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IGCSE PHYSICS 0625 · TOPICAL PAST PAPERS

Radioactivity

Paper 2 — Theory / Structured Questions (topical compilation)

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Radioactivity P2

Question # 1: May June/2004/P2/Q8

The pie chart in Fig. 8.1 shows the relative contributions made by different sources to background radiation.

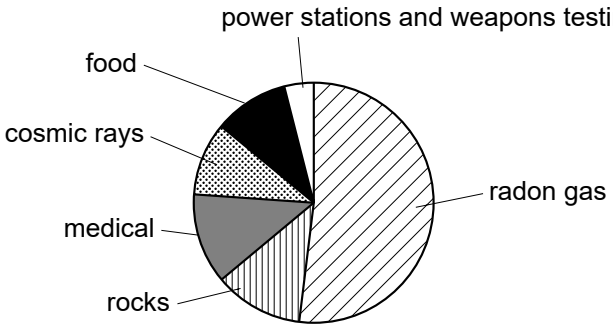


Fig. 8.1

(a) Which source makes the greatest contribution to the background radiation?

.....[1]

(b) State one effect of background radiation.

.....

.....

.....[1]

(c) Where do cosmic rays come from?

.....

.....[1]

(d) The nucleon number (mass number) of $^{220}_{86}Rn$ is 220.
Define *nucleon number*.

.....

.....[1]

(e) Radon ($^{220}_{86}Rn$) decays by the emission of an alpha-particle.
State the proton number (atomic number) and the nucleon number (mass number) of the nucleus left after an alpha-particle is emitted from this nucleus.

proton number ……..

nucleon number …….
[2]

Question # 2: May June/2006/P2/Q8

A radioactive source undergoes radioactive decay.

(a) Explain what is meant by *radioactive decay*.

.....

.....

..... [2]

(b) Gamma-rays from a radioactive source are used to treat some foods.

The gamma-rays kill bacteria in the food so that it stays fresh.

Some people are worried that food treated in this way becomes radioactive. A scientist tests three food samples. She measures the count-rate of the food before and after treatment with gamma-rays. The results are shown in the table below. The radioactive source is not present during any test.

food sample	count-rate before treatment / counts per minute	count-rate after treatment / counts per minute
A	29	32
B	32	28
C	30	31

(i) Explain why there is a measured count-rate before the food is treated.

.....

.....

.....

..... [1]

(ii) Determine and explain whether the treated food becomes radioactive.

.....

.....

.....

.....

.....

..... [2]

Question # 3: May June/2007/P2/Q8

(a) Explain how it is possible for an element to have different isotopes.

.....

.....

.....

..... [1]

(b) State what is meant by the *half-life* of a radioactive isotope.

.....

.....

.....

..... [2]

(c) Fig. 8.1 shows how the number of atoms of a radioactive isotope changes with time.

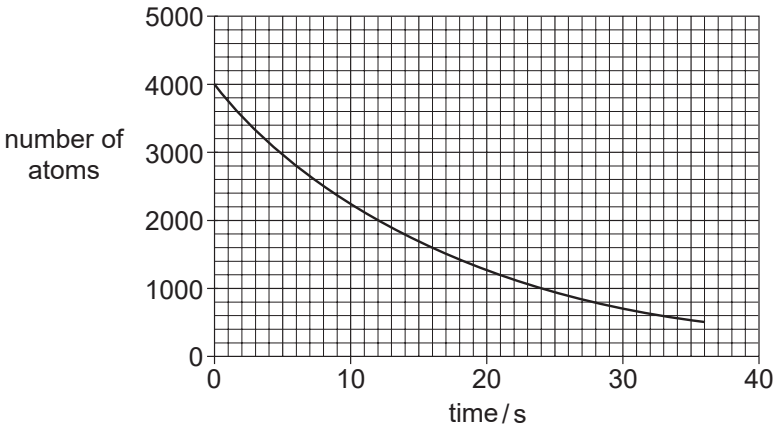


Fig. 8.1

Determine the half-life of the radioactive isotope. On Fig. 8.1, show how you obtained your result.

half-life = ... [2]

Question # 4: May June/2010/P22/Q8

A radioactive rock emits gamma-rays. A teacher plans an experiment to show a class that the emission of gamma-rays from the rock is random in time.

(a) (i) State the apparatus that the teacher needs to detect the gamma-rays.

.....

..... [1]

(ii) State one safety precaution that the teacher must take.

.....

..... [1]

(iii) Describe how the experiment is performed.

.....

.....

.....

.....

.....

..... [2]

(b) Describe what is meant by a *gamma-ray*.

.....

..... [2]

Question # 5: May June/2011/P22/Q8

Fig. 8.1 illustrates the process that occurs in the core of a nuclear reactor.

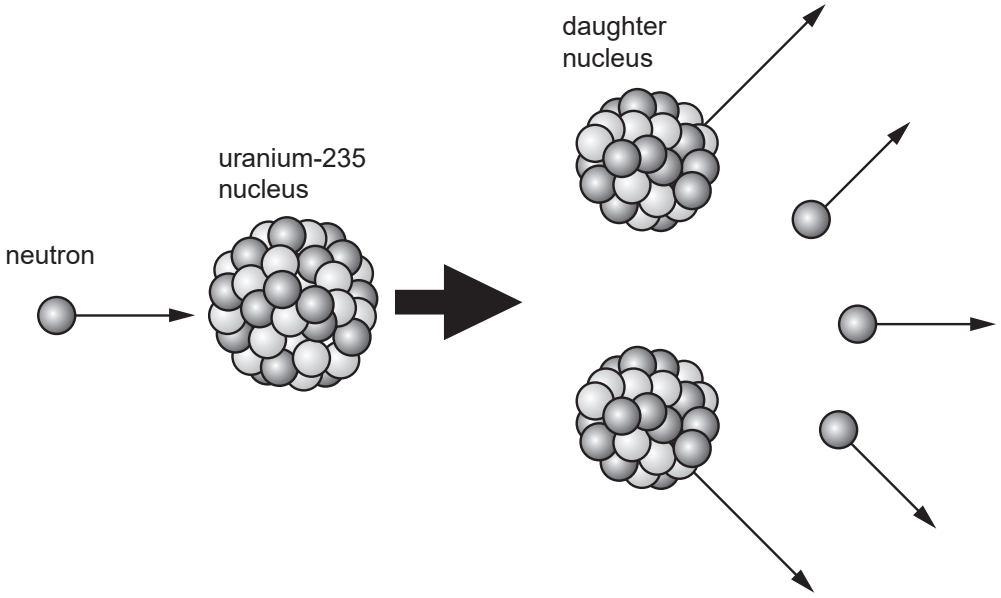


Fig. 8.1

(a) State the name of the process illustrated in Fig. 8.1.

