AQA GCSE PHYSICS (HIGHER) · 8463

PHYSICS



EXAM QUESTION PACK

4.4.2 ATOMS AND NUCLEAR RADIATION (PACK 3)

SCORE	PERCENTAGE
/146	%

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Q1.

Radioactive nuclei can emit alpha, beta or gamma radiation.

(a) Which type of radiation is the most penetrating?

Tick **one** box.

Alpha (α) ☐

Beta (β) ☐

Gamma (γ) ☐

(1)

(b) Which type of radiation is the most ionising?

Tick **one** box.

Alpha (α) ☐

Beta (β) ☐

Gamma (γ) ☐

(1)

(c) Which type of radiation has the longest range in air?

Tick **one** box.

Alpha (α) ☐

Beta (β) ☐

Gamma (γ) ☐

(1)

When radioactive isotopes in the Earth's crust decay they release energy.

The decay causes the heating of rocks in the crust.

(d) The diagram below shows the decay of uranium-238 (U-238) into thorium-234 (Th-234).

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$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

Complete the table below to show the number of neutrons and protons in the nuclei.

Isotope	Number of neutrons	Number of protons
uranium-238	146	
thorium-234		90

(2)

(e) Geothermal power stations pump water through heated rocks.

The temperature of the water increases from 20 °C to its boiling point of 100 °C

Calculate the change in thermal energy when the mass of water heated is 150 kg

Specific heat capacity = 4 200 J/kg °C

Use the Physics Equations Sheet.

_____

_____

_____

Change in thermal energy = _____ J

(3)

(Total 8 marks)

Q2.

The Chernobyl disaster was a nuclear accident that happened in 1986

Radioactive isotopes were released into the environment.

The radioactive isotopes emitted alpha, beta and gamma radiation.

(a) What is an alpha particle?

Tick **one** box.

2 charged particles and 2 neutral particles. ☐

2 charged particles and 4 neutral particles. ☐

4 charged particles and 2 neutral particles. ☐

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4 charged particles and 4 neutral particles. ☐

(1)

(b) Which statement about beta radiation is true?

Tick **one** box.

It is the fastest moving type of radiation. ☐

It is the type of radiation with a negative charge. ☐

It is the type of radiation with the greatest mass. ☐

It is the type of radiation with the greatest range in air. ☐

(1)

(c) Which statement about gamma radiation is true?

Tick **one** box.

It is a low frequency electromagnetic wave. ☐

It causes the charge of the nucleus to change. ☐

It causes the mass of the nucleus to change. ☐

It has a very long range in air. ☐

(1)

The table below shows the half-lives of two of the radioactive isotopes that contaminated the environment.

Isotope	**Half-life**
Caesium-137	30 years
Iodine-131	8 days

(d) A soil sample was taken from the area around Chernobyl in 1986

The soil sample was contaminated with equal amounts of caesium-137 and iodine-131

Explain how the risk linked to each isotope has changed between 1986 and 2018

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Both isotopes emit the same type of radiation.

_____

_____

_____

_____

_____

_____

_____

(4)

(e) Determine the year when the activity of the caesium–137 in the soil sample will be 1/32 of its original value.

_____

_____

_____

Year = _____

(3)

(Total 10 marks)

Q3.

Gamma radiation is emitted from the nuclei of some atoms.

(a) What is a gamma ray?

Tick **one** box.

A helium nucleus ☐

A high speed electron ☐

A neutron ☐

A type of electromagnetic radiation ☐

(1)

(b) Which would be the best absorber of gamma radiation?

Tick **one** box.

