Mark schemes

1 (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]

2 (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]

3 (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]

4

(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]

5 (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]

6 (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]

7 (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]

8 (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]

9 (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]

10 (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]

11 (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]

12 (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]

13 (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]

14 (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]

15 (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]

16 (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]

17 (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]

18 (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]

19 (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]

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

1

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

1

[2]

21 (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]

22 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]

23 (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]

24 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]

25 (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]

26 (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]

27 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]

28 *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]

29 (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]