Nuclear Fission And Fusion

These practice questions can be used by students and teachers and is

Suitable for GCSE AQA Physics Topic Question 8463

Level: GSCE AQA 8463

Subject: Physics

Exam Board: GCSE AQA

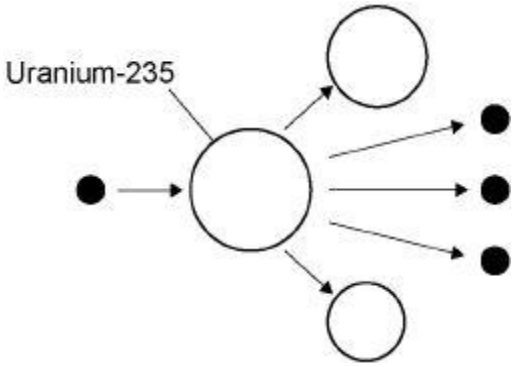
Topic: Nuclear Fission And Fusion

Q1.

Nuclear power can be used to generate electricity through nuclear fission.

Figure 1 shows the process of nuclear fission.

Figure 1



(a) Complete the sentences.

Choose answers from the box.

gamma rays	**light rays**	**proton**	**neutron**	**nucleus**	**X-rays**

During the process of nuclear fission, a uranium _____

absorbs a _____ .

Electromagnetic radiation is released in the form of _____ .

(3)

(b) The UK needs at least 25 000 000 kW of electrical power at any time.

A nuclear power station has an electrical power output of 2 400 000 kW

Calculate how many nuclear power stations are needed to provide 25 000 000 kW of electrical power.

_____

_____

_____

_____

Number of nuclear power stations = _____

(2)

(c) State **two** environmental issues caused by generating electricity using nuclear power stations.

1. _____

_____

2. _____

_____

(2)

(d) The UK currently generates a lot of electricity by burning natural gas. This process releases carbon dioxide into the atmosphere.

Figure 2 shows how the concentration of carbon dioxide in the atmosphere has changed over the past 115 years.

Figure 2

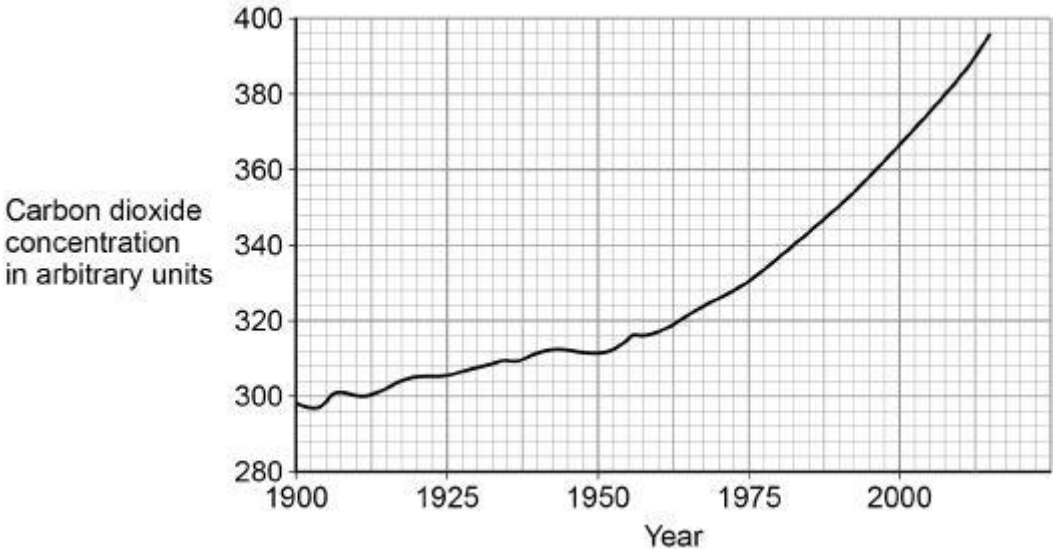
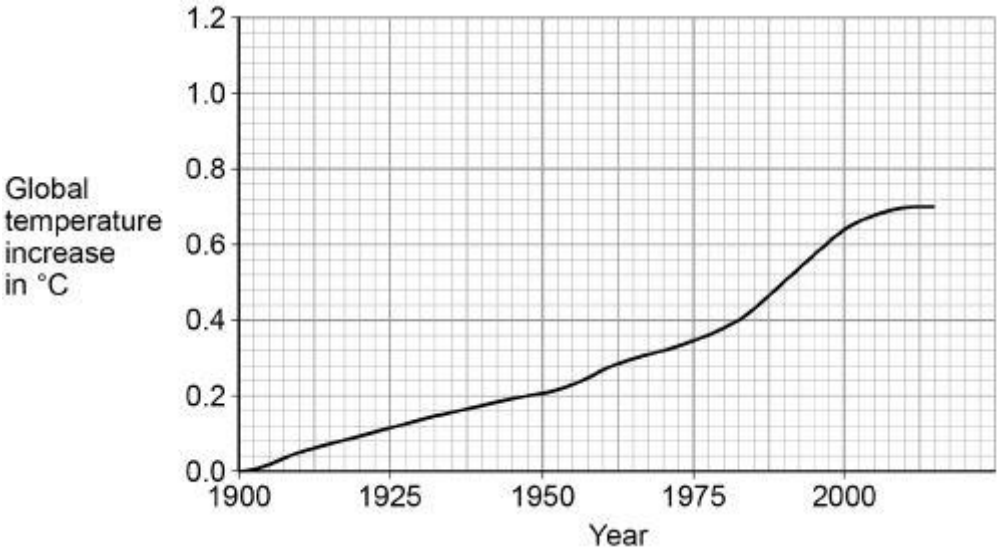


Figure 3 shows how the global temperature has changed over the past 115 years.

Figure 3



Give **one** similarity and **one** difference between the data in **Figure 2** and **Figure 3**.

Similarity _____

_____

_____

Difference _____

_____

_____

(2)

(Total 9 marks)

Q2.

Nuclear power stations generate electricity through nuclear fission. Electricity can also be generated by burning shale gas.

(a) Shale gas is natural gas trapped in rocks. Shale gas can be extracted by a process called fracking. There is some evidence that fracking causes minor earthquakes. Burning shale gas adds carbon dioxide to the atmosphere.

Describe the advantages of nuclear power compared with the use of shale gas to generate electricity.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(b) What is the name of **one** fuel used in nuclear power stations?

_____

(1)

(c) Describe the process of nuclear fission.

_____

_____

(4)

(Total 8 marks)

Q3.

Nuclear fission and nuclear fusion are two processes that release energy.

(a) The following nuclear equation represents the fission of uranium-235 (U-235).

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{energy}$$

Chemical symbols:

- Ba = barium
- Kr = krypton
- $^{1}_{0}n$ = neutron

Describe the process of nuclear fission.

Use the information in the equation.

(4)

(b) Explain what happens in the process of nuclear fusion.

(3)

(c) Fission reactors are used in nuclear power stations.

Engineers are developing fusion reactors for use in power stations.

Fusion uses isotopes of hydrogen called deuterium and tritium.

- Deuterium is naturally occurring and can be easily extracted from seawater.
- Tritium can be produced from lithium. Lithium is also found in seawater.

The table shows the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Type of fuel	**Energy released from 1 kg of fuel in joules**
Fusion	3.4×10^{14}
Fission	8.8×10^{13}

Suggest **two** advantages of the fuel used in a fusion reactor compared with the fuel used in a fission reactor.

1. _____

2. _____

(2)

(Total 9 marks)

Q4.

(a) Uranium has two natural isotopes, uranium-235 and uranium-238.

Use the correct answer from the box to complete the sentence.

electrons	neutrons	protons

The nucleus of a uranium-238 atom has three more _____ than the nucleus of a uranium-235 atom.

(1)

(b) Uranium-235 is used as a fuel inside a nuclear reactor.
Energy is released from nuclear fuels by the process of nuclear fission.

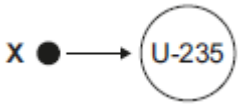
What is the energy released from nuclear fuels inside a nuclear reactor used for?

_____

(1)

(c) **Figure 1** shows the nucleus of an atom of uranium-235 (U-235) about to undergo nuclear fission.

Figure 1



(i) Before nuclear fission can happen the nucleus of a uranium atom has to absorb the particle labelled **X**.

What is particle **X**?

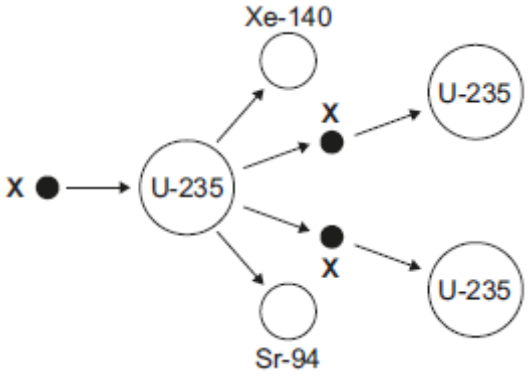
Tick (✔) **one** box.

an electron ☐ a neutron ☐ a proton ☐

(1)

(ii) The process of nuclear fission, shown in **Figure 2**, causes the nucleus of the uranium-235 (U-235) atom to split apart and release two of the particles X.

Figure 2



Complete **Figure 2** to show how the particles **X start** a chain reaction.

(2)

(Total 5 marks)

Q5.

(a) Brown dwarf stars are thought to have been formed in the same way as other stars. They are too small for nuclear fusion reactions to take place in them.
Brown dwarf stars emit infrared radiation but are not hot enough to emit visible light.

(i) Describe how a star is formed.

_____

_____

_____

_____

(2)

(ii) Describe the process of nuclear fusion.

_____

_____

_____

(1)

(iii) Scientists predicted that brown dwarf stars existed before the first one was discovered in 1995.

Suggest **one** reason why scientists are now able to observe and identify brown dwarf stars.

_____

_____

_____

(1)

(b) In the 18th century some scientists suggested a theory about how the planets formed in the Solar System. The theory was that after the Sun formed, there were cool discs of matter rotating around the Sun. These cool discs of matter formed the planets. The scientists thought this must have happened around other stars too.

