AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



EXAM QUESTION PACK

4.4.4 NUCLEAR FISSION AND FUSION (PACK 2)

SCORE	PERCENTAGE
/100	%

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Q1.

The statement in the box is from an article in a science magazine.

Scientists think that all the elements on Earth are also present throughout the Universe.

(a) (i) Name the process by which these elements were formed.

_____

(1)

(ii) Where did the elements form?

_____

(1)

(iii) What caused these elements to be distributed throughout the Universe?

_____

(1)

(b) Scientists have only examined a tiny fraction of the Universe. What is the basis for the statement in the science magazine?

_____

_____

(1)

(Total 4 marks)

Q2.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

Explain briefly how stars like the Sun are thought to have been formed.

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(Total 2 marks)

Q3.

(a) Nuclear power stations use the energy released by *nuclear fission* to generate electricity.

(i) Explain what is meant by *nuclear fission*.

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_____

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(2)

(ii) How does nuclear fission lead to a chain reaction?

You may give your answer as a labelled diagram.

_____

_____

(1)

(b) Although nuclear fuels are relatively cheap the total cost of generating electricity using nuclear fuels is expensive. Why?

_____

_____

(1)

(c) The table compares the energy released from 1 kg of coal and 1 kg of uranium.

Coal	29 MJ
Uranium	580 000 MJ

1 MJ = 1 000 000 joules

State **one** benefit to the environment of using a concentrated fuel like uranium to generate electricity rather than using the energy from coal.

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(1)

(Total 5 marks)

Q4.

(a) Explain how stars produce energy.

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(2)

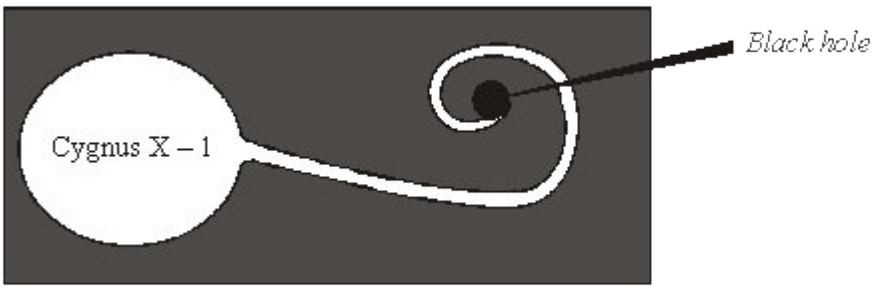
(b) What evidence is there to suggest that the Sun was formed from the material produced when an earlier star exploded?

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(1)

(c) It is thought that gases from the massive star Cygnus X-1 are spiralling into a black hole.



(i) Explain what is meant by the term *black hole*.

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(2)

(ii) What is produced as the gases from a star spiral into a black hole?

_____

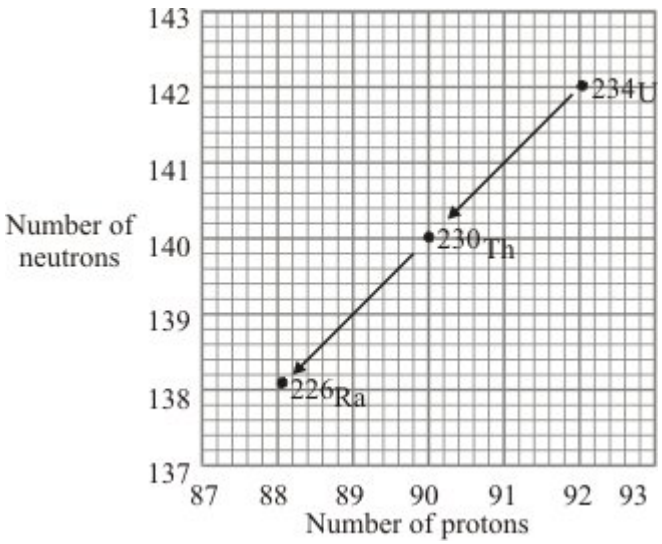
(1)

(Total 6 marks)

Q5.

(a) Uranium-234 (^{234}U) is a radioactive element. The graph shows the number of protons and neutrons in the nuclei of the elements formed when uranium-234 decays.

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(i) How does the graph show that uranium-234 (^{234}U) and thorium-230 (^{230}Th) emit alpha particles?

_____

(1)

(ii) What makes uranium and thorium different elements?

_____

(1)

(iii) Radioactive decay may also produce gamma radiation.

Why does the emission of gamma radiation **not** cause a new element to be formed?

