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MARKSCHEME

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ASTRONOMY

Standard Level

Paper 2

11 pages

Subject Details: Astronomy SL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[40 marks]** and **ONE** question in Section B **[20 marks]**. Maximum total = **[60 marks]**.

1. A markscheme often has more marking points than the total allows. This is intentional. Do **not** award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is signified by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

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

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. 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 markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing ***OWTTE*** (or words to that effect).

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

9. 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. Indicate this with **ECF** (error carried forward).

10. Significant figures are **only** penalized where noted.

11. *EOR* : Evidence Of Rule : normally associated with a methodology used.

12. *ORA* : Or Reverse Argument.

SECTION A

1. (a) n: number density (of particles);
m: (average) mass (of particle);
T: (absolute) temperature; ***[3]***

(b)

	… make gravitational collapse *more* likely.	**… make gravitational collapse *less* likely.**
An increase in *n* would …	✓	
An increase in *m* would …	✓	
An increase in *T* would …		✓

[3]

(c) $M_{\text{Total}} = 1.0 \times 10^{31}\,\text{kg}$

$$M_{\text{J}} = \frac{9}{4}\sqrt{\frac{1}{2\pi \times 10^{9}}}\frac{1}{\left(3.4 \times 10^{-27}\right)^{2}}\left(\frac{1.38 \times 10^{-23} \times 100}{6.67 \times 10^{-11}}\right)^{\frac{3}{2}};$$

$2.\underline{3}(11) \times 10^{32}$; ***[2]***

*Award **[2]** for the correct answer, given to 2 significant figures.*
The second mark is not given for an answer of 2.3×10^{32} – in this case, the candidate may have written the equation down and substituted correctly, but has not shown that they have actually carried out the calculation.

(d) If n is increased from $1 \times 10^{9}\,\text{m}^{-3}$ to $1 \times 10^{13}\,\text{m}^{-3}$, then M_{J} decreases to $2.3(11) \times 10^{30}\,\text{kg}$. With M_{J} now less than M_{Total}, the cloud is likely to contract.

$M_{\text{J}} = 2.3(11) \times 10^{30}\,\text{kg}$;
$M_{\text{J}} < M_{\text{Total}}$; ***[2]***

2. (a) Sky satellite;
TV satellite;
spy satellite;
weather satellite;
any type of satellite;
Hubble Space telescope;
The International Space station; ***[1 max]***
Award ***[1 max]*** *for any reasonable answer.*
If the students states a probe or observatory of some kind (e.g., SOHO, Hinode spacecraft), then a check is needed to ensure it is in orbit around the Earth rather than (like SOHO and Hinode) in a solar orbit near the Earth.

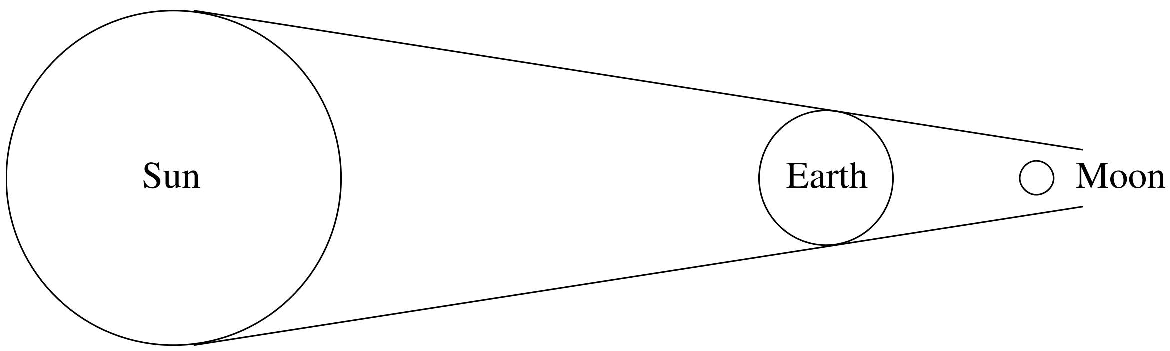
(b) material thrown out from the Earth;
gravitationally caught (by the Earth) / went into orbit (around the Earth); ***[2]***

