AS
PHYSICS
7407/2

Paper 2

Mark scheme

June 2019

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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	Answers	Additional Comments/Guidelines	Mark
01.1	MAX 2 Uncertainty in one/each reading is 1 mm $_1$✓ OR The measurement involves making two readings / there are two uncertainties (to be considered) in this measurement $_1$✓ Difficulty / uncertainty in locating (exact) position of (centre of) spot $_2$✓ Or Difficulty / uncertainty in lining up the (centre of the) spot with a graduation on the ruler $_2$✓ Or Difficulty / uncertainty in locating the position of A / B $_2$✓ the uncertainties from two (readings) are added $_3$✓	Allow the uncertainty in (reading) the position of a spot is 1 mm. $_1$✓ Owtte Do not allow: • because the smallest division is 1 mm • hard to see measurements to less than 1 mm (need to link to position of spot (or A or B) • "because of both sides of the ruler" on its own • "ruler slightly misaligned" too vague insufficient includes: • uncertainty doubles • uncertainty is twice the smallest division • Random error or human error or error without further detail. However: The uncertainty doubles because there are two readings scores MP1 Also: The uncertainty doubles because there are two readings with identical uncertainties would score 2 marks. Mention of range of repeated measurements÷2 is not applicable in this case.	2

01.2	(Adds the uncertainties =) 4 (mm) $_1$✓ Or Use of *by substitution* (percentage uncertainty=) $\frac{\text{uncertainty}}{\text{value}}$ (×100) (%) $_1$✓ (% uncertainty =) 0.**74 or** 0.7 (c.a.o) $_2$✓ (**1 or 2 significant figures only**)	*1st mark* Expect to see: (percentage uncertainty=) $\frac{4}{544}$ (×100) (%) Maximum 1 mark for Condone (in substitution): • 2/289, 2/255, 2/272, 2/544, 4/289, 4/255, 4/272 • power of ten errors (POT errors) • must be a recognisable uncertainty Maximum 1 mark for use of (percentage uncertainty=) $\frac{\text{uncertainty}}{\text{mean (value)}}$ (×100) (%) along with substitutions of • 2/289, 2/255, 2/272, 2/544, 4/289, 4/255, 4/272, 4/544 • power of ten errors condone for 1 mark ((2/289 + 2/255) x 100 =) 1.48% or 1.5% *2nd mark* Condone working leading to 2nd mark for: Use of (percentage uncertainty=) $\frac{2}{272}$ Do not allow mean of two separate % uncertainties **or** incorrect formula quoted and used in workings	2

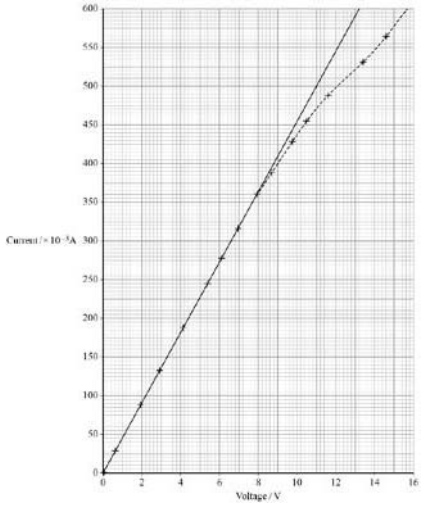
01.3	MAX 2 The <u>percentage</u> uncertainty in *c* is smaller <u>than for a or b</u> because *c* has a larger value (than *a* or *b* separately)$_1$✓ **or** <u>%</u> uncertainty in *c* is half the percentage uncertainty in $a + b$ $_1$✓ **or** The <u>percentage</u> uncertainty in *c* is smaller <u>because</u> its uncertainty is smaller for the same data value $_1$✓ *c*'s (% uncertainty =) 0.37 or 0.4 $_2$✓ **or** *c*'s (% uncertainty =) $\frac{2}{544} \times 100$ $_2$✓ idea that *c*'s measurement involves fewer readings than the sum of *a* and *b* $_3$✓ **or** idea that *c* requires fewer measurements than the sum of *a* and *b* $_3$✓	Insufficient: • c has a smaller uncertainty • $a + b$ has a larger uncertainty • The uncertainty of $a + b$ is combined Accept converse Where numbers are quoted, these must be consistent with terms used. 4 readings, 2 readings 2 measurements, 1 measurement	2

