Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Astronomy

[SPH21]

Assessment

MARK SCHEME

Physics Subject Specific Instructions

It is essential that, before using the mark scheme, markers familiarise themselves with the following guidance.

General

To ensure that all candidates receive the same treatment, the mark scheme must be applied consistently.

The mark scheme for each question shows typical intermediate steps, the answer expected and the marks available for each part of the question.

In cases where a candidate has responded with a seemingly correct response which has not been anticipated in the mark scheme, the marker must make a professional judgement of the correct physics/validity of the response when awarding marks.

Brackets (...) are used to indicate information which is not essential for the mark to be awarded. Alternative answers are indicated by 'or', or the symbol for or, '/'.

Multiple/Cancelled Responses

If a candidate provides multiple responses, the general principle to be followed is that 'right + wrong = wrong'.

Responses considered to be neutral are not penalised. For example, if additional irrelevant information is given in an explanation that does not contradict the correct information given, the mark(s) can be awarded.

In a numerical problem if two different solutions are presented without a definitive answer on the answer line, credit should not be given. If an answer is given on the answer line, then the solution that has led to the answer given should be marked according to the mark scheme.

If a candidate clearly cancels their working by scoring it out, then this should not be marked. It is not the role of the marker to select from the candidate's response what should or should not be marked.

Marking Numerical Problems

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, if obtained from a valid starting point, gets full credit, even if all the intermediate steps are not shown.

This “correct answer” rule does not apply in situations where candidates have been asked to ‘show your working’ or ‘show that’. These answers must be valid in all stages to obtain full credit.

The answer to a ‘show that’ question should be quoted to one more significant figure than that given in the question.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation.

The normal penalty for an arithmetical error is to lose the mark(s) for the answer/unit line. An arithmetic error should be penalised for one mark only. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value of a quantity given in a question.

10^n errors count as arithmetical slips and incur a penalty of one mark.

If a candidate rounds a value incorrectly this should be penalised one mark. However, care must be taken not to penalise a candidate for rounding correctly in parts leading up to their final answer in an unstructured numerical problem.

Answers should be given in decimal form. Fractional answers will not be credited with the answer mark.

Error Carried Forward

An ECF can occur between parts of a question or, in more unstructured numerical problems, within a part.

When an incorrect answer is carried forward from one question to the next, full credit should be awarded in the part where the incorrect answer is used, provided all the working is correct.

Within a part, ECF is applied where a candidate does an incorrect calculation, for example calculates a value for R incorrectly using V/I and then goes on to use their calculated value or R to calculate a resistivity value. The penalty is applied in they V/I calculation but then the value of R can be carried forward so that the remainder of the marks are available to the candidate provided all the remainder of their working is correct.

The ECF within a part will only apply in numerical problems where more than one calculation is required in a part.

Significant Figures

Candidates should show an awareness of using a sensible number of significant figures in their answers, based on the values given in the question. In SPH11, SPH21, APH11 and APH21, unless specifically asked for in the question, candidates will not be penalised for incorrect significant figures.

In SPH31, SPH32, APH31 and APH32, all answers should be given to a suitable number of significant figures and penalties will be applied in these papers unless otherwise stated in the mark schemes.

Units
In the majority of questions, the unit will be stated on the answer line.

When the unit is omitted, candidates will be clearly asked to state an appropriate unit and this will be credited in the mark scheme.

Where there is a final calculation required to get from the unit of the answer calculated to the unit on the answer line the required unit will be stated in the question. For example, if wavelength was calculated and the answer line was in nm a statement ‘Give your answer in nanometres’ would be included.

The unit on the answer line will generally be the SI unit but may in some cases be a more appropriate unit. For example, if values of mass in g and momentum in g cm s^{-1} were given, the unit on answer line for speed could reasonably be cm s^{-1} without prompt.

