Red shift and the Universe

Questions

Name: _____

Class: _____

Date: _____

Time: **63 minutes**

Marks: **63 marks**

Comments:

1 The Big Bang theory attempts to explain the origin of the Universe.

(i) What is the Big Bang theory?

_____

_____

(1)

(ii) What can be predicted from the Big Bang theory about the size of the Universe?

_____

(1)

(Total 2 marks)

2 Read the passage.

> In the SolarSystem, the inner planets, such as the Earth, contain elements which are eavierthan the elements hydrogen and helium.
>
> Our star,the Sun, is a medium sized star. If a star is much more massive than the Sunit will eventually swell into a red giant, start to contract, continue tocontract and finally explode.

(a) What is the explosion called?

_____

(1)

(b) Explain why scientists believe that the Solar System was formed from the material produced when earlier stars exploded.

_____

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(3)

(Total 4 marks)

3 Explain how observations at the red end of the spectrum of light from galaxies have led to one theory about the origin of the Universe.

(Total 6 marks)

4 (a) Satellites fitted with various telescopes orbit the Earth. These telescopes detect different types of electromagnetic radiation.

Why are telescopes that detect different types of electromagnetic waves used to observe the Universe?

(1)

(b) In 2005 a space telescope detected a star that exploded 13 billion years ago. The light from the star shows the biggest *red-shift* ever measured.

(i) What is *red-shift*?

(1)

(ii) What does the measurement of its red-shift tell scientists about this star?

(1)

(c) Red-shift provides evidence for the ‘big bang’ theory.

(i) Describe the 'big bang' theory.

_____

_____

_____

_____

(2)

(ii) Suggest what scientists should do if new evidence were found that did not support the 'big bang' theory.

_____

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_____

(1)

(Total 6 marks)

5 Astronomers use red shift in two ways.
They calculate the distance to each galaxy from Earth.
They also calculate the speed at which galaxies are moving away from Earth.

The table shows some results. Distance is given in zettametres, Zm. One zettametre is 10^{21} metres.

Galaxy	Distance from Earth to galaxy in Zm	Speed at which galaxy is moving away from us in Zm per billion years	Time the galaxy has been moving away from us in billions of years (Calculated by distance ÷ speed)
Abell 963	25 000	1950	12.8
Abell 1302	14 000	1100	
Abell 1314	4 100	320	12.8
Abell 1978	18 000	1400	12.9
Abell 2255	10 000	770	13.0

(a) Complete the data for Abell 1302.

(1)

(b) Describe the relationship between the distance to a galaxy and the speed at which the galaxy is moving away from us.

_____

_____

(1)

(c) Explain how the data for time provides evidence for the theory that the origin of the Universe was a huge explosion ('big bang').

_____

_____

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(2)

(Total 4 marks)

6 (a) Observation of the spectra from distant galaxies provides evidence to support the 'Big Bang' theory.

(i) Complete the following sentence.

Many scientists think that the 'Big Bang' theory describes the _____

_____

(1)

(ii) Tick (✓) **one** box to complete the sentence.

The discovery of cosmic microwave background radiation was important because it ...

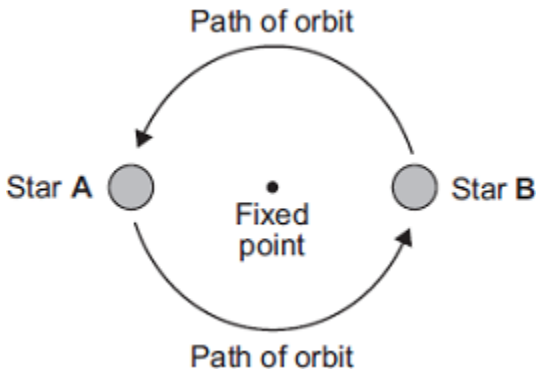
proved the 'Big Bang' theory to be correct. ☐

