PEARSON EDEXCEL IGCSE PHYSICS · 4PH1

PHYSICS



EXAM QUESTION PACK

SECTION 7: RADIOACTIVITY AND PARTICLES (PACK 1)

SCORE	PERCENTAGE
/230	%

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Q1.

In 2011, a nuclear accident happened at Fukushima in Japan.

This released radioactive materials into the environment.

A month later, the radioactivity of seaweed on the west coast of USA was tested.

The seaweed was found to contain radioactive iodine-131.

The half-life of iodine-131 is 8.0 days.

(a) Three samples of the same mass of seaweed were taken.

The number of counts in 10 minutes of the samples are shown in the table.

	sample 1	sample 2	sample 3
number of counts in 10 minutes	3970	3970	3985

Explain why three separate samples were used.

(2)

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(b) Iodine-131 emits beta particles.

There was not a high risk to the public from the iodine-131 in the seaweed.

Explain **one** reason why the risk was not high.

(2)

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(Total for question = 4 marks)

Q2.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross and then mark your new answer with a cross ☒.

(a) Which of these astronomical objects is the largest?

(1)

☒ **A** a comet

☒ **B** the Earth

☒ **C** the Moon

☒ **D** the Sun

(b) Which of these types of radiation is the most ionising?

(1)

☒ **A** alpha

☒ **B** beta

☒ **C** gamma

☒ **D** ultraviolet

(c) Which of these is the unit for resistance?

(1)

☒ **A** ampere

☒ **B** ohm

☒ **C** volt

☒ **D** watt

(d) Which of these parts of the electromagnetic spectrum has the shortest wavelength?

(1)

☒ **A** infrared

☒ **B** microwave

☒ **C** ultraviolet

☒ **D** x-ray

(e) Which of these temperatures is the same as 0 °C?

(1)

☒ **A** -273 K

☒ **B** 3 K

☒ **C** 273 K

☒ **D** 373 K

(Total for question = 5 marks)

Q3.

A scientist wants to determine the half-life of a radioactive isotope.

The scientist measures the count rate from the radioactive isotope.

(a) State how the scientist should correct the count rate for background radiation.

(1)

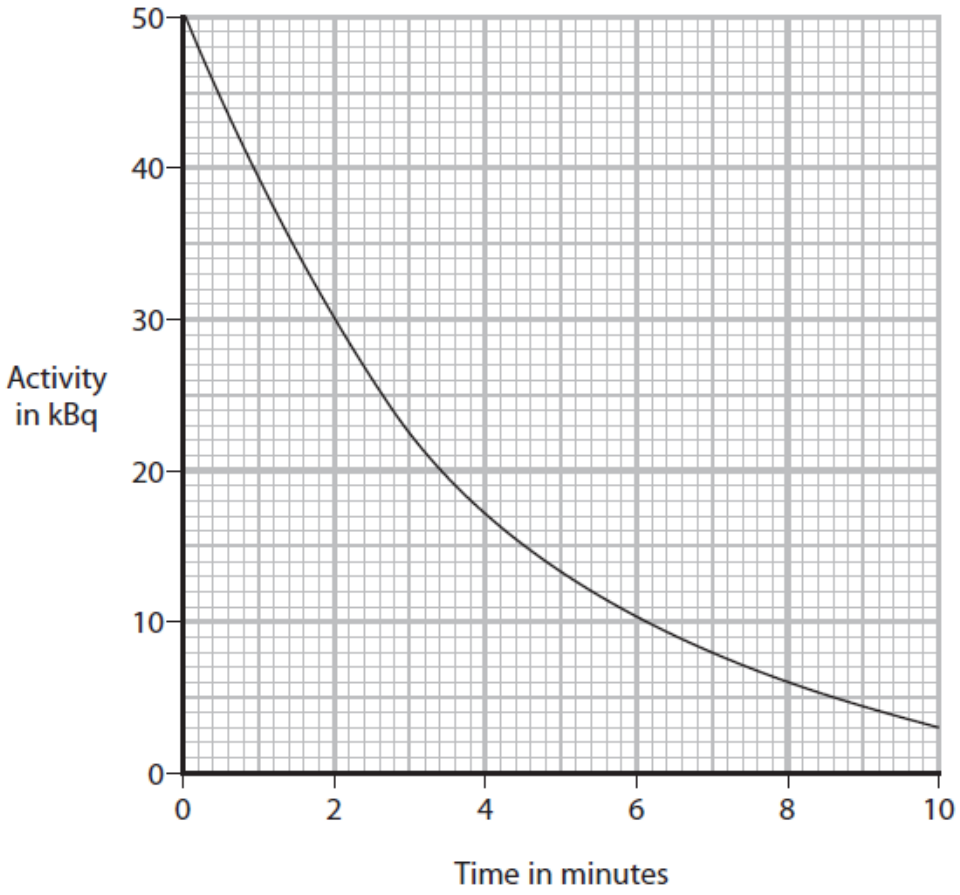
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(b) The graph shows how the activity of the radioactive isotope varies with time.



(i) Explain what is meant by the term **half-life**.

(2)

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(ii) Use the graph to determine the half-life of this isotope.

(2)

half-life = ... minutes

(Total for question = 5 marks)

Q4.

Radon is a radioactive gas that contributes to background radiation.

(a) Describe what is meant by the term **background radiation**.

(2)