.....[1]

(b) Describe what happens during this process.

.....

.....

.....[2]

(c) Some of the waste from a nuclear reactor is radioactive with a long half-life.

Explain what is meant by

(i) *radioactive*,

.....

.....[1]

(ii) a *long half-life*.

.....

.....[2]

Question # 6: May June/2014/P21/Q8

A hospital laboratory uses a small sample of a radioactive isotope of iodine, $^{131}_{53}\mathrm{I}$.

(a) (i) Describe the structure of the nucleus of an atom of this isotope.

.....

..... [2]

(ii) The sample is radioactive. Describe what happens in radioactive decay.

.....

.....

..... [2]

(b) The count in one minute from the source is measured several times. Fig. 8.1 shows the readings obtained.

2686	2759	2847	2799

Fig. 8.1

(i) Suggest why the readings are different.

.....

..... [1]

(ii) The half-life of $^{131}_{53}\mathrm{I}$ is 8.0 days. Estimate the count in one minute obtained from the sample after 24 days.

count = ... [2]

Question # 7: May June/2014/P22/Q8

An atom consists of electrons surrounding a nucleus made up of protons and neutrons.

State which of these particles

(i) have an equal and opposite charge,

..... [1]

(ii) have almost equal mass.

..... [1]

(b) The nuclide notation for carbon-14 is $^{14}_{6}C$. Carbon-14 decays by beta emission to a stable isotope of nitrogen (N).

(i) Write numbers in the empty boxes below to show the nuclide notation for this isotope of nitrogen.

$$^{14}_{6}C \rightarrow \begin{matrix}\square \\ \square\end{matrix} N + \beta$$

[2]

(ii) The half-life of carbon-14 is 5700 years.

A sample of wood from a living tree contains 2.4×10^{12} atoms of carbon-14.

A similar sample of the same size is taken from an old piece of wood. It contains 6.0×10^{11} atoms of carbon-14.

Calculate the age of the old piece of wood.

age = ... [2]

Question # 8: May June/2017/P21/Q8

A doctor has the choice of two isotopes, $^{131}_{53}I$ and $^{125}_{53}I$, to inject into a patient.

These isotopes emit radiation from deep inside the body. The radiation is detected outside the body and provides information to help the doctor find out what is wrong with the patient.

The isotope $^{131}_{53}I$ decays into a stable isotope of xenon by emitting a beta-particle (β) and a gamma ray (γ).

(a) State what is meant by a *gamma ray*.

decay equations

.....

.....[1]

(b) Complete the equation to show the radioactive decay of $^{131}_{53}I$.

$$^{131}_{53}I \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}Xe + {}^{\cdots\cdots}_{-1}\beta + \gamma$$

[2]

(c) When a nucleus of $^{125}_{53}I$ decays, only a gamma ray is emitted.

Suggest why it is better for the doctor to inject the isotope $^{125}_{53}I$ into the patient.

.....

.....

.....

.....[2]

safety, use, precautions

Question # 9: Oct Nov/2002/P2/Q8

Details of two radioactive sources used by a school are shown in Fig. 8.1.

source	radioactive source	type of radiation emitted	half-life of source
A	Co-60	gamma ray	5 years
B	Sr-90	beta particle	28 years

Fig. 8.1

(a) On Fig. 8.2, the number of Co-60 atoms in source A and the number of Sr-90 atoms in source B at time $t = 0$ has been plotted as ×.

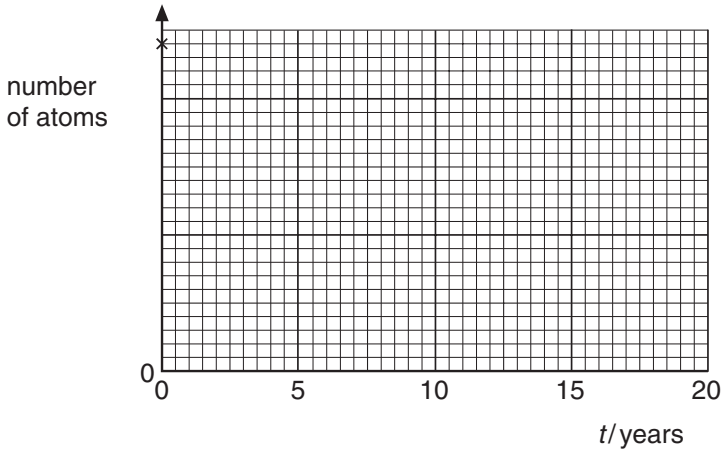


Fig. 8.2

(i) Plot accurately the number of Co-60 atoms in source A at t = 5, 10, 15 and 20 years. Draw the best line through your points.

(ii) Sketch how the number of Sr-90 atoms in source B changes from $t = 0$ to 20 years.
[3]

(b) A detector is placed near source A. It records 4000 counts in one minute from the source when $t = 0$.

A piece of lead, which absorbs 99% of gamma rays, is immediately placed between the source and the detector. Determine

(i) the counts in one minute that the detector now records from the source,

counts in one minute = ...

(ii) the time t when the detector would measure 10 counts in one minute from the source.

time = ...
[3]

Question # 10: Oct Nov/2005/P2/Q8

Fig. 8.1 is a half-scale diagram of a radioactive source stored in a safe way.

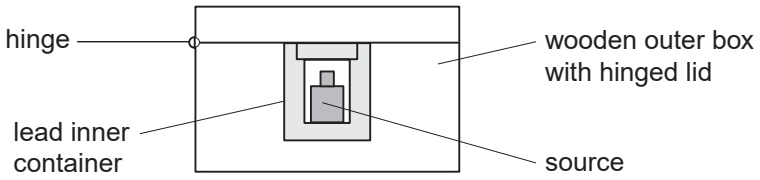


Fig. 8.1

(a) The source emits alpha-particles, beta-particles and gamma-rays.

