OXFORD
INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL AS
PHYSICS
PH02

Unit 2 Electricity, waves and particles

Mark scheme

January 2023

Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from oxfordaqaexams.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidelines	Mark	AO
01	Involve oscillations/vibration (about mean equilibrium position) at right angles ✓ to direction of energy transfer ✓	Accept displacement of vibrating particles at right angles MP1 must have idea of oscillation/vibration and at right angles. Ignore references to polarisation	2	2 × AO1
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	A material whose resistivity/resistance is zero ✓ below the critical temperature ✓	Condone 'negligible' for 'zero'	2	2 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Can generate strong magnetic fields OR They can sustain large currents ✓ There are reduced thermal/energy losses OR No damage due to overheating (of the electromagnets) ✓	 Accept 'no' for 'reduced'	2	2 × AO1
Total			**4**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03	Use of $\sin C = 1/n$ ✓ Diamond has (much) larger refractive index than glass ✓	If values of n are determined at least one must be correct to award MP1. Accept reverse argument	2	1 × AO2 1 × AO3
Total			**2**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04	Hold filter in front of sunglasses and rotate (through 360°) ✓ Any variation of intensity during rotation means polarising OR No variation during rotation means not polarising ✓ Reduced intensity occurs when polarisation planes are not aligned OR minimum when polarisation planes crossed ✓	If no other marks given, give 1 mark for either MP1 or MP2, without mention of the sunglasses.	3	3 × AO2
Total			**3**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	2 MAX from Idea of two waves travelling in opposite directions ✓ superpose /constructively interfere/give maximum amplitude ✓ because they are in phase ✓	Do not award MP3 if suggestion that waves are coherent.	2	2 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Evidence of use of all 3 dots ✓ ($\lambda = 2$ measurements added together or one single measurement from dot one to dot three) Use of $c = f\lambda$ with correct substitution ✓ Answer consistent with their measurement ✓	Evidence can be on figure 4 or a written statement Allow POT error in MP2	3	1 × AO1 1 × AO3 1 × AO4
Total			**5**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	Use $Q = It$ ✓ Number of electrons $= 3.1(3) \times 10^{15}$ ✓	Charge $= It = 100 \times 10^{-3} \times 5 \times 10^{-3}$ $= 5.0 \times 10^{-4}$ (C) Condone PoT error for MP1	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Total input energy $= QV$ ✓$= (5.0 \times 10^{-4} \times 80 \times 10^{3}) = (40$ J) output energy = efficiency × input $= 0.02 \times$ their energy input OR Heat energy dissipated = $0.98 \times$ their energy input ✓ Heat energy dissipated $= 39.2$ J ✓	Accept $P = VI$ and $E = Pt$ Ecf for Q from **06.1**	3	3 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Max 3 from Idea that more electrons are emitted (and strike anode) (per second) ✓ So more photons are emitted (per second) ✓ Intensity of X-rays goes up✓ (Max) frequency of X-rays / (max) energy of X-ray photons stays the same ✓		3	3 × AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
07.1	hf = energy of (incident) photon ✓ $E_{k(max)}$ = maximum kinetic energy of (emitted) electron ✓	Do not accept 'max' for 'maximum'	2	2 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.2	Work function ✓ Minimum energy required to remove electron from surface of metal ✓	Condone missing reference to surface of metal but must have reference to minimum or wtte.	2	2 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
07.3	Blue light photon energy > Ø **or** red light photon energy < Ø ✓ $f_b > f_r$ ✓	Alternative: Frequency of blue light > threshold frequency✓ Frequency of red light < threshold frequency✓ Allow arguments in terms of wavelength.	2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
07.4	More photons per unit time / per second✓ Idea that there is a one-to-one relationship between (incident) photon and (emitted) electron✓ so more electrons ejected (per unit time) and current increases ✓		3	3 × AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
08.1	Correctly determine resistance of parallel combination or adds their resistance of parallel combination to the $2\ \Omega$ ✓ Answer $R = 3.2\ \Omega$ ✓		2	2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
08.2	Start with a version of $\varepsilon = I(R + r)$ At least one intermediate step to give $\frac{1}{I} = \frac{R}{\varepsilon} + \frac{r}{\varepsilon}$ ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
08.3	Uses data from graph from at least half the range ✓ Use of valid method to evaluate ε $(= \frac{1}{\text{gradient}})$ ✓ ε in the range $1.37(\text{V})$ to $1.42(\text{V})$ ✓	Readings must be within half a grid square ecf their value of gradient	3	3 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
08.4	Intercept ✓1 Their value of intercept × their **08.3** ✓2 OR I and R from obtained from graph ✓1 Attempted evaluation using valid equation(s) ✓2 r consistent with their values ✓3	Accept 0.27 to 0.33 for newly read intercept OR Allow ecf for readings from **08.3** Expect to see answers in the range 0.37 to $0.47\ (\Omega)$	3	3 × AO3
Total			**9**	