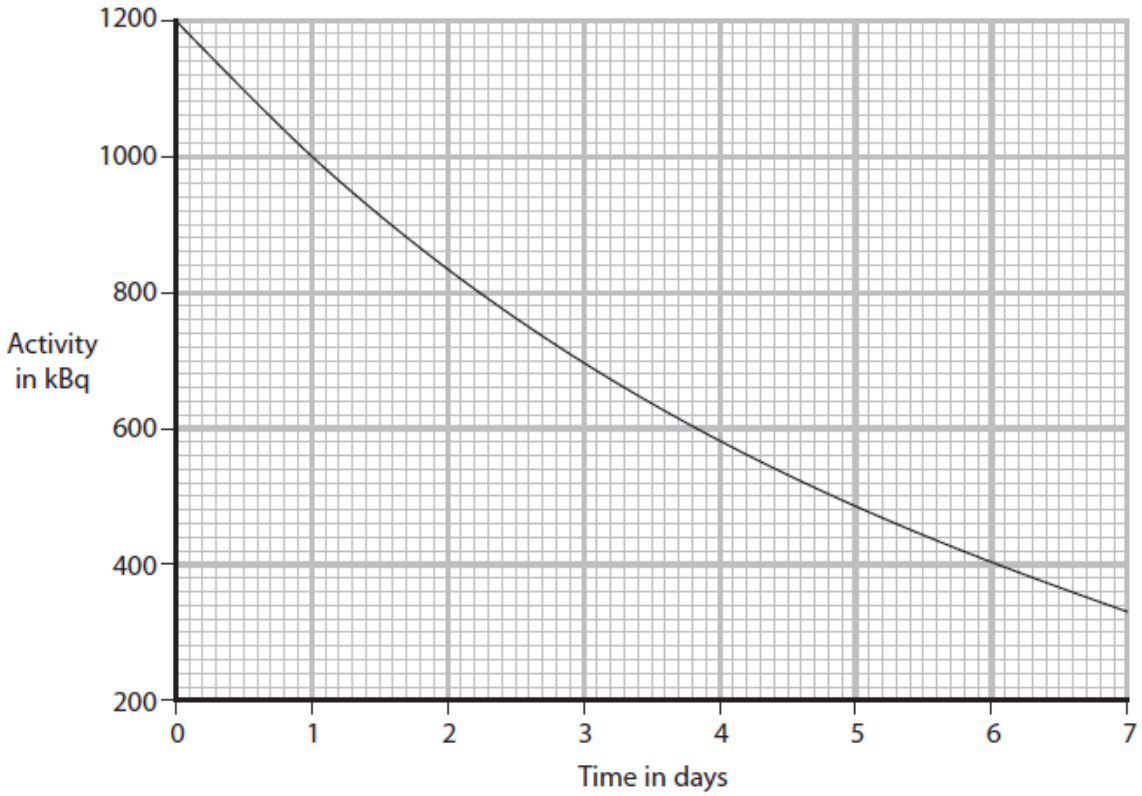
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(b) The graph shows the activity of a sample of radon-222.



(i) State what is meant by the term **half-life**.

(2)

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(ii) Use the graph to determine the half-life of radon-222.

(2)

half-life = ... days

(c) Radon-222 is formed by multiple alpha decays of uranium-234.

Complete the nuclear equation by giving the missing information.

(3)

$$^{234}_{92}U \rightarrow {}^{222}_{\square}Rn + 3\,{}^{\square}_{\square}\alpha$$

(d) Radon-222 also emits alpha radiation.

Explain the hazard to humans of breathing in air contaminated with radon-222.

(2)

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(Total for question = 11 marks)

Q5.

Cobalt-60 is a radioactive isotope of cobalt.

The table gives the activity of a sample of cobalt-60 over a period of 10 years.

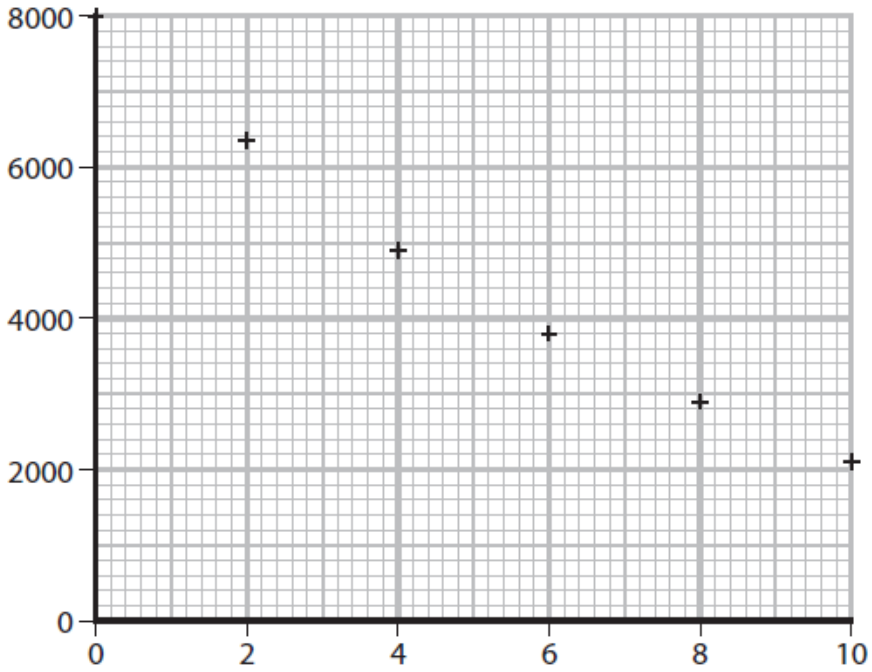
Time in years	Activity
0	8000
2	6350
4	4900
6	3800
8	2900
10	2100

(a) Give a suitable unit for activity.

(1)

.....

(b) The graph shows the data.



(i) Label both axes.

(1)

(ii) Draw the curve of best fit.

(1)

(iii) Use the graph to determine the half-life of cobalt-60.

(2)

half-life = ... years

(iv) Estimate the time taken for the activity to decrease to $\frac{1}{8}$ of its initial value.

(2)

time = ... years

(c) Cobalt-60 is produced when a neutron is absorbed by the nucleus of a stable atom of cobalt-59.

The nuclei of these two isotopes can be represented as

$^{60}_{27}Co$ $^{59}_{27}Co$

Describe a similarity and a difference for the nuclei of these two isotopes of cobalt.

(2)

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(d) Cobalt-60 decays by beta emission.

Describe what happens to the nucleus of a cobalt-60 atom during beta decay.

(2)

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(e) Cobalt-60 also emits gamma radiation.

Cobalt-60 is produced in a nuclear reactor.

Discuss the hazards involved and the precautions taken when disposing of cobalt-60.

