

Name: _____
Space Physics part 3 AQA Triple Physics
Class _____

Date: _____

Time: **82 minutes**

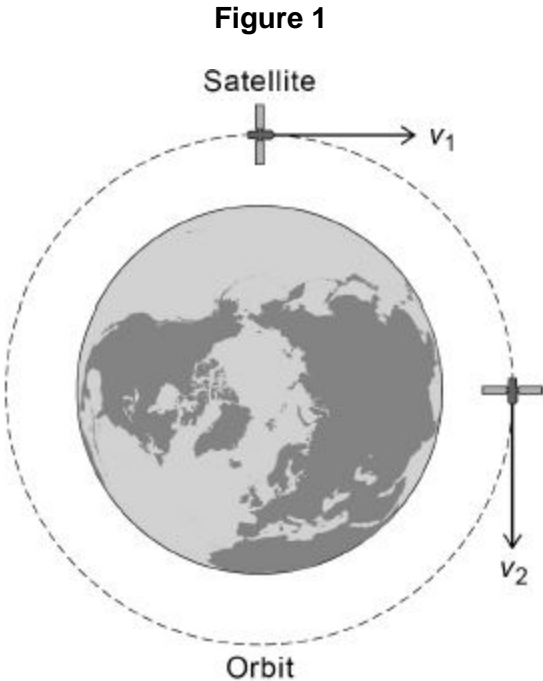
Marks: **79 marks**

Comments:

1.

A satellite is in a circular orbit around the Earth.

Figure 1 shows the velocity of the satellite at two different positions in the orbit.

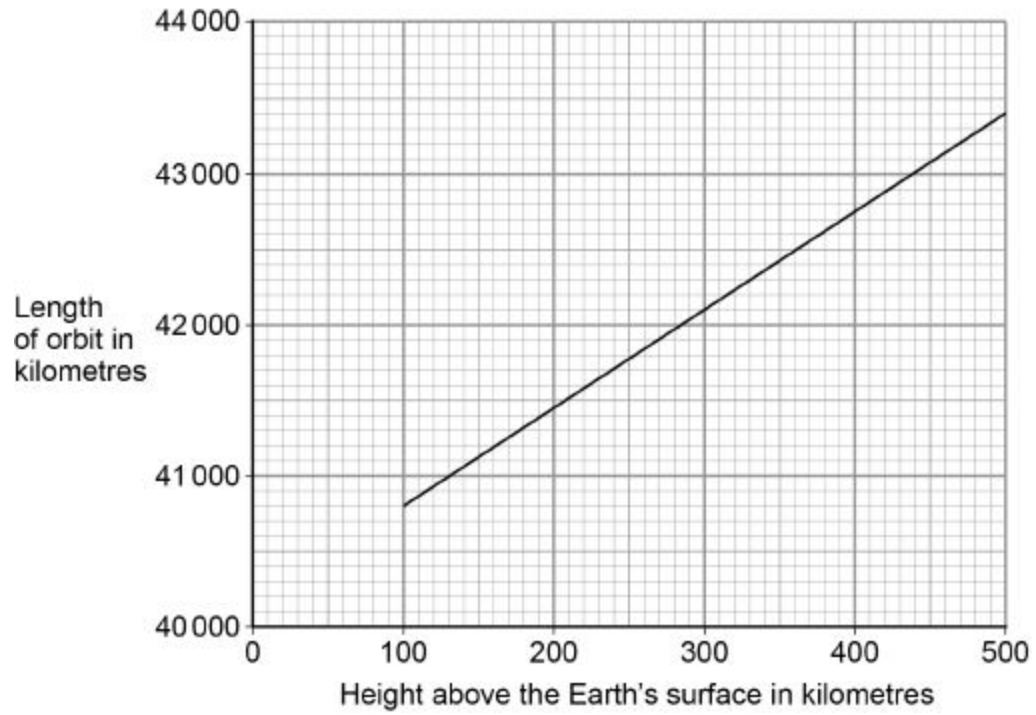


(a) Explain why the velocity of the satellite changes as it orbits the Earth.

