

AQA GCSE PHYSICS (HIGHER) • 8463

PHYSICS



EXAM QUESTION PACK

4.4.2 ATOMS AND NUCLEAR RADIATION (PACK 3)

SCORE

/146

PERCENTAGE

%

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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.

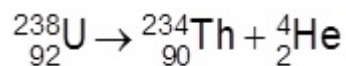
Alpha (α)	☐
Beta (β)	☐
Gamma (γ)	☐

(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).



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.

☐

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

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 $\frac{1}{32}$ 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.

A few mm of air

☐

A thick sheet of cardboard

☐

A thick sheet of lead

☐

A thin sheet of paper

☐

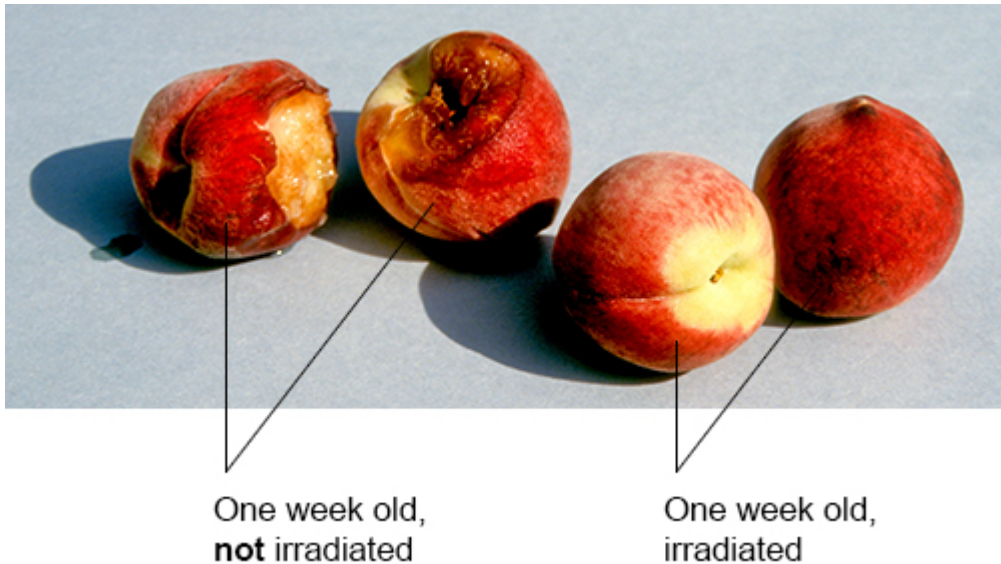
(1)

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

☐

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)

Q4.

Alpha, beta and gamma are types of nuclear radiation.

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

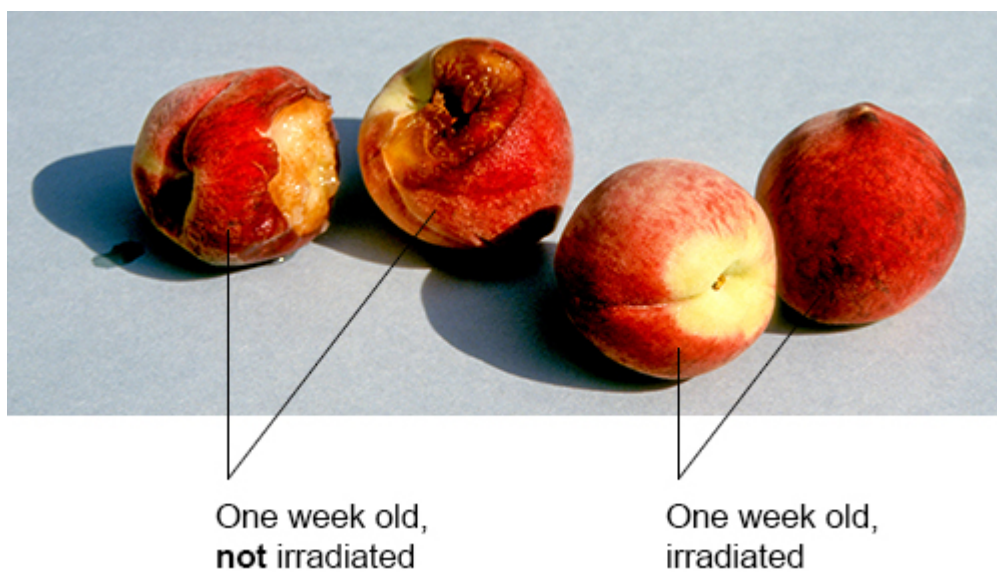
(2)

