DF
2014, February 17

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Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCSE

Astronomy

Unit 1: Understanding the Universe

Some suggestions for the answers

Wednesday 15 May 2013 – Afternoon
Time: 2 hours

Paper Reference
5AS01/01

Ladies and Gentlemen,

Some of the enclosed questions, on this 2013 Paper, have appeared in previous years' papers, in nearly identical form. I have asked you to refer to my suggested answers. Your answers to the Multiple-Choice questions can be checked quite easily.

My answers to the longer questions on this paper are very detailed — not to make difficulties for you — but to try to give you a broader insight into the Astronomy which forms the basis of these questions. I know that you are comfortable with my going (sometimes substantially) beyond the Syllabus. It is gratifying for me that you are such serious and scholarly students of the subject. Of the two — the Mark Scheme and the Examiners' Report — the latter is much the more important. Strive to find the time to absorb the information and advice which it contains. If you require clarification, please contact me in School or — if I appear not to be around — please telephone me at my home (0113) 2759421.

We have now studied eight years' previous papers, in their entirety. I think you can be confident that there will be nothing on the 2014 Paper which has not been encountered, and answered, during the past eighteen months.

Answer ALL questions.

Some questions must be answered with a cross in a box (☒).
If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☒).

1 (a) A group of astronomy students were planning to observe some constellations and planets in the night sky from the UK.

(i) In which direction would the students expect to look in order to observe Polaris?

☐ **A** East

☐ **B** North

☐ **C** South

☐ **D** West

(ii) In which part of the sky would they expect to observe a planet?

☐ **A** Goldilocks Zone

☐ **B** Kuiper Belt

☐ **C** Oort Cloud

☐ **D** Zodiacal Band

(iii) The students used computers, the internet and mobile phone applications to assist them.
Suggest **one** non-electronic **source** of information that would help them to find out which stars or planets would be visible.

....

(b) The students used a torch fitted with a red filter to aid their observations.
Why did this help?

☐ **A** They could observe more red giant stars.

☐ **B** They could observe more faint stars.

☐ **C** Their eyes could remain dark-adapted.

☐ **D** Their eyes could remain relaxed.

(c) Figure 1 shows a sketch of the brightest stars in a constellation that one of the students made.

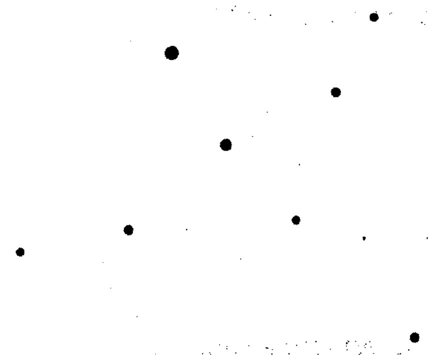


Figure 1

What is the name of the constellation shown in Figure 1?

☐ **A** Cassiopeia

☐ **B** Cygnus

☐ **C** Orion

☐ **D** Pegasus

(Total for Question 1 = 5 marks)

6

6

3 (a) Figure 2 shows parts of the constellations Pegasus and Andromeda. Two stars, **P** and **Q**, are labelled.

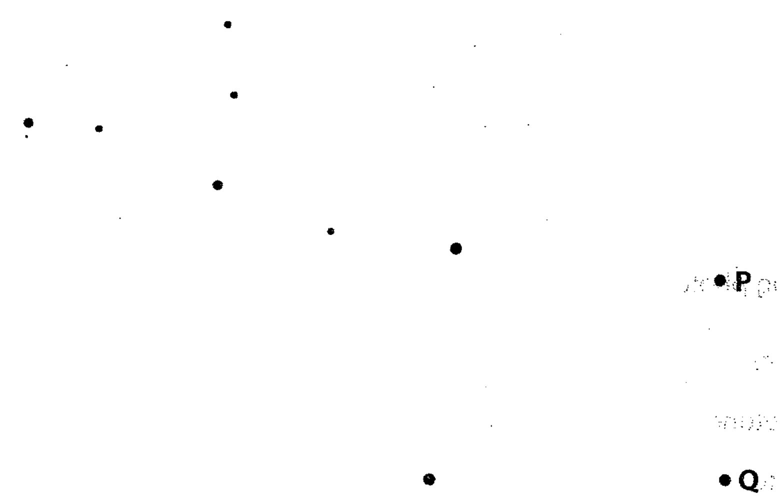


Figure 2

(i) Which bright star can be located using stars **P** and **Q**?

- ☐ **A** Arcturus
- ☐ **B** Fomalhaut
- ☐ **C** Polaris
- ☐ **D** Sirius

(ii) On Figure 2, use the letter **X** to locate the position of the Andromeda Galaxy.

P 4 1 3 4 3 A 0 6 3 2

(b) Stars in Orion's Belt can be used to locate Aldebaran and The Pleiades, an oper cluster of stars. Figure 3 shows the star Aldebaran.