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A few mm of air ☐

A thick sheet of cardboard ☐

A thick sheet of lead ☐

A thin sheet of paper ☐

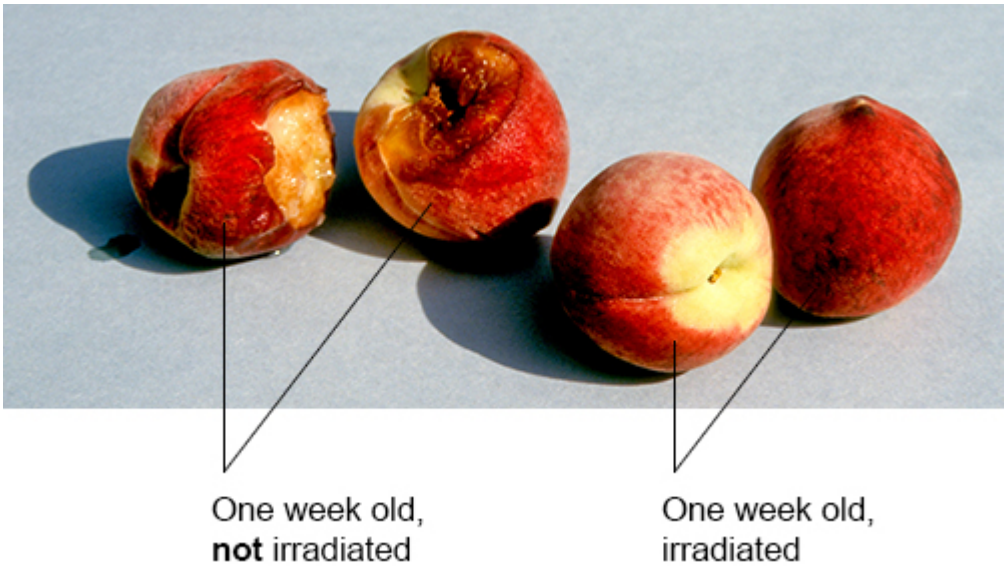
(1)

Food can be irradiated with gamma rays to kill bacteria.

Below is a photograph of peaches.

Two of the peaches were irradiated.

The photograph was taken one week after irradiation.



(c) Why do food producers need to kill bacteria on food?

Tick **two** boxes.

To change the colour of the food ☐

To decrease the rate of decay of the food ☐

To decrease the shelf life of the food ☐

To prevent food poisoning ☐

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To remove dirt from food ☐

(2)

(d) How do gamma rays kill bacteria?

Tick **one** box.

Gamma rays cause meiosis to occur ☐

Gamma rays cause mutations ☐

Gamma rays decrease the size of bacterial cells ☐

Gamma rays destroy the food source for bacteria ☐

(1)

(e) Food producers can irradiate food by passing it close to a radioactive source.

How can food producers increase the level of radiation that the food is exposed to?

Tick **two** boxes.

Boil the food before passing it close to the radioactive source ☐

Decrease the distance between the food and the radioactive source ☐

Increase the time for which the food is close to the radioactive source ☐

Put the radioactive source in a box ☐

Reduce the temperature of the radioactive source ☐

(2)

(f) A student said:

'The irradiated food would become radioactive.'

Give **one** reason why the student is **not** correct.

_____

_____

(1)

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(Total 8 marks)

Q4.

Alpha, beta and gamma are types of nuclear radiation.

(a) Explain why gamma emission does **not** change the atomic number of an element.

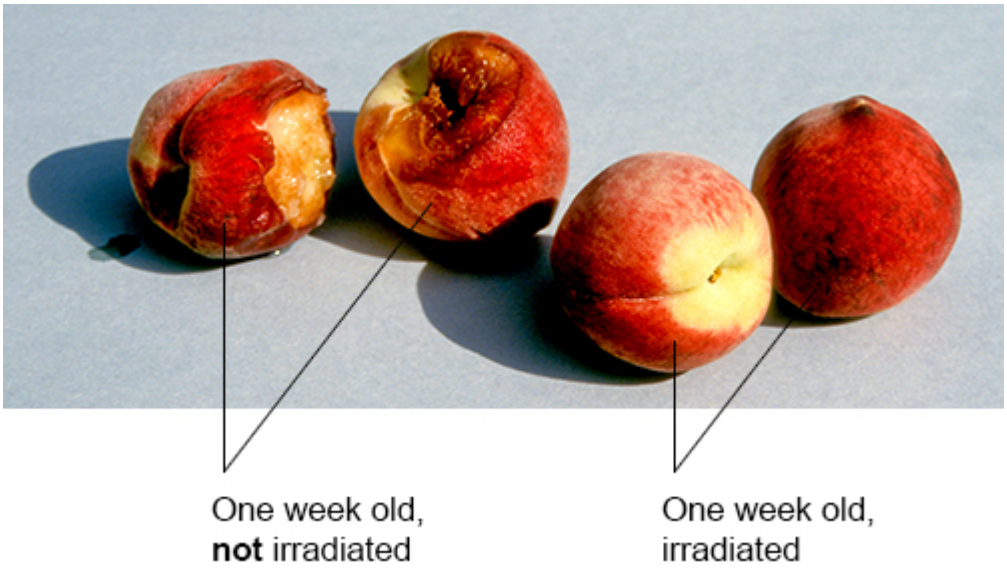
(2)

