EXAM PAPERS PRACTICE

Red Shift

These practice questions can be used by students and teachers and is

Suitable for GCSE AQA Physics Topic Question 8463

Level: GSCE AQA 8463

Subject: Physics

Exam Board: GCSE AQA

Topic: Red Shift

Q1.

In 1929, the astronomer Edwin Hubble observed that the light from galaxies moving away from the Earth had longer wavelengths than expected.

(a) What name is given to this effect?

_____

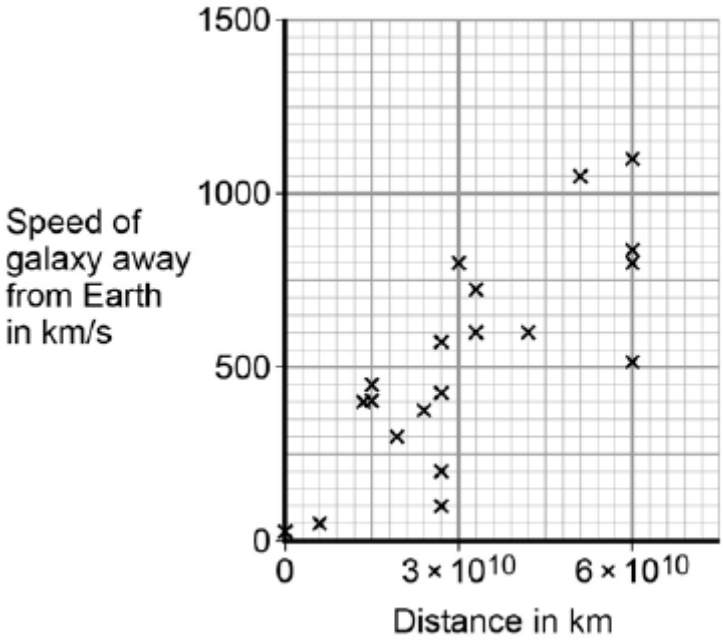
_____

(1)

(b) From his observations, Hubble was able to calculate the speed of a galaxy and the distance of the galaxy from the Earth.

Figure 1 shows the results of Hubble's calculations.

Figure 1



What relationship between the speed of a galaxy and the distance is suggested by Hubble's results?

_____

_____

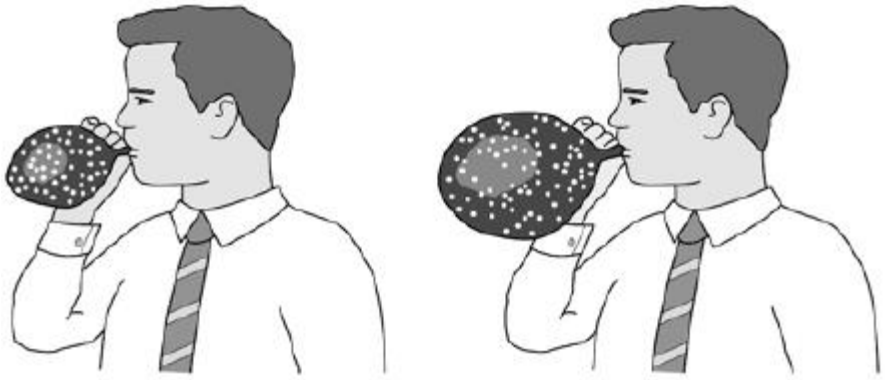
(1)

The observations made by Hubble support the idea that the Universe is expanding. This means that galaxies are continually moving away from each other and from the Earth.

Figure 2 shows a student using a balloon to model the idea of an expanding Universe.

Some dots, which represent galaxies, were marked on the balloon.
The balloon was then inflated.

Figure 2



(c) Give **one** strength and **one** weakness of this model in representing the idea of an expanding Universe.

Strength _____

_____

Weakness _____

_____

(2)

In the 1950s there were two main theories to explain how the Universe began.

Theory 1	The Universe has always existed, it is continually expanding. New galaxies are formed as older galaxies die out.
Theory 2	The Universe began from a very small region that was extremely hot and dense. The Universe has been expanding ever since.

(d) In what way do the observations made by Hubble support both Theory 1 and Theory 2?

_____

_____

_____

(1)

(e) Most scientists now believe that Theory 2 is correct.
Suggest what is likely to have caused scientists to start thinking Theory 1 is wrong.

_____

_____

_____

(1)

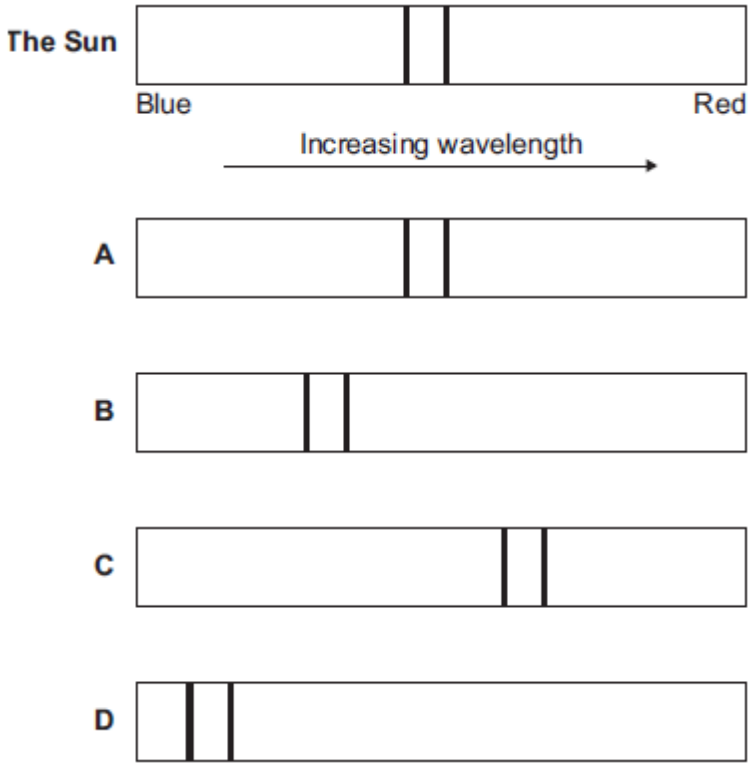
(Total 6 marks)

Q2.