AVAILABLE MARKS

1 (a)

Region	γ-rays	Infrared	Microwave	Radio	Ultraviolet	X-rays
Typical Wavelength	**10 pm** [1]	0.1 mm	**2 cm** [1]	1 m	**1×10^{-8} m** [1]	1×10^{-10} m

[3]

(b) (i) $N = \dfrac{8\times10^{-3}}{2.84\times10^{-19}}$ subs [1]

$N = 2.82\times10^{16}$ [1] [2]

(ii)

Laser Used	Energy in a single photon	Number of photons per second
10 mW laser emitting red light	**Stays the same**	**Increases**
8 mW laser emitting green light	**Increases**	**Decreases**

[1] for each correct answer [4]

(c) (i)

	Matter exhibiting wave-like behaviour	Light exhibiting wave-like behaviour	Light exhibiting particle-like behaviour
Photoelectric emission			✓
Electron beam diffraction	✓		
Young's double slits		✓	

[1] for each correct row [3]

(ii) $\lambda = 7\times10^{-7}$ m/700nm [1]

$\lambda = \dfrac{6.63\times10^{-34}}{7\times10^{-7}}$ subs [1]

$p = 9.47\times10^{-28}\,\text{kg m s}^{-1}$ [1] [3]

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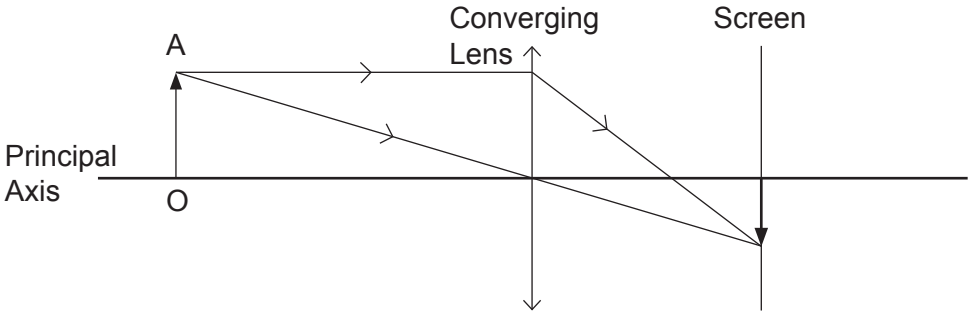
					AVAILABLE MARKS
2	**(a)**	Screen	[1]		
		Metre rule/any appropriate distance measuring instrument	[1]		
		Measurements (in any order)			
		Distance of screen from double slits	[1]		
		Distance across fringe(s)	[1]		
		Divide distance by number of fringes to get fringe separation (allow mark if stated in calculation section)	[1]		
		Calculations			
		Use of equation $\lambda = \frac{ay}{d}$ clearly stating value/meaning of each letter used	[1]	[6]	
	(b)	**(i)** $d = \frac{1}{400} = 2.5 \times 10^{-3}$ mm	[1]		
		$d = 2.5 \times 10^{-6}$ m	[1]	[2]	
		(ii) $d \sin\theta = n\lambda$			
		$2.5 \times 10^{-6} \sin\theta = 3 \times 400 \times 10^{-9}$			
		$\theta = 28.69°$	[1]		
		$2.5 \times 10^{-6} \sin 28.69 = 2 \times \lambda$	[1]		
		6×10^{-7} m e.c.f. from **(b)(i)**	[1]		
		or			
		$n_1\lambda_1 = n_2\lambda_2$	[1]		
		$3 \times 400 \times 10^{-9} = 2\lambda_2$	[1]		
		6×10^{-7} m	[1]	[3]	11

3 (a) (i)



Ray from top of object through centre of lens	[1]		
Ray parallel to P.A. then changes direction downwards after lens	[1]		
Rays meet at same location on screen	[1]		
Image correctly marked	[1]	[4]	
No arrows on rays [–1]			

(ii) Real, Inverted, diminished
(All three needed for [2], one or two correct [1]) [2]

(iii) F marked where ray crosses principal axis	[1]		
distance measured between centre of lens and F (mark correct by pupil diagram)	[1]		
20 mm $\leqslant f \leqslant$ 23 mm (Quality)	[1]	[3]	

(b) (i) Far-sighted/Hypermetropia [1]

(ii) $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

$\frac{1}{0.25} - \frac{1}{0.75} = \frac{1}{f}$ correct subs for v (including minus) [1]
correct subs for u [1]

f = 0.375 m [1]

$P = \frac{1}{f}$ [1]

P = 2.7 D [1] [5]
(using +v giving P = 5.3 D scores [3]/[5])

(iii) $\frac{1}{u} - \frac{1}{\infty} = \frac{1}{0.375}$

Correct subs	[1]		
u = 0.375 m e.c.f. from **(b)(ii)**	[1]	[2]	