(i) Thinking about this theory, what would the scientists have predicted to have been formed in other parts of the Universe?

_____

_____

(1)

(ii) Since the 1980s scientists studying young stars have shown the stars to be surrounded by cool discs of rotating matter.

What was the importance of these observations to the theory the scientists suggested in the 18th century?

_____

_____

(1)

(c) The Earth contains elements heavier than iron.

Why is the presence of elements heavier than iron in the Earth evidence that the Solar System was formed from material produced after a massive star exploded?

_____

_____

(1)

(Total 7 marks)

Q6.

Atoms are different sizes.

One of the heaviest naturally occurring stable elements is lead.

Two of its isotopes are lead-206 ($^{206}_{82}Pb$) and lead-208 ($^{208}_{82}Pb$).

(a) (i) What is meant by 'isotopes'?

_____

_____

_____

_____

(2)

(ii) How many protons are in the nucleus of a $^{206}_{82}Pb$ atom?

_____

(1)

(iii) How many neutrons are in the nucleus of a $^{206}_{82}Pb$ atom?

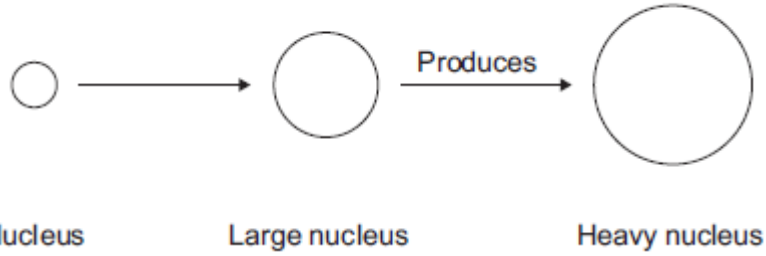
_____

(1)

(b) A nucleus can be accelerated in a particle accelerator and directed at a large nucleus. This produces a heavy nucleus that will decay after a short time.

This is shown in **Figure 1**.

Figure 1



(i) In 1984, nuclei of iron (Fe) were directed at nuclei of lead (Pb). This produced nuclei of hassium (Hs).

Complete the equation for this reaction by writing numbers in the empty boxes.

$$\square^{58}\mathrm{Fe} + \frac{\square}{\square}\mathrm{Pb} = {}^{265}_{108}\mathrm{Hs} + {}^{1}_{0}\mathrm{X}$$

(3)

(ii) Use the correct answer from the box to complete the sentence.

an electron	**a proton**	**a neutron**

The particle **X** in part (b)(i) is _____ .

(1)

(iii) After acceleration the iron nuclei travel at a steady speed of one-tenth of the speed of light.

The speed of light is 3.00×10^8 m/s.

Calculate the time taken for the iron nuclei to travel a distance of 12 000 m.

_____

_____

Time taken = _____ s

(2)

(iv) Linear accelerators, in which particles are accelerated in a straight line, are **not** used for these experiments. Circular particle accelerators are used.

Suggest why.

_____

_____

_____

_____

_____

_____

(3)

(c) Hassium-265 ($^{265}_{108}Hs$) decays by alpha emission with a half-life of 0.002 seconds.

(i) What is meant by 'half-life'?

Tick (✓) **two** boxes.

	Tick (✓)
The average time for the number of nuclei to halve	
The time for count rate to be equal to background count	
The time for background count to halve	
The time for count rate to halve	

(2)

(ii) Complete the equation for the decay of Hs-265 by writing numbers in the empty boxes.

$$^{265}_{108}Hs = \frac{\square}{\square}Sg + \frac{\square}{\square}\alpha$$

(2)

(d) The table below shows how the atomic radius of some atoms varies with atomic number.

Atomic number	**Atomic radius in picometres (pm)**
15	100
35	115

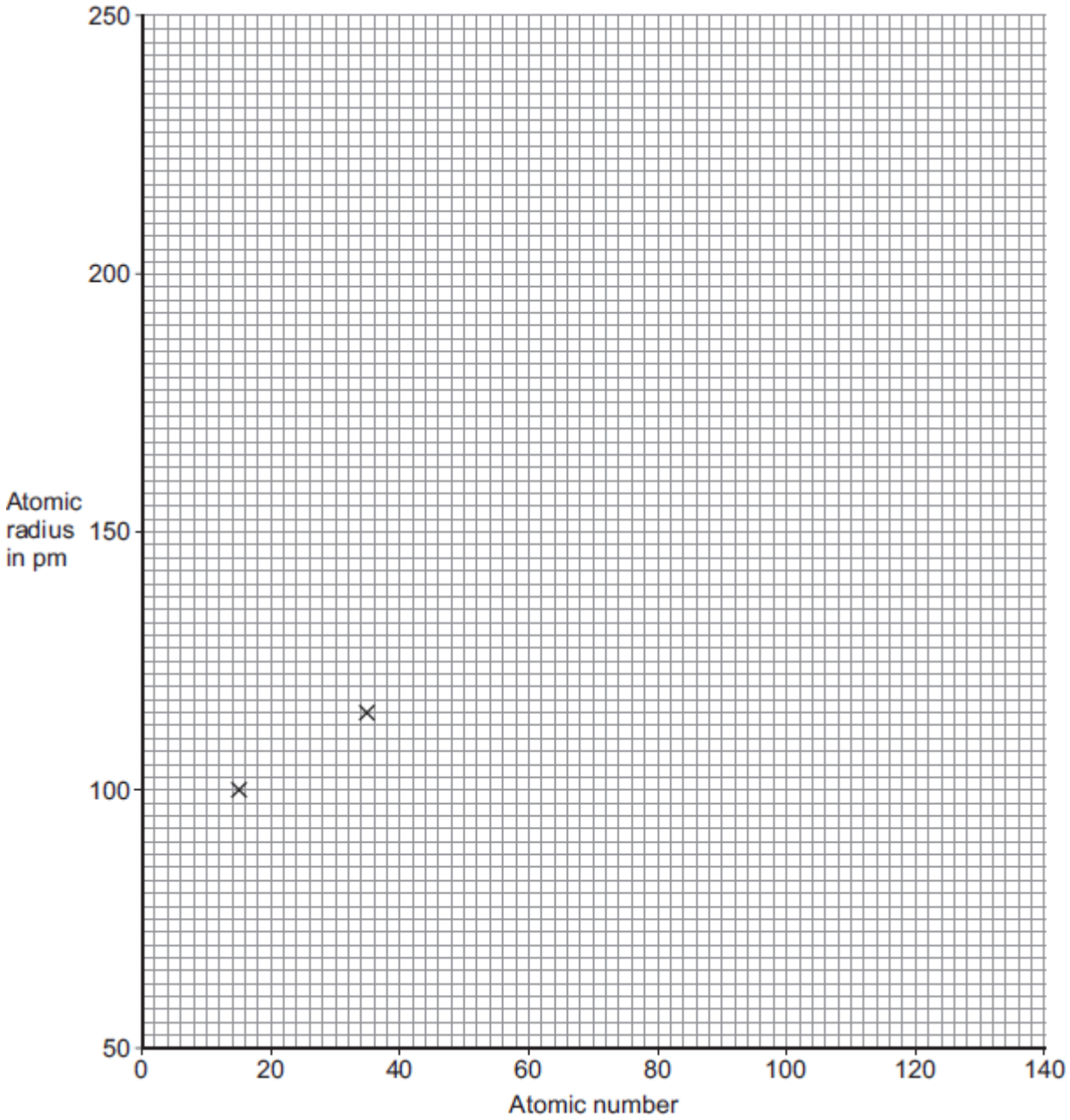
50	130
70	150
95	170

1 pm = 10^{-12} m

(i) On **Figure 2**, use the data from the table above to plot a graph of atomic radius against atomic number and draw a line of best fit.

Two points have been plotted for you.

Figure 2



(2)

(ii) Scientists believe that the element with atomic number 126 can be produced and that it will be stable.

Use your graph in **Figure 2** to predict the atomic radius of an atom with atomic number 126.

Atomic radius = _____ pm

(1)

(Total 20 marks)

Q7.

The equation below shows the process by which two atomic nuclei join to form a different nucleus.

$$^{1}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He$$

(a) Where does the process shown by the equation above happen naturally?

Tick (✓) **one** box.

Inside the Earth ☐

Inside a nuclear power station ☐

Inside the Sun ☐

(1)

(b) Use the correct answer from the box to complete the sentence.

fission	**force**	**fusion**

The process of joining two atomic nuclei to form a different nucleus is called

nuclear _____ .

(1)

(c) What is released during this process?

Draw a ring around the correct answer.

charge **energy** **force**

(1)
(Total 3 marks)

Q8.

Many countries use nuclear power stations to generate electricity.
Nuclear power stations use the process of nuclear fission to release energy.

(a) (i) What is nuclear fission?

_____

_____

(1)

(ii) Plutonium-239 is one substance used as a fuel in a nuclear reactor. For nuclear fission to happen, the nucleus must absorb a particle.

What type of particle must be absorbed?

_____

(1)

(b) Nuclear **fusion** also releases energy.
Nuclear fusion happens at very high temperatures. A high temperature is needed to overcome the repulsion force between the nuclei.

(i) Why is there a repulsion force between the nuclei of atoms?

_____

_____

(1)

(ii) Where does nuclear fusion happen naturally?

_____

(1)

(c) In 1991, scientists produced the first controlled release of energy from an experimental nuclear **fusion** reactor. This was achieved by fusing the hydrogen isotopes, deuterium and tritium.

Deuterium is naturally occurring and can easily be extracted from seawater. Tritium can be produced from lithium. Lithium is also found in seawater.

The table gives the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Type of fuel	**Energy released from 1 kg of fuel in joules**
Fusion fuel	3.4×10^{14}

Fission fuel	8.8×10^{13}

(i) Suggest **two** advantages of the fuel used in a fusion reactor compared with plutonium and the other substances used as fuel in a fission reactor.

