Nuclear Physics – 2020 A2

1. Nov/2020/Paper_41/No.12

Iodine-131 ($^{131}_{53}I$) is a radioactive isotope with a decay constant of $9.9 \times 10^{-7}\,s^{-1}$.

(a) State what is meant by:

(i) *radioactive*

....

....

.... [2]

(ii) *decay constant.*

....

....

.... [2]

(b) Some water becomes contaminated with iodine-131.
The activity of the iodine-131 in 1.0 kg of water is 560 Bq.

Determine the number of iodine-131 atoms in 1.0 kg of water.

number = ... [2]

(c) Regulations require that the activity of iodine-131 in 1.0 kg of water is to be less than 170 Bq.

Calculate the time, in days, for the activity of the contaminated water in **(b)** to be reduced to 170 Bq.

time = ... days [3]

[Total: 9]

2. Nov/2020/Paper_42/No.12

(a) **(i)** Define nuclear *binding energy*.

....

....

.... [2]

(ii) Explain what is meant by a *nuclear fission* reaction.

....

....

.... [2]

(b) A student suggests that one possible nuclear reaction is

$$^{56}_{26}\text{Fe} + ^{1}_{0}\text{n} \rightarrow ^{20}_{9}\text{F} + ^{37}_{17}\text{C}l$$

The binding energy per nucleon of a nucleus varies with the nucleon number.
Use this variation to explain why the reaction would **not** result in an overall release of energy.

....

....

....

....

.... [3]

[Total: 7]

3. June/2020/Paper_41/No.12

(a) The decay of a sample of a radioactive isotope is said to be random and spontaneous.

Explain what is meant by the decay being:

(i) *random*

....

.... [1]

(ii) *spontaneous*.

....

.... [1]

(b) A radioactive isotope X has a half-life of 1.4 hours.

Initially, a pure sample of this isotope X has an activity of 3.6×10^5 Bq.

Determine the activity of the isotope X in the sample after a time of 2.0 hours.

activity = ... Bq [3]

(c) The variation with time *t* of the actual activity *A* of the sample in **(b)** is shown in Fig. 12.1.

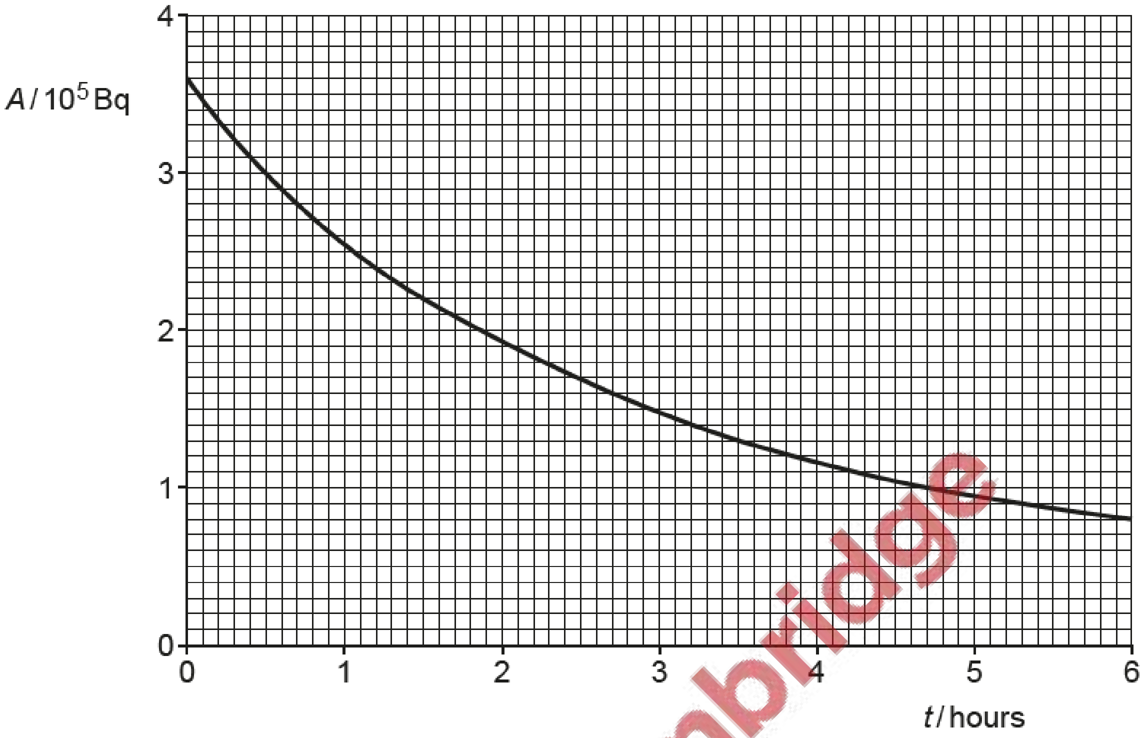

Fig. 12.1

(i) The initial activity of isotope X in the sample is 3.6×10^5 Bq.

Use information from **(b)** to sketch, on the axes of Fig. 12.1, the variation with time *t* of the activity of a pure sample of isotope X. [1]

(ii) Suggest an explanation for any difference between the actual activity of the sample shown in Fig. 12.1 and the curve you have drawn for the activity of isotope X.

....

....

.... [2]

[Total: 8]

4. June/2020/Paper_42/No.12

(a) State what is meant by the *mass defect* of a nucleus.

....

....

.... [2]

(b) Some masses are shown in Table 12.1.

Table 12.1

	mass / u
proton $^{1}_{1}p$	1.007 276
neutron $^{1}_{0}n$	1.008 665
helium-4 ($^{4}_{2}He$) nucleus	4.001 506

Show that:

(i) the energy equivalence of 1.00 u is 934 MeV

[2]

(ii) the binding energy per nucleon of a helium-4 nucleus is 7.09 MeV.

[2]

(c) Isotopes of hydrogen have binding energies per nucleon of less than 3 MeV.

Suggest why a nucleus of helium-4 does not spontaneously break down to become nuclei of hydrogen.

....

....

.... [2]

[Total: 8]

5. March/2020/Paper_42/No.12

(a) Explain what is meant by the *binding energy* of a nucleus.

....

....

.... [2]

(b) The following nuclear reaction takes place:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{55}Cs + ^{90}_{x}Rb + y^{1}_{0}n$$

(i) Determine the values of *x* and *y*.

x = ...

y = ...

[1]

(ii) State the name of this type of nuclear reaction.

.... [1]

(iii) Compare the binding energy per nucleon of uranium-235 with the binding energy per nucleon of caesium-144.

....

.... [1]

(c) Yttrium-90 decays into zirconium-90, a stable isotope.

A sample initially consists of pure yttrium-90.

Calculate the time, in days, when the ratio of the number of yttrium-90 nuclei to the number of zirconium-90 nuclei would be 2.0.

The half-life of yttrium-90 is 2.7 days.

time = ... days [3]

[Total: 8]