provided more evidence to support the 'Big Bang' theory. ☐

proved the Universe will continue to expand forever. ☐

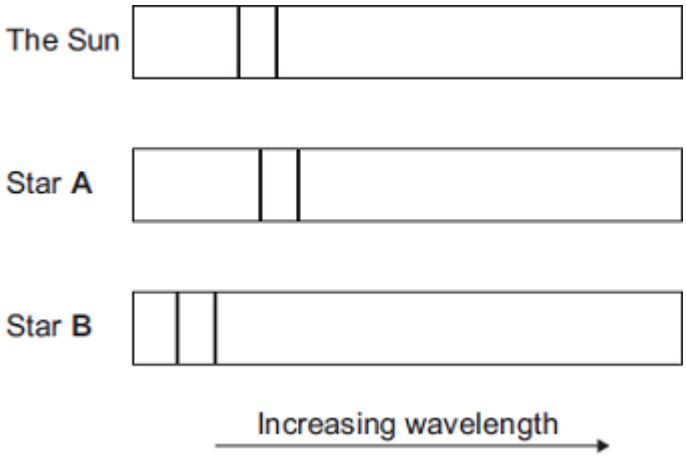
(1)

(b) Many stars are part of a binary star system. Binary star systems have two stars.



The visible spectrum from stars includes dark lines. These lines are at specific wavelengths.

The diagram shows the position of two dark lines in the spectrum from the Sun. It also shows the same lines in the spectra from two stars **A** and **B** in a binary star system at the same point in time.



(i) What name is given to the effect shown in the spectrum from star **A**?

_____

(1)

(ii) Scientists have concluded that the two stars in a binary star system orbit around a fixed point between the two stars.

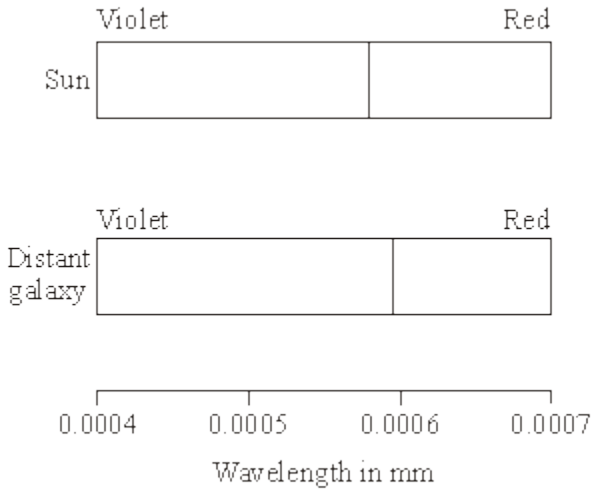
A comparison of the spectra from the two stars in a binary star system provides evidence to support this conclusion.

Explain how.

(3)

(Total 6 marks)

7 The visible part of the electromagnetic spectrum from a star includes a dark line. This line is at a specific wavelength. The diagram shows the position of the dark line in the spectrum from the Sun and in the spectrum from a distant galaxy.



(a) Explain how the spectrum 'shift' of the dark line supports the theory that the Universe began from a very small point.

