Calculates $\lambda = 1.5 \times 10^{-10}$ m e.c.f. minimum data [1]
Molecular separation = 1.5×10^{-10} (m) e.c.f. λ if $\leqslant 10^{-8}$ [1] [4] 8

Total **75**