1. _____

_____

_____

2. _____

_____

_____

(2)

(ii) Some scientists think that by the year 2050 a nuclear fusion power station capable of generating electricity on a large scale will have been developed.

Suggest **one** important consequence of developing nuclear fusion power stations to generate electricity.

_____

_____

_____

(1)

(d) Tritium is radioactive.

After 36 years, only 10 g of tritium remains from an original sample of 80 g.

Calculate the half-life of tritium.

Show clearly how you work out your answer.

_____

_____

Half-life = _____ years

(2)

(Total 9 marks)

Q9.

Stars go through a life cycle.

Some stars will finish their life cycle as a black dwarf and other stars as a black hole.

(a) The table below gives the mass, relative to the Sun, of three stars, **J**, **K** and **L**.

Star	Mass of the star relative to the Sun
J	0.5
K	14.5
L	20.0

Which **one** of the stars, **J**, **K** or **L**, will become a black dwarf? _____

Give a reason for your answer.

_____

_____

(2)

(b) Scientists can take the measurements needed to calculate the mass of many stars.

Scientists cannot calculate the mass of the star Betelgeuse.

They estimate that the star has a mass between 8 and 20 times the mass of the Sun.

(i) Betelgeuse is in the red super giant stage of its life cycle.

What will happen to Betelgeuse at the end of the red super giant stage?

_____

_____

(1)

(ii) Suggest **one** reason why scientists can only estimate and **not** calculate the mass of Betelgeuse.

_____

_____

_____

(1)

(iii) In the future, it may become possible for scientists to calculate the mass of Betelgeuse.

Suggest **one** reason why.

_____

_____

_____

(1)

(c) Describe what happens to a star, after the main sequence period, for the star to eventually become a **black dwarf**.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 10 marks)

Q10.

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

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

_____

(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?

_____

_____

(1)

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

_____

(1)

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

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

What type of radiation is emitted by molybdenum-99?

_____

Give a reason for your answer.

_____

_____

(2)

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

What is meant by the term 'half-life'?

_____

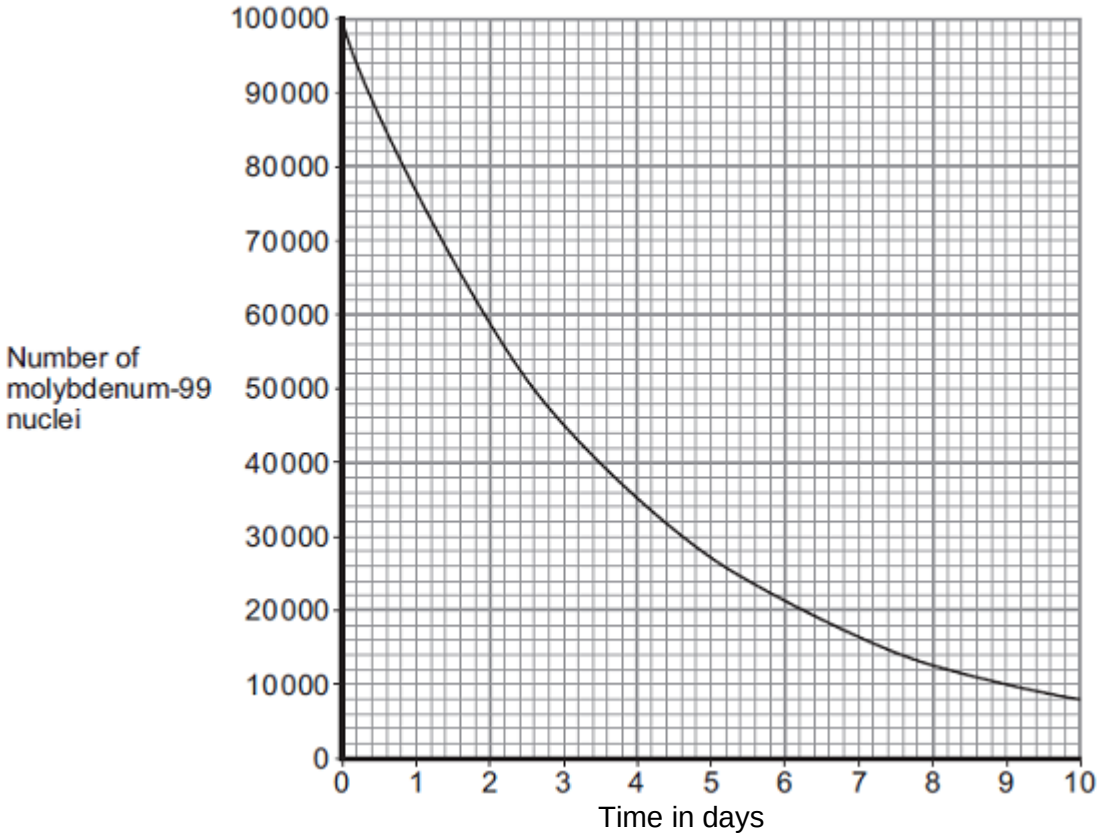
_____

_____

(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.

_____

_____

_____

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.

_____

_____

_____

_____

(2)

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

Suggest why.

_____

_____

(1)

(Total 11 marks)

Q11.

Nuclear fission and nuclear fusion are two processes that release energy.

(a) (i) Use the correct answer from the box to complete each sentence.

Geiger counter	**nuclear reactor**	**star**

Nuclear fission takes place within a _____ .

Nuclear fusion takes place within a _____ .

(2)

(ii) State **one** way in which the process of nuclear fusion differs from the process of nuclear fission.

_____

_____

(1)

(b) The following nuclear equation represents the fission of uranium-235 (U-235).

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{energy}$$

Chemical symbols:

Ba - barium

Kr - krypton

(i) Use the information in the equation to describe the process of nuclear fission.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(ii) An isotope of barium is Ba-139.
Ba-139 decays by beta decay to lanthanum-139 (La-139).

Complete the nuclear equation that represents the decay of Ba-139 to La-139.

$$^{139}\text{Ba} \longrightarrow {}^{139}\text{La} + \text{.....}$$

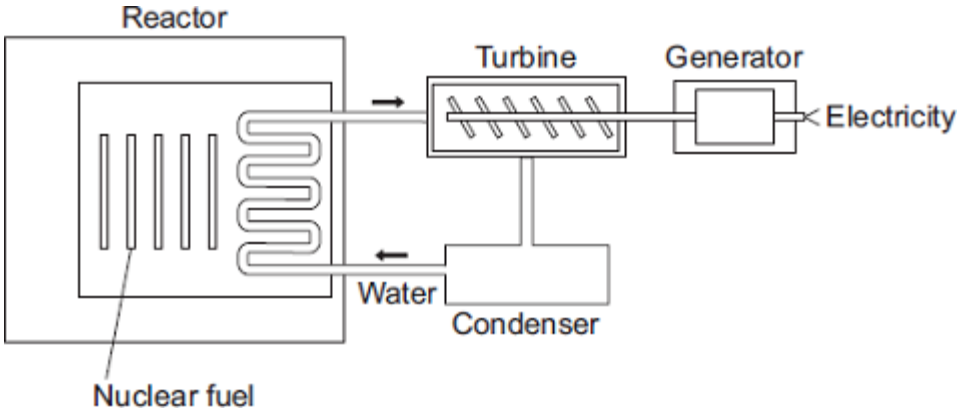
....

(3)

(Total 10 marks)

Q12.

Nuclear power stations use the energy released from nuclear fuels to generate electricity.



(a) Which substance do the majority of nuclear reactors use as fuel?

Draw a ring around your answer.

plutonium-239 **thorium-232** **uranium-235**

(1)

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

Describe what happens to the nucleus of an atom during nuclear fission.

_____

_____

_____

_____

(2)

(c) Use words from the box to complete each sentence.

condenser	**gas**	**generator**	**reactor**	**steam**	**turbine**

The energy released from the nuclear fuel is used to heat water. The water turns into _____ and this is used to drive a _____ .

This turns a _____ to produce electricity.

(3)

(Total 6 marks)

Q13.

(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.

_____

(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.

_____

_____

_____

_____

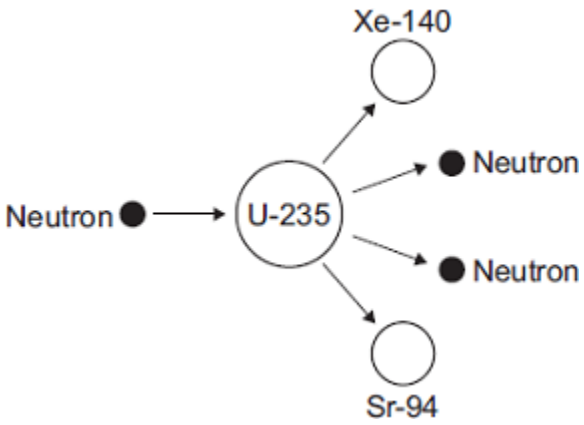
_____

_____

(3)

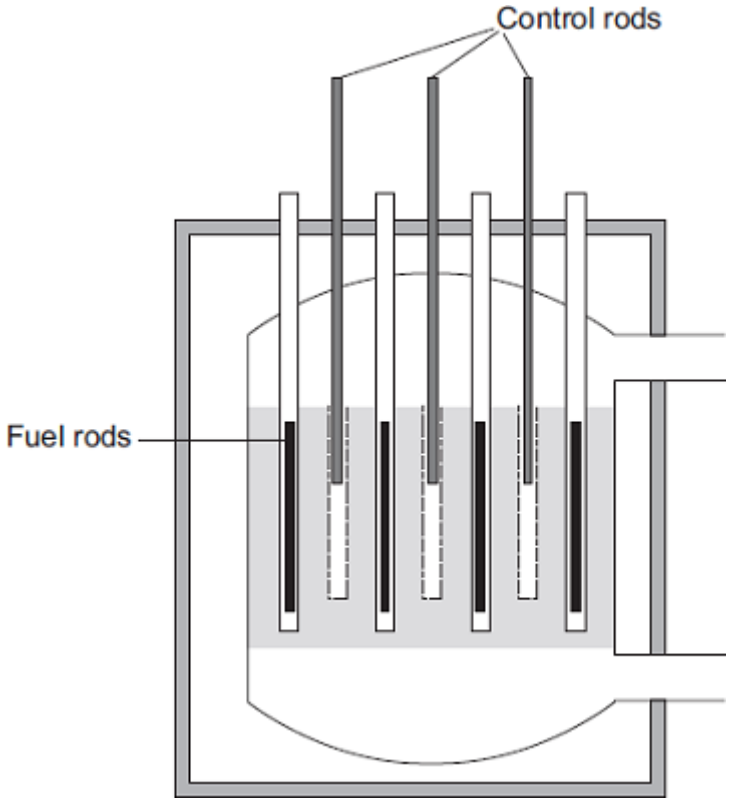
(b) The diagram shows the nuclear fission process for an atom of uranium-235.

