Q1. The table gives data about two types of low energy bulb.

Type of bulb	Power input in watts	Efficiency	Lifetime in hours	Cost of one bulb
Compact Fluorescent Lamp (CFL)	8	20%	10 000	£3.10
Light Emitting Diode (LED)	5		50 000	£29.85

(a) Both types of bulb produce the same useful power output.

(i) Calculate the useful power output of the CFL.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

.....

.....

.....

Useful power output = ... W

(2)

(ii) Calculate the efficiency of the LED bulb.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

.....

.....

.....

Efficiency = ...

(1)

(b) Sketch and label a Sankey diagram for the CFL.

(2)

(c) LED bulbs are expensive. This is because of the large number of individual electronic LED chips needed to produce sufficient light from each bulb.

(i) Use the data in the table to evaluate the cost-effectiveness of an LED bulb compared to a CFL.

.....

.....

.....

.....

(2)

(ii) Scientists are developing brighter and more efficient LED chips than those currently used in LED bulbs.

Suggest **one** benefit of developing brighter and more efficient LED chips.

.....

.....

(1)
(Total 8 marks)

Q2. A homeowner had a new gas boiler installed.

(a) The following information is an extract from the information booklet supplied with the boiler.

Fuel	Natural Gas
Water temperature	60 °C
Energy supplied to gas boiler	8.0 kJ/s (8.0 kW)
Efficiency	0.95

(i) Use the equation in the box to calculate the energy transferred each second by the gas boiler to the water inside the boiler.

$$\text{efficiency} = \frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}}$$

Show clearly how you work out your answer.

.....

.....

Energy transferred by the gas boiler each second = ... kJ

(2)

(ii) The energy value of the gas used in a home is measured in kilowatt-hours (kWh).

The homeowner has a pre-payment meter and pays £30 into his account. With a pre-payment meter, gas costs 15p per kilowatt-hour.

Use the equations in the box to calculate the total number of hours that the gas boiler would operate for £30.

energy transferred = power × time
total cost = number of kilowatt-hours × cost per kilowatt-hour

Show clearly how you work out your answer.

.....

.....

.....

.....

Number of hours = ...

(2)

(b) Although the gas boiler is very efficient, some energy is wasted.

Explain what happens to the waste energy.

.....

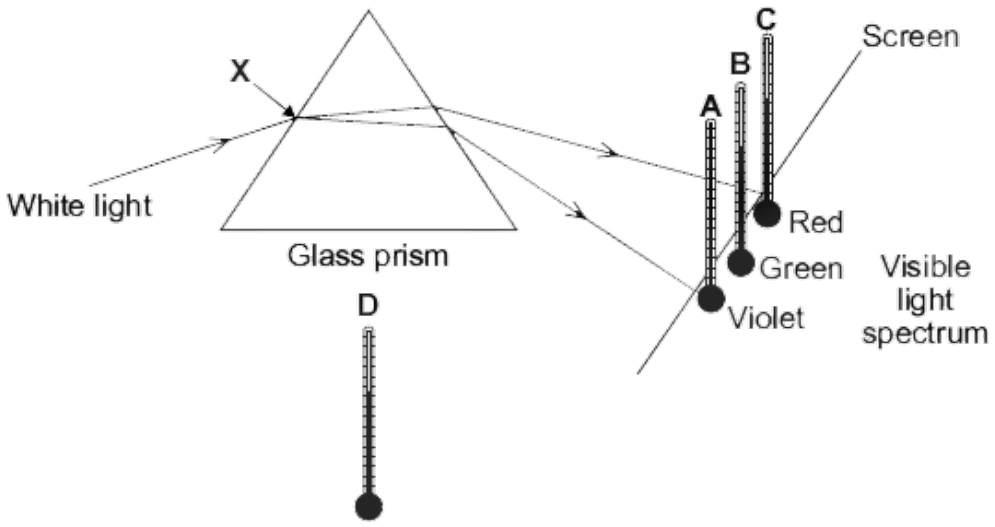
.....

.....

.....

(2)
(Total 6 marks)

Q3. The diagram shows the apparatus that a student used to investigate the heating effect of different wavelengths of light.



(a) (i) What process happens at the point labelled **X** on the diagram?

.....

