Solutions: GCSE Questions on Circular Motion, Satellites and Stellar Evolution

Q1. A student collects data from the Internet about planets in the solar system:

Name of the planet	Distance from the Sun in millions of kilometres	Time taken for one orbit of the Sun in years	Time taken to spin on its axis in hours	Average temperature on the side facing the Sun in °C
Mercury	60	0.24	1400	+430
Venus	110	0.60	5800	+470
Earth	150	1	24	+20
Mars	230	2	25	–20
Jupiter	780	12	10	–150
Saturn	1400	30	10	–180
Uranus	2900	84	17	–220
Neptune	4500	160	16	–230

(a) Name the two variables in the student's table which always have the relationship: 'As one increases, so does the other' Distance from the Sun and time taken to **orbit** the Sun (must have the word orbit as there are two time columns!)

(1 mark)

(b) (i) Give an example of two variables in the student's table which generally have the relationship: 'As one increases, the other decreases.' Distance from the Sun and temperature OR Time taken to **orbit** the Sun and temperature

(1 mark)

(ii) Which piece of data does not seem to fit the relationship in (b)(i)?
(+) 430 or (+) 470 **OR** Mercury or Venus

(1 mark)

(c) Scientists plan to launch a satellite which will orbit Mars above its equator. It will be a geostationary satellite. How many hours will it take to orbit Mars? 25 (hours)

(1 mark)

(d) Mars has two moons. Neither of them is in a geostationary orbit and they both take different times to orbit the planet. Which one of these statements is correct.

(1 mark)

A: The two moons will always be above the same point on the surface of Mars.
B: The two moons will be in different positions at different times.
C: You can never see both moons at the same time.

(e) Choose words from the box to complete the passage below.

circular	direction	friction	gravitational	speed	universal

*The moons of the planet Neptune move in circular paths around the planet. They continuously accelerate towards the centre of Neptune. The acceleration changes the ...(**X - direction**)...of each*

*moon but does not change its ...(**Y - speed**).... The force causing the acceleration is a .....(**Z - gravitational (1 mark)**).... force. - X and Y correct for other mark.* **(2 marks) (7 marks TOTAL)**

Q2. (a) Our star, the Sun, is stable. Explain what the conditions need to be for a star to remain stable.

For the star to remain stable the inward pulling **gravitational force**(s) (1 mark) must be **balanced** by the outward pushing force(s) due to **radiation pressure** (1 mark) (Syllabus quote: **Gravitational forces balance radiation pressure to make a star stable - make sure you revise from the syllabus!) - do not say 'equal' - they are in equilibrium and the markscheme does not allow 'equal'.**

(2 marks)

(b) Shortly after the 'big bang', hydrogen was the only element in the Universe. Explain how the other elements came to be formed.

Other elements came to be formed by (nuclear) **fusion** (1 mark) of **hydrogen to helium** (and then to form other elements up to iron in the periodic table) (1 mark). Heavy elements (elements heavier than iron) are only produced (by fusion) in a **supernova** (1 mark) Note that you have to remember the fusion process from Unit 2 - each time I stress that foundation facts need to be known you need to revise them!

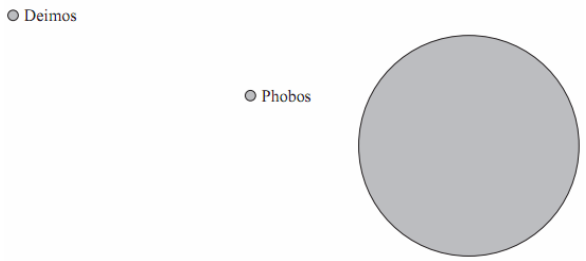
(3 marks)
(5 marks TOTAL)

Q3. This page is from a science magazine:

The Red Planet

The two natural satellites, or moons, of Mars are Phobos (fear) and Deimos (terror). They are named after the horses which pulled the chariot of Mars, the god of war in the mythology of Ancient Greece.

Phobos takes less than eight hours to orbit Mars and gets slightly closer every time it does so. Scientists predict that in about 100 million years time it will either be ripped apart by the gravitational force or will crash onto the surface of Mars.



(Not to scale)

(a) Suggest how scientists have arrived at their prediction of about 100 million years.

(2 marks)

If scientists plot the data/evidence/observations of (the rate of change in) Phobos'/the moon's orbit (**1 mark**) they can extrapolate (**1 mark**) the pattern/trend for the next 100 million years to arrive at a prediction

(b) The centripetal force on Phobos is gradually changing as it orbits Mars. Is the force increasing or decreasing? Explain your answer.

