8 Oxygen-15 ($^{15}_{8}O$) is radioactive and has a half-life of 2.04 minutes.

The decay of oxygen-15 produces positrons. For this reason, oxygen-15 is sometimes used as a tracer in positron emission tomography (PET scanning).

(a) State what is meant by a tracer.

.....

.....

..... [2]

(b) The equation for the decay of oxygen-15 is

$$^{15}_{8}O \rightarrow {}^{P}_{Q}X + {}^{R}_{S}\beta^{+} + Z$$

where X is the nucleus formed during the decay and Z is another particle.

(i) State the values of the integers *P*, *Q*, *R* and *S*.

P = ... *R* = ...

Q = ... *S* = ...

[2]

(ii) State the name of particle Z.

..... [1]

(c) **(i)** Define the activity of a sample.

.....

..... [1]

(ii) Calculate the decay constant of oxygen-15. Give a unit with your answer.

decay constant = ... unit ..... [2]

(iii) Determine the rate at which positrons are produced in a sample of oxygen-15 that has a mass of 2.85×10^{-6} kg.

rate = ... s^{-1} [4]

(d) The particles that are emitted from the body and detected outside it during PET scanning are not positrons but another type of particle.

(i) State the name of the particles that are detected.

..... [1]

(ii) Explain how these particles are formed inside the body.

.....

.....

.....

..... [2]

[Total: 15]

9 **(a)** Define activity of a radioactive sample.

.....

..... [1]

(b) Explain why the variation with time of the activity of a radioactive sample is exponential in nature.

.....

.....

.....

.....

..... [3]

(c) A sample contains a single radioactive isotope that decays to form a stable isotope.

The sample has an activity of 180 Bq at time $t = 0$.
At a time 8.4 minutes later, the activity is 120 Bq.

(i) Determine the decay constant, in min^{-1}, of the radioactive isotope.

decay constant = ... min^{-1} [2]

(ii) Use your answer in **(c)(i)** to determine the half-life, in min, of the radioactive isotope.

half-life = ... min [1]

(iii) On Fig. 9.1, sketch the variation of the activity A of the sample with t for values of t between $t = 0$ and $t = 24$ min.

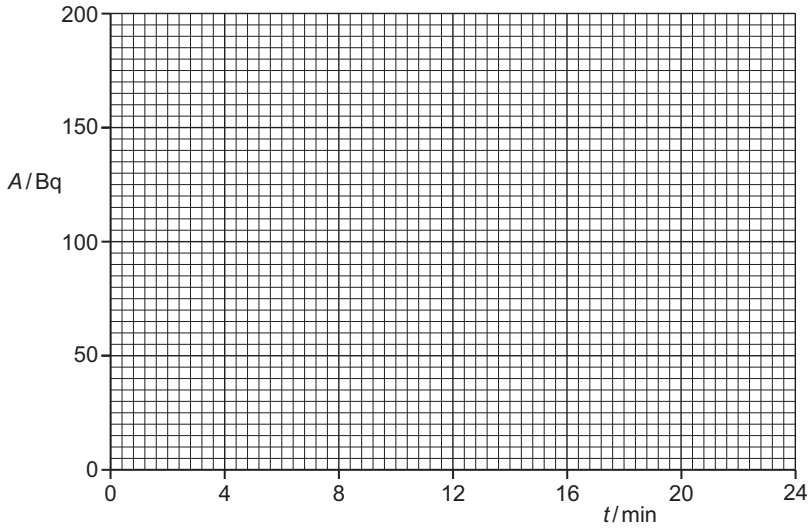

Fig. 9.1

[3]

[Total: 10]

10 **(a)** Radioactive decay is a spontaneous process.

State the meaning, in this context, of the term spontaneous.

.....

..... [1]

(b) Two radioactive isotopes X and Y each decay to form a stable isotope.
A sample initially contains only atoms of isotope X. At this time, its activity is $4A$.
Another sample initially contains only atoms of Y. At this time, its activity is A.

Fig. 10.1 shows the variation of the activity of each sample with time t between $t = 0$ and $t = 6T$.