(1)

(ii) The student put thermometer **D** outside of the light spectrum.

Suggest why.

.....

.....

(1)

(iii) The table gives the position and reading of each thermometer 10 minutes after the investigation started.

Thermometer	Position of thermometer	Temperature in °C
A	in violet light	21
B	in green light	22
C	in red light	24
D	outside the spectrum	20

What should the student conclude from the data in the table?

.....

.....

.....

.....

(2)

(b) A similar investigation completed in 1800 by the scientist Sir William Herschel led to the discovery of infrared radiation.

Suggest how the student could show that the spectrum produced by the glass prism has an infrared region.

.....

.....

.....

.....

(2)

(c) A person emits infrared radiation at a frequency of 3.2×10^{13} Hz.

Calculate the wavelength of the infrared radiation that a person emits.

Take the speed of infrared radiation to be 3.0×10^{8} m/s.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

.....

.....

.....

.....

Wavelength = ... m

(2)

(d) A thermal imaging camera detects infrared radiation. Electronic circuits inside the camera produce a visible image of the object emitting the infrared radiation.

At night, police officers use thermal imaging cameras to track criminals running away from crime scenes.

Thermal imaging cameras work better at night than during the day.

Explain why.

.....

.....

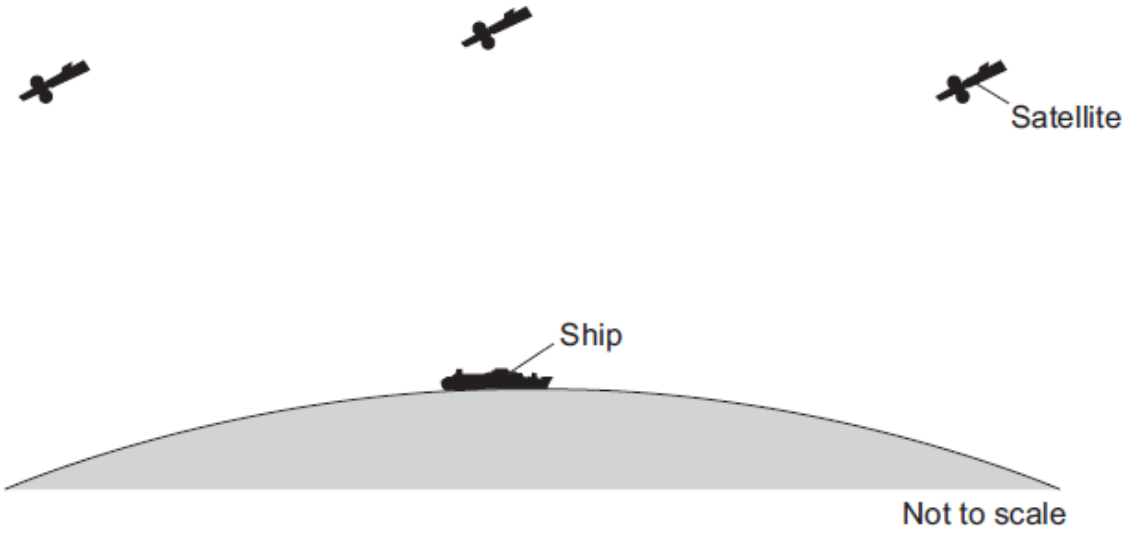
.....

.....

(2)

(Total 10 marks)

Q4. The ship in the diagram is fitted with a navigation system. The navigation system works out the location of the ship by timing the microwave signals transmitted from at least three satellites.



(a) Microwaves are one type of electromagnetic wave.

Give **two** properties that all electromagnetic waves have.

1 .....

.....

2 .....

.....

(2)

(b) The microwaves used in the navigation system are transmitted at a frequency of 1575 MHz.

Use the equation and information in the box to calculate the wavelength of the microwaves used in the navigation system.

wave speed = frequency × wavelength microwaves travel at 300 000 000 m/s 1 MHz = 1 000 000 Hz

Show clearly how you work out your answer.

.....

.....

.....

.....

Wavelength = ... m

(3)

(c) The ship is fitted with a metal aerial that receives the microwave signals from the satellites.

For the navigation system to work, what effect must the microwave signals have on the aerial?