(4)

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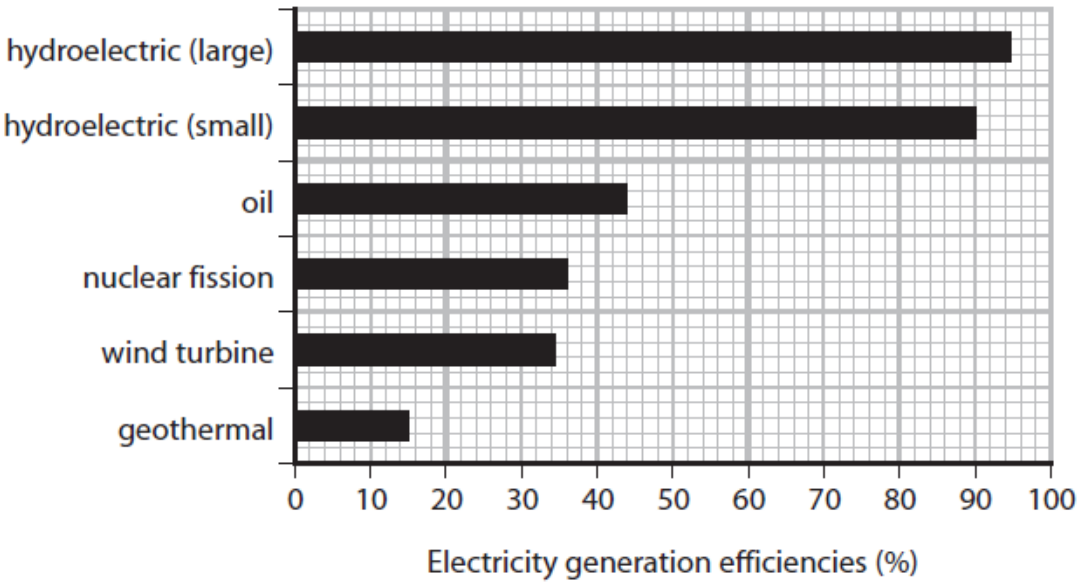
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(Total for question = 15 marks)

Q6.

The chart shows the efficiencies of different methods of generating electricity.



(a) The chart shows that the geothermal power station has an efficiency of 15%.

Explain what is meant by an efficiency of 15%.

(2)

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(b) A small hydroelectric power station has a useful energy output of 6.0 kJ.

Calculate the total energy input for this power station using information from the chart.

(4)

total energy input = ... kJ

(c) (i) Name a fuel used in the reactor of a nuclear power station.

(1)

.....

(ii) These sentences describe the process of nuclear fission.

Complete these sentences by writing a suitable word in each blank space.

(5)

A nucleus absorbs a ..... .

The nucleus formed splits because it is
..... .

The nucleus splits into two smaller nuclei called
.....

nuclei and two or three ..... .

The energy released is transferred into the
.....

energy store of the fission products.

(Total for question = 12 marks)

Q7.

(a) Bismuth-207 is a gamma emitter and is represented by the symbol

$$^{207}_{83}Bi$$

How many neutrons are in the nucleus of an atom of bismuth-207?

(1)

☒ **A** 83

☒ **B** 124

☒ **C** 207

☒ **D** 290

(b) Which of these gives the best description of gamma radiation?

(1)

☒ **A** a helium nucleus

☒ **B** a high energy electron

☒

C a high frequency electromagnetic wave

☒ **D** a subatomic particle with mass, but with no charge

(c) A technician uses this method to investigate the penetration power of gamma radiation.

- place a gamma emitting source at a fixed distance from a radiation detector
- measure the count using the detector, for a period of one minute
- place a thin sheet of lead between the source and the detector
- measure the new count using the detector, for a period of one minute
- increase the number of lead sheets between the source and detector and repeat this process

The table gives some of the variables from the technician's method.

Complete the table by placing a tick (Π) in each row to show whether each variable is an independent, a dependent or a control variable.

(3)

Variable	Independent variable	Dependent variable	Control variable
count measured using the detector			
distance between source and detector			
number of lead sheets			
time period for measuring the count			

(Total for question = 5 marks)

Q8.

A material called granite is used as a work surface in a kitchen.



(Source: Ksana_uk/Shutterstock)

(a) Granite is formed naturally and contains radioactive isotopes.

The granite work surface contributes to the background radiation in the kitchen.

Give another naturally occurring source of background radiation.

(1)

.....

(b) Granite contains the isotope thorium-232 $(^{232}_{90}\text{Th})$.

Thorium-232 decays by a sequence of alpha decays and beta decays to form radon-220 $(^{220}_{86}\text{Rn})$.

(i) State two differences between alpha radiation and beta radiation.

(2)

1 .....

.....

2 .....

.....

(ii) The incomplete nuclear decay equation summarises the decay sequence of thorium-232 into radon-220.

$$^{232}_{90}\text{Th} \longrightarrow {}^{220}_{86}\text{Rn} + \square\, {}^{4}_{2}\alpha + \square\, {}^{0}_{-1}\beta$$

Calculate the number of alpha particles and the number of beta particles emitted in this decay sequence.

(3)

number of alpha particles = ...

number of beta particles = ...

(c) Thorium-232 is a solid and remains in the work surface.

Radon-220 is a gas and is emitted from the work surface.

Thorium-232 and radon-220 both emit alpha radiation.

Discuss the hazards due to the granite work surface when a person is working in the kitchen.

Refer to contamination and irradiation in your answer.

(3)

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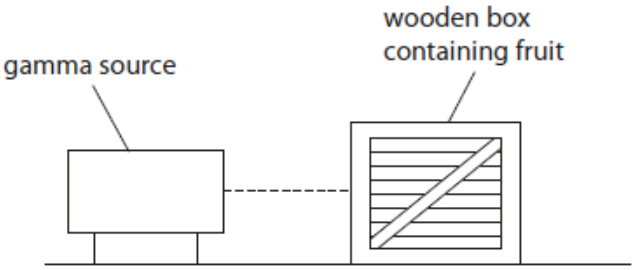
(Total for question = 9 marks)

Q9.

This question is about food preservation.

(a) The diagram shows how gamma radiation is used to irradiate fruit stored in a wooden box.

The radiation kills bacteria on the fruit.



Explain why gamma radiation is used instead of alpha radiation to kill bacteria.

(2)

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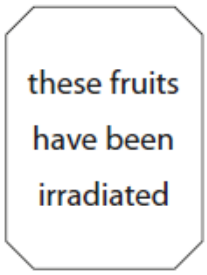
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(b) The wooden box has this label.



Explain why fruit irradiated with gamma radiation is safe to eat.

(2)

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(Total for question = 4 marks)

Q10.

This question is about Rigel, a very large star with a high surface temperature.

(a) Stars can appear as different colours because of their different surface temperatures.

Which of these colours shows the highest surface temperature for a star?

(1)

☒ **A** blue-white

☒ **B** orange

☒ **C** red

☒ **D** yellow

(b) Describe how a star is formed in a nebula.

(2)

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(c) Rigel is a main sequence star.

A star joins the main sequence when nuclear fusion of hydrogen starts in its core.

Describe the process of nuclear fusion in a star.

(3)

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(d) Astronomers think that Rigel will become a supernova in the future.

(i) Which property of a star determines whether it will become a supernova?

