

The Universe and The Big Bang

Questions

Q1.

The Sun has a mass of 2.0×10^{30} kg.
A white dwarf has a mass of 3.4×10^{29} kg.

Calculate the value of

$$\frac{\text{mass of this white dwarf}}{\text{mass of the Sun}}$$

(2)

value =

(Total for question = 2 marks)

Q2.

Figure 3 shows a Mars Exploration Rover.



(Source: photojournal.jpl.nasa.gov)

Figure 3

The mass of the rover is 190 kg.

(i) The gravitational field strength on Earth is 10 N / kg.

Calculate the weight of the rover on Earth.

Use the equation

$$\text{weight} = \text{mass} \times \text{gravitational field strength}$$

(1)

weight on Earth = N

- (ii) The weight of the rover on Mars is 700 N.
Calculate the gravitational field strength on Mars.

(2)

gravitational field strength on Mars = N/kg

(Total for question = 3 marks)

Q3.

The Asteroid Belt is part of our Solar System.

Vesta is an asteroid in the Asteroid Belt.

Vesta has an orbital speed of 1.9×10^4 m/s.

Vesta travels a distance of 2.2×10^{12} m when it orbits the Sun once.

Calculate the time taken for Vesta to orbit the Sun once.

(2)

time = s

(Total for question = 2 marks)

Q4.

* More than two thousand years ago the Earth was believed to be at the centre of the universe as shown in Figure 13.

The planets, the Moon and the Sun were believed to be in orbit around the Earth.

In 1543 Nicolaus Copernicus proposed that the Earth was a planet, and that the Earth and the other planets orbit around the Sun. This model is shown in Figure 14.

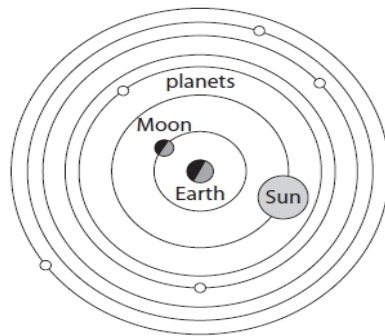


Figure 13

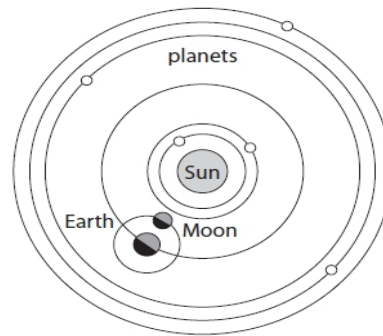


Figure 14

Discuss how evidence has changed our views of the universe.

(6)

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(Total for question = 6 marks)

Q5.

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

The Steady State theory is also a theory about the origin of the Universe.

Give **one** similarity and **one** difference when comparing the Big Bang theory with the Steady State theory.

(2)

similarity

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difference

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(Total for question = 2 marks)

Q6.

Use words from the box to complete the following sentences.

galaxy	planet	satellite
solar system	star	

(3)

- (i) Saturn is a
- (ii) The Moon is a
- (iii) Halley's Comet orbits a

(Total for question = 3 marks)

Q7.

(i) An astronomer observes light from a distant galaxy.

As the galaxy moves away from us, the spectrum of the light is

(1)

- A** blue-shifted
- B** green-shifted
- C** red-shifted
- D** violet-shifted

(ii) The shift in the spectrum of light from the distant galaxy provides evidence for the expansion of the

(1)

- A** Earth
- B** Milky Way Galaxy
- C** Solar System
- D** Universe

(Total for question = 2 marks)

Q8.

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

Observations of the expanding Universe have shown that the further away a galaxy is from the Earth, the faster the galaxy is moving away from the Earth.

Figure 15 shows how the velocity of galaxies is related to their distance from the Earth.

