Nuclear Radiation GCSE AQA Higher Physics Past Papers Questions

01.

Figure 6 shows a Van de Graaff generator that is used to investigate static electricity.

Before it is switched on, the metal dome has no net charge.

After it is switched on, the metal dome becomes positively charged.

Figure 6

1 Explain how an uncharged object may become positively charged.

[3 marks]

2 **Figure 7** shows a plan view of the positively charged metal dome of a Van de Graaff generator.

Draw the electric field pattern around the metal dome when it is isolated from its surroundings.

Use arrows to show the direction of the electric field.

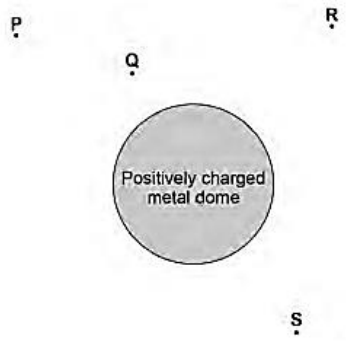
[2 marks]

Figure 7

3 Another positively charged object is placed in the electric field.

Look at **Figure 8**.

Figure 8



In which position would the object experience the greatest force?

Tick **one** box.

[1 mark]

P ☐

Q ☐

R ☐

S ☐

02.

A student models the random nature of radioactive decay using 100 dice.

He rolls the dice and removes any that land with the number 6 facing upwards.

He rolls the remaining dice again.

The student repeats this process a number of times.

Table 1 shows his results.

Table 1

Roll number	Number of dice remaining
0	100
1	84
2	70
3	59
4	46
5	40
6	32
7	27
8	23

. 1 Give **two** reasons why this is a good model for the random nature of radioactive decay.

[2 marks]

1 _____

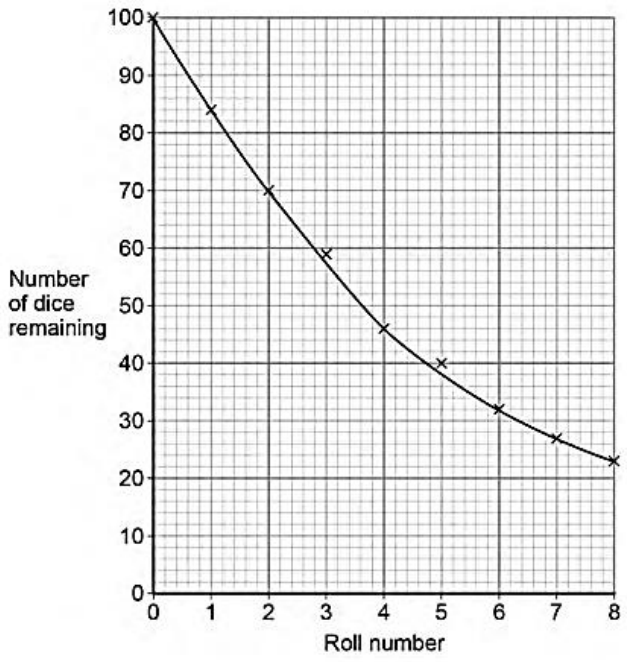
_____

2 _____

_____

The student's results are shown in **Figure 11**.

Figure 11



2 Use **Figure 11** to determine the half-life for these dice using this model.

Show on **Figure 11** how you work out your answer.

[2 marks]

Half-life = _____ rolls

A teacher uses a protactinium (Pa) generator to produce a sample of radioactive material that has a half-life of 70 seconds.

In the first stage in the protactinium generator, uranium (U) decays into thorium (Th) and alpha (α) radiation is emitted.

The decay can be represented by the equation shown in **Figure 12**.

Figure 12

$$^{238}_{92}U \longrightarrow \,^{234}_{\square}Th + \alpha$$

3 Determine the atomic number of thorium (Th) 234.

[1 mark]

Atomic number = _____

When protactinium decays, a new element is formed and radiation is emitted.

The decay can be represented by the equation shown in **Figure 13**.

Figure 13

$$^{234}_{91}Pa \rightarrow \,^{234}_{92}X + radiation$$

4 When protactinium decays, a new element, **X**, is formed.

Use information from **Figure 12** and **Figure 13** to determine the name of element **X**.

