DO NOT WRITE IN THIS AREA

4 A mass suspended from a spring is oscillating vertically. The oscillations are damped.

Which of the following statements is correct?

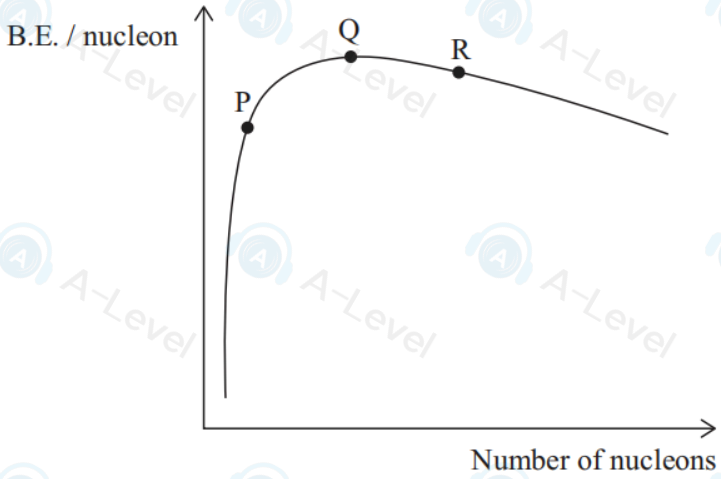
- ☒ **A** The damping force is always in the opposite direction to the acceleration.
- ☒ **B** The damping force is always in the opposite direction to the velocity.
- ☒ **C** The damping force is always in the same direction as the acceleration.
- ☒ **D** The damping force is always in the same direction as the velocity.

(Total for Question 4 = 1 mark)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

4 The graph shows how the binding energy (B.E.) per nucleon varies with the number of nucleons. The positions of three isotopes, P, Q and R, are marked on the curve.



Which row of the table lists the isotopes from least stable to most stable?

	Least stable ⟶		Most stable
☒ **A**	P	Q	R
☒ **B**	P	R	Q
☒ **C**	Q	R	P
☒ **D**	R	P	Q

(Total for Question 4 = 1 mark)

3: Energy is released when the fusion of low mass nuclei takes place.
Energy is also released when the fission of high mass nuclei takes place.

Which row of the table shows the change in binding energy per nucleon (B.E. / nucleon) for fusion and fission?

	Nuclear fusion	Nuclear fission
☒ **A**	B.E. / nucleon decreases	B.E. / nucleon decreases
☒ **B**	B.E. / nucleon decreases	B.E. / nucleon increases
☒ **C**	B.E. / nucleon increases	B.E. / nucleon decreases
☒ **D**	B.E. / nucleon increases	B.E. / nucleon increases

(Total for Question 3 = 1 mark)

5 Measurements related to a distant galaxy may be used to determine the value of the Hubble constant.

Which two measurements related to a distant galaxy must be used?

☒ **A** distance from the Earth and mass

☒ **B** distance from the Earth and recession velocity

☒ **C** luminosity and mass

☒ **D** luminosity and recession velocity

(Total for Question 5 = 1 mark)

2 Ductile materials can be used in buildings to reduce the amplitude of forced oscillations during an earthquake.

Which of the following is the reason that ductile materials are used?

☒ **A** These materials are stiff.

☒ **B** These materials are strong.

☒ **C** These materials deform elastically.

☒ **D** These materials deform plastically.

(Total for Question 2 = 1 mark)

7: A student used a detector to determine the intensity of radiation from a source of gamma radiation. After correcting for background, the intensity of radiation recorded by the detector was I_0.

A lead sheet of thickness 2.5 cm was placed between the source and the detector. The corrected intensity of radiation recorded by the detector was now $0.50 I_0$.

The original lead sheet was replaced by a new lead sheet of thickness 7.5 cm.

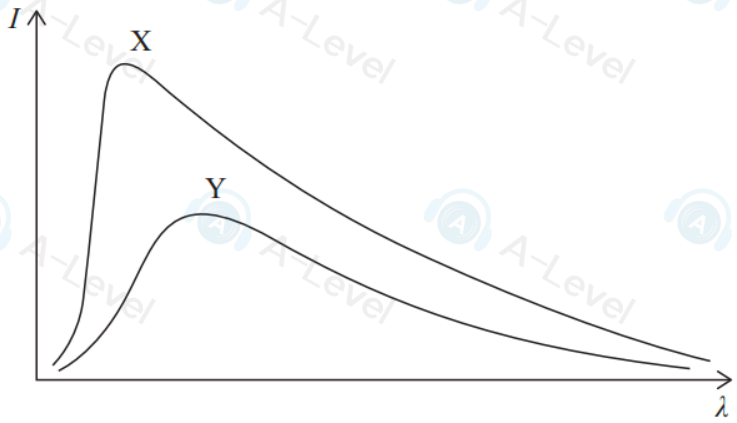
Which of the following was the corrected intensity of gamma radiation recorded by the detector?

- ☒ **A** $0.33 I_0$
- ☒ **B** $0.25 I_0$
- ☒ **C** $0.13 I_0$
- ☒ **D** $0.06 I_0$

(Total for Question 7 = 1 mark)

8: Two stars, X and Y, have the same luminosity.