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)

- (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)

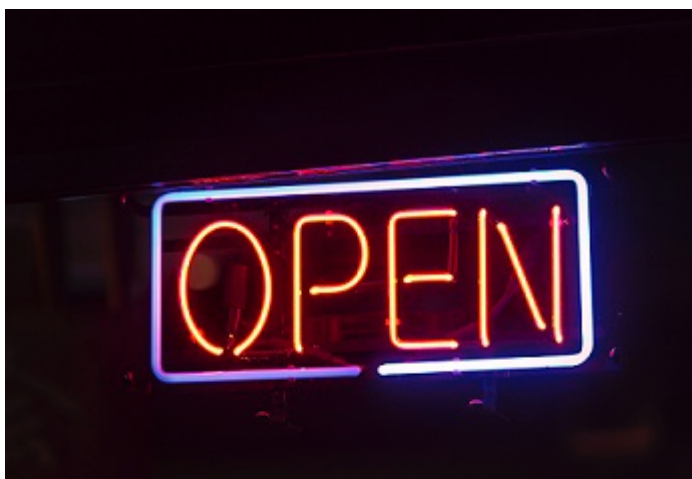
(Total 9 marks)

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.

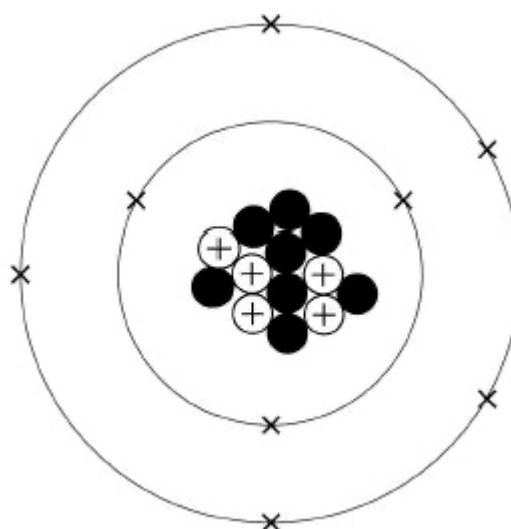
(4)

Some elements can have different isotopes.

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

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

Figure 2



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

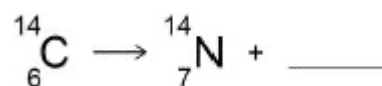
Give a reason for your answer.

(4)

Carbon-14 ($^{14}_6\text{C}$) 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.

$^0_{-1}\text{e}$	☐
$^{-1}_0\text{e}$	☐
^1_0e	☐
^0_1e	☐

(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.

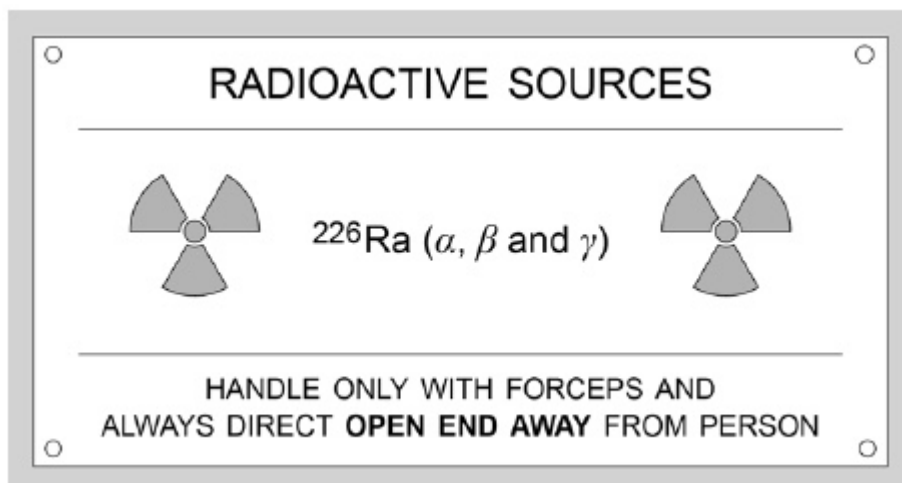
Age of skeleton = _____ years old
(2)
(Total 13 marks)

Q6.