Scientists can use the visible light spectrum from distant stars to determine whether the stars are moving.

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

(a) The diagram shows the visible light spectrum from the Sun and from four other stars, **A**, **B**, **C** and **D**.



(i) Which star, **A**, **B**, **C** or **D**, is moving away from the Earth?

(1)

(ii) How does the speed of star **B** compare with the speed of star **D**?

Tick (✓) **one** box.

Tick (✓)

The speed of star **B** is greater than the speed of star **D**.	
The speed of star **B** is less than the speed of star **D**.	
The speed of star **B** is the same as the speed of star **D**.	

(1)

(b) A radio wave is emitted by a star.
The radio wave has a wavelength of 1500 m and a frequency of 200 000 Hz.

Calculate the speed of this radio wave.

Choose the correct unit from the list below.

m **m/s** **m/s²**

_____

_____

_____

Speed = _____ unit _____

(3)

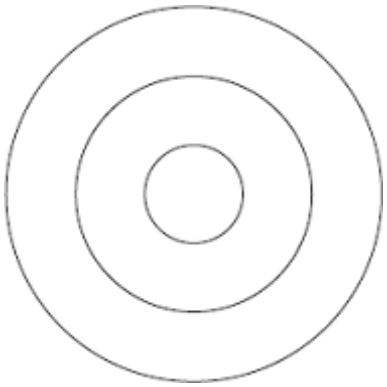
(Total 5 marks)

Q3.

A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1



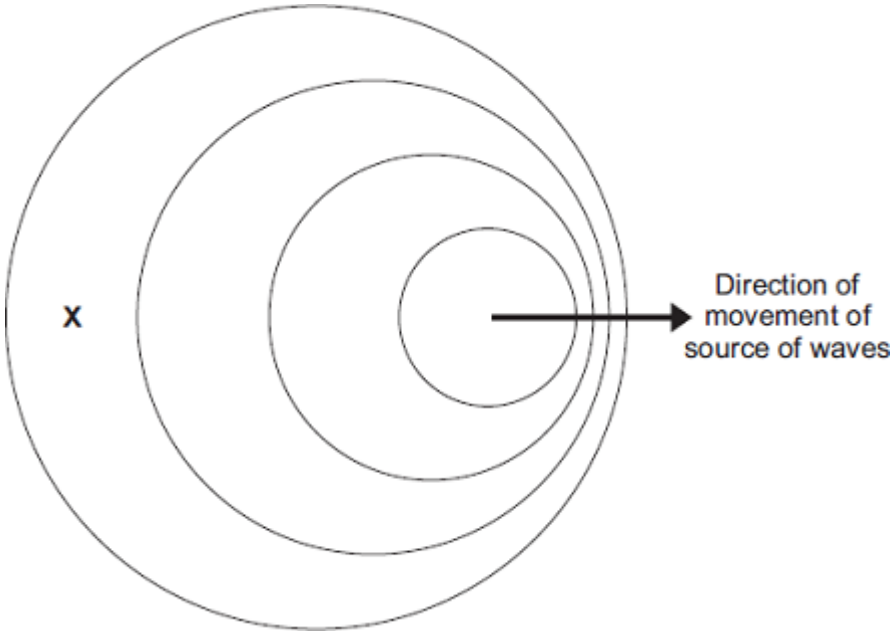
(a) Show on **Diagram 1** the wavelength of the waves.

(1)

(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)



(i) Use the correct answer from the box to complete each sentence.

decreased	**increased**	**stayed the same**

In **Diagram 2**, the observed wavelength of the waves at **X**

has _____ .

In **Diagram 2**, the frequency of the waves at **X**

has _____ .

(2)

(ii) Take measurements from **Diagram 2** to determine the wavelength of the waves received at **X**.

Give the unit.

_____

_____

Wavelength = _____

(3)

(c) The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

_____

(1)

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

_____

_____

(1)

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(iv) State **one** other piece of evidence that supports the Big Bang theory of the formation of the Universe.

_____

_____

(1)

(Total 13 marks)

Q4.

(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 ...

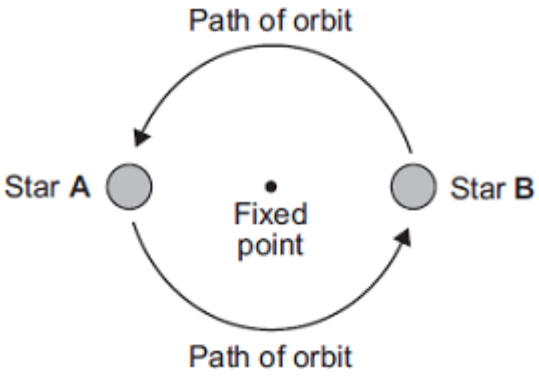
proved the 'Big Bang' theory to be correct. ☐

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

proved the Universe will continue to expand forever. ☐

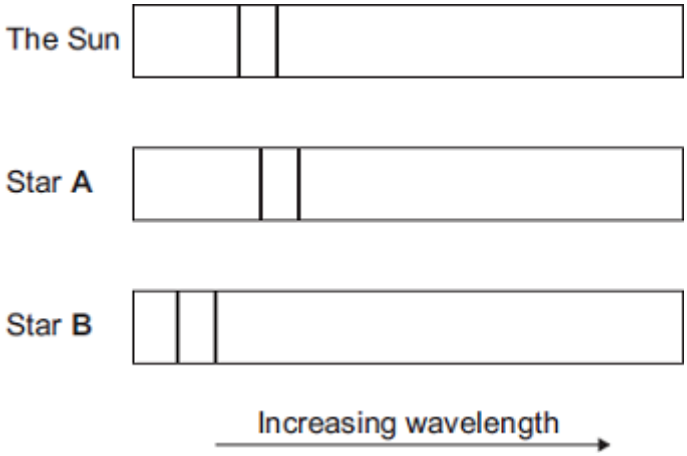
(1)

(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)

Q5.

(a) Scientists have observed that the wavelengths of the light from galaxies moving away from the Earth are longer than expected.

(i) What name is given to this observation?

_____

(1)

(ii) Draw a ring around the correct answer to complete each sentence.