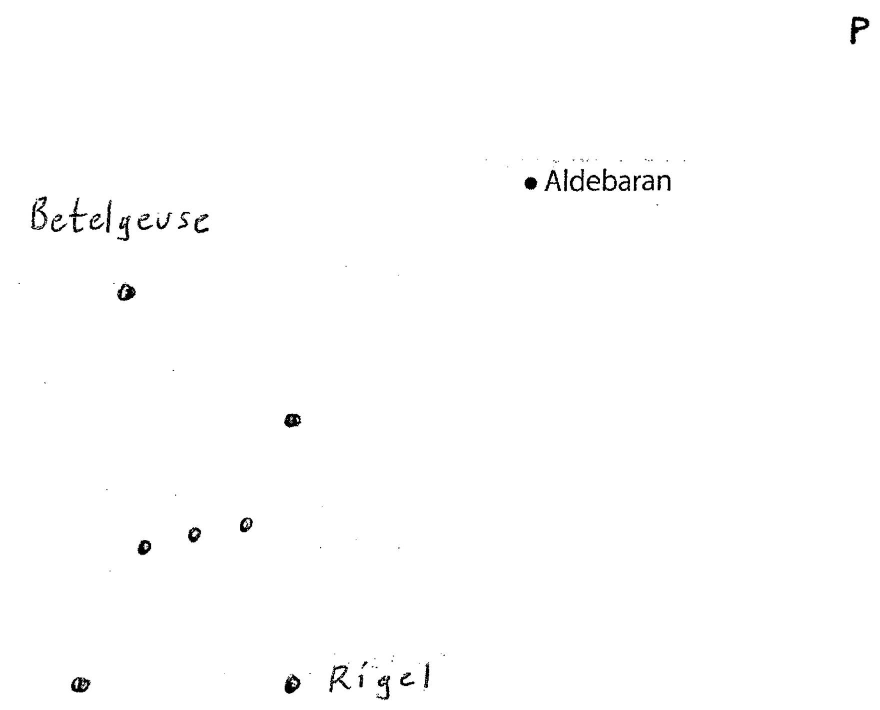


Figure 3

(i) Sketch the constellation Orion on Figure 3.

(ii) Indicate the position of The Pleiades on Figure 3 (use the letter **P**).

(c) Describe briefly the naked-eye appearance of an open cluster such as The Pleiades.

Open clusters are sometimes referred to as "galactic" clusters. The stars are fairly evenly spaced, with individual members of the cluster distinguishable from one another. Open clusters are often found to contain large quantities of interstellar dust and gas. The presence of "O" and "B" stars (hot) indicates that such clusters are relatively young, in terms of the cosmic time scale.

(Total for Question 3 = 6 marks)

4 (a) Which of the following is the longest interval of time?

- ☐ **A** one sidereal day
- ☐ **B** one solar day
- ☐ **C** the Moon's rotational period
- ☐ **D** the Moon's phase cycle

(b) How many minutes does it take for the Earth to spin on its axis through 1 degree?

....

(c) Which of these parts of the Sun is the hottest?

- ☐ **A** chromosphere
- ☐ **B** corona
- ☐ **C** photosphere
- ☐ **D** sunspot

(d) What is the approximate temperature of the Sun's photosphere? Include the unit.

....

(e) Which month of the year has the largest number of hours of daylight in the UK?

- ☐ **A** December
- ☐ **B** March
- ☐ **C** June
- ☐ **D** September

(f) In which month of the year do shadow sticks give the shortest shadows at noon in the UK?

....

(Total for Question 4 = 6 marks)

9

6 A class of astronomy pupils were observing the Milky Way on a clear night.

(a) Describe the naked-eye appearance of the Milky Way in the night sky.

A faint, hazy band, stretching across the whole night sky. This band, about 20° broad, approximately along a great circle, is most bright in the

(b) Sometimes the Milky Way is faint or barely visible because of light pollution.
Suggest **two** different **sources** of light pollution.

(Total for Question 6 = 4 marks)

⑥ (a) continued.

constellation of Sagittarius (a summer constellation in the Northern hemisphere). Diametrically opposite on the celestial sphere, in the constellations Perseus and Orion, the Milky Way is rather indistinct and unspectacular. This irregular band of diffuse light indicates the plane of the Galaxy. Even binoculars will resolve it into countless stars.

P 4 1 3 4 3 A 0 1 2 3 2

7 (a) A student observed Polaris at an angle of elevation of 53° above the horizon.

(i) What was the latitude of the student?

(1)

....

(ii) Later in the year, the student observed Polaris from a latitude of 5° further south. What was the elevation of Polaris from this new latitude?

(1)

....

(b) With the aid of a diagram, explain how measurements using long exposure photographs of circumpolar stars can be used to determine the rotation period of the Earth.

(3)

Refer to my detailed diagram in an answer to an identical question on a previous paper.

....

....

....

....

....

(Total for Question 7 = 5 marks)

8 *(a) One possible origin of water on Earth is from the impact of comets.

Describe how astronomers can test this experimentally.

Using unmanned space probes to compare the chemistry (composition) of cometary material with that of the Earth.

(b) The Drake Equation is a mathematical equation that combines factors to estimate the number of planets in our Galaxy that might contain intelligent life.

State **two** factors in the Drake Equation.

Sir Frank Drake: in 1961 he wrote an equation for the probability of a contactable civilisation, living on another planet in the Milky Way.

1. The number of stars in the Galaxy.
2. The fraction of those stars with planetary systems.

(Total for Question 8 = 6 marks)

3. The number of planets per solar system, with an environment suitable for life.
4. The number of planets capable of sustaining life.
5. Fraction of life-forms that are intelligent
6. The fraction of these that can, and wish, to communicate.
7. Fraction of the lifetime on which civilisations can exist.

I have not been persuaded that this is a suitable topic for inclusion in our syllabus.

Just <u>HOW</u> can any of these be evaluated?

9 (a) Figure 5 shows a Butterfly Diagram for sunspots that were visible between the years 1910–1976.

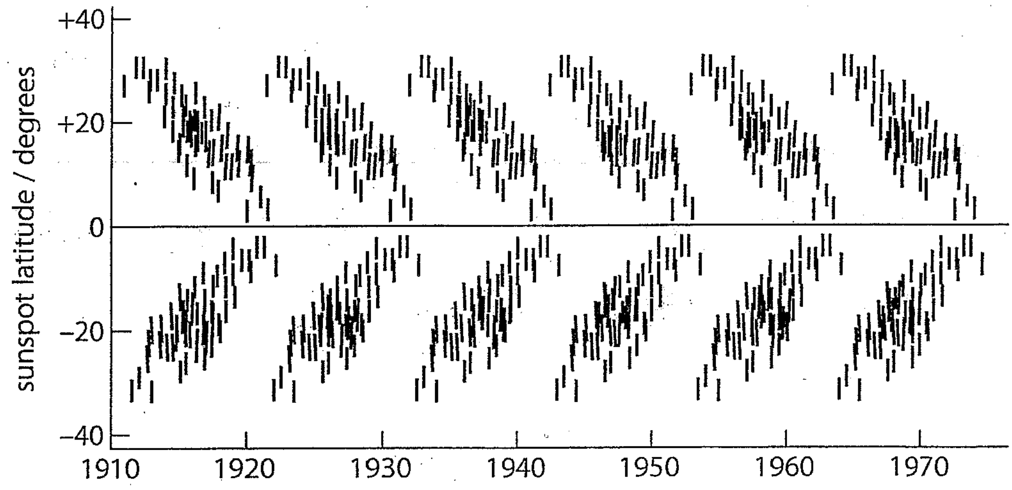


Figure 5

Use Figure 5 to estimate:

(i) the length of the solar cycle in years

....