(c) the far side of the Moon is more cratered/is saturated with craters / *ORA*;

Plus any one of the following: ***[1 max]***
it is not (partially) shielded by the presence of the Earth / *OWTTE* / *ORA*;
the mare/seas have covered the surface/craters on the near side / *OWTTE* / *ORA*;
the crust on the near side is thinner than the far side / *OWTTE* / *ORA*; ***[2 max]***

(d) the moon spins;
with a period equal to the time for one orbit around the Earth; ***[2]***
Award ***[2]*** *for "The Moon is tidally locked to the Earth". The answer "The Moon's orbit is synchronous" does not have enough detail to be credit worthy.*

(e)



the order of the objects is Sun – Earth – Moon; *(accept reverse order)* ***[1]***
The Sun's rays are NOT required – only the relative positions.

(f) light refracts through the <u>atmosphere of the Earth</u>;
red light is less scattered by the atmosphere, hence the Moon looks red / *OWTTE*; ***[2]***
The first mark only, can be given for "Light diffracts around the Earth".

3. (a) (nuclear) bulge;
(galactic) halo; ***[2]***

(b) the presence of high mass/OB-type/very bright stars;
triggered by spiral density waves; ***[2]***

(c) the disc is where all the gas is;
gas is required to form stars / stars form by the contraction of gas (clouds) / *OWTTE*; ***[2]***
Accept the reverse argument with reference to the Halo/Bulge.

(d) the bright stars (forming the spiral arms) die quickly/are short lived;
new star growth is triggered (to replace the stars that have died quickly) …;
… by spiral density waves/by waves moving through the galaxy;
spiral density waves rotate around/through the disc/galaxy …;
… with a (rotational) speed slightly different to the galaxy; ***[2 max]***

(e) red-shift means that the (relative) motion is away from us;
if the galaxy were expanding, all stars would be red-shifted;
stars "behind us and further out" are travelling slower than us (around the galactic centre) / *ORA*;
our relative motion is away from them; ***[2 max]***

4. (a) the age of the universe $= 13.8\times10^{9}$ years

therefore, age of the universe $= 13.8\times10^{9}\times(365.25\times24\times60\times60) = 4.35(49)\times10^{17}$ s

$4.35(49)\times10^{17}$; **[1]**

If the student uses 365 days, the answer is $4.35(20)\times10^{17}$.

(b) using $v = \frac{d}{t} \Rightarrow d = vt = 3.00\times10^{8}\times4.35\times10^{17} = 1.3(05)\times10^{26}$ m

$d = vt$ / $d = ct$ / $d = 3.00\times10^{8}\times4.35\times10^{17}$;

$1.3(05)\times10^{26}$ m; **[2]**

Accept ECF from (a) i.e., $d = 3.00\times10^{8}\times(a)$.

(c) $V = \frac{4}{3}\pi r^{3} = \frac{4}{3}\pi\times\left(1.3\times10^{26}\right)^{3} = 9.2(03)\times10^{78}\,\text{m}^{3}$

correct use of the value from (b) into the equation for *V*;

$9.2(03)\times10^{78}\,\text{m}^{3}$; **[2]**

Using 1.305×10^{26} gives $9.2(09)\times10^{78}\,m^{3}$. Allow ECF from (b).

(d) $M_{universe} = 3\times10^{22}\times1.99\times10^{30} = 5.97\times10^{52}\,\text{kg} = 6\times10^{52}\,\text{kg}$

6×10^{52}; **[1]**

The answer should be given to 1 significant figure.

(e) $D = \frac{M}{V} = \frac{6\times10^{52}}{9.3\times10^{78}} = 6\times10^{-27}\,\text{kg m}^{-3}$

$\frac{6\times10^{52}}{9.3\times10^{78}}$;

$6\times10^{-27}\,\text{kg m}^{-3}$; **[2]**

The final answer should be given to 1 significant figure.

