Radioactivity

Name & set

1 Table 1 gives some information about the radioisotope strontium-90.

Table 1

Atomic number	38
Mass number	90
Half-life	28.1 years

Strontium-90 emits ß (beta) particles. Table 2 gives some information about these ß-particles.

Table 2

Material	*Distance particles can penetrate the material before all of them are absorbed (mm)*
Aluminium	0.70
Paper	1.90
Steel	0.24
Uranium	0.10

(a) (i) Use the information in table 2 to put in numbers to complete the gaps in this statement:

A nucleus of strontium-90 contains a total of _____ nucleons; _____ of these are

protons and _____ of them are neutrons. [3]

Strontium decays into Yttrium (chemical symbol **Y**) by emitting a ß-particle.

(ii) Write down the equation for the decay of strontium

_____

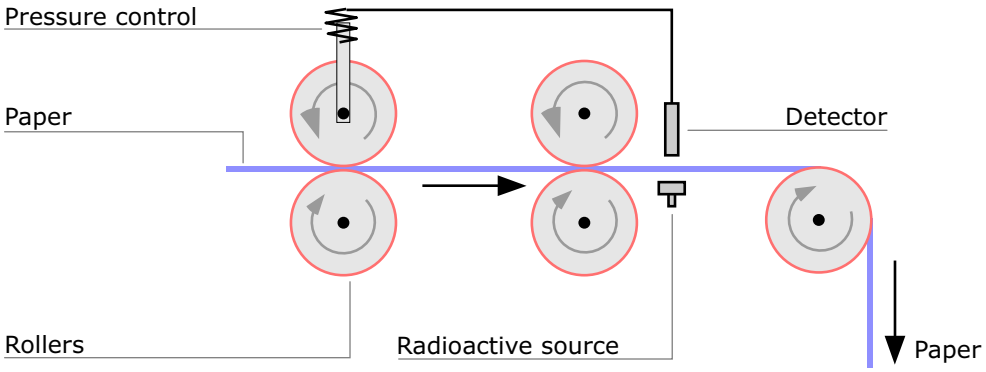
_____ [2]

(b) There are four materials listed in Table 2. Which one of these do ß-particles pass through most easily?

_____ [1]

question 1 continued:

(c) When paper is made it is passed between rollers. The pressure of the rollers affects the thickness of the paper. The process can be controlled using ß-radiation. This is shown in the diagram.



(i) What apparatus could be used to detect the radiation?

_____ [1]

(ii) Explain how this arrangement can control the thickness of the paper.

_____

_____

_____ [3]

(iii) The control process has to be adjusted regularly. If this is not done, the machine starts to produce paper that is too thin. Explain this.

_____

_____

_____ [2]

(iv) Paper can become charged by passing through rollers. It picks up dust, which spoils the quality of the paper. Radiation gets rid of this charge. Explain how radiation does this.

_____

_____

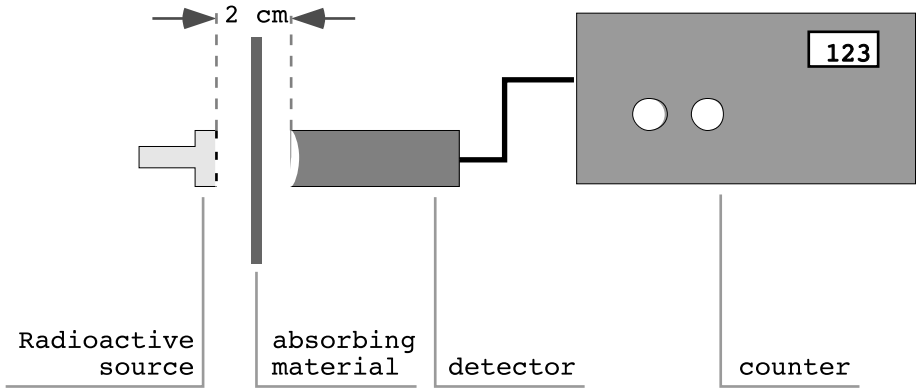
_____ [2]

(v) Strontium-90 could not be used when making cardboard which is about 2 mm thick. Why not? (2)

_____

_____ [2]

2 (a) The apparatus below is used to investigate the radiation emitted by a source. It is known that the source gives out two types of radiation.