[1 mark]

_____

5 Determine the type of radiation emitted as protactinium decays into a new element.

Give a reason for your answer.

[2 marks]

6 The teacher wears polythene gloves as a safety precaution when handling radioactive materials.

The polythene gloves do **not** stop the teacher's hands from being irradiated.

Explain why the teacher wears polythene gloves.

[2 marks]

03.

Electricity is generated in a nuclear power station.

Fission is the process by which energy is released in the nuclear reactor.

1 **Figure 14** shows the first part of the nuclear fission reaction.

Complete **Figure 14** to show how the fission process starts a chain reaction.

[3 marks]

Figure 14

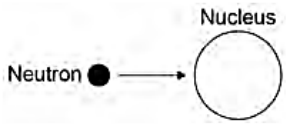
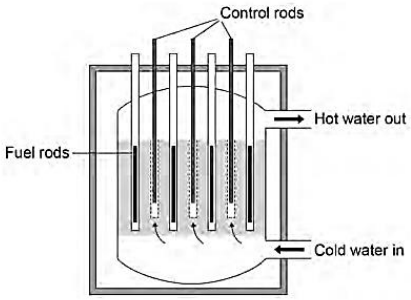


Figure 15 shows the inside of a nuclear reactor in a nuclear power station.

Figure 15



2 In a nuclear reactor a chain reaction occurs, which causes neutrons to be released.

The control rods absorb neutrons.

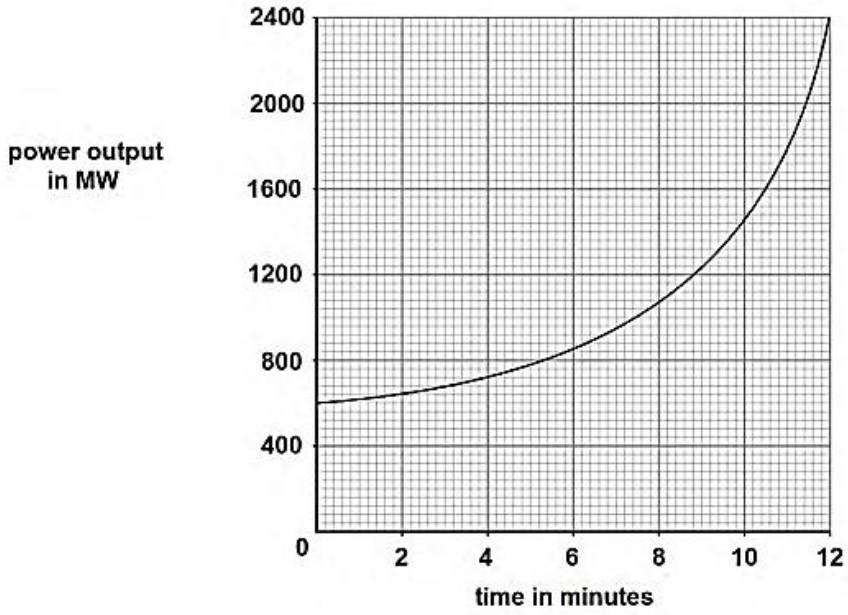
The control rods can be moved up and down.

Explain how the energy released by the chain reaction is affected by moving the control rods.

[2 marks]

Figure 16 shows how the power output of the nuclear reactor would change if the control rods were removed.

Figure 16



3 Calculate the rate of increase of power output at 10 minutes.

[2 marks]

Rate of increase of power output = _____ MW / minute

04. A teacher used a Geiger-Muller tube and counter to measure the number of counts in 60 seconds for a radioactive rock.

1 The counter recorded 819 counts in 60 seconds. The background radiation count rate was 0.30 counts per second.

Calculate the count rate for the rock.

[3 marks]

Count rate = _____ per second

2 A householder is worried about the radiation emitted by the granite worktop in his kitchen.

1 kg of granite has an activity of 1250 Bq. The kitchen worktop has a mass of 180 kg.

Calculate the activity of the kitchen worktop in Bq.