(ii) the next year (after 1...

Answered on earlier papers.

....

(iii) the appro... ...ots at the beginning of the solar cycle.

....

(b) The solar wind is responsible for the appearance of aurorae on Earth.

(i) Name **one** type of charged particle contained in the solar wind.

The solar wind consists mainly of protons and electrons, in approximately equal numbers, called a plasma.

(ii) Explain briefly how the solar wind causes aurorae.

The inner of the Van Allen Radiation Belts* interacts with the upper atmosphere of the Earth, to produce the colourful Aurora Borealis ("northern lights") and the Aurora Australis in the high southern latitudes

* James Alfred Van Allen, born in 1914, in Iowa. He and his students discovered the Belts, using instruments on Explorer 1, in 1958. This discovery came as a complete surprise to the scientific community

(Total for Question 9 = 6 marks)

10 Figure 6 shows the orbits of the Earth and Mars around the Sun.

CAUTION

One of my rants is on the horizon...

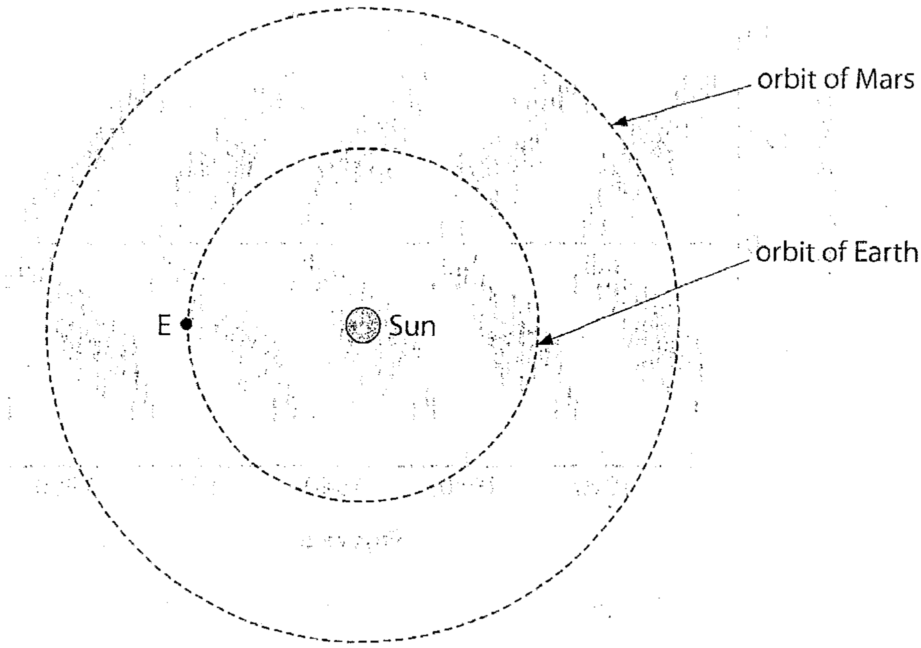


Figure 6

(a) Once a year the Earth is at position E. On Figure 6, indicate the position of Mars when it is at:

(i) conjunction (use the letter **C**)

(ii) opposition (use the letter **O**).

This is woefully incorrect, because the units cannot be employed. How does one infer that T is measured in years?

(b) The mean distance from Mars to the Sun is 1.5 AU.

(i) Calculate the orbital period of Mars and give the unit.

Ugh! → Use the equation $T^2 = r^3$ How can s^2 equal m^3 ?

We have to use the equation as it is presented, but it is so wrong. It is an erroneous development of K $\underline{II}$. For any secondary revolving around a primary,

$\frac{T^2}{r^3}$ = constant. That is, for all the planets, eg. Jupiter, Mars, Saturn, etc:

$$\frac{T_J^2}{r_J^3} = \frac{T_M^2}{r_M^3} = \frac{T_S^2}{r_S^3} \text{ etc.}$$

It saddens me to write:

$(1 \cdot 5)^3 = T^2$

$\therefore 3 \cdot 375 = T^2$

$\therefore \sqrt{3 \cdot 375} = T$

$\therefore$ $T = 1 \cdot 8(4)$ years

14

(ii) How far is Mars from the Earth when it is at opposition?

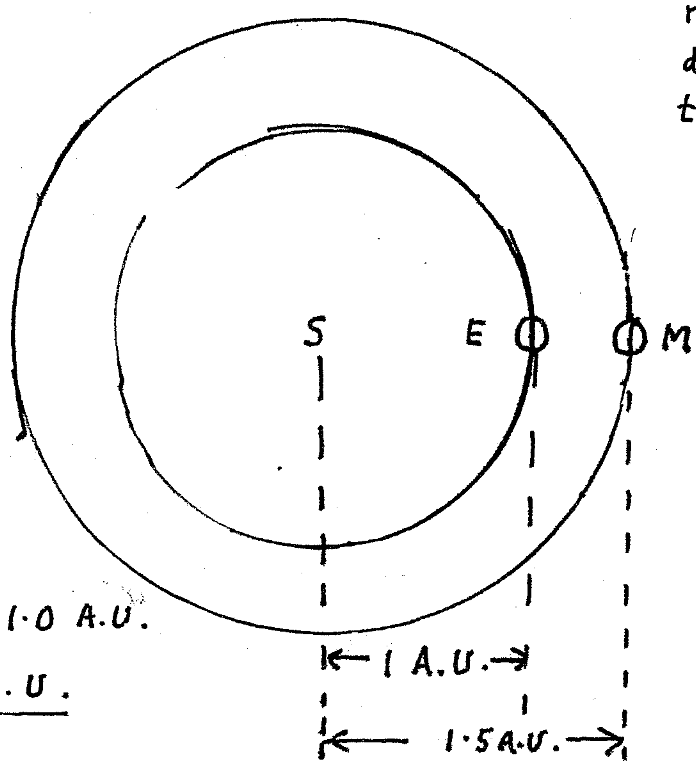
(iii) Suggest **one** reason ~~why~~ that Mars appears brightest at opposition.

