Radioactivity Assignment 1

1.

(a) Draw a graph of number of neutrons against number of protons, showing the trend of stable isotopes. /2

(b) Explain why the ratio of neutrons to protons for stable isotopes of that element increases as the atomic number of an element increases. /2

(c) On the graph drawn for part a, indicate the regions where alpha decay, beta minus decay, beta plus decay and spontaneous fission occur. /2

(d) Using the characteristics of the nuclei in each region, explain why each type of decay corresponds to that respective area. /4

2. Complete the table below:

Type of emission	Symbol	Charge (C)	Mass (kg)	Charge number	Mass number
Alpha					
Beta minus					
Beta plus					
Gamma					

/4

3. Complete the following nuclear decay equations:

(a) $^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} +$

(b) $^{234}_{90}\mathrm{Th} \rightarrow {}^{234}_{91}\mathrm{Pa} +$ +

(c) $^{40}_{19}\mathrm{K} \xrightarrow{\beta^-}$

(d) $^{210}_{83}\mathrm{Bi} \rightarrow \mathrm{Po} + {}^{0}_{-1}\mathrm{e} + \bar{\nu}$

(e) $\mathrm{Po} \rightarrow {}^{206}_{82}\mathrm{Pb} + {}^{4}_{2}\mathrm{He}$

(f) $^{212}_{82}\mathrm{Pb} \rightarrow {}^{212}_{83}\mathrm{Bi} +$ + /3

4. Explain why alpha particles are emitted with discrete energies. /2

5. State the mass number and charge number for the following and give reasons for each.
(a) electron
(b) positron
(c) neutrino
(d) antineutrino
(e) gamma ray

/5

6.

(a) Write a nuclear equation for the conversion of:
(i) a neutron into a proton /1
(ii) a proton into a neutron /1

(b) Using conservation laws that apply to nuclear reactions, justify the production of each of the particles in the equations for part a. /2

7. Explain why alpha or beta decay is often accompanied by the emission of gamma rays with discrete energies. /2

8. Compare and explain the penetration through matter of alpha, beta and gamma radiations. /3

9. Sketch diagrams comparing the deflections of alpha, beta and gamma radiations in
(a) electric fields
(b) magnetic fields

/3

TOTAL /36

Radioactivity Assignment 2

1.

(a) State three sources of ionising radiation and state one type of radiation produced by each source. /3

(b) Explain how ionising radiation can damage living matter. /2

(c) State three examples of how radiation dosages can be minimised. /3

2. A radioactive sample of francium initially consists of 2.0×10^{9} nuclei. Francium has a half-life of approximately 22 minutes. Calculate the number of francium nuclei remaining after 66 minutes.

/2

3. A herd of gentle dromeosaurs have to their dismay discovered a large sample of americium-241 in their favourite nesting ground.

(a) The herd's top medical professionals have determined that once the activity of the sample reduces to 6.25% of its initial activity, it will be safe to nest there. Given that the half-life of americium-241 is 432 years, calculate how many years they will have to use a different nesting ground for.

/2

(b) Sketch a graph of the percentage activity of americium-241 over this time period.

/2

(c) It just so happens that an ice age is starting. Explain the effect that the decreasing temperature will have on the half-life of the americium and therefore the time the dromeosaurs must wait for their nesting place to be safe. Give a reason for your answer.

/2

4. If a radioactive sample is emitting a beta particle, on average, once every 5 minutes, determine the activity of the sample.

/2

5.

(a) Describe how beta plus decay can lead to the production of photons by annihilation, and explain why two photons travelling in opposite directions are produced. /2

(b) In the most common case, the total energy of the two gamma photons emitted corresponds to the total mass of a positron and an electron. Calculate the energy of each gamma photon in MeV. /2

6.

(a) State and explain two places in the human body where the radioisotopes used in PET can become concentrated. /2

(b) Describe how a ring of photon detectors allows the location of a tracer radioisotope in a human body to be determined. /3

(c) Explain why PET facilities need to be located near particle accelerators. /2

(d) State one use of each of the following isotopes in PET:

(i) oxygen-15 /1

(ii) fluorine-18 /1

TOTAL /31