Q1.(a) There are many isotopes of the element molybdenum (Mo).

What do the nuclei of different molybdenum isotopes have in common?

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(1)

(b) The isotope molybdenum-99 is produced inside some nuclear power stations from the nuclear fission of uranium-235.

(i) What happens during the process of nuclear fission?

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(1)

(ii) Inside which part of a nuclear power station would molybdenum be produced?

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(1)

(c) When the nucleus of a molybdenum-99 atom decays, it emits radiation and changes into a nucleus of technetium-99.

$$^{99}_{42}\text{Mo} \longrightarrow {}^{99}_{43}\text{Tc} + \text{Radiation}$$

What type of radiation is emitted by molybdenum-99?

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Give a reason for your answer.

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(2)

(d) Technetium-99 has a short half-life and emits gamma radiation.

What is meant by the term ‘half-life’?

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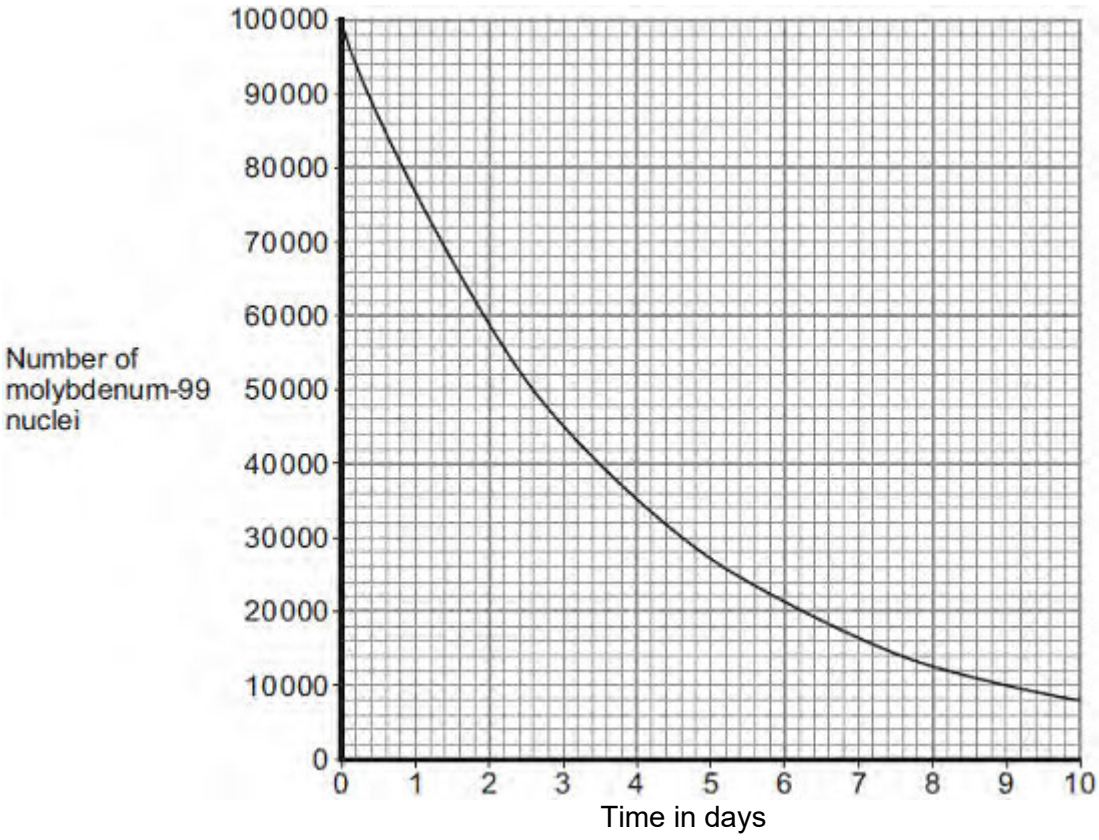
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(1)

(e) Technetium-99 is used by doctors as a medical tracer. In hospitals it is produced inside a technetium generator by the decay of molybdenum-99 nuclei.

(i) The figure below shows how the number of nuclei in a sample of molybdenum-99 changes with time as the nuclei decay.



A technetium generator will continue to produce sufficient technetium-99 until 80% of the original molybdenum nuclei have decayed.

After how many days will a source of molybdenum-99 inside a technetium-99 generator need replacing?

Show clearly your calculation and how you use the graph to obtain your answer.

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Number of days = ...

(2)

(ii) Medical tracers are injected into a patient's body; this involves some risk to the patient's health.