Trivial — and an insult to your intelligence. However, note all the answers in the Mark Scheme.

(Total for Question 10 = 6 marks)

Ladies and gentlemen, Please excuse my elaborating on the obvious, but a few of you did answer this type of question wrongly, on the 2012 Paper. (your "Mock" paper).

Sorry, the orbital radii are not drawn correctly to scale.



(10) (b) (ii)

1·5 A.U. − 1·0 A.U.

= 0·5 A.U.

P 4 1 3 4 3 A 0 1 7 3 2

15 15

11 Table 1 lists the properties of 5 stars in a constellation.

star	apparent magnitude	spectral type	absolute magnitude
α	+0.2	F	+4.2
β	+0.5	G	+5.0
γ	+2.2	O	−7.8
δ	+4.2	B	−0.7
ε	+6.8	K	+6.9

Table 1

(a) How many times would star α appear brighter than γ?

$\Delta m = 2.0 \quad \therefore \Delta B = (2.5)^2 = 6.25$

(1)

(b) Give the **Greek letter** of the faintest star that would be visible with the naked eye on a clear night.

δ

(1)

(c) Give the **Greek letter** of the star in the table that is:

"Wow O Be A Fine Girl; kiss Me Right Now, Sweetie / slap"

(i) the hottest

γ

(1)

(ii) located furthest to the right on the H-R Diagram

ε

(1)

(iii) the most luminous.

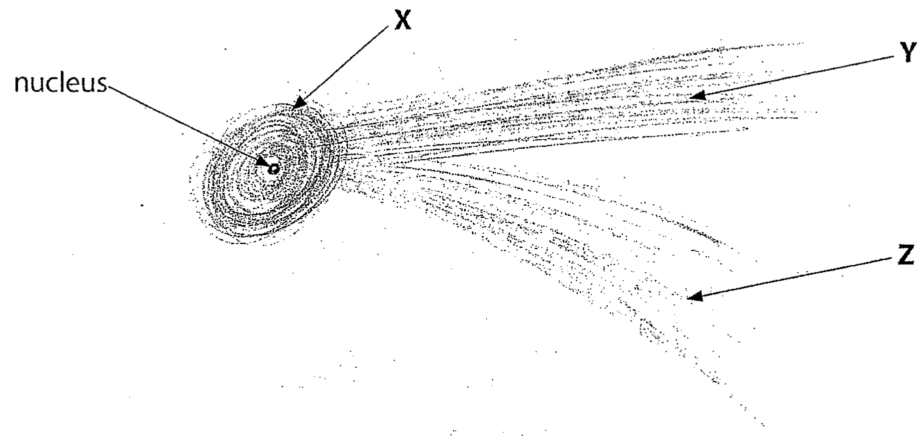
γ.

(1)

(Total for Question 11 = 5 marks)

P 4 1 3 4 3 A 0 1 8 3 2

12 (a) Figure 7 shows a sketch of a typical long-period comet with its nucleus labelled.



Often blue

Figure 7

(i) Name the parts of the comet labelled **X**, **Y** and **Z**.

(3)

X The coma (Formed by the vaporisation of parts of the nucleus.)

Y The ion tail

Z The dust tail

(ii) Where is the most likely origin of long-period comets?

(1)

The Oort Cloud. The Solar System is surrounded by a huge, spherical cloud of comets at distances stretching to tens of thousands of A.U. The Dutch astronomer, Jan Oort. His cometary theory was developed in 1927.

(iii) Why is the feature labelled **Z** slightly curved?

Due to light reflected and scattered from small dust particles which were ejected, and are now pursuing individual orbits around the Sun.

(b) The Sun's pull of gravity on a short-period comet is 16 times stronger when the comet is at perihelion compared with when the comet is at aphelion.

If the closest distance from the comet to the Sun is 1.2 AU, what is the distance from the Sun when the comet is furthest away?

(2)

For the gravitational force to be $\frac{1}{16}$ at aphelion than it is at perihelion, the distance must be 4 times greater: that is, 4·8 A.U.

(Total for Question 12 = 6 marks)

17 17

13 (a) Figure 8 shows *Apollo* astronauts setting up parts of the ALSEP that were used to study the lunar environment and interior.

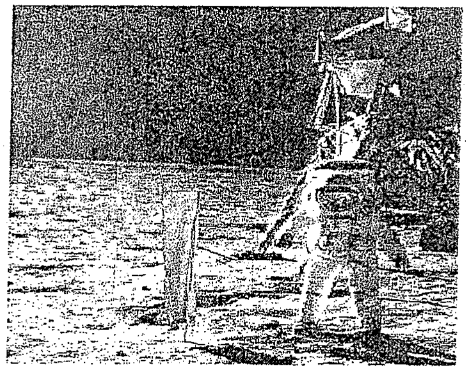


Figure 8

State the specific purposes of **two** instruments in t' ‾P.

(2)

1 ....

2 ....

Use my answers to previous papers.

(b) Figure 9 shows the near si‹ ...ul landing of the *Apollo* programme wa‹ ...of *Apollo 11* landed in the Sea of Tranquility.

