OXFORD

INTERNATIONAL
AQA EXAMINATIONS

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Physics

PH02-Unit 2 Electricity, waves and particles
Mark scheme

June 2018

Version/Stage: 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 Assessment Writer.

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 aqa.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	Marking guidance	Mark	Comments
01.1	(semi-conductor) diode ✓	1	Allow LED Allow phonetic spellings
01.2	Correct reading of current (48 ± 4 mA) from graph ✓ 18.0 or 18.8 or 19.6 (Ω) ✓	2	Condone power of ten error for current for 1st mark only Answers must be from 48 ± 2 mA. May be given as 2 sf.

Question	Marking guidance	Mark	Comments
02.1	minimum energy to remove an electron from the surface of a copper/metal ✓	1	
02.2	$4.65 \times 1.60\times10^{-19} = 7.44\times10^{-19}$ (J) ✓ Use of $f = \frac{\Phi}{h}\left(\frac{7.44\times10^{-19}}{6.63\times10^{-34}}\right)$ ✓ 1.12×10^{15} (Hz) ✓	3	Allow 2nd mark only for failure to convert work function into joule.
02.3	850×10^{12} Hz **OR** photon energy = 3.5 eV seen ✓ no photoelectrons emitted because *f* below threshold frequency **OR** no photoelectrons emitted because photon energy below ϕ ✓	2	Power of ten must be seen; do not allow SI prefix. Must give a reason. Comparison may be in joule. Allow valid conclusion based on an incorrect conversion of THz or an ecf from their 2.2

Question	Marking guidance	Mark	Comments
03	T = 0.51 (s) ✓ Use $T = 2\pi\sqrt{\frac{m}{k}}$ in either substitution or re-arrangement ✓ 30 (N m^{-1}) ✓	3	Condone use of 5.1 for T for 2nd and 3rd mark 2 marks for 0.30 (N m^{-1})
04	**Name**: material dispersion ✓ **Cause**: different wavelengths (of white light) travel at different speeds (in the optical fibre) **OR** have different refractive indices ✓	2	
05	Use of $\mu = \frac{m}{l}$ ($\frac{3.3\times10^{-3}}{0.75}$ **OR** 4.4×10^{-3} kg m^{-1} seen) ✓ Substitution into $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ (eg $\frac{1}{2\times0.75}\sqrt{\frac{20}{4.4\times10^{-3}}}$) ✓ f = 45 (Hz) ✓	3	Allow use of m (3.3×10^{-3}) for μ for this mark Allow 2 marks for 52 Hz (ie use of m)

Question	Marking guidance	Mark	Comments
06.1	infinite ✓	1	Condone "very large"
06.2	Evidence of using graph to get gradient **OR** use of intercept (2 V) and a data point eg (1, 1.2) ✓	1	Must be a correct pair of coordinates.
06.3	$E = 2.00$ (V) ✓ Substitution into $E = I(R + r)$ (eg candidate's $E = 2.1(R + 0.8)$) ✓ $0.15(2)$ (Ω) ✓ **OR** Total $R = 2.00/2.1 = 0.95$ ✓ $R = 0.95 - 0.8$ ✓ $0.15(2)$ (Ω) ✓	3	Alternative method: Deduce pd correctly (0.32 V) and substitute into $R = V/I = 0.32/2.1$ Allow reasonable range for data extraction Allow 1 max for any extrapolation done by extending the grid and line but reward a "mathematical" extrapolation such as using similar triangles.

Question	Marking guidance	Mark	Comments
07.1	Oscillation ✓ Direction (of oscillation) parallel to direction of propagation of wave ✓	2	Allow "vibration" or a description of an oscillation OWTTE
07.2	$\lambda = \frac{5.0}{12.8} = 0.39$ m ✓ Use of $f = \frac{c}{\lambda}$ with 340 and their λ ✓ 870.4 (Hz) ✓ **OR** Time t for 12.8 cycles = $\frac{5.0}{340}$ s **and** time T for 1 cycle = $\frac{t}{12.8}$ ✓ $f = \frac{1}{T}$ ✓ 870.4 (Hz) ✓	3	Allow 871.8 (Hz) (must be at least 4 sf)
07.3	72 or 288 (degrees) ✓	1	
07.4	Recognition that 13 cycles are needed ✓ New λ = 0.385 (m) i.e. $\frac{5.0}{13}$ **OR** new $T = \frac{1.46\times10^{-2}}{13}$ ✓ New f = 884 (Hz) ✓ their new f - 870 (Hz) ✓	4	Allow for rounding errors Their new f must be greater than 870. Allow use of their **7.2**

