A-LEVEL
PHYSICS
7408/3BA

Paper 3 Section B Astrophysics

Mark scheme

June 2020

Version: 1.0 Final

206A7408/3BA/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

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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.

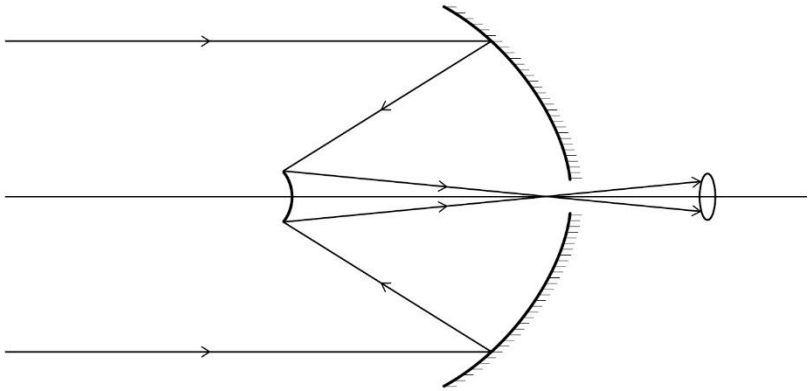
When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use 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.

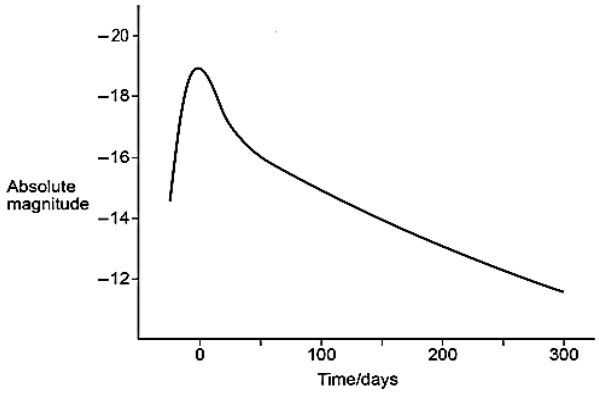
An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Additional comments/Guidance	Mark	AO
01.1	Diagram of Cassegrain telescope with both mirrors correct ✓ two rays correct ✓ 	The first mark is for a concave primary mirror and convex secondary. Condone lack of shading. Hole in primary can be inferred from rays passing through. Primary must not look like two mirrors. Condone flat secondary if labelled convex. Do not condone if concave. The second mark is for the two rays, initially parallel to the principal axis, reflecting from the primary mirror to the secondary, and then crossing on the principal axis after secondary and before passing through primary. Condone crossing after primary if before a lens. Ignore arrows on rays. No lens needed; ignore rays after lens if drawn. Poorly drawn rays, eg curved, loses mark.	2	AO1.1b
01.2	Resolution $= \frac{450 \times 10^{-9}}{0.21} = 2.14 \times 10^{-6}$ (rad) ✓ Smallest detail $= 2.14 \times 10^{-6} \times 12.5 \times 10^{6} = 27$ m ✓ Sensible comment about comparison and decision made ✓	For MP2 student may find angle subtended by 1 km crater (8.0×10^{-5} rad) then compare angles for MP3 MP3 for example 27 m is $1/40$th of crater.	3	AO3.1a

Question	Answers	Additional comments/Guidance	Mark	AO
01.3	Collecting power $\propto$ area ✓ Ratio $= 2.4^2 / .21^2 = 130$ OR calculates both areas and states Hubble is much bigger ✓	MP1 is for student showing they know dependence on area. Condone collecting power $\propto$ d^2 if it is clear that d is diameter. MP2 for clear comparison	2	AO2.1f
01.4	At least 2 clear comparisons made ✓✓ Decision made about which telescope, justified in terms of the impact of at least one comparison on the image (likely to be reflecting).✓	Problems of refractors: Can suffer spherical aberration and chromatic aberration. Reflecting are lighter. Reflecting are shorter. Mirrors do not suffer from chromatic aberration. Problems of reflectors: Spider/secondary mirror block some of the light/reduce image brightness/cause diffraction effects. Ignore discussion of cost/difficulty of construction/air trapped in refracting telescope.	3	AO3.1b
Total			**10**	