This observation gives scientists evidence that

light can be stretched.
galaxies are changing colour.
the Universe is expanding.

(1)

(iii) There is a pattern linking the size of the observed increase in the wavelengths of light from a galaxy and the distance the galaxy is from the Earth.

Which **one** of the graphs, **L**, **M** or **N**, shows the correct pattern?

Write the correct answer in the box. ☐

(1)

(b) Observations help scientists answer questions about the Universe.

Scientists **cannot** answer every question.

Which **one** of the following questions **cannot** be answered by scientists?

Tick (✓) **one** box.

How old is the Universe? ☐

Why was the Universe created? ☐

How fast does light travel through the Universe? ☐

(1)

(Total 4 marks)

Q6.

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?

_____

_____

_____

_____

(2)

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

_____

_____

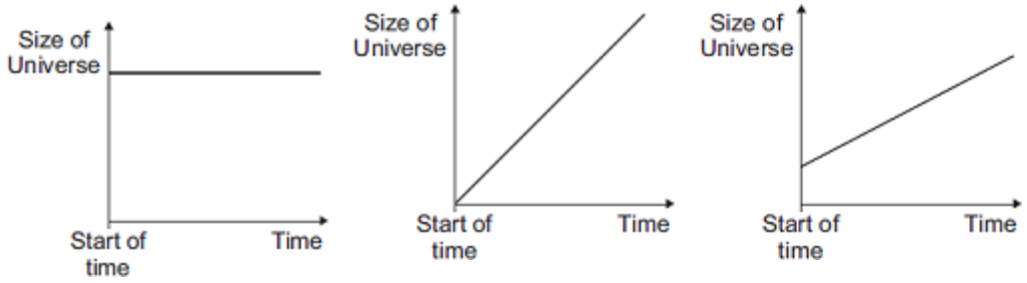
(1)

(Total 9 marks)

Q7.

The 'big bang' theory is one theory explaining the origin of the Universe.

(a) The graphs **X**, **Y** and **Z**, show how the size of the Universe may have changed with time.



Which graph would the 'big bang' theory suggest is correct?

Write your answer, **X**, **Y** or **Z**, in the box. ☐

Explain the reason for your answer.

_____

_____

_____

_____

(3)

(b) In 1948, an alternative to the 'big bang' theory, called the 'steady state' theory, was developed.
The 'steady state' theory suggested that the Universe, although expanding, has always existed without a beginning in time.

(i) Complete the following sentence by drawing a ring around the correct line in the box.

The measurement of red-shift in the light from distant galaxies provides evidence

to support

only the ‘big bang’ theory.
only the ‘steady state’ theory.
both the ‘big bang’ and ‘steady state’ theories.

(1)

(ii) In 1965, scientists rejected the ‘steady state’ theory in favour of the ‘big bang’ theory.

Suggest what might cause scientists to stop supporting one theory and to start supporting an alternative theory.

_____

_____

_____

(1)

(Total 5 marks)

Q8.

(a) The ‘Big Bang’ theory uses red-shift as evidence to explain the beginning of the Universe.

How does the red-shift from distant galaxies provide evidence for the beginning of the Universe?

_____

_____

_____

_____

_____

_____

(3)

(b) Cosmic microwave background radiation (CMBR) is a type of electromagnetic radiation. CMBR fills the Universe. It was first discovered in 1965 by two astronomers called Penzias and Wilson.

(i) What do scientists believe is the origin of CMBR?

_____

_____

(1)

(ii) Why was the discovery of CMBR so important to the scientists believing the 'Big Bang' theory to be correct?

_____

_____

(1)

(iii) How is the wavelength of CMBR likely to change, if at all, over the next billion years?

_____

Give a reason for your answer.

_____

_____

(2)

(Total 7 marks)

Q9.

Optical telescopes may be used to observe galaxies. Some optical telescopes are on the Earth and some are on satellites in space.

Scientists have observed that the wavelengths of the light from galaxies moving away from the Earth are longer than expected. This observation is called red-shift.

(i) What does the size of the red-shift tell the scientists about the distance a galaxy is from the Earth?

_____

_____

(1)

(ii) Complete the following passage.

Red-shift provides evidence to support the 'big bang' theory. The 'big bang' theory is one of the ways of explaining the _____ of the Universe.

(1)

(Total 2 marks)

Q10.

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

(a) (i) Explain what is meant by the 'Big Bang' theory.

_____

_____

_____

_____

(2)

(ii) The light arriving from distant galaxies provides scientists with evidence to support the 'Big Bang' theory.

Explain how.

_____

_____

_____

_____

(2)

(b) At a meeting held in 2005, a group of scientists claimed that new data had been collected that showed the 'Big Bang' theory to be wrong. Other scientists said that there was no reason to doubt the 'Big Bang' theory.

What should scientists do when a theory does **not** appear to be supported by new data?

_____

_____

_____

_____

(2)

(c) Scientists can answer many questions about the Universe, but not the question:

Why was the Universe created?

Suggest a reason why this question **cannot** be answered by scientists.

_____

_____

(1)

(Total 7 marks)

Q11.

(a) Scientists use telescopes to observe stars and galaxies.
Some telescopes are on Earth, but some are on satellites in space.

Why do telescopes in space give better images than telescopes on the Earth?

_____

_____

(1)

(b) Scientists have observed that the wavelengths of the light given out from galaxies that are moving away from the Earth are longer than expected.

(i) What name is given to this observation?

Put a tick (✓) in the box next to your answer.

blue-shift	☐
green-shift	☐
red-shift	☐

(1)

(ii) Complete the following sentence by drawing a ring around the correct line in the box.

