Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2013

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

THURSDAY 20 JUNE, MORNING

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 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)**	Vibrations at right angles to the direction of the **wave travel**	[1]		
	(b)	**(i)** $\lambda = 6\,(\text{cm})$	[1]		
		(ii) Amplitude = 2.7 (cm)	[1]		
	(c)	**(i)** C	[1]		
		(ii) 270° or 1.5 π (allow 90° or $\frac{\pi}{2}$)	[1]		
	(d)	**(i)** $T = 1/f = \frac{1}{0.2}$	[1]		
		(ii) Cosine wave, with $\geqslant$ 2 cycles	[1]		
		amplitude 2.7 cm, period 5 s, at t = 0 s s = +2.7 cm	[1]	[2]	
	(e)	Polarisation restricts wave vibrations to one **plane**, + e.g. longitudinal waves have vibrations along direction of wave so polariser has no effect	[1]		9
2	**(a)**	The angle of incidence for which the angle of refraction is 90°	[1]		
	(b)	**(i)** Angle of refraction is 90°	[1]		
		Totally internally reflected i = r (ignore arrows)	[1]	[2]	
		(ii) Total internal reflection (TIR)	[1]		
		(iii) (Critical angle measured and) reciprocal of sin C is n or $n = \frac{1}{\sin C}$	[1]		
	(c)	$n = \frac{\sin i}{\sin r}$	[1]		
		subs consistent with ${}_gn_a$ or ${}_an_g$	[1]		
		C = 41°	[1]	[3]	8
		(If 42°: must have evidence of correct processing for > [1])			

						AVAILABLE MARKS
3	**(a)**	**(i)**	Point (on principal axis) where rays **parallel** (to principal) axis converge (after refraction) N.B. principal axis must be mentioned		[1]	
		(ii)	Upright, enlarged, **virtual**		[1]	
	(b)		Object inside F	[1]		
			2 rays used to locate image and image drawn	[2]		
			Eye correctly positioned	[1]		
			Penalty virtual rays not dotted [–1] and/or arrows on rays [–1]			
			S.E. Real image – maximum [2] from both rays + image [1] **and** eye [1]		[4]	
	(c)		$v = (-)2u$ or $\frac{1}{u} - \frac{1}{2u} = \frac{1}{f}$	[1]		
			$u = 6\,cm$	[1]		
			$v = (-)\ 12\ cm$	[1]	[3]	9
4	**(a)**	**(i)**	Single wavelength/frequency	[1]		
			Waves **spread out** (after passing through slits)	[1]		
			(Maintain) constant phase relationship/difference	[1]		
			(Where two waves meet the total displacement is the vector) **sum of the individual displacements**	[1]	[4]	
		(ii)	(Parallel) equi-spaced, alternate bright and dark fringes (**or** by diagram)		[1]	
	(b)		Subs into $\lambda = \frac{ay}{D} = \frac{0.8 \times 10^{-3} \times 0.6 \times 10^{-3}}{75 \times 10^{-2}}$ **or** "64" sig fig in ans	[1]		
			$\lambda = 640\ nm$	[1]		
			orange/red No e.c.f. and dependent on correct λ	[1]	[3]	8
5	**(a)**		Measure length of 1 cycle	[1]		
			Multiply length by time-base setting	[1]		
			Frequency = $\frac{1}{\text{Period}}$	[1]	[3]	
	(b)	**(i)**	$\frac{1}{4}\lambda$ shown, node on water surface		[1]	
		(ii)	$\frac{3}{4}\lambda$ shown, 2nd node $> \frac{l_2}{2}$ above water surface		[1]	
		(iii)	$(\lambda = v/f = 345/295) = 1.17\ (m)$		[1]	
		(iv)	e.c.f. for λ and **b(i)** and **b(ii)**			
			$l_1 = \lambda/4 = 0.293\ (m)$	[1]		
			$l_2 = 3\lambda/4 = 0.879\ (m)$	[1]	[2]	8

AVAILABLE MARKS

6 **(a)** Non-invasive,
(patient does not need to recover from operation) [1]
Is not in as much danger from infection or anaesthetic [1] [2]

(b) **(i)** Non-coherent bundle
of optical fibres (delivers light to area) [1]

(ii) Coherent bundle [1]
of **multiple fibres** transmits image (via t.i.r.) **or** a description
of what "coherent" means here [1] [2]

(c) **(i)** Echo (from internal structure) [1]
Conversion to an electrical signal [1] [2]

(ii)
- Amplitude v Brightness
- Static probe v moving probe
- Depth determination v picture

Any **two** [2]

(iii) **Couples** transducer to skin avoiding **excess reflection** of signal at **air–skin boundary** [1]
Both points required

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. Arguments may sometimes stray from the point. There are some errors in grammar, punctuation and spelling, but not such as to suggest a 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]

(d) X-ray [1]
Radio [1] [2] 14

					AVAILABLE MARKS
7	**(i)**	Energy must be supplied to free electron or ionize atom	[1]		
		(Stationary) free electron has zero energy	[1]	[2]	
	(ii)	Atom has fixed energy levels that electrons fall between	[1]		
		$E = hf$ or $E \propto f$	[1]	[2]	
	(iii)	10		[1]	
	(iv)	13.6 eV		[1]	
	(v)	Subtraction of energy levels + choice of 10.2 eV	[1]		
		$eV \rightarrow J$	[1]		
		Subs into $E = hc/\lambda$	[1]		
		Answer (122 nm)	[1]	[4]	10
		(S.E. wrong stage chosen maximum [3]/[4])			
8	**(a)**	**(i)** Diffraction **or** polarisation **or** refraction **or** interference		[1]	
		(ii) Photoelectric effect		[1]	
		(iii) **Moving particles** have wavelike nature **or** associated wavelength		[1]	
		(iv) Inverse curve, asymptotic with both axes		[1]	
	(b)	Pattern of **concentric** (bright and dark) fringes	[1]		
		(As electron energy increased) diameter of circles decreases	[1]	[2]	
	(c)	**(i)** Momentum $(= 6.63 \times 10^{-34}/1.51 \times 10^{-10}) = 4.39 \times 10^{-24}$ (kg m s^{-1})		[1]	
		(ii) $KE = 0.5 \times 9.11 \times 10^{-31} \times (4.39 \times 10^{-24}/9.11 \times 10^{-31})^2 = 1.06 \times 10^{-17}$(J)			
		e.c.f Subs [1] Ans [1]		[2]	9
				Total	**75**