A teacher handles the box. Explain how the teacher is completely protected from the alpha- and beta-particles but only partially protected from the gamma-rays.

.....

.....

.....

..... [2]

(b) Describe and explain how the teacher should remove the source from the box safely.

.....

.....

.....

..... [2]

(c) The source is brought near a radiation detector.

(i) Name a suitable detector.

..... [1]

(ii) Describe how you would use the detector to show that the source emits particles at random.

.....

.....

.....

..... [2]

Question #11: Oct Nov/2008/P2/Q8

The reaction that takes place at the centre of the Sun can be represented as

$$2{}_{1}^{1}\mathrm{p} + 2{}_{0}^{1}\mathrm{n} \longrightarrow {}_{2}^{4}\mathrm{He}.$$

(a) State the name of this type of reaction.

..... [1]

(b) The speed of light is $3.0 \times 10^{8}\,\mathrm{m/s}$.

(i) The mass of the helium nucleus (${}_{2}^{4}\mathrm{He}$) produced is different from the total mass of the two protons and the two neutrons. The difference is $6.6 \times 10^{-29}\,\mathrm{kg}$.

Explain why energy is released during the reaction.

.....

.....

..... [2]

(ii) Calculate the energy released in this reaction. State the formula used.

energy = ... [3]

Question # 12: Oct Nov/2010/P22/Q7

(a) Explain what is meant by *background radiation*.

.....

.....

.....[2]

(b) Describe how one human activity has led to an increase in background radiation.

.....

.....

.....[2]

Question # 13: Oct Nov/2010/P22/Q8

Explain, in outline, how a low-density cloud of hydrogen in space becomes a star.

.....

.....

.....

.....

.....

.....[4]

Question # 14: Oct Nov/2011/P21/Q8

(a) One radioactive isotope of iodine is $^{131}_{53}\mathrm{I}$. As a nucleus of this isotope decays, it emits a beta-particle (symbol: β) and it becomes a nucleus of an isotope of xenon (symbol: Xe).

Complete the equation in nuclide form, for this decay.

$$^{131}_{53}\mathrm{I} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{Xe} + {}^{\cdots\cdots}_{\cdots\cdots}\beta$$

[2]

(b) A sample of a radioactive isotope emits both beta-particles and gamma-rays.

Fig. 8.1 shows these two types of radiation entering a magnetic field.

Fig. 8.1

The direction of the magnetic field is into the page.

On Fig. 8.1, mark **and** label the path taken by

(i) the beta-particles, [1]

(ii) the gamma-rays. [1]

(c) Emission from a radioactive source is a random process.

State two ways in which the process is random.

1. .....

2. .....

[2]

Question # 15: Oct Nov/2012/P22/Q7

A small piece of metal taken from a nuclear reactor is radioactive.

(a) Describe a method to determine whether the piece of metal emits gamma-rays.

.....

.....

.....

.....

.....

.....[3]

(b) State two safety precautions that must be taken when handling the piece of metal.

1. .....

.....

2. .....

.....

[2]

Question # 16: Oct Nov/2013/P21/Q8

A radioactive sample emits only beta-particles and gamma-rays.

(a) Describe, with the aid of a labelled diagram, an experiment that shows that the sample does **not** emit alpha-particles.

.....

.....

.....

.....

.....[3]

(b) State two safety precautions that must be taken when working with the radioactive sample.

1. .....

2. .....
[2]

Question # 17: Oct Nov/2013/P22/Q8

A smoke detector containing an alpha-particle source is fixed to the ceiling in a room. The alpha-particles ionise the air between two metal plates so that a battery produces a current between the plates.

If smoke enters the detector, it reduces the current between the plates and an alarm sounds.

Fig. 8.1 shows the arrangement.

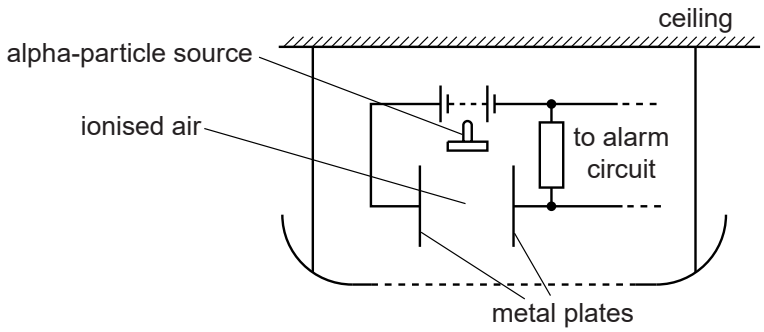


Fig. 8.1

(a) A technician removes the source from the smoke detector and measures the count rate of the source.

(i) Suggest two precautions that the technician should take when working with the source.

1. .....

2. .....
[2]

(ii) The technician measures the count rate, in counts / s, five times. On each occasion, the arrangement of the equipment is the same.

The values obtained are: 81 77 80 83 and 79.

Suggest why the values are different.

.....

.....[1]

(b) Radioactive sources that emit beta-particles or gamma-rays are not used in smoke detectors. State and explain two reasons for this.

1. .....

.....

2. .....

.....
[3]

Question # 18: Oct Nov/2016/P22/Q7

Plutonium-238 is a radioactive isotope that decays by alpha-particle emission. It also emits gamma-rays.

(a) The nuclide notation for plutonium-238 is $^{238}_{94}Pu$.

Describe the structure and composition of a neutral atom of plutonium-238.

.....

.....

.....

.....[3]

(b) Alpha-particles, beta-particles and gamma-rays all cause ionisation. The ionisation of substances in the human body can be hazardous.

(i) State how the ionising effect of beta-particles compares with

1. the ionising effect of alpha-particles,

characteristics

.....[1]

2. the ionising effect of gamma-rays.

.....[1]

(ii) State two precautions that are taken when radioactive substances are moved in a safe way.

1. .....

safety, use, precautions .....

2. .....

.....

[2]

Question # 19: Oct Nov/2017/P21/Q8

A sample of the radioactive isotope radon-222 decays by the emission of alpha-particles.

