



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022**

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Astronomy

[SPH21]

MONDAY 6 JUNE, MORNING

**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.

10ⁿ 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 for R to calculate a resistivity value. The penalty is applied in the 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 the answer line for speed could reasonably be cm s^{-1} without prompt.

COVID-19 Context

Given the unprecedented circumstances presented by the COVID-19 public health crisis, senior examiners, under the instruction of CCEA awarding organisation, are required to train assistant examiners to apply the mark scheme in case of disrupted learning and lost teaching time. The interpretation and intended application of the mark scheme for this examination series will be communicated through the standardising meeting by the Chief or Principal Examiner and will be monitored through the supervision period. This paragraph will apply to examination series in 2021–2022 only.

			AVAILABLE MARKS		
1	(a)	particles oscillate perpendicular to the direction of motion of the wave	[1] [1] [2]	11	
	(b)	oscillations confined to one plane	[1]		
	(c) (i)	$f = v/\lambda$ $\frac{56}{2.24}$ 25 (Hz)	[1] [1] [1] [3]		
	(ii)	$T = 1/f$ = 0.04 s ecf (i) time axis values correct 40 ms, 80 ms amplitude 15 cm At least 2 cycles, sinusoidal waves	[1] [1] [1] [1] [1] [5]		
	2	(a)	1 year = 3.16×10^7 s $1 \text{ ly} = 3 \times 10^8 \times 3.16 \times 10^7 = 9.46 \times 10^{15} \text{ m}$ $\times 8 \times 10^6 = 7.57 \times 10^{22} \text{ m}$		[1] [1] [1] [3]
		(b) (i)	$v (= H_0 d) = 2.4 \times 10^{-18} \times 7.6 \times 10^{22}$ $v = 1.82 \times 10^5 \text{ m s}^{-1}$		[1] [1] [2]
		(ii)	$z (= v/c)$ e.c.f. from v subs: $\frac{v}{3 \times 10^8}$ $z = 6.0 \times 10^{-4}$		[1] [1] [2]
		(c) (i)	$\Delta\lambda (= z \lambda) = 6.0 \times 10^{-4} \times 656 (\times 10^{-9})$ e.c.f. from z 0.40 nm		[1] [1] [2]
		(ii)	1000 times smaller		[1]
		3	(a)		the minimum energy required for an electron to escape metal
(b)			$E = hf_0$ $E = 1.6 \times 10^{-19} \times 2.0 = 3.2 \times 10^{-19} \text{ J}$ $f = 3.2 \times 10^{-19} / 6.63 \times 10^{-34} = 4.83 \times 10^{14} \text{ Hz}$	[1] [1] [1] [3]	
(c) (i)	$n = 1 \times 10^{-9}$ Subs into $E = \frac{hc}{\lambda}$ $= 6.03 \times 10^{-19} \text{ J}$ Subtract $3.2 \times 10^{-19} \text{ J}$ ecf (b) $\frac{1}{2} m v_{\text{max}}^2 = 2.83 \times 10^{-19} \text{ J}$ $v_{\text{max}} = 7.88 \times 10^5 \text{ m s}^{-1}$		[1] [1] [1] [1] [1] [1] [6]		
(ii)	same maximum velocity		[1]		
(iii)	no electrons will be emitted below the threshold frequency		[1] [1] [2]		
				14	