Food can be irradiated to make it safer to eat.

Below is a photograph of peaches.

Two of the peaches were irradiated.

The photograph was taken one week after irradiation.



(b) Explain why irradiating food makes it safer to eat.

(3)

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(c) Food is packaged and then irradiated.

Explain why food is irradiated using gamma radiation rather than alpha or beta radiation.

_____

_____

_____

_____

(2)

(d) Some people are concerned that irradiated food could be radioactive.

Describe how irradiated food is different from food that is radioactive.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q5.

Neon is an element. Neon is used in advertising signs.

Figure 1 shows a neon sign.

Figure 1



(a) Explain why the atoms of neon give out electromagnetic radiation when the tube is connected to an electricity supply.

_____

_____

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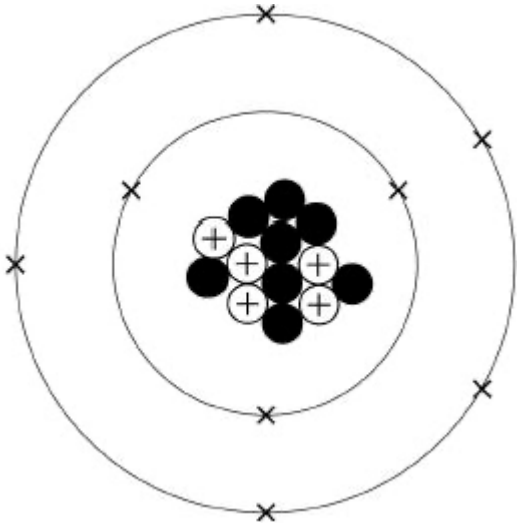
(4)

Some elements can have different isotopes.

(b) An isotope of carbon can be shown as $^{13}_{6}C$

Figure 2 shows an **incorrect** diagram of the structure of an atom of $^{13}_{6}C$

Figure 2



Explain why the diagram of the atomic structure shown in **Figure 2** is incorrect.

Give a reason for your answer.

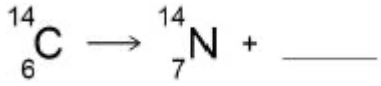
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(4)

Carbon-14 ($^{14}_{6}C$) is a radioactive isotope of carbon. Carbon-14 undergoes **beta** decay.

Figure 3 shows an incomplete nuclear equation for the radioactive decay of carbon-14.

Figure 3



(c) Which of the following correctly completes the nuclear equation in **Figure 3**?

Tick **one** box.

$^{0}_{-1}e$ ☐

$^{-1}_{0}e$ ☐

$^{1}_{0}e$ ☐

$^{0}_{1}e$ ☐

(1)

(d) Explain the change in atomic number in the nuclear equation shown in **Figure 3**.

(2)

(e) The half-life of carbon-14 is 5730 years.

Carbon-14 is used for carbon dating. Carbon dating can tell us how old some objects are.

A skeleton was carbon dated. The results showed that there was only 12.5% of the original amount of carbon-14 left in the skeleton.

Calculate the age of the skeleton.