(a) As alpha-particles travel through air, the air is ionised.

characteristics

(i) Describe the composition of an alpha-particle.

.....

.....

..... [1]

(ii) Explain how an alpha-particle ionises air.

.....

.....

..... [2]

(iii) State how the relative ionising effect of alpha-particles compares with that of

1. beta-particles,

.....

2. gamma rays.

.....
[1]

half-life

(b) The half-life of radon-222 is 3.3×10^5 s.

The number of radon-222 atoms in the sample is 4.8×10^4.

(i) Determine the time that it takes for the number of radon-222 atoms in this sample to decrease to 1.5×10^3.

time = ... [3]

randomness, background

(ii) Suggest one reason why, in practice, the time for the number of radon-222 atoms to decrease to 1.5×10^3 may differ slightly from the value obtained in **(b)(i)**.

.....

..... [1]

Question # 20: May June/2018/P22/Q11

A smoke detector contains a small radioactive source of americium-241. The source emits alpha-particles.

(a) **(i)** In the space below, draw a diagram of an apparatus that can be used to show that the source emits alpha-particles.

detection

[2]

(ii) Describe how this apparatus is used.

.....

.....

.....

.....[2]

(iii) Explain how the results of the test show that the source emits alpha-particles.

.....

.....

.....

.....[2]

(b) The smoke detector works because alpha-particles from the source ionise the air.

Compare the relative ionising effects and penetrating powers of alpha-particles, beta-particles and gamma rays.

ionising effects .....

.....

penetration effects .....

.....

[2]

characteristics

half-life

(c) Americium-241 has a half-life of 430 years.

(i) Radium-224 is another element that emits alpha-particles. It has a half-life of 3.6 days.

Explain why americium-241 is more suitable as the radioactive source in a smoke detector than radium-224.

.....

.....

.....[1]

(ii) A smoke detector contains 8.0×10^{11} atoms of americium-241.

Calculate the time taken for the number of atoms of americium-241 to fall to 1.0×10^{11}.

safety, use

time = ...[3]

(d) When used correctly, the radioactive source in the smoke detector is less harmful than background radiation.

(i) State one harmful effect of background radiation.

.....[1]

(ii) A radioactive source is picked up using a long-handled tool. Explain why this is safer than using a short-handled tool.

.....

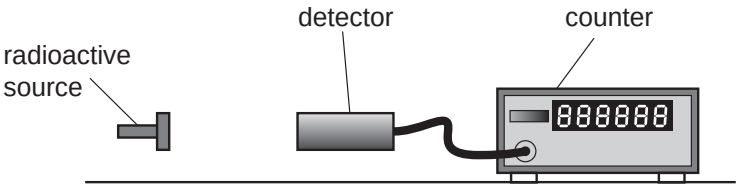
.....

.....

.....[2]

Question # 21: May June/2019/P21/Q11

A teacher carries out an experiment on radioactivity using the apparatus shown in Fig. 11.1.



detection

Fig. 11.1 (not to scale)

The count rate is a measurement of the count during one minute.

(a) **(i)** State the name of one type of radiation detector.

..... [1]

(ii) State one safety precaution the teacher must take when using a radioactive source.

.....

randomness

..... [1]

(b) The teacher states that the emissions from the radioactive source are random in time.

(i) State what is meant by *random in time*.

.....

..... [1]

(ii) Describe how the apparatus is used to show that the emissions are random in time.

.....

..... [2]

background

(c) **(i)** State what is meant by *background radiation*.

.....

..... [1]

(ii) The teacher measures the count rate due to the source.

Describe how the count rate is corrected for the background radiation.

.....

.....

..... [2]

(d) The corrected count rate is recorded for various distances *d* between the source and the detector. Fig. 11.2 shows a graph of the results obtained.

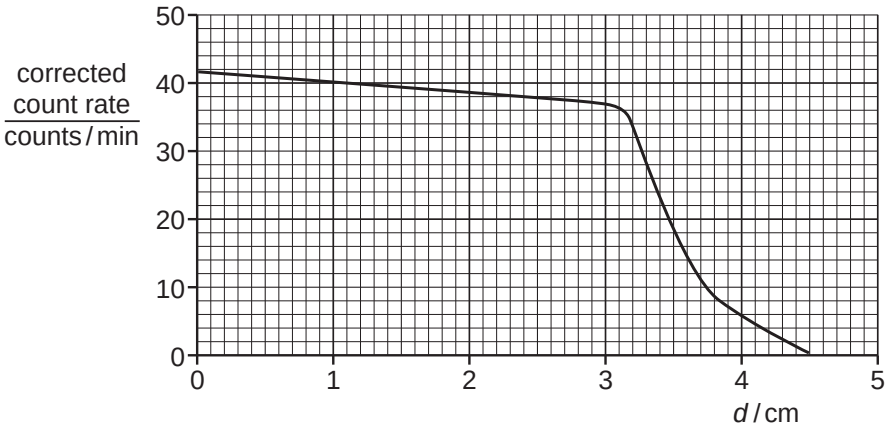


Fig. 11.2

(i) Determine the maximum distance that the radiation travels in air.

..... [1]

(ii) State the name of the radiation emitted by the radioactive source and give a reason for your answer.

radiation is .....

reason .....

.....

[2]

(iii) As the radiation from the source travels in the air it causes ionisation.

Describe what is meant by *ionisation* of the air.

.....

.....

..... [1]

(e) The half-life of another radioactive source is 40 minutes.

Initially, the corrected count rate from this source is 300 counts / minute.

On Fig. 11.3, plot suitable points and draw a graph of the corrected count rate as it changes with time.

