Pearson Edexcel

Additional Assessment Materials
Summer 2021

Pearson Edexcel GCSE in Physics (1PH0) Foundation

Resource Set Topic D: Radioactivity

Questions

(Public release version)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

5 Figure 8 shows a helium nucleus.

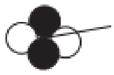


Figure 8

(a) Two of the particles in the helium nucleus are neutrons.

State the name of the other two particles in the helium nucleus.

(1)

Proton

(b) (i) Describe the difference between a fusion reaction and a fission reaction.

(2)

Fusion is the process of nuclei combining to produce a larger nuclei and fission is the process of a larger nucleus splitting into smaller nuclei.

(ii) Nuclear fusion does not happen at low temperatures because of electrostatic repulsion between

(1)

☐ **A** beta particles

☐ **B** electrons

☐ **C** neutrons

☒ **D** protons

(c) The energy released per kilogram of fuel in a fusion reaction is 845 000 GJ.

The energy released per kilogram of fuel in burning oil is 0.0394 GJ.

(i) Calculate the ratio of the energy released in fusion compared with the energy released in burning oil.

Use the equation

$$\text{ratio} = \frac{\text{energy released from fusion}}{\text{energy released by burning oil}}$$

(2)

$$\frac{845000}{0.0394}$$

$= 21446000$

≈ 21000000

ratio = 2.1×10^7

(ii) State **two** advantages of using a fusion reactor rather than burning oil in a power station.

(2)

1 Produces a larger amount of energy compared to an oil station.

2 Does not release greenhouse gasses.

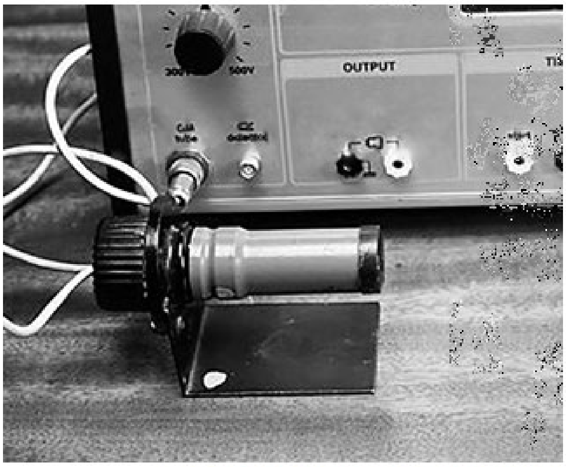
(iii) State **two** of the difficulties that need to be overcome to produce a fusion reactor.

(2)

1 Producing a sufficient high temperature

2 Producing a sufficient high pressure

9 Figure 17 shows a Geiger-Müller (GM) tube used for measuring radioactivity.



©Andrew Lambert Science Photo Library

Figure 17

(a) Describe how a teacher should use a Geiger-Müller (GM) tube to compare the count-rates from two different radioactive rocks.

(4)

Measure the background radiation. Keep a rock in front of the GM tube for a known time and record the count rate. Subtract the background radiation from this value to obtain the count rate of the rock. Do the same process separately with the other rock. Repeat the experiment multiple times and obtain a mean.

(b) A hospital uses a radioactive isotope with a half-life of 6 hours.

A technician measures a count rate of 80 counts per minute (cpm) from this isotope.