(3)

- (b) **Figure 2** shows how the length of a satellite orbit depends on the height of the satellite above the Earth's surface.

Figure 2



A satellite orbits 300 km above the Earth's surface at a speed of 7.73 km/s.

Calculate how many complete orbits of the Earth the satellite will make in 24 hours.

Number of complete orbits = _____

(5)

In 1772, an astronomer called J Bode developed an equation to predict the orbital radii of the planets around the Sun.

The table shows Bode's predicted orbital radii and the actual orbital radii for the planets that were known in 1772.

Planet	Predicted orbital radius in millions of kilometres	Actual orbital radius in millions of kilometres
Mercury	60	58
Venus	105	108
Earth	150	150
Mars	240	228
Jupiter	780	778
Saturn	1500	1430

(c) The predicted data can be considered to be accurate.

Give the reason why.

(1)

(d) J Bode used his equation to predict the existence of a planet with an orbital radius of 2940 million kilometres.

The planet Uranus was discovered in 1781.

Uranus has an orbital radius of 2875 million kilometres.

Explain why the discovery of Uranus was important.

(2)

(Total 11 marks)

2.

(a) Which one of the following types of electromagnetic wave has the highest frequency?

Tick **one** box.

- Gamma rays
- Infrared
- Microwaves
- Ultraviolet

(1)

(b) What makes microwaves suitable for sending communications to a satellite in space?

(1)

(c) Scientists have detected short bursts of radio waves emitted from a distant galaxy. The scientists think that the radio waves may have been emitted from a neutron star. What event leads to a neutron star forming?

(1)

(d) Some of the radio waves from the distant galaxy have a frequency of 1.2 gigahertz (GHz).

Which of the following is the same as 1.2 GHz?

Tick **one** box.

1.2×10^3 Hz

1.2×10^6 Hz

1.2×10^9 Hz

1.2×10^{12} Hz

(1)

(e) Radio waves travel through space at a speed of 3.0×10^8 m/s

Calculate the wavelength of the 1.2 GHz radio waves emitted from the distant galaxy.

Wavelength = _____ m

(3)

(f) When radio waves are absorbed by an aerial they may create an alternating current in an electrical circuit.

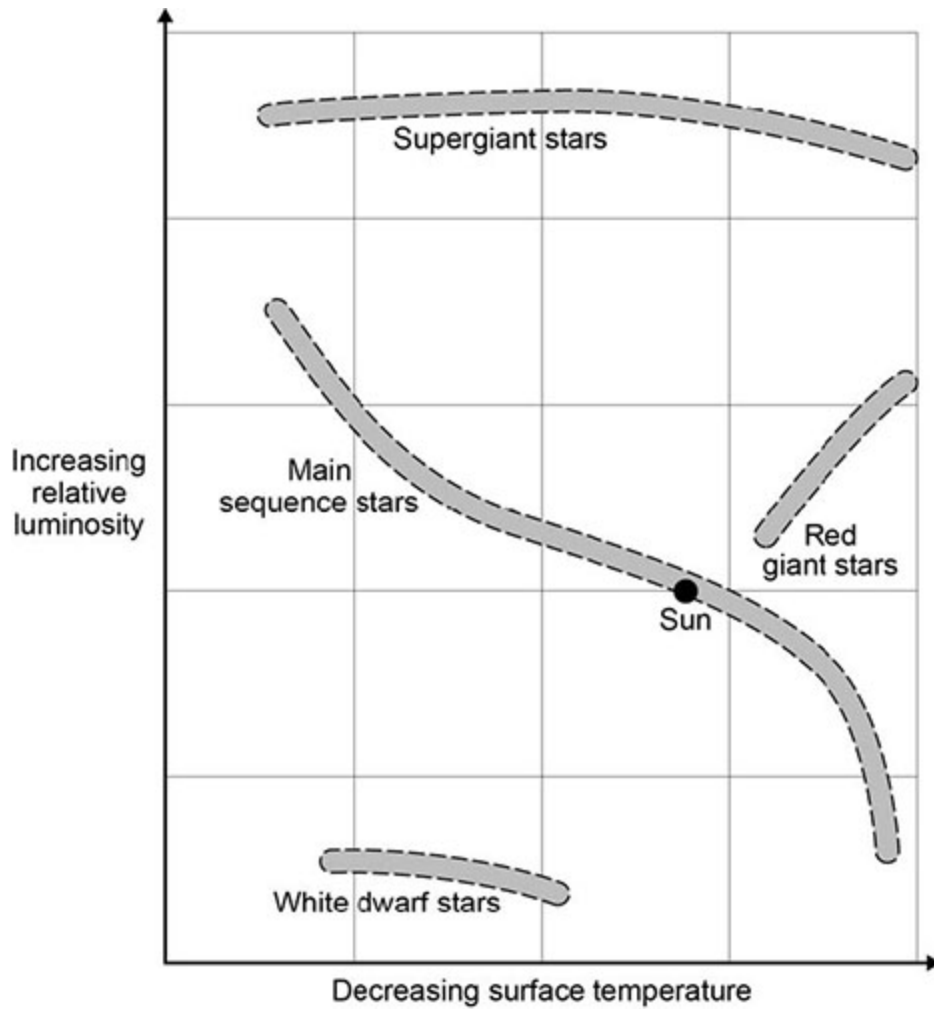
If an alternating current is created what frequency would it have?