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

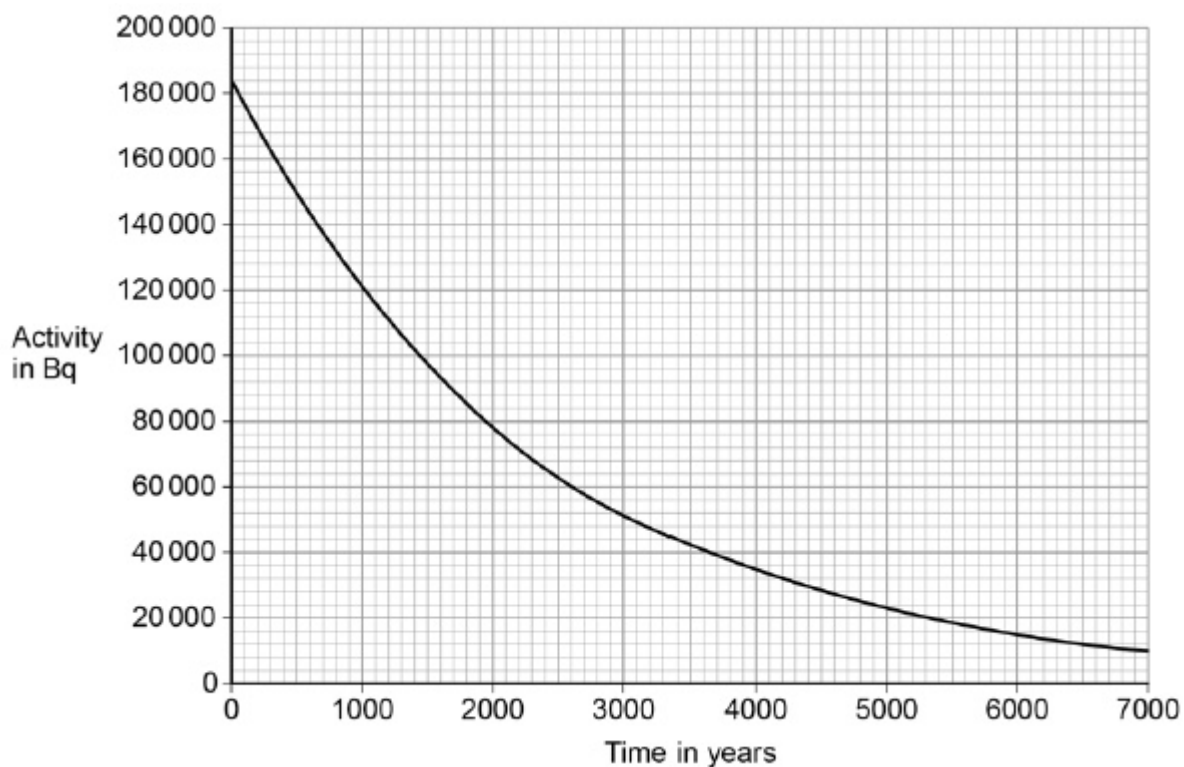
Radium-226 emits α , β and γ radiation.

Figure 1



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

Figure 2



Show your working on **Figure 2**.

(2)

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

(2)

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

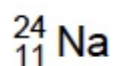
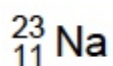
(6)

(Total 10 marks)

Page 13 of 42

Some street lamps contain sodium.

Below are two isotopes of sodium.



- (a) What are isotopes?

(2)

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

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.

(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.

(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.

[illegible]

Q9.

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

$^{14}_6\text{C}$ is a radioactive isotope with a half-life of 5730 years.

second.

The tree died 17 190 years ago.

Determine what the count rate of the $^{14}_6\text{C}$ isotope was when the tree died.

Count rate = _____ decays per second

(2)

(c) Some molecules in air contain $^{14}_6\text{C}$.