Various materials were placed between the source and the detector. For each material the count rate, corrected for background radiation, was recorded as follows:

Material between source and detector	*Count rate in counts per minute*
Air	300
Thin sheet of paper	301
5 mm thick aluminium sheet	45
10 mm thick lead sheet	42

Which two radiations did the source emit? _____ [1]

Give *two* reasons for your answer.

1 _____

_____

_____ [1]

2 _____

_____

_____ [1]

(b) A radioactive isotope of gold has the symbol $^{195}_{79}\mathrm{Au}$.

If this isotope is injected into the bloodstream of a patient it can be used by doctors as a tracer to monitor the way the patient's heart works. The isotope emits *gamma* radiation that is detected outside the patient's body.

(i) Why would an isotope that emits alpha radiation be unsuitable as a tracer to monitor the working of the heart?

_____

_____

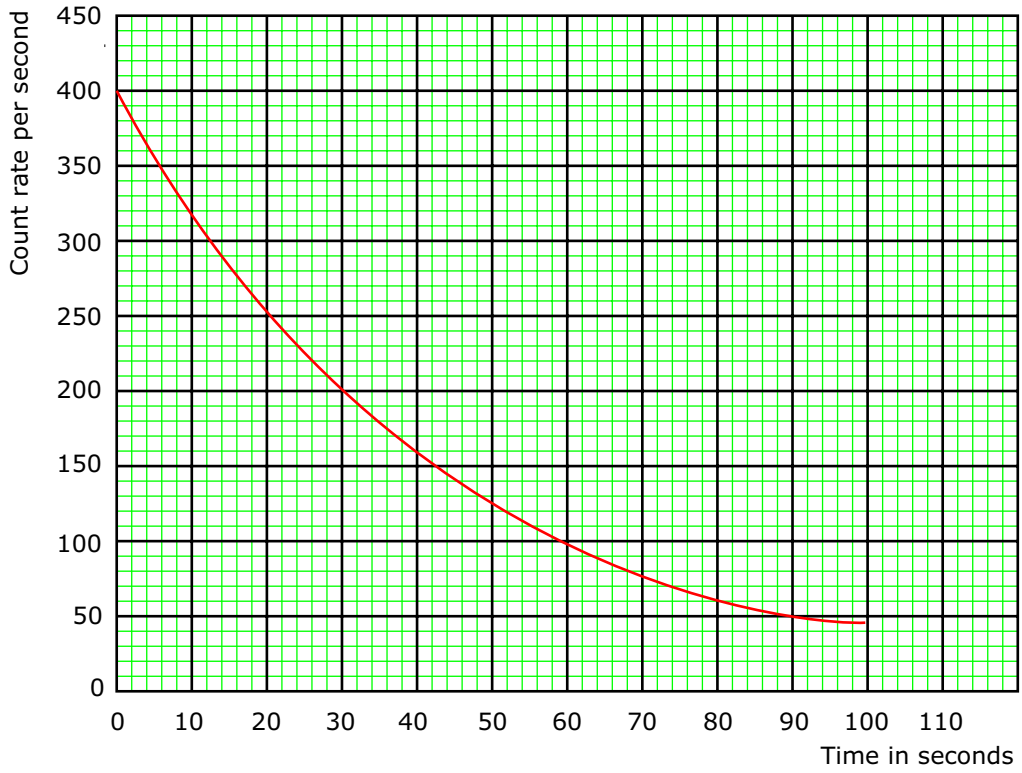
_____ [1]

question 2 continued

(ii) Give one *non*-medical use for a radioactive tracer.

_____ [1]

(c) The graph below shows how the count rate from a sample of gold 195 changes with time. (The graph has been corrected for background level.)



(i) What is meant by *background level*?

_____

_____ [1]

(ii) Use the graph to find the half-life of gold 195. You should show clearly on the graph how you obtain your answer.