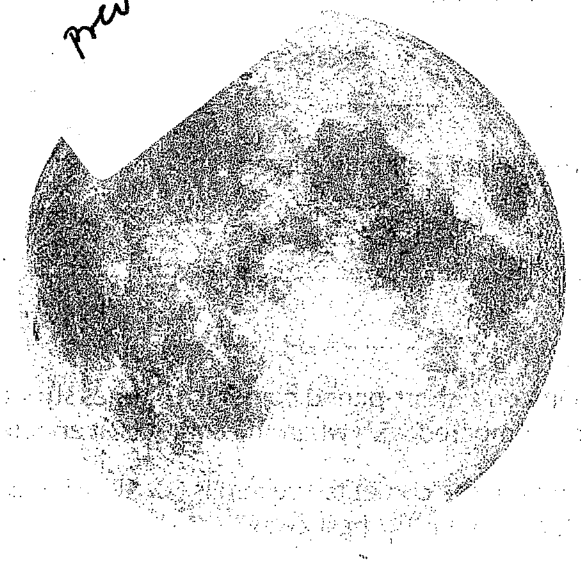


Figure 9

On Figure 9, use an arrow to show the location of the Sea of Tranquility.

(1)

P 4 1 3 4 3 A 0 2 0 3 2

*(c) The Giant Impact Hypothesis can explain the origin of the Moon.
Describe briefly the Giant Impact Hypothesis.

I assume that the asterisk means that continuous prose is expected, and not the "bullet" points provided in the Mark scheme. I suggest that you pay particular attention to the Examiners' Report.

The expected answer from the candidates would, in my opinion, have been difficult to accommodate within six lines.

(Total for Question 13 = 6 marks)

I have just read the Mark scheme. Its emphases and mine do have some differences.

The Moon is a planet in a geological sense because of its size and character, though not in an astronomical sense because it orbits the Earth, rather than the Sun.

Our Moon owes its origin, apparently, to a giant impact, in which much of the debris from a fragmented impactor, plus some ejecta from the outer layers of the larger "target" body, ended in orbit around the larger body.

This larger body subsequently cooled and developed into the Earth, and the orbiting debris accreted to form the Moon. It is likely that this Moon-forming impact was the final, giant impact to have affected the Earth, since any subsequent, similar impact would have certainly destroyed the Moon, or allowed it to escape.

14 (a) Figure 10 shows an incomplete 'Tuning Fork' diagram.

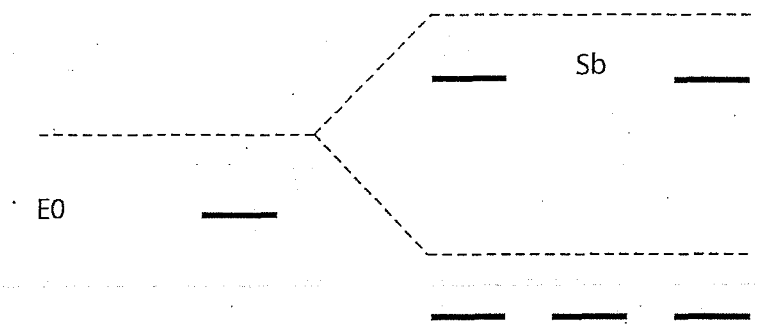


Figure 10

(i) Which astronomer was the first to classify galaxies in this way?

(1)

☐ **A** Neil Armstrong

☐ **B** Galileo Galilei

☐ **C** Edwin Hubble

☐ **D** Isaac Newton

(ii) On Figure 10, write the letters showing the type of galaxy on the six missing labels.

(3)

(iii) Which common type of galaxy is **not** shown on Figure 10?

(1)

(b) Figures 11 and 12 show two galaxies.

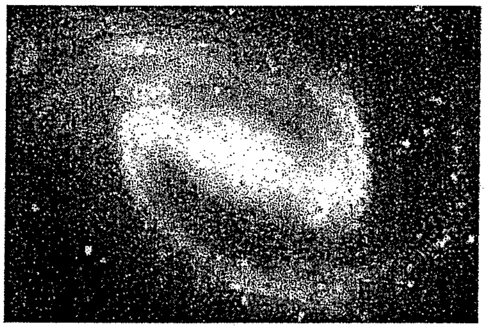


Figure 11

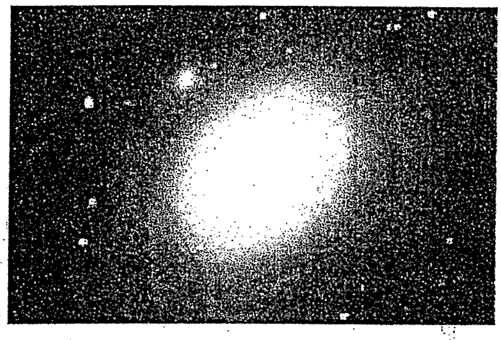


Figure 12

State the type of galaxy shown in:

(i) Figure 11

(1)

(ii) Figure 12.

(1)

(Total for Question 14 = 7 marks)

Your answers to number fourteen should be easy to check against the Mark Scheme.

21

15 (a) Figure 13 shows how different wavelengths of electromagnetic radiation penetrate the atmosphere to various extents.