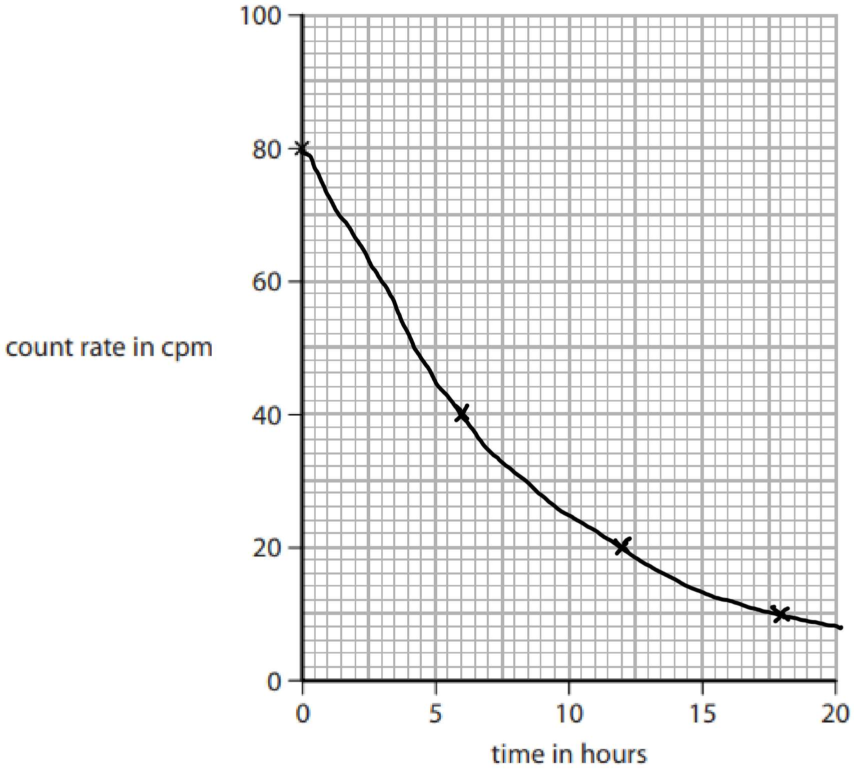


Figure 18

Complete the graph on Figure 18, as accurately as possible, to show how the count-rate from this isotope will change from the time of the first measurement.

The first point is already drawn in Figure 18.

(3)

*(c) A radioactive rock is placed near to the front of a Geiger-Müller (GM) tube.

A radioactivity count-rate is first made in air.

The count-rate is measured again with each of three different absorbers between the rock and the GM tube.

Figure 19 shows the count-rates measured.

absorber	count-rate in counts per minute
3 cm of air	1272
thin sheet of paper	931
3 mm thick sheet of aluminium	328
2 cm thick sheet of lead	21

Figure 19

A scientist has an idea that the rock emits three different types of radiation.

Explain how the data in this table supports the scientist's idea.

(6)

When a thin sheet of paper is placed, the count rate decreases from 1272 to 931, so it contains alpha radiation.

When a sheet of Aluminium is placed, the count rate decreases from 1272 to 328 so it contains beta radiation.

When a sheet of lead is placed the count rate decreases from 1272 to 21 so it contains gamma radiation.

4 (a) (i) Use words from the box to complete the sentences below about ions.

absorbing	gaining	inner	losing	outer

(2)

Atoms may form positive ions by losing electrons.

The electrons involved in forming positive ions are the outer electrons.

(ii) Which of these radiations is both electromagnetic and ionising?

(1)

- ☐ **A** alpha
- ☐ **B** beta minus
- ☒ **C** gamma
- ☐ **D** neutron

(iii) Which type of radiation will travel the shortest distance in air?

(1)

- ☒ **A** alpha
- ☐ **B** beta minus
- ☐ **C** beta plus
- ☐ **D** gamma

(b) Lead-214 is a radioactive isotope.

(i) State **one** way in which radioactive isotopes can be harmful to people.

(1)

Can cause mutations in DNA

(ii) Lead-214 emits β^- particles.

Describe what happens to the nucleus of a lead-214 atom when it emits a β^- particle.

(2)

A neutron decays to a proton and emits a beta particle. So the nucleus now has one more proton and one less neutron. However, the nucleon number remains the same.

(c) The typical size of an atom is

(1)

☐ **A** 10^{-5} m

☒ **B** 10^{-10} m

☐ **C** 10^{-15} m

☐ **D** 10^{-20} m

(d) The mass of a proton is 1.6726×10^{-27} kg.
The mass of an electron is 9.1094×10^{-31} kg.

Calculate how many times the mass of a proton is greater than the mass of an electron.

Give your answer to two significant figures.

(3)

$$\frac{1.6726 \times 10^{-27}}{9.1094 \times 10^{-31}}$$

$= 1836 \approx 1800$

.......1800....... times

5 (a) Radioactivity is used in PET scanners in hospitals.

(i) Describe **one** use of PET scanners in hospitals.

(2)

To record the blood flow to organs and tissues.

(ii) State **two** precautions that hospital staff should take when working with radioactivity.

(2)

1 Shielding themselves from the source.

2 Wear protective clothing with a film badge.

(b) (i) X-rays can be used in diagnosis and treatment from outside the body. Some x-rays are absorbed by bone as they travel through the body.

Figure 4 shows how the intensity of the x-ray beam gets less as the x-rays travel further through the bone.