Half-life = _____ [2]

(iii) Give two benefits of using an isotope with a short half-life as a tracer to monitor the heart.

1 _____

_____

_____ [1]

2 _____

_____

_____ [1]

SEG 1995

3 (a) The table gives some information about an isotope of iodine $^{131}_{53}\mathrm{I}$ which decays to give xenon.

nucleon (mass) number	131
proton (atomic) number	53
radiation emitted	beta particle

(i) How many neutrons are there in an atom of this iodine isotope?

_____ [1]

(ii) From which part of the iodine atom does the beta particle come?

_____ [1]

(iii) Complete the equation below for the decay of the iodine into xenon.

$$^{131}_{53}\mathrm{I} \rightarrow \mathrm{Xe} + ^{0}_{-1}\beta$$

In 1986 a nuclear reactor exploded at a power station in Chernobyl in the Ukraine. Some radioactive fuel rods exploded when the fission chain reaction ran out of control. A cloud of radioactive material spread over several European countries causing normal background radiation levels to rise. A major part of the radioactive material was iodine-131 with a half-life of 8 days. Caesium-137 and caesium-131, were also emitted; these have half-lives of 2 years and 30 years respectively.

(i) What is meant by the phrase '*causing normal background radiation*'?

_____

_____ [1]

(ii) In what way is the structure of caesium-131 atom different from the structure of a caesium-137 atom?

_____

_____ [2]

(iii) What fraction of iodine–131 would be left after 40 days?

_____

_____

_____

_____ [3]

(iv) In 1996 people are more likely to be concerned about the isotopes of caesium than about the isotopes of iodine. Why?

_____

_____ [2]

SEG 1996

4 (a) Isotopes of the radioactive element uranium occur naturally in small proportions in some rocks. The table gives information about one uranium isotope.

nucleon (mass) number	238
proton (atomic) number	92
radiation emitted	alpha particle

(i) How many neutrons are there in an atom of this uranium isotope?

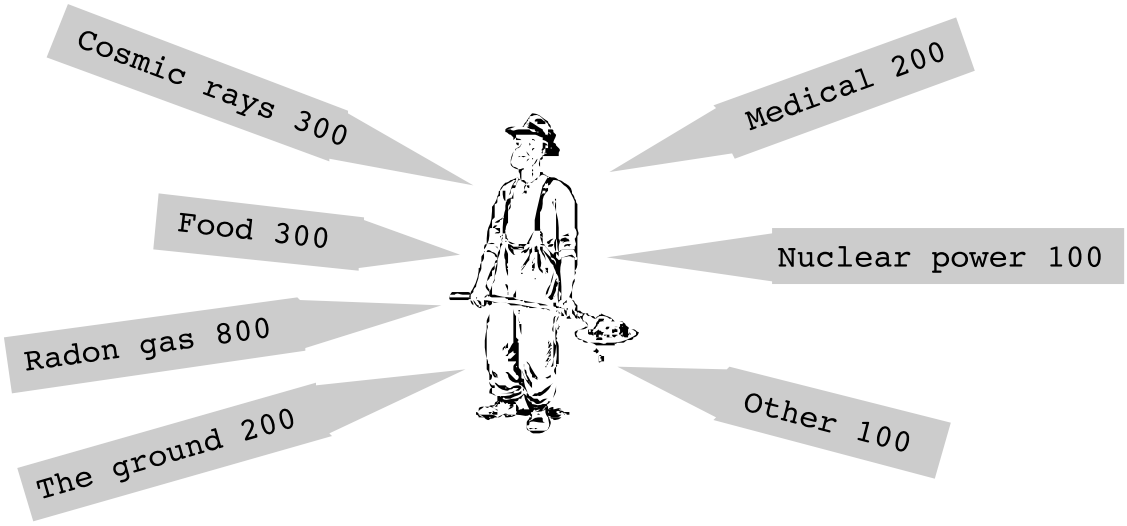
_____ [1]

(ii) From which part of the uranium atom does the alpha particle come?

_____ [1]

(b) The diagram below shows the average radiation dose a person in the British Isles receives in one year from background radiation. The radiation dose is measured in a unit called the **microsievert**.