01.4	(when laser is switched on) always stand behind the laser (unless taking readings) ✓ Or if <u>in front of</u> laser (when switched on) look away from the laser (eg when taking readings) ✓ Or if <u>in front of</u> laser (when switched on) don't look at/towards the laser (eg when taking readings) ✓ Or don't look directly into the laser (beam)✓ Or direct laser towards nearest wall ✓ Or switch off laser when not in use ✓ Or ensure (glass) reflective surfaces are covered (prevent reflections) ✓ Or Do not shine the laser onto a reflective surface✓ Or place safety notices outside the laboratory [room] ✓ Or don't shine laser at eye level ✓ Or mark positions with pen/pencil and measure after laser switched off ✓ Or laboratory is normally illuminated (not darkened) ✓	Where a list of safety measures has been given: • Treat more than one correct as neutral • Penalise incorrect safety measure in a list that may include correct safety measures. Do not credit weak statements: • Do not look at the laser • Don't point the laser anywhere except at the grating • Don't look directly at the laser Beware of references to "the light".	1

01.5	(tan $\theta = \frac{0.544}{1.280}$ $= \theta =) 23.0(^\circ)$ ✓	allow 2 or more significant figure answer acceptable common answers: 23, 23.0, 23.03, 23.025, 23.0255 Where more than 3 sf quoted, the number must be correct. alternative method (valid attempt to determine distance from grating to spot **E**, eg (distance = $(\sqrt{0.544^2+1.280^2}) = 1.391)$ (sin $\theta = \frac{0.544}{1.391} = 0.391$) $(\theta =) 23.0(^\circ)$ ✓ allow 2 or more significant figure answer acceptable common answers: 23, 23.0, 23.03, 23.025, 23.0255 Condone mid-calculation rounding leading to errors in 4th sf where quoted.	1

01.6	use of $n\lambda = d\sin\theta$ $_1$✓ or (if nothing else seen) d = 3.3 x 10^{-6} m $_1$✓ $\lambda = 6.5(2) \times 10^{-7}$ (m) $_2$✓	ecf	Use of: Correct rearrangement where subject would be λ or correct substitution of *n, d and θ* Expect to see n=2 , d=3.3(3) x 10^{-6} , θ = 23(.0) Condone **one** error in substitution for n or d in a correctly rearranged equation where subject would be λ *(or where answer indicates the correct working for incorrect numbers, d error leads to* 5.86 x 10^4*)* Condone power of ten errors in working 2 or 3 sf only where 3 sf quoted answer must be in range 651 to 652 nm (or ecf) Common ecf (sin θ error in 1.5): Expect to see an answer that rounds to 7.1 x 10^{-7} m to 2 sf	**2**

01.7	The second mark ($_2$✓) is contingent on the award of the first mark ($_1$✓). Increase distance from grating to screen / increase y $_1$✓ (This will increase distance y (and/or c) therefore) decreasing the <u>percentage</u> uncertainty in y / *c* / fringe spacing / θ / sin θ $_2$✓ Or Use a higher-order spot $_1$✓ (This will increase distance from centre spot to higher-order spot therefore) decreasing the <u>percentage</u> uncertainty in the fringe spacing/θ/sin θ $_2$✓ Or Measure distance between A and E $_1$✓ (This increases the distance therefore) decreasing the <u>percentage</u> uncertainty in c $_2$✓	Do not accept: • darkened room • use a (vernier) caliper • use a travelling microscope • Repeat • Repeat and average • Computer / data logger / camera • Ruler with smaller divisions • Make the maxima further apart (details on how this is achieved are required) • Increase distance between laser and screen. Decreases the <u>percentage</u> uncertainty in y $_2$✓ Condone reference to this distance as *c* No details of determination of *c* are required.	**2**
Total			**12**

