



Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

### 1 Key words

1. nebula
2. hydrogen
3. surface temperature
4. Big Bang
5. expanding
6. astronomical units
7. light-years
8. conservation of energy

K • 4

Each carries 0.5 mark.

### 2 Label the diagram

- |                                  |                                    |
|----------------------------------|------------------------------------|
| 1. red giant                     | 4. supernova                       |
| 2. white dwarf (small, hot, dim) | 5. red supergiant                  |
| 3. protostar (no fusion yet)     | 6. black hole (the heaviest cores) |

K • 3

Each carries 0.5 mark.

### 3 Multiple choice

- i. d. hydrogen

K • 1

Nebulae are mostly **hydrogen** (about three-quarters), with most of the rest helium. That is why stars, which form from them, are mostly hydrogen too.

- ii. c. supernova

K • 1

A **supernova** is the explosion. A neutron star (seen as a pulsar) or a black hole is what is **left** after it.

- iii. c. nebula → protostar → star → red supergiant → supernova → black hole

U • 1

A massive star becomes a **red supergiant**, explodes as a **supernova**, and can leave a **black hole**. A black dwarf and a white dwarf come from Sun-like stars, which don't explode as supernovae, and the red giant stage comes **before** any explosion, not after.

- iv. b. All the matter and energy of the universe came from one common, extremely dense beginning.

U • 1

According to the Big Bang theory, all matter and energy came from one hot, dense beginning. Whether the expansion has a limit is not known (it seems not to); and by the principle of conservation of energy, the total amount of energy doesn't change.

- v. a. Rigel

U • 1

Blue-white means hotter: Rigel's surface is about 12,000 K, Betelgeuse's only about 3,500 K. Color is the thermometer astronomers use for stars they can never visit.

### 4 Very short answers

- a. MARKING SCHEME

K • 1

✓ What is left when the core of a very massive star collapses, with gravity so strong that nothing, not even light, can escape from it.

- b. MARKING SCHEME

K • 1

✓ The distance light travels in one year ( $9.46 \times 10^{15}$  m).



- c. MARKING SCHEME K · 1  
✓ NAST (Nepal Academy of Science and Technology).

## 5 Short answers

- a. MARKING SCHEME U · 2  
✓ Any one difference, e.g. a nova is a smaller outburst that throws off only the outer gas; a supernova is a tremendous explosion that blows a massive star apart.  
✓ Any second difference, e.g. after a nova the star survives (as a white dwarf); after a supernova a neutron star or black hole is left.
- b. MARKING SCHEME U · 2  
✓ Stars are born in nebulae: gravity pulls gas and dust together into protostars.  
✓ A protostar becomes a star when fusion begins, so, like a nursery, a nebula is where new stars form (e.g. the Orion Nebula).
- c. MARKING SCHEME A · 2  
✓ Like a star, Jupiter is made mainly of hydrogen and helium.  
✓ It doesn't have enough mass (about 80 times more would be needed) for its core to get hot and squeezed enough for hydrogen fusion to start.

## 6 Long answer

### ANSWER

U · 4

In about **5 billion years**, the hydrogen in the Sun's core will run out. The core will shrink and heat up until helium fuses into carbon. The extra heat will make the Sun's outer layers swell to perhaps 200 times their present size: the Sun will become a **red giant**, swallowing Mercury and Venus and possibly the Earth. Its outer layers, weakly held, will then drift off into space as a glowing shell of gas. The core left behind will be a **white dwarf**, about the size of the Earth, hot but dim, with no fusion. Over an extremely long time it will cool and fade into a cold, dark **black dwarf**. The Sun is not massive enough to explode as a supernova or become a black hole.

### MARKING SCHEME

- ✓ In about 5 billion years the hydrogen in the core runs out; the core shrinks and heats up until helium fuses into carbon.
- ✓ The outer layers swell and the Sun becomes a red giant (swallowing Mercury and Venus, possibly the Earth).
- ✓ The outer layers drift off into space (a planetary nebula), and the core is left as a white dwarf, about the size of the Earth.
- ✓ The white dwarf slowly cools into a black dwarf; the Sun is not massive enough to become a supernova or a black hole.

## 7 Numerical problem

### ANSWER

A · 2

distance =  $5.2 \times 1.5 \times 10^{11} \text{ m} = 7.8 \times 10^{11} \text{ m}$ .

time = distance ÷ speed =  $7.8 \times 10^{11} \div (3 \times 10^8) = 2600 \text{ s}$ , about 43 minutes.

### MARKING SCHEME

- ✓ Distance =  $5.2 \times 1.5 \times 10^{11} = 7.8 \times 10^{11} \text{ m}$ .
- ✓ Time =  $7.8 \times 10^{11} \div 3 \times 10^8 = 2600 \text{ s}$  (about 43 minutes).



## 8 Think

### ANSWER

HA - 2

The iron was made by fusion inside a massive star that lived and died before the Sun was born. When the star exploded as a supernova, the iron was scattered into space and mixed into the nebula from which the Sun and the Earth formed; from the Earth's rocks and soil it reached us through plants and food.

### MARKING SCHEME

- ✓ It was made by fusion inside a star (a massive star) that died before the Sun formed.
- ✓ The star's explosion (supernova) scattered it into space, into the nebula from which the Sun and the Earth formed (and from the soil it reached us through food).

## 9 Activity: Where do matter and energy go? (Activity 12.2)

(not marked)

### WHAT STUDENTS SHOULD FIND

A human (about 70 years): the body decomposes; its carbon, nitrogen, water and minerals return to the soil and air, and its stored energy goes to the decomposers and leaves as heat. Wood (years to centuries): rotting or burning turns it into carbon dioxide, water, minerals (ash) and heat. A star (millions to trillions of years): its outer layers are scattered as gas and dust that form new nebulae, stars and planets; its energy has gone out as light and heat; its core remains as a white dwarf, neutron star or black hole. Nothing is lost: matter and energy only change form, as the principle of conservation of energy says.

## See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at [science-playground.com/booking](http://science-playground.com/booking).

- **Coupled Pendulums** (exhibit): Start one pendulum: its swing dies as the other's grows, energy passing back and forth.

| Marks by level | Knowledge | Understanding | Application | Higher ability | Total |
|----------------|-----------|---------------|-------------|----------------|-------|
| Marks          | 12        | 11            | 4           | 2              | 29    |