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Age of skeleton = _____ years old

(2)

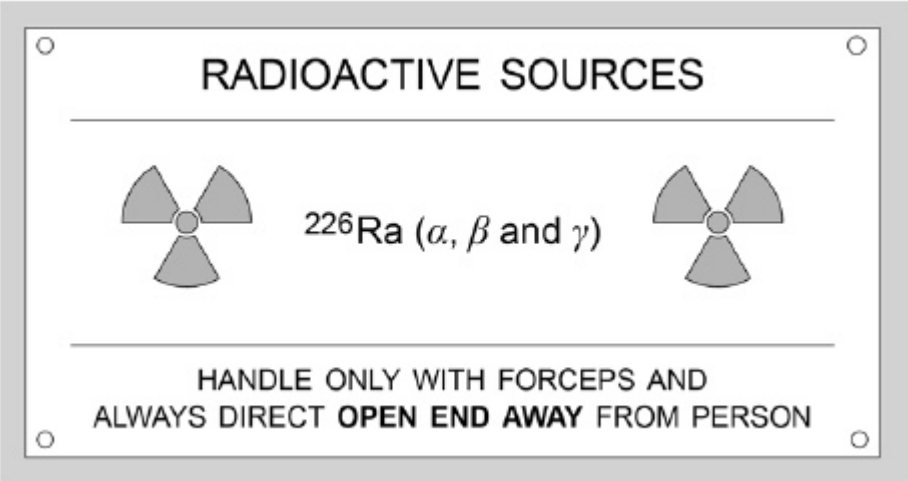
(Total 13 marks)

Q6.

Figure 1 shows the label from a box containing radium-226

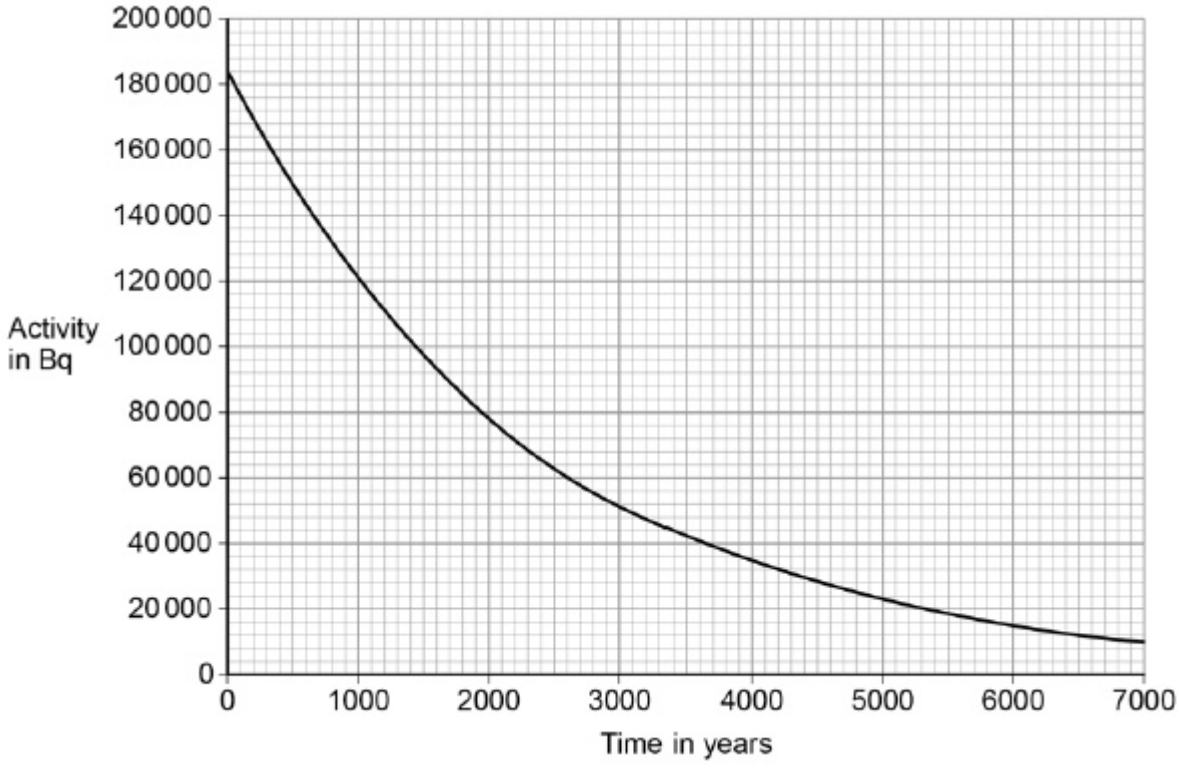
Radium-226 emits α, β and γ radiation.