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?

_____

_____

_____

_____

(2)

(Total 8 marks)

Q14.

Stars go through a life cycle. About 90 % of all stars are in the 'main sequence' period of the life cycle.

(a) Stars are stable during the 'main sequence' period of the life cycle.

Why?

_____

_____

(1)

(b) The table gives an estimated time for the number of years that three stars, **X**, **Y** and **Z**, will be in the 'main sequence' period of their life cycle.

Star	Relative mass of the star compared to the Sun	Estimated 'main sequence' period in millions of years
X	0.1	4 000 000
Y	1.0	9 000
Z	40.0	200

(i) This data suggests that there is a pattern linking the mass of a star and the number of years the star is in the 'main sequence' period of its life cycle.

What is the pattern suggested by the data?

_____

_____

(1)

(ii) Scientists cannot give the exact number of years a star will be in the 'main sequence' period.

Suggest why.

_____

_____

(1)

(iii) Nuclear fusion is the process by which energy is released in stars.

Which **one** of the following can be concluded from the data in the table?

Draw a ring around the correct answer in the box to complete the sentence.

The rate of nuclear fusion in a large star is

faster than
the same as
slower than

in a small star.

Explain the reason for your answer.

_____

_____

_____

_____

(3)

(c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate*.

Describe what happens to a star **much bigger** than the Sun, once the star reaches the end of the 'main sequence' period of its life cycle.

Your answer should include the names of the stages the star passes through.

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(Total 12 marks)

Q15.

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.

(2)

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

(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?

(1)

(Total 5 marks)

Q16.

(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.

(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.

(2)

(Total 6 marks)

Q17.

(a) Nuclear fission is used in nuclear power stations to generate electricity. Nuclear fusion happens naturally in stars.

(i) Explain briefly the difference between *nuclear fission* and *nuclear fusion*.

(2)

(ii) What is released during both nuclear fission and nuclear fusion?

(1)

(b) Plutonium-239 is used as a fuel in some nuclear reactors.

(i) Name another substance used as a fuel in some nuclear reactors.

_____

(1)

(ii) There are many isotopes of plutonium.

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

_____

(1)

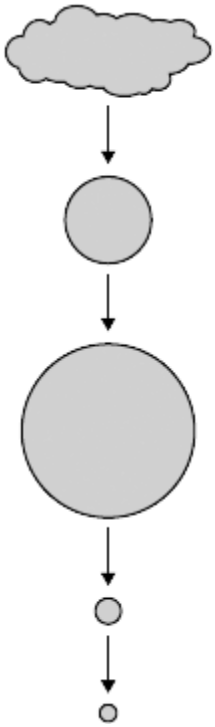
(Total 5 marks)

Q18.

(a) The diagram shows the lifecycle of a star.

(i) Use words or phrases from the box to complete the sentences contained in the diagram.

black dwarf	**black hole**	**protostar**	**red giant**



Gas and dust are pulled together to form a

_____

The star gives out energy as a main sequence star.

The star expands forming a _____

The star shrinks to form a white dwarf.

The star fades away as a _____

(3)

(ii) The table compares the approximate size of three stars with the size of the Sun.

Star	Size
Alpha Centauri A	the same as the Sun
Betelgeuse	1120 times bigger than the Sun
Cephei	1520 times bigger than the Sun

Which **one** of these three stars has the lifecycle shown in part (a)(i)?

_____

Give a reason for your answer.

_____

_____

(2)

(b) Which one of the following describes the process by which energy is given out in stars?

Tick (✓) **one** box.

Atomic nuclei inside the star join together. ☐

Atomic nuclei inside the star split apart. ☐

Gases inside the star burn. ☐

(1)

(Total 6 marks)

Q19.

(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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

Q20.

The names of three different processes are given in **List A**.
Where these processes happen is given in **List B**.

Draw a line to link each process in **List A** to where the process happens in **List B**.

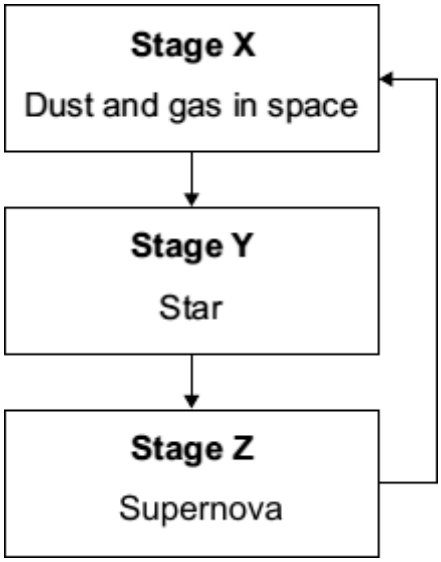
Draw only **three** lines.

List A	**List B**
Process	**Where it happens**
	in a star
fusion	
	in a nuclear reactor
chain reaction	
	in a smoke precipitator
alpha decay	
	in the nucleus of an atom

(Total 3 marks)

Q21.

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**?

_____

(1)

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

Explain why the star remains stable.

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(2)

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

_____

_____

(1)

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

_____

_____

(1)

(Total 7 marks)

Q22.

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

$$^{225}_{88}\text{Ra} \longrightarrow {}^{225}_{89}\text{Ac} + \boxed{\text{Radiation}}$$

What type of radiation is emitted by radium-225?

Draw a ring around your answer.

alpha **beta** **gamma**

Explain the reason for your answer.

_____

_____

_____

_____

_____

_____

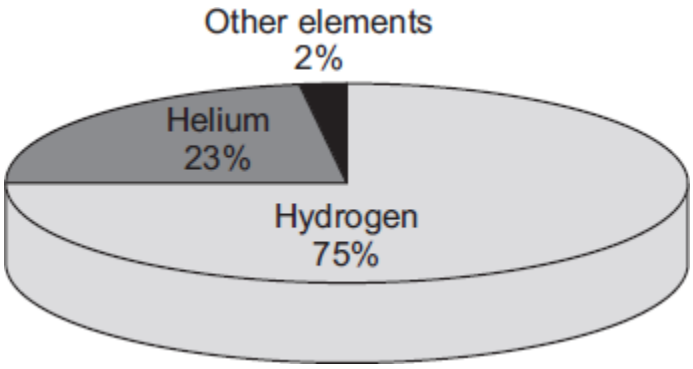
(Total 3 marks)

Q23.

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.

(3)

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

Identify this opinion and suggest how scientists could justify it.

(2)

(Total 5 marks)

Q24.

The process of nuclear fusion results in the release of energy.

(a) (i) Describe the process of nuclear fusion.

_____

_____

(2)

(ii) Where does nuclear fusion happen naturally?

_____

(1)

(b) For many years, scientists have tried to produce a controlled nuclear fusion reaction that lasts long enough to be useful. However, the experimental fusion reactors use more energy than they produce.

(i) From the information given, suggest **one** reason why nuclear fusion reactors are not used to produce energy in a nuclear power station.

_____

_____

(1)

(ii) Suggest **one** reason why scientists continue to try to develop a practical nuclear fusion reactor.

_____

_____

(1)

(Total 5 marks)

Q25.

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

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

_____

_____

_____

_____

_____

_____

(2)

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

Explain how the other elements came to be formed.

(3)

(Total 5 marks)

Q26.

(a) Uranium atoms do not always have the same number of neutrons.
What are atoms of the same element that have different numbers of neutrons called?

(1)

(b) By emitting an alpha particle, an atom of uranium-235 decays into an atom of thorium.

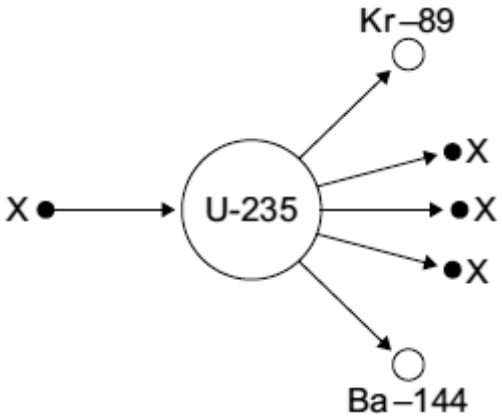
An alpha particle, which is the same as a helium nucleus, is represented by the symbol $^{4}_{2}He$.

The decay can be represented by the equation below.

Complete the equation by writing the correct number in each of the two boxes.

(2)

(c) The diagram shows an atom of uranium-235 being split into several pieces.



(i) Name the process shown in the diagram.

_____

(1)

(ii) Name the particles labelled **X**.

_____

(1)

(d) Uranium-235 is used as a fuel in some nuclear reactors.
Name another substance used as a fuel in some nuclear reactors.

_____

(1)

(Total 6 marks)

Q27.

Every star goes through a 'life cycle'.

(a) Describe how a star forms.

_____

_____

_____

_____

_____

(2)

(b) During a long period of its life, a star remains in a stable state.

Explain why a star remains stable.

_____

_____

_____

_____

_____

(2)

(c) Some stars are much more massive than the Sun.

Describe what will happen to a star, originally much more massive than the Sun, after it reaches its red giant stage.

_____

_____

_____

_____

_____

(2)

(Total 6 marks)

Q28.

Four different processes are described in **List A**. The names of these processes are given in **List B**.

