A-LEVEL
Physics
7408/3BA

PAPER 3 SECTION B – Astrophysics

Mark scheme

June 2017

Version: 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

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 weber/metre^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	ID details
01	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. No gap needed in primary. Primary should not look like two mirrors Condone flat secondary if labelled convex. Do not condone concave secondary 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 (as they pass through the primary). Ignore arrows on rays. No lens needed, but ignore rays after lens if drawn. Poorly drawn rays eg curved, loses mark.	1 1	A01a
Total			**2**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
02.1	B brighter with support (eg diameter of B bigger) ✓ (The brightness of the image is determined by the collecting power and) collecting power related to D^2 or area✓ Calculation of areas or d^2 ✓	Allow 'reflecting telescope' B. An unsupported answer gains no marks Ignore references to resolving power or unit W.	1 1 1	A03/1a
02.2	Two objects will just be resolved when the first minimum/edge of the airy disc in the diffraction pattern of one image ✓ Coincides with central maximum/centre of the airy disc of the other. ✓	Correct diagrams can gain both marks Ignore references to formula	1 1	A01/1a
02.3	B is better because it has a larger diameter ✓ Minimum angular separation/angular resolution depends on 1/D	No mark awarded for an unsupported answer. The first is for arguing that B is better due to larger diameter The second mark is for identifying the relationship between angular resolution and diameter. Correct calculations can gain both marks, using any wavelength.	Max 2	A03/1a
Total			**7**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
03.1	Distance at which 1AU✓ subtends an angle of 1/3600th degree ✓ or Diagram with 1AU, 1pc and 1/3600th degree labelled ✓	Allow 1 arc second for angle 1AU can be shown as Sun Earth distance 1pc can be either long side	2	A01/1a A01/1b
03.2	They are the same spectral class and therefore have similar temperatures. ✓ They have the same apparent magnitude, but K is significantly further away, therefore K has a greater power output (P)/ brighter absolute magnitude ✓ As $P=\sigma AT^4$ to have a greater power output than R at the same temperature, K must have a greater area, and therefore be bigger. ✓	No mark for the answer on its own. First mark for identifying same T Second mark for identifying greater P Condone greater for brighter Condone luminosity for absolute magnitude Third mark for use of Stefan's Law and obtain the answer.	3	AO3/1a
03.3	Substitution into $\lambda_{max}T = 0.0029$ mK ✓ To give $T = 2.9 \times 10^{-3} / 1.0 \times 10^{-6} = 2.9 \times 10^3$ K ✓	Condone power of ten errors in first mark	2	A02/1f
03.4	The spectral class is related to the temperature✓ So the star is in spectral class M And is therefore Rasalgethi ✓	Allow ecf from 03.3 – see spec for table of spectral class and temperature The second mark is for the correct class and therefore star identified	2	A02/1e
03.5	Rasalgethi		1	A02/1e

Question	Answers	Additional Comments/Guidance	Mark	ID details
03.6	Use of m-M = 5 log (d/10) To give 3.1 – M = 5 log(2.3) ✓ 3.1 – M = 1.8 ✓ M = 1.3 ✓	First two marks are for the substitution of M, m and unit of d and correct log. Detect one mark for each error; more than two errors give 0/3 Third mark for the correct calculation: allow ecf for up to two errors	3	A02/1f
Total			**13**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
04.1	Absolute magnitude scale gettingg more negative going up and Time scale with 0 along axis, going up to between 10 and 400 ✓ Line drawn going up and down, with LHS steeper than steepest part of RHS✓ Line drawn increasing quickly with peak at absolute magnitude between -18 and -20✓	The first mark is for the scales The second is for the curve The third is for the value of the peak	3	A01/1a
04.2	Object whose absolute magnitude is known (and whose apparent magnitude can be measured.) ✓	Do not allow fixed or constant for 'known' But condone predictable Do not allow 'directly measured' Condone intrinsic or inherent brightness, or luminosity for absolute magnitude	1	A01/1a
04.3	Measurements of supernovae do not agree with predictions (from Hubble's Law)✓ So Universe must be expanding at increasing rate/accelerating ✓ (Controversial as) no known energy source for expansion or reference to dark energy ✓		1 1 1	A01/1a
Total			**7**	

<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>05</td><td>
The mark scheme gives some guidance as to what statements are expected to be seen in 1 or 2 mark (L1), or 3 or 4 mark (L2) and 5 or 6 mark (L3) ans wer. Guidance provided in section 3.10 of the ‘Mark Scheme Iinstructions’ document should be used to assist in marking this question.
<table>
<tr><th>Mark</th><th>Criteria</th><th>QoWC</th></tr>
<tr><td>6</td><td>All three methods described.
All three methods applied to Earth-like planets.
Judgement reached</td><td rowspan="2">The student presents relevant information coherently, employing structure, style and spg to render meaning clear. The text is legible</td></tr>
<tr><td>5</td><td>Only two methods described and all three applied,
Or
All three described and only two applied.</td></tr>
</table>
</td><td>
Transit – dips in brightness as planet crosses in front of star from our point of view.

Alignment must be correct for planets to eclipse, so many possible candidates not observed. Earth-like planet could be observed provided not too far away.

Radial velocity (Doppler) – periodic shift in spectra of star due to star’s movement around common centre of mass with planet.

Earth-like planet mass much less than mass of Sun-like star so effect slight. Earth-like planet could be detected with highly sensitive spectrometers.

Direct observation – very unlikely as Earth-like planet to small and too near star and too cool to be detected against the brightness of the Sun-like star. Unlikely to be detected.
</td><td>3

3</td><td>A01a

AO3/1b</td></tr>
</table>

	4	**Two methods described and applied,** **Or three described and only one applied**	**The student presents relevant information and in a way which assists the communication of meaning. The text is legible. SPG are sufficiently accurate not to obscure meaning**			
	3	**Three methods described,** **Or** **Two methods described and one applied**				
	2	**Only one method described and applied** **Or two methods described with application**	**The student presents some relevant information in a simple form. The text is usually legible. SPG allows meaning to be derived although errors are sometimes obstructive.**			
	1	**Only one method described**				
	0	**No relevant information**	**The student's presentation, SPG seriously obstruct understanding**			

	Higher Level (5 or 6 marks) All three methods of measurement are described (transit, radial and direct observation) Problems associated with each one are discussed, with particular reference to detecting an object an Earth – like planet. **Intermediate Level (3 or 4 marks)** Only two of the three methods are described and little effort is made to link the methods to the detection of an Earth-like planet. **Low level (1 or 2 marks)** Only one method is described, or two methods poorly. Little or no reference is made to the detection of an Earth-like planet. *(a more detailed mark scheme will be produced with levelled statements)*			

Total			**6**