Figure 1



(a) **Figure 2** shows how the activity of the radium-226 will change.

Figure 2



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Determine the half-life of radium-226.

Show your working on **Figure 2**.

Half-life = _____ years

(2)

(b) Radium-226 was discovered by Marie Curie in 1898.

The notebooks she used were contaminated with radium-226 and are still hazardous.

Explain why the notebooks are still hazardous.

(2)

(c) Explain how the properties of α, β and γ radiation affect the level of the hazard at different distances.

(6)

(Total 10 marks)

Q7.

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Some street lamps contain sodium.

Below are two isotopes of sodium.

$^{23}_{11}Na$ $^{24}_{11}Na$

(a) What are isotopes?

_____

_____

_____

_____

(2)

(b) How many protons and neutrons are in a nucleus of $^{23}_{11}Na$?

Number of protons = _____

Number of neutrons = _____

(2)

(c) The sodium atoms emit light.

What would cause light to be emitted from a sodium atom?

Tick **one** box.

Electrons being emitted from the nucleus.	☐
Electrons falling to a lower energy level.	☐
Electrons leaving the atom when it is ionised.	☐
Electrons moving to a higher energy level.	☐

(1)

(d) In a street lamp, solid sodium is melted and vaporised.

Describe how the arrangement of the sodium atoms changes as the sodium goes from solid to liquid to gas.

_____

_____

_____

_____

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_____

_____

_____

_____

(4)

The table shows the power ratings of some types of sodium lamp.

Type of sodium lamp	Power in Watts
A	35
B	50
C	70
D	100
E	150

(e) Some main roads are lit by type **E** sodium lamps.

Calculate the energy transferred by one type **E** sodium lamp in 1 hour.

_____

_____

_____

_____

_____

Energy transferred = _____ J

(3)

(f) Many housing estates are lit by type **A** sodium lamps.

Suggest **two** advantages of using type **A** sodium lamps on housing estates.

1. _____

2. _____

(2)

(Total 14 marks)

Q8.

The arrangement of electrons in atoms can change.

(a) Describe what might happen to make an electron move from a lower energy level to a higher energy level in a neon atom.

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_____

_____

(1)

(b) Describe what happens when an electron moves from a higher to a lower energy level in a neon atom.

_____

_____

_____

_____

(2)

(c) The table shows information about radiation doses.

	Radiation dose in millisieverts
Mean annual dose from natural sources	2.7
Mean dose from one aircraft flight	3.0×10^{-2}

The mean annual dose a person receives from natural sources is greater than the mean dose from one aircraft flight.

Calculate how many times greater.

_____

_____

_____

Number of times greater = _____

(2)

(d) X-rays can be harmful.

Suggest why some people think X-rays are more dangerous than they really are.

_____

_____

(1)

(e) Ionising radiation can be used to treat patients in hospital.

People working in hospitals must limit their exposure to ionising radiation.

Explain how the use of ionising radiation in hospitals can be both useful **and** harmful.

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(Total 12 marks)

Q9.

Two isotopes of carbon are $^{12}_{6}C$ and $^{14}_{6}C$.

(a) Describe **two** similarities and **one** difference in the atomic structure of the two isotopes.

You should refer to the **number** and **type** of sub-atomic particles in each isotope.

Similarity 1 _____

_____

Similarity 2 _____

_____

Difference _____

_____

(3)

$^{14}_{6}C$ is a radioactive isotope with a half-life of 5730 years.