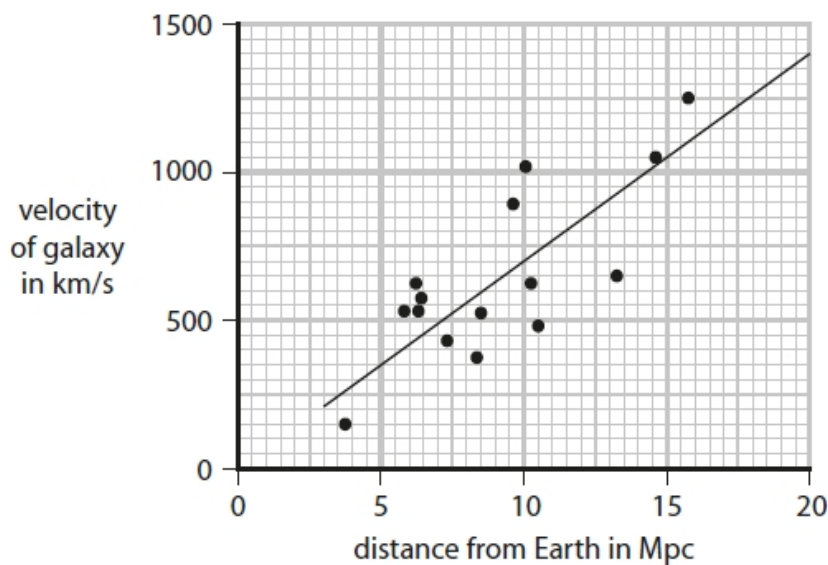


Figure 15

Mpc is a unit of distance used for large distances in space.

(i) Use Figure 15 to estimate the velocity of a galaxy that is 15 Mpc away from the Earth.

(1)

velocity = km/s

(ii) Calculate the gradient of the line shown in Figure 15.

State the unit.

(3)

gradient = unit

(iii) The gradient of the line in Figure 15 can be used to estimate the age of the Universe.

Explain why the gradient of the line in Figure 15 can only provide an **estimate** of the age of the Universe.

(2)

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(Total for question = 6 marks)

Q9.

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

Which of these provides evidence that the Universe had a beginning?

(1)

- A** the discovery of other galaxies
- B** the discovery of the moons of Jupiter
- C** the discovery of planets orbiting distant stars
- D** the discovery of cosmic microwave background (CMB) radiation

(Total for question = 1 mark)

Q10.

The Big Bang theory gives an explanation for the origin of the Universe.

Explain how evidence supports the ideas that

- the Universe is expanding
- the Universe began at a single point.

(6)

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(Total for question = 6 marks)

Q11.

The Big Bang theory is one theory for the origin of the Universe.

The Big Bang theory suggests:

- the Universe had a beginning
- the Universe is still expanding.

Evidence that the Universe is still expanding comes from observations of light from distant galaxies.

Describe how light from distant galaxies shows that the Universe is still expanding.

(2)

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(Total for question = 2 marks)

Q12.

Any object weighs less on the Moon than it does on the Earth.

The gravitational field strength on the Moon is different from the gravitational field strength on the Earth.

Suggest **two** reasons why the gravitational field strength on the Moon is different from the gravitational field strength on the Earth.

(2)

1

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2

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(Total for question = 2 marks)

Q13.

- (i) A long time ago, scientists believed that the Earth was at the centre of the Solar System. Evidence has since proved that the Sun is at the centre of the Solar System. State **one other** idea about the Solar System that **has** changed over time.

(1)

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- (ii) Figure 13 shows data for some of the planets of the Solar System.

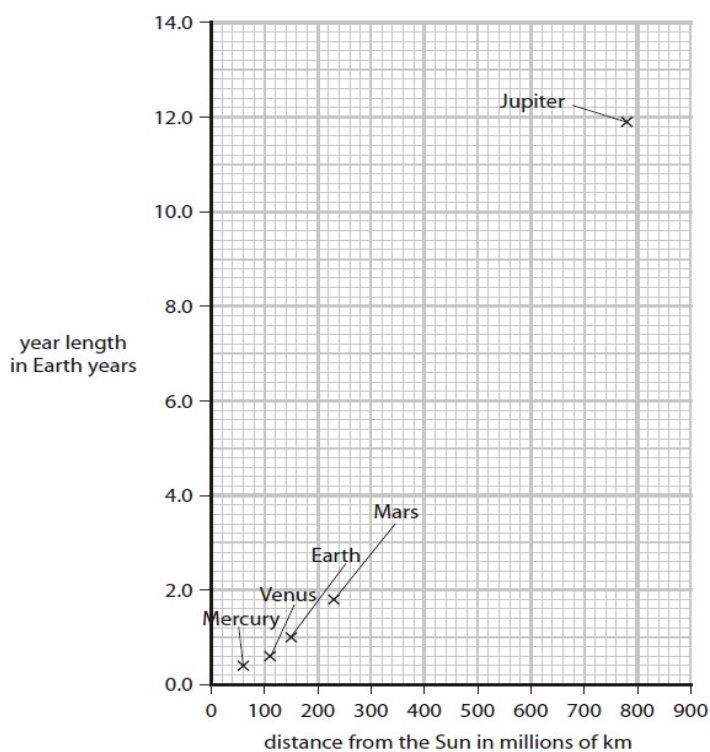


Figure 13

Ceres is an asteroid that orbits the Sun between Mars and Jupiter. It takes Ceres 4.6 Earth years to make one orbit of the Sun.