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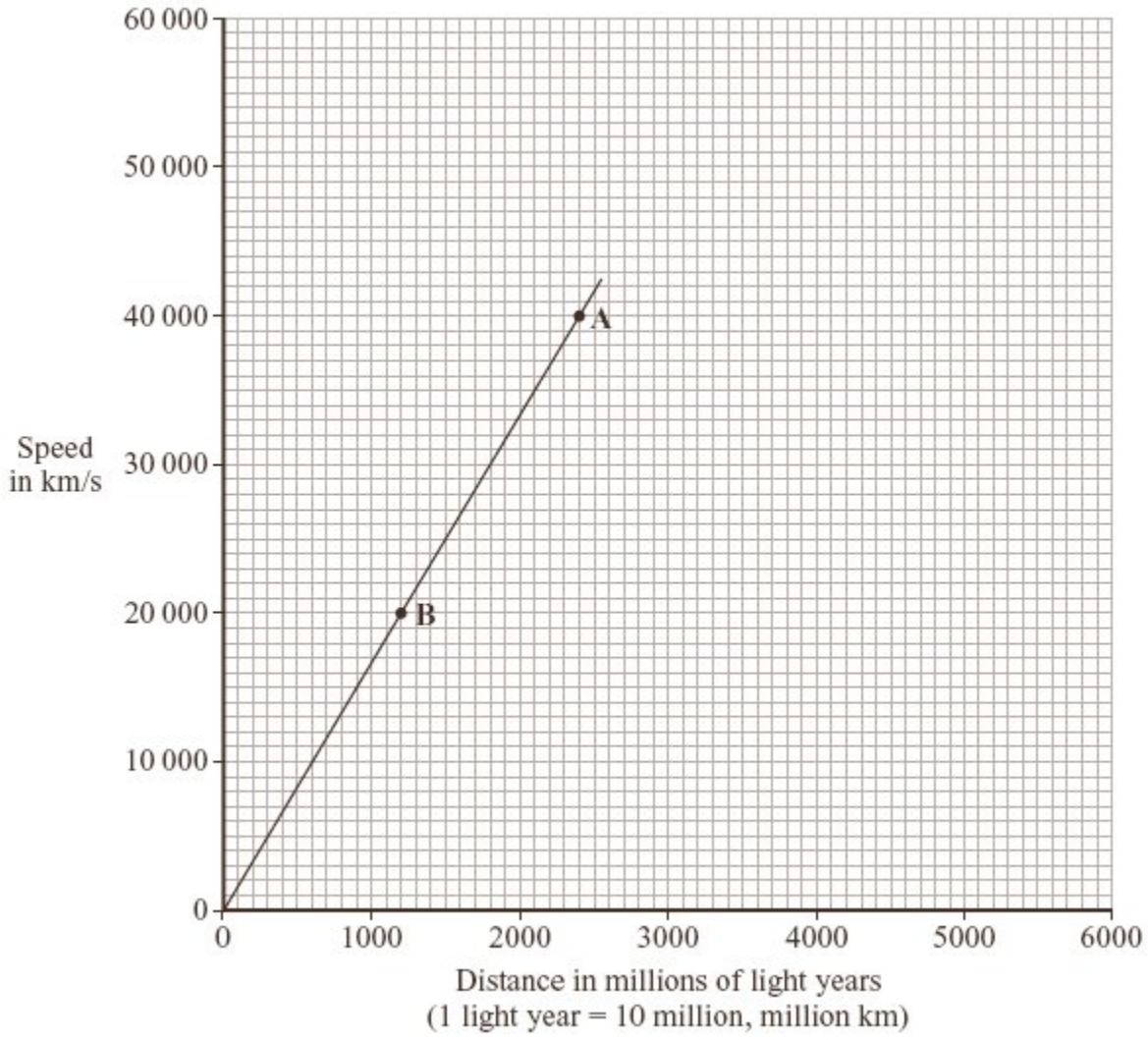
(3)

(b) From data collected, a graph can be drawn that links the speed of a galaxy with the distance of the galaxy from the Earth.



(i) How does the visible light spectrum from galaxy **A** look different from the visible light spectrum from galaxy **B**?

_____

_____

(1)

(ii) A third galaxy, **C**, seems to be travelling away from the Earth at about 60 000 km/s.

Estimate how far galaxy **C** might be from the Earth, showing how you use the graph to do this.

_____

_____

Distance between galaxy **C** and the Earth = _____ million light years

(2)

(Total 6 marks)

8 (a) In 1929, the astronomer Edwin Hubble observed that the light from galaxies that are moving away from the Earth showed a *red-shift*.

What is *red-shift* ?