(b) A sample of $^{14}_{6}C$ from a fossilised tree gives a count rate of 20 decays per

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second.

The tree died 17 190 years ago.

Determine what the count rate of the $^{14}_{6}C$ isotope was when the tree died.

Count rate = _____ decays per second

(2)

(c) Some molecules in air contain $^{14}_{6}C$.

Explain how $^{14}_{6}C$ atoms from the air can become part of human cells.

(5)

(Total 10 marks)

Q10.

The nuclei of some isotopes are radioactive.

(a) Which of the following statements could apply to a radioactive nucleus?

Tick **one** box.

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The nucleus will emit an atom. ☐

The nucleus will emit light. ☐

The nucleus will emit a neutron. ☐

The nucleus will emit sound. ☐

(1)

(b) Potassium-40 is a radioactive isotope present in food, such as bananas.

The following equation shows how potassium-40 will decay into calcium-40

$$^{40}_{19}\text{potassium} \longrightarrow {}^{40}_{20}\text{calcium} + {}^{0}_{-1}\text{e}$$

Give one similarity and one difference between nuclei of potassium-40 and calcium-40

Similarity _____

Difference _____

(2)

(c) The activity of a sample of potassium-40 is measured 3 times.

The measurements are given below.

4906 Bq **4956 Bq** **4889 Bq**

Which of the following statements explains why the readings are different?

Tick **one** box.

Radioactive decay is constant. ☐

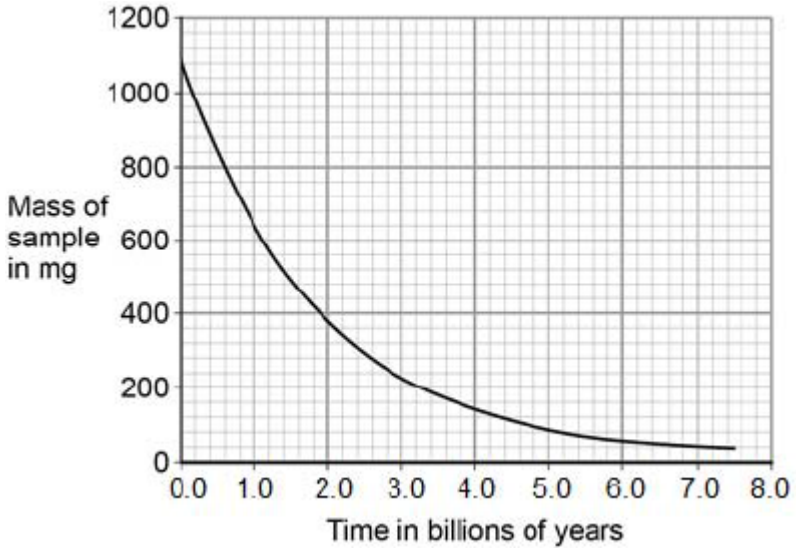
Radioactive decay is hazardous. ☐

Radioactive decay is random. ☐

(1)

(d) The figure below shows how the activity of a sample of potassium-40 changes over time.

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Use the figure above to determine the half-life of potassium-40.

_____

_____

Half-life = _____ billion years

(2)

(e) When food is eaten, some of the radiation the food emits is detectable outside the body.

Which type of radiation would not be detectable outside the body?

Tick **one** box.

alpha ☐

beta ☐

gamma ☐

(1)

(Total 7 marks)

Q11.

Some small fractures do not show up on an X-ray image.

To see the fracture doctors inject the patient with a radioactive isotope.

The image is formed by detecting radiation as it leaves the body.

The figure below shows an image of a foot after the patient was injected with the radioactive isotope technetium-99.

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© Ni Qin/ Getty Images

Technetium-99 emits gamma radiation.

(a) What is gamma radiation?

_____

_____

(1)

(b) Explain why a gamma emitter is used.

_____

_____

_____

_____

(2)

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

Give the meaning of the term **half-life**.