Use the graph to estimate the distance of Ceres from the Sun.

Show your working.

(3)

distance of Ceres from the Sun = millions of km

(Total for question = 4 marks)

Q14.

Satellites are used to gather data about the origin of the Universe.

The Big Bang theory is a theory about the origin of the Universe.

Evidence for the Big Bang theory is provided by red-shift and CMB radiation.

(i) Describe what is meant by red-shift.

(2)

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(ii) Explain how red-shift provides evidence for the Big Bang theory.

(2)

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(iii) The Cosmic Background Explorer (COBE) satellite observed CMB radiation from 1989 to 1993.

State what the 'M' in CMB radiation stands for.

(1)

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(iv) State what is meant by 'cosmic background radiation'.

(1)

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(v) Explain how the presence of CMB radiation provides evidence for the Big Bang theory.

(2)

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(Total for question = 8 marks)

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	substitution (1) $\frac{3.4 \times 10^{29}}{2.0 \times 10^{30}}$ evaluation (1) 0.17	award 1 mark for 1.7 to any incorrect power of 10 ignore any units given award full marks for the correct answer without working	(2)

Q2.

Question number	Answer	Additional guidance	Mark
(i)	1900 (N)	allow 1862 1864 190×10 $190 \times 9.8(1)$	(1)

Question number	Answer	Additional guidance	Mark
(ii)	rearrangement (1) $\frac{700}{190}$ evaluation (1) 3.7 (N/kg)	$(g =) \frac{W}{m}$ allow numbers that round up to 3.7 (N/kg) award full marks for the correct answer without working	(2)

Q3.

	Answer	Additional guidance	Mark
	rearrangement and substitution (1) $(t =) \frac{2.2 (\times 10^{12})}{1.9 (\times 10^4)}$ evaluation (1) 1.2×10^8 (s)	allow numbers that round to 1.2×10^8 e.g. 1.1579×10^8 award full marks for correct answer without working.	(2) AO2

Q4.

Question Number	Answer	Mark
	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p style="text-align: center;">AO1 strand 1 (6)</p> <ul style="list-style-type: none"> • idea that telescopic evidence supported the heliocentric model e.g. observing the moons of Jupiter supported a sun-centred solar system • detail e.g. it was Galileo's observations of the moons of Jupiter • the moons rotate around Jupiter i.e. not everything rotates about the earth • other observations by telescope – discoveries of the planets Uranus and Neptune + the asteroid belt • (detailed) photographic evidence • use of computer modelling • satellite observations • heliocentric model verified by Voyager missions (space probes) 	(6) AO 1 1

Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> No rewardable material.
Level 1	1-2	<ul style="list-style-type: none"> Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	<ul style="list-style-type: none"> Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	<ul style="list-style-type: none"> Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Q5.

Question number	Answer	Additional guidance	Mark
	<p>similarity (both have) expanding Universe (1)</p> <p>difference one from: Steady State, Universe has no beginning (1)</p> <p>Steady State theory requires the continual formation of new matter, the Big Bang theory does not (1)</p>	different interpretation of CMBR	(2) AO1

Q6.

Question number	Answer	Additional guidance	Mark
	<p>(i) planet (1)</p> <p>(ii) satellite (1)</p> <p>(iii) star (1)</p>	<p>in this order</p> <p>accept recognisable spellings</p>	(3)

Q7.

Question Number	Answer	Mark
(i)	<p>The only correct answer is C red-shifted</p> <p>A is not correct because the spectrum is not blue-shifted B is not correct because the spectrum is not green-shifted D is not correct because the spectrum is not violet-shifted</p>	(1) comp

Question Number	Answer	Mark
(ii)	<p>The only correct answer is D Universe</p> <p>A is not correct because the shift does not provide evidence for the expansion of Earth. B is not correct because the shift does not provide evidence for the expansion of the Milky Way Galaxy C is not correct because the shift does not provide evidence for the expansion of the Solar system</p>	(1) comp

Q8.

Question number	Answer	Additional guidance	Mark
(i)	1050 \pm 20 (km/s)		(1) AO3 marked with dii

Question number	Answer	Additional guidance	Mark
(ii)	attempt at $\frac{\Delta y}{\Delta x}$ (1) evaluation (1) 70 \pm 5 unit (1) km/s/Mpc	could be seen on graph award 2 marks for correct answer without working independent mark km/s Mpc s ⁻¹ or per second	(3) AO3

Question number	Answer	Additional guidance	Mark
(iii)	an explanation linking: points are scattered widely about the line (on graph) (1) giving wide range of possible gradients (1)	there are many possible best fit lines	(2) AO3

Q9.

