Radioactivity

Question 1

(*c*) (*i*) What are isotopes?
What is a *radioisotope*?
Define the half-life of a radioisotope. (13)

(*ii*) John Joly was an Irish scientist who in 1914 pioneered the treatment of cancer using a radium compound containing radium–226.

Complete the following nuclear equation to show the alpha decay of radium–226.

$$^{226}_{88}\mathbf{Ra} \rightarrow \_\_\_\_\_ + \_\_\_\_\_$$ (6)

(*iii*) Radium–223 undergoes alpha decay and is also used in radiotherapy.
Starting with a sample containing 1.0×10^{-4} moles of radium–223, how many of these atoms remain when 87.5% of the sample has decayed? (6)

Question 2

(*c*) What change takes place in the nucleus of an atom when beta decay occurs?

Question 3

(*c*) Write a balanced nuclear equation for the beta-particle decay of the $^{223}_{87}\mathbf{Fr}$ nucleus.

Question 4

(*c*) Caesium–137 is a radioactive isotope of the alkali metal caesium. Caesium–137 was released into the atmosphere when Japanese nuclear reactors were damaged by a tsunami in 2011. Caesium–137 decays by beta-particle emission with a half-life of 30 days.

(*i*) Define *radioactivity*. (6)

(*ii*) Give **two** differences between chemical reactions and nuclear reactions. (6)

(*iii*) Give **two** properties of beta-particles. (6)

(*iv*) A certain mass of caesium–137 leaked on a particular day. What fraction of this mass remained as caesium–137 after 90 days? (7)

Question 5

(*c*) What are *isotopes*? (5)

Define (*i*) *radioactivity*, (*ii*) *radioisotope*. (8)

Carbon–14 decays by beta particle emission. Write a balanced equation to describe beta-decay of the carbon–14 nucleus. (6)

The world's oldest shoe, found in a cave in Armenia, is pictured on the right. In June 2010, having been radiocarbon dated, it was reported to be 5500 years old.

Explain why the carbon–12 to carbon–14 isotope ratio in the shoe leather changed over the 5500 years since the shoe was made. (6)

Question 6

(*a*) Give **two** properties of cathode rays.

Question 7

(*b*) Define (*i*) *radioactivity*, (*ii*) the *half-life* of a radioactive isotope. (10)

Americium–241 is a radioactive isotope used in domestic smoke detectors. Americium–241 has a half-life of 432 years and decays by emitting alpha particles to produce neptunium.

Determine the value of A and the value of Z in the following nuclear equation for the alpha decay of an americium–241 nucleus. (6)

$$^{241}_{95}\mathbf{Am} \rightarrow {}^{A}_{Z}\mathbf{Np} + {}^{4}_{2}\mathbf{He} + \mathbf{energy}$$

Alpha particles are hazardous to human health. State one risk associated with exposure to alpha radiation. (3)

Explain why the occupants of a house fitted with smoke detectors containing americium–241 are not at risk from alpha radiation emitted by these devices. (3)

Householders are advised to replace the batteries in smoke detectors regularly. Explain whether or not the americium–241 needs to be replaced regularly also. (3)

Question 8

(*c*) Give **two** differences between a nuclear reaction and a chemical reaction.

Question 9

(*a*) Define radioactivity. (6)

(*i*) State **two** properties of beta (β) particles. (6)

(*ii*) Write an equation for the nuclear reaction involved in the beta decay of ^{14}C (carbon-14). (6)

(*iii*) Explain how the carbon-14 isotope allows certain archaeological discoveries to be dated. (7)

Question 10

(*f*) List the following three types of radiation in order of <u>increasing</u> penetrating power

alpha- (α-) **beta- (β-)** **gamma- (γ-)**