Explain how $^{14}_6\text{C}$ 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.

- 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



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

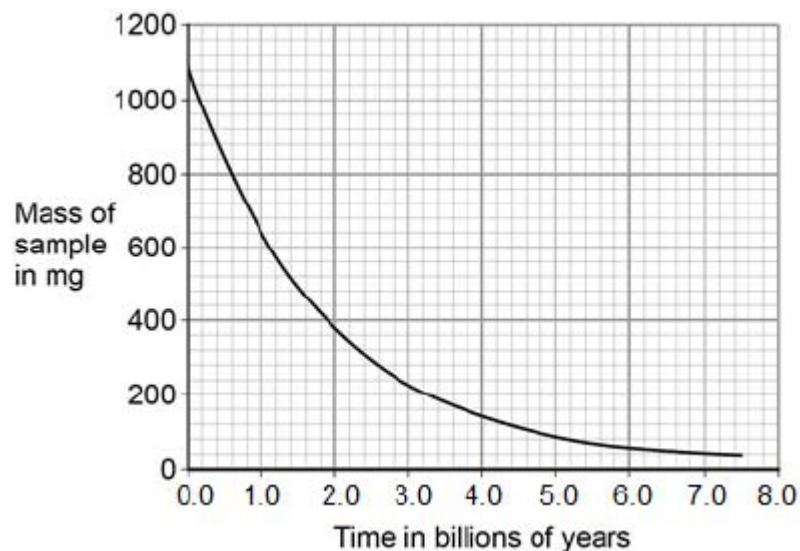
Which of the following statements explains why the readings are different?

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.



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.



© 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.

(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 _____

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)

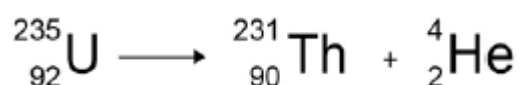
(Total 9 marks)

Q13.

This question is about radioactive decay.

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

Figure 1



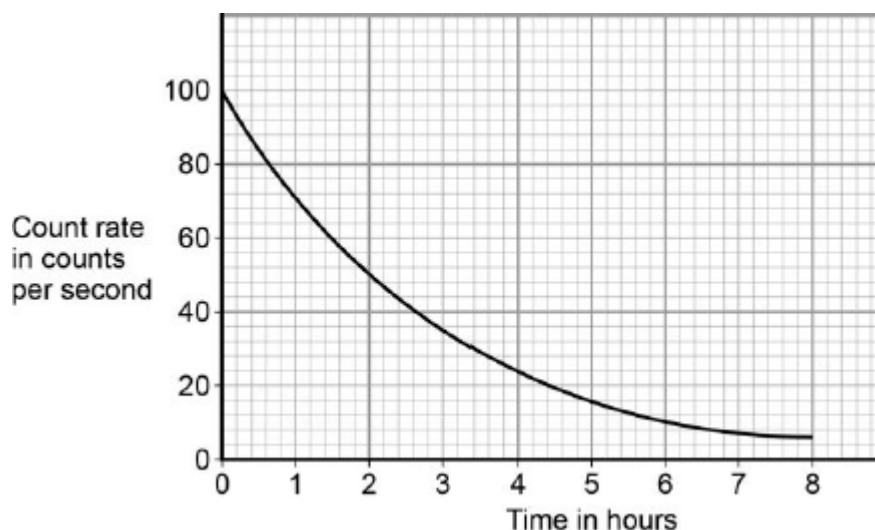
Use information from **Figure 1** to complete the table below.