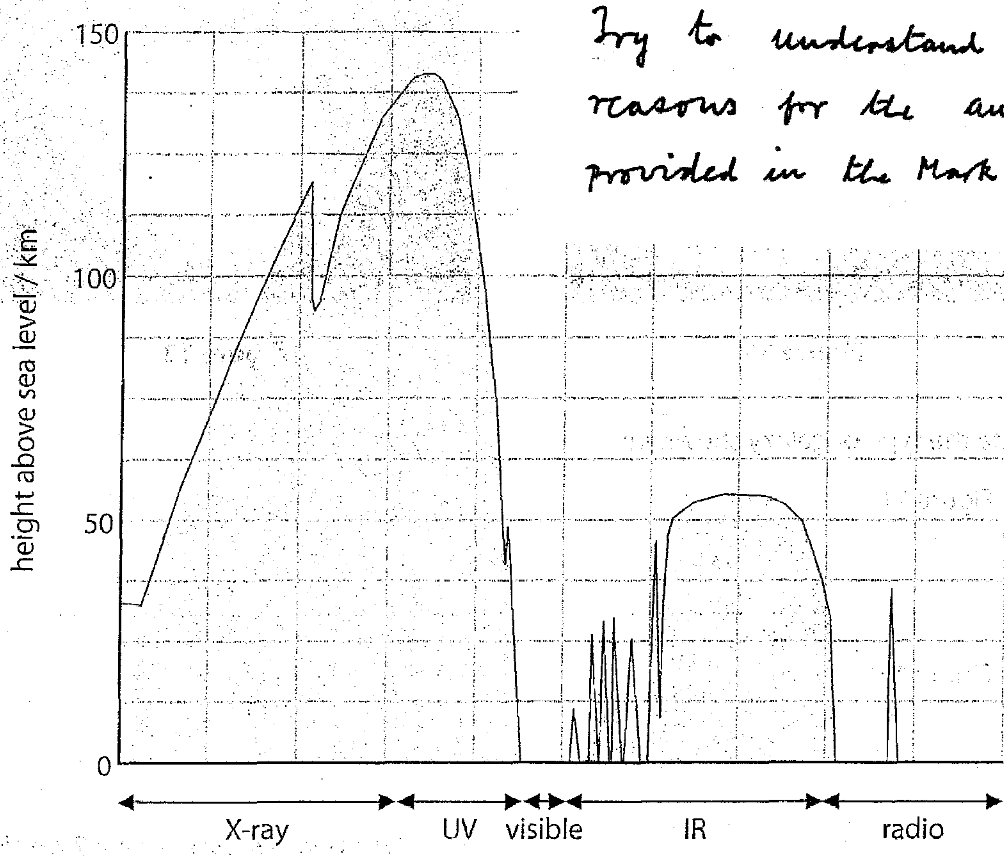


Figure 13

Try to understand the reasons for the answers provided in the Mark scheme.

(i) Use Figure 13 to determine the type of radiation that is absorbed by our atmosphere **the most**.

(1)

....

(ii) Use Figure 13 to determine **one** type of radiation that is able to penetrate to sea level.

(1)

....

P 4 1 3 4 3 A 0 2 4 3 2

(b) Name **one** gas in the Earth's atmosphere that absorbs:

(i) ultraviolet radiation

(1)

(ii) infrared radiation.

JF[2]

(c) Beyond the Earth's atmosphere lie the Van Allen Belts.
Describe briefly how the Van Allen Belts were discovered.

(2)

In 1958, an American physicist, James Alfred Van Allen and his research students, were using simple radiation detectors on the satellites Explorer 1 and Explorer 3, to survey cosmic ray intensities above the atmosphere. They discovered a large population of energetic, charged particles were trapped by the magnetic field of the Earth.

These formed two distinctive torroidal (doughnut-shaped) regions, the Van Allen radiation belts. The inner belt consists largely of protons (Hydrogen ions) and electrons and originates from the Solar wind and the ionosphere. The outer belt is populated from the Solar wind. The high-energy fraction of these particles in these belts is a hazard to space travellers. The charged particles also affect electronic instruments.

16 Table 2 lists the stellar coordinates of 5 stars in the constellation Leo.

star	Right Ascension	declination / °
α	10 h 08 min	+12
β	11 h 49 min	+15
γ	10 h 20 min	+20
δ	11 h 14 min	+21
ε	9 h 46 min	+24

Table 2

(a) Michelle observes the constellation Leo.
Give the **Greek letter** of the star that appear

We have covered this topic in great detail

(i) highest in the sky

....

(ii) furthest west.

....

(b) Michelle records the culmination of star γ at 20:00 (on her watch).

(i) What is meant by the term **culmination**?

....

(ii) At what time on her watch would star α culminate on the same night?

....

(iii) At what time on her watch would star γ culminate 4 nights later?

....

(Total for Question 16 = 6 marks)

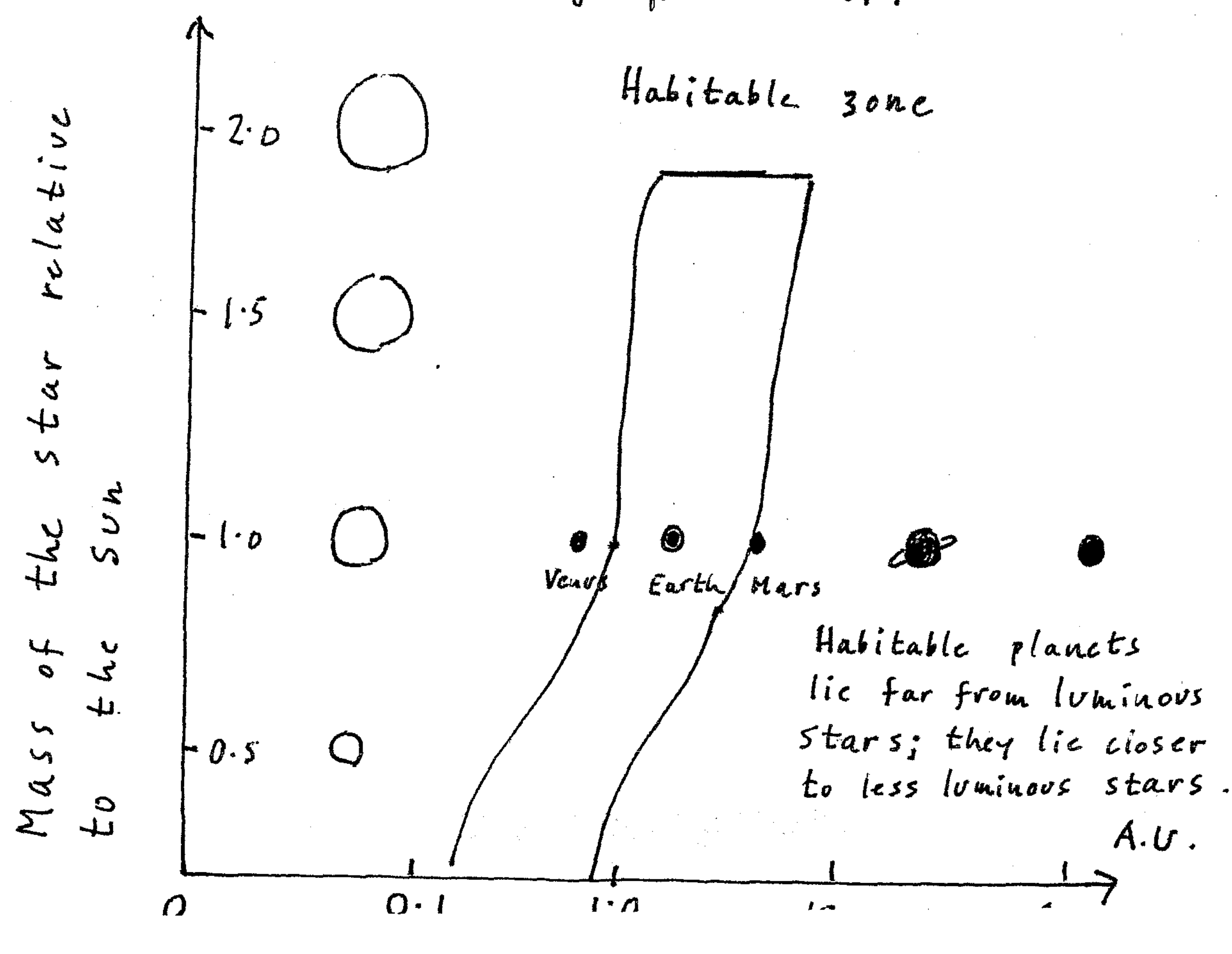
17 (a) Name and describe **one** method used by astronomers to obtain evidence for exoplanets.