This observation gives evidence for the idea that the universe is

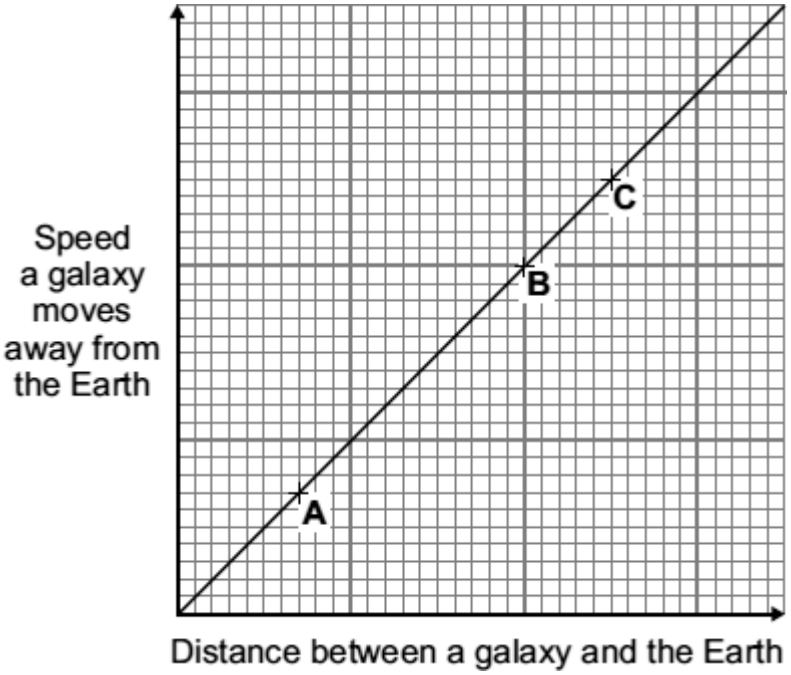
shrinking.

not changing.

expanding.

(1)

(c) Use the graph to answer the following questions.



(i) What is the link between the speed that a galaxy moves away from the Earth and the distance between the galaxy and the Earth?

_____

_____

(1)

(ii) The positions of three galaxies, **A**, **B** and **C**, are marked on the graph.

From which galaxy, **A**, **B** or **C**, would the wavelength of the light reaching the Earth seem to have changed the most?

Galaxy _____

Give a reason for your answer.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q12.

(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* ?

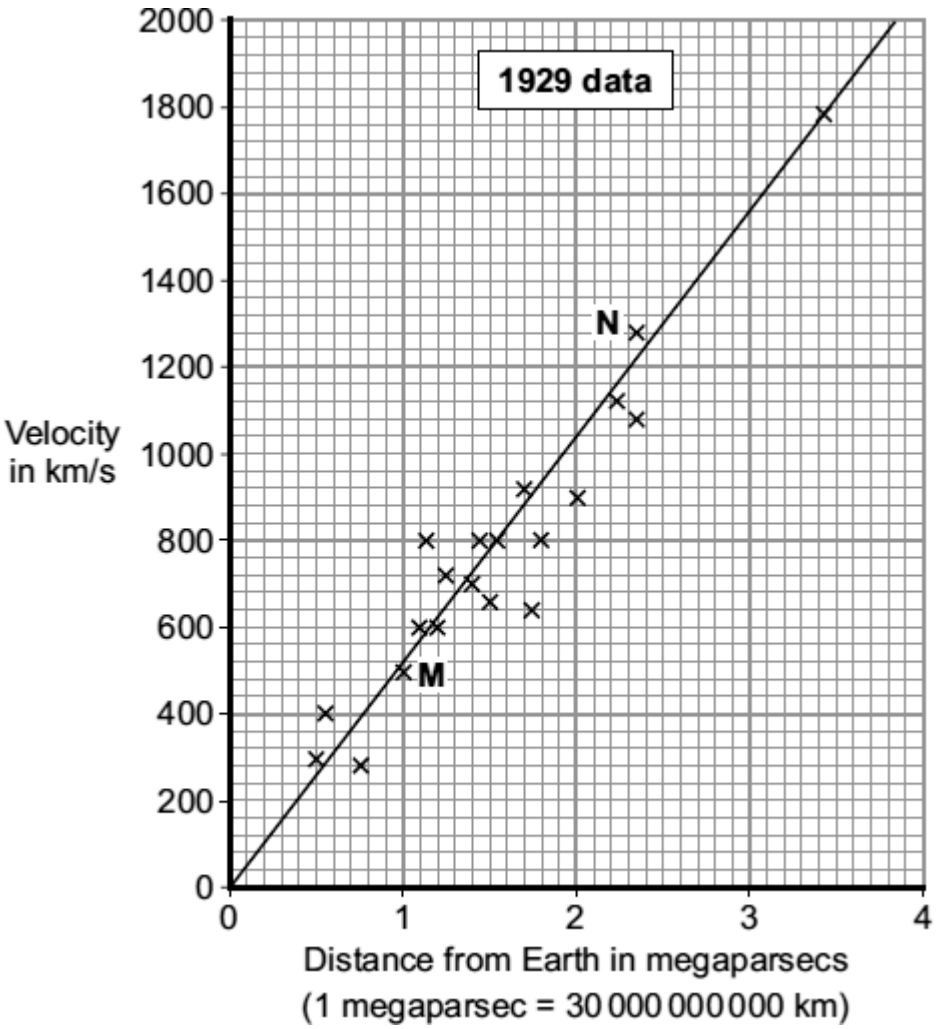
_____

_____

(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.

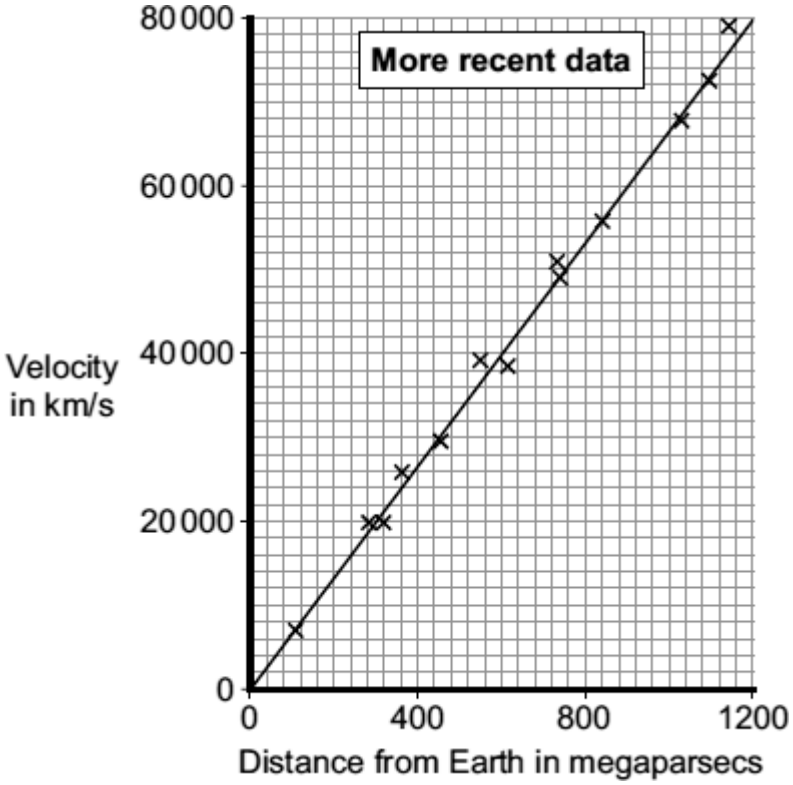
_____

_____

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)

Q13.