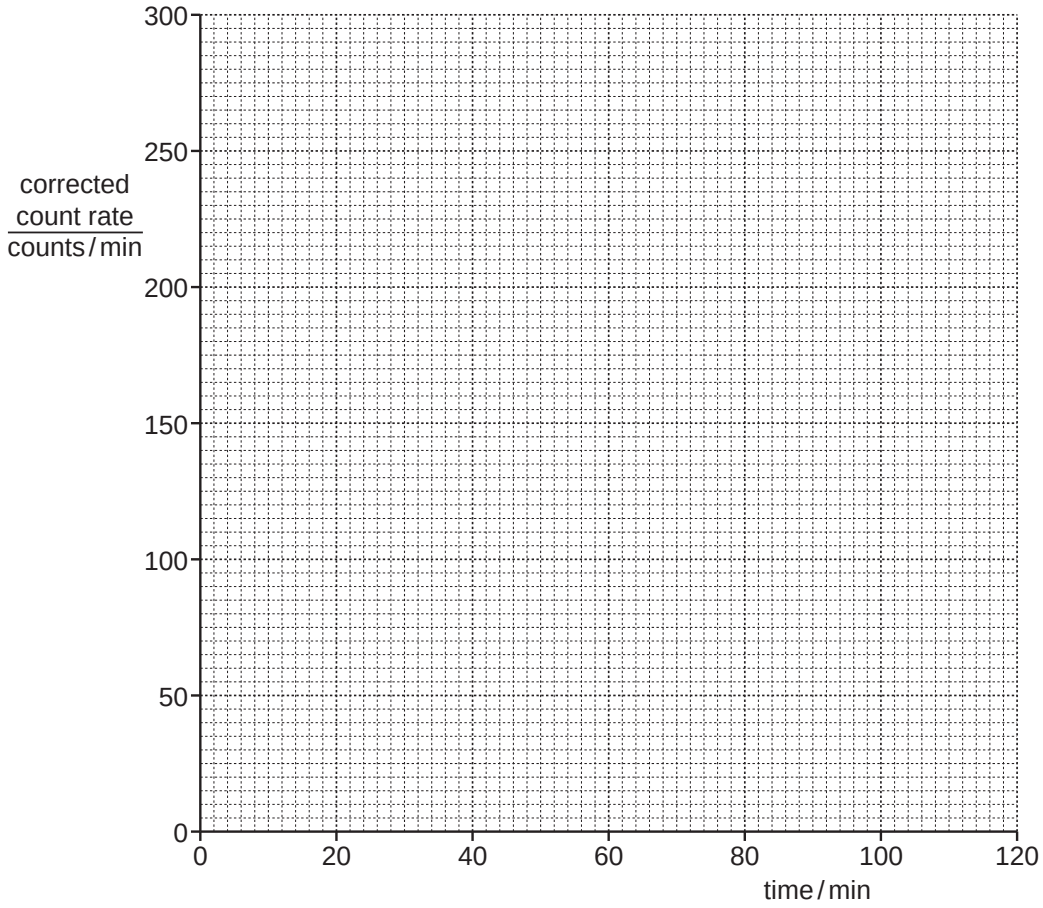


Fig. 11.3

[3]

[Total: 15]

fusion, star formation

Question # 22: May June/2019/P22/Q11

(a) Stars are formed inside a cloud of gas and dust in space.

When a star forms, the cloud first becomes smaller as it collapses.

(i) State what causes the gas cloud to collapse.

..... [1]

(ii) Eventually nuclear fusion occurs in the star.

State **two** conditions required for nuclear fusion to occur in the star.

1. .....

2. .....
[2]

(b) When a large star explodes, nuclei of heavy elements are formed.

One such nucleus is uranium-235 ($^{235}_{92}U$).

(i) State the name and the number of each type of particle found in one nucleus of $^{235}_{92}U$.

name of particle ..... number found in nucleus .....

name of particle ..... number found in nucleus .....
[2]

(ii) State one feature that is the same for the nuclei of all isotopes of uranium.

.....

..... [1]

fusion, fission

(iii) A nucleus of $^{235}_{92}U$ in a nuclear reactor can undergo nuclear fission.

Describe the process of nuclear fission in a nuclear reactor.

.....

.....

..... [2]

(iv) State one difference between nuclear fusion and nuclear fission.

.....

..... [1]

decay equations

(v) The nucleus of $^{235}_{92}U$ is not stable.

It decays by the emission of an alpha-particle (α) into a nucleus of thorium (Th).

Complete the nuclear equation that represents this decay.

$$^{235}_{92}U \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}Th + {}^{\cdots\cdots}_{2}\alpha$$

[2]

(c) Geiger and Marsden carried out an experiment to investigate the scattering of alpha-particles. Fig. 11.1 shows a diagram of the apparatus that they used.

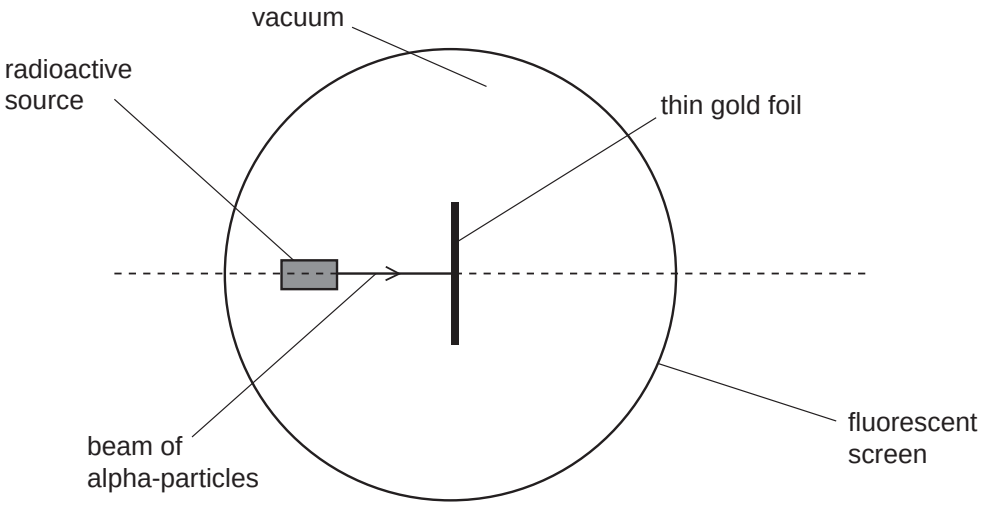


Fig. 11.1

When an alpha-particle strikes the fluorescent screen a flash of light is emitted.

(i) On Fig. 11.1, mark with a letter P where most flashes occur on the screen. [1]

(ii) Describe what is seen on the other parts of the screen.

.....

