

Life cycle of stars and element formation

AQA GCSE Separate Physics 8463 only | Foundation and Higher | Mainly Paper 2; fusion link to Paper 1

Estimated/untrials: 35–40 min independent +15–20 min review | 24 parts | 48 marks

Specification points covered

4.8.1.1: star formation from a nebula and main-sequence equilibrium
4.8.1.2: Sun-like and massive-star pathways; element formation and dispersal
4.4.4.2: fusion of light nuclei; mass converted to energy of radiation

An observatory team prepares a display about star-forming clouds, two model stars R and T, and material used in new planets.

Use the supplied evidence and GCSE stellar model. Explain links, not just stage names. Show numerical working and units. All questions are for both tiers; the model data are illustrative.

1 Interpreting a star forming cloud

Cloud P contains gas and dust. A dense region contracts under gravity and becomes hotter, but its centre has not yet reached the temperature for sustained hydrogen fusion.

1(a) What is the astronomical name for a cloud of gas and dust such as P? **[1 mark]**

1(b) Explain how contraction of cloud P can eventually lead to a main-sequence star. **[3 marks]**

1(c) The team labels the hot, contracting object in P a main-sequence star. Use the supplied observation to explain why this label is premature. **[1 mark]**

1(d) A visitor says P will become a star only if oxygen arrives so that its gas can burn. Explain the error and identify the energy-releasing process in a main-sequence star. **[2 marks]**



2 Comparing two stable stars

Table 1 is a simplified model for two single main-sequence stars. Both currently fuse hydrogen in their cores. Initial mass means mass when the star began its life; lifetimes are approximate model values.

Table 1

Star	Initial mass / Sun mass	Main-sequence lifetime / million years
R	1.0	10 000
T	20	8

2(a) Which star in Table 1 is the better model for the Sun's broad lifecycle route? Use the mass information. **[1 mark]**

2(b) How many times greater is T's initial mass than R's? **[1 mark]**

2(c) R's radius stays approximately constant during its main-sequence lifetime. Explain this stability in terms of forces and the source of energy. **[2 marks]**

2(d) A trainee says a stable R must have stopped all fusion. Explain why this does not follow. **[1 mark]**

2(e) A visitor predicts that T must stay on the main sequence longer because it starts with more fuel. Use Table 1 and the supplied fact that T uses its fuel much faster to evaluate the prediction. **[2 marks]**



3 Following different stellar pathways

Use Figure 1 as a reference model, not a scale drawing or timeline. R begins with a Sun-like mass; T is much more massive. Apply the paths to the evidence in each question.