The centripetal force on Phobos is **increasing** (1 mark) therefore the moon will be pulled **nearer to** Mars) (1 mark)

(2 marks)

(c) Scientists expect that the mass of Mars and the mass of Phobos will not increase. Explain what will happen to the gravitational force on Phobos as it orbits Mars.

The gravitational force will **increase** (1 mark) because Phobos will get/be **closer to Mars**. (1 mark)

Solutions: GCSE Questions on Circular Motion, Satellites and Stellar Evolution

(2 marks)
(6 marks TOTAL)

Q4. Immediately after the 'big bang', at the start of the Universe, there were only atoms of the element hydrogen (H). Now the Universe contains atoms of over one hundred elements.

(a) Explain how atoms of the element helium (He) are formed in a star.

(Nuclear) fusion (1 mark) of hydrogen nuclei (1 mark) - Do not credit any response which looks like 'fission' or the 'word' 'fussion

(2 marks)

(b) Explain how atoms of very heavy elements, such as gold (Au), were formed.

Fusion of the nuclei of other/lighter elements (1 mark) during a **supernova** (1 mark) - *Reference to the Big Bang nullifies both marks - At the Big Bang there were no elements - then protons condensed out (and a proton is a hydrogen nucleus)*

(2 marks)

(c) Explain how, and when, atoms of different elements may be distributed throughout the Universe.

When we get the explosion of a star (a super nova) (1 mark) at the end of the 'life' of large star elements get flung out into space as dust. (1 mark)

(2 marks)
(6 marks TOTAL)

Q5. The table gives data on the Solar System

Name of planet	Average distance from the Sun in millions of kilometres	Average orbital speed in kilometres per second
Mercury	60	48
Venus	108	35
Earth	150	30
Mars	228	24
Jupiter	778	13
Saturn	1430	9.6
Uranus	2860	6.8

(a) A student studies this data and comes to the following conclusion:

"For the planets in the table, the average orbital speed is very nearly inversely proportional to the planet's average distance from the Sun."

(i) This conclusion is ***not*** correct. Use the data for Saturn and Uranus to explain how the student's conclusion is ***not*** correct.

Only use data they specify!

This question showed that many students did not understand what inversely proportional meant.

If A and B are proportional then if you double A, B will double - if you triple A B will triple etc.

Solutions: GCSE Questions on Circular Motion, Satellites and Stellar Evolution

If C and D are inversely proportional if you double C then D will halve - if you triple C then D will be a third of the value it was... If you multiply two things that have an inverse relationship together you will always get the same answer - a constant. C x D = CD; 2C x $\frac{1}{2}$ C = CD; 3C x $^1/_3$ D = CD etc.
Uranus is twice the distance from the Sun as Saturn (**1 mark**) (but) 6.8 is not half of 9.6 (**1 mark**) so they are not inversely proportional. **(2 marks)**

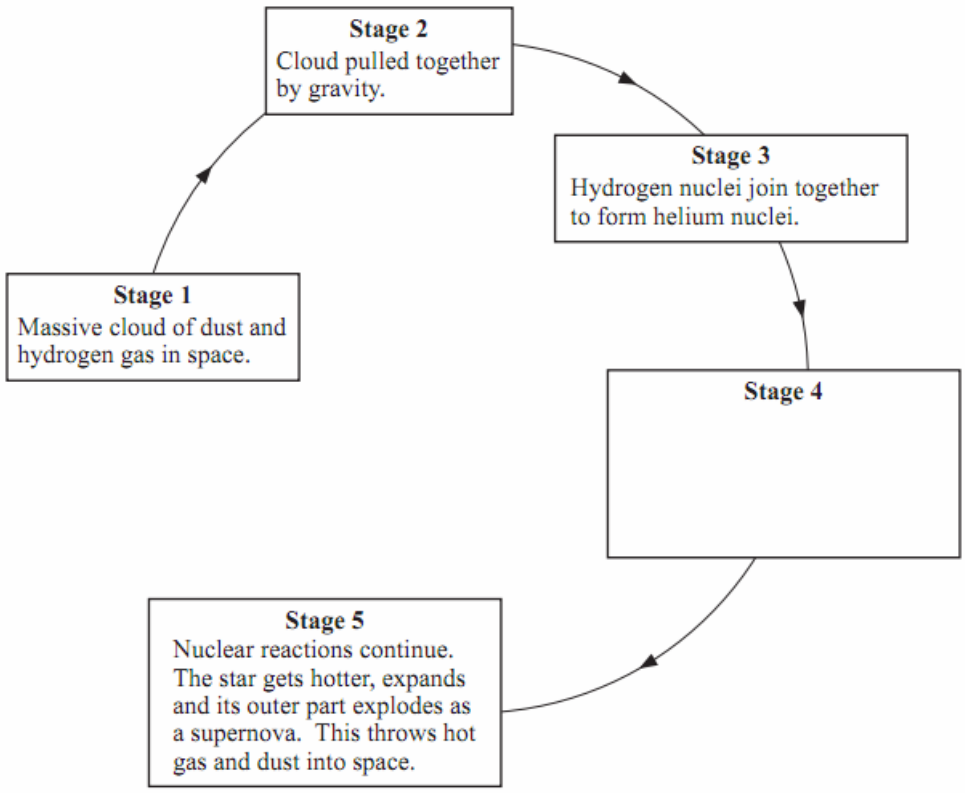
(ii) For all the listed planets, write a correct conclusion for the connection between the average distance from the Sun and the orbital speed.

