Markscheme

May 2017

Astronomy

Standard level

Paper 2

12 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Shortcut	Annotation	Explanation	Shortcut
	Correct point – 1 mark will be added to the score for each tick placed up to the maximum for the question part. Please make sure that the number of ticks = the number of marks	ALT 1		Does not answer question	
	Unclear			Answer acceptable	ALT 6
	Omission mark	ALT 3		Power of 10 error	ALT 7
	Arithmetic error			Indicates that the point has been noted, but no credit has been given **or** to confirm that an examiner has checked a sub-part of a question that has not been answered.	ALT 2
	Alternative solution			Text box for comments – used for additional marking comments, it can be used in conjunction with a specific tick if that is appropriate. You might like to have a word document of regularly used comments that can be copied and pasted into the text box.	ALT 8
	Benefit of the doubt	ALT 4		Dynamic; can be sized to highlight area	ALT 9
	Contradiction			Dynamic; horizontal line that can be expanded	
	Error carried forward	ALT 5		Award 0 marks. 0 marks will be added to the marks panel when this annotation is stamped on the script.	ALT 0

You **must** make sure you have looked at all pages. Please put the  annotation on any blank page, to indicate that you have seen it.

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through RM™ Assessor, by e-mail or telephone – if through RM™ Assessor or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through RM™ Assessor or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of RM™ Assessor, please contact emarking@ibo.org.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative word is indicated in the "Answers" column by a slash (***/***). Either word can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading **ALTERNATIVE 1** *etc*. Either alternative can be accepted.

8. Words inside chevrons **« »** in the "Answers" column are not necessary to gain the mark.

9. Words that are <u>underlined</u> are essential for the mark.

10. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

11. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

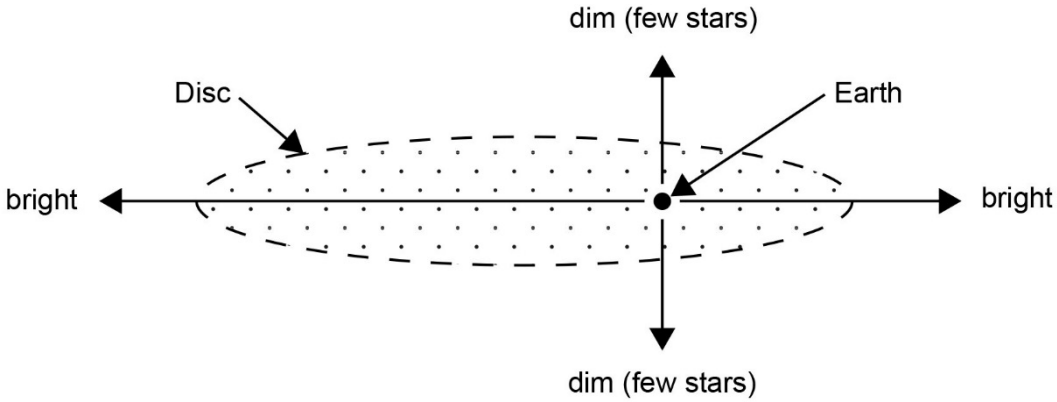
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

Section A

Question			Answers	Notes	Total
1.	**a**	**i**	neutrino**«**s**»** ✓		**1**
		ii	*any two for **[2 max]** from:* released because the positron is anti-matter ✓ released when positrons are released ✓ are <u>electron</u> neutrinos ✓ conserve Lepton number ✓		**2 max**
	b	**i**	remains / moves around in the core ✓		**1**
		ii	annihilated ✓ by a reaction/contact with the electrons ✓ to form γ-rays ✓		**3**
		iii	thermalized ***OR*** scatter off the charged material ✓ turned into x-rays ✓		**2**
	c		approx 1 000 000 years ✓	*Accept any answer in the range 100 000 to 1000 000 years.*	**1**

Question			Answers	Notes	Total
2.	**a**		*Any one from:* average density of the Earth is not the same as the density of the surface material ✓ composition of material within the Earth (*eg*, magma) is seen to be different to the composition of surface material ✓ shadow zones for s-waves through the Earth ✓ magnetism of planet which clearly does not come from the surface material ✓		**1 max**
	b		must have accreted homogeneously ✓ its interior has never been hot enough for differentiation to occur / *OWTTE* ✓		**2**
	c		material is vaporised in the **«**giant**»** impact ✓ volatile material can escape ✓ water is volatile ✓		**3**
	d		*Any three from:* fragments of the impactor in or near the crater ✓ interior lower than the surroundings ✓ an ejecta blanket with inverted stratigraphy ✓ material formed by impact shock **«***eg*, glass, impact melt**»** ✓	*Accept any sensible argument.*	**3 max**
	e		*Any one from:* gravity is lower on Io than on Earth ✓ bubbles of volatiles form at greater depth **«**than on Earth**»** ✓ favours efficient volatile release ✓		**1 max**