		AVAILABLE MARKS	
4	electrons exist in discrete energy levels	[1]	5
	fall/transition back to lower energy level	[1]	
	emit photon/discrete bundle/quantum of energy as they drop	[1]	
	energy emitted is equal to difference in energy of two levels	[1]	
	observed as light of specific wavelength	[1] [5]	
5	(a) one correct ray	[1]	8
	second correct ray	[1]	
	object in correct position marked as arrow	[1]	
	arrows on rays directed from O to I	[1] [4]	
	(b) $m = 22 (= v/u)$	[1]	
	$v = 3.5 \text{ m}, u = 3.5/22 = 0.16 \text{ m}$	[1]	
	subs into lens equation $1/f = 1/0.16 + 1/3.5$ ecf their u, v values	[1]	
	$f = 0.15 \text{ m}$	[1]	
	S.E. $f = 3.35 \text{ m},$ or $f = 2.25 \text{ m}$ [3]	[4]	
6	(a) level in which electrons can remain for longer time	[1]	6
	excited level	[1] [2]	
	(b) greater number of electrons	[1]	
	in higher energy level (than ground state)	[1] [2]	
	(c) photons/waves are all in phase	[1]	
(d) one frequency/wavelength/colour	[1]		
7	(a) (i) metal/graphite foil/film/crystal	[1]	11
	(ii) fluorescent screen	[1]	
	concentric, accept diagram	[1]	
	(bright) rings	[1] [3]	
	(iii) electrons exhibit charged particle properties when accelerated	[1]	
	in E-field/by voltage/by p.d./by charge/electron gun	[1]	
	exhibit wave properties when diffracted/interference	[1]	
	/superposition	[1] [2]	
	(b) (i) $p = mv$	[1]	
	subs for m	[1]	
$1.27 \times 10^{-23} \text{ (kg m s}^{-1}\text{)}$	[1]		
$\lambda (= h/p) = 5.24 \times 10^{-11} \text{ m}$ ecf p	[1] [4]		
(ii) gamma (accept x-rays)	[1]		

		AVAILABLE MARKS			
8	(a) n is the order number of the fringe	[1]	9		
	d is grating slit spacing	[1]			
	θ is angle between $n = 0$ and n th order beam	[1] [3]			
	(b) $d = (200 \times 10^3)^{-1}$	[1]			
	5×10^{-6} m	[1]			
	$\sin \theta = 660 \times 10^{-9} / 5 \times 10^{-6}$ subs into equation	[1]			
	$\theta = 7.59^\circ$	[1]			
	$\tan 7.59^\circ = 0.148/D$	[1]			
	$D = 1.11$ m	[1]			
	S.E. $D = 2.22$ m [5], using $a\lambda/d$ to get 1.12 m [6] or 2.24 m [5]	[6]			
9	(a) (i) hypermetropia/long sightedness	[1]	7		
	(ii) eyeball too short/lens too thin/cornea insufficiently curved	[1]			
	(iii) the closest point that an object can clearly be focused on or equivalent	[1]			
	(b) converging lens drawn in front of eyeball	[1]			
	Two rays from object converged by spectacle lens e.c.f. their lens further converging by eye lens	[1]			
	Rays meeting on retina	[1] [4]			
	10	(a) the resultant displacement of two (or more) waves meeting at a point		[1]	10
		Is equal to sum of their (individual) displacements at that point		[1] [2]	
		(b) (i) zero path difference from each speaker to that point		[1]	
		Constructive interference or correctly described		[1] [2]	
(ii) mean of 42 and 44 is 43 cm for y		[1]			
subs into $\lambda = ay/d = 0.8 \times 0.43/1.12$		[1]			
$\lambda = 0.307$ m		[1]			
$f = v/\lambda = 334/0.307$ e.c.f. for λ		[1]			
1087		[1]			
1100 Hz		[1] [6]			
11	(a) $n^{-1} = \sin C$ and $\sin C = 1/2.45$ or $\sin C = 0.413$	[1]	9		
	$C = 24.4$	[1] [2]			
	(b) (i) angle of incidence in the diamond greater than critical angle	[1]			
	Total internal reflection has occurred/more to less dense	[1] [2]			
	(ii) normal line drawn at point where ray meets BC	[1]			
	reflected ray within diamond	[1]			
	angle of incidence 60°	[1] [3]			
	(iii) incident angle in the diamond is smaller than critical angle (20°)	[1]			
	ray would have refracted into the air, or correct diagram	[1] [2]			
	Total			100	