[2 marks]

Activity = _____ Bq

. 3 The average total radiation dose per year in the UK is 2.0 millisieverts.

Table 1 shows the effects of radiation dose on the human body.

Table 1

Radiation dose in millisieverts	**Effects**
10 000	Immediate illness; death within a few weeks
1000	Radiation sickness; unlikely to cause death
100	Lowest dose with evidence of causing cancer

The average radiation dose from the granite worktop is 0.003 millisieverts per day.

Explain why the householder should **not** be concerned about his yearly radiation dose from the granite worktop.

One year is 365 days.

[2 marks]

. 4 Bananas are a source of background radiation. Some people think that the unit of radiation dose should be changed from sieverts to Banana Equivalent Dose.

Suggest **one** reason why the Banana Equivalent Dose may help the public be more aware of radiation risks.

[1 mark]

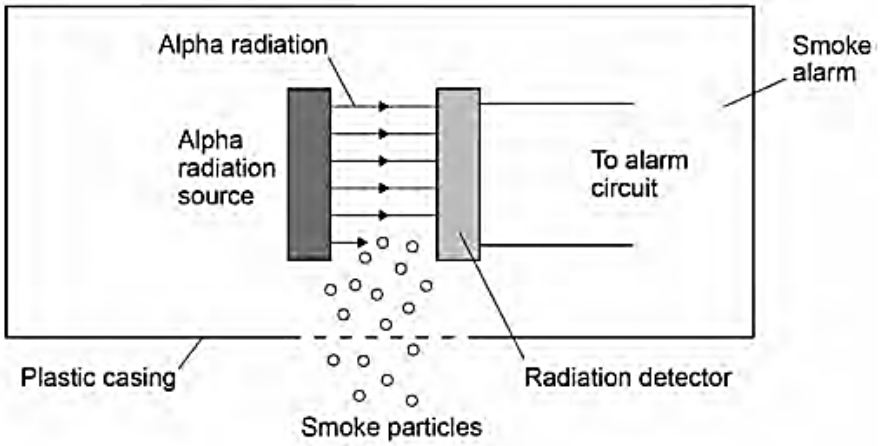
8

05.

Smoke alarms contain an alpha radiation source and a radiation detector.

Figure 9 shows part of the inside of a smoke alarm.

Figure 9



1 The smoke alarm stays off while alpha radiation reaches the detector.

Why does the alarm switch on when smoke particles enter the plastic casing?

[1 mark]

2 Why is it safe to use a source of alpha radiation in a house?

[1 mark]

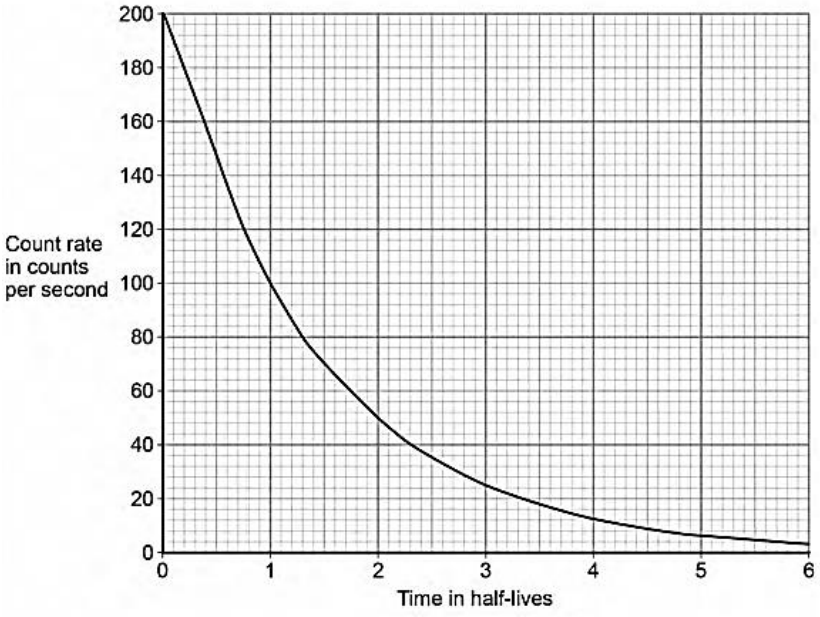
3 The smoke alarm would not work with a radiation source that emits beta or gamma radiation.

