Pearson Edexcel

Additional Assessment Materials
Summer 2021

Pearson Edexcel GCSE in Physics (1PH0)
Higher

Resource Set Topic D: Radioactivity

Questions

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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 you 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- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow you to adapt them to use with your candidates.

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. The mapping guidance will also highlight where the question originally came from to allow you to access further support materials (mark schemes, examiner reports).
- Use of these assessment materials will assist you in assessing candidates' current performance in areas not assessed elsewhere. Their use will also provide an extra opportunity for candidates to demonstrate their performance at the end of their course of study.

These materials are only intended to support the summer 2021 series.

Summer 2018 Paper 1 Higher

3 Figure 4 shows a Geiger-Müller (GM) tube used for measuring radioactivity.

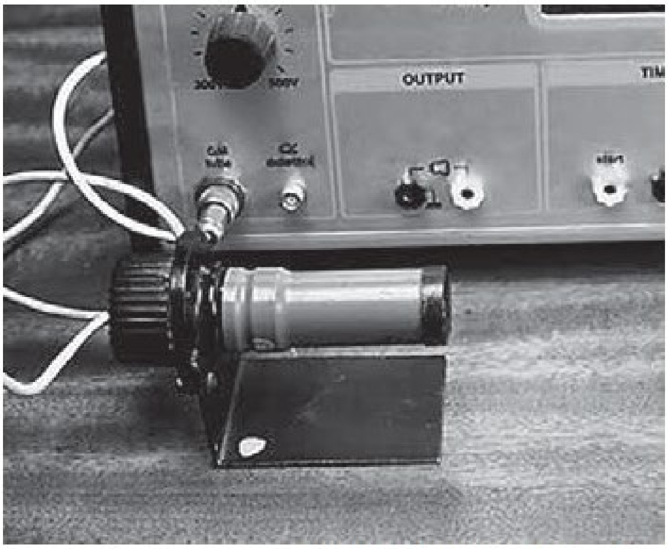

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Figure 4

(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.

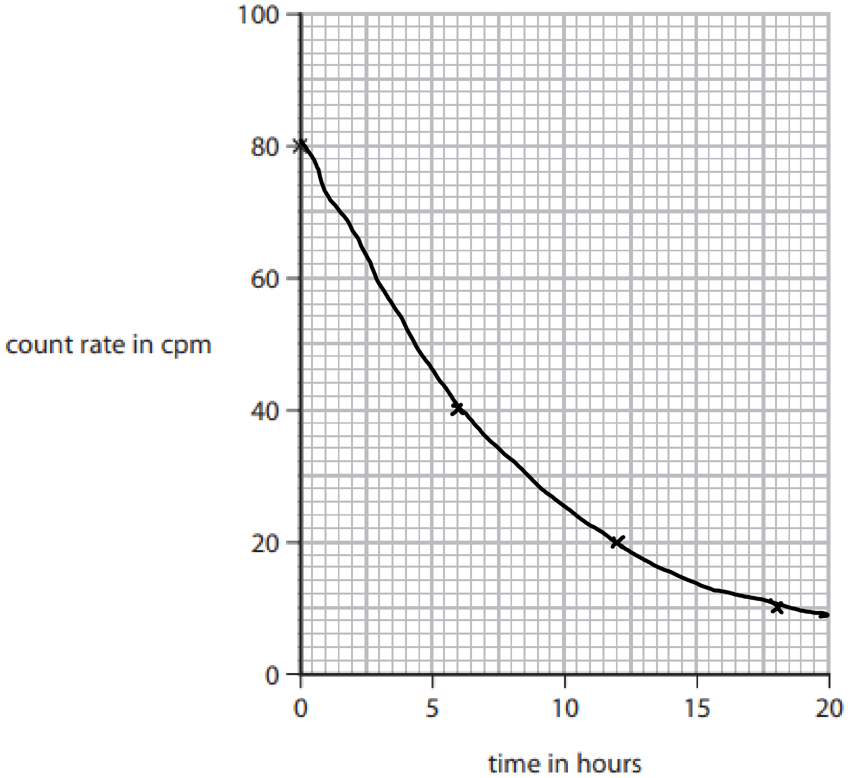

Figure 5

Complete the graph on Figure 5, 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 5.

(3)

(c) One radioactive source used in hospitals is technetium (Tc).

Technetium is produced from the radioactive decay of molybdenum (Mo).

Complete the following nuclear equation.