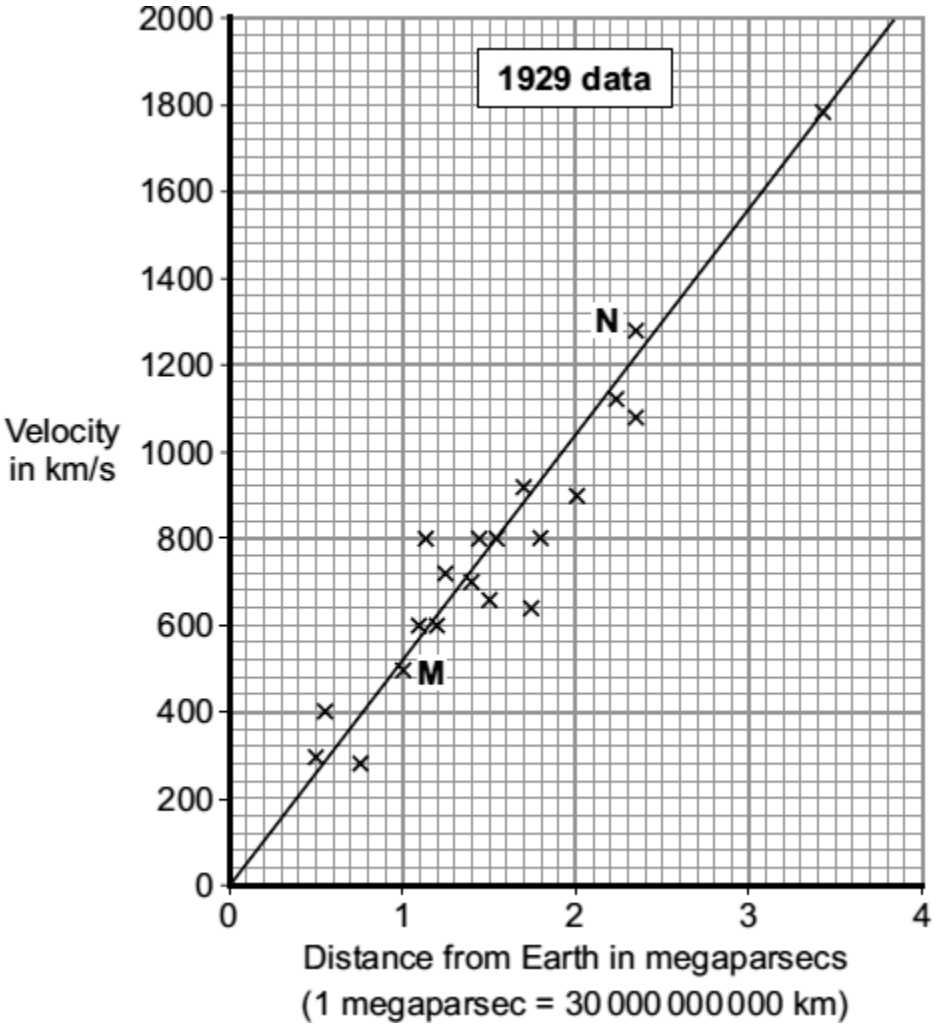
_____

_____

(1)

(b) By measuring the *red-shift*, Hubble was able to calculate the speed at which the galaxies are moving away from the Earth. He was also able to calculate the distance of these galaxies from the Earth.

The graph shows some of the data calculated by Hubble.



(i) The data from two galaxies, **M** and **N**, has been included in the graph. The light from galaxy **M** has a smaller *red-shift* than the light from galaxy **N**.

What does the difference in *red-shift* tell scientists about the two galaxies, **M** and **N**?

_____

_____

_____

(2)

(ii) The gradient of the line drawn on the graph gives a number known as the Hubble constant. The Hubble constant can be used to estimate when the universe began.

Use the graph to calculate the value of the Hubble constant.

Show clearly how you obtained your answer.

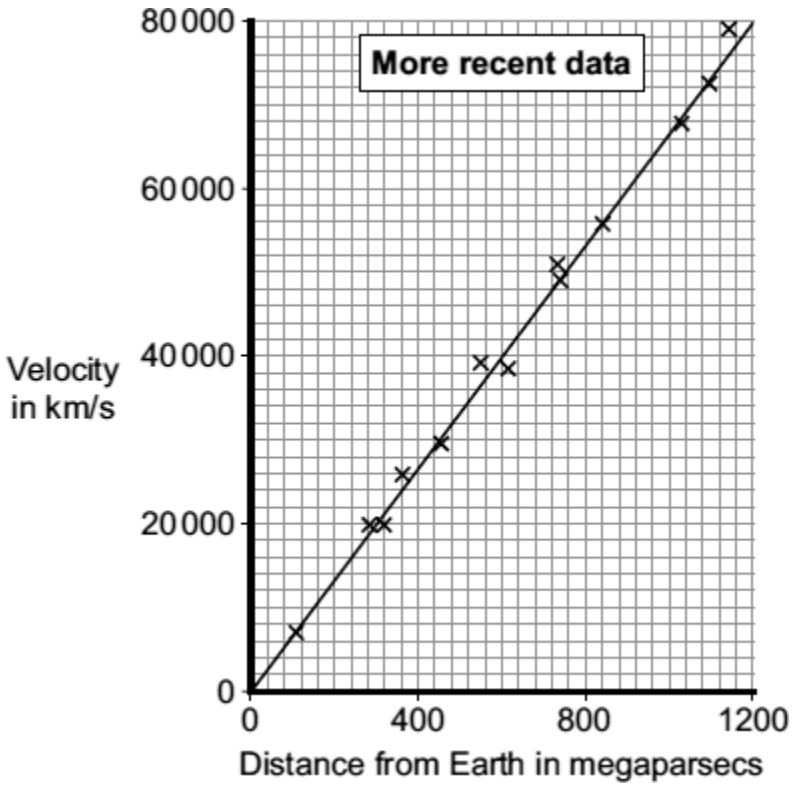
_____

_____

Hubble constant = _____ km/s per megaparsec

(2)

(iii) More recently, data has been obtained from more distant galaxies.