The graph shows how the intensity I of radiation received at Earth from star X and star Y varies with wavelength λ.



Which of the following statements can be deduced from the graph?

- ☒ **A** Star X has a higher surface temperature and is closer than star Y.
- ☒ **B** Star X has a lower surface temperature and is closer than star Y.
- ☒ **C** Star X has a higher surface temperature and is further away than star Y.
- ☒ **D** Star X has a lower surface temperature and is further away than star Y.

(Total for Question 8 = 1 mark)

6: In a laboratory, the background count rate is 22 counts per minute.

A detector is placed 25 cm from a gamma source. The count rate recorded by the detector is 54 counts per minute.

The detector is then placed 50 cm from the source.

Which of the following is the expected number of counts per minute?

☒ **A** $\left(\frac{54 - 22}{2}\right) + 22$

☒ **B** $\left(\frac{54 - 22}{4}\right) + 22$

☒ **C** $\left(\frac{54 + 22}{2}\right) - 22$

☒ **D** $\left(\frac{54 + 22}{4}\right) - 22$

(Total for Question 6 = 1 mark)

DO NOT WRITE IN THIS AREA DO NOT W

8 Which row of the table gives the relative ionising power and penetration of gamma radiation?

	Ionising power	Penetration
☒ **A**	low	low
☒ **B**	low	high
☒ **C**	high	low
☒ **D**	high	high

(Total for Question 8 = 1 mark)

DO NOT WRITE IN THIS A

2 Which of the following can be used to determine the distance to a nearby star?

☒ **A** Doppler shift

☒ **B** Hertzsprung–Russell diagram

☒ **C** Hubble's law

☒ **D** Trigonometric parallax

(Total for Question 2 = 1 mark)

T WRITE IN THIS AREA

(b) Explain how this Hertzsprung-Russell diagram shows that the star cluster is not a young star cluster.

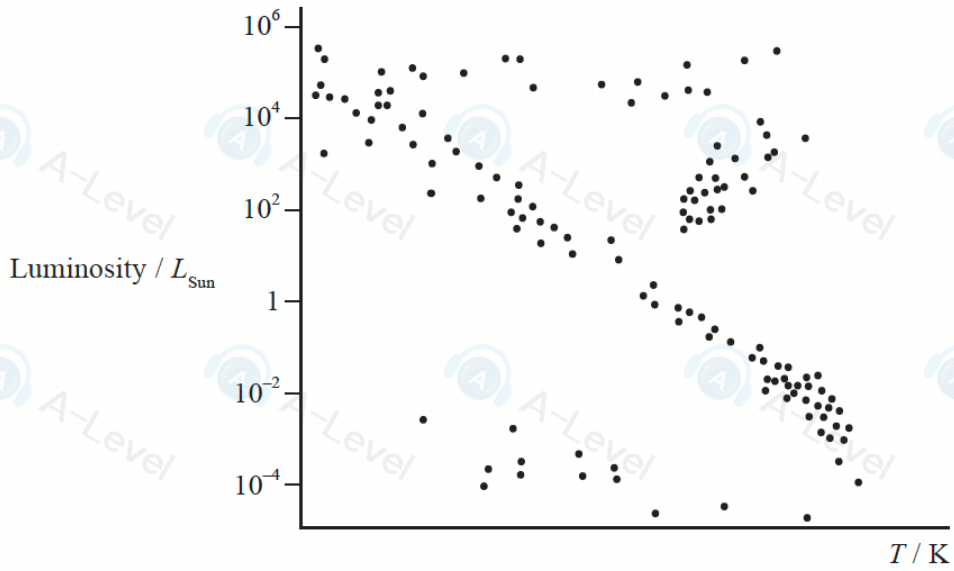
You should refer to groups of stars and their positions on this diagram.

(3)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

20 The Hertzsprung-Russell diagram for a star cluster is shown.



(a) Add a scale to the horizontal axis.