name .... The Doppler Shift Method

description of method .... Because two bodies are orbiting each other, about their joint centre of mass, the presence of the exoplanet causes the star to inscribe a small circle, as its companion revolves around it. This wobble can be detected as a Doppler shift in the light of the: as the star recedes, its light is red-shifted.

(17) (b) To map out the planetary systems of other stars, astronomers are keen to find planets of lower mass that lie farther away from their host star than the "hot Jupiters" (planets which lie very close to their parent stars.)

Around each star is a "habitable zone", where a planet lying at such a distance from its star would be of the right temperature to host liquid water, and thus the possibility of life. The key distance depends on the luminosity of the star.



25 25

18 (a) Most cosmologists agree that the Universe began in an event known as the Big Bang. Name and explain **one** piece of evidence that supports this.

Powerful evidence was the discovery of the Cosmic Microwave Radiation. As the Universe expanded, the energy left over from the "Big Bang" cooled until the present day, where we observe it as uniform background radiation, corresponding to a temperature of 2·7k.

*(b) Some cosmologists have proposed different models for the past evolution of the Universe.
Name and describe **one** of these models.

The cosmologist Fred Hoyle prefered to believe in a more sustainable vision of the cosmos. In his perpetual "steady state" universe, matter and space were being continually created and destroyed, and so could have existed for an unlimited time. By the 1960s, Hoyle's static picture had to give way, due to the weight of evidence which favoured the Big Bang.

(c) The terms **Dark Matter** and **Dark Energy** have been introduced by cosmologists. Describe briefly the significance of these terms in relation to the future evolution of the Universe.

Dark matter features whenever there is gravity at work. The fate of the entire Universe depends on its overall mass. The attraction provided by gravitation counterbalances the expansion following the Big Bang explosion. There are three possible outcomes. Either the universe is so massive that gravity wins, and eventually collapses back on itself (a closed Universe ending in a big crunch), or it is precisely balanced and the expansion gradually slows through gravity; or there is too little mass and it expands for ever (an open universe).

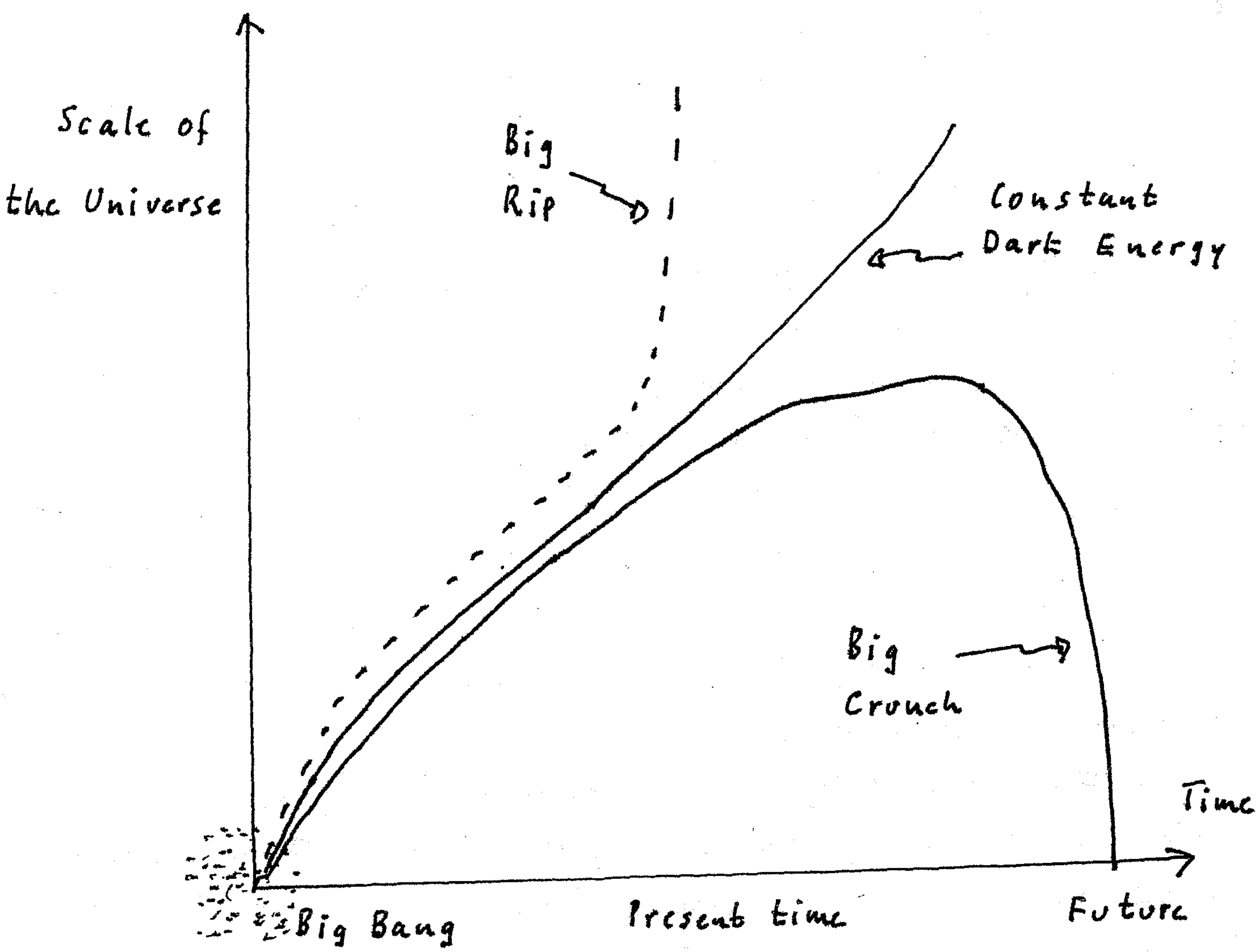
In the 1930s, Fritz Zwicky realised that a nearby giant cluster of galaxies behaved in such a way which implied that its mass was much greater than the mass of all the stars in the galaxies within it. →

