A-LEVEL
PHYSICS
7408/3BA

Paper 3 Section B Astrophysics

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

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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
01.1	2 rays brought to red focus and two rays brought to blue focus on PA Blue ray focus closer to lens than red ray ✓	Accept one ray of each colour provided they pass through the PA Accept rays that stop at the PA Accept violet for blue Accept any two colours in the right order Accept initials for colours Accept hand-drawn rays unless obviously curved Rays can bend at centre of lens or at either (or both) surfaces(s)	1
01.2	Concave convex ✓		1

<table>
<tr>
<td>01.3</td>
<td>
The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th></tr>
<tr><td>6</td><td>All 4 aspects analysed, including calculation of resolving power/ratio of resolving powers for two telescopes.
6 marks can be awarded even if there is an error and/or parts of one aspect missing.</td></tr>
<tr><td>5</td><td>A good attempt to analyse 3 aspects, which must include quantitative or algebraic discussion of resolution or collecting power</td></tr>
<tr><td>4</td><td>Two aspects successfully discussed and one partially discussed. Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>Two aspects discussed, or one discussed and two others covered partially. There may be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>Only one aspect discussed successfully, or makes a partial attempt at more than one aspect.</td></tr>
<tr><td>1</td><td>None of the four aspects covered without significant error; at least one relevant comment.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table>
</td>
<td>
The following statements are likely to be present.
A Structure
Similarity: both use reflecting (parabolic) surface.L1
Difference: Radio – no secondary reflector, detector placed at focal point of primary, wire mesh for dish L1
Treat as neutral: radio telescope arrays, optical only during dark
B Positioning
Similarity: both capable of being on Earth's surface as little absorption by atmosphere at optical or radio wavelengths. The presence of both on the planet can be inferred if reference is made to altitude. L2
Difference: Light pollution requires optical telescopes to be away from centres of population; distortions due to atmosphere require optical to be high up; obscuration by clouds requires optical to be high up or in dry places/radio telescopes need to be located in a (radio) quiet area/radio can be at lower altitude. L2
Treat as neutral: comments about placing either A or B in space,
C Collecting power
D^2: much larger D for radio means much greater collecting power /8× greater (but sources tend to be very weak) compared to optical.
CPB/CPA = $110^2/39.3^2 = 7.8$
D Resolving power
λ/D; B large D but extremely large λ means generally low resolving power compared to A.
So A likely to provide more detailed image.
</td>
<td>6

AO1-1a (2)
AO2-1a (2)
AO3-1b (2)</td>
</tr>
</table>

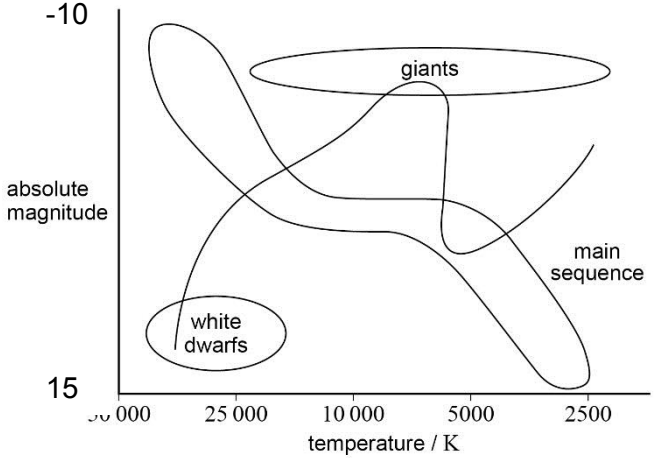
		Evidence of calculations, eg For optical min λ angle = 8.9×10^{-9} rad For radio min λ angle = 2.3×10^{-5} rad (could compare max λ angle; 4.6×10^{-8} and 9.1×10^{-3})	
Total			**8**

Question	Answers	Additional Comments/Guidelines	Mark
02.1	Hipparcos scale: (brightest 1) down to 6 dimmest (visible in good conditions) ✓ Gamma A and HD 66141 much dimmer than two brightest stars / not much brighter than magnitude 6 ✓ Only two stars (Gomeisa and Procyon) likely to be seen (unless conditions are good) ✓	6 dimmest may be inferred. Accept reverse argument.	1 2
02.2	Gomeisa (is a B class star) ✓ (B class stars are hot enough) to have electrons/hydrogen in n=2 state ✓	Condone "The B class star" for first mark	1 1
02.3	Same spectral class so similar temperature ✓ Absolute magnitude of Gamma A (and therefore power output) brighter (greater) than HD 66141 ✓ Due to Stefan's Law, Gamma A has larger area, and therefore larger diameter ✓	Accept same temperature Confusion with apparent magnitude, max 1 Accept power ,but Not brightness, of Gamma A is greater without direct reference to Abs Mag P prop to A at constant T equivalent to is enough for Stefans Law	3