(1)

$$^{99}_{42}\text{Mo} \rightarrow {}^{99}_{43}\text{Tc} + {}^{0}_{-1}\beta$$

10 Fusion and fission are nuclear reactions in which large amounts of energy are released.

(a) (i) In a fusion reaction, two hydrogen nuclei are forced together to form a helium nucleus.

Explain why a very high temperature is needed for this reaction to happen.

(3)

The high temperatures allow the hydrogen atoms to overcome the electrical repulsion due to the positive like charges of the nucleus (which is a result due to protons in the nucleus).

(ii) In a fusion reaction, the combined mass of the two small nuclei is greater than the mass of the resulting nucleus.

This decrease in mass, m, appears as energy, E, according to the equation.

$$E = mc^2$$

c is the speed of light = 3.0×10^8 m/s.

The energy released in one fusion reaction is 4.5×10^{-12} J.

Calculate the decrease in mass.

(3)

$$4.5 \times 10^{-12} = m \times (3 \times 10^8)^2$$

$$m = \frac{4.5 \times 10^{-12}}{(3 \times 10^8)^2} = 5 \times 10^{-29}$$

decrease in mass = 5×10^{-29} kg *(b) Nuclear fission is used in nuclear reactors in some power stations.

In the reactor, a fission chain reaction is maintained and controlled to produce a supply of energy to generate electricity.

Figure 14 is a diagram of a nuclear reactor.

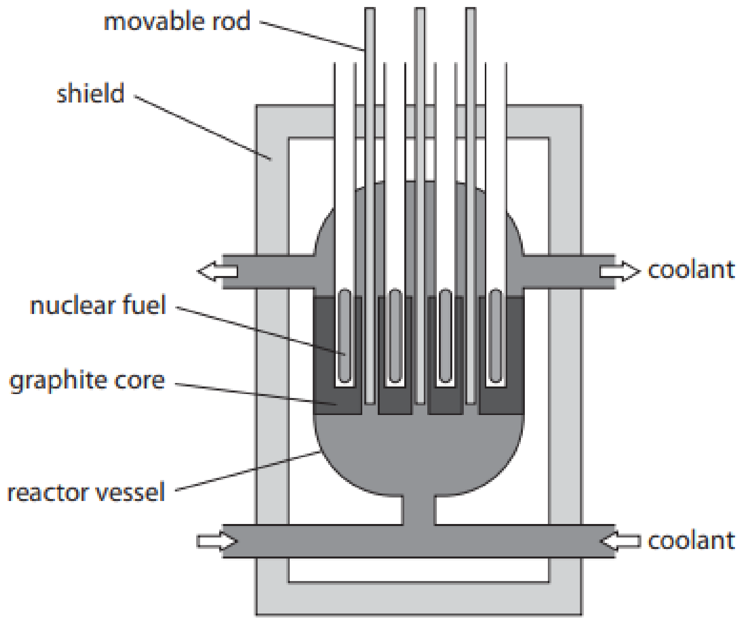

Figure 14

Explain how the graphite core and the movable rods are used to maintain and control the chain reaction.

(6)

Neutrons are constantly released in the chain reaction. However, some neutrons are too fast which needs to be controlled. Control rods are hence used to control the speed of the reaction. The graphite core acts as the moderator and slows down the neutrons while the moveable rods absorb excess neutrons. The moveable rods can be adjusted to have more or less amount of neutrons available for the reaction to occur.

Summer 2019 Paper 1 Higher

3 (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)

Geiger-Muller tube

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

(2)

1 Rocks

2 Nuclear waste

(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 → 250000 → 125000

5700 + 5700 + 5700 = 17100

age of wood = 17100 years

(d) Carbon-14 decays into nitrogen-14.

The symbol for nitrogen-14 is $^{14}_{7}N$

Explain what happens in a carbon-14 nucleus when it decays to a nitrogen-14 nucleus.
(2)

A neutron of Carbon-14 converts to a proton and a beta particle. The number of neutrons would decrease by one and the number of protons will increase by one.

8 (a) Energy from the nuclei of atoms can be used in medical diagnosis and treatment.

(i) Fluorine-18 is a radioactive isotope used in PET scanners for medical diagnosis.

Explain why fluorine-18 must be produced close to the hospital where it is used.
(2)

Fluorine-18 has a very short half-life as it is used inside human body. Hence, the fluorine must be quickly transported before it decay to unusable levels.

(ii) Some tumours inside the body can be treated by using either alpha radiation or gamma radiation.