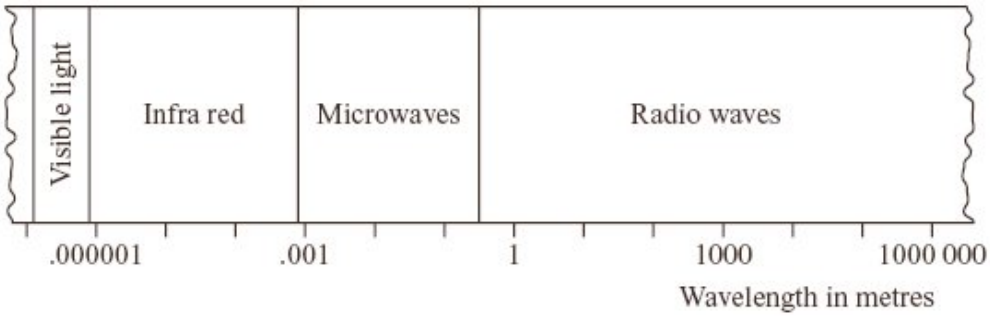
.....

.....

(1)

(Total 6 marks)

Q5. The diagram represents part of the electromagnetic spectrum.



(i) Visible light travels through air at 300 000 000 m/s.

Why can we assume that radio waves travel through air at the same speed as light?

.....

(1)

(ii) A radio station broadcasts at a frequency of 200 kHz.

Use the following equation to calculate the wavelength of the waves broadcast by this radio station. Show clearly how you work out your answer.

wave speed = frequency × wavelength

.....

.....

Wavelength = ……. m

(2)

(iii) Draw a vertical line on the diagram above to show the position of this radio wave in the electromagnetic spectrum.

(1)

(Total 4 marks)

Q6. All radio waves travel at 300 000 000 m/s in air.

(i) Give the equation that links the frequency, speed and wavelength of a wave.

.....

(1)

(ii) Calculate the wavelength, in metres, of a radio wave which is broadcast at a frequency of 909 kHz. Show clearly how you work out your answer.

.....

.....

.....

Wavelength = ... metres

(2)

(Total 3 marks)

Q7. (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* ?

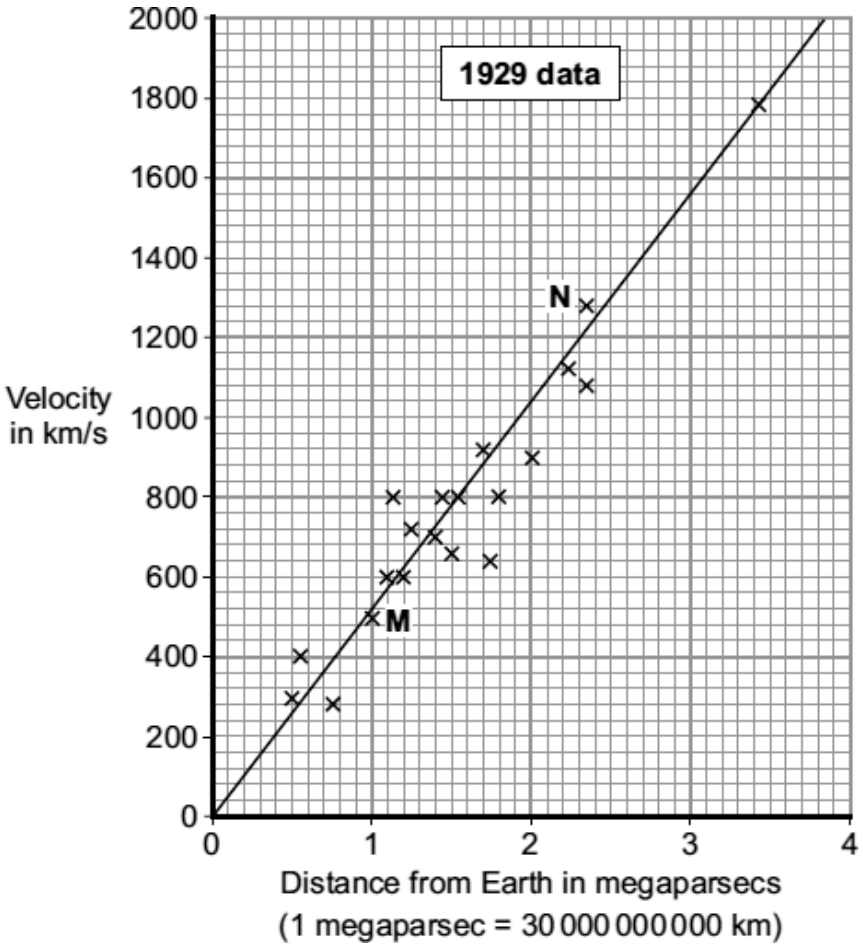
.....

