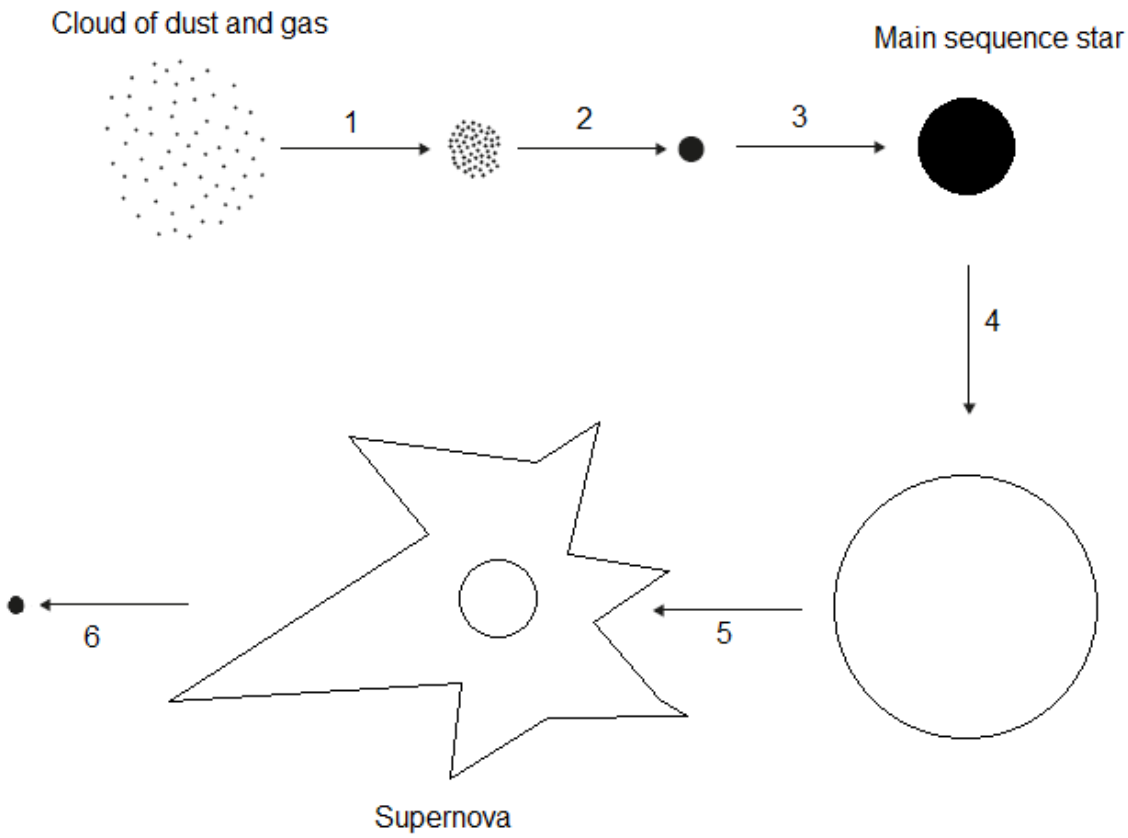
4-8 Space – Physics

1.0 **Figure 1** shows the life cycle of a star.

Figure 1



1.1 What can you tell about the size of the main sequence star whose life cycle is shown in **Figure 1**?

[1 mark]

Tick **one** box.

It is much smaller than the Sun ☐

It is about the same size as the Sun ☐

It is much bigger than the Sun ☐

1.2 What causes the cloud of dust and gas to collapse in step **1** in **Figure 1**?

[1 mark]

Tick **one** box.

- Fusion ☐
- Gravity ☐
- Kinetic energy ☐
- Radiation pressure ☐

1.3 Which **two** types of object could the star become after step **6** in **Figure 1**?

[2 marks]

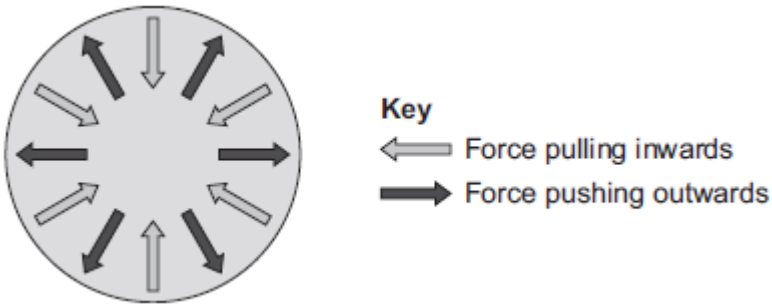
Tick **two** boxes.