(1)

The diagram shows four groups of stars.

The surface temperature and relative luminosity determine which group a star is in.

A star with a relative luminosity of 1 emits the same amount of energy every second as the Sun.



(g) The Sun is in the group of main sequence stars. These stars are stable.

Explain why a star remains stable.

(2)

(h) At different points in their lifecycle stars change from one group to another.

Describe what will happen to the Sun between it leaving the main sequence group and becoming a white dwarf.

Use information from the diagram.

(4)

(Total 8 marks)

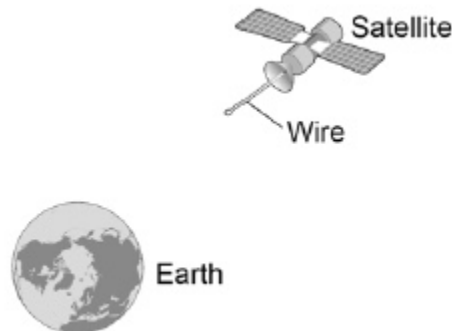
3.

Scientists have used a satellite system to investigate the idea of generating electricity in space.

As the system orbited the Earth a 20 km copper wire was reeled out.

Before the wire snapped a current of 1 amp was induced in the wire.

Figure 1



(a) What provides the force needed to keep a satellite in orbit around the Earth?

(1)

(b) Explain how a current is induced in the wire.

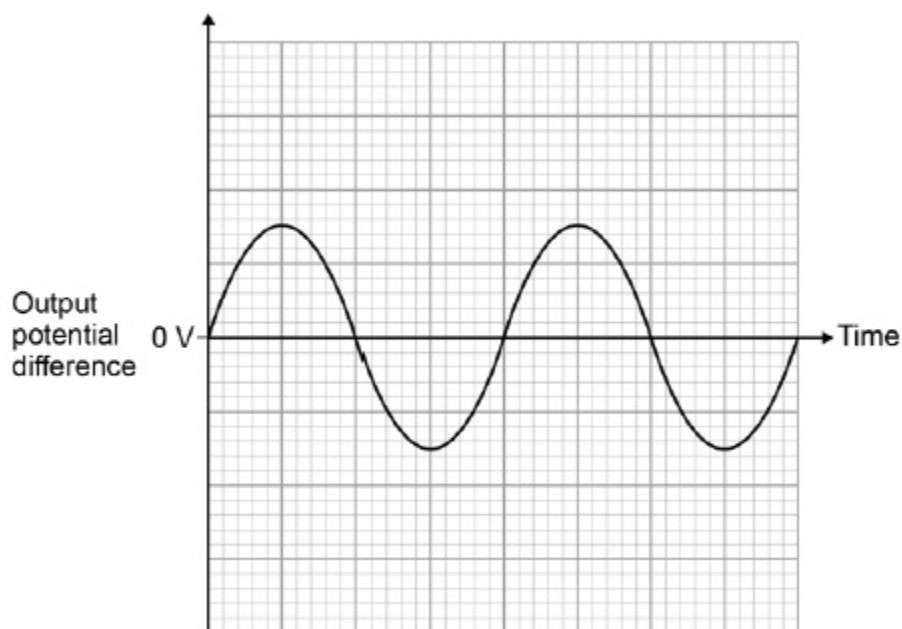
(3)