Explain why the source of alpha radiation is usually inside the body but the source of gamma radiation can be outside the body.
(4)

The source of alpha should be placed inside the body as alpha particles cannot penetrate thick skin to reach the tumor cells. However, gamma rays can easily penetrate skin and reach the tumor cells. Furthermore, the high energy gamma source can be easily removed away from the patient after the treatment to minimize radiation.

(b) (i) In a controlled chain reaction of uranium-235, which of these could cause a uranium-235 nucleus to undergo fission?

(1)

☐ **A** an alpha particle

☐ **B** a beta particle

☒ **C** a neutron

☐ **D** a proton

(ii) The kinetic energy of one of the particles released in a fission reaction is 1.2×10^{-11} J.

The mass of the particle is 1.4×10^{-25} kg.

Calculate the velocity of the particle.

(3)

$$KE = \frac{1}{2} \times m \times v^2$$

$$1.2 \times 10^{-11} = \frac{1}{2} \times 1.4 \times 10^{-25} \times v^2$$

$$v^2 = \frac{2(1.2 \times 10^{-11})}{1.4 \times 10^{-25}}$$

$$= 1.309 \times 10^{7} \approx 1.3 \times 10^{7}$$

velocity of the particle = 1.3×10^{7} m/s

Autumn 2020 Paper 1 Higher

1 (a) Radioactive substances are used in the generation of electricity.

State **two** other uses of radioactive substances.

(2)

1 Carbon-dating in old relics

2 In medicine by killing cancerous cells

(b) Figure 1 is a diagram of a nuclear reactor, used in the generation of electricity.

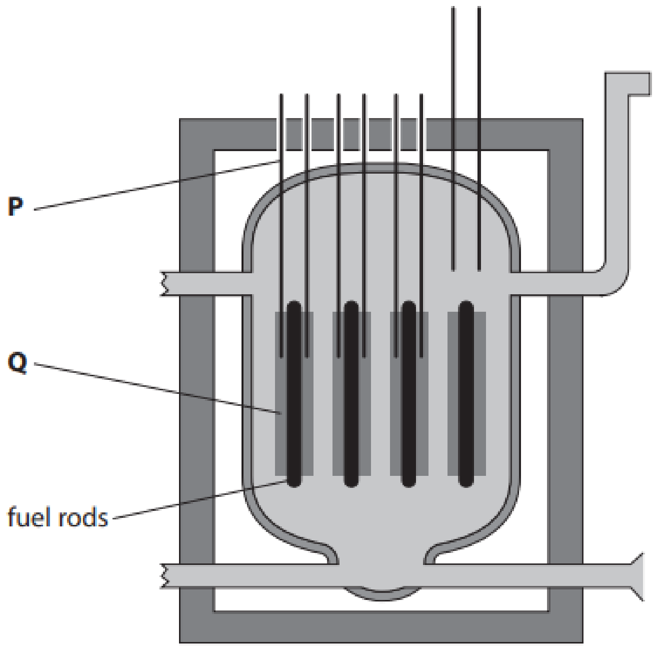

Figure 1

P may be used to shut down the reactor when necessary.
Q slows down neutrons to enable a chain reaction to take place.

State the name of the two parts labelled **P** and **Q**.

(2)

P Control rods

Q Graphite moderator

(c) Explain how neutrons enable a nuclear chain reaction to take place.

(2)

The neutrons released in a fission reaction produce additional fission reactions in a chain-like reaction.

7 (a) Which of these describes isotopes of an element?

(1)

☒ **A**	same atomic number	different number of neutrons
☐ **B**	same atomic number	different number of protons
☐ **C**	same mass number	different number of neutrons
☐ **D**	same mass number	different number of protons

(b) Figure 9 represents a decay that can happen inside the nucleus of an atom.

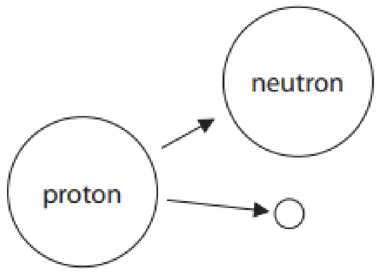

Figure 9

Which decay is represented in Figure 9?

(1)

☐ **A** alpha

☐ **B** beta minus

☒ **C** beta plus

☐ **D** gamma

(c) The half-life of cobalt-60 is 5 years.

A school cobalt source had an activity of 38.5 kBq in the year 2000.

Estimate the activity of this source in the year 2020.

(3)

38.5 — 2000

5

19.25 — 2005

5

9.625 — 2010

5

4.8125 — 2015

5

2.40625

≈ 2.4

activity = 2.4 kBq

(d) Explain what can happen to the body if a person has a prolonged exposure to gamma rays.