- Black dwarf ☐
- Black hole ☐
- Neutron star ☐
- Red dwarf ☐
- Red giant ☐

1.4 During step **3** in **Figure 1**, two forces start to act on the star.

These are shown in **Figure 2.**

Figure 2



How do these forces change during the life cycle of the star?

[2 marks]

Tick **one** box for each step.

Step in Figure 1	Force pulling inwards is bigger	Force pushing outwards is bigger	The forces are balanced
Main sequence star			
Step 4			

1.5 Each second, fusion in the Sun converts some of its mass to energy. This means that the Sun is losing mass all the time.

Table 1 contains information about the Sun.

Table 1

Mass of Sun	2.0×10^{30} kg
Mass lost each second	4.3×10^{9} kg
Lifetime of the Sun left	5×10^{9} years

Calculate the percentage of the Sun's mass that will be converted to energy in the remainder of its lifetime.

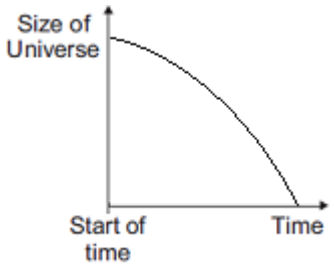
[3 marks]

Percentage of mass converted to energy = _____%

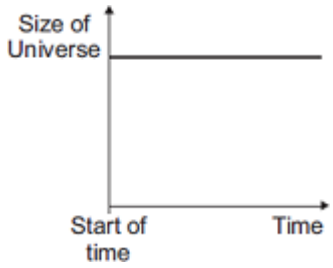
2.0 The Big Bang theory is the model used by most scientists to explain the way the universe has developed.

The graphs **W, X**, **Y** and **Z** show ways that the size of the universe may have changed.

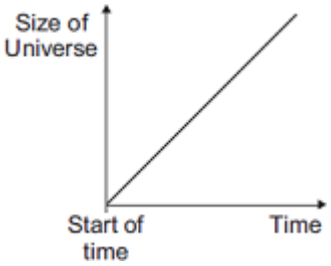
Graph W



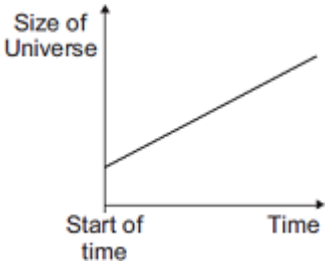
Graph X



Graph Y



Graph Z



2.1 Explain which graph is closest to the predictions of the Big Bang theory.

[2 marks]

Graph: _____

Explanation: _____

_____

_____

_____

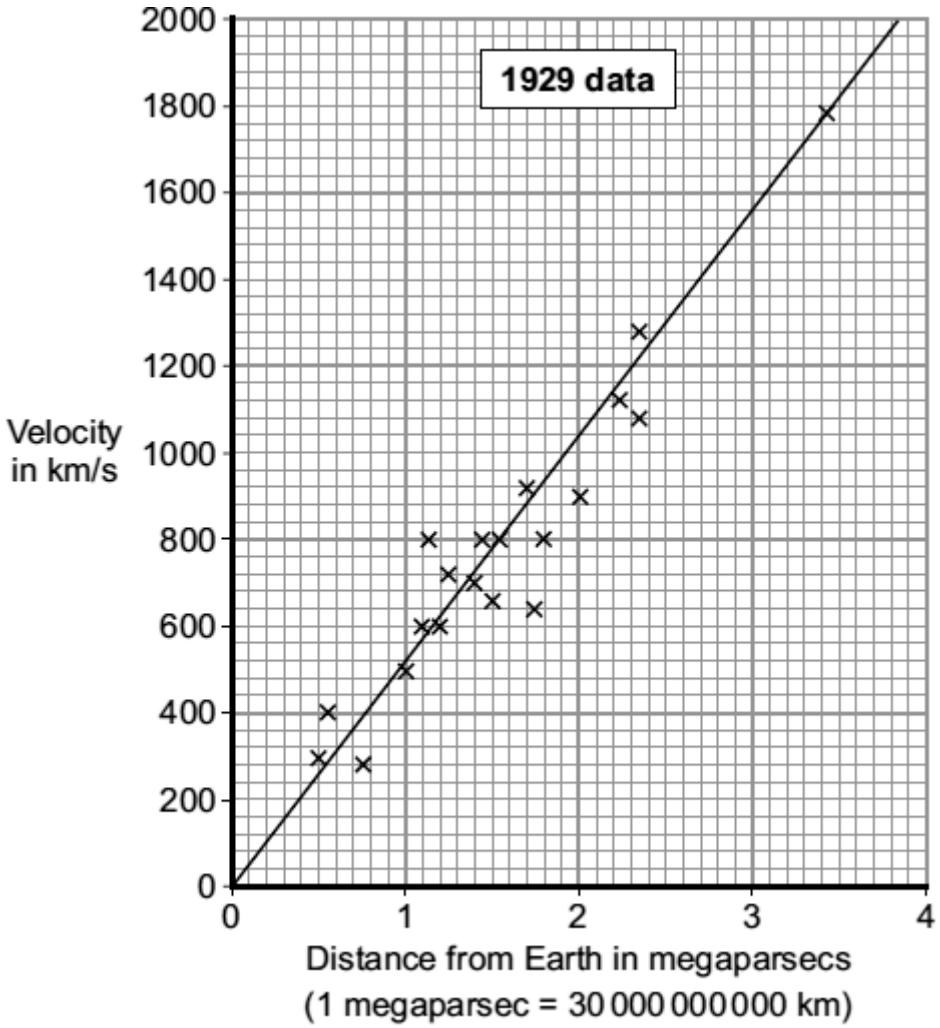
2.2 Some of the evidence for the Big Bang comes from the red-shift of galaxies.