Question	Answers	Additional comments/Guidance	Mark	AO
02.1	Tick (✓) only against Tsih	Accept other clear indication (eg x)	1	AO1.1b
02.2	Temperature: Attempt to use Wiens Law. ✓ Correct calculation of T for both stars. ✓ Colour: Links colour to wavelengths produced ✓ Schedar longer wavelengths so 'redder' than Caph ✓ Or Links temperature to spectral class ✓ Caph F (therefore White), Schedar K (therefore Orange) ✓	For Caph $T = \frac{2.9 \times 10^{-3}}{410 \times 10^{-9}} = 7250$ K (6900–7630) For Schedar $T = \frac{2.9 \times 10^{-3}}{660 \times 10^{-9}} = 4400$ K (3600–5200) Allow ecf for incorrect temperatures. No mark for just stating colours	4	1× AO1.1b 1× AO2.1f 2× AO3.1a
02.3	Caph ✓		1	AO2.1e
02.4	Conversion of distance to parsec (70) ✓ Use of $m - M = 5\log(\frac{d}{10})$ to give $M = m - 5\log(\frac{d}{10})$ ✓ $(M = 2.2 - 5\log(\frac{70}{10}))$ = –2.0 (–2.025) ✓	1 mark for correct distance conversion 1 mark for re-arranging formula 1 mark for correct answer (min 2 sf) Ecf for incorrect conversion only if there is an attempt to convert.	3	3× AO2.1b

Question	Answers	Additional comments/Guidance	Mark	AO
02.5	$R_s\ (= \frac{2GM}{c^2}) = \frac{2 \times 6.67 \times 10^{-11} \times 15 \times 1.99 \times 10^{30}}{(3.00 \times 10^8)^2} =$ ✓ 4.4×10^4 m ✓	OK to use ≈ instead of = (as in the specification) Allow ecf for POT error only.	2	2× AO2.1b
Total			**11**	

Question	Answers	Additional comments/Guidance	Mark	AO
03.1	It has a known absolute magnitude. ✓	Other wordings are possible. It must be clear that the candidate knows that it is the intrinsic power/brightness that must be known.	1	AO1.1a
03.2	Peak between -18 and -20 AND axis correct direction ✓ Time scale 40 to 500 days ✓ Lhs steeper than rhs (by eye) ✓	−ve sign essential Allow magnitude and/or time axes starting at 0 Accept any unit for time which fits with the 40-500 days range. Ideal graph:  	3	AO1.1a

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidance</th><th>Mark</th><th>AO</th></tr>
<tr><td>03.3</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 3 areas covered with at least two aspects covered in some detail.
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 fair attempt to analyse all 3 areas. If there are several errors or missing parts then 5 marks should be awarded.</td></tr>
<tr><td>4</td><td>Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.</td></tr>
<tr><td>3</td><td>One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.</td></tr>
<tr><td>2</td><td>Only one area discussed or makes a partial attempt at two areas.</td></tr>
<tr><td>1</td><td>None of the three areas covered without significant error.</td></tr>
<tr><td>0</td><td>No relevant analysis.</td></tr>
</table></td><td>Examples of points which might be made in a good answer.
Data
• Also need z (or red shift).
• Use z value to find velocity ($v = zc$).
• Measure wavelength of spectral lines

Graph
• Plot graph of velocity on y-axis vs distance on x-axis.
• v in km/s, distance in Mpc.
• H is gradient of graph.

Limitations
• Value of apparent magnitude may be affected by what the light passes through.
• Much variation in the data (there must be specific reasons given e.g. variations between galaxies or random errors in measurement).
• At large distances accelerating universe will affect graph.
• Need data from lots of supernovae</td><td>2

2

2</td><td>AO1.1a

AO2.1a

AO3.1b</td></tr>
<tr><td>Total</td><td></td><td></td><td>10</td><td></td></tr>
</table>

Question	Answers	Additional comments/Guidance	Mark	AO
04.1	Use of $P = \sigma A T^4$ ✓ Ratio $= \frac{\sigma A_M T_M{}^4}{\sigma A_S T_S{}^4} =$ $(1.4 \times 10^{10})^2 \times 53000^4 \,/\, (7.0 \times 10^8)^2 \times 5700^4 = 3.0 \times 10^6$ ✓	Award mp 1 for substituting data for either the Sun or Melncik 34	2	AO2.1f
04.2	Star will undergo supernova collapse or Star will form a neutron star/black hole ✓ which produces a gamma ray burst and consequence for life or reference to being highly collimated ✓	Examples of consequence for life :kills cells/ damages DNA.	2	AO3.1b
Total			**4**	