(2)

DNA mutations may occur in cells and cause ionizations that may damage tissues.

(e) A G-M tube is connected to a counter.
A teacher places the G-M tube near to a radioactive source.
A student starts the counter and clock at the same time and writes down the readings shown on the counter every 15 s.

The student plots the readings with a line of best fit, as shown in Figure 10.

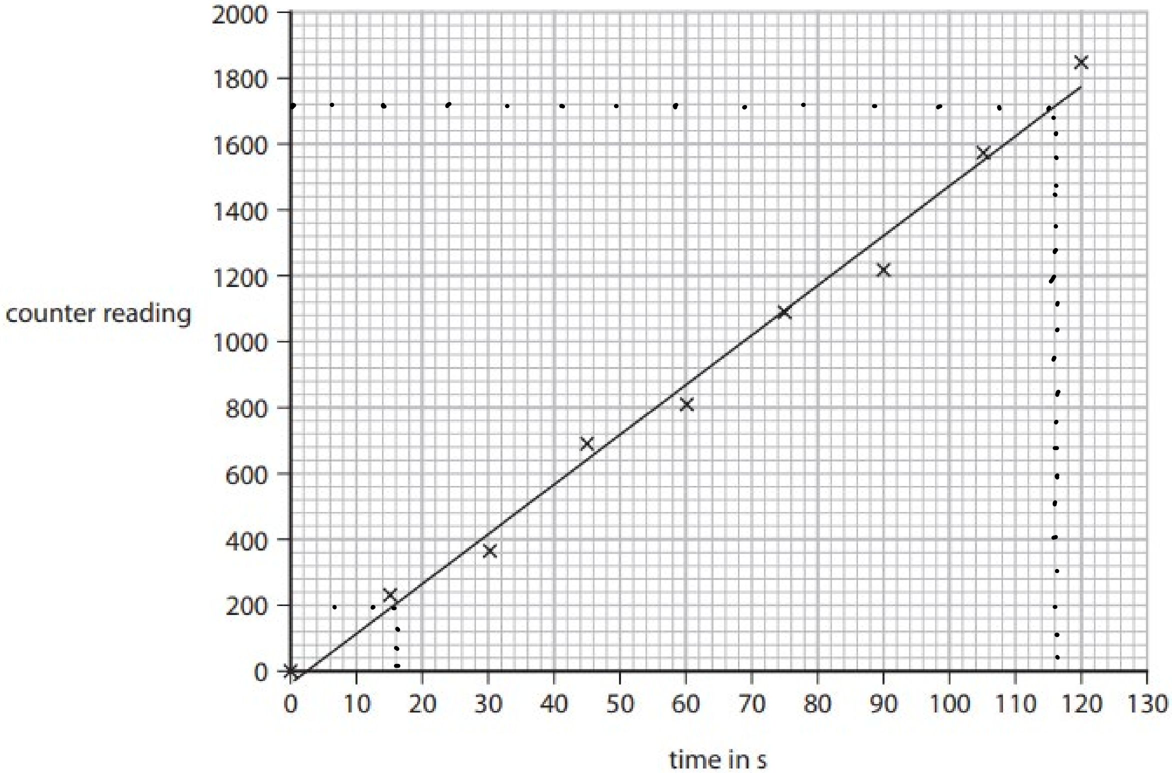

Figure 10

(i) Calculate the average count rate, in counts / s, from the graph.

Show your working on the graph.

(2)

$$\frac{1720 - 200}{116 - 16} = \frac{1520}{100} = 15.2$$

average count rate = 15.2 counts / s

(ii) The student says that the experiment must have been done carelessly because the data seemed quite scattered away from the best fit line.

The teacher claims such results should be expected in radioactivity experiments.

Justify the teacher's claim.

(2)

Radioactive decays are in their nature, a random process. Due to this, fluctuations should be anticipated but an overall trend should be observed.

*(c) The global demand for electricity is increasing.

There is a debate about whether nuclear power generation should or should not contribute to meeting this increasing demand.

Discuss the arguments for and against using nuclear power to meet the increasing global demand for electricity.

(6)

Nuclear power plants have been credited to not emitting polluting gasses and hence not contributing to global warming. Furthermore, the power station has a high lifetime and low fuel cost. However, they have been criticized for the negative effects of the disposal of radioactive waste including health and economical disadvantages. The initial cost and the cost to decommission power plants can be high and can cause catastrophic events in meltdowns.

TOTAL FOR PAPER IS 62 MARKS