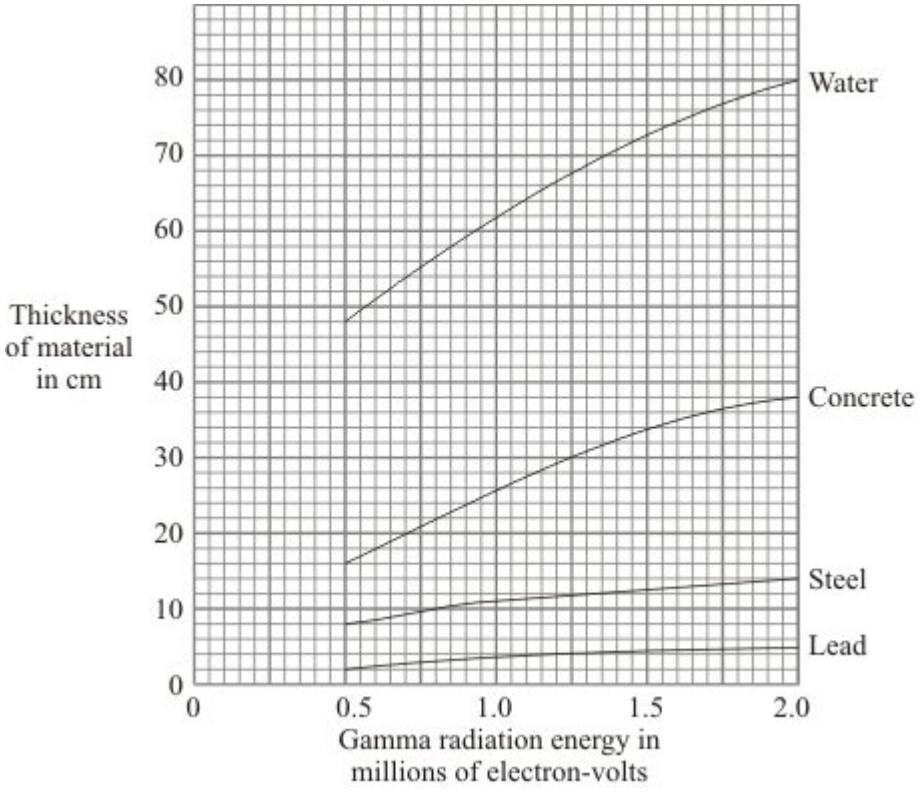
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(1)

(b) The graph shows how the thickness of different materials needed to absorb 90% of the gamma radiation emitted by a source depends on the energy of the radiation. The energy of the gamma radiation is given in units called electron-volts.

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(i) Which of the materials shown is least effective at absorbing gamma radiation? Use the information in the graph to give a reason for your answer.

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(1)

(ii) For gamma radiation of energy 1.5 million electron-volts, how many times more effective is steel than water at absorbing the radiation? Show clearly how you obtain your answer.

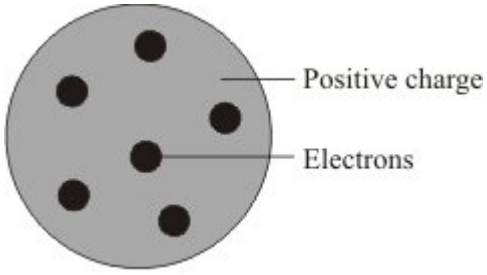
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(2)

(c) Scientists in the early twentieth century thought that atoms were made up of electrons scattered inside a ball of positive charge. This was called the 'plum-pudding' model of the atom.



Plum pudding model

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Rutherford and Marsden did an experiment, in which a beam of alpha particles was aimed at a thin sheet of gold.
Explain how the results of this experiment led to a new model of the atom.
You may include one or more diagrams in your answer.

(3)
(Total 9 marks)

Q6.

(a) Most of the Sun is hydrogen. Inside the core of the sun, hydrogen is being converted to helium. What name is given to this process and why is the process so important?

(2)

(b) Describe what will happen to the Sun as the core runs out of hydrogen.

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(3)

(Total 5 marks)

Q7.

The first commercial nuclear power station in the world was built at Calder Hall in Cumbria.

(a) The fuel used at the Calder Hall power station is uranium. Natural uranium consists mainly of two isotopes: uranium-235 $\left({}^{235}_{92}U\right)$ and uranium-238 $\left({}^{238}_{92}U\right)$. The nucleus of a uranium-235 atom is different to that of a uranium-238 atom.

(i) Where is the nucleus in an atom?

_____

(1)

(ii) Name the **two** types of particle found in the nucleus.

_____ and _____

(2)

(iii) How is the nucleus of a uranium-238 atom different to the nucleus of a uranium-235 atom?

_____

_____

_____

(2)

(b) In the nuclear reactor fission of uranium atoms takes place in reactions such as the one shown below.

$${}^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{138}_{53}I + {}^{95}_{39}Y + 3({}^{1}_{0}n)$$

The nuclear reactions are carefully controlled in the power station so that a chain reaction takes place.