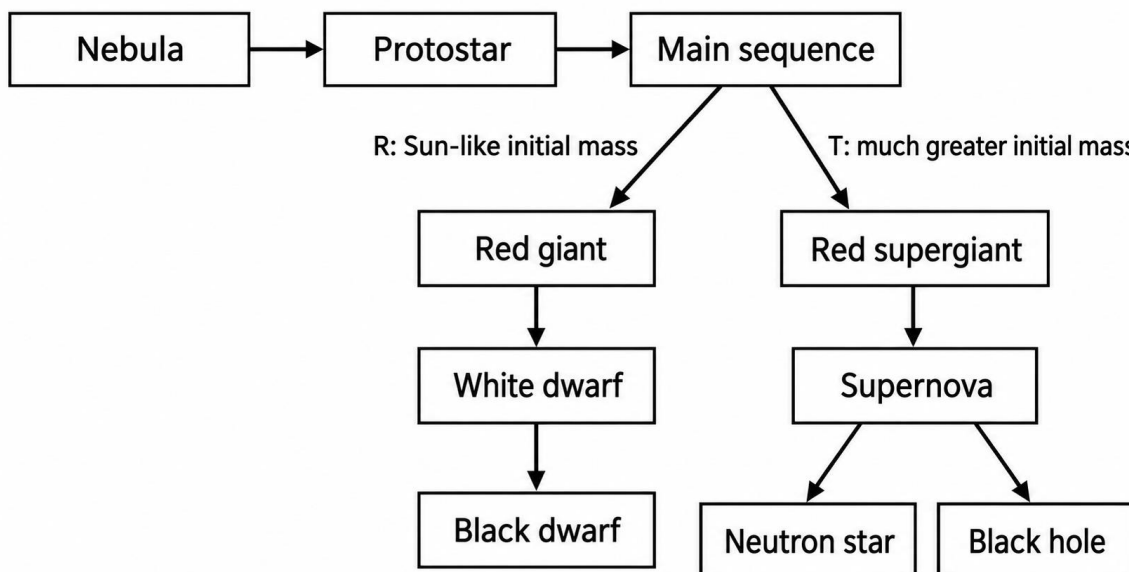


Figure 1

3(a) R begins to run out of hydrogen in its core. State its next major lifecycle stage and the change in its overall size. **[1 mark]**

3(b) A later image shows R and T as large red objects. Explain why their red appearance alone cannot determine which final remnant each will leave. **[2 marks]**

3(c) After R loses its outer layers, the team finds a small hot remnant with no sustained fusion. Identify the remnant and describe its long-term change. **[2 marks]**

3(d) T produces a brilliant outburst and an expanding cloud of debris. Name the event and describe what it does to the material in the outer part of the star. **[2 marks]**

3(e) Two stars that began much more massive than the Sun leave different remnants: a neutron star and a black hole. Explain why this does not contradict Figure 1. **[2 marks]**



4 Explaining the elements in new worlds

The observatory detects helium in main-sequence T. Later stages can produce carbon and iron before an explosion; gold is detected in material from a supernova. Use the GCSE model. Carbon is lighter than iron; gold is heavier.

4(a) In main-sequence T, hydrogen becomes less abundant while helium becomes more abundant. Explain this pattern and how the process supplies energy. **[2 marks]**

4(b) Could carbon and iron be produced inside a massive star before the supernova? Explain using successive nuclear reactions. **[2 marks]**

4(c) A display claims that the gold was made by ordinary hydrogen fusion in a Sun-like main-sequence star. Explain why this is not the GCSE account. **[2 marks]**

4(d) Trace how carbon and iron made in T could later become part of a rocky planet forming in a different cloud. Distinguish making the elements from moving them. **[3 marks]**



5 Accounting for material that leaves a star

Table 2 gives illustrative mass budgets after the two stars have evolved. R leaves a white dwarf; T leaves a neutron star in this model. Assume the difference is expelled material; ignore mass converted to radiation for these calculations.

Table 2

Model star	Initial mass / kg	Remaining core mass / kg
R	2.0×10^{30}	1.2×10^{30}
T	4.0×10^{31}	3.0×10^{30}

5(a) Use Table 2 to calculate the mass of material expelled by R. Give your answer in standard form. **[2 marks]**

5(b) Calculate the percentage of R's initial mass represented by this expelled material. **[2 marks]**

5(c) T's final core is only 1.5 times the Sun's mass. A trainee therefore concludes T never had a much greater mass than the Sun. Use Table 2 to explain why this is wrong. **[2 marks]**

5(d) The white dwarf left by R still emits light. Does this prove that it is still a main-sequence star? Explain the energy source. **[2 marks]**



6 Writing the observatory explanation

Use R and T throughout your account. Plan a clear order and connect the observations to the physics. The diagram is a reference; stage names alone are not a full explanation.

6(a) The team's display follows material from a nebula into R and T and later into new planets. Write a linked account comparing the stars. Include formation and main-sequence stability, their different later stages, and how T can supply newly formed elements for future planets. **[6 marks]**

6(b) A trainee says one night of observing R and T directly shows a whole star completing every lifecycle stage. Use the supplied timescales to explain the limitation and how observations of different stars still help. **[2 marks]**

Review: distinguish nuclei from atoms, initial mass from present radius, and producing elements from distributing them. Use inward gravity and outward pressure when explaining stability.

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