Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2015

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 underlined 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) a strip of the sky (approximately 8°) about the ecliptic;
the (12/13) constellations that lie on the path of the Sun across the sky; **[1 max]**

(b) Rigel **and** has the smallest Apparent Magnitude; **[1]**

(c) *Apparent brightness*: 9.88×10^{-8};
Absolute brightness: 3.84×10^{-5};
Absolute magnitude: -6.0 ; **[3]**

(d) Rigel and Mintaka;
either calculation or a statement that the product of their masses divided by the distance squared is greatest; **[2]**
The second mark should not be awarded for a statement which only refers to the distance **or** *the product of the masses*.
A statement about the combined masses is not credit worthy.

(e) $F_{Orion} = 6.5\times10^{16}\,N$;
$F_{Sun\text{-}Earth} = 3.6\times10^{22}\,N$;
$F_{Sun\text{-}Earth} >> F_{Orion} / 5.5\times10^{5}$ times larger for the Earth–Sun; **[3]**

2. (a) *minimum nebula theory*: the total mass of the nebula was about the mass of the Sun / ***OWTTE***;
maximum nebula theory: the total mass of the nebula was about twice the mass of the Sun / ***OWTTE***; **[2]**

(b) the maximum nebula theory easily explains this by assuming that the lost mass took the angular momentum with it; **[1]**

(c) electric force; **[1]**

(d) the coagulation rate falls;
because the density of the nebula falls; **[2]**

(e) there will be lots of planetesimals gravitationally attracted;
runaway growth – the growth of one planetesimal outpaces the rest to form the planetary embryo; **[2]**

(f) giant/(very) large/(very) high energy impact occurs between the Earth and another object;
The first mark requires some statement that the collision is not just one of the many collisions occurring, but is one that has a huge amount of energy.

material thrown out but gravitationally held (to form the Moon); **[2]**

3. (a) trigonometric parallax;

*Any **two** for* **[2 max]** :
the star is seen with respect to background stars that are very distant;
two angles measured six months apart;
parallax angle (ϕ) measured to star (using background stars as a fixed reference);
distance found using $\frac{1}{\phi}$;
distance found in parsecs; **[3]**

(b) *EITHER*:

Cepheid variables;
*Any **two** for* **[2 max]** :
luminosity varies over regular time/period;
period directly proportional to luminosity;
distance measured by measuring brightness $(b) / b = \frac{L}{4\pi d^2}$;

OR

spectroscopic method;
*Any **two** for* **[2 max]** :
spectra from star used to estimate the luminosity;
brightness is measured;
use of the inverse square law; **[3]**

(c) *EITHER*:

Hubble's law;
*Any **two** for* **[2 max]** :
red-shift is related to distance;
red-shift measured using light output/spectra;
wavelength is measured for a known spectral line;
distance calculated if Hubble's constant is known;

OR

brightest cluster galaxy;
*Any **two** for* **[2 max]** :
this is a statistical argument;
the brightest/second brightest/third brightest, *etc* galaxy in any cluster has a known luminosity;
brightness is measured;
use of the inverse square law; **[3]**

(d) something that reduces the light able to reach us / ***OWTTE***;
the effect of intergalactic dust/gas/clouds/nebulae / ***OWTTE***; **[1 max]**
Do not allow "it is moving faster than we thought".

4. (a) Olber's paradox states that the night sky should be light not dark / ***OWTTE***;
red-shift explains that the visible light is red-shifted into the IR / ***OWTTE***; **[2]**

(b) normal red-shift is due to the actual motion of the object through space / ***OWTTE***;
cosmological red-shift is due to the motion of an object caused by the expansion of spacetime / due to the apparent motion of an object / ***OWTTE***; **[2]**

(c) *homogeneous*: the same everywhere / ***OWTTE***;
isotropic: the same in all directions / ***OWTTE***; **[2]**

(d) all things must move on spacetime / ***OWTTE***;
mass distorts spacetime (to produce the motion we view as gravitationally accelerated) / ***OWTTE***; **[2]**

(e) hydrogen and helium (and lithium) were the only elements produced in the Big Bang / ***OWTTE***;
the universe is still mainly hydrogen and helium / ***OWTTE***; **[2]**

Section B

A whiff of dark matter on the ISS

5. (a) matter is destroyed/converted / ***OWTTE***;
into electromagnetic/gamma radiation; **[2]**

(b) ${}^{0}_{-1}e + {}^{0}_{+1}e \rightarrow \gamma + \gamma'$

baryon numbers are **both** correct for the left hand side;
charge numbers are **both** correct for the left hand side;
the right hand side has **two** gamma photons; **[3]**
An indication that the gamma photons may be different is **not** *required.*

(c) $\Delta E = 2\,mc^2 = 2 \times 9.11 \times 10^{-31} \times 9 \times 10^{16}$;
$\Delta E = 1.64 \times 10^{-13}\,\text{J}$; **[2]**
The answer should state the correct units to get the final mark.