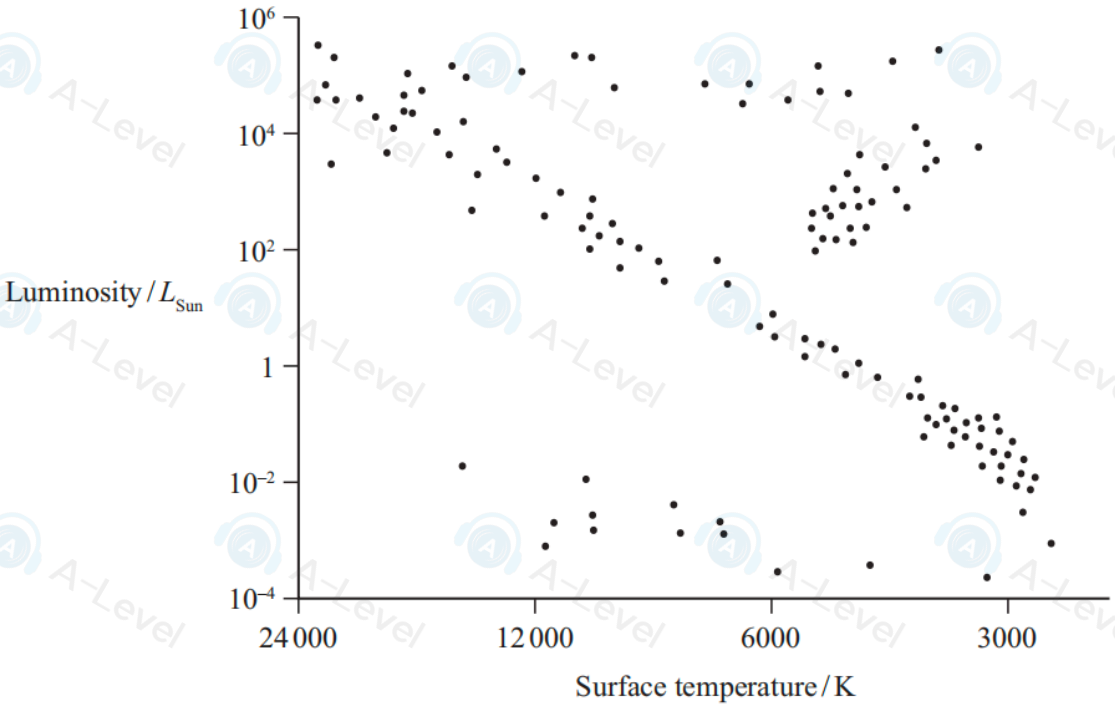
(2)

(b) Explain how this Hertzsprung-Russell diagram shows that the star cluster is not a young star cluster.

You should refer to groups of stars and their positions on this diagram.

(3)

18: The Hertzsprung-Russell diagram shows the relationship between the luminosity and the surface temperature of a range of stars.

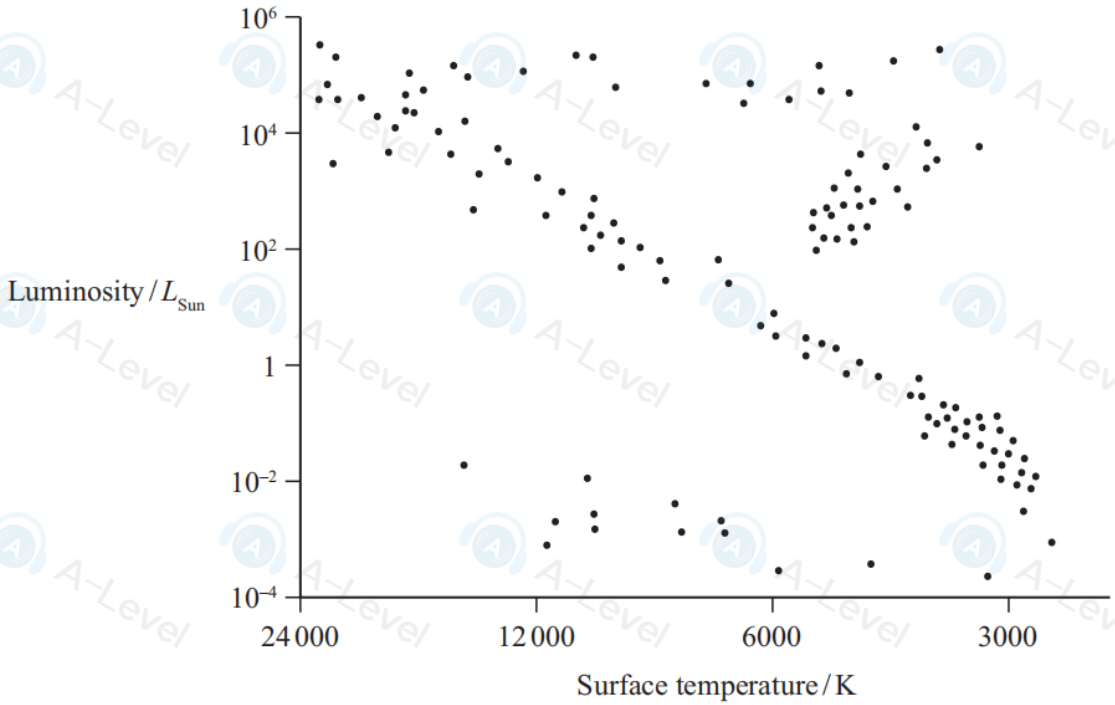


(a) The Sun is a main sequence star.

(i) Label the position of the Sun on the diagram with the letter **S**.

(1)

18: The Hertzsprung-Russell diagram shows the relationship between the luminosity and the surface temperature of a range of stars.



(a) The Sun is a main sequence star.

(i) Label the position of the Sun on the diagram with the letter **S**.

(1)

(ii) In the final stages of the Sun's evolution, it will become a white dwarf star.

Draw on the diagram a possible path of the Sun as it evolves to a white dwarf star.

(2)

*(b) Describe the stages in the evolution of the Sun from a main sequence star to a white dwarf star.

(6)

(c) Explain why the Sun will stay on the main sequence for a much greater time than the most massive main sequence stars.

(2)

(Total for Question 18 = 11 marks)