WJEC Physics GCSE
Topic 2.7: Types of radiation
Questions by topic

1.

Radioactive carbon-14 is an isotope of carbon. It is produced high in the atmosphere when a neutron (n) combines with a nitrogen (N) nucleus, releasing a proton (p) in the process.

Carbon-14 written in the form $^{A}_{Z}X$ is $^{14}_{6}C$.

(a) Write down carbon-12 in the form $^{A}_{Z}X$. .... [1]

(b) The nuclear reaction that produces carbon-14 is written below.

$$^{1}_{0}n \quad + \quad ^{\cdots\cdots}_{7}N \longrightarrow \; ^{14}_{6}C \quad + \quad ^{1}_{\cdots\cdots}p$$

Fill in the missing numbers in the equation above. [2]

(c) Complete the following sentences with the number of particles, if any, in a $^{14}_{6}C$ **nucleus**. [3]

A $^{14}_{6}C$ **nucleus** contains .... protons.

A $^{14}_{6}C$ **nucleus** contains .... neutrons.

A $^{14}_{6}C$ **nucleus** contains .... electrons.

6

2.

A list of radioisotopes and their decay mode is shown in the table below.

Radioisotope	Decay mode
Radon - 272	α
Strontium - 90	β
Silver - 110	β and γ
Iodine - 131	γ
Radium - 226	α and γ

The table below shows the count rate detected from three of the radioisotopes above when different absorbers are placed between the source and counter. The distance between the counter and the radioisotope is fixed at 2 cm.

Radioisotope	Count rate (units)			
	No absorber	Paper	Aluminium	Lead
X	21	20	21	6
Y	74	73	56	15
Z	44	32	33	12

Use the information in **both** tables to identify radioisotopes **X, Y** and **Z** giving your reasoning. [5]

Radioisotope **X** is ....

Reasoning:

....

....

....

Radioisotope **Y** is ....

Reasoning:

....

....

....

Radioisotope **Z** is ....

Reasoning:

....

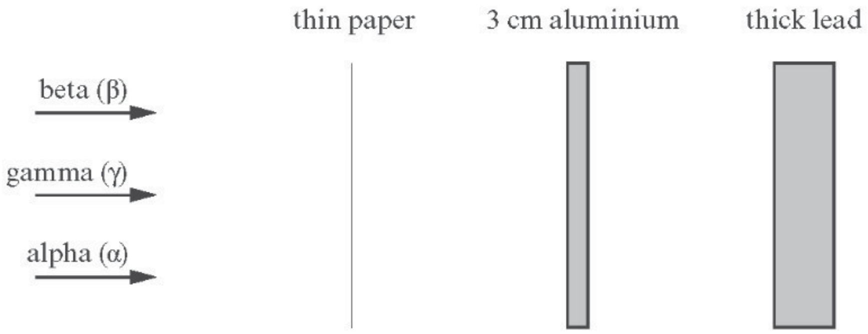
....

....

5

3.

The diagram shows three types of radiation, alpha (α), beta (β) and gamma (γ).

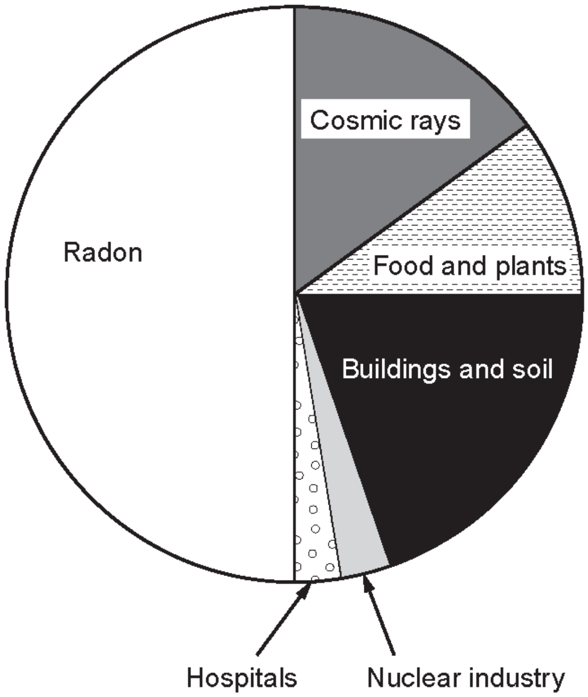


Continue each arrow to show how far **each type** of radiation travels before it gets absorbed. [3]

3

4.

The sources of background radiation in a part of the U.K. are shown in the pie chart below.



(a) A single reading of the total background radiation showed 20 counts taken in a minute.