Question	Marking guidance	Mark	Comments
08.1	tan θ = 0.878/2.000 (= 23.7°) ✓	1	
08.2	$d = 1.67\times10^{-6}$ (m) ✓ Substitution into $\lambda = d \sin\theta$ **OR** $\lambda = \frac{\sin\theta}{N}$ ✓ 6.7×10^{-7} (m) **OR** 6.8×10^{-7} (m) ✓	3	Condone power of ten error in d for 1st and 2nd marks Accept other values if appropriate unit given (eg 670 nm)
08.3	light from different slits overlaps (because of diffraction) ✓ two wavelength path difference (from adjacent slits) ✓ (resulting in) zero phase difference (at screen) OWTTE ✓ constructive interference occurs✓	**max** 3	Allow appropriate marking points if clear on a diagram eg light diffracting from slits; 2 λ path difference
08.4	Use of $n = \frac{d}{\lambda}$ (eg $1.67\times10^{-6} \div 532\times10^{-9}$) **OR** $n = 3.1$ seen ✓ order $n = 3$ ✓ 3 + central + 3 = 7 ✓	3	Condone power of ten error in λ for 1st mark Allow methods that show sin $\theta > 1$ for $n = 4$ or sin $\theta < 1$ for $n = 3$

Question	Marking guidance	Mark	Comments
09.1	Any three from Electrons (from beam) collide with metal target or anode✓ Idea of excitation followed by de-excitation OWTTE ✓ …involving the inner/K shell ✓ Photons emitted during de-excitation ✓ Photon energy = difference in energy levels ✓	max 3	Must be clear about which electrons are moving
09.2	$60\,000 \times 1.6\times10^{-19}$ **OR** 9.6×10^{-15} J seen ✓ Use of $\lambda = \frac{hc}{E}$ $(= 6.63\times10^{-34} \times 3\times10^{8} \div 9.6\times10^{-15})$ ✓ 2.1×10^{-11} (m) ✓	3	Allow power of ten error Allow use of $E=hf$ and $c=f\lambda$ Accept other values if appropriate unit given
09.3	λ_{min} approximately halved (by eye) ✓ K_α and K_β wavelengths unchanged ✓	2	Ignore other features of the graph

Question	Marking guidance	Mark	Comments
10.1	angle of incidence = $40° \pm 1°$ <u>and</u> angle of refraction = $27° \pm 1°$ seen in calculation or on diagram for ray **X** ✓ Use of $\frac{\sin i}{\sin r}$ ✓ Refractive index from $i = 40°$ and either $r = 27°$ or $28°$ ✓	3	Accept 2 or 3 sf only Expect answers in the range 1.37 to 1.42
10.2	One value of percentage uncertainty calculated correctly ✓ Percentage uncertainties for $\sin i$ and $\sin r$ added ✓ Absolute uncertainty in the range 0.07 to 0.09 ✓	3	Allow fractional instead of percentage uncertainties No sf penalty Allow ECF from **10.1**
10.3	Ray **Z** because it has the largest angle of incidence/refraction ✓ Percentage uncertainty = $\frac{\text{absolute uncertainty}}{\text{angle of incidence}} \times 100$ ✓	2	Accept "percentage uncertainty is inversely proportional to angle" or a comparison of absolute uncertainty (± 1) to angle.

Question	Marking guidance	Mark	Comments
11.1	Use of $W = mg$ (= 12.5 × 9.81) ✓ Use of $P = Fv$ (= 123 × 0.0015) ✓ 0.184 (W) ✓ **OR** Use of GPE = mgh (= 12.5 × 9.81 × 1.8) ✓ Use of $t = d \div v$ (= $1.8 \div 1.5 \times 10^{-3}$) ✓ 0.184 (W) ✓	3	Condone use of 10 for g Condone power of ten error for v 3 or more sf required for answer Condone use of 10 for g Condone power of ten error for v 3 or more sf required for answer
11.2	One from Greater mass✓ Increased speed of fall ✓	max 1	
11.3	Overall efficiency = $0.08 \div 0.18(4)$ **OR** Useful output power of gear system = $0.6 \times 0.18(4)$ ✓ 0.72 **OR** 0.73 **OR** 0.74 ✓	2	 Condone efficiencies as percentages provided that "%" included
11.4	Use of $R = \frac{V^2}{P}$ **OR** Use of $I = \frac{P}{V}$ and $R = \frac{V}{I}$ ✓ 91 (Ω) ✓	2	Condone POT error or use of 0.18 W for 1st mark

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