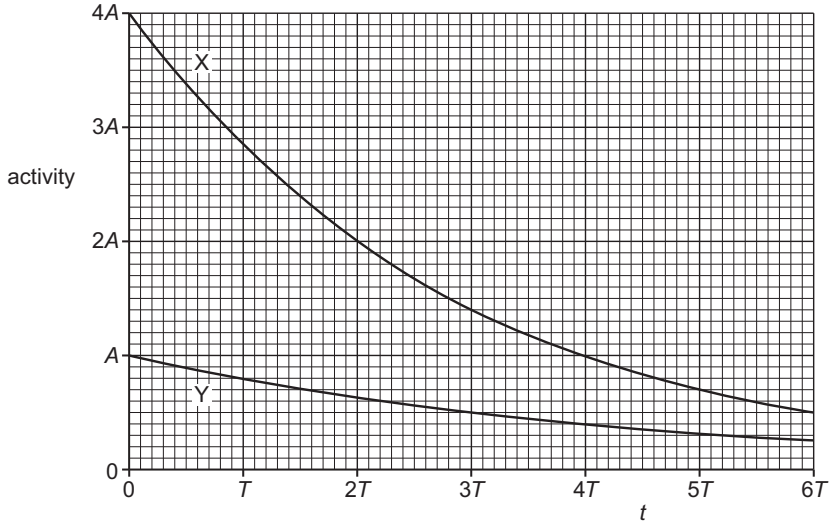

Fig. 10.1

(i) Complete Table 10.1 to give expressions, in terms of either or both of A and T, for the quantities indicated for each of the samples.

Table 10.1

sample	half-life	decay constant	initial activity	initial number of nuclei
X			$4A$	
Y			A	

[3]

(ii) Determine, in terms of T, the time at which the two samples will have equal activities.

time = ... T [3]

(c) A radiation detector is placed near to one of the samples in **(b)**.

Explain why the count rate measured by the detector is less than the activity of the sample.

.....

.....

..... [2]

[Total: 9]

9 **(a)** Define activity of a radioactive sample.

.....

..... [1]

(b) Explain why the variation with time of the activity of a radioactive sample is exponential in nature.

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(c) A sample contains a single radioactive isotope that decays to form a stable isotope.

The sample has an activity of 180 Bq at time $t = 0$.
At a time 8.4 minutes later, the activity is 120 Bq.

(i) Determine the decay constant, in min^{-1}, of the radioactive isotope.

decay constant = ... min^{-1} [2]

(ii) Use your answer in **(c)(i)** to determine the half-life, in min, of the radioactive isotope.

half-life = ... min [1]

(iii) On Fig. 9.1, sketch the variation of the activity A of the sample with t for values of t between $t = 0$ and $t = 24$ min.

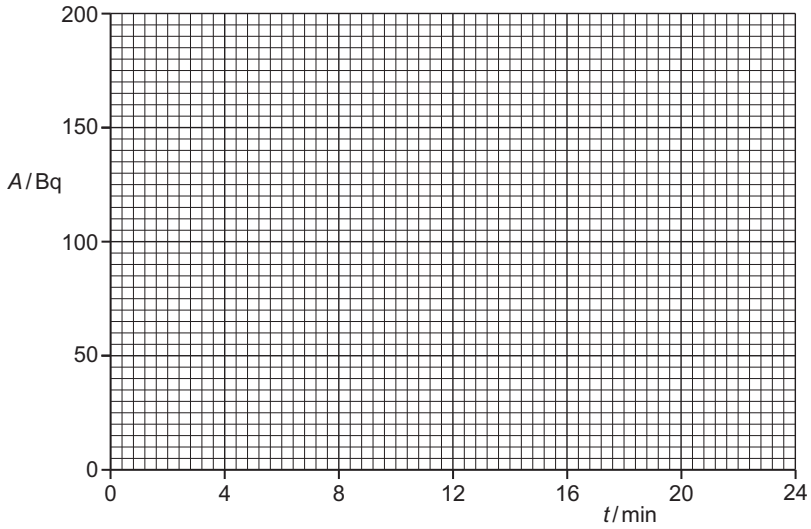

Fig. 9.1

[3]

[Total: 10]