..... [1]

(iii) State two conclusions about atoms of gold that resulted from this experiment.

.....

.....

.....

..... [2]

[Total: 15]

Question # 23: May June/2020/P21/Q7

Two isotopes of carbon are carbon-12 and carbon-14.

One of these isotopes, carbon-14, undergoes radioactive decay.

(a) Describe what is meant by *radioactive decay*.

.....

..... [2]

(b) Carbon-12 has a proton number (atomic number) of 6 and a nucleon number (mass number) of 12.

Complete Table 7.1 for a neutral atom of each of these two isotopes.

Table 7.1

	carbon-12	carbon-14
number of protons	6	
number of neutrons		
number of electrons		

[2]

(c) A sample of carbon-14 is contained in a thin aluminium container of thickness 0.2 mm.

Radiation from the sample is detected outside the container.

When the thickness of the aluminium is increased to 6 mm, no radiation from the sample is detected outside the container.

characteristics

(i) State the type of radiation which is stopped by increasing the thickness of the aluminium.

..... [1]

(ii) Explain how you know that the sample does **not** emit one other type of radiation.

.....

.....

.....

..... [2]

[Total: 7]

Question # 24: May June/2020/P22/Q7

Radon-222 is an isotope of radon which undergoes a series of radioactive decays.

Fig. 7.1 is a diagram showing the proton number (atomic number) and nucleon number (mass number) of nuclei involved in the series of decays.

The point P represents a nucleus of radon-222.

Starting at P, a nucleus of radon-222 decays to Q; then from Q to R; then from R to S; then from S to T; and finally from T to U.

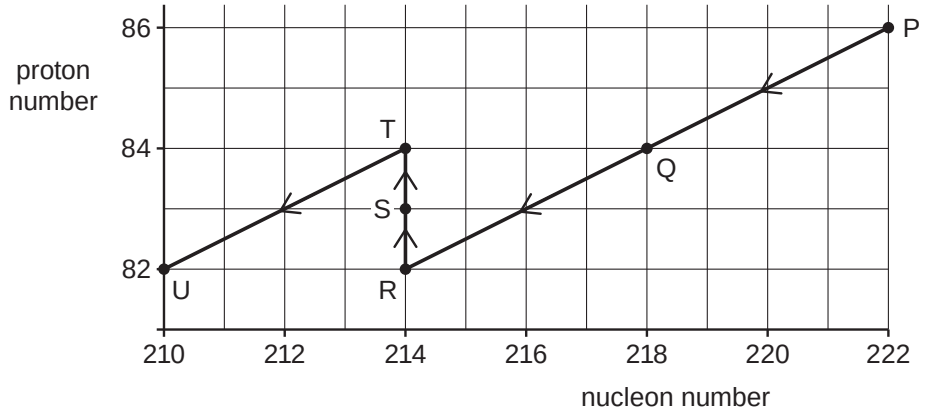


Fig. 7.1

(a) (i) State two points on Fig. 7.1 which represent isotopes of the same element.

..... [1]

(ii) Different isotopes of the same element have different atomic compositions.

State how the composition of their atoms is different.

.....

..... [1]

(b) A nucleus of radon-222 emits an alpha-particle as it decays.

(i) The radioactive decay of a single nucleus is random.

Explain what is meant by the *random* radioactive decay of a nucleus.

.....

.....

..... [1]

(ii) In nuclide notation, radon-222 is written as $^{222}_{86}Rn$.

When a nucleus of radon-222 emits an alpha-particle (α), it decays to an isotope of polonium (Po).

Complete the decay equation below for this decay.

$$^{222}_{86}Rn \rightarrow \overset{\cdots\cdots}{\cdots\cdots}Po + \overset{\cdots\cdots}{\cdots\cdots}\alpha$$

[2]

(c) **(i)** State the name of the particle emitted as a nucleus of R decays to a nucleus of S.

..... [1]

(ii) Describe the change in the composition of a nucleus of R as it decays to a nucleus of S.

.....

.....

..... [2]

[Total: 8]

Question # 25: Oct Nov/2018/P21/Q10

(a) Two neutral atoms are atoms of different isotopes of the same element.

State

(i) one similarity in the structures of these two atoms,

..... [1]

(ii) one difference between the structures of these two atoms.

..... [1]

(b) The isotope plutonium-239 decays by the emission of an alpha-particle (symbol α) to an isotope of uranium (symbol U). The half-life for this decay is 2.4×10^4 years.

(i) Complete the equation for this decay.

decay equations

$$^{239}_{94}\text{Pu} \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{U} + {}^{\cdots\cdots}_{\cdots\cdots}\alpha$$

[3]

(ii) The count rate measured due to a pure sample of plutonium-239 is 6400 counts / second.

Calculate the count rate after a period of 1.2×10^5 years has elapsed.

half-life

count rate = ... [3]

(iii) Fig. 10.1 shows an alpha-particle entering a uniform magnetic field.

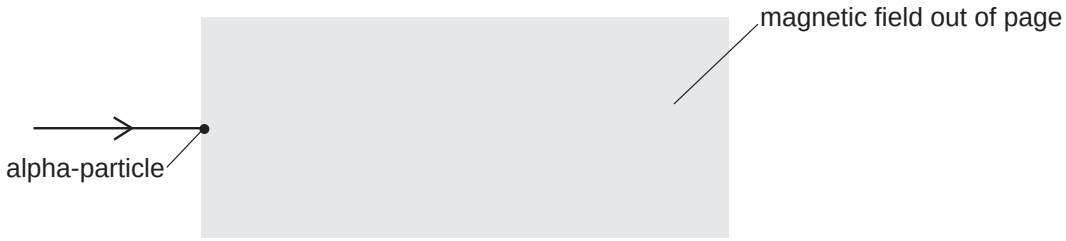


Fig. 10.1

characteristics

1. On Fig. 10.1, draw the path of the alpha-particle in the magnetic field. [2]

2. Explain why the alpha-particle follows the path you drew in **(b)(iii)1**.

.....

..... [1]

fission

(c) In a nuclear reactor at a power station, plutonium-239 is made to undergo nuclear fission.

(i) State what is meant by *nuclear fission*.

.....