(i) What percentage of the background radiation comes from radon gas? Show clearly how you get to your answer.



_____

_____ [2]

(ii) Airline pilots are exposed to higher amounts of cosmic rays than most other professions. Explain this.

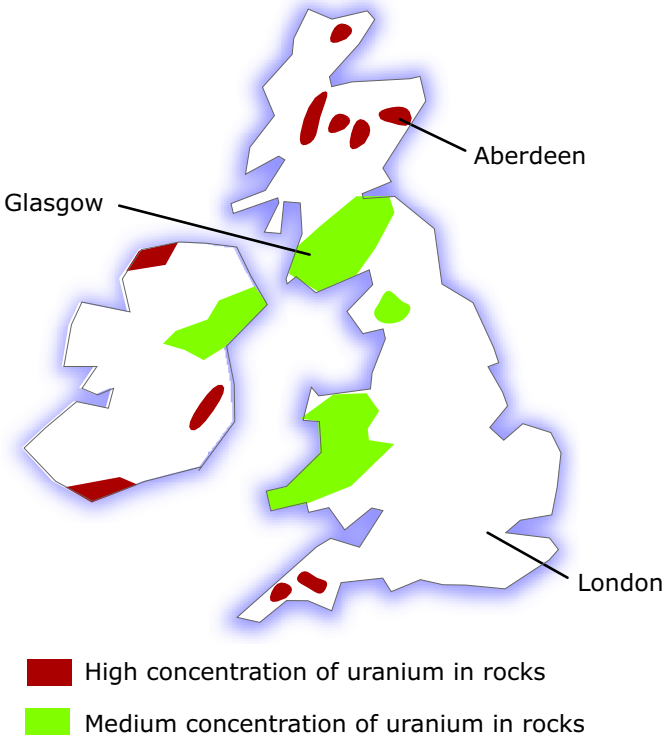
_____

_____

_____ [2]

question 4 continued

(c) The map shows areas of the British Isles where rocks containing uranium are found. After uranium decays, radon gas is formed.



(i) How does the average radiation dose received by a person living in Aberdeen compare with that received by a person living in London?

_____ [1]

(ii) Give a reason for your answer

_____

_____ [2]

(d) Radon gas decays by the emission of alpha particles into polonium-218, a radioactive solid. High concentrations of radon have recently been found in some houses. The gas rises through small cracks in the Earth's rocks and enters the house through the floor.

(i) What instrument could be used to measure the level of radioactivity in the house?

_____ [1]

(ii) It is potentially dangerous to have a high level of radon inside a home. Explain why.

_____

_____

_____ [2]

SEG 1997

5 A group of medical physicists are planning to use a radioactive isotope inside the body of a patient. The isotope that they have decided to use is iodine, $^{131}_{53}\mathrm{I}$.

(a) In an atom of this isotope, how many protons and neutrons are there?

_____ Protons and _____ Neutrons [2]

(b) This isotope decays by means of beta decay. After an atom decays, how many protons and neutrons are there?

_____ Protons and _____ Neutrons [2]

(c) What are the beta particles that are given off when the iodine decays?

_____ [1]

(d) Why is a beta emitter more suitable for this use than an alpha emitter?

_____

_____ [2]

Before administering the isotope to the patient, the physicists had to carry out an experiment to determine the half-life of the isotope. They took a series of readings of the background count, and came up with a value of 15 counts per minute. Then they took a series of readings of the activity due to a source containing the radioactive isotope.

At the start of their experiment, their reading was 14,495 counts per minute. After 32 days, the recorded count rate was 920 counts per minute.

(e) Use these figures to calculate a value for the half-life of the isotope.

_____

_____ [2]

(f) Give the name of the device that they could use to detect the radiation.

_____ [1]

(g) Give three sources of background radiation.

_____

_____ [3]

For another part of their work, they are asked to prepare a radioactive sample that can be used to treat a cancerous growth on the skin of a patient.

(h) What type of radiation would you recommend for this use? Give reasons for your choice.

_____

_____

_____ [3]