The 'steady state' theory was once a popular alternative to the 'big bang' theory.

The 'steady state' theory suggested that the universe, although expanding, had no origin and it has always existed. As the universe expands, a small amount of matter is created to keep the universe looking exactly the same all of the time.

(a) When considering the origin of the universe, what is the difference between the 'big bang' theory and the 'steady state' theory?

_____

_____

_____

_____

(2)

(b) The light from distant galaxies shows a *red-shift*.

(i) What is *red-shift*?

_____

_____

(1)

(ii) Why does red-shift provide evidence to support both the 'big-bang' theory and the 'steady state' theory?

_____

_____

_____

_____

(2)

(c) The 'steady state' theory was important in encouraging new research into the universe.

Suggest a reason why scientists were keen to carry out new research.

_____

_____

(1)

(d) Scientists can answer many questions about the universe, but not the question:

'Why was the universe created?'

Suggest a reason why this question cannot be answered by scientists.

_____

_____

(1)

(Total 7 marks)

Q14.

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.

_____

_____

_____

_____

_____

_____

(3)

(Total 4 marks)

Q15.

(a) Complete the **two** spaces in the sentence.

Stars form when enough _____ and gas from _____ are pulled together by gravitational attraction.

(2)

(b) How are stars able to give out energy for millions of years?

Put a tick (✓) next to the answer.

By atoms joining together ☐

By atoms splitting apart ☐

By burning gases ☐

(1)

(c) There are many billions of stars in our galaxy. Our Sun is one of these stars. What is the name of our galaxy?

_____

(1)

(d)

Why was the Universe created?

We cannot expect scientists to answer this question. What is the reason for this?

Put a tick (✓) next to the reason.

It will take too long to collect the scientific evidence. ☐

The answer depends on beliefs and opinions, not scientific evidence. ☐

There is not enough scientific evidence. ☐

(1)

(Total 5 marks)

Q16.

Light is given out by the Sun and a distant galaxy.

(a) Compared to the light from the Sun, the light from the distant galaxy has moved towards the red end of the spectrum.

(i) What name is given to this effect?

_____

(1)

(ii) Complete the following sentence by drawing a ring around the line in the box that is correct.

The fact that light from a distant galaxy seems to move towards the red end of the spectrum gives scientists evidence that

galaxies are shrinking
galaxies are changing colour
the universe is expanding

(1)

(b) Scientists have a theory that the universe began from a very small point and then exploded outwards.

(i) What name is given to this theory?

_____

(1)

(ii) Which statement gives a reason why scientists think that the universe began with an explosion?

Put a tick (✓) in the box next to your choice.

At the moment it is the best way of explaining our scientific knowledge. ☐

It can be proved using equations. ☐

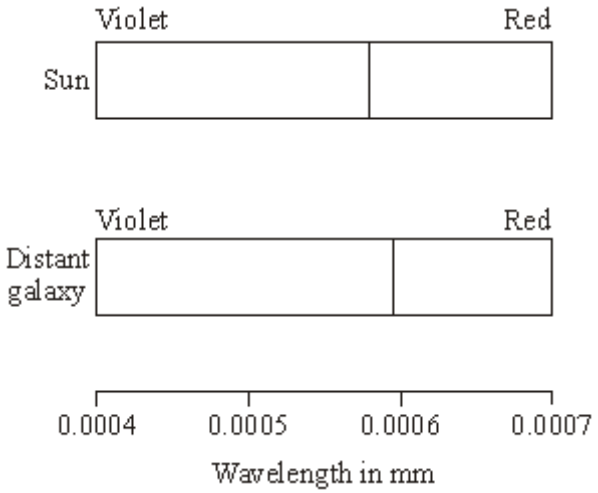
People felt the explosion. ☐

(1)

(Total 4 marks)

Q17.

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.