An alternator is connected to a data logger.

The data logger is connected to a computer.

Figure 2 shows how the output potential difference of the alternator varies with time.

Figure 2



(c) The coil inside the alternator now rotates at twice the frequency.

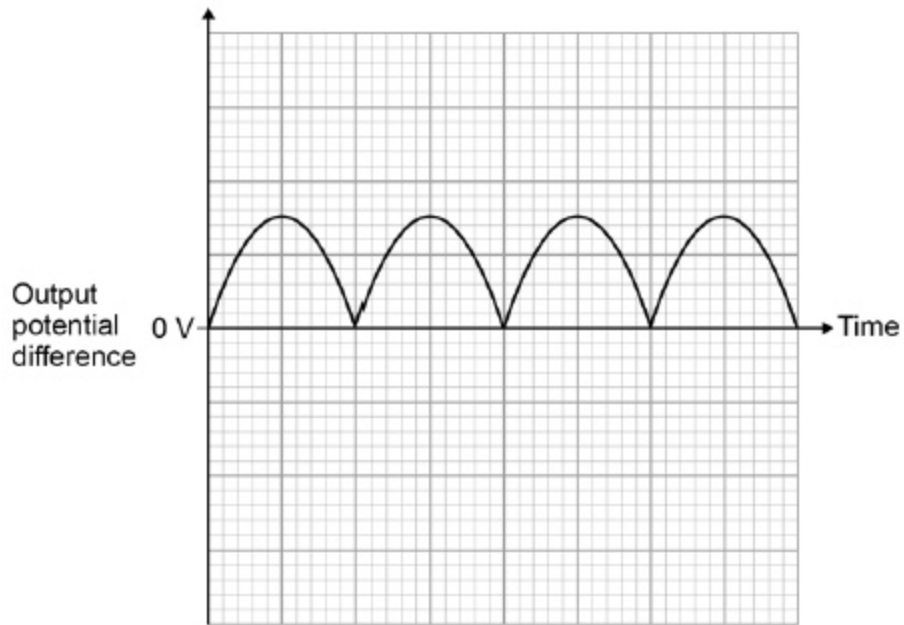
Draw on **Figure 2** to show how the output potential difference varies with time at this new frequency.

(2)

Another type of generator is now connected to the data logger and computer.

Figure 3 shows how the output potential difference varies with time for this generator.

Figure 3



(d) What name is given to this second type of generator?

(1)

(e) Look at **Figure 2** and **Figure 3**.

Give one difference between the outputs from the two types of generator.

(1)

- (f) The charger used to charge the battery inside a laptop computer contains a small transformer.

The charger plugs into the mains electricity supply.

mains electricity supply = 230 V

number of turns on the primary coil of the transformer = 690

number of turns on the secondary coil of the transformer = 57

Calculate the potential difference applied by the charger across the battery inside the computer.

