A-LEVEL
PHYSICS
7408/1

Paper 1

Mark scheme

June 2022

Version: 1.0 Final

226A7408/1/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.

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

Copyright information

AQA retains the copyright on all its publications. However, registered schools/colleges for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to schools/colleges to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Copyright © 2022 AQA and its licensors. All rights reserved.

Physics - Mark scheme instructions to examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.
2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.
2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

3.2 Marking procedure for calculations

Full marks can usually be given for a correct numerical answer without working shown unless the question states 'Show your working'. However, if a correct numerical answer can be evaluated from incorrect physics then working will be required. The mark scheme will indicate both this and the credit (if any) that can be allowed for the incorrect approach.

However, if the answer is incorrect, mark(s) can usually be gained by correct substitution / working and this is shown in the 'extra information' column or by each stage of a longer calculation.

A calculation must be followed through to answer in decimal form. An answer in surd form is never acceptable for the final (evaluation) mark in a calculation and will therefore generally be denied one mark.

3.3 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.4 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are likely to be restricted to calculation questions and should be shown by the abbreviation ECF or *conseq* in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.5 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited (eg fizix) **unless** there is a possible confusion (eg defraction/refraction) with another technical term.

3.6 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.7 Ignore / Insufficient / Do <u>not</u> allow

'Ignore' or 'insufficient' is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

'Do **not** allow' means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.8 Significant figure penalties

Answers to questions in the practical sections (7407/2 – Section A and 7408/3A) should display an appropriate number of significant figures. For non-practical sections, an A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the **final** answer in a calculation to a specified number of significant figures (sf). This will generally be assessed to be the number of sf of the datum with the least number of sf from which the answer is determined. The mark scheme will give the range of sf that are acceptable but this will normally be the sf of the datum (or this sf -1).

An answer in surd form cannot gain the sf mark. An incorrect calculation **following some working** can gain the sf mark. For a question beginning with the command word 'Show that…', the answer should be quoted to **one more** sf than the sf quoted in the question eg 'Show that X is equal to about 2.1 cm' –

answer should be quoted to 3 sf. An answer to 1 sf will not normally be acceptable, unless the answer is an integer eg a number of objects. In non-practical sections, the need for a consideration will be indicated in the question by the use of 'Give your answer to an appropriate number of significant figures'.

3.9 Unit penalties

An A-level paper may contain up to 2 marks (1 mark for AS) that are contingent on the candidate quoting the correct unit for the answer to a calculation. The need for a unit to be quoted will be indicated in the question by the use of 'State an appropriate SI unit for your answer'. Unit answers will be expected to appear in the most commonly agreed form for the calculation concerned; strings of fundamental (base) units would not. For example, 1 tesla and 1 Wb m^{-2} would both be acceptable units for magnetic flux density but 1 kg m^2 s^{-2} A^{-1} would not.

3.10 Level of response marking instructions

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

Determining 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. i.e. if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2.