(f) $6\times10^{-27}\,\text{kg m}^{-3}$ is less than the critical density of $1\times10^{-26}\,\text{kg m}^{-3}$ and so, this would suggest that the universe will expand forever

$6\times10^{-27}\,\text{kg m}^{-3} < 1\times10^{-26}\,\text{kg m}^{-3}$;

(this would suggest that) the universe will expand forever; **[2]**

Allow ECF associated with the value from (e) compared with $1\times10^{-26}\,kg\,m^{-3}$.

SECTION B

New Phenomena on the Sun

5. (a) resolution = 0.2 arcsec = $\frac{0.2}{3600} \times \frac{2\pi}{360} = 9.696 \times 10^{-7}$ radians

$S = d\theta = 1.5 \times 10^{11} \times 9.696 \times 10^{-7} = 1.45 \times 10^{5}$ m

the correct conversion of the angle into radians / 9.696×10^{-7} ;
1.45×10^{5} m ; ***[2]***
There is no ECF within the part-question, for an error made in the conversion of the angle.

(b) the chromosphere has nothing in it to produce "events";
the chromosphere has very little matter in it;
the chromosphere is never visible against the light from the Sun; ***[1 max]***

(c) the chromosphere has mostly hydrogen; ***[1]***

(d) 6563 angstroms is 656.3 nm = 656.3×10^{-9} m = 6.563×10^{-7} m

6563×10^{-10} m / 656.3×10^{-9} m / 6.563×10^{-7} m ; ***[1]***
*Award **[0]** for 656.3 nm.*

(e) $c = f\lambda \Rightarrow f = \frac{c}{\lambda} = \frac{3.00 \times 10^{8}}{6563 \times 10^{-10}} = 4.57 \times 10^{14}$ Hz

$f = \frac{c}{\lambda}$ / $\frac{3.00 \times 10^{8}}{6563 \times 10^{-10}}$;
4.6×10^{14} Hz / 4.57×10^{14} Hz / 4.571×10^{14} Hz ; ***[2]***
The final answer should be given to 3 significant figures but allow 2 to 4. The Units MUST be included for the final mark: Hz / s / s^{-1}.

(f) the light is stated to be H_{α}
the atom/an electron relaxes/drops from a higher level/state/orbital to a lower one;
the level changes from "3" to "2"; ***[2]***
The first mark must be for a process which is a relaxation.
The second mark must have the correct level numbers.

(g) the Sun is too bright / its intensity is negligible compared with the Sun's/photosphere / OWTTE; ***[1]***

(h) solar wind / solar outflow / (charged) particles leaving the Sun/photosphere; ***[1]***

(i) the (dynamic/changing) magnetic field of the Sun; ***[1]***

(j) $f = \frac{1}{T} = \frac{1}{10 \times 60} = 1.7 \times 10^{-3}\,\text{Hz}$

$f = \frac{1}{T} / \frac{1}{10 \times 60}$;
$1.7 \times 10^{-3}\,\text{Hz}$; ***[2]***

If the student calculates $\frac{1}{10}$ *they get the first mark. They can get the second if they correctly write down the units as* min^{-1}*. Do NOT accept* m^{-1} *in place of* min^{-1}*.*

(k) a rapid/sudden/fast change of the magnetic field;
due to magnetic recombination; ***[2]***

(l) (the magnetic recombination) results in the collapse of the field down to the sun's surface/photosphere / (the magnetic recombination) results in the movement of (charged) material towards the sun's surface/photosphere;
the flare is produced when the material collides with the material on the photosphere; ***[2]***

(m) astronauts in space are vulnerable to intense radiation;
astronauts in space are vulnerable to high-energy particles;
flares can disrupt radio communications (on Earth);
flares can disrupt electrical systems (on Earth); ***[2 max]***