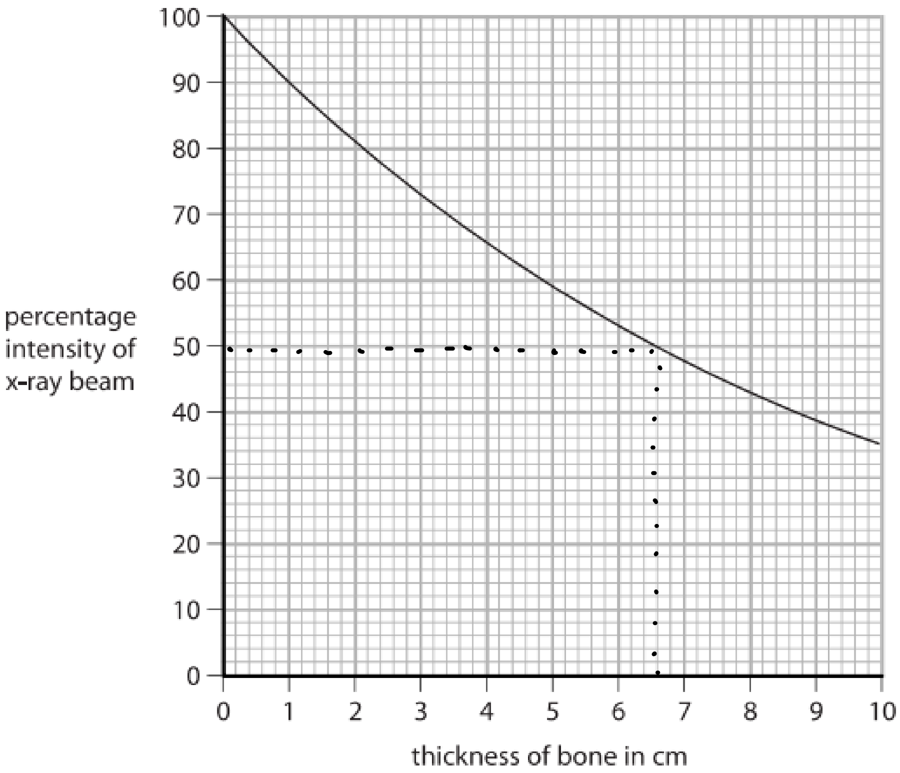


Figure 4

Use the graph to determine the thickness of bone that will reduce the percentage intensity of the x-ray beam by half.

(2)

thickness = 6.6 cm

(ii) Radioactive isotopes may be placed inside the body for treatment.
The energy absorbed by tissue in the body needs to be known.

The number of joules of energy absorbed by each kilogram of tissue is measured in one of the units shown.

This unit is

(1)

☐ **A** kg/W

☒ **B** J/kg

☐ **C** kg/J

☐ **D** W/kg

(c) Nuclear power is used for generating electricity.

(i) State **two** advantages of generating electricity using nuclear power compared with generating electricity from gas-fired power stations.

(2)

1 No CO_2 and harmful greenhouse gasses produced.

2 Highly reliable

(ii) Using nuclear power stations to generate electricity is unpopular with many people.

State **two** reasons why nuclear power stations are unpopular.

(2)

1 Risk of nuclear meltdowns.

2 Negative effects of handling nuclear waste due to radiation.

9 (a) Carbon-13 and carbon-14 are isotopes of carbon.

Nuclei of carbon-13 and carbon-14 can be represented by these symbols

$$^{13}_{6}C \quad \text{and} \quad ^{14}_{6}C$$

Complete the table for an atom of carbon-13 and an atom of carbon-14.

(2)

	number of neutrons in the nucleus	**number of electrons in orbit around the nucleus**
carbon-13	7	6
carbon-14	8	6

(b) (i) State the name of an instrument that can be used to measure radioactivity.

(1)

GM tube

(ii) State **two** sources of background radiation.

(2)

1 Underground rocks

2 Cosmic rays from space

(c) Carbon-14 is radioactive and has a half-life of 5 700 years.

The number of radioactive carbon-14 atoms in a very old piece of wood is found to have decreased from 1 000 000 to 125 000.

Determine the age of the piece of wood.

(2)

1000000 → 500000 : 5700
500000 → 250000 : 5700
250000 → 125000 : 5700
Total: 17100

age of wood = 17100 years

*(d) In 1908 a scientist called Rutherford was investigating ideas about atoms.

His students fired a beam of alpha particles at a thin piece of gold foil.

Figure 10 shows the arrangement of the experiment.

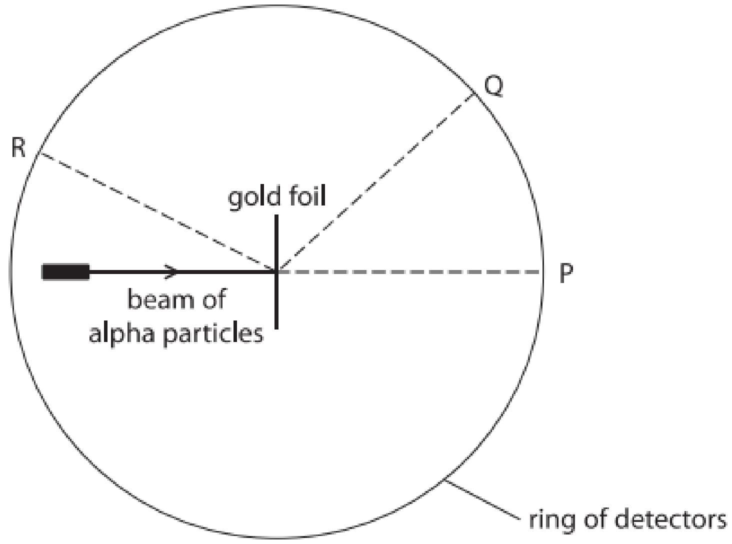


Figure 10

Some alpha particles were found at all parts of the ring of detectors.