The greater the (average) distance from the Sun the smaller the (average orbital) speed (of the planet) OR the converse OR the distance is inversely proportional to the square of the orbital speed. **(2 marks).**
Allow a correct but non-comparative statement e.g. 'a far away planet moves slowly', for (**1 mark**)
(2 marks)

(b) The student knows the following:
The planets all move in ellipses (slightly squashed circles). What is the connection between this statement and the headings in the table?
Only the average distance and speed can be given (**1 mark**) in the headings because the distance and speed is not constant throughout the orbital path (**1mark**) They will both vary because the orbit is an ellipse not a circle.

(2 marks)
(6 marks TOTAL)

Q6. The diagram shows part of the life cycle of a star which is much bigger than the Sun.



(a) (i) What is the relationship between the masses of the dust and gas in the cloud in Stage 2 and the force of gravity between them?
The bigger the masses (of the dust and gases) the bigger the force of gravity (between them).
(1 mark)

(ii) What is the relationship between the distance apart of the dust and gas in the cloud in Stage 2 and the force of gravity between them?

The greater the distance (between the dust and gases) the smaller the force of gravity (between them)

(1 mark)

(b) In Stage 3 the star remains stable for millions of years. Explain why.
Radiation 'pressure' and gravity (or gravitational attraction) are balanced (or are in equilibrium)

or there is sufficient hydrogen/fuel to last a very long time

(2 marks)

(c) What happens in Stage 4?

any two from:

- hydrogen runs out / is used up
- nuclei larger than helium nuclei formed (but not larger than iron)
- (star expands to) / become(s) a red giant

(2 marks)
(6 marks TOTAL)

Q7. The London Eye is the largest observation wheel in the world. The passengers ride in capsules. Each capsule moves in a circular path and accelerates.

(a) Explain how the wheel can move at a steady speed and the capsules accelerate at the same time.

Acceleration is (rate of) change of velocity (1mark). Velocity is a vector - it has direction and magnitude (1mark). The direction (of each capsule) changes as it goes round even though its speed is constant. (1mark)

(2 marks max)

(b) In which direction does each capsule accelerate?

To(wards) the centre (of the wheel) **(1 mark)**

(c) What is the name of the resultant force that causes the capsules to accelerate? The centripetal force **(1 mark)**

(d) The designers of the London Eye had to consider three factors which affect the resultant force described in part (c). Two factors that increase the resultant force are

- an increase in the speed of rotation
- an increase in the total mass of the wheel, the capsules and the passengers.

Name the other factor that affects the resultant force and state what effect it has on the resultant force.

Far too many just stated the factor and didn't get the mark becuase they did not explain the effect it had!

The greater the **radius or diameter or circumference** (of the wheel) the smaller the force required to make it go in a circle

(1 mark)
(5 marks TOTAL)

Q8. (a) Suggest a word to replace the space in the sentence:

Stars form when enough dust and gas are pulled together by the force of gravity

(1 mark)

(b) How are stars able to give out energy for millions of years?

A: By ~~atoms~~ nuclei joining together

B: By atoms splitting apart

C: By burning gases

This is a poor question - they really should have said 'nuclei' NOT atoms! In chemistry atoms join and split from each other when molecules are formed and broken apart - fusion and fission are the joining of nuclei and splitting of a nucleus - just shows that the exam board aren't too brilliant!

(1 mark)

(c) There are many billions of stars in our galaxy. Our Sun is one of these stars. What is the name of our galaxy? The Milky Way

(1 mark)

(d) '*Why was the Universe created?*' We cannot expect scientists to answer this question. What is the reason for this?

A: It will take too long to collect the scientific evidence.

B: The answer depends on beliefs and opinions, not scientific evidence.

C: There is not enough scientific evidence.

(1 mark)

(4 marks TOTAL)

Grand Total : 45 marks - time allocation 45 minutes