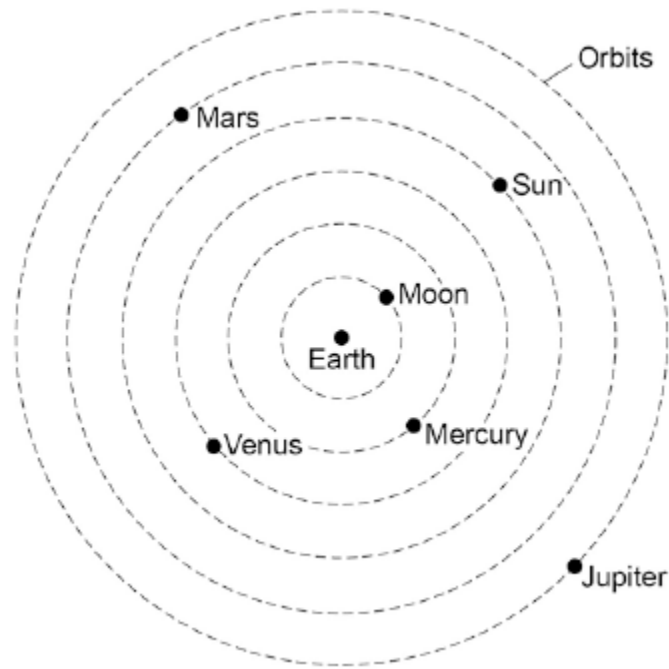
Potential difference = _____ V

(3)

(Total 11 marks)

4.

The figure below shows what scientists over 1000 years ago thought the solar system was like.



- (a) Give **one** way that the historical model of the solar system shown in the figure above is different from what we now know about the solar system.

(1)

- (b) Give **one** way that the solar system shown in the figure above is the same as what we now know about the solar system.

(1)

- (c) The first artificial satellite to orbit the Earth was launched into space in 1957.

Describe the orbit of an artificial satellite.

(1)

(d) What provides the force needed to keep a satellite in its orbit?

Tick **one** box.

friction

gravity

tension

(1)

(e) All stars go through a lifecycle.

The star Mira will go through a supernova stage in its lifecycle but the Sun will not.

How is the star Mira different to the Sun?

(1)

(Total 5 marks)

5.

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

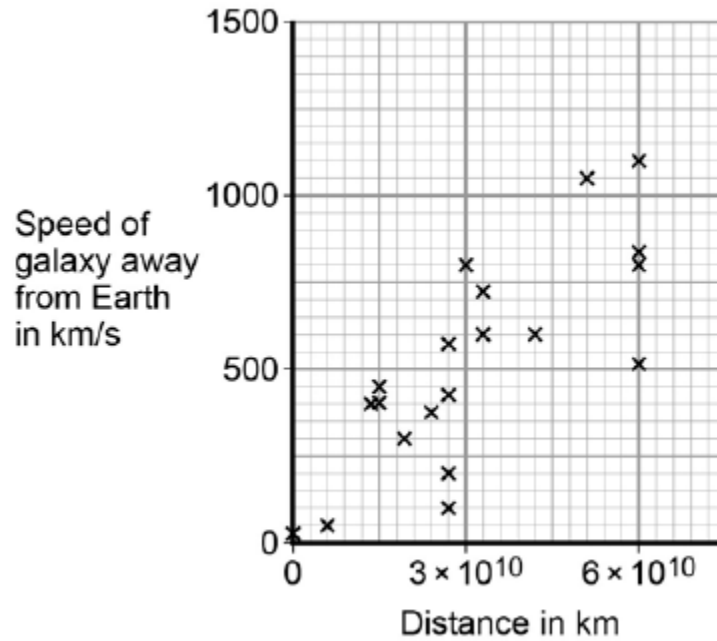
(a) What name is given to this effect?

(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?