Question	Answers	Additional Comments/Guidelines	Mark
02.1	Acceptable line ✓ Condone one failure from the following list A. Line straight up to point 8 (expect ruled but condone freehand drawing) B. Line shows balance of points on each side of drawn line C. Line goes within region of data cross D. Appropriate continuous transition between line and curve E. Beyond point 12 shows either curve of decreasing gradient OR straight line through points 12 to 15 F. Thin line and non-variable thickness G. Line of acceptable quality, eg not hairy or kinked **Please annotate on CMI+**	The line must intersect with the cross of the data point. However, condone point 14 or 15 being off line of best fit for a smooth curve. Condone partially erased and redrawn. Do not allow double line under any circumstance. Allow a curve with a slight inflection at point 14 (see example below) Allow a split line where linear section has been extrapolated to the top of the grid e.g.  	1

02.2	Circle drawn around data point 9 (8, 360×10^{-3}) ✓	Condone circle drawn around data point 10 (8.7, 390×10^{-3}) **provided that** linear section of line intersects with this cross.	1

02.3	Correct read off for voltage from candidate line $_1$✓ Correct answer using $\left(\frac{\frac{their\ V}{0.55} - 22.2}{22.2}\right) \times 100$ $_2$✓	This voltage must be within one half-square of actual value. Penalise mid-calculation rounding. Condone missing % sign; 2 or 3 significant figures for answer. Penalise Physics Error of using gradient of tangent to determine the resistance.	2

02.4	circuit **D** is correct $_1$✓ circuit **A** is incorrect because the ammeter is not measuring the current in **R** OR ammeter is not in series with **R** OR the ammeter is measuring the current in the power supply $_2$✓ circuit **B** is incorrect because the voltage range (shown in the data) cannot be produced OR cannot achieve voltage less than (about) 5 V $_3$✓ circuit **C** is incorrect because the voltmeter is not in parallel with **R** OR the voltmeter is not measuring the voltage across **R** OR the voltmeter reading equals emf minus voltage across **R** $_4$✓	Ignore unclear or incorrect explanation for MP1 $_2$✓ $_3$✓ and $_4$✓ are awarded for correct explanations **not** for a statement that a circuit is incorrect. for $_1$✓ accept implied answer that circuit **D** is correct if circuits **A**, **B** and **C** are all stated to be incorrect for $_2$✓ any suggestion that in circuit **A** the voltmeter is in the wrong position forfeits the mark Condone circuit B is incorrect "because the voltage cannot go down to zero" for $_3$✓. Or Condone circuit B is incorrect "there is less variation in voltage because the resistors are in series" $_3$✓. for weak statements in MP2 and MP4 1 mark for 'circuit **A** is incorrect because ammeter is in wrong place' **and** 'circuit **C** is incorrect because voltmeter is in the wrong position' If **A** / **B** / **C** is identified as correct then **MAX 2** for two statements that correctly explain why the others are unsuitable. If no other marks awarded: **MAX 1** for "Circuit **B** is correct because the ammeter in series with resistor **R and** the voltmeter is in parallel with **R**".	4

Total			**8**

Question	Answers	Additional Comments/Guidelines	Mark
03.1	Neutron number increases by one **and** proton number decreases by one $_1$✓ Or A proton changes/decays to a neutron $_1$✓ (because) up (quark) changes to a down (quark) $_2$✓	Allow use of symbols: *N* increases by one and *Z* decreases by one Allow this expressed as an equation symbols for proton and neutron. Allow u (quark) changes to d (quark) Allow uud –> dud Where decay equation is attempted, condone incorrect leptons (quarks must be correct).	2