(1)

☒ **A** colour

☒ **B** distance from Earth

☒ **C** mass

☒ **D** temperature

(ii) Describe the evolution of Rigel after it leaves the main sequence.

(3)

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(Total for question = 10 marks)

Q11.

A teacher investigates the penetrating ability of the gamma rays from a gamma source.

This is the teacher's method.

- place the gamma source at a distance of 25 cm from a radiation detector
- place a 1 cm thick absorbing material between the source and the detector
- measure the radiation count from the source for a time period of 3 s
- calculate the count rate in counts per second
- repeat the measurement two more times

The teacher repeats this method for different absorbing materials.

(a) Name a suitable radiation detector that the teacher could use.

(1)

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(b) State the independent variable in the teacher's investigation.

(1)

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(c) Explain why every absorbing material used in the investigation has a thickness of 1 cm.

(2)

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(d) Suggest one improvement the teacher could make to this method.

(1)

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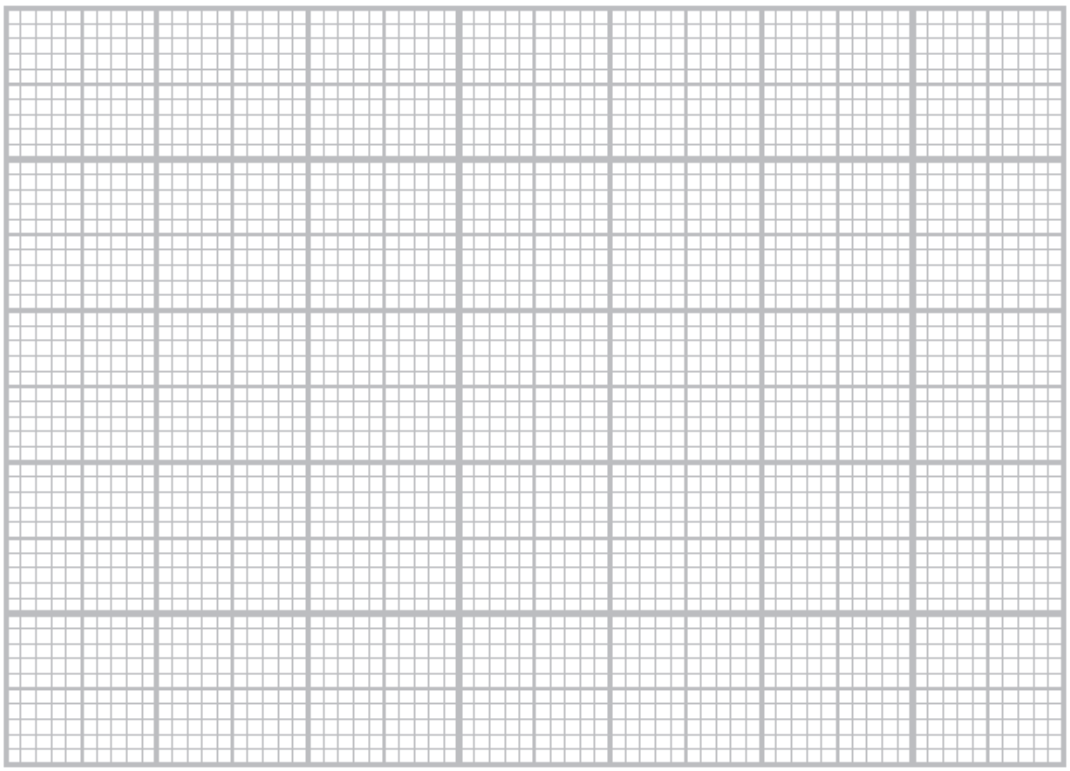
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(e) The table shows the teacher's results for seven different absorbing materials.

Absorbing material	Count rate in counts per second			
	Test 1	Test 2	Test 3	Mean
plastic	248	230	226	235
copper	138	127	147	137
wood	226	231	224	227
aluminium	204	211	190	202
lead	96	102	92	97
glass	204	192	190	195
stone	205	200	205	203

(i) On the grid, plot a bar chart of the mean count rate for each absorbing material.

(3)



(ii) Why is a bar chart the correct way to display the results?

(1)

☒ **A** absorbing material is a continuous variable

☒ **B** absorbing material is not a continuous variable

☒ **C** count rate is a continuous variable

☒ **D** count rate is not a continuous variable

(iii) A student concludes that plastic is the best absorber of gamma radiation because plastic gives the largest mean count rate.

Evaluate the student's conclusion.

(2)

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(Total for question = 11 marks)

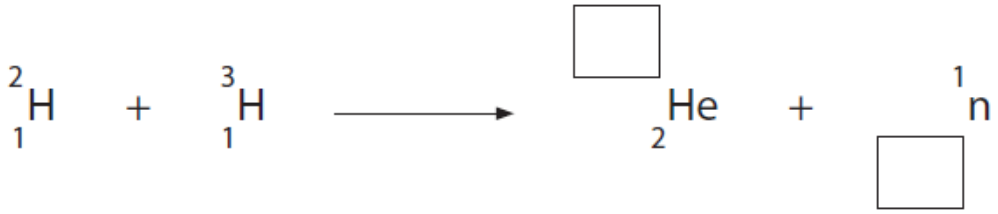
Q12.

This is a question about nuclear energy.

(a) Nuclear fusion can take place between different isotopes of hydrogen to produce an isotope of helium.

(i) Complete the nuclear equation for this process.

(2)



(ii) This process also results in the release of energy.

State where the fusion process takes place naturally.

(1)

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(iii) Explain why the isotopes of hydrogen must be heated to a very high temperature for fusion to take place.

(3)

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(b) Nuclear fission also results in a release of energy.

Explain how nuclear fission differs from nuclear fusion.