The exemplar materials used during standardisation will help you to determine the appropriate level. 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
01.1	${}^{4}_{2}\alpha$ ✓+ ${}^{234}_{90}\mathrm{Th}$ ✓	1 mark each for alpha and Th; numbers must be correct Must see "+" for full marks Condone He for alpha If no other mark is given, one mark can be awarded if He-3 is used and A and Z are correct MAX 1 for extra particles but condone "+ $2e^{(-)}$" (not 2β) Ignore symbol that is used for Thorium	2	2 x AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
01.2	Idea that a neutron changes to proton/beta minus decay ✓ The particle is W^- because This is a weak interaction / it involves the weak force / there is a quark change and indication that charge is conserved ✓	For MP1 condone "down quark changes to up quark". Evidence for MP1 can be found in the form of equations or diagrams. Second mark requires some explanation of why particle is negative. MAX 1 for a complete consistent inverse interaction leading to W^+.	2	1 x AO2 1 x AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.3	*(FOR:)* Lines **C** is in (both) hydrogen (and helium spectra) OR Line **E** is in (both) sodium (and helium spectra)✓ *(AGAINST:)* Line **D** is missing (is in neither the hydrogen nor the sodium spectra) ✓	Treat references to **A**, **B** and **F** in FOR or AGAINST as neutral. Must link line to an element Ignore any discussion of any "missing" lines in the helium spectrum. Condone use of 390 / 440 / 490 / 505 / 590 / 670 (nm) for **A**/**B**/**C**/**D**/**E**/**F** Condone emission for absorption	2	2 x AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
01.4	Wavelength = 580 nm to 590 nm ✓ Use of $E = hc/$(their wavelength) ✓ Conversion of their E in J to eV ✓	Expect to see answer in range 2.11 to 2.14 (eV) ✓ When an energy difference between two spectral wavelengths is correctly calculated, only MP2 and MP3 can be scored.	3	1 x AO3 2 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
01.5	Photon is energy carrier OWTTE ✓ In absorption atom becomes excited/moves to higher energy state/level (by absorbing photon) ✓ In emission atom de-excited/moves to lower energy state (by emitting photon) ✓	Condone omission of reference to energy states/levels in either MP2 or MP3 but not both. Treat discussion of any other irrelevant phenomenon or incorrect physics as talk out in that marking point. Allow "energy shell" but not "shell". Condone electron for atom Suggestions that limit transitions to/from ground state penalise in either MP2 or MP3 once only.	3	3 x AO1
Total			**12**	

Question	Answers	Additional comments/Guidelines	Mark	AO
02.1	down quark changes to up quark ✓	Allow "d→u" Condone udd→uud Condone U for u but not D for d. Do not accept answers with extra particles.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.2	Idea that (graph shows that) beta particles (from C-14) have a range of (kinetic) energies ✓ There is a fixed/maximum/total amount of energy (released by C-14) so there must be another particle that carries the energy differences/missing energy away ✓	A mention of conservation of energy on its own is insufficient for MP2.	2	2 x AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.3	neutron ✓	Condone "n" but not "N". Do not allow "udd".	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
02.4	Calculation of minimum energy produced in annihilation of positron and electron (from rest mass energy ×2) E.g. $2 \times 0.51\ \text{MeV} = 1.6 \times 10^{-13}$ J ✓ (2 photons produced so) energy per photon = 8.2×10^{-14} J ✓ Conclusion consistent with their calculated minimum energy. ✓ ALTERNATIVE One calculation of mass equivalence of photon energy✓ Calculation of remaining mass equivalents OR deduction about the other two photon energies ✓ Only G3 has sufficient energy to have been made in annihilation. ✓	Calculation of the photon energy based on one particle can get MP2. The 'correct' answer would be a conclusion leading to G3 only. If no other mark awarded, award one mark for determining rest energy of positron or electron in J. Allow mass equivalent calculations in (M)eV Allow explanation in terms of positron and electron for annihilation in alternative MP3	3	3 x AO3
Total			**7**	

