



Big bang, red shift and doppler effect



73 minutes



73 marks

Q1. (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)

Q2.

(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)

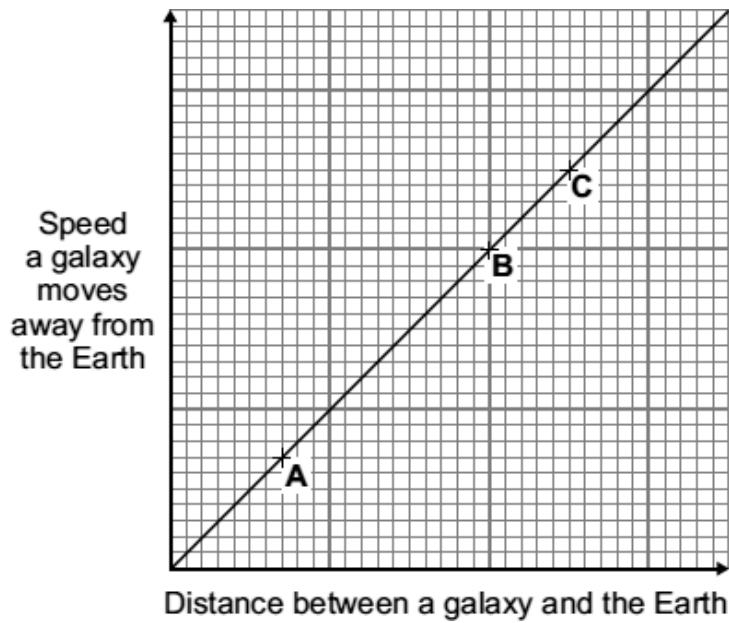
(ii) Complete the following sentence by drawing a ring around the correct line in the box.

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)

Q3. 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)

Q4. 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)

Q5. 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.

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(Total 6 marks)

Q6. The Big Bang theory attempts to explain the origin of the Universe.

(i) What is the Big Bang theory?

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.....

(1)

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

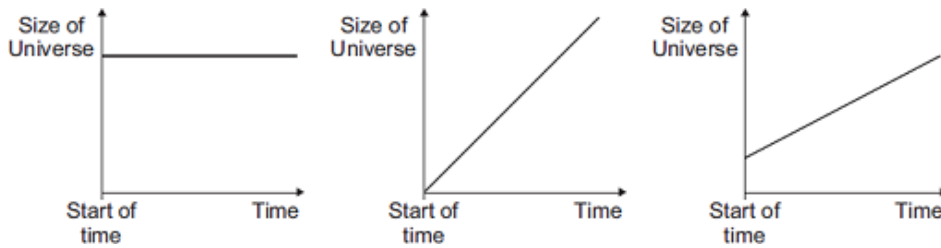
.....

(1)

(Total 2 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)

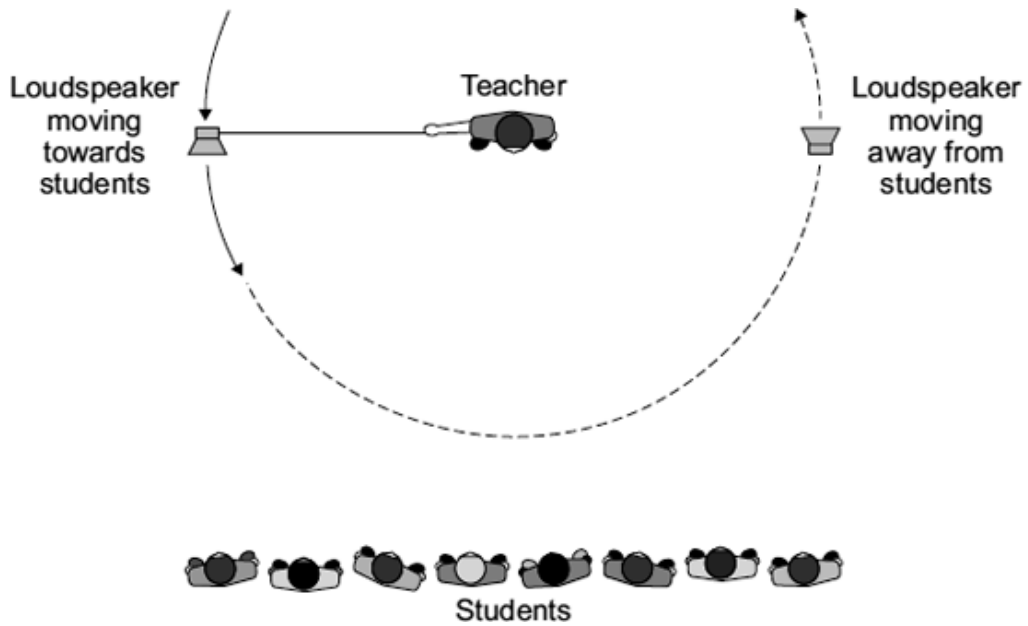
(ii) In 1965, scientists rejected the 'steady stat' theory in favour of the 'big bang' theory.