(2)

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(Total for question = 8 marks)

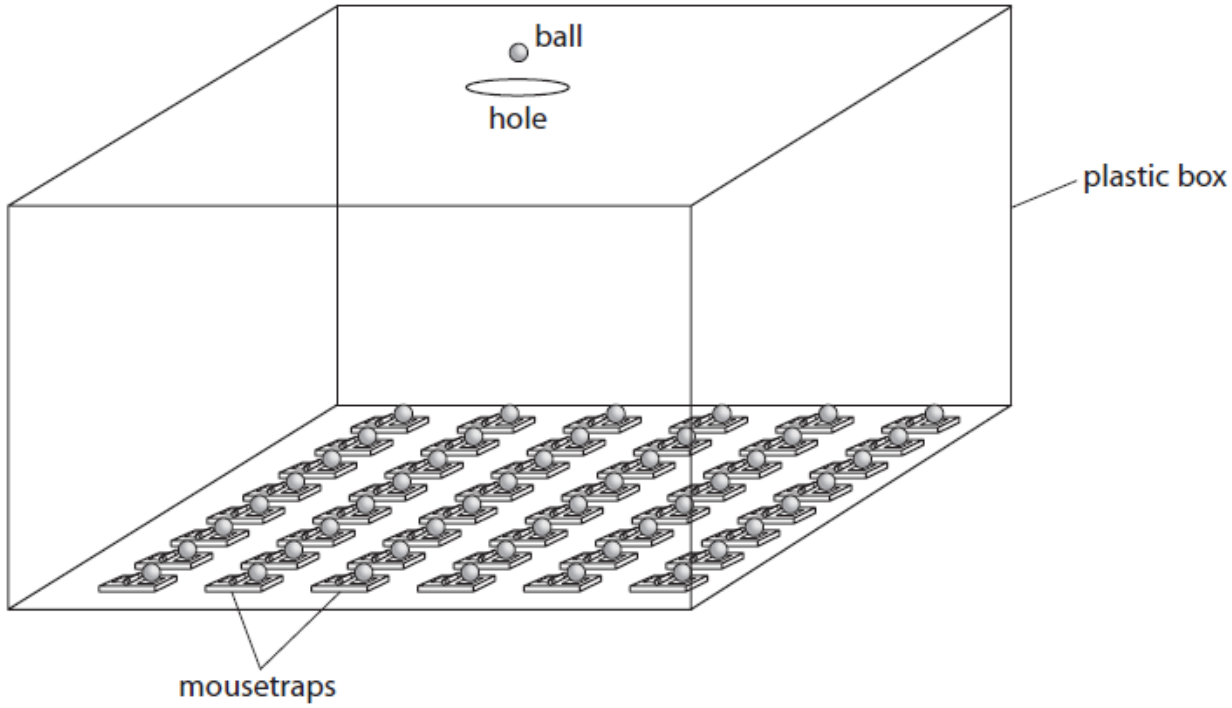
Q13.

The diagram shows a model of a chain reaction in a nuclear fission reactor.

A ball falls through the hole and hits a mousetrap.

This mousetrap then releases another ball.

Each released ball hits a different mousetrap.



(a) Each mousetrap represents a uranium-235 nucleus.

(i) Name the particle represented by the balls.

(1)

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(ii) Describe what is meant by the term **nuclear fission**.

(2)

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(iii) Describe what is meant by the term **chain reaction**.

(2)

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(b) The walls of a real nuclear reactor are not made of plastic.

Give a suitable material for the walls of a real nuclear reactor.

(1)

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(c) Use words from the box to complete the sentences about the moderator and control rods in a nuclear reactor.

(4)

absorb	ionise	neutralise	reflect	slow
boron	granite	graphite	paper	uranium

The moderator in a nuclear reactor can be made of
..... .

The moderator is designed to .....
neutrons.

The control rods in a nuclear reactor can be made of
..... .

The control rods are designed to .....
neutrons.

(Total for question = 10 marks)

Q14.

This question is about nuclear fission.

(a) The isotope uranium-235 can be made to undergo nuclear fission.

Describe the process of nuclear fission for uranium-235.

(4)

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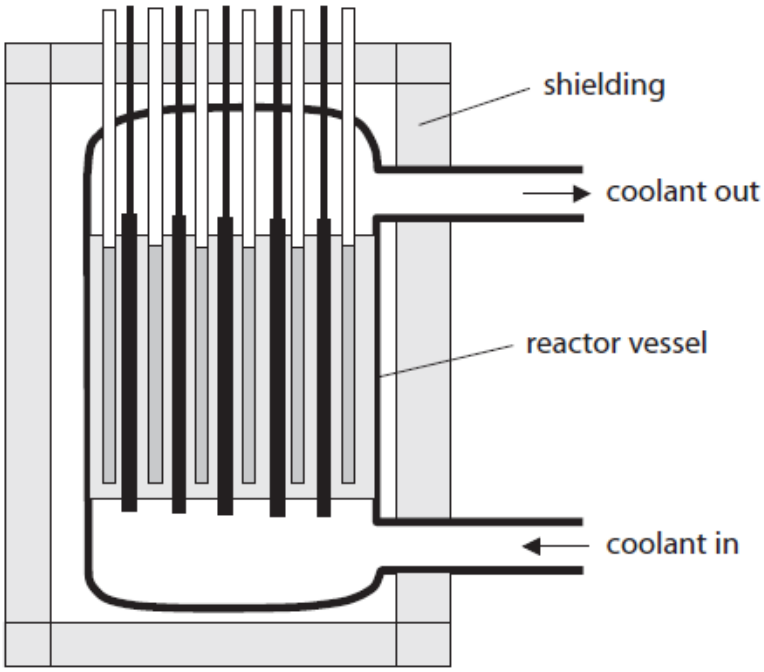
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(b) Some power stations use the nuclear fission of uranium-235 to generate electricity.

Fission takes place inside a nuclear reactor.



(i) Explain why a nuclear reactor is usually surrounded by thick concrete.

(2)

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(ii) The coolant from the nuclear reactor is used to heat steam to a very high temperature.

Steam is water in the gas state.

Using ideas about particles, explain why a pressure is exerted on the tubes containing the steam.

(3)

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(Total for question = 9 marks)

Q15.

This question is about a nuclear fission chain reaction.

(a) Uranium-235 is an isotope of uranium that can undergo nuclear fission.

The table gives some statements about this fission process.

Add ticks (✓) to the table to show which statements are correct.

(3)

Statement	Correct (✓)
uranium-235 loses a proton to become uranium-236	
uranium-235 absorbs a neutron to become uranium-236	
daughter cells are produced when uranium-236 splits	
the nuclear energy store of uranium-236 increases when it splits	
two or three neutrons are usually released when uranium-236 splits	
energy is transferred to the kinetic store of the fission products when uranium-236 splits	

(b) State which product of nuclear fission causes the next uranium-235 nucleus to split in the chain reaction.

(1)

.....

(c) Uranium-235 is radioactive and emits alpha radiation.

Which of these statements describes alpha radiation?

(1)

☒ **A** an electromagnetic wave

☒ **B** a helium nucleus

☒ **C** a high energy electron

☒ **D** a high energy neutron

(d) Some of the products of nuclear fission are radioactive because their nuclei have too many neutrons.