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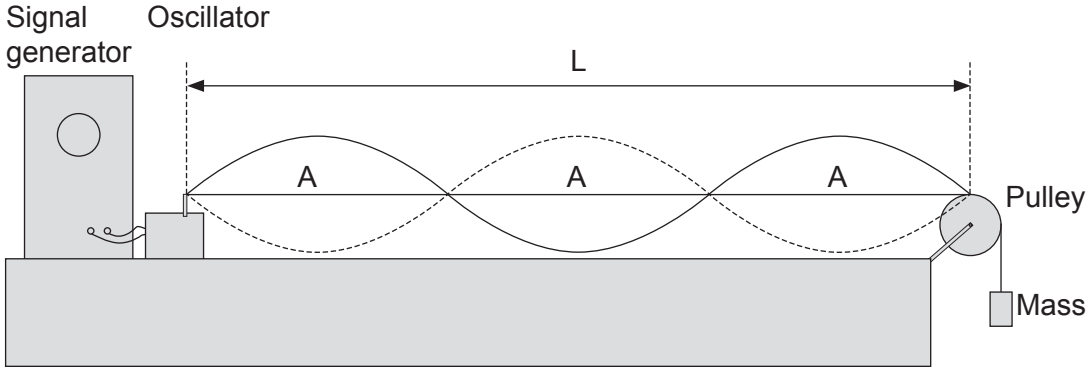
AVAILABLE MARKS

						AVAILABLE MARKS
4	**(a)**	For a given set of media/for light travelling from one medium to another the ratio of the sines of the angle of incidence and refraction is a constant $\frac{\sin i}{\sin r}$ is a constant	[1]	[2]		
	(b)	**(i)** Normal at 90° to boundary where ray hits PQ	[1]			
		Emergent ray refracts away from normal	[1]	[2]		
		(ii) $n = \frac{\sin i}{\sin r}$				
		$1.48 = \frac{\sin 30}{\sin r}$ / r = 19.75° subs or value	[1]			
		90 – 19.75 = 70.25°	[1]			
		180 – 60 – 70.25 = 49.75°	[1]	[3]		
		(iii) i = 90° – 49.75° = 40.25° Calculates i at PQ	[1]			
		${}_{glass}n_{air} = \frac{1}{{}_{air}n_{glass}} = 0.6757$	[1]			
		$n = \frac{\sin i}{\sin r}$				
		$0.6757 = \frac{\sin 40.25}{\sin r}$				
		R = 73° (use of θ = 50°, R = 72°)	[1]	[3]		10
5	**(a)**	**(i)** (Illumination bundle) to carry light from the light source to the object/to illuminate the object	[1]			
		(Image bundle) to carry the image from the object to the eye/camera	[1]			
		The image bundle is coherent while the illumination bundle is not Allow explanation i.e. parallel/maintains spacial relationship for last mark	[1]	[3]		
		(ii) Any combination of instrument and use from the list below Forceps – Biopsy Cauteriser/Heated element/electrode – To stop bleeding Extractors – to remove foreign objects Needle – for stitching Small scalpel – for making incisions Allow: Water/Air channel – to clear mucus/fluid Suction – to remove fluid/take sample (Allow correct alternative)		[2]		
		(iii) n_{core} = 1.52 and $n_{cladding}$ = 1.34	[1]			
		TIR only occurs when going from an optically more dense to less dense medium or speed of light must be faster in cladding than the core for **TIR** to occur	[1]	[2]		

					AVAILABLE MARKS
(iv)	$_{core}n_{cladding} = {}_{core}n_{air} \times {}_{air}n_{cladding}$				
	$_{core}n_{cladding} = \frac{1}{1.52} \times 1.34$ eqn or subs	[1]			
	$_{core}n_{cladding} = 0.8816$	[1]			
	$0.8816 = \frac{\sin C}{\sin 90}$ subs or equation	[1]			
	$C = 61.8°$	[1]	[4]		
(v)	Specific example Inspection/repair of pipes, engines or other mechanical equipment Espionage – clandestine viewing of a location (Accept any correct non-medical use)		[1]		
(b)	X-rays	[1]			
	Taken in numerous direction/X-ray tube rotated about patient	[1]			
	Computer/software constructs cross-sectional image from X-ray images	[1]	[3]		15
6 **(a)** **(i)**					