(i) Calculate the total number of counts per minute (cpm) from cosmic rays and food and plants **together**. [2]

.... cpm

(ii) Describe how a more reliable value of the total background radiation could have been found. [2]

....

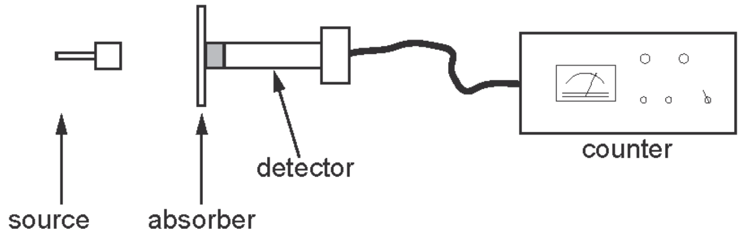
....

....

(iii) Give the name of **one** source of background radiation that depends largely on the rocks in the area in which the measurement is taken. [1]

....

(b) A radiation detector is connected to a counter in a classroom. Absorbers were placed directly in front of the detector in an attempt to find which radiation was being given off by the radioactive source americium-241.



The following results were obtained.
The figures **include** the mean background radiation count of 20 cpm.

Absorber	Reading obtained (counts per minute)
none	350
thin card	20
3 mm of aluminium	21
20 mm lead	1

Use the information in the table above and your knowledge of radioactivity to answer the following questions.

(i) Calculate the mean number of counts per minute emitted by the americium-241. [2]

.... cpm

(ii) Explain which **type** of radiation is given off by the source. [2]

....

....

....

(iii) Give a reason why pupils in the class did not need to be shielded from the source's radiation. [1]

....

(iv) Explain how the data shows that background radiation is mainly gamma. [2]

....

....

....

(v) State why the count rates measured beyond the aluminium are different from the mean background count. [1]

....

13

5.

(a) In a laboratory, a radiation detector was placed in front of a radioactive source. The readings were carefully taken every minute and are shown below.

Time (mins)	1	2	3	4	5
Detector reading (counts)	34	36	40	31	34

(i) Put a tick (✓) alongside the **one** correct reason below for the readings not being the same every minute. [1]

Detector was probably not working properly.	
Radioactive decay is random.	
The source was faulty.	
The times were not carefully measured.	
The detector was moved nearer the source in the 5 minutes.	

(ii) Calculate the mean number of counts every minute. [2]

Mean counts = ...

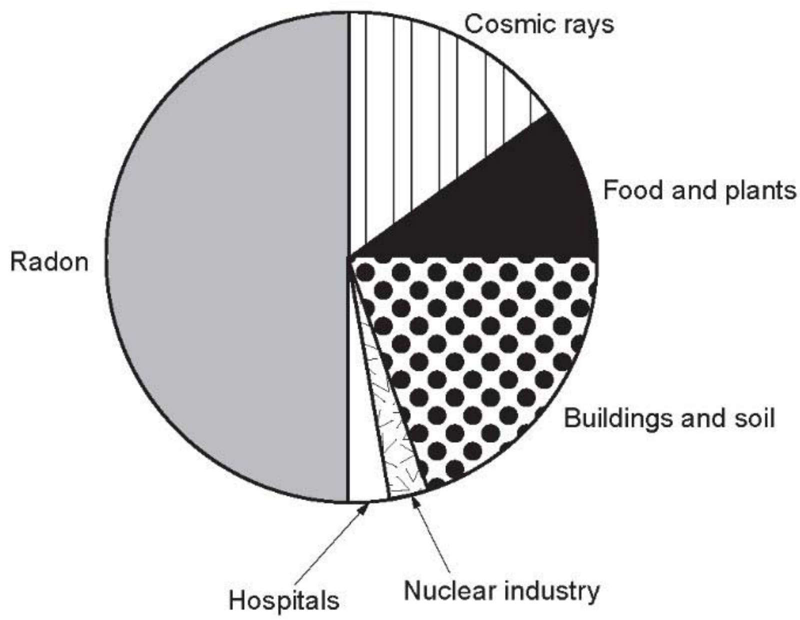
(iii) State how the method used above could be changed to find the count rate of the background radiation in the laboratory. [1]

....

....

(b) The sources of background radiation are shown in the pie chart below.

Sources of background radiation



(i) Use the information in the pie chart to answer the questions that follow.

(I) Name the background source that gives the same percentage as hospitals. [1]

....

(II) State the percentage of background radiation that comes from radon. [1]

.... %

(ii) State the reason why the amount of radon varies across the country. [1]

....