These nuclei become more stable when a neutron changes into a proton.

State which type of radiation is emitted by radioactive nuclei with too many neutrons.

(1)

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(Total for question = 6 marks)

Q16.

(a) Uranium-235 captures a neutron and undergoes nuclear fission in a chain reaction.

The equation shows a possible nuclear fission reaction.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{97}_{40}Zr + {}^{135}_{52}Te + x\,{}^{1}_{0}n$$

Calculate x, the number of neutrons released by this fission reaction.

(2)

x = ...

(b) Describe what is meant by a **chain reaction**.

(3)

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(c) Iodine-129 is an isotope found in radioactive waste from nuclear power stations.

Iodine-129 has a half-life of approximately 15 million years.

A sample of iodine-129 has an activity of 72 kBq.

Show that the time required for the sample to have an activity less than 5 kBq is approximately 60 million years.

(3)

(d) Some radioactive waste from nuclear power stations has a very long half-life.

Discuss precautions that must be taken when disposing of this radioactive waste.

(5)

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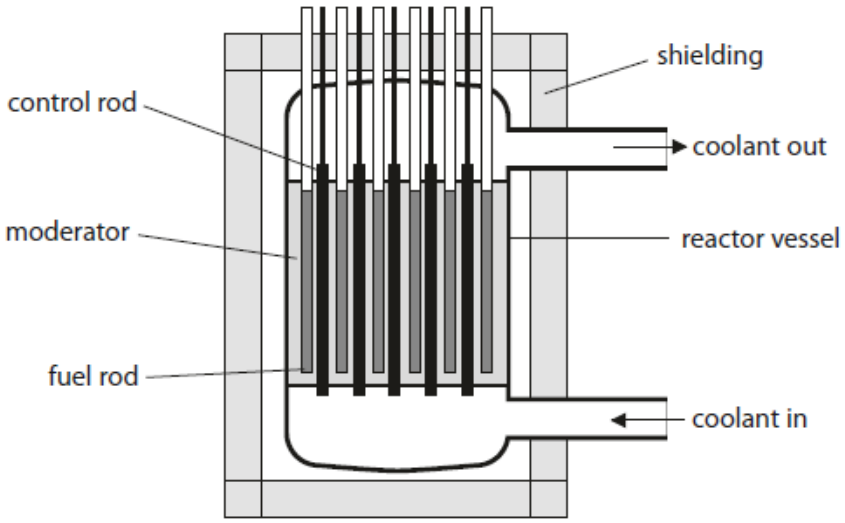
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(Total for question = 13 marks)

Q17.

(a) The diagram shows a nuclear reactor.



Each part of the nuclear reactor has a function and is made of a suitable material for its function.

Complete the table by giving the missing information.

(5)

Part	Function	Suitable material
control rod		boron
moderator		graphite
shielding	prevents irradiation of workers	
fuel rod		

(b) Heavy water is a compound of oxygen and an isotope of hydrogen called deuterium.

Deuterium is formed by the fusion of protons.

(i) State the meaning of the term **isotope**.

(2)

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(ii) Explain the difference between nuclear fission and nuclear fusion.

(2)

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(iii) State a location where nuclear fusion takes place.

(1)

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(iv) Explain why fusion cannot take place at low temperature or low pressure.

(2)

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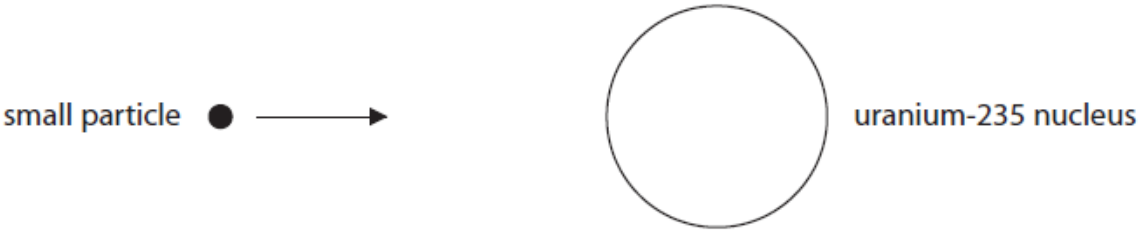
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(Total for question = 12 marks)

Q18.

This is a question about a nuclear reactor.

(a) The diagram shows a small particle about to collide with a uranium-235 nucleus inside the reactor.



The nucleus absorbs this small particle and undergoes nuclear fission.

(i) State the name of the small particle.

(1)

.....

(ii) State what happens to the nucleus in nuclear fission.

(1)

.....

.....

(iii) State the name of the energy store that increases during nuclear fission.

(1)

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(b) The fission products emit gamma radiation.

Explain why the nuclear reactor is surrounded by thick concrete shielding.

(3)

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(Total for question = 6 marks)

Q19.

(a) Which statement describes the term **atomic number** for a nucleus?

(1)

☒ **A** number of electrons in the nucleus

☒ **B** number of neutrons in the nucleus

☒ **C** number of protons in the nucleus

☒ **D** number of protons and neutrons in the nucleus

(b) Which statement describes the term **mass number** for a nucleus?

(1)

☒ **A** number of electrons in the nucleus

☒ **B** number of neutrons in the nucleus

☒ **C** number of protons in the nucleus

☒ **D** number of protons and neutrons in the nucleus

(c) Which statement describes the term **isotopes**?

(1)

☒ **A** atoms with the same number of electrons but a different number of protons

☒ **B** atoms with the same number of neutrons but a different number of electrons

☒ **C** atoms with the same number of neutrons but a different number of protons

☒ **D** atoms with the same number of protons but a different number of neutrons

(d) An atom contains 8 protons, 8 neutrons and 8 electrons.

Which of these would result in a negatively charged ion of the same element?

(1)

☒ **A** adding an electron

☒ **B** adding a proton

☒ **C** removing an electron

☒ **D** removing a proton

(e) It is not possible to predict exactly when a radioactive nucleus will decay.

Which feature of radioactive decay best explains this observation?

(1)

☒ **A** radioactive decay can change the structure of the nucleus

☒ **B** radioactive decay happens at random

☒ **C** radioactive decay is irreversible

☒ **D** radioactive decay makes a nucleus more stable

(f) Which of these is the correct unit for measuring the activity of a radioactive sample?