The results from the more recent data give a totally different value for the Hubble constant to the one calculated from the 1929 data.

Which set of data, the 1929 or the more recent, is most likely to give the value closest to the true value for the Hubble constant?

Draw a ring around your answer.

1929 **more recent**

Give a reason for your answer.

_____

_____

(1)

(c) The Andromeda galaxy is not moving away from the Earth. It is actually moving towards the Earth. This means that the light from Andromeda shows a blue-shift.

How do the wavelength and frequency of the light from Andromeda seem to have changed when viewed from the Earth?

_____

_____

_____

_____

(2)

(Total 8 marks)

9 Galaxies emit all types of electromagnetic wave.

(a) (i) Which type of electromagnetic wave has the shortest wavelength?

_____

(1)

(ii) State **one** difference between an ultraviolet wave and a visible light wave.

_____

_____

(1)

(b) Electromagnetic waves travel through space at a speed of 3.0×10^8 m/s.

The radio waves emitted from a distant galaxy have a wavelength of 25 metres.

Calculate the frequency of the radio waves emitted from the galaxy and give the unit.

_____

_____

_____

Frequency = _____

(3)

(c) Scientists use a radio telescope to measure the wavelength of the radio waves emitted from the galaxy in part (b) as the waves reach the Earth. The scientists measure the wavelength as 25.2 metres. The effect causing this observed increase in wavelength is called red-shift.

(i) The waves emitted from most galaxies show red-shift.

What does red-shift tell scientists about the direction most galaxies are moving?

_____

_____

(1)

(ii) The size of the red-shift is **not** the same for all galaxies.

What information can scientists find out about a galaxy when they measure the size of the red-shift the galaxy produces?

_____

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_____

(2)

(iii) What does the observation of red-shift suggest is happening to the Universe?

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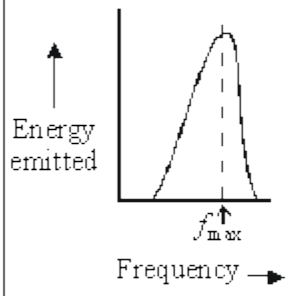
(1)

(Total 9 marks)

10 Read the following information about cosmic microwave background radiation.

Then use it to answer the questions below.

A Microwave "noise" reaches Earth with almost the same intensity from every direction. It is called cosmic microwave background radiation.	**B** All bodies with a temperature above zero kelvin (–273°C) emit electromagnetic radiation.	**C** Measurements made by the COBE satellite showed that there are very slight "ripples" in the cosmic microwave background radiation.
D Bodies which emit radiation do so across a range of frequencies, as shown on the graph.  	**E** Radiation in the microwave region of the electromagnetic spectrum reaches Earth from many stars and galaxies.	**F** In 1965, the astronomers Penzias and Wilson stopped trying to eliminate "noise" from their microwave detectors and studied it instead.
G The frequency at which a body radiates most energy (f_{max}) is directly proportional to the kelvin temperature.	**H** Cosmic microwave background radiation has an energy profile matching a temperature of 3 kelvin (–270°C).	**I** Because of the expansion of the Universe, the temperature of radiation from the time of the big bang will now be only a few kelvin.
J The early universe could not have been completely uniform otherwise galaxies would never have formed.		

(You may find it helpful to begin by deciding which items of information belong to which question.)

(a) Explain, as fully as you can, why the frequency profile of electromagnetic radiation is an indication of temperature.

(3)

(b) Describe, in as much detail as you can, what cosmic microwave background radiation is and how it was discovered.

(3)

(c) Explain, as fully as you can, how cosmic microwave background radiation fits in with the idea that the Universe, as it now is, began with a big bang.

(4)

(d) Some people think that Penzias and Wilson's discovery of cosmic microwave background radiation was just lucky. Others disagree.

What do you think? Give reasons for your answer.

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(2)

(Total 12 marks)