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

.....
.....
.....

(1)
(Total 5 marks)

Q8. The diagram shows a teacher using a loudspeaker to demonstrate an important effect. The loudspeaker, which produces a note of constant frequency, is swung around in a circle.



(a) As the loudspeaker moves towards the students, the frequency of the note heard by the students increases.

What happens to the note heard by the students as the loudspeaker moves away from them?

.....
.....

(1)

(b) The teacher is using the demonstration to model the red-shift in light that is observed from most distant galaxies.

(i) Which **one** of the following statements gives the main reason why models are used in science?

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

Models can help to explain an effect or theory.

Models can prove that a theory is correct.

Models can help to generate new ideas.

(1)

(ii) Explain how this demonstration can be used as a model for red-shift.

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.....
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(2)

(c) Red-shift provides evidence to support the theory that the Universe began from a very small initial point.

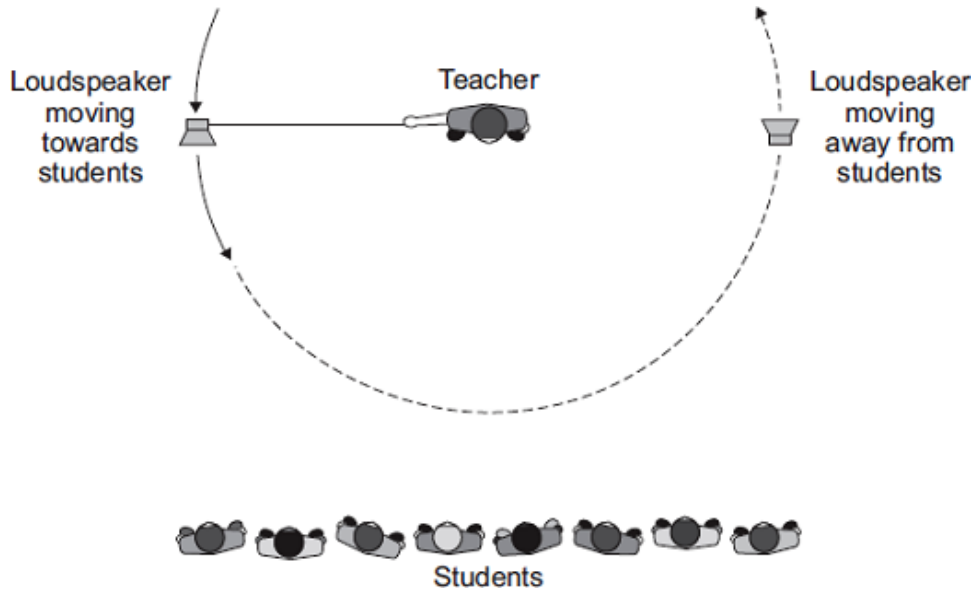
What name is given to this theory?

.....

(1)

(Total 5 marks)

Q9. The diagram shows a teacher using a loudspeaker to demonstrate an important effect. The loudspeaker produces a note of constant frequency and is swung around in a circle.



(a) As the loudspeaker moves towards the students, the frequency of the note heard by the students increases.

What happens to the note heard by the students as the loudspeaker moves away from them?

.....

(1)

(b) The teacher is using the demonstration to model the red-shift in light observed from most distant galaxies.

(i) Which part of the demonstration:
 represents a moving galaxy?

.....

is like the red-shift?

.....

(2)

- (ii) Which **one** of the following statements gives the main reason why models are used in science?

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

Models can help to explain an effect or theory.

Models can prove that a theory is correct.

Models can prove that a theory is wrong.

(1)

- (c) Red-shift provides evidence to support the theory that the Universe began from a very small initial point.

What name is given to this theory?

.....