(1)

☒ **A** becquerel (Bq)

☒ **B** coulomb (C)

☒ **C** joule (J)

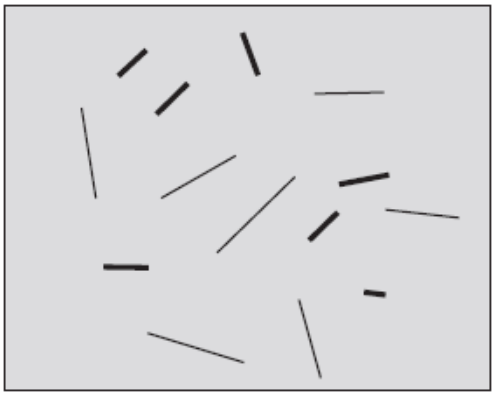
☒ **D** watt (W)

(Total for question = 6 marks)

Q20.

(a) The diagram shows tracks produced by radiation in a device called a cloud chamber.

The tracks are formed when particles ionise the material in the cloud chamber.



Alpha particles produce the shorter, thicker tracks.

Beta particles produce the longer, thinner tracks.

Explain why alpha particles produce the shorter, thicker tracks.

(2)

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(b) Uranium-235 is an isotope of uranium that can decay by emitting an alpha particle.

(i) Describe what is meant by the term **isotope**.

(2)

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(ii) Complete the equation for the decay of uranium-235

(2)

$$^{235}_{92}U \rightarrow \square^{231}Th + \square^{}_{2}\alpha$$

(iii) Uranium-235 decays to thorium-231 with a half-life of 700 million years.

When a rock was formed, it contained 6400 million uranium-235 nuclei and no thorium-231 nuclei.

Show that after 2100 million years there are seven times more thorium nuclei than uranium nuclei in the rock.

(5)

(Total for question = 11 marks)

Q21.

Gallium-67 is a radioactive isotope of gallium used as a medical tracer.

Medical tracers are placed in the body to diagnose illnesses.

The tracer emits radiation which can be used to find the position of the tracer in the body.

(a) Gallium-67 can be represented using the symbol

$$^{67}_{31}Ga$$

Give the number of protons and the number of neutrons in gallium-67.

(2)

number of protons = ...

number of neutrons = ...

(b) When gallium-67 decays it emits gamma radiation.

Explain why this makes it an effective medical tracer.

(2)

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(c) Gallium-68 is another radioactive isotope of gallium that can be used as a medical tracer.

Describe the difference between the nucleus of gallium-68 and the nucleus of gallium-67.

(2)

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(Total for question = 6 marks)

Q22.

A teacher uses a radioactive source containing atoms of the isotope radium-226.

(a) Give a safety precaution that would reduce the teacher's exposure to radiation when working with the radioactive source.

(1)

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(b) Radium-226 can be represented using the symbol

$$^{226}_{88}Ra$$

How many neutrons are in the nucleus of an atom of radium-226?

(1)

☒ **A** 88

☒ **B** 138

☒ **C** 226

☒ **D** 314

(c) The teacher investigates the type of radiation emitted from the radioactive source.

(i) Give the name of a piece of apparatus that detects ionising radiation.

(1)

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(ii) The teacher finds that the radiation emitted from the radioactive source is not detected when the detector is more than
5 cm away from the source.

State the type of radiation emitted by the radioactive source.

(1)

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(d) The number of radium-226 atoms in the source decreases over time, with a half-life of 1600 years.

(i) State what is meant by the term **half-life**.

(2)

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(ii) The radioactive source contains 2.66×10^{21} atoms of radium-226.

Approximately how many atoms of radium-226 will remain in the source after 800 years?

(1)

☒ **A** 0.67×10^{21}

☒ **B** 1.33×10^{21}

☒ **C** 1.88×10^{21}

☒ **D** 2.66×10^{21}

(Total for question = 7 marks)

Q23.

This question is about stars.

(a) Describe the stages in the evolution of a star similar in mass to the Sun.

(4)

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(b) The process of energy release in the core of a star is different to the process of energy release in a nuclear reactor in a power station.

Describe how these processes of energy release are different.

(3)

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(Total for question = 7 marks)

Q24.

Technetium-98 and technetium-99 are isotopes of the element technetium.

(a) (i) Describe the difference between the nuclei of technetium-98 and technetium-99

(2)

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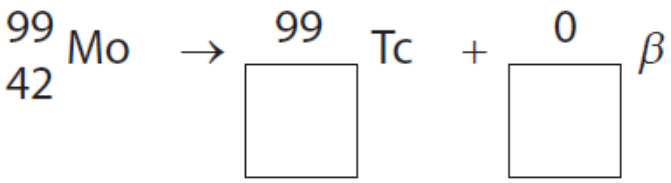
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(ii) Technetium-99 is formed when the element molybdenum-99 decays.

Complete the nuclear equation for the decay of molybdenum into technetium-99

(2)



(b) Describe an experiment that a scientist could use to demonstrate that the emission from technetium-99 is gamma radiation.

Include details of a safety precaution in your answer.

(5)

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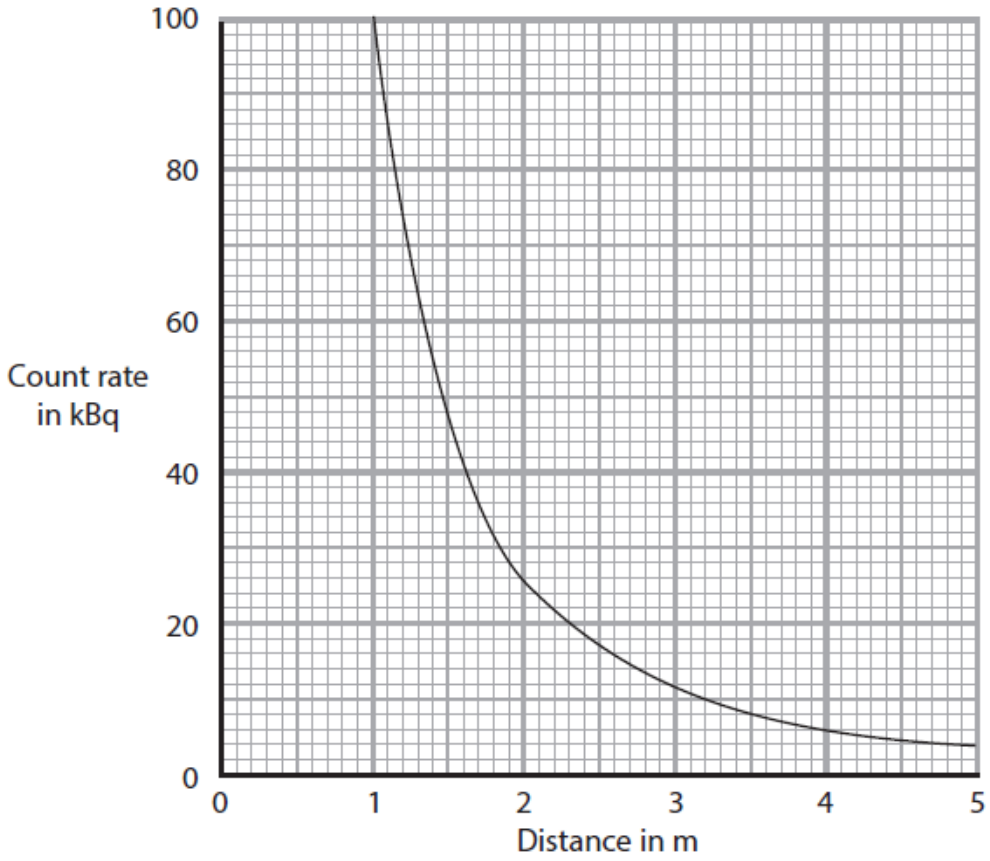
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(c) A scientist measures the count rate at different distances from the technetium source.