	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

☐

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 _____

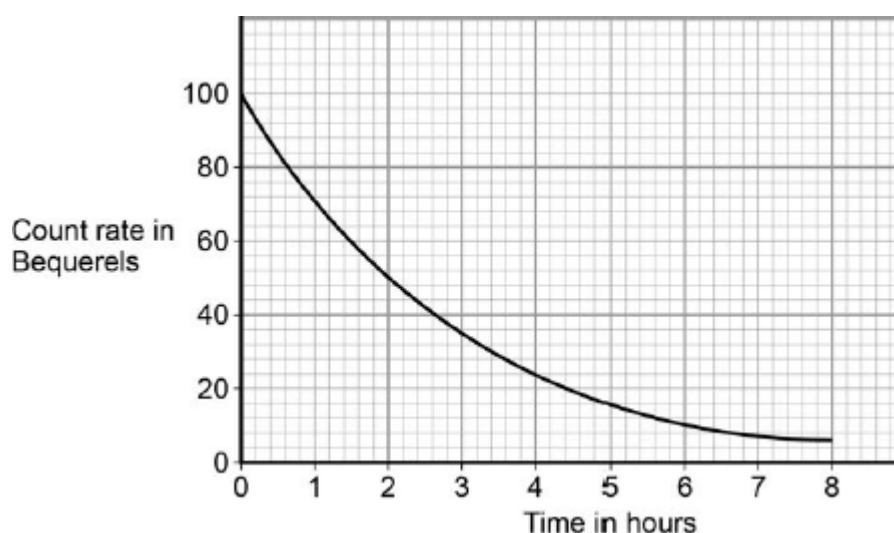
Tumours that do not invade other tissues are called _____

(2)

(Total 8 marks)

Q14.

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



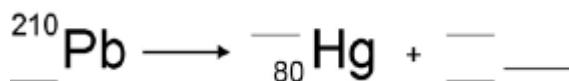
- (a) Predict how long it will take for the count rate to fall from 100 to 1.56 Bequerels.

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.



(3)

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

(5)

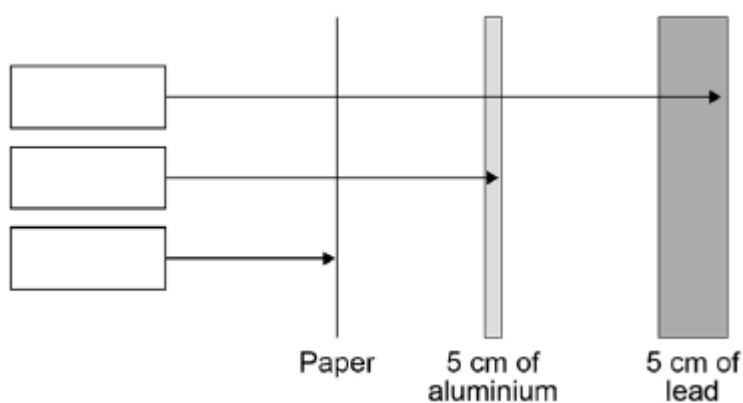
(Total 10 marks)

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. _____

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)

Mark schemes

Q1.

(a) gamma

1

(b) alpha

1

(c) gamma

1

(d)

isotope	number of neutrons	number of protons
uranium-238	146	92
thorium-234	144	90

1

1

(e) $\Delta\theta = 80^\circ\text{C}$

1

$$E = 150 \times 4200 \times 80$$

1

$$E = 50\,400\,000 \text{ (J)}$$

allow 50 000 000 (J)

1

*allow **max 2** marks for correct calculation using incorrect value of $\Delta\theta$*

*allow **1** mark for correct calculation using $\theta = 20$
or $\theta = 100$*

*an answer of 50 400 000 scores **3** marks*

[8]

Q2.

(a) 2 charged particles and 2 neutral particles

1

(b) it is the type of radiation with a negative charge

1

(c) it has a very long range in air

1

(d) risk / activity associated with iodine-131 has decreased by a large amount

1

because of short half-life

allow many half-lives have passed

allow half-life is only 8 days

2nd marking point dependent on 1st marking

point

1

risk / activity associated with caesium-137 will not have decreased by much

allow activity has halved

1

because of long half-life

allow only one half-life has passed

4th marking point dependent on 3rd marking point

1

(e) 5 half-lives

allow any correct method

e.g. $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = 1/32$

1

$5 \times 30 = 150$

1

$1986 + 150 = 2136$

1

any calculation using a value of 137 scores zero

an answer of 2136 scores 3 marks

[10]

Q3.

(a) a type of electromagnetic radiation

1

(b) a thick sheet of lead

1

(c) to decrease the rate of decay of the food

1

to prevent food poisoning

1

(d) gamma rays cause mutations

1

(e) decrease the distance between the food and the radioactive source

1

increase the time for which the food is close to the radioactive source

1

(f) (because) the source of radiation is not in the food

allow source of radiation is / remains outside food

1

[8]

Q4.