The table in Figure 11 shows how many alpha particles were detected at P, at Q and at R, in one experiment.

position	number of alpha particles detected
P	72340
Q	25
R	2

Figure 11

Explain what the information in Figure 10 and Figure 11 shows about the structure of an atom.

(6)

Most of the alpha particles were not deflected and the conclusion of an atom being mostly comprised of empty space was taken.

Some alpha particles were deviated due to the repulsive forces between the alpha particle and positive charge in the nucleus of the atom. Therefore the charge of an atom's nucleus was stated as positive from the above discovery.

Very few particles deviated more than 90 degrees so the mass of an atom was thought to be concentrated at a very small space (the nucleus).

5 (a) Figure 8 shows the symbol for the nucleus of an atom of strontium-90.

$$^{90}_{38}Sr$$

Figure 8

(i) How many protons are in the nucleus of an atom of strontium-90?

(1)

☒ **A** 38

☐ **B** 52

☐ **C** 90

☐ **D** 128

(ii) How many neutrons are in the nucleus of an atom of strontium-90?

(1)

☐ **A** 38

☒ **B** 52

☐ **C** 90

☐ **D** 128

(b) The half-life of strontium-90 is 29 years.

The table in Figure 9 gives some information about how the mass of a sample of strontium-90 changes with time.

mass of strontium-90 in g	time in years
1600	0
800	29
400	58

Figure 9

Complete the table in Figure 9.

(2)

(c) A teacher sets up an experiment to show some students how far beta particles travel in air.

Figure 10 shows some of the equipment she uses.

(Source: *www.einstein.yu.edu*)

Figure 10

(i) State the scientific name for the radioactivity detector shown in Figure 10.

(1)

GM counter/tube

The teacher also has:

- a radioactive source that emits only beta particles
- a metre rule.

(ii) State **two** precautions the teacher must take to protect herself from the effects of radioactivity.

(2)

1 Maintain distance with the source at all times.

2 Reduce the time of exposure with the source.

(iii) Describe how the teacher could show how far beta particles travel in air.

(4)

Keep the GM tube at a fixed position and keep the source at 1 cm away from the tube and take the reading. Move the source away from the tube at 1cm additions and take each reading separately, keeping the time of exposure the same. Plot an activity vs. distance graph and conclude the distance at which the radiation reading has dropped significantly and possibly only reads the value of background radiation.

7 (a) Use words from the box to complete the sentences about nuclear fission of uranium-235 (U-235).

chain	chemical	fuse
neutrons	protons	split

(3)

A neutron hits a nucleus of U-235 and causes the nucleus to split .

Each fission releases energy, two daughter nuclei and some neutrons .

In a nuclear reactor, one fission can set off a controlled chain reaction.

(b) Both U-235 and oil can be used as energy sources for generating electricity.

1 kg of natural uranium can result in the generation of 45 000 units of electricity.

1 kg of oil can result in the generation of 5.0 units of electricity.

Calculate the mass of oil needed to generate the same amount of electricity as 1 kg of natural uranium.

(2)

$$\frac{45000}{5}$$

mass of oil = 9000 kg

(c) Both using nuclear fuel and burning oil produce harmful waste products.

State **one** harmful waste product from each process.

(2)

using nuclear fuel Radioactive waste

burning oil Harmful greenhouse gasses

*(d) Figure 14 shows a household smoke alarm that uses radioactivity to detect smoke.

Courtesy NASA/JPL-Caltech

Figure 14

The radioactive source in the smoke detector is americium–241.

The table in Figure 15 shows some information about americium–241 and two other radioactive sources.

radioactive source	type of radiation	half-life
americium–241	alpha	433 years
actinium-225	alpha	10 days
cobalt-60	gamma	5.27 years

Figure 15

Explain why americium-241 is the best of these three sources to use in this smoke detector.

Use information from Figure 15 and your own knowledge about radiation.

Your answer should refer to

- properties of alpha and gamma radiation
- half-life.

(6)

americuium has a very high half-life compared to other sources and it allows the apparatus to be used for a very long time without replacement. cobalt also has an acceptable half life as it only needs to be replaced after a few years and therefore can be considered.
However, cobalt-60 is not a good source as it emits gamma radiation which has a larger range and penetrating power causing health concerns for the users. Alpha particles has a low penetration power and less range

therefore, is suitable and safe. Hence, americium is the best source as it adheres to both of the conditions to be convenient in maintaining and safe to use.

TOTAL FOR PAPER IS 82 MARKS