Question number	Answer	Mark
	The only correct answer is D the discovery of cosmic microwave background (CMB) radiation A is not correct because it does not indicate the Universe had a beginning B is not correct, it is evidence against the geocentric model of the Universe C is not correct, it is evidence for other solar systems	(1) AO1

Q10.

Question Number	Answer	Mark
	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p>	(6)

AO1 strand 1 (6 marks)**evidence for expansion**

- red shift
- light from distant galaxies/stars
- shifted to red side of em spectrum
- (observed) wavelength of light is longer
- showing source moving away
- (nearly) all galaxies show this
- Doppler effect
- (expanding at an increasing rate / dark energy)

evidence for beginning at a point

- CMBR
- microwave radiation left over from beginning
- the increase of recessional velocities with distance - (extrapolating)
- microwaves because of cooling
- detected from all over the sky

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	<ul style="list-style-type: none">• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1)• Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	<ul style="list-style-type: none">• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1)• Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	<ul style="list-style-type: none">• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1)• Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Summary for guidance			
Level	Mark	Additional Guidance	General additional guidance – the decision within levels
	0	No rewardable material.	
Level 1	1–2	<u>Additional guidance</u> some element of physics about the expansion / single point origin	<u>Possible candidate responses</u> red shift shows expansion or CMBR connected with beginning
Level 2	3–4	<u>Additional guidance</u> more detail about one piece of evidence or basic detail about two pieces of evidence	<u>Possible candidate responses</u> red shift connected with galaxies moving away (from earth observer) CMBR to do with release of radiation at the beginning
Level 3	5–6	<u>Additional guidance</u> Understanding is detailed and fully developed. includes detail about both pieces of evidence (one may be stronger than the other but both should feature for level 3)	<u>Possible candidate responses</u> red shift connected with galaxies moving away (from earth observer) with the further they are away the faster they are moving away CMBR to do with release of (leftover) radiation at the beginning □ microwaves because of cooling – detected from all over the sky

Q11.

Question number	Answer	Additional guidance	Mark
	A description to include: wavelength (of the light) (1) appears to increase (1) [increase must be linked with wavelength]	Red shift/Doppler effect (Red shift) shows galaxy moving away accept answers in terms of frequency	(2) AO1

Q12.

Question number	Answer	Additional guidance	Mark
	Any two of the following 1. mass (1) 2. radius (1) 3. density (1)	allow made of different substance/ material if no other mark awarded, allow 1 mark for (Moon is) smaller or Earth is bigger	(2) AO2

Q13.

Question Number	Answer	Additional guidance	Mark
(i)	examples: planets have moons (1) the Earth rotates (spins) (1) planets orbit the Sun (1) Pluto is no longer a planet (1) orbits are elliptical (not circular) (1) there are more planets than previously thought (1) ours is not the only solar system (1) Earth is {round/spherical/not flat} (1) planets are not wandering stars.	answers must be to do with the solar system	(1)

Question Number:	Answer	Additional guidance	Mark
(ii)	<p>smooth curve drawn on the graph (1)</p> <p>horizontal line drawn from 4.6 Earth years to intercept the drawn line/curve (1)</p> <p>EITHER: their reading from line / curve (1)</p> <p>OR</p> <p>430±30 (million km) (1)</p>	<p>accept curve up to Mars followed by a straight line</p> <p>plot point at year length = 4.6</p> <p>reading on distance axis ± half small square from their graph</p> <p>award full marks for the correct answer without working</p>	(3)

Q14.

Question Number	Answer	Additional guidance	Mark
(i)	<p>a description to include:</p> <p>wavelength (of e.m. radiation) increased / frequency decreased (1)</p> <p>as the (star) moves away (from us) (1)</p>	<p>don't penalise planet instead of object</p> <p>stretched/moves to(wards) red end of spectrum</p> <p>spectral lines move towards the red end of the spectrum</p>	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
(ii)	<ul style="list-style-type: none"> an explanation linking: big bang has expanding universe (1) with galaxies moving away (from each other) (1) 	<p>from (original) explosion started at a point</p> <p>accept stars moving away (not objects or planets here) the further away they are the greater is their (recessional) speed idea</p>	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
(iii)	microwave		(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
(iv)	(radiation) that comes from all over the sky / space / the universe	from the big bang / explosion	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
(v)	<p>an explanation linking:</p> <ul style="list-style-type: none"> the Big Bang theory has a beginning / initial explosion (1) that releases / gives out radiation (1) 	<p>explosion from a point</p> <p>radiation still present</p>	(2) AO 1 1