03.2	Conversion of 0.52 MeV to eV seen $_1$✓ Or Conversion of 0.52 MeV to J $_1$✓ Or Use of $p = \frac{E}{c}$ $_1$✓ $(p =) 2.77 \times 10^{-22}$ or 2.8×10^{-22} $_2$✓ **c.a.o**	5.2×10^5 (eV) seen Condone POT error in conversion to joule Expect to see: 8.32×10^{-14} (J) With substitution of student's value for E (where conversion hasn't been completed or completed incorrectly)	2
03.3	Shades detector opposite **P** ✓	The leader line from label 'patient's head' passes through a box. Expect to see shaded the box below the 'leader line' box. Allow either of the boxes adjacent to expected box. Penalise more than one box shaded.	1
03.4	2 photons (are produced) / Photons must move off in opposite directions (along the same line)$_1$✓ The photons must have equal and opposite momentum / must conserve momentum $_2$✓		2

03.5	Use of (gradient=) $\frac{\Delta v}{\Delta t}$ $_1$✓ $4.5(1) \times 10^{-6}$ (m s^{-2}) $_2$✓	Condone power of ten errors and leaving time in hours (or incorrect conversion to seconds) Correct read off; condone errors in read off that lead to $\pm$ 1mm s^{-1} in Δv and ± 0.02 h in Δt. For 1 mark expect to see (79-60)÷ 1.18 (65-60) ÷ 0.3 (70-60) ÷0.6 (75-60) ÷ 0.92 (76-60) ÷ 1 **Max 1** for answer where there is failure to notice false origin. MP2 is available in this case where there is only the false origin error. Range = 4.40× $10^{-6} \leq$ *accepted value* <4.65× 10^{-6}	2

03.6	Acceleration increases$_1$✓ Larger change in momentum (because more photons are reversing direction of motion) <u>therefore</u> a larger force on solar sail $_2$✓ **Or** More momentum gained per second (from the photons) $_2$✓ **Or** Larger force on photons <u>therefore</u> larger force on sail $_2$✓	Condone correct acceleration statement linked to incorrect explanation.	2

Total			**11**

Question	Answers	Additional Comments/Guidelines	Mark
04.1	**Method 1:** Attempts to determine area under curve / by counting squares $_1$✓ Multiplies their (total) area (or charge) by 24 (V) $_2$✓ 240 (J) $_3$✓ **Method 2:** Attempt to determine average current (over first 200 ms in range 45 A to 55 A) $_1$✓ Use of $E = I \times V \times t$ $_2$✓ 240 (J) $_3$✓	Allow POT error on area of square in $_1$✓ and $_2$✓ Evidence seen by calculations **or** from counting squares **or** from division of area into **at least two** recognisable geometrical shapes (triangles, rectangles, trapezia) answer in range 220 J to 264 J Substitutes current value (or Δ current) with t = 200 ms and V = 24 V. Condone POT Allow as two stage $Q=It$ and $E=QV$ Or $P= VI$ **and** $E=Pt$ answer in range 220 J to 264 J	3

04.2	(KE gained) =) $65(.0)$ (J) **or** (PE gained) =) $58(.3)$ (J) $_1$✓ Use of efficiency = $\frac{\text{an output energy}}{\text{ans from part 04.1}}$ **or** (total output = 65 + 58 =) 123 (J) $_2$✓ (Efficiency =) 0.51 or 51% $_3$✓	Allow output energy = 65 /58/ 120 /123 or candidate ke + pe Allow ecf from 4.1 for all 3 marks. Answer to at least 2 sf. Range is 0.467 to 0.56 (46.7 % to 56 %)	3
04.3	Heating occurs / temperature increases when there is a <u>current</u> (in the thermistor) (due to I^2R) $_1$✓ (When the temperature increases) the resistance of thermistor decreases (whereas fixed resistor remains high) $_2$✓ (Lower resistance from thermistor means) less wasted power $_3$✓ OR (Lower resistance from thermistor means) more pd dropped across the motor (less wasted voltage) $_3$✓	Alternatively: (Lower resistance from the thermistor means) less voltage drop across thermistor $_3$✓	3
Total			**9**

Question	Key
05	D
06	D
07	A
08	B
09	B
10	D
11	D
12	C
13	B
14	C
15	B
16	A
17	C
18	A
19	A
20	C

Question	Key
21	D
22	C
23	B
24	D
25	C
26	B
27	C
28	D
29	B
30	A
31	B
32	B
33	C
34	A