Explain the risk to the patient of using a radioactive substance as a medical tracer.

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(2)

(iii) Even though there may be a risk, doctors frequently use radioactive substances for medical diagnosis and treatments.

Suggest why.

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(1)
(Total 11 marks)

Q2. (a) Our star, the Sun, is stable.

Explain what the conditions need to be for a star to remain stable.

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(2)

(b) Shortly after the 'big bang', hydrogen was the only element in the Universe.

Explain how the other elements came to be formed.

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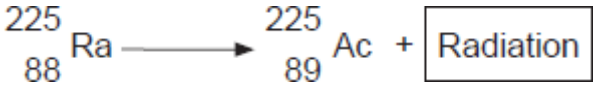
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(3)
(Total 5 marks)

Q3. When the nucleus of a radium-225 atom decays, it changes into a nucleus of actinium-225.



What type of radiation is emitted by radium-225?

Draw a ring around your answer.

alpha **beta** **gamma**

Explain the reason for your answer.

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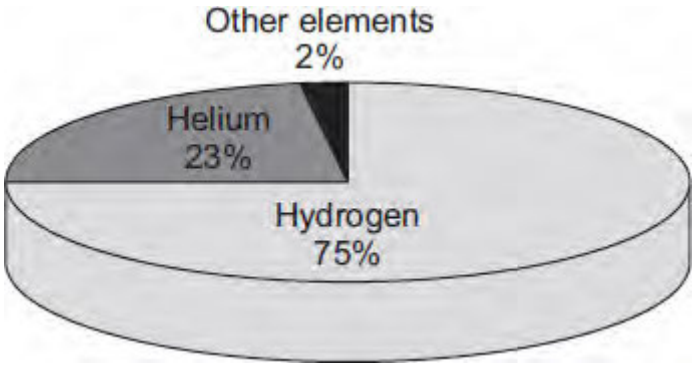
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(Total 3 marks)

Q4. This passage is from a web page.

Our nearest star, the Sun

The pie chart shows the proportions of chemical elements in the Sun.



Most of the Sun's helium has been produced from the Sun's hydrogen by the process of nuclear fusion. This process also produces vast quantities of energy. The process takes place in the core of the Sun at a temperature of about 15 million °C and has been going on for about 4.5 billion years. During this period of time, the Sun has remained stable and scientists think that it will remain stable for several billion years into the future.

(a) Explain why the Sun remains stable.

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(3)

(b) A scientific opinion is expressed on this web page.

Identify this opinion and suggest how scientists could justify it.

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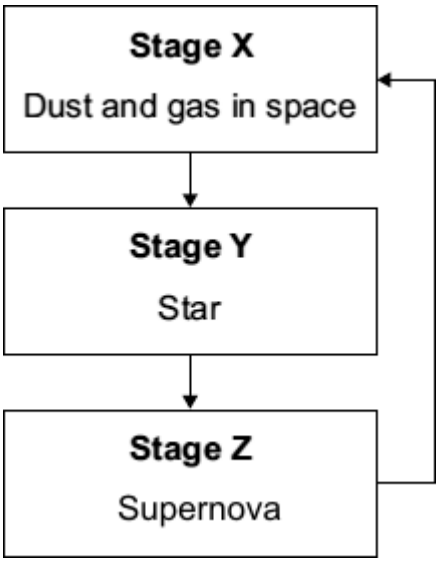
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(2)

(Total 5 marks)

Q5. The flowchart shows a simple version of the life cycle of a star that is much more massive than the Sun.



(a) What causes the change from **Stage X** to **Stage Y**?

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(1)

(b) For most of its time in **Stage Y**, the star is stable.

Explain why the star remains stable.

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(2)

(c) (i) Explain how a star is able to produce energy in **Stage Y**.

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(2)

(ii) Why is a star in **Stage Y** able to give out energy for millions of years?

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(1)

(d) What happens to the elements produced in a supernova?

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(1)

(Total 7 marks)

Q6. (a) As part of its life cycle, a star changes from being a protostar to a main sequence star.

Explain the difference between a protostar and a main sequence star.

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(2)

(b) The early Universe contained only atoms of hydrogen. The Universe now contains atoms of over one hundred different elements.

Explain how the different elements now contained in the Universe were formed.

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(3)
(Total 5 marks)

Q7.(a) Nuclear power stations generate about 14% of the world's electricity.

(i) Uranium-235 is used as a fuel in some nuclear reactors.

Name **one** other substance used as a fuel in some nuclear reactors.

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(1)

(ii) Energy is released from nuclear fuels by the process of nuclear fission.