Explain, as fully as you can:

(i) how fission of uranium atoms takes place in a nuclear reactor;

_____

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_____

(ii) how this leads to a chain reaction;

_____

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(iii) why it can be used to generate electricity.

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(4)

(Total 9 marks)

Q8.

The first commercial nuclear power station in the world was built at Calder Hall in Cumbria.

The atoms produced by the fission of uranium are also radioactive. The used fuel is sent to a reprocessing plant where it can be safely treated.

(i) Calder Hall power station is next to the Sellafield reprocessing plant. Suggest an advantage of having the two plants close together.

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(1)

(ii) One of the radioactive products is iodine-138. This has a half-life of 6 seconds.
A sample of radioactive material contains 2000 atoms of iodine-138.
How long will it take for the number of iodine-131 atoms to decrease to 125?

_____

_____

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Answer = _____ seconds

(3)

(Total 4 marks)

Q9.

Nuclear fusion in the Sun releases large amounts of energy.

(i) Explain what is meant by nuclear fusion.

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(3)

(ii) Why is energy released by such nuclear fusion reactions?

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(2)

(Total 5 marks)

Q10.

(a) The Sun is at the stable stage of its life.

Explain, in terms of the forces acting on the Sun, what this means.

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(3)

(b) At the end of the stable stage of its life a star will change.

Describe and explain the changes that could take place.

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(6)

(Total 9 marks)

Q11.

Our Sun is just one of many millions of stars in a galaxy called the Milky Way.

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Our Sun is in the main stable period of a star's lifetime. The massive force of gravity draws its matter together. This force is balanced by the very high temperatures, from the fusion of hydrogen atoms, which tend to make the Sun expand. Describe and explain what will happen to the Sun as the hydrogen is eventually used up.

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(Total 3 marks)

Q12.

Studying stars gives scientists evidence about the evolution of the Universe.

(a) (i) In astronomy, what is meant by a black hole?

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(2)

(ii) How is it possible to detect a black hole?

_____

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(2)

(b) The changes which happen in stars result in new elements being formed.

Nuclei of the heaviest elements are found in the Sun.

Describe how these nuclei are formed.

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(2)

(Total 6 marks)

Q13.

One theory of the origin of the Universe was that billions of years ago all matter was in one place, then it exploded ('big bang').
Describe, in as much detail as you can, how our star (the Sun) formed from the time when there was just dust and gas (mostly hydrogen) up to now when it is in its main stable period.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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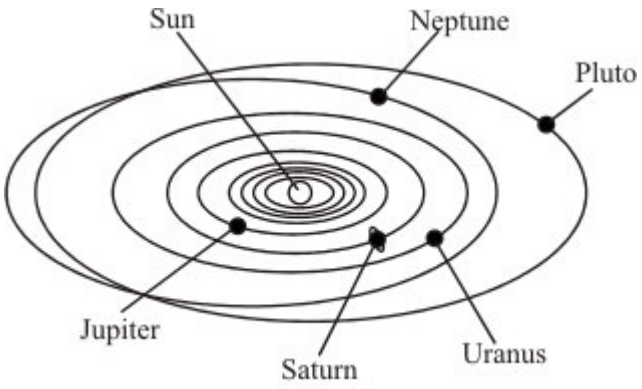
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(Total 5 marks)

Q14.

The Sun at the centre of our solar system is a star.

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(a) The Sun contains nuclei of the heaviest elements. Atoms of these heaviest elements are also present in the planets of the solar system. What does this suggest about the material from which the solar system is formed?

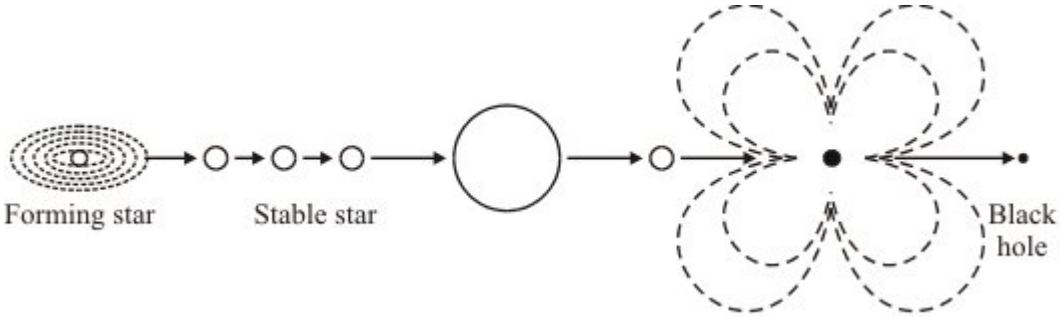
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(1)

(b) Stars form from gas (mostly hydrogen) and dust.