Draw a line to link each description in **List A** to its correct name in **List B**.
Draw only **four** lines.

List A	List B
the nuclei of two atoms joining together	gamma emission
the nucleus of an atom splitting into several pieces	electric current
an atom losing an electron	ionisation
an electric charge moving through a metal	nuclear fission
	nuclear fusion

(Total 4 marks)

Q29.

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 the Universe contains atoms of over one hundred elements.

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

(2)

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

(2)

(c) Explain how, and when, atoms of different elements may be distributed throughout the Universe.

(2)

(Total 6 marks)

Q30.

The table gives information about the three types of particle that make up an atom.

Particle	Relative mass	Relative charge
Proton		+1
Neutron	1	

Electron	very small	–1

(a) Complete the table by adding the **two** missing values.

(2)

(b) Use the information in the table to explain why an atom has no overall electrical charge.

_____

_____

_____

_____

(2)

(c) Uranium has two natural isotopes, uranium-235 and uranium-238.
Uranium-235 is used as a fuel inside a nuclear reactor.
Inside the reactor, atoms of uranium-235 are split and energy is released.

(i) How is the structure of an atom of uranium-235 different from the structure of an atom of uranium-238?

_____

_____

(1)

(ii) The nucleus of a uranium-235 atom must absorb a particle before the atom is able to split.

What type of particle is absorbed?

_____

(1)

(iii) The nucleus of an atom splits into smaller parts in a reactor.

What name is given to this process?

_____

(1)

(Total 7 marks)

Q31.

This passage is from a science magazine.

> *A star forms when enough dust and gas are pulled together. Masses smaller than a star may also be formed when dust and gas are pulled together.*

(a) What is the force which pulls the dust and gas together?

_____

(1)

(b) Complete the sentences.

(i) The smaller masses may be attracted by the star and become

_____ .

(1)

(ii) Our nearest star, the Sun, is stable because the gravitational forces and the radiation pressure are _____ .

(1)

(iii) The Sun is one of billions of stars in the galaxy called the

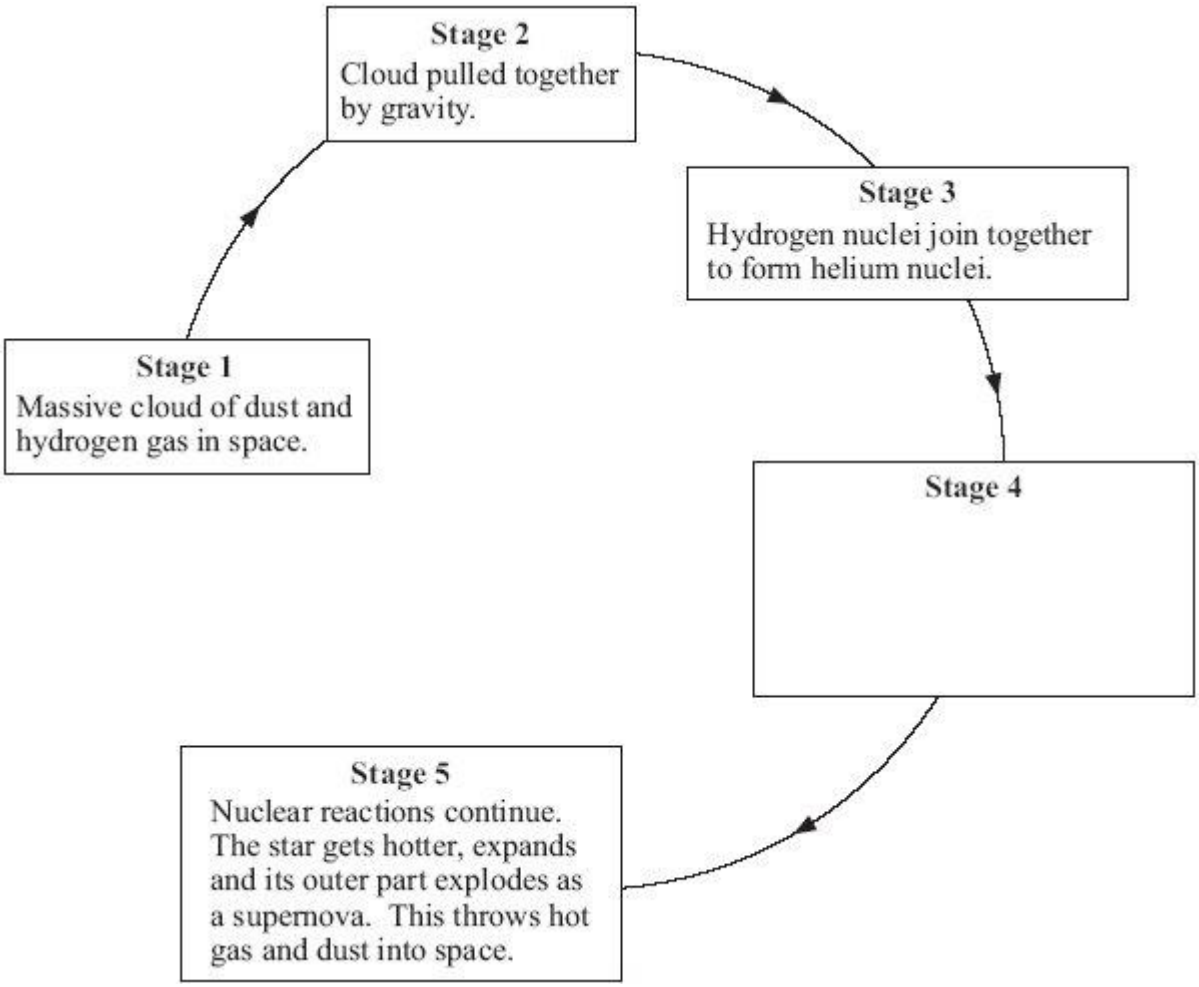
_____ .

(1)

(Total 4 marks)

Q32.

The diagram shows part of the life cycle of a star which is much bigger than the Sun.



(a) (i) What is the relationship between the masses of the dust and gas in the cloud in **Stage 2** and the force of gravity between them?

_____

_____

(1)

(ii) What is the relationship between the distance apart of the dust and gas in the cloud in **Stage 2** and the force of gravity between them?

_____

_____

(1)

(b) In **Stage 3** the star remains stable for millions of years.

Explain why.

_____

_____

_____

_____

_____

(2)

(c) What happens in **Stage 4**?

_____

_____

_____

_____

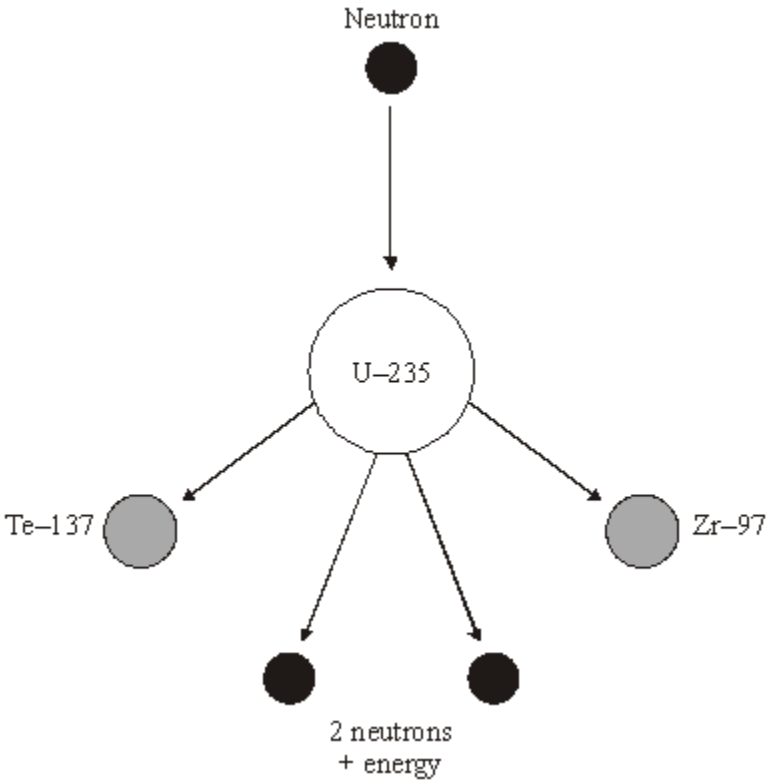
_____

(2)

(Total 6 marks)

Q33.

(a) The diagram shows what can happen when the nucleus of a uranium atom absorbs a neutron.



(i) What name is given to the process shown in the diagram?

_____

(1)

(ii) Explain how this process could lead to a chain reaction.

You may wish to add further detail to the diagram to help your answer.

_____

_____

_____

_____

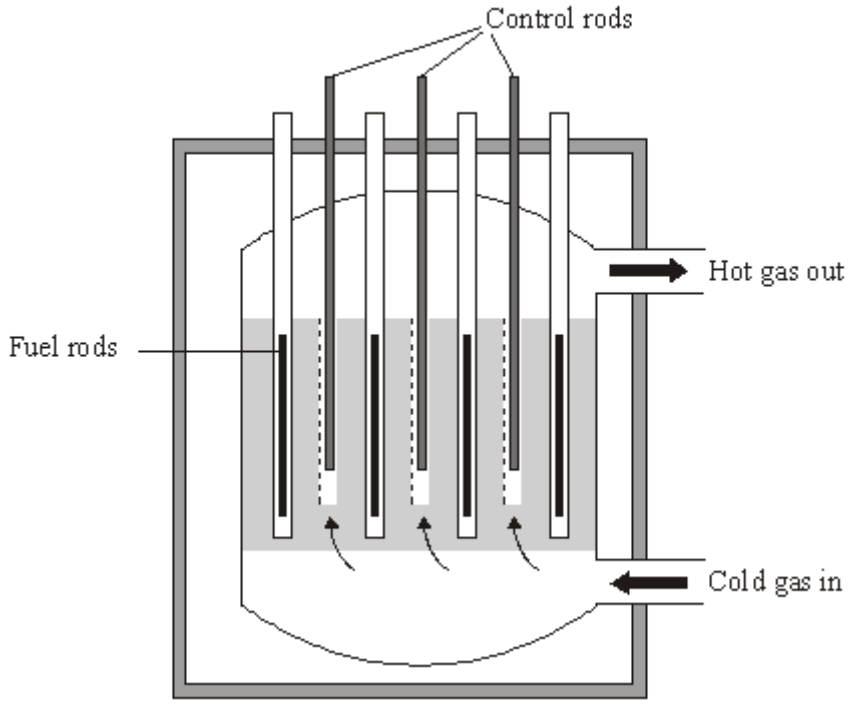
(2)

(iii) How does the mass number of an atom change when its nucleus absorbs a neutron?