_____

_____

_____

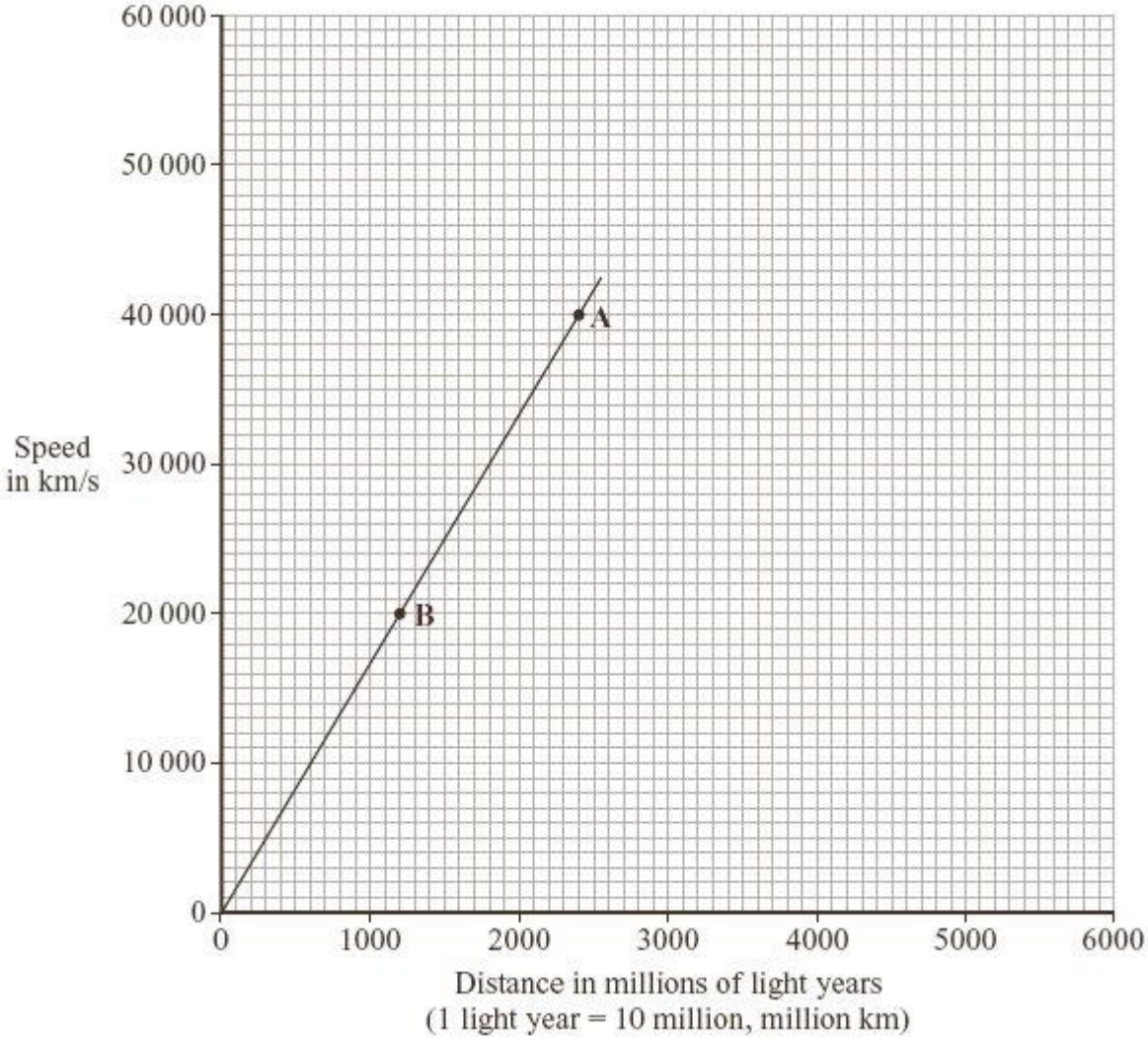
_____

_____

_____

(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)

Q18.

(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.

_____

_____

_____

(1)

(Total 6 marks)

Q19.

(a) The light spectrum from a distant galaxy shows a red shift.

What is meant by *red shift* and what does it tell us about distant galaxies?

_____

_____

_____

_____

(2)

(b) What name is given to the theory that the Universe started with a massive explosion?

_____

(1)

(Total 3 marks)

Q20.

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)

Q21.

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

(i) What is the Universe?

_____

_____

(1)

(i) What are the main ideas of the Big Bang theory?

_____

_____

_____

(2)

(iii) What is thought to be happening to the size of the Universe?

_____

(1)

(Total 4 marks)

Q22.

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)

Q23.

Astronomers believe that the Universe is expanding.

(i) How might the Universe have started?

_____

_____

(1)

(ii) State and explain briefly, **one** piece of scientific evidence which may be used to support this belief.

_____

_____

_____

_____

(2)

(Total 3 marks)

Q24.

Studies of light from distant galaxies have provided evidence for the theory that the Universe started from one place and is expanding. Explain how.

_____

_____

_____

_____

_____

(Total 3 marks)

Q25.

'Red shift' is one of the pieces of evidence which led scientists to propose the 'big bang' theory.

(a) Describe the big bang theory.

_____

_____

_____

_____

(2)

(b) *To gain full marks for this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.*

Explain how red shift provides evidence for the big bang theory.

_____

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

Q26.

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').

_____

_____

_____

_____

(2)

(Total 4 marks)

Q27.

What does the Big Bang theory state? In your answer you may include evidence for the theory.

(Total 4 marks)

Q28.

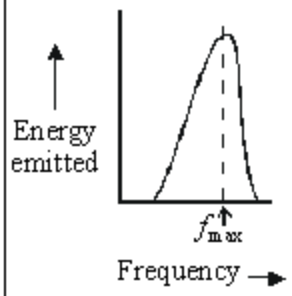
Explain, in as much detail as you can, the scientific evidence for the “big bang” theory of the origin of the Universe.

(Total 5 marks)

Q29.

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.

(2)

(Total 12 marks)

Mark schemes

Q1.

(a) red–shift

1

(b) the further away from the Earth, the faster a galaxy is moving

1

(c) **strength**
as the balloon expands the dots get further apart, representing the galaxies moving apart

1

weakness
dots are only on the surface of the balloon, galaxies are throughout the universe
or
there is a limit to how far the balloon can expand

1

(d) both theories suggest that the Universe is expanding

1

(e) new evidence / observations that cannot be explained by Theory 1

accept specific example of new evidence ie CMBR

1

[6]

Q2.

(a) (i) C

1

(ii) The speed of star **B** is less than the speed of star **D**.

1

(b) 300 000 000

*allow **1** mark for correct substitution ie 200 000 × 1500 provided no subsequent step shown*

2

m / s

allow unit correctly indicated in list if not written in answer space

1

[5]

Q3.

(a) wavelength correctly shown

1

(b) (i) increased

1

decreased

1

(ii) 17-18 inclusive

1

evidence of measurement divided by 3 or mean of 3 separate measurements

1

mm

accept cm if consistent with answer

1

(c) (i) red shift

1

(ii) moving away

1

(iii) the furthest galaxies show the biggest red shift

1

(meaning that) the furthest galaxies are moving fastest

1

(so the) Universe is expanding

1

(extrapolating backwards this suggests that) the Universe started from an initial point

1

(iv) cosmic microwave background radiation

allow CMBR

1

[13]

Q4.

(a) (i) origin of the Universe

accept (why) the Universe is expanding

*do **not** accept origin of the Earth*

1

(ii) provided more evidence to support the 'Big Bang' theory

1

(b) (i) red-shift

accept Doppler (shift)

1

(ii) (at the point in time shown the observed spectrum from) star A (shows it) is moving away from the Earth

accept star A is moving away

star A shows red-shift is insufficient

1

light from star B shows a decrease in wavelength

accept light from star B shows blue-shift

accept light from star B shows an increase in frequency

1

so star B is moving towards Earth

1

[6]

Q5.