What is meant by red-shift?

[1 mark]

Edwin Hubble measured the red-shift of galaxies. He was then able to work out the speed the galaxies were moving away from the Earth. He was also able to calculate the distance of the galaxies from the Earth. **Graph 1** shows some of the data collected by Hubble.

Graph 1



2.3 The gradient of the line drawn on the graph gives a number known as the Hubble constant. This can be used to estimate when the universe began.

Calculate the Hubble constant shown by this graph.

Show your working on the graph.

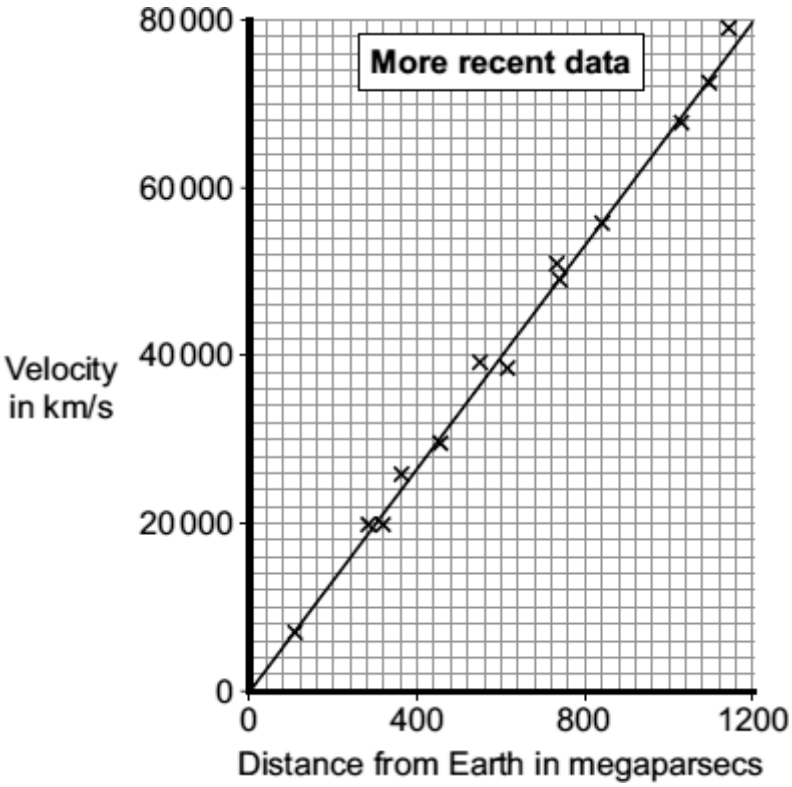
[3 marks]

Hubble constant = _____ km/s per megaparsec

2.4 More recently, scientists have collected data from other galaxies.

This data is shown in **Graph 2**.

Graph 2



State **two** differences between the **galaxies** shown in **Graph 1** and **Graph 2**.

[2 marks]

1. _____

_____

2. _____

2.5 The gradient of **Graph 2** is 67 km/s per megaparsec.

Suggest why this gradient is completely different to your answer to part **2.3.**

[2 marks]