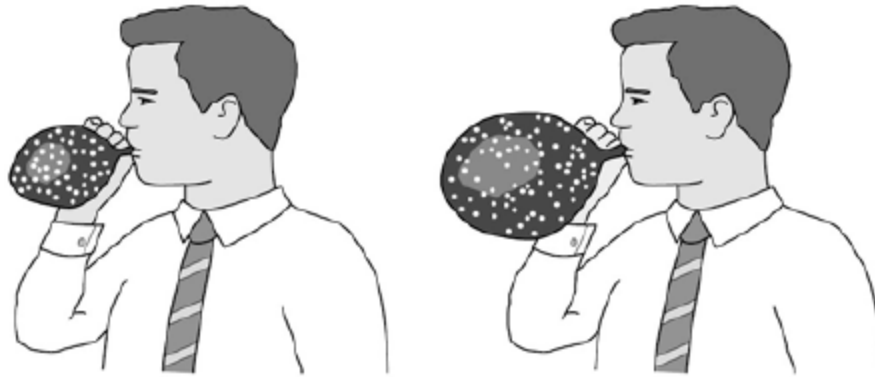
(1)

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)

6.

- (a) Brown dwarf stars are thought to have been formed in the same way as other stars. They are too small for nuclear fusion reactions to take place in them. Brown dwarf stars emit infrared radiation but are not hot enough to emit visible light.

- (i) Describe how a star is formed.

(2)

- (ii) Describe the process of nuclear fusion.

(1)

- (iii) Scientists predicted that brown dwarf stars existed before the first one was discovered in 1995.

Suggest **one** reason why scientists are now able to observe and identify brown dwarf stars.

(1)

- (b) In the 18th century some scientists suggested a theory about how the planets formed in the Solar System. The theory was that after the Sun formed, there were cool discs of matter rotating around the Sun. These cool discs of matter formed the planets. The scientists thought this must have happened around other stars too.

- (i) Thinking about this theory, what would the scientists have predicted to have been formed in other parts of the Universe?

(1)

- (ii) Since the 1980s scientists studying young stars have shown the stars to be surrounded by cool discs of rotating matter.

What was the importance of these observations to the theory the scientists suggested in the 18th century?

(1)

- (c) The Earth contains elements heavier than iron.

Why is the presence of elements heavier than iron in the Earth evidence that the Solar System was formed from material produced after a massive star exploded?

(1)

(Total 7 marks)

7.

The early Universe contained only the lightest element.

- (a) Use the correct answer from the box to complete the sentence.

hydrogen	iron	uranium
----------	------	---------

The early Universe contained only _____ .

(1)

- (b) Use the correct answer from the box to complete the sentence.

main sequence star	protostar	supernova
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The heaviest elements are formed only in a _____ .

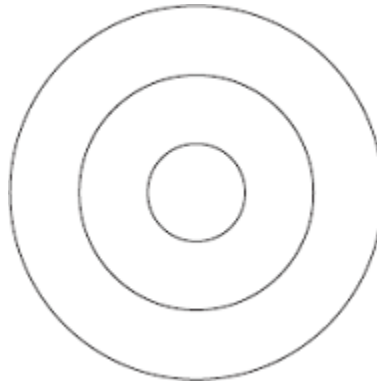
(1)

8.

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

Diagram 1 shows the waves at an instant in time.

Diagram 1



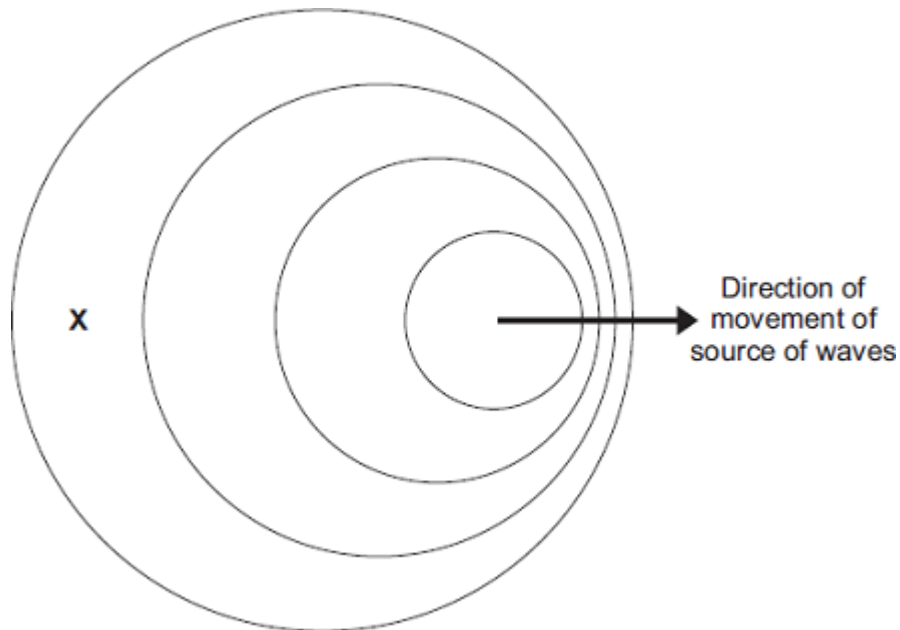
(a) Show on **Diagram 1** the wavelength of the waves.