(a) (gamma emission) does not change the number of protons

- 1
- (because gamma emission) is not a particle
allow (gamma emission) is an (electromagnetic) wave
 1
- (b) prevents food poisoning
 1
- (by) killing the bacteria / microorganisms / moulds
 1
- that produce toxins
ignore references to decay
 1
- (c) (only) gamma rays can pass (all the way) through packaging (to reach the food / bacteria)
allow converse
 1
- (and also) gamma rays pass all the way through the food without damaging / ionising the food
allow converse
 1
- ignore contamination*
ignore no damage to food unqualified
- (d) radioactive food contains a source of radiation
or
 radioactive food is emitting radiation
 1
- (whereas)
 irradiated food has been exposed to (an external source of nuclear) radiation
 1
- [9]**

Q5.

- (a) atoms / electrons gain energy
 1
- (some) electrons move to a higher energy level
allow (sub) shell for energy level
 1
- (so) as the electrons fall to a lower / original energy level
allow (sub) shell for energy level
 1
- (EM) radiation with a frequency / wavelength within the visible region of the spectrum is emitted
 1
- (b) there should be two electrons on the inner shell (not three)
 1

there should only be four electrons in the outer shell

or

there should only be six electrons in total

1

there should be one more proton

allow should be six protons

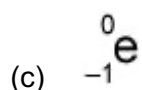
1

there should be one fewer neutron

allow should be seven neutrons

1

allow 2 marks for one of the neutrons should be a proton



1

(d) a neutron splits into a proton **and** an electron

allow beta particle for electron

1

so there is an extra proton (in the nucleus)

1

(e) 12.5% is 3 half lives

or

5730×3

1

17 190 (years old)

1

an answer of 17 190 (years old) scores 2 marks

[13]

Q6.

(a) horizontal line drawn from
92 000 Bq

allow 90 000–94 000

1

1600 years

allow 1500–1700

1

(b) only (119) years have passed

1

activity has not dropped by much

1

(c)

Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.
--

5-6

Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1-2
No relevant content	0
Indicative content properties • alpha is the least penetrating • alpha is the most ionising • alpha has least range in air • beta is the second most penetrating • beta is the second most ionising • beta has the second longest range in air • gamma is the most penetrating • gamma is the least ionising • gamma has the greatest range in air hazard (linked to correct property) • short-range alpha most dangerous • mid-range beta most dangerous • long range gamma most dangerous	

6

[10]

Q7.

- (a) atoms with the same number of protons
allow atoms of the same element

1

but with a different number of neutrons

1

- (b) protons = 11

1

neutrons = 12

1

- (c) electrons falling to a lower energy level

1

- (d)

Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.	3-4
Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.	1-2
No relevant content	0
Indicative content solid - atoms closely packed - atoms in a regular arrangement - atoms vibrate about a fixed position liquid - atoms are close together - atoms are not in regular arrangement - atoms can move past each other gas - atoms are well separated - atoms are not in regular arrangement - atoms move randomly at high speeds	

4

(e) 60×60

1

$$E = 150 \times 3600$$

1

$$E = 540\,000 \text{ (J)}$$

an answer of 540 000 (J) scores 3 marks

1

(f) less energy transferred

1

not as bright

1

[14]

Q8.

(a) any **one** from:

- heating
- electricity
- electromagnetic radiation

1

- (b) electromagnetic radiation is emitted 1
- in the (visible) region of the spectrum
allow as light 1
- (c) $(3.0 \times 10^{-2} =) 0.03$ 1
- $(2.7 / 0.03 =) 90$
an answer of 90 scores 2 marks 1
- (d) any **one** from:
- can't see X-rays
 - not common experience
 - experience of cancer / severity of consequence
 - lack of understanding of probability
- allow people are scared of X-rays / radiation* 1

(e)

Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5-6
Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1-2
No relevant content	0
Indicative content uses • used to diagnose problems • X-rays and CT scans • sterilising instruments • because it kills bacteria • radiotherapy • to treat <u>cancer</u> • used to kill cancer cells • medical tracers • gamma knives harm	

• can change / mutate DNA • causing cells to grow uncontrollably • causing tumours / cancer • from regular exposure causing increased dose • to eggs / sperm / embryos	
--	--

6

[12]

Q9.