Explain why.

[2 marks]

4 **Figure 10** shows how the count rate detected from the radiation source in the smoke alarm changes with time.

Figure 10



The smoke alarm switches on when the count rate falls to 80 counts per second.

Explain why the radiation source inside the smoke alarm should have a long half-life.

[2 marks]

5 **Figure 11** shows a patient who has been injected with a radioactive source for medical diagnosis.

Figure 11

Explain the ideal properties of a radioactive source for use in medical diagnosis.

[4 marks]

10

06.

Nuclear power stations generate electricity through nuclear fission. Electricity can also be generated by burning shale gas.

1 Shale gas is natural gas trapped in rocks. Shale gas can be extracted by a process called fracking. There is some evidence that fracking causes minor earthquakes. Burning shale gas adds carbon dioxide to the atmosphere.

Describe the advantages of nuclear power compared with the use of shale gas to generate electricity.

[3 marks]

2 What is the name of **one** fuel used in nuclear power stations?

[1 mark]

. 3 Describe the process of nuclear fission.

[4 marks]

8

07.

Polonium-210 $\left({}^{210}_{84}\mathrm{Po}\right)$ is a radioactive isotope that decays by emitting alpha radiation.

1 Complete the decay equation for polonium-210

[2 marks]

$${}^{210}_{84}\mathrm{Po} \longrightarrow \square\!\!\square\mathrm{Pb} + {}^{4}_{2}\mathrm{He}$$

2 Explain why contamination of the inside of the human body by a radioactive material that emits alpha radiation is highly dangerous.

[3 marks]

3 A sample of polonium-210 was left for 414 days.

After this time it had a mass of 1.45×10^{-4} g

The half-life of polonium-210 is 138 days.

Calculate the initial mass of the sample.

[3 marks]

Initial mass = _____ g

8

08.

Radioactive waste from nuclear power stations is a man-made source of background radiation.

1 Give **one** other man-made source of background radiation.

[1 mark]

Nuclear power stations use the energy released by nuclear fission to generate electricity.

2 Give the name of **one** nuclear fuel.

[1 mark]

3 Nuclear fission releases energy.

Describe the process of nuclear fission inside a nuclear reactor.

[4 marks]

. 4 A new type of power station is being developed that will generate electricity using nuclear fusion.

Explain how the process of nuclear fusion leads to the release of energy.

[2 marks]

. 5 Nuclear fusion power stations will produce radioactive waste. This waste will have a much shorter half-life than the radioactive waste from a nuclear fission power station.

Explain the advantage of the radioactive waste having a shorter half-life.

[2 marks]

10

09.

Energy from the Sun is released by nuclear fusion.

1 Complete the sentences.

[2 marks]

Nuclear fusion is the joining together of _____.

During nuclear fusion the total mass of the particles _____.

2 Nuclear fusion of deuterium is difficult to achieve on Earth because of the high temperature needed.

Electricity is used to increase the temperature of 4.0 g of deuterium by 50 000 000 °C.

specific heat capacity of deuterium = 5200 J/kg °C

Calculate the energy needed to increase the temperature of the deuterium by 50 000 000 °C.

Use the Physics Equation Sheet.

[3 marks]

_____

_____

_____

_____

_____

Energy = _____ J

. 3 The idea of obtaining power from nuclear fusion was investigated using models.

The models were tested before starting to build the first commercial nuclear fusion power station.

Suggest **two** reasons why models were tested.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

. 4 Generating electricity using nuclear fusion will have fewer environmental effects than generating electricity using fossil fuels.

Explain **one** environmental effect of generating electricity using fossil fuels.

