Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2019

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[SPH21]

FRIDAY 17 MAY, 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 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)**	0.087	[1]		
	(b)	0.087 = Δλ/486 ecf **(a)**	[1]		
		Δλ = 42 nm	[1]		
		528 nm	[1]	[3]	4
		SE: 444 [2]/[3], 532 [2]/[3], 447 [1]/[3]			
2	**(a)**	At the boundary between two media (or equivalent)	[1]		
		Ratio of sin i to sin r is constant	[1]	[2]	
	(b) **(i)**	Glass block and ray box labelled in correct position	[1]		
		i correctly labelled	[1]		
		r correctly labelled	[1]	[3]	
	(ii)	Draw outline of glass block and normal	[1]		
		Mark incident ray and exit point/ray	[1]		
		(Remove block) and join rays	[1]		
		Measure i and r using a protractor	[1]		
		Repeat for at least 5 angles	[1]	[5]	
	(c)	Calculate sin i and sin r	[1]		
		Plot sin i against sin r	[1]		
		Straight line through origin	[1]	[3]	13
3	**(a)** **(i)**	Cannot tell	[1]		
		False	[1]		
		Cannot tell	[1]		
		True	[1]	[4]	
	(ii)	1.2, 2.8 ($\pm$ 0.05 tolerance, $\frac{1}{2}$ sq)	[1]		
		Difference = 1.6 s	[1]		
		T = 2.5 s	[1]		
		Ratio 1.6/2.5 or suitable alternative	[1]		
		230° or 1.28π radians or 4.02 radians	[1]		
		Consistent unit	[1]	[6]	
	(b) **(i)**	Vibration (of particles) is parallel to the direction the wave travels		[1]	
	(ii)	Speed = 857 m s^{-1}	[1]		
		λ = 0.45 m	[1]		
		v = f λ	[1]		
		subs 857 = f (0.45)	[1]		
		1900 Hz	[1]	[5]	16
		SE: 2142.5 Hz [4]/[5]			

					AVAILABLE MARKS
4	**(a)**	y = 0.021 m	[1]		
		subs into equation	[1]		
		5.7×10^{-7} m	[1]		
		570 nm (560 nm)	[1]	[4]	
		SE: 533 nm [3]/[4], 8000 nm or 4000 nm [2]/[4]			
	(b)	$d = 5 \times 10^{-6}$ m	[1]		
		tan θ = 0.15/0.75	[1]		
		θ max = 11.3°	[1]		
		subs into equation	[1]		
		n = 1.72	[1]		
		3 fringes	[1]	[6]	10
5	**(a)**	myopia/short sight	[1]		
		Lens too strong/eyeball too long/cornea too curved	[1]		
		Rays converge at a point in front of retina (diagram or text)	[1]		
		Concave lens used for correction (labelled on diagram or text)	[1]		
		Diverges light before entering eye (diagram or text)	[1]	[5]	
	(b) **(i)**	$P = \frac{1}{f}$ with f value in m	[1]		
		−0.22 D to 0.01 D	[1]	[2]	
	(ii)	(−1/450) = **1/u – 1/25** ecf **(i)**	[1]		
		26.5 cm	[1]	[2]	9
6	**(a)**	Light can sometimes behave as a wave and sometimes as a particle	[1]		
		Wave phenomena, e.g. polarisation, interference, diffraction	[1]		
		Particle model, e.g. photoelectric effect, emission spectra, laser	[1]		
		Both − reflection	[1]	[4]	
	(b)	momentum = 4.34×10^{-22} kg m s^{-1}	[1]		
		subs of h and p	[1]		
		1.53×10^{-12} m	[1]	[3]	7
		SE: 2.8×10^{-9} [2]/[3]			
7	**(a)**	Progressive wave transfers energy (in the direction the wave travels)	[1]		
		Standing wave – energy stored	[1]	[2]	
	(b) **(i)**	8 = 16 λ, λ = 0.5 m	[1]		
		Any wave with nodes at either end	[1]		
		wave form correct – 2 complete wavelengths	[1]	[3]	
	(ii)	Recognition of 1 m = $\frac{1}{2}$ λ	[1]		
		4 Hz	[1]	[2]	7

					AVAILABLE MARKS
8	**(a)**	(Same i), different r for each colour/wavelength	[1]		
		$n = \frac{\sin i}{\sin r}$, different n for each colour	[1]		
		Each colour is a different wavelength	[1]	[3]	
	(b)	1.652	[1]		
		1.613	[1]		
		n = sin i/sin r subs $\frac{\sin 48}{\sin r}$ = n value	[1]		
		26.7° or 27.4°	[1]		
		Difference 0.7°	[1]	[5]	
	(c)	n = 1.630	[1]		
		$\sin c = \frac{1}{n}$ or sin c = 1/1.630 subs	[1]		
		37.8°	[1]	[3]	11
9	**(a)**	Amount of absorption depends on type of tissue they pass through	[1]		
		Film is sensitive to X-ray exposure or equivalent	[1]	[2]	
	(b)	Accelerated by a **high** voltage/to **high** speed	[1]		
		hit tungsten target (accept metal)	[1]		
		Excite inner shell/low energy electrons	[1]		
		Cause electrons to fall into **low** energy levels from high levels	[1]	[4]	6
10	**(a)**	Electrons emitted (from a metal)	[1]		
		When em radiation or photons are incident on its surface	[1]		
		Frequency greater than threshold or equivalent (accept high enough frequency)	[1]	[3]	
	(b)	**(i)** $f = 1.18 \times 10^{15}$ Hz	[1]		
		$E = hf$ or $E = \frac{hc}{\lambda}$	[1]		
		$E = 7.83 \times 10^{-19}$ J	[1]	[3]	
		(ii) $P = 3.36 \times 10^{-8}$ W	[1]		
		E = P × t	[1]		
		t = 1071 s	[1]		
		17.8 minutes	[1]	[4]	
		SE: use P = 28 $t = 2.14 \times 10^{-8}$ mins [3]/[4]			
		(iii) 4.6×10^{13} ecf **(b)(i)**	[1]		
		(iv) 3.52×10^{-19} J	[1]		
		Difference in energies = 4.3×10^{-19} ecf **(b)(i)**	[1]		
		$\frac{1}{2}(9.11 \times 10^{-31}) v^2 = 4.3 \times 10^{-19}$	[1]		
		$v = 9.7 \times 10^5$ m s^{-1}	[1]	[4]	
		SE: 8.79×10^5 m s^{-1} [3]/[4], 7.83×10^{19} used leading to 1.3×10^6 m s^{-1} [2]/[4]			
	(c)	1. Increases	[1]		
		2. Stays the same/decrease	[1]	[2]	17
			Total		**100**