(d) $\text{E}_{\text{Total}} = 1.64 \times 10^{-13} \times 400\,000$;
$\text{E}_{\text{Total}} = 6.56 \times 10^{-13}\,\text{J}$; **[2]**
Remember to allow ECF from (c).

(e) *Award* **[1 max]** *for any* ***one*** *from*:
high energy radiation in space;
radiation/particles from outside the solar system;
radiation/particles in space from supernova explosions;

Award **[1 max]** *for any* ***one*** *from*:
the universe is mainly hydrogen and helium;
hydrogen and helium are the most abundant nuclei; **[2]**
Do not allow the second mark for simply saying that "protons are very common – being in all nuclei", this is not enough – the reference to hydrogen would generally be expected.

(f) *Pulsar*:
spinning neutron star;
(spinning) remains of a giant star after its SN explosion;
Accept any sensible answer.

Dark Matter:
mass in the universe that does not give out light/that is not detected by its light;
mass that is only detected by its gravitational effect;
Statement in M4 not quite true.
Accept any sensible answer.

Supernova:
the explosion at the end of a giant star's life;
produces a black hole/neutron star; **[6]**

(g) collisions between neutralinos produce high energy positrons;
they are neutral / are not affected by the electric force; **[1 max]**

(h) it may form 90 %/a majority of the universe / about 25 % of the mass-energy of the universe;
it will allow us to work out the size/shape of the universe;
it will allow us to work out the ultimate fate of the universe;
we will not understand the universe if we do not know what the majority is; **[2 max]**
Accept any sensible answer.

NASA's Curiosity rover drills sandstone slab on Mars

6. (a) $W = mg \Rightarrow g = \frac{W}{m} = \frac{3.34\times10^{3}}{900}$;

$W = 3.7\left(\text{N/kg}\right)$; **[2]**

(b) $g = \frac{GM}{r^{2}} \Rightarrow M = \frac{gr^{2}}{G} = \frac{3.7\times\left(\frac{6.77\times10^{6}}{2}\right)^{2}}{6.67\times10^{-11}}$;

$M = 6.36\times10^{23}\,(\text{kg})$; **[2]**

(c) $D = \frac{M}{V} = \frac{6.36\times10^{23}}{\frac{4}{3}\pi r^{3}}$;

$D = 3900\left(\text{kg/m}^{3}\right)$; **[2]**

Remember to allow ECF from (b).

(d) (crater age =) 3.6 ± 0.2 billion years
3.6 billion years;
$\pm\, 0.2$; **[2]**

(e) *age of Earth* $= \left(4.5 - 3.6\right) = 0.9$ billion years;
assumption: the Earth and Mars were formed at the same time; **[2]**

(f) ejected material could leave Mars and be deposited on Earth / ***OWTTE***;
ejected material could contain basic/microbial life / the basic life from Mars could seed life on Earth / ***OWTTE***; **[2]**

(g) to reduce the risk of anomalous data affecting the conclusions;
to allow average values to be calculated;
to give a higher chance of finding evidence for ... ; **[1 max]**
Accept any sensible answer.

(h) $5.5\,\text{km}$ is equivalent to 2×10^9 billion years therefore 1m is equivalent to $\frac{2\times10^9}{5500}=3.64\times10^5$ years;
Accept any correct scaling factor for depth vs age.

So, $6.5\,\text{cm}$ is equivalent to $3.64\times10^5\times6.5\times10^{-2}$;

2.36×10^4 years; **[3]**
The student must have at least one more significant figure than the required answer – to show that they did the calculation and did not simply write some numbers down and set them equal to the answer.

(i) *Any **two** sensible answers.*
For example:
to collect more information on the different abundances of the elements to support theories for the development of the solar system;
to look for signs of life on other planets in the solar system to add to our knowledge about the factors important in its development; **[2]**

(j) *Any **one** sensible comment based on why Mars was selected.* **[1]**

*Any **one** sensible comment based on why Venus was **not** selected.* **[1]**
For example: "Venus has an aggressive atmosphere that would destroy the rover".

Effectively one comment can get both marks by implication.
For example: "unlike Mars, Venus has an aggressive atmosphere that would destroy the rover".