.....

(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.

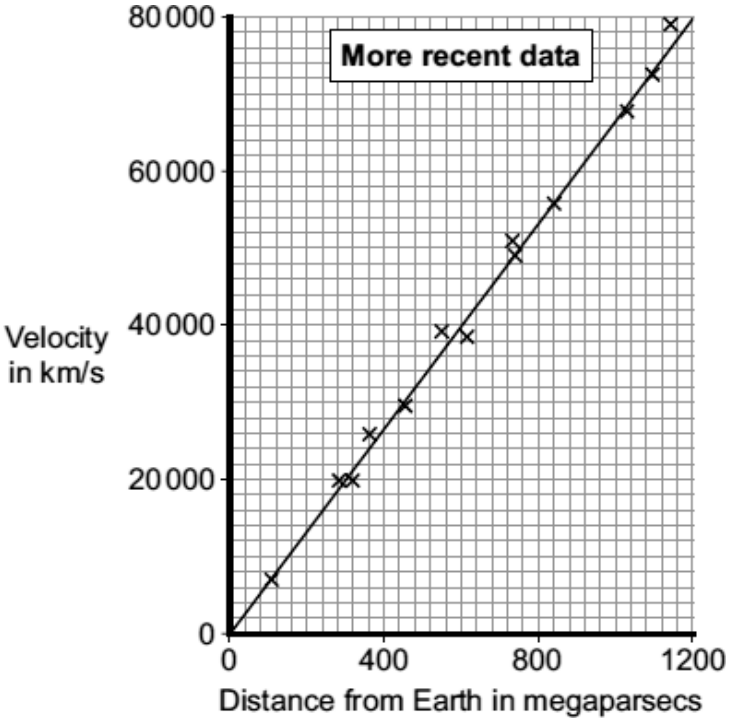
.....

.....

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)

Q8. '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)

Q9. (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.

.....

.....

.....

.....

(2)

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

.....

.....

.....

(1)

(Total 8 marks)

M1. (a) (i) $efficiency = \frac{useful\ energy\ out\ (\times 100\%)}{total\ energy\ in}$

1.6 (W)

*allow **1** mark for correct substitution ie* $0.2 / \frac{20}{100} = \frac{output}{8}$

2

(ii) $efficiency = \frac{useful\ energy\ out\ (\times 100\%)}{total\ energy\ in}$

32 (%) / 0.32
or
their (a)(i) ÷ 5 correctly calculated
ignore any units

1

(b) two output arrows
one arrow should be wider – judged by eye

1

narrower arrow labelled light or useful (energy / output / power)
only scores if first mark awarded

and

wider arrow labelled waste (energy / output / power)
accept heat
ignore numerical values

1

(c) (i) any **two** from:

- comparison over same period of time of relative numbers of bulbs required eg over 50 000 hours 5 CFL's required to 1 LED
  accept an LED lasts 5 times longer
- link number of bulbs to cost eg 5 CFL's cheaper than 1 LED
  an answer in terms of over a period of 50 000 hours CFLs cost £15.50 (to buy), LED costs £29.85 (to buy) so CFLs are cheaper scores both marks
  an answer in terms of the cost per hour (of lifetime) being cheaper for CFL scores 1 mark if then correctly calculated scores both marks
- over the same period of time LEDs cost less to operate (than CFLs)

2

(ii) any **one** from:

- price of LED bulbs will drop
  *do **not** accept they become cheaper*
- less electricity needs to be generated
  accept we will use less electricity
- less CO_2 produced
- fewer chips needed (for each LED bulb)
- fewer bulbs required (for same brightness / light)
- less energy wasted
  *do **not** accept electricity for energy*

1

[8]