[2 marks]

_____

_____

_____

_____

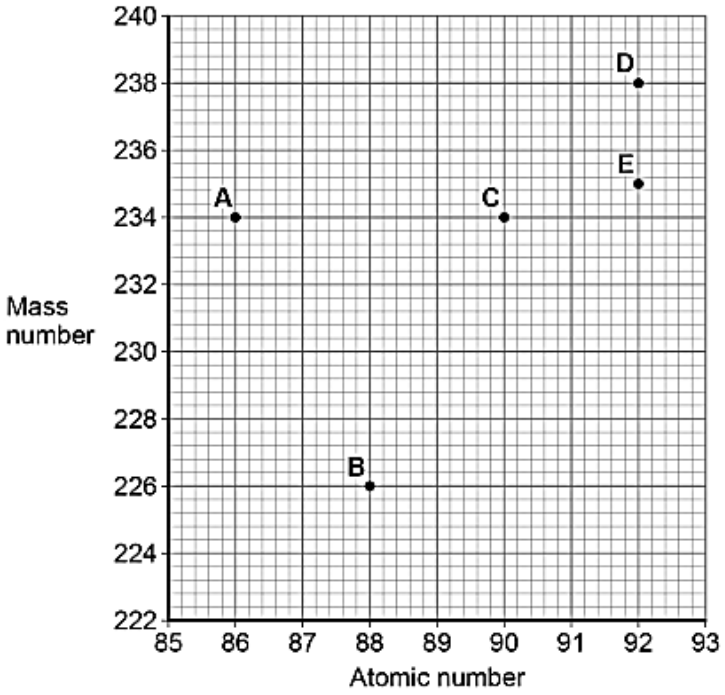
_____

—
9

10.

Figure 6 shows the mass number and the atomic number for the nuclei of five different atoms.

Figure 6



1 How many neutrons are there in a nucleus of atom **A**?

[1 mark]

. 2 Which **two** atoms in **Figure 6** are the same element?

[1 mark]

Tick (✓) **one** box.

A and **B** ☐

A and **C** ☐

C and **D** ☐

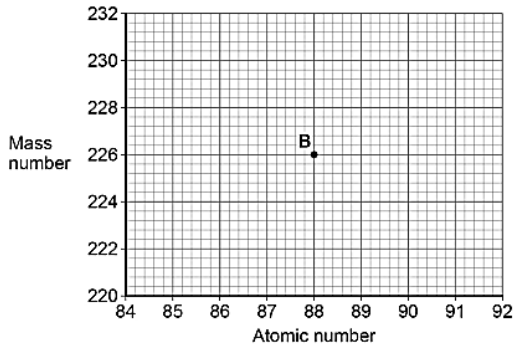
D and **E** ☐

. 3 Nucleus **B** decays by emitting an alpha particle.

Draw an arrow on **Figure 7** to represent the alpha decay.

[2 marks]

Figure 7



. 4 What is meant by the 'random nature of radioactive decay'?

[1 mark]

. 5 A polonium (Po) nucleus decays by emitting an alpha particle and forming a lead (Pb) nucleus.

$$Po \rightarrow Pb + \alpha$$

The lead (Pb) nucleus then decays by emitting a beta particle and forms a bismuth (Bi) nucleus.

$$Pb \rightarrow Bi + \beta$$

The bismuth (Bi) nucleus then decays by emitting a beta particle and forms a polonium (Po) nucleus.

$$Bi \rightarrow Po + \beta$$

Explain how these three decays result in a nucleus of the original element, polonium.

[3 marks]

— 8

11.

Alpha particles, beta particles and gamma rays are types of nuclear radiation.

1 What does an alpha particle consist of?

[1 mark]

2 A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

Complete the nuclear equation for this decay by writing the missing number in each box.

[2 marks]

$$\square_{36}\mathrm{Kr} \longrightarrow \square^{85}\mathrm{Rb} + {}^{0}_{-1}\mathrm{e}$$

3 Internal contamination of the human body means radioactive material is inside the human body.

Explain how the risk from internal contamination is different to the risk from external irradiation by a source of alpha radiation.

[5 marks]

___
8

12. Some isotopes emit nuclear radiation.

. 1 Carbon-14 and carbon-12 are isotopes of carbon.

Compare the structure of an atom of carbon-14 with the structure of an atom of carbon-12.

[3 marks]

. 2 Carbon-14 is a radioactive isotope.

Carbon-14 has a half-life of 5700 years.

What does 'a half-life of 5700 years' mean?

[1 mark]

Table 1 gives the half-life of some other radioactive isotopes.