- (a) both have 6 electrons

1

both have 6 protons

1

carbon-12 contains 6 neutrons **but** carbon-14 contains 8 neutrons
allow carbon-14 has 2 more neutrons

1

- (b) $\frac{17190}{5730} = 3$ (half lives)

1

$(20 \times 2 \times 2 \times 2 =) 160$

an answer of 160 scores 2 marks

1

- (c) carbon-14 is in (some) carbon dioxide (in air)

1

carbon-14 / carbon dioxide taken in (by plants) in photosynthesis

1

becomes part of glucose / starch / carbohydrate

1

plant eaten by humans / herbivores / passed up food chain
allow carbon compounds passed up food chain

1

starch is digested

or

glucose diffuses into cells

or

glucose stored as glycogen in cells

1

[10]

Q10.

- (a) The nucleus will emit a neutron.

1

- (b) **Similarity**
- same mass number
 allow same number of nucleons (protons + neutrons)
- 1
- difference**
- different atomic number
 allow different number of protons
- 1
- (c) Radioactive decay is random.
- 1
- (d) 1.3 (billion years)
 allow 1.2-1.4 (billion years)
- 2
- allow 1 mark for horizontal line drawn from ~ 550*
- (e) alpha
- 1
- [7]**

Q11.

- (a) electromagnetic radiation from the nucleus
 'electromagnetic radiation' is insufficient
- 1
- (b) (Gamma is the most penetrating) so a large proportion of the emitted radiation will
 leave
 the body
- 1
- more easily detected outside the body
- 1
- (c) (average) time it takes for the number of nuclei of the isotope in a sample to halve
- or**
- (average) time it takes for the count rate from a sample containing the isotope to fall
 to half its initial level
- 1
- (d) initially there is a high level of hazard.
- 1
- level of hazard drops to a low level quickly
- 1
- answer must imply short period of time*
- (activity initially high) due to short half-life
- or**
- (drops to safe level quickly) due to short half-life

(e) it is exposed to ionising radiation

1

1

(f) does not become radioactive

1

[9]

Q12.

(a) 10 000

1

(b) **Increase**

absorb electromagnetic radiation

1

Decrease

emit electromagnetic radiation

1

(c) atomic number is the number of protons

1

mass number is the number of protons and neutrons

1

(d) **Level 2 (3–4 marks):**

A clear comparison, with logical structure.

Level 1 (1–2 marks):

Fragmented points, with no logical structure.

0 marks:

No relevant content

Indicative content

Beta decay

- Atomic number increases by one
- When a neutron decays into a proton

Alpha decay

- Atomic number decreases by two
- When an alpha particle is emitted

Comparison

Both change number of protons (hence new element / transmutation)

Beta decay increases atomic number and alpha decay decreases (explicit)

NB No credit is given for different number of protons = new element.

4

[9]

Q13.

(a) (mass number) 231

1

(protons) 92

1

(neutrons) 141

1

(b) 2 / two (hours)

1

(because) count rate halves in that time

1

(c) A high-speed electron

1

(d) uncontrolled

1

benign

1

[8]

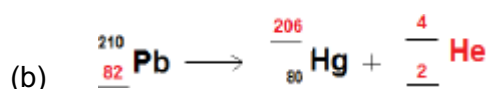
Q14.

(a) half-life read from graph = 2 hours

1

time to fall to 1.56 is six half lives = $6 \times 2 = 12$ (hours)

1



one mark for each correct element in the equation

3

(c) ionising radiation turns atoms into ions

1

which can break up molecules

1

this can change DNA

1

causing mutations to genes

1

which can cause cancer

1

[10]

Q15.

(a) gamma

allow 1 mark for 1 or 2 correct

beta

alpha

2

(b) any **two** from:

- do not point (radioactive) source at students
- keep (radioactive) source outside the box for minimum time necessary
- wear safety glasses **or** eye protection **or** do not look at source
- wear gloves
- hold (radioactive) source away from body
- hold (radioactive) source with tongs / forceps

2

(c) as time increases count rate decreases

1

count rate halves every 80 seconds

1

(d) half-life is 80 seconds

1

so after 200 seconds count rate = 113

1

(e) because a very small amount of radiation will be emitted **or** will be similar to / same as background radiation

1

[9]

Examiner reports

Q1.