2.6 What have recent observations of supernovae suggested about the velocities of distant galaxies?

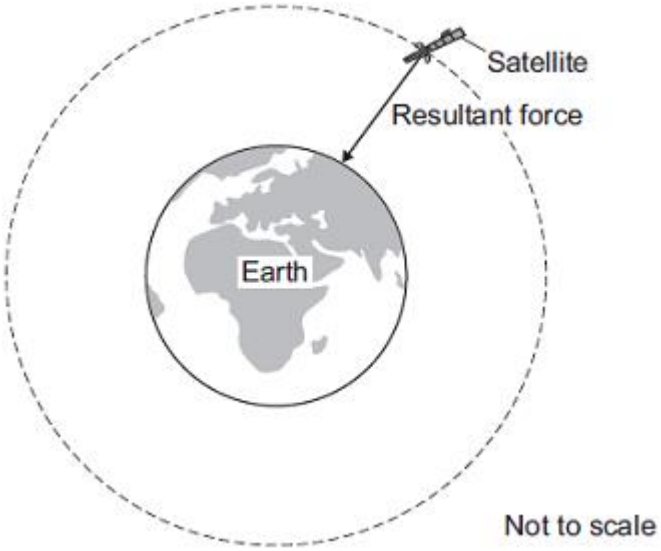
[1 mark]

3.0 When the universe was created, almost all of the atoms that existed were hydrogen. Now there are over 100 different elements.

Explain how the atoms of other elements were formed.

[6 marks]

4.0 Man-made satellites can orbit the Earth, as shown in the figure below.



The satellite experiences a resultant force directed towards the centre of the orbit.

4.1 Which of the following statements are true?

[2 marks]

Tick **one** box for each statement.

	True	False
The resultant force is due to air resistance with the upper atmosphere.		
The speed of a satellite in a stable orbit changes.		
The velocity of a satellite is different at different parts of its orbit.		
The height of a satellite is the same as the radius of its orbit.		

4.2 **Table 2** gives data for five different satellites orbiting the Earth.

Table 2

Satellite	Average height above Earth's surface in kilometres	Time taken to orbit Earth once in minutes
A	370	93
B	697	99
C	827	103
D	5 900	228
E	35 800	1440

A geosynchronous satellite stays about the same part of the Earth at all times.

Which satellite (**A** to **E**) in **Table 2** is geosynchronous?

[1 mark]

Satellite: _____

4.3 A company wants to make a satellite that orbits the Earth in 150 minutes.

Estimate the height of the satellite above the Earth's surface.

[1 mark]

Height above the Earth's surface = _____ km

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	It is much bigger than the Sun		1
1.2	Gravity		1
1.3	Black hole Neutron star		1 1
1.4	Main sequence star: Forces are balanced Step 4: Force pushing outwards is bigger		1 1
1.5	Total mass per year = $4.3 \times 10^9 \times 60 \times 60 \times 24 \times 365$ $= 1.4 \times 10^{17}$ $5 \times 10^9 = 6.8 \times 10^{26}$ kg Percentage lost = $(6.8 \times 10^{26} / 2.0 \times 10^{30}) \times 100 = 0.034$ (%)		1 1 1

Qu No.		Extra Information	Marks
2.1	**(Y)** Shows universe expanding From a very small point	No mark for Y	 1 1
2.2	Wavelength of light (from distant galaxies) increases / frequency decreases		1
2.3	Large triangle drawn on graph showing numbers used Gradient calculated eg (1560 – 0) / (3 – 0) = 520	Must take up at least half of the graph	1 1 1
2.4	Galaxies are further away Galaxies are faster		1 1
2.5	**Two** from: Better equipment / more accurate measurements Greater number of galaxies surveyed (Greater distance / velocity means) more of the universe included		2
2.6	Distant galaxies are receding ever faster		1

Qu No.		Extra Information	Marks
3.0			
Level 3:	Clear, coherent, logically structured answer linking the fusion of small elements into large elements with the energy and / or forces within stars. Both main sequence stars and supernovae included in answer. Examples given are correct. No errors in science.		5-6
Level 2:	Answer links elemental formation to fusion, with some correct detail and no major errors in science. Attempt to link fusion to energy and / or forces within stars. Likely to only reference main sequence stars **or** supernovae.		3-4
Level 1:	Answer links elemental formation to fusion. No link to energy or forces. Contains errors or major omissions.		1-2
Indicative content			
	Fusion In main sequence stars: Hydrogen to helium Elements up to iron formed in main sequence stars Gravitational forces cause high pressure and temperature at centre And / or GPE becomes KE Repulsive forces from nuclei overcome In supernovae explosions Bigger elements formed and scattered Ignore references to mass deficit and energy released. Ignore references to equilibrium of forces on star		

Qu No.				Extra Information	Marks
4.1		**True**	**False**	**2** marks for all ticks correct **1** mark for 3 ticks correct	2
	The resultant force is due to air resistance with the upper atmosphere.		✓		
	The speed of a satellite in a stable orbit changes.		✓		
	The velocity of a satellite is different at different parts of its orbit.	✓			
	The height of a satellite is the same as the radius of its orbit.		✓		
4.2	E				1
4.3	3000 km			Allow 2500 – 3500	1