_____

_____

(1)

(d) After treatment, hospital equipment may become contaminated.

Describe the level of the hazard associated with contamination with technetium-99.

You should include in your answer a description of how the level of hazard changes over time.

_____

_____

_____

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_____

_____

_____

(3)

(e) Some of the hospital equipment may also be irradiated during treatment.

Describe how equipment becomes irradiated.

_____

_____

(1)

(f) Why is irradiated equipment not hazardous?

_____

_____

(1)

(Total 9 marks)

Q12.

Atoms are very small and most of their mass is concentrated in the nucleus.

Electrons orbit at different distances from the nucleus.

(a) A nucleus is much smaller than an atom.

Approximately how many times smaller is a nucleus than an atom?

Tick **one** box.

100 ☐

1000 ☐

10 000 ☐

100 000 ☐

(1)

(b) The electrons in an atom can only orbit at specific distances from the nucleus.

State what causes an electron's distance from the nucleus to increase or decrease.

Increase _____

_____

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Decrease _____

_____

(2)

(c) Atoms have different atomic numbers and mass numbers.

In terms of sub-atomic particles, describe the difference between an atom's atomic number and its mass number.

_____

_____

_____

_____

(2)

(d) Transmutation is the name given to a process where one element changes into another.

Explain and compare how two different types of radioactive decay can cause transmutation.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 9 marks)

Q13.

This question is about radioactive decay.

(a) **Figure 1** shows a nuclear equation for the decay of an atom of uranium.

Figure 1

$$^{235}_{92}U \longrightarrow {}^{231}_{90}Th + {}^{4}_{2}He$$

Use information from **Figure 1** to complete the table below.

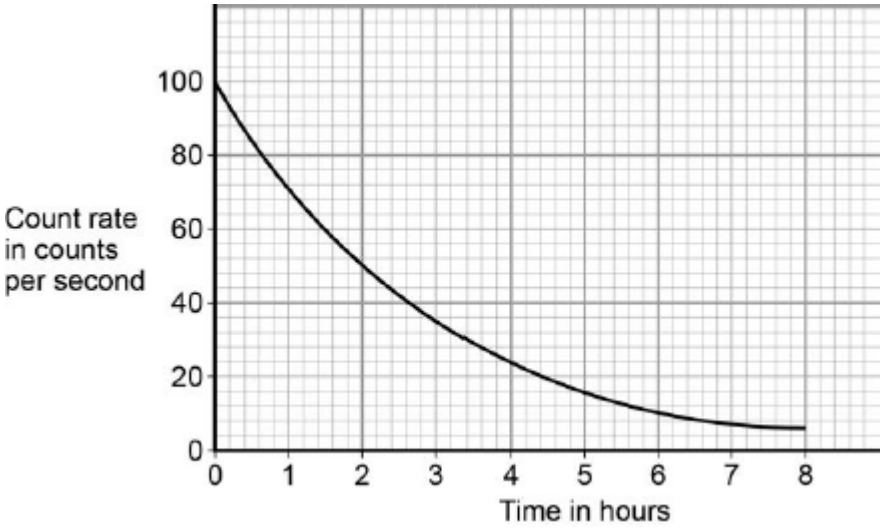
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	U	Th
Mass number	235	
Number of protons		90
Number of neutrons	143	

(3)

(b) **Figure 2** shows how the count rate from a radioactive isotope changes with time.

Figure 2



What is the half-life of the radioactive isotope?

Explain why you chose that value.

Half-life = _____ hours

Explanation _____

_____

(2)

(c) When a radioactive isotope decays it can produce beta particles.

What is a beta particle?

Tick **one** box.

A high-speed electron ☐

A neutron and an electron ☐

A neutron and a proton ☐

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A helium nucleus ☐

(1)

(d) Beta particles can cause cancer.

Complete the sentences.