- (a) In the first of three multiple choice questions about radiation the majority of students chose the correct answer for the most penetrating.
- (b) Just 51% knew the most ionising radiation.
- (c) 46% knew which radiation has the longest range.
- (d) 77% of students scored at least 1 mark and 66% scored both for correctly determining the number of protons and neutrons in the nuclei.
- (e) In this calculation, students were asked to choose the appropriate equation from the Physics Equations Sheet and most did so successfully. The majority of students gained all 3 marks. Some students did not use the correct temperature change. As in other questions, students should check the number of zeros in their workings and final answer.

Q2.

- (a) 51% of students knew what an alpha particle consists of.
- (b) 70% of students knew that a particle of beta radiation has a negative charge.
- (c) 63% of students knew that gamma radiation has a very long range in air.
- (d) 45% of students scored marks on this question. Students who failed to score often understood there is a risk associated with nuclear radiation but were unable to relate that to the changing levels of radiation with time. There were lots of misconceptions about half-life, the most common being that iodine-131 would not emit any radiation after two half-lives.

Q3.

- (a) 77% of students knew gamma rays are a type of electromagnetic radiation.
- (b) 66% of students knew that a thick sheet of lead would be the best absorber of gamma radiation.
- (c) Over half of students knew that bacteria on food are killed to decrease the rate of decay of food. Fewer knew that this helps prevent food poisoning, with many believing it removes dirt from food.
- (d) 19% of students knew that gamma rays kill bacteria by causing mutations. Most students responded that gamma rays decrease the size of bacterial cells.
- (e) 34% of students could select both choices describing how food producers could increase the level of radiation that the food is exposed to.
- (f) 3% of students understand that for food to be radioactive, the source needs to be within the food itself. Common misconceptions and incorrect answers seen include:
 - bacteria / viruses / pathogens are affected by the gamma radiation, but the food itself isn't

- irradiation is the opposite of radioactivity
- it is impossible for food to be radioactive
- the food was not exposed to the gamma rays for long enough to become radioactive.

Q4.

- (a) 26% of students could identify that gamma emission is an electromagnetic wave. 2% of students could explain that gamma emission does not change the number of protons.
- (b) The most common mark awarded was for the idea that irradiating food kills microorganisms. Answers were often too vague regarding preventing food poisoning, with more students referring to best before dates, which was insufficient.

Misconceptions referring to the half-life of the food being extended were seen. There were also misconceptions regarding food that has been irradiated becoming radioactive.

- (c) Some students could relate their knowledge of properties of gamma radiation to being able to pass through packaging. Recall of penetration properties needed to be applied to the situation given in the question.
- (d) Some students could state that irradiated food has been exposed to a source of radiation, or that radioactive food emits radiation, however, 6% of students did both to give a full answer. The most common misconception was that the term irradiated means removing a source of radiation from food.

Q5.

- (a) 84% of students did not gain any marks in this high demand question. 3% of students achieved three or four marks. The most common mark given was for electrons / atoms gaining energy.
- (b) This question discriminated between students very well with almost equal proportions of students spread across the mark range. Students would appear to have a sound understanding of atomic structure, with 85% achieving at least one mark, and 20% achieving full marks.

Common misconceptions were that 'electrons must be drawn in pairs' and 'neutrons should equal protons'. Some stated that the number of protons, electrons and neutrons was wrong without stating details.

- (c) 69% of all students answered this question correctly. The fourth option was the most common incorrect choice.
- (d) A significant number of students gave answers in term of nitrogen changing into carbon. Few answers offered the complete story of a neutron splitting to produce a proton and an electron.

There was considerable confusion about the meaning of the subscripted and superscripted numbers preceding the atomic symbols. The subscripted number was taken to be the number of electrons. As a result many answers were in terms of atomic number increasing because an electron had been gained. 16% of students achieved one or two marks for this question.

- (e) 13% of students understood the idea of half-life sufficiently to achieve both marks. Otherwise students attempted to calculate 12.5% of 5730. The most common reasonable error was to use the calculation for 4 half-lives.