_____

(1)

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



Source: adapted from 'Physics Matters', by Nick England. Published by Hodder and Stoughton, 1989. Reproduced by permission of Hodder and Stoughton Ltd.

The reactor contains control rods used to absorb neutrons.

Suggest what happens when the control rods are lowered into the reactor.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q34.

Read the passage.

> In the SolarSystem, the inner planets, such as the Earth, contain elements which are eavierthan the elements hydrogen and helium.
>
> Our star,the Sun, is a medium sized star. If a star is much more massive than the Sunit will eventually swell into a red giant, start to contract, continue tocontract and finally explode.

(a) What is the explosion called?

_____

(1)

(b) Explain why scientists believe that the Solar System was formed from the material produced when earlier stars exploded.

_____

_____

_____

_____

_____

_____

(3)

(Total 4 marks)

Q35.

(a) Complete the **two** spaces in the sentence.

Stars form when enough _____ and gas from _____ are pulled together by gravitational attraction.

(2)

(b) How are stars able to give out energy for millions of years?

Put a tick (✓) next to the answer.

By atoms joining together ☐

By atoms splitting apart ☐

By burning gases ☐

(1)

(c) There are many billions of stars in our galaxy. Our Sun is one of these stars. What is the name of our galaxy?

_____

(1)

(d)

Why was the Universe created?

We cannot expect scientists to answer this question. What is the reason for this?

Put a tick (✓) next to the reason.

It will take too long to collect the scientific evidence. ☐

The answer depends on beliefs and opinions, not scientific evidence. ☐

There is not enough scientific evidence. ☐

(1)

(Total 5 marks)

Mark schemes

Q1.

(a) nucleus

1

neutron

1

gamma rays

1

in this order only

(b) $\frac{25\,000\,000}{2\,400\,000}$

1

11

*an answer of 10.4 with no working scores **1** mark*

1

*an answer of 11 scores **2** marks*

(c) any **two** from:

- waste is radioactive

  allow nuclear waste

- waste has a long half-life

  allow waste remains dangerous for a long time

- waste is toxic
- waste needs to be buried

  allow waste is difficult to dispose of

- risk of catastrophic accidents

  allow named accident e.g. Fukushima, Chernobyl, Three Mile Island

- fuel is non-renewable

2

(d) **similarity:**
(carbon dioxide concentration and global temperature have) both increased

allow they both show a positive correlation

1

difference:
the carbon dioxide (concentration) continues to increase whereas temperature (increase) levels off

allow carbon dioxide (concentration) increases more quickly than temperature (increase)

1

[9]

Q2.

(a) any **three** from:

- no <u>carbon dioxide</u> emitted (to produce electricity)
  no greenhouse gases is insufficient
- doesn't cause global warming
  allow climate change or greenhouse effect for global warming
- nuclear power doesn't cause earthquakes
- more energy released per kg of fuel (compared to shale gas)

3

(b) uranium
or
plutonium
ignore any numbers given

1

(c) a <u>neutron</u> is absorbed by a (large) nucleus
a description in terms of only atoms negates first two marking points

1

the nucleus splits into two (smaller) nuclei

1

releasing energy (and gamma rays)

1

and (two / three) neutrons

1

[8]

Q3.

(a) a uranium <u>nucleus</u>

1

absorbs a neutron

1

(uranium-236 nucleus) splits into two smaller nuclei
or
Kr and Ba nuclei
or
krypton and barium nuclei

1

and releases 3 neutrons and energy

1

(b) light nuclei

1

join to form a heavier nucleus

allow hydrogen nuclei for light nuclei

allow helium nucleus for heavier nucleus

1

(some of the) mass of the nuclei is converted to energy

allow particles for nuclei

1

(c) any **two** from:

- easy to obtain / extract
- available in (very) large amounts
- releases more energy (per kg)

*do **not** accept figures **only***

naturally occurring is insufficient

seawater is renewable is insufficient

less cost is insufficient

allow produces little / no radioactive waste

2

[9]

Q4.

(a) neutrons

1

(b) generate electricity

accept produce electricity

accept heat water

accept produce steam

turns turbines is insufficient

1

(c) (i) a neutron

1

(ii) two particles **X** released from the uranium-235

1

uranium-235 shown splitting into two fragments
or
each particle **X** shown colliding with a uranium-235 and producing 2 further particles **X**

one uranium-235 shown splitting is sufficient, provided no contradiction shown

1

[5]

Q5.

(a) (i) (enough) dust and gas (from space) is pulled together

accept nebula for dust and gas
accept hydrogen for gas
accept gas on its own
dust on its own is insufficient
mention of air negates this mark

1

by:
gravitational attraction
or
gravitational forces
or
gravitaty
ignore any (correct) stages beyond this

1

(ii) joining of two (atomic) nuclei (to form a larger one)
do not accept atoms for nuclei

1

(iii) more sensitive astronomical instruments / telescopes
or
infrared telescopes developed
accept better technology
more knowledge is insufficient

1

(b) (i) (other) planets / solar systems
do not accept galaxy
moons is insufficient

1

(ii) provided evidence to support theory
accept proves the theory

1

(c) elements heavier than iron are formed only when a (massive) star explodes
accept materials for elements
accept supernova for star explodes
accept stars can only fuse elements up to (and including) iron

1

[7]

Q6.

(a) (i) (atoms with the) same number of protons
allow same atomic number
or *same proton number*

1

(atoms with) different number of neutrons
allow different mass number

1

(ii) 82

1

(iii) 124

1

(b) (i) $\begin{array}{|c|}\hline 58 \\ \hline 26 \\ \hline \end{array}\mathrm{Fe} + \begin{array}{|c|}\hline 208 \\ \hline 82 \\ \hline \end{array}\mathrm{Pb}$

1 *mark for each correct box*

3

(ii) (a) neutron

1

(iii) 4.0×10^{-4} (s)
or
0.0004

$3.00 \times 10^{8} \times 0.1 = 12\,000 / t$
*gains **1** mark*

2

(iv) particles need to travel a large distance

1

equipment would have to be very long

1

with circular paths long distances can be accommodated in a smaller space

1

(c) (i) the average time for the number of nuclei to halve

1

the time for count rate to halve

1

(ii) $\begin{array}{|c|}\hline 261 \\ \hline 106 \\ \hline \end{array}\mathrm{Sg} + \begin{array}{|c|}\hline 4 \\ \hline 2 \\ \hline \end{array}\alpha$

1 *mark if top boxes total = 265*

and *bottom boxes total = 108*
1 *mark for 4 and 2 for alpha*

2

(d) (i) 3 plotted points
± ½ *small square*

1

best line through points

1

(ii) 190−205 (pm)
or correct from student's line

1

[20]

Q7.

(a) inside the Sun

1

(b) fusion

1

(c) energy

1

[3]

Q8.

(a) (i) splitting of a(n atomic) nucleus
do not accept splitting an atom

1

(ii) Neutron

1

(b) (i) nuclei have the same charge
or
nuclei are positive
accept protons have the same charge

1

(ii) (main sequence) star
accept Sun or any correctly named star
accept red (super) giant

1

(c) (i) any **two** from:
- easy to obtain / extract
- available in (very) large amounts
- releases more energy (per kg)
*do **not** accept figures only*
- produces little / no radioactive waste.

naturally occurring is insufficient

seawater is renewable is insufficient

less cost is insufficient

2

(ii) any **one** from:

- makes another source of energy available
- increases supply of electricity
- able to meet global demand
- less environmental damage
- reduces amount of other fuels used.

accept any sensible suggestion

accept a specific example

accept a specific example

1

(d) 12

*allow **1** mark for obtaining 3 half-lives*

2

[9]

Q9.

(a) J

reason only scores if J is chosen

1

(only) stars (about) the same / smaller size / mass as the Sun become black dwarfs

accept smaller than the Sun

accept it is the smallest

accept (only) small stars become black dwarfs

1

(b) (i) become a supernova
or
it will explode

ignore subsequent correct stages

1

(ii) cannot take measurements needed
or
do not have the technology

*do **not** accept cannot measure mass*

1

(iii) advances in (measuring) techniques / technology / knowledge

1

(c) any **five** from:

ignore any information up to the end of the main sequence

Apply the list rule if more than 5 points are made

- star expands (to become)
- a red giant

  red supergiant is incorrect
- heavier elements are formed (by fusion)

  elements heavier than iron are formed is incorrect
- star shrinks (to become)
- a white dwarf

  supernova, neutron star, black hole are incorrect
- star cools / fades
- star stops emitting energy / radiation

  star loses all energy is insufficient

5

[10]

Q10.

(a) (same) number of protons

same atomic number is insufficient

1

(b) (i) nuclei split

*do **not** accept atom for nuclei / nucleus*

1

(ii) (nuclear) reactor

1

(c) beta

1

any **one** from:
- atomic / proton number increases (by 1)

  accept atomic / proton number changes by 1
- number of neutrons decreases / changes by 1
- mass number does not change

  (total) number of protons and neutrons does not change
- a neutron becomes a proton

1

(d) (average) time taken for number of nuclei to halve
or
(average) time taken for count-rate / activity to halve

1

(e) (i) 6.2 (days)

Accept 6.2 to 6.3 inclusive
*allow **1** mark for correctly calculating number remaining as 20 000*
or
*allow **1** mark for number of*
80 000 plus correct use of the graph (gives an answer of 0.8 days)

2

(ii) radiation causes ionisation

allow radiation can be ionising

1

that may then harm / kill healthy cells

accept specific examples of harm, eg alter DNA / cause cancer

1

(iii) benefit (of diagnosis / treatment) greater than risk (of radiation)

accept may be the only procedure available

1

[11]

Q11.