The graph shows how the count rate changes with distance from the technetium source.



The scientist suggests that the relationship between the count rate and distance is

$$(\text{distance})^2 \times \text{count rate} = \text{constant}$$

Use data from the graph to determine whether these results support this relationship.

(4)

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(Total for question = 13 marks)

Q25.

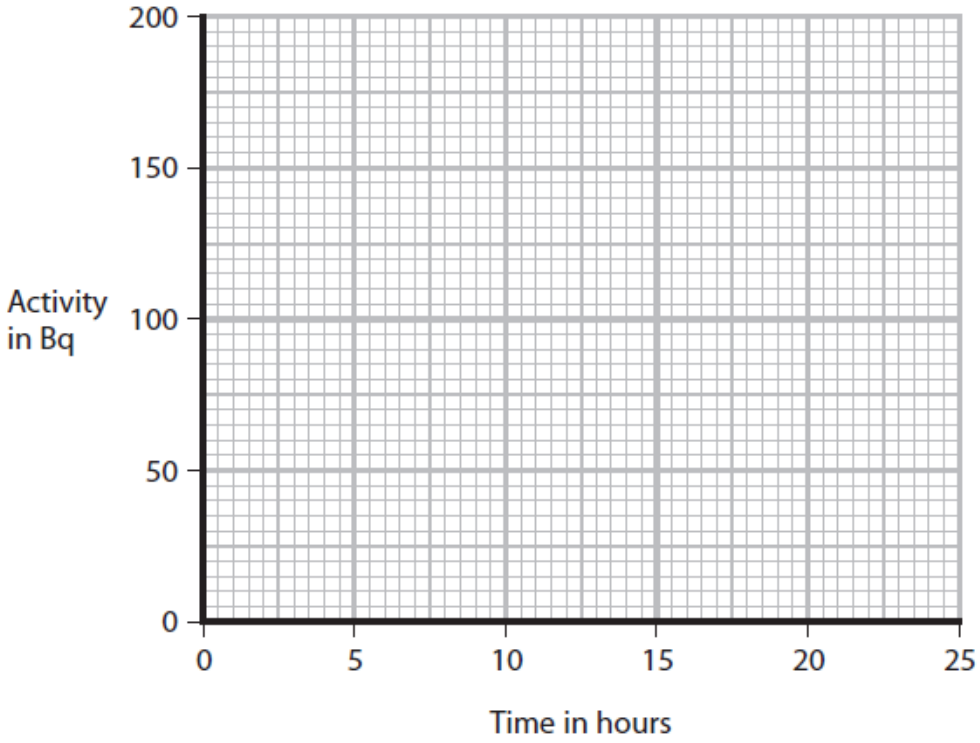
Technetium-99m is an isotope of the element technetium.

(a) Technetium-99m has a half-life of 6 hours.

A sample of technetium-99m has an initial activity of 160 Bq.

Complete the graph to show how the activity of this sample of technetium-99m changes over a period of 24 hours.

(3)



(b) Technetium-99m has a half-life of 6 hours and can be used as a medical tracer.

It is injected into a patient's blood and moves around the patient's body.

Technetium-99m emits gamma radiation, which is used to locate the position of the tracer in the patient's body.

(i) Technetium-99m does not exist naturally.

Suggest why technetium-99m is usually made at the hospital where it is used.

(1)

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(ii) Explain why technetium-99m is an effective isotope to use as a medical tracer.

(2)

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(c) The gamma radiation emitted by technetium-99m is potentially harmful to humans.

Discuss the risks of using technetium-99m to doctors and to patients.

(3)

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(Total for question = 9 marks)

Q26.

The Sun is a main sequence star.

In the Sun, hydrogen nuclei are changed into helium nuclei, releasing energy.

(a) Name the process that changes hydrogen into helium.

(1)

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(b) Describe the evolution of the Sun when it leaves the main sequence.

(2)

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(c) The Sun's core has a mass of approximately 7×10^{29} kg.

Approximately 75% of the mass of the core is hydrogen.

(i) Calculate the approximate mass of hydrogen in the Sun's core.

(1)

mass of hydrogen = ... kg

(ii) When most of the hydrogen nuclei in the Sun's core have been changed into

helium nuclei the Sun will leave the main sequence.

The Sun's core loses approximately 9×10^{19} kg of hydrogen each year.

Estimate the time until the Sun leaves the main sequence.

Give your answer to one significant figure.

(2)

time = ... years

(Total for question = 6 marks)

Q27.

This question is about the Sun.

(a) The Solar System consists of the Sun and other astronomical objects.

Complete the diagram to show how a planet and a comet orbit the Sun.

(2)



(b) The Sun is a yellow main sequence star.

(i) Name the evolutionary stage of the Sun before it became a main sequence star.

(1)

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(ii) The colour of a star is related to its surface temperature.

Explain what will happen to the colour of the Sun after it leaves the main sequence.

(2)

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(c) The Sun emits a stream of charged particles called the solar wind.

The solar wind contains high-energy alpha and beta particles.

(i) Describe three differences between alpha and beta particles.

(3)

1 .....

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2 .....

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(ii) A spacecraft travels through the Sun's solar wind on its journey from Earth to Mars.

Explain why the solar wind does not make the spacecraft radioactive.

(2)

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(Total for question = 10 marks)