Describe, in as much detail as you can, what forces allow a stable star to exist and how the star may eventually form a black hole.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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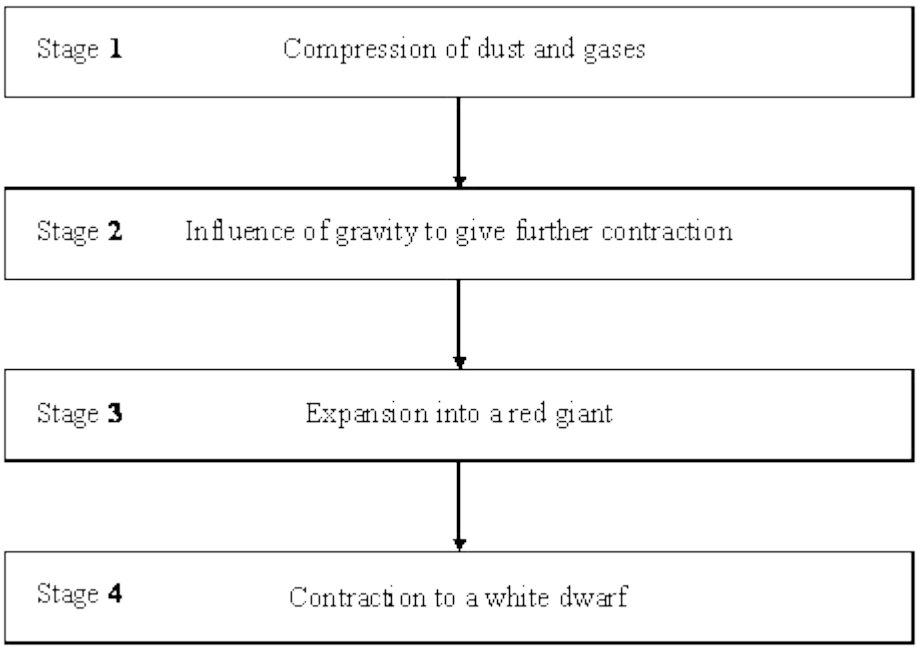
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(6)

(Total 7 marks)

Q15.

The flowchart shows four stages thought to occur in the evolution of a star such as our Sun.



At a particular time a star might have reached one of these stages or be between stages or be at a further stage. What period in its evolution has our star, the Sun, reached?

_____

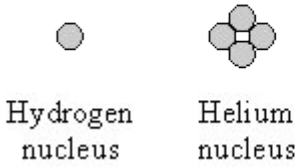
(Total 1 mark)

Q16.

At the very high temperatures in the sun, hydrogen is converted into helium. It takes four hydrogen nuclei to produce one helium nucleus.

The table shows the relative masses of hydrogen and helium nuclei.

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Nucleus	Relative Mass
hydrogen	1.007825
helium	4.0037

(a) Use these figures to calculate what happens to the mass of the sun as hydrogen is converted to helium.

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_____

_____

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(3)

(b) Use your answer to part (a) to explain how the sun has been able to radiate huge amounts of energy for billions of years.

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(2)

(Total 5 marks)

Q17.

The energy radiated by a **main sequence** star like the Sun is released by a nuclear fusion reaction in its core.

Read the following information about this reaction then use it to answer the questions below.

- The net result of the nuclear fusion reaction is that four hydrogen nuclei produce one helium nucleus. There is a loss of mass of 0.7%.
- For nuclear fusion to occur nuclei must collide at very high speeds.
- The energy released during the reaction can be calculated as shown:

  energy released [J] = loss of mass [kg] × (speed of light [m/s²])

  (The speed of light is 3×10^8 m/s)

(a) Calculate the energy released when 1g of hydrogen fuses to form helium.

(*Show your working*.)

_____

_____

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(4)

(b) The table shows the lifetimes and surface temperatures of main sequence stars with different masses.

MASS OF STAR [SUN = 1]	LIFETIME ON MAIN SEQUENCE [MILLION OF YEARS]	SURFACE TEMPERATURE * [KELVIN]
0.5	200 000	4000
1	10 000	6000
3	500	11 000
15	15	30 000

[* The higher the surface temperature of a star, the higher the temperature and pressure in its core.]

(i) Describe the relationship between the lifetime of a main sequence star and its mass.

_____

_____

_____

(2)

(ii) Suggest an explanation for this relationship.

_____

_____

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(3)

(Total 9 marks)

Q18.

Describe, in as much detail as you can, the life history of a star like our Sun.

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(Total 6 marks)

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