(a) (i) nuclear reactor

1

star

1

(ii) nuclei are joined (not split)

accept converse in reference to nuclear fission

*do **not** accept atoms are joined*

1

(b) (i) any **four** from:

- neutron
- (neutron) absorbed by U (nucleus)

  ignore atom
  *do **not** accept reacts*
  *do **not** accept added to*
- forms a larger nucleus
- (this larger nucleus is) unstable
- (larger nucleus) splits into two (smaller) nuclei / into Ba and Kr
- releasing three neutrons and energy

  accept fast-moving for energy

4

(ii) 56 (Ba)

1

57 (La)

*if proton number of Ba is incorrect allow **1** mark if that of La is 1 greater*

1

$^{0}_{-1}\beta$

accept e for β

$$^{139}_{56}Ba \longrightarrow {}^{139}_{57}La + {}^{0}_{-1}\beta$$

*scores **3** marks*

1

[10]

Q12.

(a) uranium-235

accept any correct indication

1

(b) splits / breaks (into two smaller parts)

nucleus is separated is insufficient

*do **not** accept atom splits – on its own*

1

and (two / three) neutrons

1

(c) steam

correct order only

1

turbine

1

generator

1

[6]

Q13.

(a) (i) plutonium (239)

accept Pu / Thorium / MOX (mixed oxide)

*do **not** accept uranium-238 **or** hydrogen*

1

(ii) (energy) used to heat water and

1

produce (high pressure) steam

1

the steam drives a turbine (which turns a generator)

1

(b) Neutron(s) shown 'hitting' other U-235 nuclei

one uranium nucleus is sufficient

1

U-235 nuclei (splitting) producing 2 or more neutrons

1

(c) any **two** from:

- neutrons are absorbed (by boron / control rods)

- there are fewer neutrons
- chain reaction slows down / stops
  accept fewer reactions occur

2

[8]

Q14.

(a) forces (within the star) are balanced
if specific forces are mentioned they must be appropriate

1

(b) (i) bigger the mass (of the star) the shorter the 'main sequence' period
accept bigger the star the shorter the time

1

(ii) any **one** from:

- insufficient evidence
- do not know (exact) amount of hydrogen in star
  accept do not know (exact) mass of star
- time too long (to measure directly)
- may be other factors (not yet known) that determine length of 'main sequence' period
- values are based on theory / calculation

1

(iii) faster than

1

larger stars have a shorter 'main sequence' period so they must have the faster (rate of) nuclear fusion
there must be a link between shorter 'main sequence' and nuclear fusion, this may be implied from the first marking point

1

the end of 'main sequence' happens as the hydrogen in (the core of) a star is used up
or
(since) they use up hydrogen at a faster (rate)
accept more massive stars (are brighter so) release energy faster

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1-2 marks)
There is a basic description of what happens to a star much larger than the Sun after the 'main sequence' period.
OR
Two stages are correctly named and are in the correct sequence.

Level 2 (3-4 marks)
There is a clear description of what happens to a star much larger than the Sun after the 'main sequence' period.
AND
At least two stages are correctly named and are in the correct sequence.

Level 3 (5-6 marks)
There is a detailed description of what happens to a star much larger than the Sun after the 'main sequence' period.
AND
At least three stages are named, in the correct sequence. There are no additional incorrect stages given.

Examples of the points made in the response:

extra information

- (the core of the) star runs out of hydrogen
- (the star) expands (to form)
- (the star) cools (to form)
    - *the core shrinks*
    - *helium starts to fuse to form other elements*
- a red supergiant

  accept super red giant
  *do **not** accept red giant*

    - (outer layers) explode
        - *fusion of lighter elements to form heavier elements (up to iron)*
- as a supernova
    - elements heavier than iron are formed

      accept heaviest elements are formed
    - core shrinks
- becoming a neutron star
    - if mass large enough (core collapses)
- (to form) a black hole

if a correct description and sequence for a star the same size as the Sun and much bigger than the Sun given without clearly indicating which is which is limited to Level 2

6

[12]

Q15.

(a) fusion

*do **not** credit any response which looks like 'fission'*

1

of hydrogen / H (atoms)

credit only if 1st mark point scores

1

(b) fusion of other / lighter atoms / elements

reference to big bang nullifies both marks

1

during supernova / explosion of star(s)

1

(c) the (available) evidence: supports this idea
or
does not contradict this idea
or
can be extrapolated to this idea
or
(electromagnetic) spectrum from other stars is similar to sun

1

[5]

Q16.

(a) *answers must be in terms of nuclear fuels*

concentrated source of energy

idea of a small mass of fuel able to generate a lot of electricity

1

that is able to generate continuously

accept it is reliable
***or** can control / increase / decrease electricity generation*
idea of available all of the time / not dependent on the weather
ignore reference to pollutant gases

1

the energy from (nuclear) <u>fission</u>

1

is used to heat water to steam to turn turbine linked to a generator

1

(b) carbon dioxide is not released (into the atmosphere)

1

but is (caught and) stored (in huge natural containers)

1

[6]

Q17.

(a) (i) (nuclear) fission is the splitting of a (large atomic) nucleus

*do **not** accept particle/atom for nucleus*

1

(nuclear) fusion is the joining of (two atomic) nuclei (to form a larger one)

do not accept particles/atoms for nuclei

1

(ii) energy

accept heat/radiation/nuclear energy
accept gamma (radiation)
do not accept neutrons/neutrinos

1

(b) (i) uranium (–235)

accept U (–235)
ignore any numbers given with uranium
accept thorium
accept MOX (mixed oxide)
*do **not** accept hydrogen*

1

(ii) (same) number of protons

accept (same) atomic number
accept (same) positive charge
ignore reference to number of electrons

1

[5]

Q18.

(a) (i) protostar

correct order only

1

red giant

1

black dwarf

1

(ii) Alpha Centauri A

accept any correct indication, eg alpha, centauri, A

reason only scores if Alpha Centauri A is chosen

1

stars (about) same size as Sun form white / black dwarfs
or
very large stars form red super giants / supernova/black hole

it is the same size as the Sun is insufficient

same life cycle as the Sun is insufficient

1

(b) Atomic nuclei inside the star join together

1

[6]

Q19.

(a) a protostar is at a lower temperature
or
a protostar does not emit radiation /energy

1

as (nuclear) fusion reactions have not started

accept heat or light for energy

1

(b) by (nuclear) fusion

accept nuclei fuse (together)

nuclear fusion and fission negates this mark

1

of hydrogen to helium

1

elements heavier than <u>iron</u> are formed in a <u>supernova</u>

accept a specific example e.g. heavier elements such as gold are formed in a supernova

accept heavier elements (up to iron) formed in red giant/red super giant

reference to burning (hydrogen) negates the first 2 marks

1

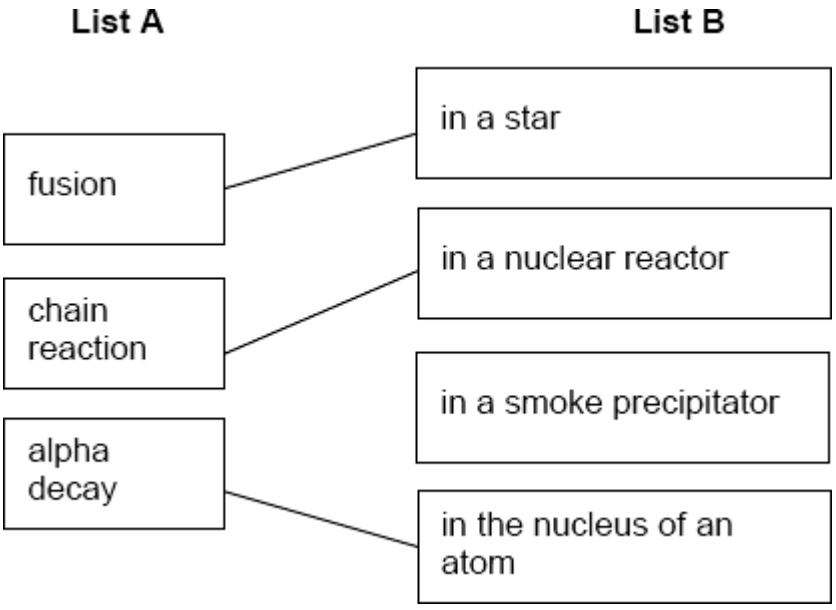
[5]

Q20.

three lines correct

*allow **1** mark for each correct line*

*if more than 1 line is drawn from a box in **List A**, mark each line incorrect*



[3]

Q21.

(a) gravitational attraction

accept 'gravity'

accept (nuclear) fusion

1

(b) radiation 'pressure' and gravity / gravitational attraction

must be in correct context

1

are balanced / in equilibrium

accept are equal and opposite

*do **not** accept 'equal'*

or

there is sufficient / a lot of hydrogen / fuel

*do **not** accept constant supply of hydrogen*

to last a very long time / for (nuclear) fusion

this mark only scores if linked to the supply of hydrogen / fuel

reference to burning negates both marks

1

(c) (i) (conversion of) hydrogen to helium

accept (conversion of) lighter elements to heavier elements

1

by (nuclear) fusion

*note do **not** credit spelling of 'fusion' which could be 'fission'*

reference to burning negates both marks

1

(ii) massive supply / lots of hydrogen

1

(d) distributed throughout the Universe / space

*do **not** accept Solar System for Universe*

1

[7]

Q22.

beta

reason may score even if alpha or gamma given

1

any **two** from:

- mass number does not change
  or
  total number of protons and neutrons does not change
- atomic / proton number increases by 1
  or
  number of protons increases by 1
- number of neutrons goes down by 1

*allow for **2** marks a neutron splits / changes into a proton and electron / beta*

*candidates that answer correctly in terms of why alpha **and** gamma are not possible, gain both marks*

2

[3]

Q23.