This energy is used to generate electricity.

Describe how this energy is used to generate electricity.

Do **not** explain the nuclear fission process.

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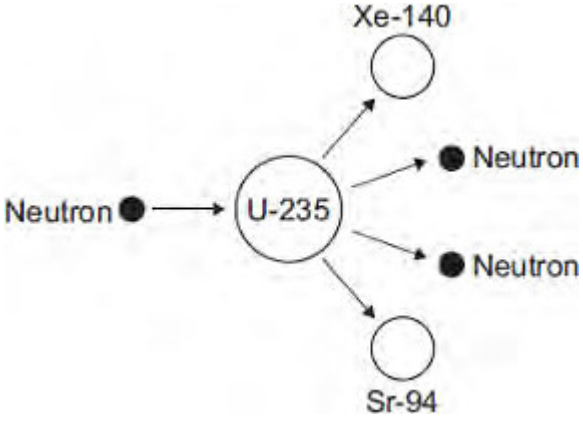
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(3)

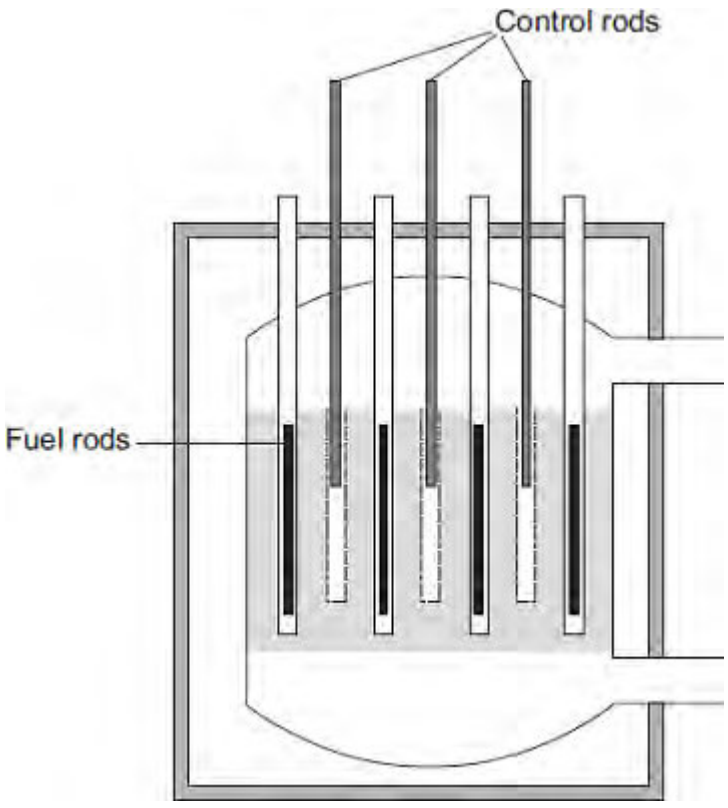
(b) The diagram shows the nuclear fission process for an atom of uranium-235.

Complete the diagram to show how the fission process starts a chain reaction.



(2)

(c) The diagram shows the cross-section through a nuclear reactor.



The control rods, made from boron, are used to control the chain reaction. Boron atoms absorb neutrons without undergoing nuclear fission.

Why does lowering the control rods reduce the amount of energy released each second from the nuclear fuel?

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(2)
(Total 8 marks)

Q8.(a) Nuclear fuels and the wind are two of the energy sources used to generate electricity in the UK.

Explain the advantages of using energy from nuclear fuels to generate electricity rather than using energy from the wind.

Include in your answer a brief description of the process used to generate electricity from nuclear fuels.

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(4)

(b) In the UK, most electricity is generated in power stations that emit carbon dioxide into the atmosphere. The impact of these power stations on the environment could be reduced by the increased use of 'carbon capture' technology.

Describe how 'carbon capture' would prevent the build-up of carbon dioxide in the atmosphere.

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(2)
(Total 6 marks)

Q9. Read this statement from a website.

Immediately after the 'big bang', at the start of the Universe, there were only atoms of the element hydrogen (H).

Now there are over one hundred elements.
Scientists think that all the elements on Earth are also present throughout the Universe.

(a) Explain how atoms of the element (He) are formed in a star.

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(2)

(b) Explain how atoms of very heavy elements, such as gold (Au), were formed.

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(2)

(c) Scientists have only examined a tiny fraction of the Universe.

What is the basis for scientists thinking that the elements found on Earth are present throughout the Universe?

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(1)
(Total 5 marks)