Question	Answers	Additional comments/Guidelines	Mark	AO
09.1	Use of tan in attempt to calculate θ ✓ Doubles 12.4 / θ to get $24.8°$ ✓	Do not allow use of double slit equation. In MP2 there must be some indication where the factor of 2 comes from.	2	1 × AO1 1 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
09.2	Use of $d\sin$ (their θ) $= n\lambda$ ✓ ($d\sin 12.4 = 2 \times 540 \times 10^{-9}$ 5.027×10^{-6} m) Finding $\frac{1}{\text{their value of } d}$ ✓ Answer that rounds to 200 ✓	accept substitution into formula or rearrangement; allow one error in substitution Condone PoT error in MP2 Expect 199, condone 200 / 2.0×10^2 but not 2×10^2	3	3 × AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
09.3	Less diffraction or smaller θ and reference to relationship between angle and wavelength ✓ the new light source has a shorter wavelength ✓ Idea that colour changes towards blue end of spectrum✓	If no other mark awarded allow for one mark: spots are closer OR distance between maxima decreased OR different colour	3	3 × AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
10.1	Use of $E = \frac{hc}{\lambda}$ ✓ Use of $P = NE$ with their value of E ✓ Correct answer (3.3×10^{16}) ✓		3	1 × AO1 2 × AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
10.2	Value of R_L from graph $= 30\ \text{k}\Omega$ ✓ Use of potential divider equation to give their R_L divided by 2 ✓	Allow 28 to 32 kΩ accept ratios	2	1 × AO3 1 × AO4

Question	Answers	Additional comments/Guidelines	Mark	AO
10.3	(at greater light levels) R_L decreases ✓ (therefore must) reduce $R_{\text{variable resistor}}$ ✓ (So that) the ratio of the resistances returns to original value / so that V_1 returns to its original value ✓	Allow MP3 for current discussion leading to V_1 returning to original value.	3	3 × AO3
Total			**8**	

Question	Answers	Additional comments/Guidelines	Mark	AO
11.1	Idea that it stops the microphone picking up noises in the background/other sounds ✓		1	AO4

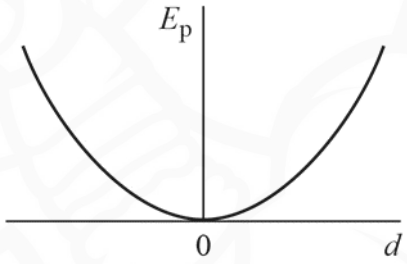
Question	Answers	Additional comments/Guidelines	Mark	AO
11.2	191 (μs) ✓	CAO	1	AO2

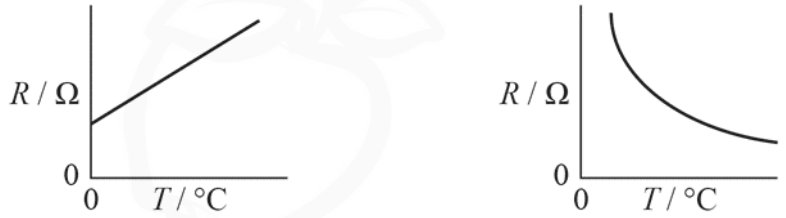
Question	Answers	Additional comments/Guidelines	Mark	AO
11.3	(±) 15 (μs) ✓	CAO	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.4	$3.9(3) \times 10^3$ (m s^{-1}) ✓	Accept 2 or 3 sf only	1	AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
11.5	One of the percentage uncertainties correctly calculated ✓ 9.2(%) ✓	Allow decimal or percentage Expect to see 1.3% and 7.9% accept 1 or 2 sf only	2	1 × AO2 1 × AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
11.6	The amplitude of the sound pulse gets weaker/smaller (as it travels) so would not trigger microphone B ✓ Microphone sensitivity needs to be high so this might trigger it with any noise ✓	Accept pulse/sound volume too low to measure If no other mark awarded, accept for one mark idea that uncertainty in t would increase	2	2 × AO4
Total			**8**	

Question	Key	Answer	AO
12	**A**	6.25×10^9	AO2
13	**A**	0.6 V.	AO2
14	**B**	$0.7f$	AO2
15	**D**	increases the critical angle at the surface of the core.	AO1
16	**B**	increases increases	AO1
17	**D**	$8R$	AO2
18	**C**	1600 W	AO2
19	**C**	The amplitude is a minimum at **Q**.	AO3
20	**D**		AO2
21	**D**	C Ω s	AO3

22	**B**		AO1
23	**A**	4.0 25	AO2
24	**C**	0.50 m	AO2
25	**C**	2λ	AO2