Continuation of p. 25

(18) (c) continued.

<u>Dark Energy</u>: Its origin remains elusive. It is thought to be energy associated with the vacuum of space, creating a negative pressure in regions devoid of gravity-attracting matter, and thus causing regions of "empty" space to inflate.

We do not know if it is truly a constant, whether it always takes the same value, right across the Universe and for all time (as do gravity and the speed of light). In its more general form it has also been called "quintessence", or the fifth force, encompassing all the possible ways in which its strength could change with time. It is a "hot" topic of study for physicists.



Question (18) is absurd at this level. The Mark scheme defies one understanding ...

19 In the 1930s Edwin Hubble made observations of distant galaxies.
Using the Doppler principle, Hubble proposed the theory of an expanding Universe.

(a) Describe the Doppler principle.

Doppler, Christian Johann (1803 – 1853) Austrian mathematician and physicist

The change in apparent frequency of a source of light (or sound) due to the relative motion of source and observer.

(b) An astronomer determines the wavelength of a spectral line in the spectrum of a distant galaxy to be 680 nm. The same spectral line at rest has a wavelength of 510 nm.

Use this data to determine the recession velocity of the galaxy and give the unit.
The speed of light is 300 000 km/s.

Use the formula

$$\frac{v}{c} = \frac{\lambda - \lambda_0}{\lambda_0}$$

$\Delta\lambda = 680\ nm - 510\ nm = \underline{170\ nm}$

$\therefore \frac{\Delta\lambda}{\lambda_0} = \frac{170\ nm}{510\ nm} = \frac{1}{3}$

$\therefore \frac{1}{3} = \frac{v}{3 \times 10^8\ m\ s^{-1}}$ $\therefore$ velocity of the galaxy, v, $= 1 \times 10^8\ m\ s^{-1}$

(c) The astronomer makes observations of another distant galaxy and calculates that its recession velocity is 150 000 km/s. If the value of the Hubble Constant is 75 km/s/Mpc, determine the distance to this galaxy and give the unit.

Use the formula

$v = Hd$

"H" is better written as "H_0" meaning the value NOW. It should also be described as the Hubble Parameter, because of its dependence on time. We have to conform to the nomenclature of the Board, I suppose ...

Rearranging the above equation:

$d = \frac{v}{H}$

Substituting:

$d = \frac{150\,000\ km\ s^{-1}}{75\ km\ s^{-1} (Mpc)^{-1}}$

$d = 2000\ Mpc$

(Total for Question 19 = 8 marks)

P 4 1 3 4 3 A 0 2 9 3 2

20 (a) A star has an apparent magnitude of +1.8.

(i) How far away would the star be if its absolute magnitude was also +1.8? Include the unit.

Clearly, 10 pc

(ii) A second star has the same absolute magnitude but is twice as far away from us. Is the apparent magnitude of the second star smaller or larger than +1.8?

The second star would be one-quarter as bright. Its apparent magnitude numerically would be larger.

(b) Two stars, α and δ, have the same absolute magnitude, but star δ is 4 times further away than α. If the apparent magnitude of α is –0.3, deduce the apparent magnitude of δ.

The stars, α and δ, have the same Absolute Magnitude, M.
∴ they have the same luminosity. This inference is a crucial one to draw.
The inverse-square law tells us that δ will be sixteen times fainter than α. Let the apparent magnitude difference between α and δ be Δm

Then

$$16 = (2\cdot51)^{\Delta m}$$

Taking logarithms to base 10 of both sides:

$$\log_{10} 16 = \Delta m \cdot \log_{10} 2\cdot51$$

Rearranging:

$$\Delta m = \frac{\log_{10} 16}{\log_{10} 2\cdot51} = \frac{1\cdot204}{0\cdot4(0)} = 3$$

That is, δ, at its distance, would be three magnitudes fainter than α

∴ the apparent magnitud of δ would be 2·7

N. B. →

P 4 1 3 4 3 A 0 3 0 3 2

20(b). I am pleased to note that the Board expects candidates to answer this from first principles. That is, to use the inverse-square law. There is no reference to the Modulus Equation, although it could be employed. Of the two answers displayed in the Examiners' Report, make a particular study of the answer which was awarded full marks. Do you find it easier to understand than my approach? Without wishing to appear mean-spirited, I think that the second candidate did not deserve full marks, because the physical principles were not stated in full. Incidentally, his/her answer illustrates the result of an undue reliance on an electronic calculator: nine decimal places quoted in the solution ...

In order to be even-handed with my observations, the Mark Scheme seems to be spectacularly unhelpful in connexion with 20(b). I doubt that any unsure candidate would obtain much assistance from the almost total lack of an explanation.

Am I being pernickety or —— even worse —— pedantic?

DF

2014, February 17