	Correct shape	[1]		
	All A correctly identified	[1]	[2]	
(ii)	2L/3 or 0.667L		[1]	
(b) **(i)**	Signal generator Speaker L Cylinder N N N			
	Correct shape	[1]		
	All N correctly identified	[1]	[2]	
(ii)	4L/5 or 0.8L		[1]	
(iii)	Use of $v = f\lambda$			
	$330 = 650\lambda$	[1]		
	$\lambda = 0.508\,m$			
	$L = 0.635\,m$ e.c.f. from **(b)(ii)**	[1]	[2]	8

7 **(a)** Pedestrians won't hear the car
or equivalent [1]

(b) **(i)** The source of the sound is moving towards the observer/
microphone so waves become bunched together [1]
Doppler effect [1] [2]

(ii) *using wavelengths*:

$\lambda = \frac{330}{300} = 1.10\,\text{m}$ $\lambda_o = \frac{330}{280} = 1.18\,\text{m}$

$\lambda = \left(\frac{v_w - v_s}{v_w}\right)\lambda_o$ or equivalent eqn [1]

$1.10 = \left(\frac{330 - v_s}{330}\right) 1.18$ subs [1]

$v_s = 22\,\text{m s}^{-1}$ [1]
$79.2\,\text{km h}^{-1}$ [1]

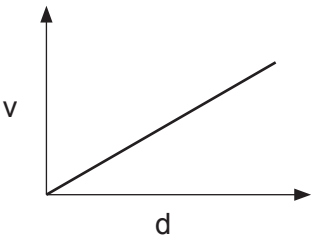
or using frequency:

$f = \left(\frac{v_w}{v_w - v_s}\right) f_o$ eqn [1]

$300 = \left(\frac{330}{330 - v_s}\right) 280$ subs [1]

$v_s = 22\,\text{m s}^{-1}$ [1]
$79.2\,\text{km h}^{-1}$ [1] [4]
(f and f_0/λ and λ_0 reversed giving 84.9 km h^{-1} scores [3]/[4])

(c) **(i)**



Straight line through origin [1]

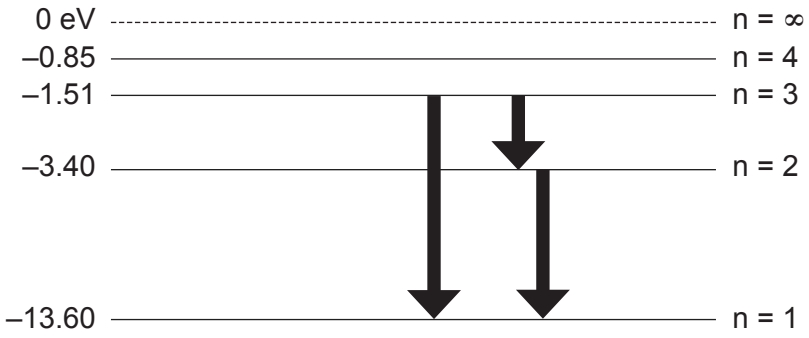
(ii) Further away galaxies are moving away faster [1]
The Universe is currently expanding or
At some point in the past all the matter existed in a single point
(called a singularity) [1] [2]

(iii) Calculate the gradient [1]

(iv) $t = \frac{1}{H_o}$ [1]

$t = 4.2 \times 10^{17}\,\text{s}$ [1] [2] 13

AVAILABLE MARKS

					AVAILABLE MARKS
8	**(a)**	**(i)**	$E = -1.51 - -13.6$ $E = 12.09$ eV [1] $E = 1.934 \times 10^{-18}$ J conversion from eV to J (award independently) [1] $E = hc/\lambda$ or $E = hf$ and $c = f\lambda$ [1] $\lambda = 1.03 \times 10^{-7}$ m [1] [4]		
		(ii)	 All 3 arrows [2] [2] Any 2 correct [1] ([–1] if no arrowhead or incorrect direction)		
		(iii)	Selection of N = 3 to N = 2 [1] $\lambda = 6.58 \times 10^{-7}$ m [1] [2]		
	(b)		The material/electrons in the ink absorb photons with UV wavelength raising the energy level of the electrons [1] The electron drops down to the ground state through intermediate energy levels [1] emitting photons with lower frequency/longer wavelength within visible range [1] [3]		11
				Total	**100**