7

6.

Radioactive substances are used in a wide variety of applications, which range from medical to industrial, commercial and research.

(a) The list below shows information about some radioisotopes of cobalt and iodine.

- Iodine-123 has a half-life of 13 hours and emits gamma.
- Iodine-125 has a half-life of 59 days and emits gamma.
- Iodine-127 is stable.
- Iodine-129 has a half-life of 1.6 years and emits beta.

- Cobalt-55 has a half-life of 17.3 hours and emits beta.
- Cobalt-58 has a half-life of 70 days and emits beta.
- Cobalt-59 is stable.
- Cobalt-60 has a half-life of 5.3 years and emits both beta and gamma.

Radioactive isotopes are used widely in many medical applications. In treating brain tumours, patients are exposed to an **external** cobalt source of radiation to kill cancerous cells. To check the behaviour of the thyroid gland, patients swallow a liquid containing a radioactive **tracer** of iodine.
From the list above select **one** isotope that is suitable to be used for treating brain tumours and **one** that is to be used as a radioactive tracer. Explain the reasoning for your choice of each. [6 QWC]

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

(b) Radioactive isotopes are also used in other applications. Americium-241 is a radioactive isotope which is used in smoke detectors. It decays into neptunium by giving out an alpha particle ($^{4}_{2}He$).

(i) Complete the decay equation below. [2]

$$^{241}_{\cdots\cdots}Am \longrightarrow \, ^{\cdots\cdots}_{93}Np + \, ^{4}_{2}He$$

(ii) Explain why the radiation from a smoke detector presents no danger to people living in a house. [2]

....

....

7.

(a) The table below lists **most** of the regions of the electromagnetic spectrum.

Tick (✓) the boxes next to the regions that are ionising radiations. [2]

Region	Ionising radiation
radio waves	
microwaves	
infra-red	
visible	
ultraviolet	
X-rays	

(b) Three other types of ionising radiation are **alpha**, **beta** and **gamma** radiation.

(i) Which of these is the most penetrating radiation? .... [1]

(ii) Which of these is the least ionising radiation? .... [1]

(c) Nuclear waste emits ionising radiations.

State **two** reasons why the storage of nuclear waste is difficult. [2]

1. ....

2. ....

8.

A class of students were using dice to model radioactive decay.

- There were 8 groups of students.
- Each group of students had 50 dice.
- The 50 dice were rolled.
- Any that landed with a 6 facing upwards were removed.
- The remaining dice were counted.
- The remaining dice were rolled again and again, taking away the 6's each time.
- The table shows the results from one group and from the whole class.