Table 1

Isotope	Half-life in seconds
Nitrogen-18	0.62
Nitrogen-17	4.17
Fluorine-17	64.37
Fluorine-18	6584.34

. 3 A sample of fluorine-17 has an activity that is one quarter of its original activity.

Calculate the age of the sample of fluorine-17.

[2 marks]

Age = _____ s

. 4 All of the isotopes in **Table 1** emit beta radiation.

Explain which isotope would cause the biggest risk to a person's health based only on the half-life of each isotope.

[3 marks]

. 5 People who work in the nuclear power industry need to be aware of irradiation and contamination.

Describe the difference between irradiation and contamination.

[2 marks]

. 6 Give **one** health risk to a person working close to a source of nuclear radiation.

[1 mark]

. 7 Workers in nuclear power stations are monitored to check the radiation they emit.

A worker stands 1 cm away from a radiation detector.

The amount of radiation the worker emits is recorded.

Explain why the worker needs to stand close to the radiation detector.

[2 marks]

8 Workers in the nuclear power industry are exposed to nuclear radiation.

Pilots on aircraft are exposed to cosmic radiation from space.

daily dose caused by working in a nuclear power station = 0.00050 mSv

hourly dose from cosmic rays to a pilot while flying = 0.0030 mSv

Calculate the number of days it takes for a nuclear power station worker to receive the same dose as a pilot flying for 24 hours.

[3 marks]

Number of days = _____

17

13.

Scientists developed new models of the atom as new particles were discovered.

1 Draw **one** line from each particle to the year it was discovered.

[2 marks]

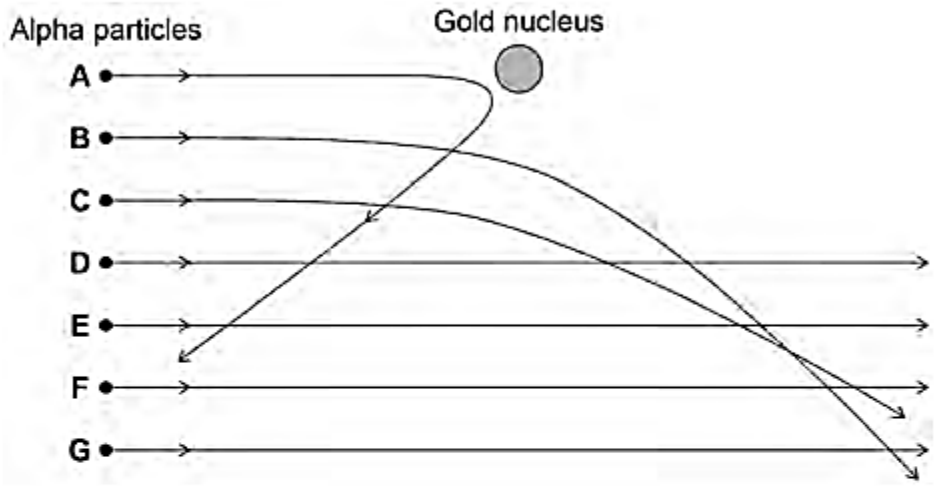
Particle	Year of discovery
Electron	1897
Neutron	1911
Nucleus	1920
Proton	1932

The nucleus was discovered using an alpha particle scattering experiment.

Alpha particles were directed at a sheet of gold foil.

Figure 8 shows the paths taken by seven alpha particles, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

Figure 8



. 2 Explain why alpha particle **A** takes the path shown in **Figure 8**.

[2 marks]

. 3 Explain why the path of alpha particle **B** is more tightly curved than the path of alpha particle **C**.

[2 marks]

]. 4 What can be deduced about the atom from the paths taken by alpha particles **D**, **E**, **F** and **G** in **Figure 8**?

[1 mark]

Tick (✓) **one** box.

The atom contains a nucleus. ☐

The atom contains protons, neutrons and electrons. ☐

The atom is mostly empty space. ☐

]. 5 How is the Bohr model of the atom different from the nuclear model of the atom?

[1 mark]

]. 6 Explain how an electron can move up and down between energy levels in an atom.

[2 marks]

10