(1)

(Total 5 marks)

Q10. 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)

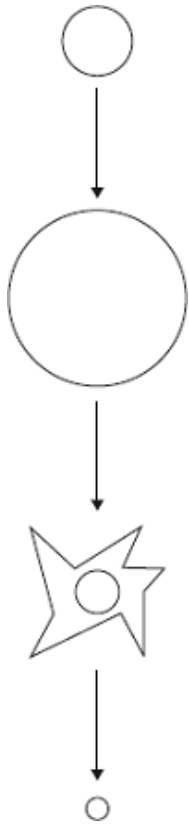
(Total 4 marks)

Q11. The diagram shows part of the lifecycle of a very large star.

Use words or phrases from the box to complete the sentences contained in the diagram.

black hole	red supergiant	supernova	white dwarf
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(3)



The star is stable.

The star expands forming
a

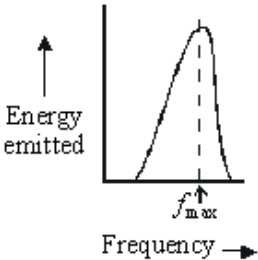
The star collapses, the outer layers explode
as a

The centre collapses further and further until
it finally forms a

(Total 3 marks)

Q12. Read the following information about cosmic microwave background radiation.

Then use it to answer the questions below.

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

(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.

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(3)

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

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(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.

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(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)

Q13. Describe, in as much detail as you can:

- the evidence that the size of the observable Universe is changing;
- the evidence that, billions of years ago, all the matter in the Universe was tightly packed together in the same place.

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(Total 5 marks)

Q14. (a) A student listens to the sound waves produced by a car siren. When the car is stationary, the student hears a constant frequency sound.

Describe how the wavelength and frequency of the sound waves heard by the student change when the car is driven away from the student.

.....
.....
.....
.....

(2)

(b) 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)

(c) 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)

(d) Red-shift provides evidence for the 'big bang' theory.

(i) Describe the 'big bang' theory.

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.....

(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 8 marks)

- M1.** (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]

- M2.** (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]

- M3.** (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]**

- M4.** (i) an innumerable collection of galaxies 1
accept any word meaning a large number for innumerable
accept all the galaxies
*do **not** accept everything*
- (ii) all matter concentrated at a (single) point 1
accept all matter part of a single 'superatom'
- single (massive) explosion (sending matter outwards) 1
- (iii) increasing or expanding 1
- [4]**

- M5.** 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 1
- [6]**

- M6.** (i) an enormous explosion causing matter to spread from one point 1

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

1

[2]

M7. (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]

M8. (a) frequency / pitch decreases

accept wavelength increases

accept it / the note becomes deeper / lower

it / the note decreases is insufficient

quieter is neutral

1

(b) (i) Models can help to explain an effect or theory.

1

(ii) (moving) loudspeaker represents the (moving) galaxy
accept sound waves represent light waves 1

the decrease in frequency of the sound is like red-shift
accept increase in frequency is like blue-shift
accept answers in terms of wavelength change
accept sound going away from you is like red-shift
accept red-shift happens when galaxies / stars move away (from Earth)
this accept only scores if first marking point scores 1

(c) big bang 1 [5]

M9. (a) frequency / pitch decreases
accept wavelength increases
accept it / the note becomes deeper / lower
it / the note decreases is insufficient
quieter is neutral 1

(b) (i) (moving) loudspeaker 1

change in sound as loudspeaker moves away 1

(ii) models can help to explain an effect or theory 1

(c) big bang 1 [5]

M10. (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]

M11. red supergiant
do **not** accept red giant 1

supernova 1

black hole 1

[3]

M12. (a) answer includes items:
B D G
each for 1 mark 3

(b) answer includes items:
A E F [allow H here for a further 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]

##

(NB. Answers referring to planets to gain zero marks
Answers in terms of stars – deduct 1 mark)

- A light from (most) other galaxies shows a red-shift
- B this means that these galaxies and our own galaxy are moving apart / Universe expanding
- C the red-shift of more distant galaxies is greater
- D this means that the further apart galaxies are the faster they are moving away from each other
- E the relationship is proportional so this means that in the past they all set out from the same point

*each properly related point
for 1 mark*

[5]

- M14.** (a) wavelength increases
accept the crests are further apart
ignore waves are further apart 1
- frequency decreases
accept pitch decreases
ignore references to amplitude 1
- (b) 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
- (c) (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

- (d) (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

[8]