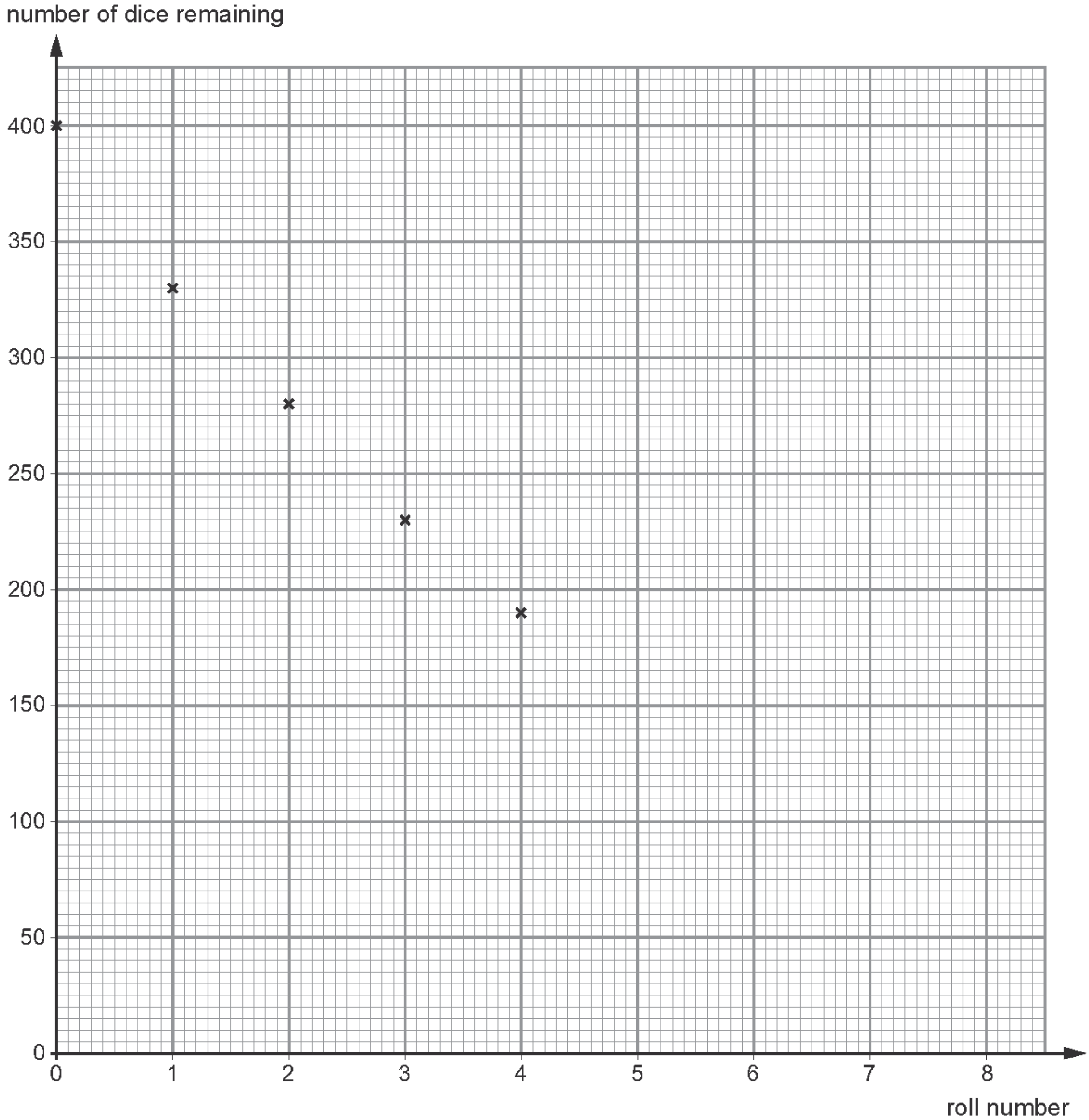
Roll number	Number of dice remaining	
	One group's results	Class results
0	50	400
1	42	330
2	37	280
3	28	230
4	26	190
5	22	160
6	18	130
7	13	110
8	5	90

(a) Each group's results were added together to give the class results. Give **one** reason why the bigger sample size makes the data more repeatable. [1]

....

....

(b) The graph shows part of the data from the whole class.
Plot the remaining data and draw a suitable line. [3]



(c) The "half-life" for this modelled decay is the number of rolls needed for the number of dice to halve. *(The number of rolls will include fractions.)*

(i) Use the class results in the table on page 10 to estimate the half-life. [1]

half-life = ... rolls

(ii) Now use the graph to find the half-life. Show the method you use on the graph. [2]

half-life = ... rolls

(iii) Suggest why it is better to use the graph than the table to estimate the half-life. [1]

....

....

(iv) Use the graph to find how many rolls it took for the number of dice to fall to $\frac{1}{4}$ of the original value. Comment on your answer. [2]

number of rolls = ...

....

....

(d) An experiment was carried out to obtain similar data using the radioactive isotope, protactinium 234, which is a beta emitter. The **initial count** rate was measured to be 80 counts per second. After 210 s the count rate had dropped to 10 counts per second.

(i) Find the half-life of protactinium 234. [2]

half-life = ... s

(ii) Calculate how long it would take for the count rate to drop from 80 to 2.5 counts per second. [2]

time taken = ... s

(iii) State the unit of activity of a radioactive source. [1]

....

15

9.

Isotopes of iodine can be used to study the thyroid gland in the body.

A small amount of the radioactive isotope is injected into a patient and the radiation is detected outside the body. Two isotopes that could be used are $^{123}_{53}\text{I}$ and $^{131}_{53}\text{I}$.

(a) Answer the following questions in terms of the numbers of particles.

(i) State **one** similarity between the nuclei of $^{123}_{53}\text{I}$ and $^{131}_{53}\text{I}$. [1]

....

....

(ii) State **one** difference between the nuclei of $^{123}_{53}\text{I}$ and $^{131}_{53}\text{I}$. [1]

....

....

(b) The nucleus of $^{131}_{53}\text{I}$ decays into xenon (Xe) by giving out beta (β) and gamma (γ) radiation.

(i) What is beta radiation? [1]

....

