8.1 Star life cycles and orbits

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS main sequence • supernova

Objective

Build the skills to answer exam questions on **stars and the solar system** : how stars form, the main sequence, the life cycle of stars, how elements are made, planets, moons, comets and orbits.

You must be able to:

- describe how a star forms and why it is stable on the main sequence
- describe the life cycle of a star like the Sun and of a much bigger star
- explain how elements are made by fusion and in supernovae
- explain how gravity keeps planets, moons, comets and satellites in orbit

1 Key knowledge and worked examples

Stars and orbits

idea	equation or rule
birth	gravity pulls a cloud of dust and gas (a nebula) together into a protostar; it heats up until hydrogen fuses
main sequence	the outward pressure from fusion energy balances the inward pull of gravity, so the star is stable for billions of years
a star like the Sun	main sequence → red giant → white dwarf → black dwarf
a much bigger star	main sequence → red supergiant → supernova → neutron star or black hole
elements	fusion in stars makes elements up to iron; heavier elements are made in supernovae and spread into space
orbits	gravity gives the centripetal force: the direction changes but the speed in a circular orbit stays the same; a closer orbit needs a higher speed

Worked example 1: orbital speed. A satellite moves in a circle of radius 7000 km. One orbit takes 6000 s. Find its speed.

1. Known: $r = 7000$ km, $T = 6000$ s.
2. Rule: speed $= \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{T}$.
3. Numbers: $\frac{2\pi \times 7000}{6000}$.
4. Result: 7.3 **km/s**.

Worked example 2: an ending. A star is 20 times the mass of the Sun. Name the stage after the red supergiant and what is left.

1. Known: the star is much bigger than the Sun.
2. Rule: big stars explode at the end.
3. Apply: a supernova; the core collapses.
4. Result: **supernova, then a neutron star or a black hole**.

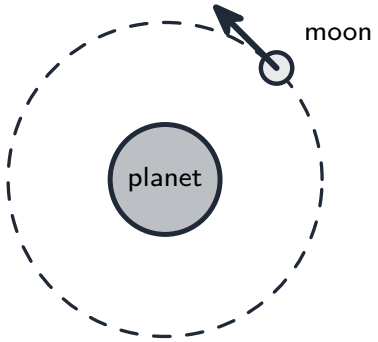
Answer shapes: name the two forces and say they balance; in an orbit the velocity changes because its direction changes.

2 Practice

2.1 The cards show the stages in the life of a star like the Sun. Write them in the right order. [2]

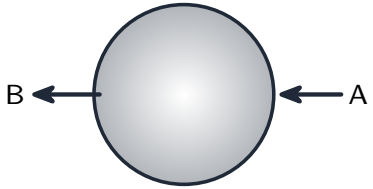
red giant | nebula | white dwarf | main sequence | protostar

2.2 A moon moves in a circular orbit around a planet. Name the force that keeps it in orbit and give its direction. [2]

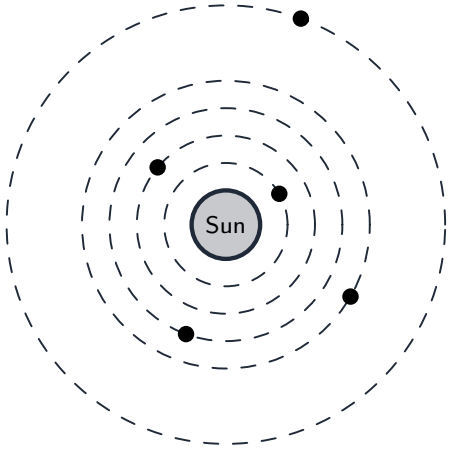


3 Exam-style questions

3.1 The diagram shows two forces on a main-sequence star. Name forces A and B. Explain why the star stays the same size for billions of years. [3]



3.2 The table gives data for five planets. All the orbits are almost circles around the Sun.



planet	distance from Sun / million km	orbital speed / km/s	time for one orbit / years
Mercury	58	47.9	0.24
Venus	108	35.0	0.62
Earth	150	29.8	1.00
Mars	228	24.1	1.88
Jupiter	778	13.1	11.9

(a) Describe how the orbital speed changes with distance from the Sun. Explain why. [3]

(b) Calculate the distance the Earth travels in one orbit. [2]

(c) A comet moves in a long, thin elliptical orbit. Describe and explain how its speed changes during one orbit. [3]

(d) Describe the life cycle of a star much bigger than the Sun. Explain how the elements in the planets were made. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- nebula → protostar → main sequence; → red giant → white dwarf

2.2

- **gravity** (gravitational force); towards the centre of the planet

3.1

- A: gravity, pulling inwards
- B: outward pressure from the energy released by fusion
- the two forces are equal (balanced), so the star does not get bigger or smaller

3.2

(a) the further from the Sun, the lower the speed; gravity is weaker further away; a smaller force is needed for a slower orbit, so far planets move more slowly

(b) distance $= 2\pi r = 2\pi \times 150 =$ **942** million km

(c) it moves fastest when it is closest to the Sun; slowest when it is furthest away; gravity is stronger close to the Sun and pulls it faster as it falls in

(d) points to include:

- a nebula of dust and gas is pulled together by gravity into a protostar; hydrogen fusion starts
- main sequence: forces balanced; then it swells into a red supergiant and fuses heavier elements up to iron
- it explodes as a supernova; the core becomes a neutron star or a black hole
- elements heavier than iron are made in the supernova
- the explosion spreads the elements into space, where they form new stars and planets

Levels: **5**–**6** a full, logical answer with correct physics and correct terms; **3**–**4** several correct points, partly linked; **1**–**2** one or two relevant points.

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