Question	Answers	Additional comments/Guidelines	Mark	AO
03.1	Volume of A = area × length = $4.16 \times 10^{-4}\ \text{m}^3$ OR Mass of A = $\text{W/g} = 3.6\ \text{kg}$ ✓ Use density equation ✓ Compares a calculated property of brass (e.g. weight, length or diameter) with A OR the calculated density of A with density of brass OR the calculated mass of A with the calculated mass of brass and therefore brass ✓ Example: Volume of A = area × length = $4.16 \times 10^{-4}\ \text{m}^3$✓ Mass if brass = density × volume = $3.58\ \text{kg}$✓ Weight = $3.58 \times 9.81 = 35\ \text{N}$ (which is weight of A) and therefore brass is correct. ✓	Condone POT error in MP1 Do not allow use of weight in density equation Do not accept 8.3 x 10^3 for density of A . Award zero marks for an unsupported answer "Brass" Only award MP3 if answer "brass" given.	3	3 x AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
03.2	Use of $T = (35) \cos 55$ ✓ 2 x their T (= 40 N) ✓		2	2 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.3	Angle (to horizontal) decreases ✓ (Weight/tension in rope remains constant at 35 N) So horizontal components (from tension in rope) increase ✓ (Therefore tension in cable must increase)	Do not award MP2 if answer suggests that tension in rope increases. Do not allow "tension increases" for credit.	2	2 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.4	Component of the force at right angle to door = 41 cos (90−12) / 41 sin (12) = 8.5 N ✓ Moment = 8.5 × 0.95 = 8.1 (N m) ✓ Allow ecf from their value of weight component .	Alternative: Perpendicular distance = 0.95 sin (12) = 0.198 m ✓ Moment = 41 × 0.198 = 8.1 ✓ Allow ecf from their value of perpendicular distance. (Calculator value is 8.098 160 3) Award zero marks for simply multiplying 41 N × 0.95 m.	2	2 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
03.5	ALTERNATIVE 1 Increase weight / density / mass / volume of **A** ✓ Increases tension (and therefore moment) ✓ ALTERNATIVE 2 Position pulley **R** further (out) from gate hinges / increase diameter of pulley **R** ✓ Increases angle and therefore bigger perpendicular component (and therefore moment). ✓ ALTERNATIVE 3 Decrease angle of rope eg by putting P and fixed point closer together / further to right ✓ Increases tension (and therefore moment) ✓ ALTERNATIVE 4 Move **D** further from hinge/**R** OR make **C** longer ✓ Increases perpendicular distance (and therefore moment) ✓	Any 2 alternatives If more than two answers given, mark first two. Ignore the 1 and 2 in answer lines.	4	4 x AO3
Total			**13**	

Question	Answers	Additional comments/Guidelines	Mark	AO
04.1	$R = \frac{V^2}{P} = \frac{6.2^2}{4.5} = 8.5(4)\ (\Omega)$✓	Condone use of *W* for *P*.	1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
04.2	Calculation of current in lamp (0.73 A) OR Calculation of current in 12 Ω resistor (0.52 A) OR Calculation of parallel pair resistance (5.0 Ω) ✓ Calculation of total circuit current (1.2(4) A) OR Calculation of total circuit resistance (7.5 Ω) OR Expression of potential divider arrangement $\frac{\varepsilon - 6.2}{r} = \frac{6.2}{\text{external } R}$ OR $\frac{\varepsilon}{\text{total circuit restance}} = \frac{6.2}{\text{external R}}$ ✓ (emf = terminal pd + Ir = 6.2 + (1.24 × 2.5)) 9.3(1) V ✓	Allow ecf from **04.1** Allow alternative methods Give full credit to answers that use 9Ω : Expected values for this method are Lamp current = 0.69 A Current in 12 Ω resistor = 0.52 A Parallel pair resistance = 5.1(4) Ω Total circuit resistance = 7.6(4) Ω Total circuit current = 1.2(1) A emf = 9.2(1) V	3	3 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.3	Evidence of calculation of $A\ (=\pi\,(d/2)^2 = 2.84\times10^{-8})$ ✓ Use of their *A* in the resistivity equation = RA/l ✓ To give $5.1\times10^{-8}\ (\Omega\text{m})$✓	Allow POT errors in MP1 and MP2 Allow answers that round to $5.10\times10^{-8}\ (\Omega\text{m})$	3	3 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
04.4	Resistance increases ✓ Reduces current through lamp and lamp dimmer OR Greater pd across plugs as potential divider and lamp dimmer✓	Do not condone explanations that confuse current and potential difference. Do not condone "current across" or "pd through".	2	2 x AO3

Question	Answers	Additional comments/Guidelines	Mark	AO
04.5	(Resistance increases) Reduces current in circuit / battery OR Increases (external) circuit resistance ✓ Reduces pd dropped across internal resistance of cell / increases terminal pd so lamp brighter. ✓	Award MAX 1 for arguments dealing with initial dimming of bulb when wire attached. Condone "pd across lamp and resistor / parallel section" for "terminal pd". Condone "lost volts".	2	2 x AO3
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
05.1	Use of time = angle ÷ angular speed ✓ To get 3.5 (s) ✓	Alternative for MP1: Accept distance÷speed when circumference has been calculated. Accept answers that round to 3.49	2	2 x AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.2	Arrow towards centre of turntable . ✓		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.3	Use of $F = mrw^2$ OR determination of centripetal acceleration and then *F=ma* ✓ To give 0.097 N ✓	Shown by substitution. Condone use of diameter or radius halved in MP1. Accept negative answer. Calculator value: 0.0972	2	2 x AO2