M2. (a) (i) 7.6

*allow **1** mark for correct substitution and / or transformation*

ie $0.95 = \frac{x}{8}$

95 × 8.0

2

(ii) 25 (hours)

*allow **1** mark for obtaining number of kWh = 200*
an answer of 26(.3) gains both marks

2

(b) any **two** from

- transferred to the surroundings / air / atmosphere
- becomes spread out
- shared between (many) molecules
- (wasted as) heat / sound

2

[6]

M3. (a) (i) refraction

accept refracted
reflection, diffraction and dispersion are incorrect

1

(ii) to check rise in temperature (of other thermometers) was due to the (different wavelengths of) light

accept as a control / comparison

to measure room temperature is insufficient

1

(iii) any **two** from three:

- different colours produce different heating effects / (rises in) temperatures
- red light produces the greatest heating effect / (rise in) temperature

or

- violet produces the least heating effect / (rise in) temperature
- all colours produce a greater heating effect than outside the spectrum

an answer

the longer the <u>wavelength</u> the greater the (rise in) temperature

or

the lower the <u>frequency</u> the greater the (rise in) temperature gains both marks

2

(b) move a thermometer into the infrared region / just beyond the red light

allow use an infrared camera / infrared sensor

1

the temperature increases beyond 24(°C)

accept temperature higher than for the red light

1

(c) $v = f \times \lambda$

9.4×10^{-6}

accept 9.375×10^{-6} or 9.38×10^{-6}

or

0.0000094

accept 0.000009375

***or** 0.00000938*

*allow **1** mark for correct substitution*

ie $3 \times 10^{8} = 3.2 \times 10^{13} \times \lambda$

2

(d) at night the surroundings are cooler

accept at night the air is colder

there is no heat from the Sun is insufficient

or

at night there is a greater temperature difference between people and surroundings

1

(so surroundings) emit less infrared (than in daytime)

accept camera detects a greater contrast

or

gives larger difference in infrared emitted (between people and surroundings)

1

[10]

M4. (a) any **two** from:

- travel at the same speed (through a vacuum)

  if a value is given it must be correct

  accept air for vacuum

  accept travel at the speed of light

- can travel through a vacuum / space

  *do **not** accept air for vacuum*

- transfer energy
- can be reflected
- can be refracted
- can be diffracted
- can be absorbed
- transverse
- travel in straight lines

  accept any other property common to electromagnetic waves

  *accept travel at the same speed through a vacuum for **both** marks*

  both radiated from the Sun is insufficient

2

(b) 0.19 (0)

accept any answer that rounds to 0.19

*accept 0.2 for all **3** marks provided working is shown*

*0.2 without working gains **2** marks*

*allow **2** marks for a correct substitution and transformation using frequency in hertz*

ie wavelength = $\frac{300\,000\,000}{1575\,000\,000}$

or

*allow **1** mark for changing MHz to Hz*

*allow **1** mark for correct substitution using 1575 or incorrectly converted frequency*

*answers 190476 and 190000 gain **2** marks*

3

(c) create an alternating current with the same frequency
(as the microwaves / signals / 1575 (MHz))

ignore reference to change in temperature

1

[6]

M5. (i) all electromagnetic waves travel at the same speed through a vacuum, (so assume same speed in air)

accept 'all parts of spectrum' for electromagnetic waves

1

(ii) 1500 (m)

allow 1 mark for correct transformation and substitution

allow 1 mark for using 200 000 Hz

*answers 1 500 000 = **1** mark*

2

(iii) line drawn at correct position

anywhere between 1000 and next section (10 000)

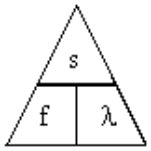
accept their value for (a)(ii) drawn in the correct position

1

[4]

M6. (i) speed = frequency × wavelength

accept the equation rearranged
*accept v **or** s = f × λ*
do not allow w for wavelength
do not accept



unless subsequent calculation correct

1

(ii) 330 (m)

allow 1 mark for

$$\lambda = \frac{300\,000\,000}{909\,000}$$

***or** 300 000 000 = 909 000 × λ*
***or** answer of 330000(m) **or** 330033(m)*

2

[3]

M7. (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]

M8. (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]

M9. (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) <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

(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) <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

[8]