(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?

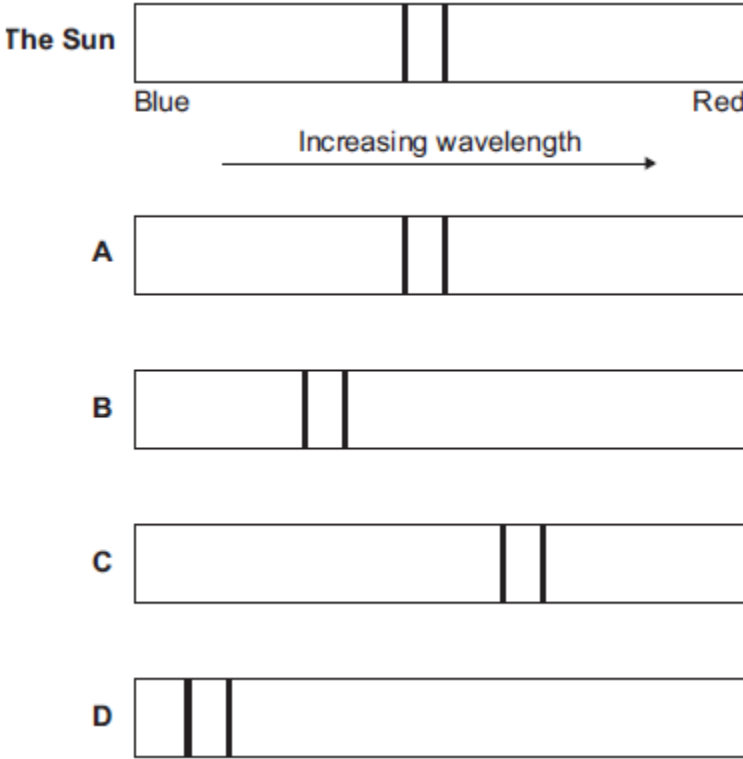
(1)

9.

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)

Mark schemes

1.

- (a) (force of) gravity causes the satellite to accelerate (towards the Earth)

allow satellite is (constantly) accelerating

1

the acceleration causes a change in direction

acceleration causes a change in speed negates this

mark point

1

velocity changes because direction changes

1

- (b) length of orbit taken from graph = 42 100 (km)

1

$$42\,100 = 7.73 \times \text{time}$$

or

$$\text{time} = \frac{42\,100}{7.73}$$

allow

their distance = 7.73 × time

1

$$\text{time (1 orbit)} = 5446(\text{s})$$

allow a value consistent with their distance

1

$$\text{number of orbits} = \left(\frac{24 \times 3600}{5446} \right)$$

$$= 15.86$$

allow $\left(\frac{24}{1.51} \right) = 15.86$

allow a value consistent with their distance

1

$$\text{number of orbits} = 15$$

allow a value consistent with their distance

an answer of 16 scores 4 marks

1

or

length of orbit taken from graph = 42 100 (km) (1)

$$7.73 = \frac{\text{distance}}{24 \times 3600} \quad (1)$$

distance = 667 872 (km) (1)

$$\text{number of orbits} = \left(\frac{667872}{42100} \right)$$

= 15.86 (1)

allow a value consistent with their two distances

number of orbits = 15 (1)

allow a value consistent with their two distances

up to full marks can be awarded for a method

calculating velocity in km/h and time in hours

an answer of 15 scores 5 marks

(c) the predicted data is very close to the actual data

1

(d) supported the prediction (made by Bode)

allow predicted and actual values are very close

1

so provides evidence that the equation is true / correct / works / accurate

allow proves for provides evidence

1

[11]

2.