(a) (forces due to) gravity and radiation pressure

1

correct direction of forces

1

(forces) are balanced / equilibrium / equal

*accept for **3** marks an answer in terms of*
sufficient hydrogen (1)
to keep fusion reaction (1)
reference to burn / burning negates this mark
going at a continuous /steady rate (1)
*if fuel is used instead of hydrogen maximum of **2** marks*

1

(b) the Sun will remain stable (for several billion years)

1

based on evidence

accept a specific example of evidence

eg that the Sun has remained stable during the life of our planet / for 4.5 billion years

or

still contains more than 50 % hydrogen

or

by comparison with the lifecycle of (similar) stars

allow a refutation

eg not based on prejudice / whim / hearsay / folk law / historical or religious authority

1

[5]

Q24.

(a) (i) (two) nuclei (of light elements) join

accept hydrogen atoms for nuclei

1

forming a larger / heavier nucleus / one

accept comparative term equivalent to larger

accept forms a helium (nucleus / atom) this mark only scores if fusion is in terms of hydrogen atoms

1

(ii) stars

accept a named star

e.g. the Sun

accept nebula

mention of planets negates answer

1

(b) (i) any **one** from:

- (currently) only experimental
- reaction does not last long enough
- use more energy than they produce

allow difficult to control

*do **not** allow inefficient on its own*

1

(ii) any **one** from:

- will give another source of energy
- unlimited fuel supplies / energy

accept unlimited hydrogen

- would not produce any radioactive waste

accept less radioactive waste
accept nuclear for radioactive
*do **not** accept toxic waste*

- want to show that it can be done
  accept any sensible suggestion
  *do **not** accept answers only in terms of fossil fuels or carbon dioxide*

1

[5]

Q25.

(a) gravitational force(s) (1)
accept 'gravity'

balanced by (force(s) due to) radiation pressure (1)
accept equal

2

(b) by (nuclear) fusion (1)

of hydrogen to helium (other light elements) (1)
allow 'low density' for light
accept hydrogen nuclei / atoms form helium
response must clearly link one element(s) producing others
fusion to produce helium (2)

heavy element / elements heavier than iron are only produced (by fusion) in a supernova (1)
allow dense for heavy
ignore any reference to elements undergoing radioactive decay (to form other elements)

3

[5]

Q26.

(a) isotopes

1

(b) $^{231}_{90}Th$

1

correct order only

1

(c) (i) (nuclear) fission
accept fision
*do **not** accept any spelling that may be confused with fusion*

1

(ii) neutron / neutrons

1

(d) plutonium (239)

accept MOX (mixed oxide)

accept Pu

*do **not** accept uranium 238 / hydrogen*

1

[6]

Q27.

(a) (enough) dust and gas (from space)

accept nebula for dust and gas

accept hydrogen for gas

mention of air negates this mark

1

pulled together by:

- gravitational attraction
  or
- gravitational forces
  or
- gravity

1

(b) forces (in the star) are balanced

accept equal and opposite for balanced

accept in equilibrium for balanced

1

forces identified as gravity and radiation pressure

both forces are required

*gravitational forces inwards balance / equal radiation pressure outwards for **2** marks*

*accept for **2** marks an answer in terms of sufficient hydrogen to keep the fusion reactions going*

*accept for **1** mark an answer in terms of sufficient fuel to keep the fusion reactions going*

1

(c) (explodes as) a supernova

1

any **one** from:

- outer layer(s) thrown into space

  *do **not** accept just 'thrown into space'*

- scatters dust and gas into space (for the formation of new stars)

  *do **not** accept just 'dust and gas'*

- elements distributed throughout space

  *do **not** accept just 'distributed'*

- matter left behind / core may form a neutron star

  *do **not** accept just 'neutron star'*

- a black hole will form if the gravitational forces are enormous / sufficient mass is left behind

  *do **not** accept just 'black hole'*

  *do **not** accept any references to 'dark bodies' or 'black dwarfs'*

  black hole forms if star is large enough is insufficient

1

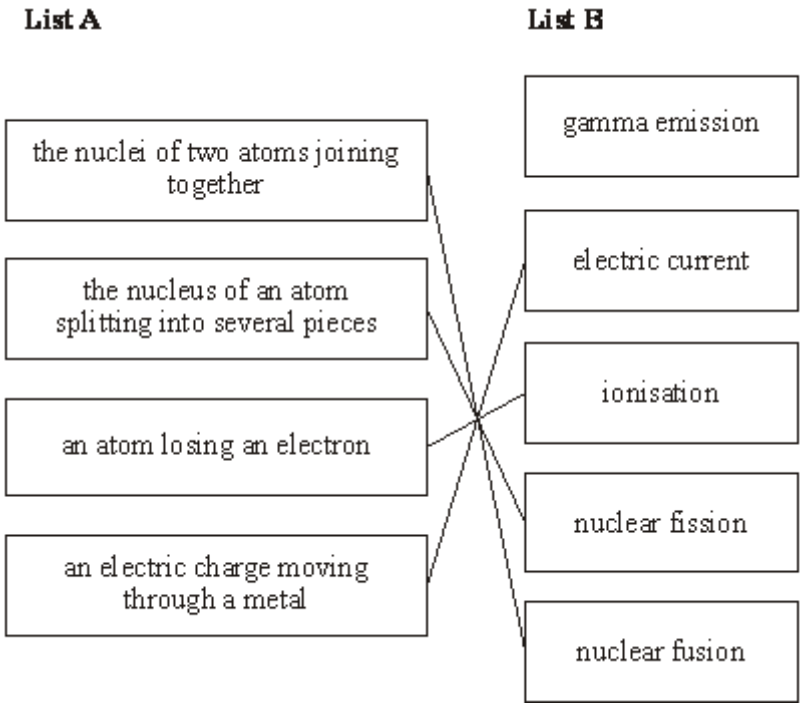
[6]

Q28.

four lines correct

*allow **1** mark for each correct line*

if more than 1 line is drawn from a box in List A, mark each line incorrect



[4]

Q29.

(a) fusion (1)

of hydrogen/H (atoms)(1)

*do **not** credit any response which looks like 'fission' **or** the 'word' 'fussion'*

credit only if a nuclear reaction

2

(b) fusion of other/lighter atoms/elements (1)

reference to big bang nullifies both marks

during super nova/explosion of star(s) (1)

2

(c) explosion of star(s)/super nova (1)

reference to big bang nullifies both marks reference to the star running out of energy/material nullifies both marks

at the end of the 'life' of star(s) / when they 'die' (1)

2

[6]

Q30.

(a)

Particle	Relative Mass	Relative charge
Proton	1	
Neutron		0

accept one, accept +1
*do **not** accept –1*

1

accept zero

*do **not** accept no charge/ nothing/neutral unless given with 0*

1

(b) equal numbers/amounts of protons and electrons

1

protons and electrons have equal but opposite charge

accept protons charge +1 and electron charge –1

accept (charge) on proton
cancels/balances (charge) on electron

accept positive (charges) cancel out the negative(charges)

neutrons have no charge is neutral

*do **not** accept total charge of protons, electrons (and neutrons) is 0 unless qualified*

1

(c) (i) (3) fewer neutrons

accept lower/ smaller mass number

*do **not** accept different numbers of neutrons*

any mention of fewer/more protons/electrons negates mark
accept answers in terms of U-238 providing U-238 is specifically stated i.e. U-238 has (3) more neutrons

1

(ii) neutron

1

(iii) (nuclear) fission
accept fision
*do **not** accept any spelling that may be taken as fusion*

1

[7]

Q31.

(a) gravitational
accept gravity
*do **not** accept weight*

1

(b) (i) planet(s)
accept comet(s)
accept asteroid(s)
*do **not** accept moon(s)*

1

(ii) balanced
accept equal / the same / are in equilibrium

1

(iii) Milky Way
accept milky way

1

[4]

Q32.

(a) (i) the bigger the masses (of the dust and gases then) the bigger the force / gravity (between them)
accept the converse

1

(ii) the greater the distance (between the dust and gases then) the smaller the force / gravity (between them)
accept the converse

1

(b) radiation 'pressure' and gravity / gravitational attraction these are balanced / in equilibrium

1

must be in correct context
*do **not** accept are equal*

or there is sufficient / a lot of hydrogen / fuel to last a very long time

second mark consequent on first

1

(c) any **two** from:

- hydrogen runs out / is used up
- nuclei larger than helium nuclei formed

  *accept bigger atoms are formed however do **not** accept any specific mention of an atom with a mass greater than that of iron*
- (star expands to) / become(s) a red giant

2

[6]

Q33.

(a) (i) (nuclear) fission

*accept fision providing clearly **not** fusion*

1

(ii) (released) neutrons are absorbed by further (uranium) nuclei

accept hit nuclei for absorbed / hit
*do **not** accept atom for nuclei*

1

more neutrons are released (when new nuclei split)

*accept for **both** marks a correctly drawn diagram*

1

(iii) increases by 1

or goes up to 236

1

(b) any **two** from:

- (more) neutrons are absorbed

  accept there are fewer neutrons
- (chain) reaction slows down / stops

  accept keeping the (chain) reaction controlled
- less energy released

  accept heat for energy
  accept gases (from reactor) are not as hot

2

[6]

Q34.

(a) (a) supernova (explosion)

1

(b) solar system contains heavy elements / elements heavier than hydrogen and helium (1)

these (heavy) elements are / were formed by (nuclear) fusion (1)

accept minor misspellings for 'fusion'
*but **not** anything which could also be 'fission'*

(at the very high temperature(s)) in a super nova / when stars explode (1)

3

[4]

Q35.

(a) dust

accept 'solid (s)'

1

space

accept 'from supernova / supernovum / supernovas'

1

(b) By atoms joining together

only one ticked or otherwise unambiguously identified

1

(c) Milky Way (galaxy)

1

(d) The answer depends on beliefs and opinions, not scientific evidence.

only one ticked or otherwise unambiguously identified

1

[5]