..... [1]

(ii) State what happens to a plutonium-239 nucleus in the nuclear reactor to cause fission.

.....

..... [1]

(iii) State one advantage of generating electricity in a nuclear power station rather than using

1. an oil-fired power station,

.....

..... [1]

2. an array of wind turbines.

.....

..... [1]

Question # 26: Oct Nov/2018/P22/Q6

Fig. 6.1 shows a radiation detector placed on a laboratory bench.

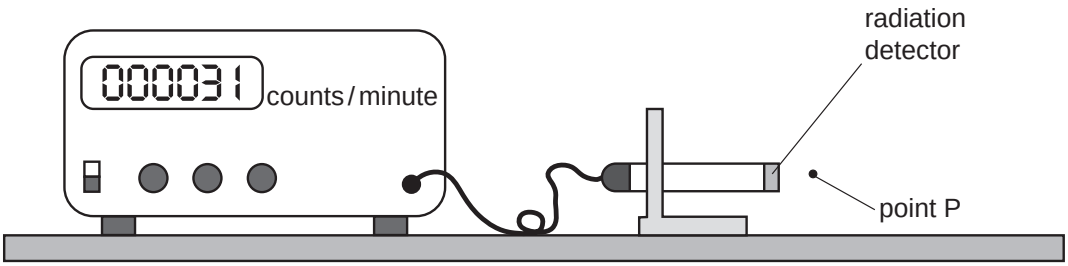


Fig. 6.1

The detector is switched on and six readings of the count rate are recorded.

The table in Fig. 6.2 shows the readings obtained.

reading number	1	2	3	4	5	6
count rate / counts/minute	31	36	29	32	31	33

Fig. 6.2

(a) Using all the readings obtained, determine an average value for the background count rate.

background count rate = ... [1]

characteristics

(b) Fig. 6.1 shows a point P which is a very short distance from the end of the radiation detector. A sample of the radioactive isotope cobalt-60 is placed at P. The average value of the count rate obtained is now 975 counts / minute.

The average count rate is determined with different objects between the radiation detector and the sample. The table in Fig. 6.3 shows the results obtained.

object	average count rate / counts / minute
no object	975
four sheets of paper	976
0.50 mm thickness sheet of aluminium	117
2.0 cm thickness sheet of lead	52

Fig. 6.3

(i) Indicate, by placing ticks (✓) in the appropriate boxes, the radiation emitted by cobalt-60.

decay equations

☐ alpha-particles ☐ beta-particles ☐ gamma rays

[1]

(ii) This radiation is produced when a nucleus of cobalt-60 ($^{60}_{27}$Co) decays into a nucleus of the daughter product X. Product X is not radioactive.

Determine

1. the number of protons in a nucleus of X,

number of protons = ... [1]

2. the number of neutrons in a nucleus of X.

number of neutrons = ... [1]

(c) The half-life of cobalt-60 is 5.3 years.

(i) State what is meant by *half-life*.

.....

.....

..... [2]

(ii) When there is a lead sheet between the detector and the sample, the average count rate is obtained from six readings taken at one-minute intervals. The six readings are given in the table in Fig. 6.4.

randomness

reading number	1	2	3	4	5	6
count rate / counts / minute	61	46	43	56	49	57

Fig. 6.4

There are reasons for suggesting that the variation in these readings is random and not because the number of cobalt-60 atoms in the sample is decreasing.

State two of these reasons.

1. .....

.....

2. .....

.....

[2]

Question # 27: Oct Nov/2019/P21/Q7

Table 7.1 shows the composition of four neutral atoms and one atom that has been ionised.

These five particles are labelled P, Q, R, S and T.

Table 7.1

	P	Q	R	S	T
number of electrons	17	18	18	19	20
number of neutrons	20	20	24	23	21
number of protons	17	19	18	19	20

(a) The charge on an electron is -1.6×10^{-19} C.

(i) State which of P, Q, R, S and T is the ionised atom.

..... [1]

(ii) State the size and the sign of the charge on the ionised atom.

charge = ... [1]

(b) State which pair from P, Q, R, S and T are isotopes of the same element.

..... [1]

decay equations

(c) One of the atoms is a radioactive isotope that decays to produce one of the other atoms.

(i) Deduce which atom decays in this way.

..... [1]

(ii) Deduce which atom is the product of this decay.

..... [1]

(iii) Deduce which type of radioactive decay occurs.

..... [1]

(iv) The half-life for this radioactive decay is 33 years.

A radioactive sample contains a large number of the atoms that decay in this way.

Determine the fraction of this number of atoms that will decay in 99 years.

half-life

fraction that decays = ... [3]

[Total: 9]

Question # 28: Oct Nov/2019/P22/Q10

All the isotopes of the gas radon are radioactive.

(a) State **one** similarity and **one** difference between the nuclei of two different isotopes of radon.

similarity .....

decay equations

difference .....

[2]

(b) The isotope radon-222 decays by alpha-particle emission to an isotope of polonium (Po). The proton number (atomic number) of polonium is 84.

(i) Determine the number of neutrons in an atom of the polonium isotope.

number of neutrons = ... [2]

(ii) Determine the number of protons in an atom of radon-222.

number of protrons = ... [2]

(iii) Describe how a neutral atom of helium (${}^{4}_{2}\mathrm{He}$) differs from an alpha-particle.

.....

..... [1]

(c) In an experiment to collect a small quantity of helium, a sample of radon-222 is enclosed in an inner glass tube which has a very thin wall. Fig. 10.1 shows that this tube is placed inside a container that is initially evacuated.

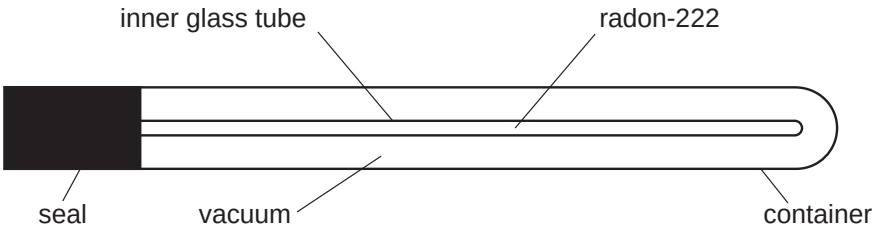


Fig. 10.1

Both the container and the inner glass tube are sealed.

