# Year 12 Science: Stars: fusion, the HR diagram and life cycles

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. What stops a main sequence star from collapsing under gravity?

2. Where on the HR diagram are white dwarfs, and why are they dim?

3. If a star were moved to 3 times its distance from us, what fraction of its brightness would we see?

4. What does a star of 30 Sun masses become at the end of its life?

5. How far is 4.24 light-years in km, using 1 light-year = $9.5 \times 10^{12}$ km?

## Exam-style question: two stars near the Southern Cross

**Alpha Centauri A is a yellow, Sun-like main sequence star 4.37 light-years away. Gamma Crucis, at the top of the Southern Cross, is a red giant much further away, yet both are easy to see.**

6. Compare the colour, surface temperature and position on the HR diagram of the two stars.

7. Explain how Gamma Crucis can be cooler than Alpha Centauri A but far more luminous.

8. Explain how a Sun-like star changes from the main sequence into a red giant, referring to gravity, fuel use and energy.

9. Explain why a star of 15 Sun masses ends very differently from Alpha Centauri A.

## Fix the mistake

10. Correct this statement: "A red star is cool, so it must be dim and low on the HR diagram."

11. Correct this statement: "Massive stars live longest because they have the most fuel."

12. Correct this statement: "The Sun will explode as a supernova."

13. Correct this statement: "The temperature axis on an HR diagram increases to the right."

## Answer key (for parents and tutors)

1. What stops a main sequence star from collapsing under gravity?
   **Outward pressure from the energy released by fusion in its core balances gravity.**
2. Where on the HR diagram are white dwarfs, and why are they dim?
   **Bottom left: they are hot but tiny, so their small surface gives out little energy.**
3. If a star were moved to 3 times its distance from us, what fraction of its brightness would we see?
   **$1 \div 3^2 = 1/9$ of its brightness.**
4. What does a star of 30 Sun masses become at the end of its life?
   **A black hole, after a supernova.**
5. How far is 4.24 light-years in km, using 1 light-year = $9.5 \times 10^{12}$ km?
   **$4.24 \times 9.5 \times 10^{12} = 4.0 \times 10^{13}$ km.**
6. Compare the colour, surface temperature and position on the HR diagram of the two stars.
   **Alpha Centauri A: yellow, about the Sun's temperature, on the main sequence near the middle; Gamma Crucis: red, cooler, at the top right among the giants (Achieved).**
7. Explain how Gamma Crucis can be cooler than Alpha Centauri A but far more luminous.
   **Merit: luminosity depends on temperature and surface area, so a cooler star can be more luminous if it is much larger. Excellence: each square metre of Gamma Crucis gives out less energy than Alpha Centauri A, but its surface area is so much larger that its total output is far greater, which puts it at the top right of the HR diagram; it looks bright from Earth despite being further away.**
8. Explain how a Sun-like star changes from the main sequence into a red giant, referring to gravity, fuel use and energy.
   **Achieved: it runs out of hydrogen in its core and swells into a red giant. Merit: without fusion support, gravity squeezes the core, turning gravitational potential energy into heat; hydrogen fuses in a shell, and the outer layers expand and cool. Excellence: the core heats until helium fuses into carbon; the extra energy pushes the outer layers out, so the star becomes larger, cooler (red) and more luminous, moving up and right on the HR diagram.**
9. Explain why a star of 15 Sun masses ends very differently from Alpha Centauri A.
   **Achieved: it will end in a supernova instead of a white dwarf. Merit: its strong gravity heats the core enough to fuse elements up to iron, then the core collapses. Excellence: iron fusion absorbs energy, so outward pressure fails and gravity collapses the core; the rebound makes a supernova and leaves a neutron star, whereas Alpha Centauri A, under 8 Sun masses, sheds a planetary nebula and leaves a white dwarf.**
10. Correct this statement: "A red star is cool, so it must be dim and low on the HR diagram."
    **Colour gives temperature only; a red giant is cool but huge, so it is very luminous and sits at the top right.**
11. Correct this statement: "Massive stars live longest because they have the most fuel."
    **They burn it far faster because gravity makes their cores hotter, so they live only millions of years.**
12. Correct this statement: "The Sun will explode as a supernova."
    **The Sun is under 8 Sun masses, so it will become a red giant, then a planetary nebula and a white dwarf.**
13. Correct this statement: "The temperature axis on an HR diagram increases to the right."
    **Temperature increases to the left: hot blue stars on the left, cool red stars on the right.**