Use words from the box.

benign	**controlled**	**differentiated**	**malignant**	**slow**	**uncontrolled**

Tumours form when cell division is _____

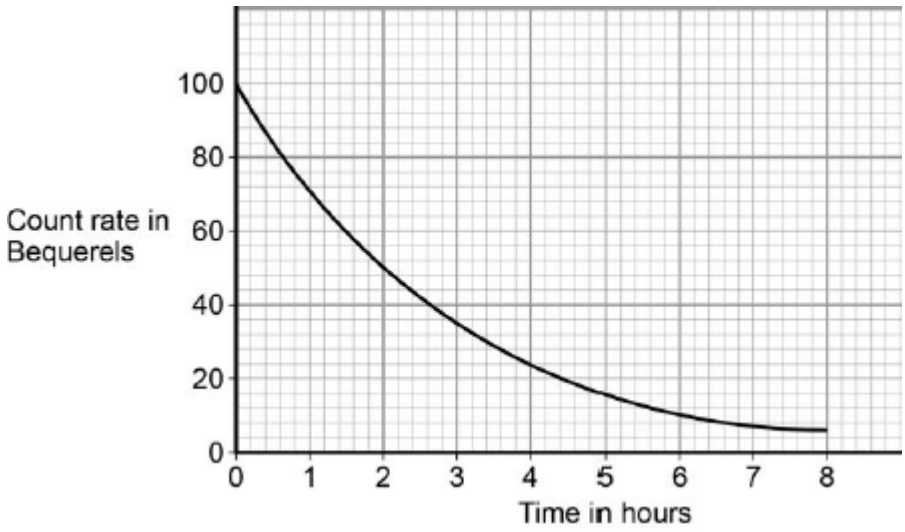
Tumours that do not invade other tissues are called _____

(2)

(Total 8 marks)

Q14.

The figure below shows how the activity of a radioactive isotope changes over an 8 hour period of time.



(a) Predict how long it will take for the count rate to fall from 100 to 1.56 Bequerels.

_____

_____

_____

Time = _____ hours

(2)

(b) Lead-210 is a radioactive isotope that decays to an isotope of mercury by alpha decay.

Complete the nuclear equation to show the alpha decay of lead-210.

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$$^{210}__Pb \longrightarrow ___{80}Hg + ____$$

(3)

(c) Explain how ionising radiation can have hazardous effects on the human body.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

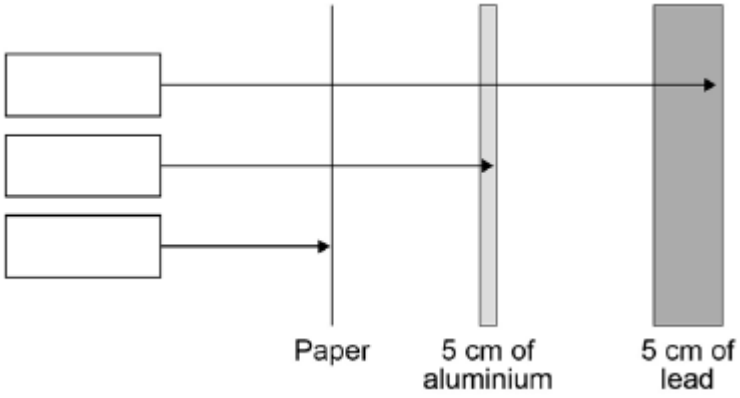
(Total 10 marks)

Q15.

Alpha, beta and gamma are types of nuclear radiation.

A teacher sets up a demonstration of the penetration properties of alpha, beta and gamma radiation.

The figure below shows the demonstration.



(a) Complete the figure above by writing the name of the radiation in each box.

(2)

(b) Give **two** safety precautions the teacher should take in the demonstration.

1. _____

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2. _____

(2)

(c) The table below shows how the count rate of a radioactive source changes with time.

Time in seconds	0	40	80	120	160
Count rate in counts / second	600	463	300	221	150

Describe the relationship shown in the table above.

(2)

(d) Use the table above to predict the count rate after 200 seconds.

Count rate = _____ counts / second

(2)

(e) The half-life of the radioactive source is very short.

Give **one** reason why the source would be much less hazardous after 800 seconds.

(1)

(Total 9 marks)

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