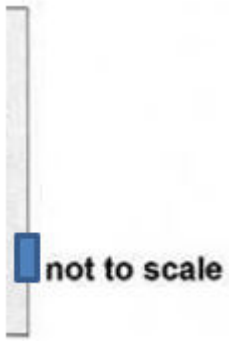
Question	Answers	Additional comments/Guidelines	Mark	AO
05.4	States block is (constantly) changing direction ✓ Uses appropriate Newton law of motion to link evidence (to show that a force acts) ✓ *Alternative 1* Block constantly changing direction (at constant speed) ✓ Uses N1 to show that a force must apply ✓ *Alternative 2* Changing direction shows (centripetal) acceleration ✓ Uses N2 to show that a force must apply ✓	Reference can be to the name of the law or to a description of what the law says. Condone lack of "resultant force" in N1 and N2. Use of "changing velocity" without reference to direction is not enough for MP1.	2	2 x AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.5	Use of pendulum equation by substitution or manipulation ✓ To give 1.55 m ✓	Allow 2+ sf Allow answer that rounds to 1.55 Use of $g = 10$ N kg^{-1} gives 1.58 – do not allow for MP2	2	2 x AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
05.6	*Amplitude* – the pendulum shadow amplitude becomes less than the block shadow amplitude ✓ *Phase* – time period decreases/changes OR frequency increases/changes (as pendulum amplitude gets less) therefore phase changes ✓	Must see a comparison for MP1 Condone: the time periods/ frequencies remain identical therefore the shadows remain in phase	2	2 x AO3
Total			**11**	

Question	Answers	Additional comments/Guidelines	Mark	AO
06.1	As angle of refraction greater than angle of incidence with reference to Snell's law / $n = \sin i \div \sin r$ OR light bends away from normal when it speeds up ✓ (Therefore $n_A > n_B$)		1	AO1

Question	Answers	Additional comments/Guidelines	Mark	AO
06.2	Calculation of angle of incidence = $90° - 43° = 47°$ ✓ Use of Snell's law to give angle of refraction $= 61(.4)$ ° cao ✓	MP1 may be seen on diagram Calculator value: 61.357 115 7	2	2 x AO2

Question	Answers	Additional comments/Guidelines	Mark	AO
06.3	Use of sin $c = 1/n$ to get $c = 48°$ OR $i = (180° - 43° - 61.4° =) 76°$ ✓ Other calculation and i greater than c therefore tir ✓ Ray reflecting off **P** to land where the top of the n of 'not to scale' label meets the glass surface ✓	Condone $77°$ but not $75°$ No ecf from MP1 to MP2 Allow a range: 	3	3 x AO3
Total			**6**	

Question	Key	Answer
07	C (AO1)	work done and the moment of a couple
08	D (AO3)	m μ p
09	B (AO1)	10^6 J
10	A (AO2)	4.4×10^7 C kg^{-1}
11	C (AO1)	from 0.5 fm to 3 fm up to 0.5 fm
12	B (AO1)	Strange particles are always created in pairs.
13	B (AO2)	sū
14	B (AO2)	maximum kinetic energy of a photoelectron
15	B (AO1)	absorbs photons of ultraviolet light from the gas and emits visible light.
16	A (AO1)	electron diffraction photoelectric effect
17	D (AO2)	a proton moving at 8×10^5 m s^{-1}
18	C (AO2)	It oscillates with a time period of 1.5 ms.
19	A (AO1)	first
20	D (AO2)	2.2×10^{-4} m
21	D (AO2)	9
22	A (AO1)	270 km

23	C (AO2)	14 m
24	B (AO2)	4100 N
25	C (AO1)	the gravitational force of the parachutist on the Earth
26	D (AO2)	0.614 N s
27	D (AO1)	$9E$
28	C (AO3)	The strain of Q is double the strain of P.
29	A (AO2)	1.1×10^{18}
30	D (AO2)	25 Ω
31	C (AO2)	54 mm s^{-1}