(ii) Complete the equation below to show the decay of Iodine-131 (I-131). [2]

$$^{131}_{53}\text{I} \longrightarrow \, ^{\cdots\cdots}_{54}\text{Xe} + \, ^{0}_{\cdots\cdots}\beta + \gamma$$

(c) The isotope $^{123}_{53}\text{I}$ decays by gamma emission. Explain why it is better to use $^{123}_{53}\text{I}$ than $^{131}_{53}\text{I}$ as a medical tracer. [2]

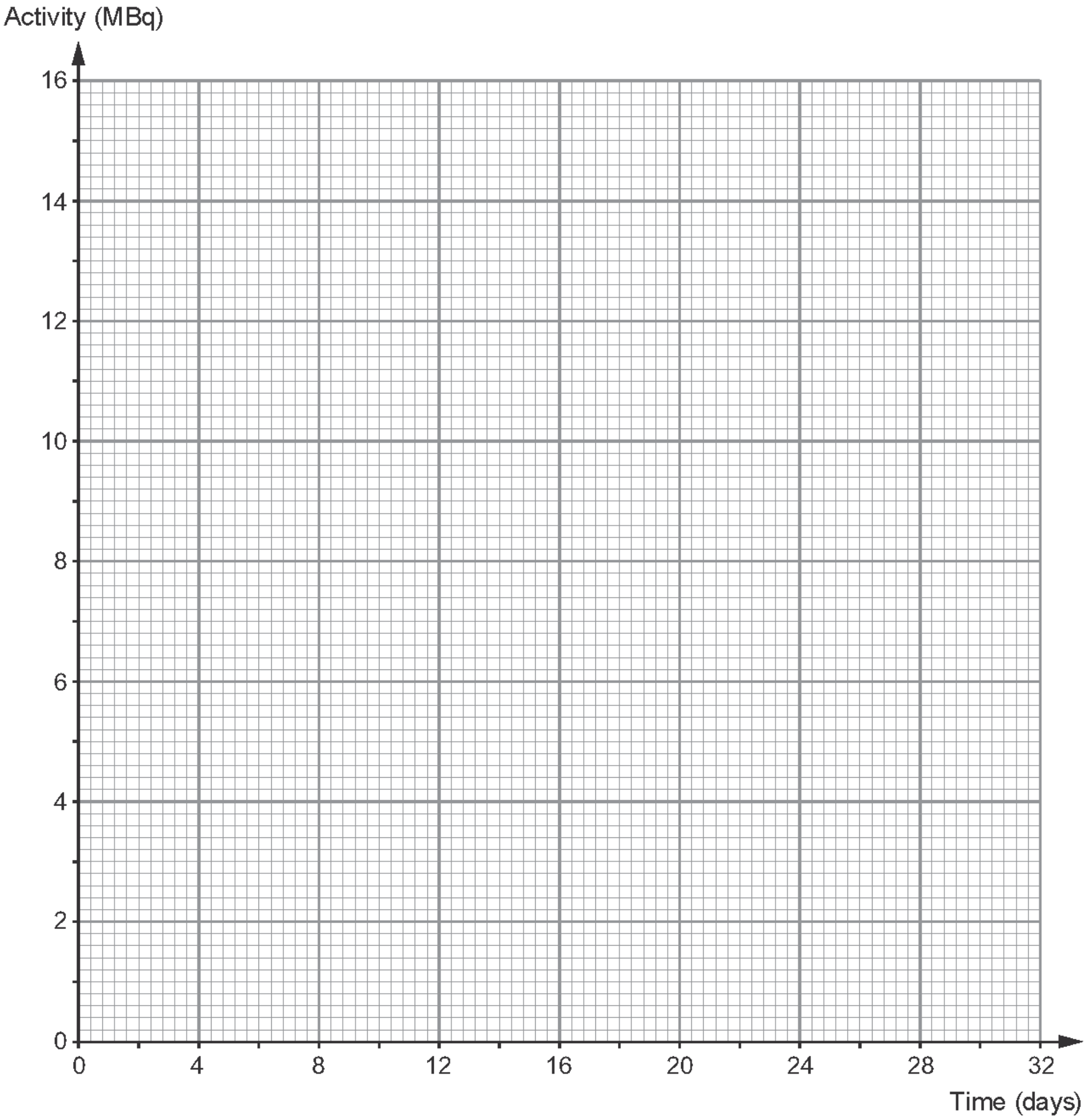
....

....

....

(d) (i) Iodine-131 has a half-life of 8 days. A sample has an initial activity of 16 MBq. Plot the data on the grid and draw a suitable line to show how the activity changes over 32 days. [3]

Time (days)	0	8	16	24	32
Activity (MBq)	16	8	4	2	1



(ii) **Draw lines** on the graph to find the time it takes for the activity to fall from 12 MBq to 3 MBq. Comment on your answer. [2]

....

....

12