(a) gamma rays

1

(b) can travel through the atmosphere

1

(c) explosion of a red super giant

or

a supernova

1

(d) 1.2×10^9 Hz

1

- (e) $3.0 \times 10^8 = 1.2 \times 10^9 \times \lambda$
an answer of 0.25 (m) scores 3 marks
allow ecf from (d)

$$\lambda = \frac{3.0 \times 10^8}{1.2 \times 10^9}$$

$$\lambda = 0.25 \text{ (m)}$$

- (g) same as the radio wave
- (f) expansion due to fusion energy

in equilibrium with gravitational collapse

forces acting inwards equal forces acting outwards gains 1 mark

- (h)

Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	3-4
Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.	1-2
No relevant content	0
Indicative content <ul style="list-style-type: none"> • Sun goes from main sequence to red giant • then from red giant to white dwarf • when the Sun changes to a red giant the surface temperature will decrease • and the relative luminosity will increase • when changing from a red giant to a white dwarf the surface temperature increases • and the relative luminosity decreases 	

- 3.** (a) gravity

1

1

1

1

1

1

4

[14]

1

- (b) as the wire moves through the Earth's magnetic field 1
- a potential difference is induced between the ends of the wire 1
- the wire must be part of a complete circuit 1
- (c) new trace shows:
- twice the frequency 1
- twice the amplitude 1
- (d) dynamo 1
- dc generator is insufficient*
- (e) the alternator pd changes polarity, the 2nd type of generator does not 1
- (f) $\frac{230}{V_s} = \frac{690}{57}$ 1
- $V_s = \frac{230 \times 57}{690}$ 1
- $V_s = 19 \text{ (V)}$ 1
- an answer of 19 (V) scores 3 marks* 1
- [11]**

4.

- (a) any **one** from:
- Earth is at the centre (not the Sun)
 - there are fewer planets
- accept there is no asteroid belt shown*
- accept there are only 5 planets (and not 8)*
- accept other planets have no moons shown* 1
- (b) Shows the moon in orbit around the Earth 1
- accept the planets have circular orbits*
- (c) circular 1
- accept elliptical*

- (d) gravity 1
- (e) Mira is much more massive 1

[5]

5. (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]

6. (a) (i) (enough) dust and gas (from space) is pulled together
accept nebula for dust and gas
accept hydrogen for gas
accept gas on its own
dust on its own is insufficient
mention of air negates this mark 1

by:
gravitational attraction
or
gravitational forces
or
gravitaty
ignore any (correct) stages beyond this 1

(ii) joining of two (atomic) nuclei (to form a larger one)

do not accept atoms for nuclei

1

(iii) more sensitive astronomical instruments / telescopes

or

infrared telescopes developed

accept better technology

more knowledge is insufficient

1

(b) (i) (other) planets / solar systems

do not accept galaxy

moons is insufficient

1

(ii) provided evidence to support theory

accept proves the theory

1

(c) elements heavier than iron are formed only when a (massive) star explodes

accept materials for elements

accept supernova for star explodes

accept stars can only fuse elements up to (and including) iron

1

[7]

7.

(a) hydrogen

1

(b) supernova

1

(c) red super giant

1

(d) any **four** from:

- fusion takes place within stars
- hydrogen formed into helium
- fusion continued and formed larger elements
- elements heavier than iron were formed in supernova
- (heavy) elements were scattered by the supernova explosion.

accept light elements formed

4

[7]

8.

(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]

9. (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]