Question			Answers	Notes	Total
3.	**a**		Sensible diagram that shows that the Earth/Sun is located <u>in the disk</u>. ✓ *Any two for **[2 max]** from:* band of light is the view of the <u>disc</u> of the galaxy ✓ when we look in other direction we are looking out of the disc ✓ disc looks bright because of the concentration of stars ✓ *The above two marks can be given for the diagram.*  		**3 max**

Question			Answers	Notes	Total
3.	**b**		*Any three from:* there would be no milky way band ***OR*** the distribution of the visible stars would be more uniform ✓ stars are generally redder ✓ there would be no observations of bright nebulae ***OR*** no bright gas clouds ✓ there would be no dark nebulae ✓ there would be no open clusters **«***eg*, the Pleiades**»** ✓	*Accept any sensible answer.*	**3 max**
	c		*Open Clusters:* *Any two **[2 max]** from:* relatively young objects ✓ result of star formation in the disc ✓ require gas to form ✓ gas for stellar creation is found in the disc ✓ *Low-metallicity (globular) clusters:* *Any two (for 2 max) from:* older stars ✓ not created from gas that had been enriched by SN/planetary nebula ✓ there is a relatively small amount of gas in the halo ✓	*Accept any sensible answer.*	**4 max**

Question			Answers	Notes	Total
4.	**a**		mass density ✓ flat spacetime geometry ✓ H_0= Hubble's constant ***AND*** G = <u>universal</u> gravitational constant ✓	*Do not just accept the value for G as its meaning.*	**3**
	b		Hubble's constant is converted to SI units as $\frac{72\times10^{3}}{1\times10^{6}\times3.08\times10^{16}} = 2.33\times10^{-18}\,\text{s}^{-1}$ So, $\rho_0 = \frac{3\times\left(2.3\times10^{-18}\right)^2}{8\pi\times6.67\times10^{-11}} = 9.7\times10^{-27}\,\text{kg m}^{-3}$ **«**correct conversion of Hubble's constant into SI units**»** $2.33\,\text{x}\,10^{-18}$ s^{-1} ✓ correct use of the formula ✓ $9.7\,\text{x}\,10^{-27}$ **«**kg m^{-3}**»** ✓	*Award mark for its correct use in the formula with appropriate conversion factors evident.* *Allow more than two significant figures.*	**3**
	c		flat spacetime is produced when the density equal critical density ✓ **«**mass of hydrogen molecule = $2\,\text{x}\,1.7\,\text{x}\,10^{-27}$ kg =**»** $3.4\,\text{x}\,10^{-27}$ kg ✓ number of molecules needed to produce a mass of $9.7\,\text{x}\,10^{-27}$ kg = $\frac{9.7\times10^{-27}}{3.4\times10^{-27}} = 2.9$ ✓ number density of molecules = $2.9\,\text{m}^{-3}$ ✓	*The units need to be given for the number density, which allows a distinction between simple working out the number of molecules and realising that this would be per cubic metre.*	**4**

Section B

Question			Answers	Notes	Total
5.	**a**		point at 500 K plotted correctly within half of one small square ✓ error bar is a total of 5 small squares / +- 2.5 small squares ✓		**2**
	b	**i**	line is a curve of the correct shape ✓ covers the full range of the data points on the graph ✓		**2**
		ii	line has to go through the error bars ✓		**1**
	c	**i**	$\lambda_{peak}T = \text{constant}$ ✓		**1**
		ii	test is used on at least two data points ✓ valid test **«** as $\lambda_{peak}T = \text{constant}$ **»**✓		**2**
	d	**i**	linear / straight line ✓		**1**
		ii	using the max-min method, $\Delta\left(\text{Log}\lambda_{\text{peak}}\right) = \frac{1}{2}\left(\text{Log}\lambda_{\text{peak}}^{\text{max}} - \text{Log}\lambda_{\text{peak}}^{\text{min}}\right) = \frac{1}{2}\left(\text{Log}0.55 - \text{Log}0.15\right) = \pm 0.282$ use of the max-min method ✓ ± 0.282 ✓		**2**
		iii	gradient = *n* **«***ie*, the power in the equation**»** intercept = Log A / Log (constant) ✓		**2**

Question			Answers	Notes	Total
5.	**e**		use of a triangle with a hypotenuse at least half the length of the line ✓ gradient in the range -1.02 to -1.07 ✓	*Award **[2]** for correct final answer.*	**2**
	f		*The intercept will need to be calculated since the point with Log T is not present*. attempt to calculate the intercept calculated using c = *y* - m*x* ✓ intercept in the range 3.4 to 3.5 ✓		**2**
	g		*n* = -1.0 ✓ *A* = 2900 ✓	*Accept any value in the range -1.0 to -1.1.* *Accept any value in the range 2500 to 3200.*	**2**
	h		μm K^{-n} ✓		**1**