(a) (i) red-shift

accept Doppler (effect)

1

(ii) the Universe is expanding

1

(iii) N

1

(b) Why was the Universe created?

1

[4]

Q6.

(a) (i) gamma

accept correct symbol

1

(ii) any **one** from:

- (ultraviolet has a) higher frequency

ultraviolet cannot be seen is insufficient

- (ultraviolet has a) greater energy
- (ultraviolet has a) shorter wavelength

ignore ultraviolet causes cancer etc

1

(b) 1.2×10^7 / 12 000 000

*allow **1** mark for correct substitution, ie $3 \times 10^8 = f \times 25$*

2

hertz / Hz / kHz / MHz

*do **not** accept hz **or** HZ*

*answers 12 000 kHz **or** 12 MHz gain **3** marks*

for full credit the numerical answer and unit must be consistent

1

(c) (i) away (from each other)

accept away (from the Earth)
accept receding

1

(ii) distance (from the Earth)

accept how far away (it is)

1

speed galaxy is moving

1

(iii) (Universe is) expanding

1

[9]

Q7.

(a) **Y**

*accept cannot be **X** as size is increasing*

1

shows Universe expanding

*this scores if **Y** or **Z** is chosen*
accept exploding outwards

1

from a (very small) point

*this only scores if **Y** is chosen*
accept from zero (size)
answers in terms of planets
negate the last two mark points

1

(b) (i) both the 'big bang' and 'steady state' theories

1

(ii) (new) evidence that supports / disproves a theory

accept proves for supports

or

(new) evidence not supported by current theory

accept there may be more evidence supporting one (theory) than the other (theory)
accept new evidence specific to this question eg measurement of CBR

or

some types of star only found in distant parts of Universe (steady state suggests should be same throughout Universe)

1

[5]

Q8.

(a) any **three** from:

- red-shift shows galaxies are moving away (from each other / the Earth)
- more distant galaxies show bigger red-shift

or

more distant galaxies show a greater increase in wavelength
accept correct reference to frequency in place of wavelength

- (in all directions) more distant galaxies are moving away faster
accept (suggests) universe is expanding
- suggests single point of origin (of the universe)

3

(b) (i) (radiation produced shortly after) 'Big Bang'
accept beginning of time / beginning of the universe for 'Big Bang'

1

(ii) any **one** from:

- can only be explained by 'Big Bang'
- existence predicted by 'Big Bang'
- provides (further) evidence for 'Big Bang'

ignore proves 'Big Bang' (theory)
ignore reference to red-shift

1

(iii) increase
accept becomes radio waves

1

universe continues to accelerate outwards
accept as universe continues to expand

or

greater red-shift

1

[7]

Q9.

(i) bigger the red-shift, further the galaxy is from the Earth
accept red-shift and distance are directly proportional
accept there is a positive correlation

1

(ii) origin / start / beginning / creation

accept expansion

1

[2]

Q10.

(a) (i) Universe began at a (very) small (initial) point

'it' refers to Universe

1

'explosion' sent matter outwards
or
'explosion' causing Universe to expand

accept gas / dust for matter

accept rapid expansion for explosion

1

(ii) light shows a red shift

owtte

the term red shift on its own does not score a mark

1

galaxies moving away (from the Earth)

'it' refers to light

'they' refers to galaxies

accept star for galaxy

*do **not** accept planet for galaxy*

1

(b) check reliability / validity of data

accept check data

accept collect more data

1

amend theory
or
discount the data

accept replace old theory with new theory

1

(c) answer involves (religious) belief
or
no / insufficient evidence

accept it cannot be tested

1

[7]

Q11.

(a) any **one** from:

- above the atmosphere
  accept no atmospheric pollution
- no clouds in the way
- no light pollution
  answers in terms of being closer to space negate
  answers in terms of looking at the Earth negate

1

(b) (i) red-shift

1

(ii) expanding

1

(c) (i) as one gets bigger the other gets bigger
accept (directly) proportional
accept positive correlation

1

(ii) **C**

1

it is furthest from the Earth
*only scores if **C** is chosen*
or
it is furthest away
or
has the largest red-shift**or**
it is moving (away) the fastest

1

[6]

Q12.

(a) wavelength (of light appears to) increase
accept frequency (appears to) decrease
accept light moves to the red end of the spectrum
*do **not** accept it moves to the red end of the spectrum*
*do **not** accept light becomes redder*

1

(b) (i) **M** is closer (to the Earth) than **N**

1

M is moving (away from the Earth) slower than **N**

1

(ii) 520
*an answer between 510 and 530 inclusive gains **1** mark*

2

(iii) more recent

no mark for this but must be given to gain reason mark

data more reliable

accept data is more accurate

or

improved equipment / techniques

more technology is insufficient

or

data obtained from more (distant) galaxies

accept a wider range of data

accept data closer to the line of best fit

***or** data less scattered*

accept no anomalous result(s)

accept all data fits the pattern

1

(c) wavelength is decreased

1

frequency is increased

1

[8]

Q13.

(a) big bang theory – universe started at one point *(*then expanded*)*

1

steady state theory – universe has no origin / has always existed

accept an answer in terms of mass
eg steady state theory mass is created

1

(b) (i) wavelength *(*of light*)* increases

accept answers in terms of frequency decrease

*accept wavelength stretched but **not** wave stretched*

or wavelength / light moves to red end of spectrum

*do **not** accept galaxy moves to the red end of the spectrum*

*do **not** accept light becomes red / redder*

1

(ii) red-shift is evidence / supports idea of expanding universe

accept prove for support

1

both theories use the idea / accept / explain why the universe is expanding

1

(c) to find evidence to support one or both theories

accept prove for support

accept to gain more knowledge about the universe

or to find evidence to disprove one or both theories

1

(d) answer involves (religious) belief

accept it cannot be tested

or no / insufficient evidence

1

[7]

Q14.