As the radon-222 decays, alpha-particles pass through the thin wall of the inner glass tube.

Fig. 10.2 shows how the total number of alpha-particles produced by the radioactive decay of the radon-222 changes as time passes.

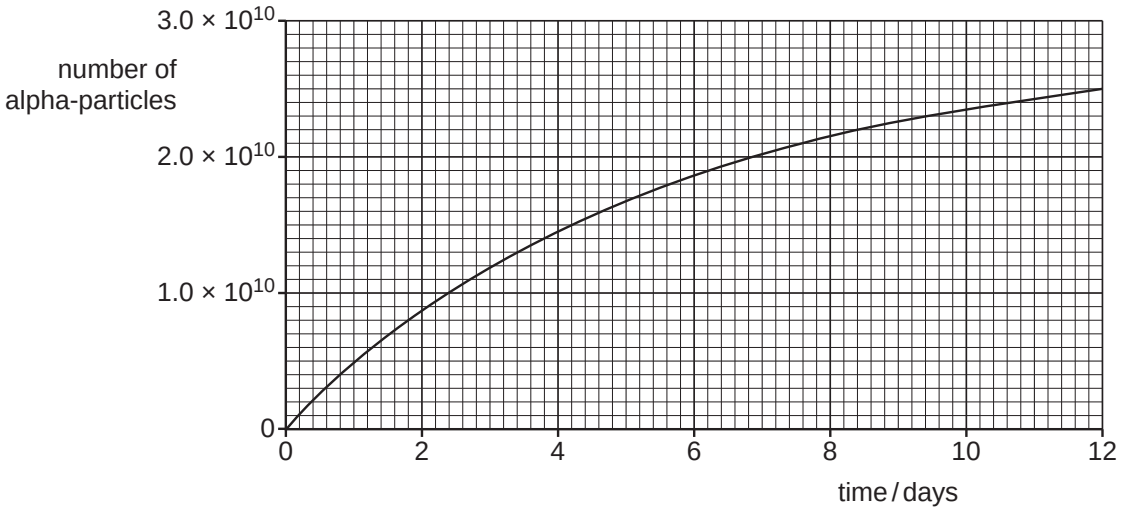


Fig. 10.2

(i) Use Fig. 10.2 to determine the number of alpha-particles produced in 7.6 days.

..... [1]

(ii) Initially, there are 2.8×10^{10} atoms of radon-222 in the inner glass tube. As each radon-222 atom decays, it produces an alpha-particle.

Calculate the number of radon-222 atoms that remain after 7.6 days.

number of atoms remaining = ... [1]

(iii) Using the number of radon-222 atoms present initially and the number present after 7.6 days, calculate the half-life of radon-222.

characteristics

half-life = ... [3]

(d) The alpha-particles become helium atoms which are collected in the vacuum shown in Fig. 10.1.

Explain, in terms of the properties of alpha-particles, why the wall of the inner glass tube must be extremely thin.

.....

..... [1]

(e) In some parts of the world, radon-222 accumulates in the air in buildings and is breathed in by people.

Explain why the presence of an alpha-emitter in the lungs is particularly hazardous.

.....

.....

..... [2]

[Total: 15]

Question # 29: Oct Nov/2020/P21/Q7

Nuclear fusion is a reaction that occurs in the Sun and other stars.

(a) Explain what is meant by *nuclear fusion*.

.....

.....

..... [2]

(b) Describe the nuclear fusion reaction that takes place in the Sun.

.....

.....

..... [1]

(c) A star forms when the temperature of a large cloud of gas in space increases as the cloud collapses inwards.

(i) State the energy transfers that occur as the cloud collapses.

.....

.....

..... [2]

(ii) The temperature increase starts a nuclear fusion reaction.

Explain why the temperature of the star eventually reaches a steady value.

.....

.....

..... [2]

[Total: 7]

Question # 30: Oct Nov/2020/P22/Q6

Phosphorus-32 ($^{32}_{15}$P) is an isotope of phosphorus that undergoes radioactive decay.

(a) The most common isotope of phosphorus is phosphorus-31.

(i) Describe the structure and composition of a neutral atom of phosphorus-31.

.....

.....

..... [2]

(ii) State how an atom of phosphorus-32 differs from an atom of phosphorus-31.

.....

..... [1]

(b) Phosphorus-32 decays by beta-particle emission to a stable isotope of sulfur. The half-life for this decay is 2.0 weeks.

(i) State how a nucleus of this isotope of sulfur is different to a nucleus of phosphorus-32.

.....

..... [1]

(ii) At time $t = 0$, a radioactive sample contains 3.2×10^{11} atoms of phosphorus-32.

Half-life

At the same moment, the sample contains no atoms of sulfur. This is shown by the cross on Fig. 6.1.

On Fig. 6.1, plot a graph to show how the total number of sulfur atoms in the sample changes with t and draw a suitable curve. [3]

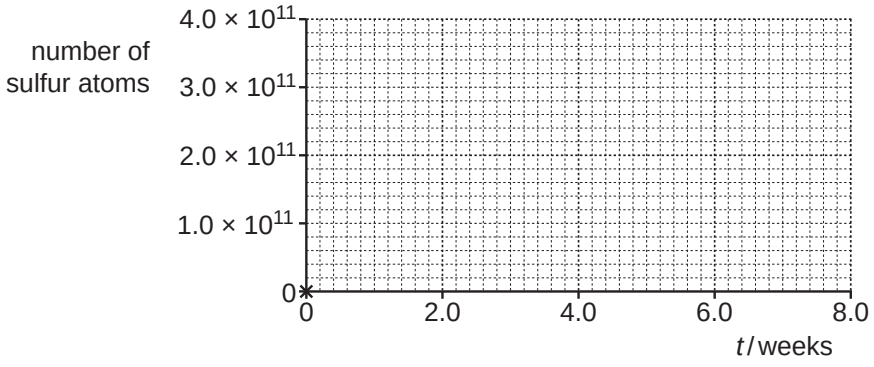


Fig. 6.1

(c) State **two** precautions taken when storing or moving radioactive materials.

1. .....

.....

2. .....

.....

[2]

[Total: 9]