M1. (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) <u>furthest</u> from the Earth

accept galaxy for stars

or

it is moving <u>away</u> the fast<u>est</u>

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) <u>explosion</u> sends matter outwards

accept <u>explosion</u> 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]

M2. (a) longer wavelength waves **or** light moved towards red end of spectrum

1

(galaxy) moving <u>away</u> 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]

M3. (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]

M4. (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]

M5. (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]

M6. (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]

M7. (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]

M8. (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]

M9. (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) increas
accept becomes radio waves

1

universe continues to accelerate outwards
accept as universe continues to expand

or

greater red-shift

1

[7]

M10. (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]