(a) (a) supernova (explosion)

1

(b) solar system contains heavy elements / elements heavier than hydrogen and helium (1)

these (heavy) elements are / were formed by (nuclear) fusion (1)

accept minor misspellings for 'fusion'
*but **not** anything which could also be 'fission'*

(at the very high temperature(s)) in a super nova / when stars explode (1)

3

[4]

Q15.

(a) dust

accept 'solid (s)'

1

space

accept 'from supernova / supernovum / supernovas'

1

(b) By atoms joining together

only one ticked or otherwise unambiguously identified

1

(c) Milky Way (galaxy)

1

(d) The answer depends on beliefs and opinions, not scientific evidence.

only one ticked or otherwise unambiguously identified

1

[5]

Q16.

(a) (i) red shift

1

accept Doppler effect

(ii) the universe is expanding

1

(b) (i) big bang

1

(ii) at the moment it is the best way of explaining.....

1

[4]

Q17.

(a) line shifts towards red end of spectrum

*do **not** accept reference to 'red light'*

*do **not** accept 'red shift' as a stand alone response*

1

wavelength (appears) to increase

1

galaxy is moving away (from the Earth)

*do **not** accept universe expanding*

or galaxy moving away from initial point

*do **not** accept planet on its own*

1

(b) (i) light from A has a greater red shift

accept light from A is more red

*do **not** accept reference to blue light*

1

(ii) 3600 (million light years)

allow 1 mark for showing that the line could be extended

or

allow 1 mark for the correct use of a point on the line

2

[6]

Q18.

(a) stars / galaxies / sources emit all / different types of electromagnetic waves / radiation

accept two or more named electromagnetic waves

accept answers in terms of frequencies / wavelengths

1

(b) (i) wavelength (of light) increases

accept frequency decreases

or

light moves to red end of spectrum

*accept redder but do **not** accept red alone*

1

(ii) it is the star (detected) furthest from the Earth

accept galaxy for stars

or

it is moving away the fastest

ignore reference to universe expanding

1

(c) (i) all matter compressed to / starts at / comes from a single point

*do **not** accept increasing gravitational pull*

accept everything / the universe for all matter

1

(massive) explosion sends matter outwards

accept explosion causes universe to expand

*ignore explosion creates the universe **or** further reference to star / Earth formation*

1

(ii) check validity / reliability of the evidence

or

change the theory to match the new evidence

accept comparison of new and old evidence

1

[6]

Q19.

(a) longer wavelength waves **or** light moved towards red end of spectrum

1

(galaxy) moving away from the Earth **or** space is expanding **or** the galaxy and Earth are moving apart

accept us for Earth

*do **not** accept galaxies expanding*

1

(b) big bang

1

[3]

Q20.

(i) an enormous explosion causing matter to spread from one point

1

(ii) it is increasing **or** expanding

1

[2]

Q21.

(i) an innumerable collection of galaxies

accept any word meaning a large number for innumerable
accept all the galaxies
*do **not** accept everything*

1

(ii) all matter concentrated at a (single) point

accept all matter part of a single 'superatom'

1

single (massive) explosion (sending matter outwards)

1

(iii) increasing or expanding

1

[4]

Q22.

light from (distant) galaxies shows shift to red end of spectrum
wavelength increased explained by galaxies moving away from us
more distant galaxies have greater recession speed seen in all directions
suggests universe is **expanding** any sensible reference to similar effect on Earth

any 6 for 1 mark each

[6]

Q23.

(i) the Universe might have started with
an explosion/"Big Bang"

1

(ii) light from galaxies is shifted to red end of spectrum
the further away the greater the red shift all galaxies receding furthest fastest
microwave background echo of big bang

for 1 mark each

2

[3]

Q24.

light from distant galaxies red shifted

accept longer wavelength for red shifted

1

further galaxies display greater red shift

1

the further away galaxies are the faster they are moving away from us (our galaxy)

1

[3]

Q25.

(a) any **two** from

- Universe started in one place
- (huge) explosion
- Universe is expanding

do not accept big bang

2

(b) Quality of written communication:
Links needed between :
galaxies, red shift, and distance / expansion

1

any **two** from

- light from (galaxies) shifted towards red end of spectrum
- the further away the galaxy, the greater the red shift
- this shows that galaxies are moving away from us
- this suggests that Universe is expanding

do not accept light from planets

2

[5]

Q26.

(a) 12.7

1

(b) the further away, the faster it is moving away

1

(c) all galaxies have been moving away from us for approximately the same length of time

1

therefore they were all probably produced at the same time

1

[4]

Q27.

any **four** related points

* the Universe (as we know it) started (about) 14 000/15 000 million years ago or (about) 15 billion years ago or between (about) 10 to 20 billion years ago

* from one point **or** from a singularity

or at the beginning of time

* in an enormous outpouring of matter (and energy)

* (and) has been expanding ever since
* (evidence is that) the galaxies are all moving away from one another
* (evidence is that) the more distant a galaxy is the faster it is moving away (from all the other galaxies)
* evidence is microwave background

or cosmic background radiation
* ... relic of an earlier **or** hot phase resulting from (shortly) after the start **or** Big Bang
* evidence is red shift
* ... of light **or** radiation from (distant) stars **or** galaxies **or** quasars **or** due to Doppler (-Fizeau) effect

*accept bya for billion years ago **or** mya for million years ago*

do not credit vague responses such as it all started with a big explosion

[4]

Q28.

ideas that: galaxies show a red-shift

gains 1 mark

but more distant galaxies show bigger red-shift

gains 2 marks

galaxies moving away/Universe expanding

gains 1 mark

but more distant galaxies moving away faster

gains 2 marks

so all Universe once in one place

for 1 further mark
(only if the previous 2 marks are also gained)

[5]

Q29.

(a) *answer includes items*:
B D G

each for 1 mark

3

(b) *answer includes items*:
A E F [allow H here for a <u>further</u> mark]

each for 1 mark

3

(c) answer includes items:
C H* I J

*each for 1 mark [*unless already credited in (b)]*

4

(d) ideas that:

- lucky in the sense that they weren't initially looking for the background radiation [others were!!!]
- more than just lucky in that they investigated it and didn't just ignore it

each for 1 mark

[NB Reference to letters only, not a prose answer, gain only ½ mark each. Total rounded down]

2

[12]