Asteroid Threatens to Hit Mars

6. (a) $164\,\text{ft} = 164 \times 0.305 = 50.0\,\text{m}$

$$27\,900\ \text{mph} = \frac{27\,900 \times 1609}{3600} = 1.25 \times 10^{4}\,\text{m}\,\text{s}^{-1}$$

$50.0\,\text{m}$; **[1]**

$1.2 \times 10^{4}\,\text{m}\,\text{s}^{-1}$ / $1.25 \times 10^{4}\,\text{m}\,\text{s}^{-1}$ / $1.247 \times 10^{4}\,\text{m}\,\text{s}^{-1}$; **[2]**

The second conversion has two marks, for each of the two conversions. As such, one mark can be given for …

$27\,900 \times 1609$

$\dfrac{27\,900}{3600}$

$\dfrac{1609}{3600}$ *This final option would be the correct two conversions, but a mistake has been made in the calculation.*

(b) *Escape velocity:* the speed needed for an object to be able to leave the surface of a planet and just escape the gravitational influence / *OWTTE*;

Asteroid: a small object in orbit around the Sun; **[2]**

The second marking point does require the fact that the object is small(er than a planet) and also, that it is in orbit around the Sun.

(c) no;

because it is presently moving away from the Earth; **[2]**

For the second marking point, do not allow "because it is closer to Mars" / "because it is being pulled towards Mars".

(d) *Location of the Impact:* north of the rover; **[1]**

Reasons:

cheaper than sending a man to Mars;

safer than sending a man to Mars;

to look for signs of life;

to look for water / look for signs of (active) volcanism;

to analyse the mineral structure of the surface / look for iron containing compounds;

assess whether the atmosphere is conducive to life; **[2 max]**

Allow any reasonable comments for the last two marks.

(e) $v_{escape} = \sqrt{\frac{2GM}{R}}$

$= \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{3.4 \times 10^{6}}}$;

$5.0 \times 10^{3}\,\text{m s}^{-1}$ / $5 \times 10^{3}\,\text{m s}^{-1}$ / $5.01 \times 10^{3}\,\text{m s}^{-1}$; ***[2]***

*Award **[2]** for correct answer given to 2 significant figures. Answers with anything other than 2 significant figures are penalized.*

(f) it would make the escape velocity greater;
because there would be a loss of (kinetic) energy (as the object moves upwards/away); ***[2]***

(g) the radius of the asteroid is 25.0 m

$D = \frac{M}{V} \Rightarrow M = DV = D \times \frac{4\pi}{3} r^{3} = 5000 \times \frac{4\pi}{3} \times 25.0^{3} = 3.27 \times 10^{8}\,\text{kg}$

radius $= 25.0\,\text{m}$;
$3.27 \times 10^{8}\,\text{kg}$; ***[2]***

*If the candidate uses the diameter of the asteroid, they have a mass of 2.62×10^{9} kg. This is worth **[1 max]**. If the answer is written to anything other than 3 significant figures, then the candidate loses **[1 max]**, to a minimum of **[0]**.*

(h) $v_{impact} = v_{present} + v_{escape} = 1.25 \times 10^{4} + 5.0 \times 10^{3} = 1.75 \times 10^{4}\,\text{ms}^{-1} = 1.8 \times 10^{4}\,\text{ms}^{-1}$

The lower value of $1.34 \times 10^{4}\,\text{ms}^{-1}$, is probably due to the effect of air resistance.

$1.75 \times 10^{4}\,\text{ms}^{-1}$ / $1.8 \times 10^{4}\,\text{ms}^{-1}$;
air resistance; ***[2]***

(i) the asteroid is less likely to burn up in the atmosphere; ***[1]***

The students needs to give more detail than simply, "the atmosphere would have less effect". The students must state a reason which gives some effect on the asteroid.

(j) a month is not a long time to measure its path;
its path has a very small curvature so uncertainties are large;
it is very difficult to precisely model paths that are very elliptical;
it is difficult to follow a precise path for such a small object; ***[1 max]***
Allow any reasonable argument.