02.4	Periodic Doppler shift in light received (from star) ✓ Due to star and planet orbiting common centre of mass ✓	Statement or implication that light is from planet loses this mark. Red and Blue shift is equivalent. Red shift could increase and decrease. Periodicity could be implied Ignore 'wobble' unless clearly explained.	2

02.5	Use of $m - M = 5 \log (d/10)$ To give $0.34 - 2.65 = 5 \log (d/10)$ ✓ $\log (d/10) = -2.31/5$ $d = 3.45$ ✓ pc ✓	Reversing magnitudes (giving 29pc) is a physics error. Can score unit mark only. Beware of $\log_e$ in expression – PE max 1 for unit Condone parsec, PC or Pc but Not ps OR pC. Unit mark cannot be awarded without an attempt at calculation. Allow correct converted unit. (e.g. 11.2 or 11.3 ✓ ly ✓; 7.1×10^5 AU; 1.1×10^{17} m) Other units can only be awarded if clear intention of conversion. (e.g. AE in calculating parsecs correctly converted to metres)	3

Total			**13**

Question	Answers	Additional Comments/Guidelines	Mark
03.1	Scale labelled from +15 up to –10 ✓	+15 bottom of white dwarves at the maximum. -10 top of giants at the lowest.	1
03.2	S between 5000 K and horizontal section of bottom line of main sequence. ✓1 Within main sequence and at 'correct' abs mag 5 ✓2	Marks are independent For the second mark the S should be closer to +5 than 0 or +10 on 'correct' scale. If only "S" is seen, assume middle of the "S". If a clearly labelled dot or × is seen, that should be used for marking.	2
03.3	Line drawn coming from the right to S, ✓1 Line drawn from S up to giants and round to white dwarfs ✓2	-10  Accept convoluted lines. Must touch giants and dwarves but does not need to go into area. Arrows are not required, but penalise any that go in the wrong direction with max 1.	2
03.4	Point P to the right and above their S ✓	Accept P on same horizontal level as S	1

3.5	Absolute magnitude of supernova (is about -20), beyond scale of HR diagram OR Supernova is shortlived / varies so cannot be assigned a position ✓1 Temperature of a supernova (peak) is too high (greater than $50\,000$ K) ✓2 Black hole – escape velocity greater than *c* OR no light emitted /absolute magnitude too dim to fit on scale ✓ 3 Temperature of a black hole would be too low (less than 2500 K ✓4	Accept "too hot"/"too cold" for temperature Insist on "absolute magnitude" not "brightness". Condone: A supernova does not last very long. Do not accept 'absolute magnitude would be zero' Max 3	Max 3
Total			**9**

Question	Answers	Additional Comments/Guidelines	Mark
04.1	Correct use of Doppler equation for both Galaxies ✓ Correct use of Hubbles law for both Galaxies ✓ Justified comparison leading to conclusion ✓	Award full credit for calculation:- 1. Hubble's constant for two galaxies and then related to Hubble's constant value in data booklet or to each other: NGC 936 is consistent (H=69 km s^{-1} Mpc^{-1}) NGC 3379 is not consistent (H=92 km s^{-1} Mpc^{-1}) 2.Using Hubble constant from data booklet to deduce if z or d in table are in agreement with calculated values for both galaxies. 3.Calculate ratio z/d for both galaxies and compare. z/d = 4.8/6.8 = 0.7 and z/d = 3/3.2 = 0.9 Condone POT errors when compared in a ratio. ECF for comparison if at least one calculation correct. (max2/3) Candidate who calculates values for only one galaxy can only score 1 mark. Credit discussion suggesting that other factors also affect galaxy velocity or distance measurements and difference not large so Hubble's Law is OK.	1 2

04.2	Distant quasars are very faint; or Type 1a supernova (or standard candle) in associated galaxy would be very faint ✓ Reference to inverse square law ✓ or Due to dark energy/accelerating universe, ✓ use of Hubble's Law/inverse square law not reliable over large distances. ✓	Condone 'barely detectable OWTTE' for faint. Condone Some quasars are situated behind intervening galaxies/gas clouds Affecting data/light received from quasar	2

Total			**5**