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PHYSICS

PH02

Unit 2 Electricity, waves and particles

Mark scheme

January 2020

Version: V1 Final Mark Scheme

201XPH02/MS

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.

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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	Marking guidance	Additional comments/guidelines	Mark
01.1	The photon (energy) is absorbed OR the atom/electron is excited ✓ (Atom moves to) -1.57 eV level ✓	Evidence for this can come from the diagram i.e. upward arrow to the correct level	2
01.2	6 ✓		1

Question	Marking guidance	Additional comments/guidelines	Mark
02.1	The maximum angle of <u>incidence</u> at which refraction occurs ✓	Accept "incidence" explained. Condone minimum angle of incidence at which total internal reflection occurs Accept the angle of incidence that produces an angle of refraction of 90°/ along the boundary	1
02.2	Use of $\sin\theta = \frac{n_2}{n_1}$ to find n_2 (= 1.3) ✓ Use of $n = \frac{c}{v}$ ✓ 2.3×10^8 (m s^{-1}) ✓	For max 1 mark, condone $1.52 = \frac{3.0 \times 10^8}{v}$	3
03	any four: V_1 decreases ✓ because voltage is shared in the ratio of the resistances ✓ and the variable resistor receives a larger (share of the) voltage ✓ V_2 stays the same ✓ because the parallel branches are independent or V_2 is still emf ✓	For V_1: Same current through R and var R, ✓ V = IR therefore larger R gets more V ✓ OR: the current (in that branch) decreases ✓ Since R is fixed, and V=IR, V decreases✓ Incorrect conclusion negates explanation marks	4

04.1	Any two:	For mp1 allow a description of diffraction	
	Diffraction at (each) slit ✓ Interference (between light from different slits) ✓ Idea that different wavelengths have maxima at different angles ✓	For MP2 accept discussion of phase difference at maxima / minima	2

04.2	correct read-off of λ from the diagram = 619 (nm) ✓ use of $E_\gamma = \frac{hc}{\lambda}$ ✓ 3.2×10^{-19} (J)✓	Ignore POT error for mp1 Allow 2 marks max if 618 or 620nm are used.	3

Question	Marking guidance	Additional comments/guidelines	Mark
05.1	clear rearrangement including: squaring f correctly ✓ substituting m/l for μ ✓		2
05.2	gradient determined correctly = 17.6 to 18.2 ($Hz^2 N^{-1}$) ✓ correct substitution and rearrangement of $1/(4lm)$ ✓ m = 5.3×10^{-3} (kg) to 5.5×10^{-3} (kg) ✓	For MP1, evidence of gradient calculation must be seen OR if a single point rather than a gradient is used, evidence of extending the line to the origin must be seen. must be at least 2 sf in final answer	3
05.3	smaller uncertainty for the tape measure ✓ because the metre rule must be used multiple times ✓	MP1 condone smaller error or more <u>precise</u> for smaller uncertainty	2

Question	Marking guidance	Additional comments/guidelines	Mark
06.1	Use of W = QV ✓ 9400 V ✓		2
06.2	Use of $E_k = \frac{1}{2}mv^2$ ✓ Use of $p = mv$ ✓ 5.2×10^{-23} (kg m s^{-1}) to at least 2 sf ✓		3
06.3	use of $\lambda = h/p$ ✓ $n = 2$ seen or implied ✓ use of (n) $\lambda = d \sin \theta$ ✓ $d = 1.5 \times 10^{-10}$ (m) cao✓	condone incorrect n for MP3 If 5×10^{-23} kg m s^{-1} used, $d = 1.5 \times 10^{-10}$(m)	4

Question	Marking guidance	Additional comments/guidelines	Mark
07.1	Minimum photon frequency required ✓ for a (photo)electron to be emitted (from a metal surface) ✓	Must have reference to light / radiation etc.	2
07.2	$\varphi = E_\gamma$ – KE (= 3.1×10^{-19} J) ✓ conversion of their φ to eV (= 2.0 eV) ✓	Condone 1sf for this question	2
07.3	Evidence of $\frac{total\ power}{(photon)\ energy}$ ✓ N = 3.5×10^{16} (s^{-1}) ✓	For one mark maximum, condone work function (**ecf**) or KE used instead of photon energy if no other error made.	2
07.4	any three: (Photo)electrons have higher (maximum) kinetic energy ✓ because each photon has more (double) energy ✓ half the number of photoelectrons emitted ✓ because half the number of photons incident on plate ✓	Accept speed / velocity for KE For MP2 accept explanation using photoelectric effect equation. Award 1 mark for MP3 and MP4 if full qualitative argument given	3

Question	Marking guidance	Additional comments/guidelines	Mark
08.1	Ratio of voltage to current ✓	accept simply V/I (as seen in spec) - with terms defined	1
08.2	correct read-off (= 2.1 A)✓ 3V/their current (= 1.4 Ω) ✓		2
08.3	Use of $P = IV$ or $P = I^2R$ or $P = V^2/R$ ✓ $P = 6.3$ ✓ $kg\ m^2\ s^{-3}$ ✓	**ecf** on 08.2 for MP1 and MP2 If 1.4Ω used, $P = 6.2$ MP3 is stand alone	3
08.4	less current passes through Y (than X) or Y receives less voltage ✓ at lower currents/voltages, the resistance (ratio of voltage to current) is less ✓ so Y has a lower resistance ✓	Full marks for reverse argument For MP2, accept the temperature is lower or there are fewer collisions between electrons and ions	3

Question	Marking guidance	Additional comments/guidelines	Mark
09.1	use of $T = 2\pi\sqrt{\frac{m}{k}}$ ✓ 0.19 (s) ✓	must be at least 2 sf	2
09.2	resonance ✓ the speed bumps provide a periodic driving <u>force</u> ✓ which matches the natural frequency/time period of the bicycle's suspension ✓	Ignore any reference to phase	3
09.3	use of distance = speed × time and recognising that the time is the same as in 09.1✓ 1.1 (m) ✓	Answer is 1.2 m if 0.2 s is used from 09.1 If no other mark awarded, one mark can be given for calculation of frequency (5.2Hz)	2

Question	Marking guidance	Additional comments/guidelines	Mark
10.1	a length that is at least $5w$ must be measured ✓ w = 10.2 to 10.9 (mm) ✓	MP1 evidence seen on diagram or through calculation 3 sf only	2
10.2	Absolute uncertainty is = ±1 mm ✓ Divides by their original measured value x 100 ✓	expect eg 1 mm/105 mm Mp2: 1 or 2 sf only MP1 and MP2 are separate marking points	2
10.3	Use of $w = \frac{\lambda D}{s}$ ✓ 520 (nm) – 535 (nm) ✓ ecf on 10.1	ecf on their *w*	2
10.4	Attempt to add three % uncertainties ecf on 10.2 ✓ Use of Absolute uncertainty = % uncertainty x λ (may be implied) ✓ Final answer 14 (nm) OR 15 (nm) cao ✓	Expect to see 1.2% + 0.6% + their **10.2** Final answer 2 sig fig only	3

Question	Key
11	**B**
12	**D**
13	**B**
14	**A**
15	**C**
16	**D**
17	**C**
18	**A**
19	**C**
20	**B**
21	**B**
22	**C**
23	**A**
24	**C**