Worksheet 4.1: Nuclear Decay Equations

PhysicsSheets

Specification: GCSE Physics (AQA 4.4.2.2 / Edexcel SP15)

Alpha Decay: ${}^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}\alpha$ (or ${}^{4}_{2}\text{He}$)
Beta Decay: ${}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta$ (or ${}^{0}_{-1}\text{e}$)
Key: A = Nucleon/Mass number (top number), Z = Proton/Atomic number (bottom number), X = Parent nucleus, Y = Daughter nucleus. **Rule:** The total mass number (A) and total atomic number (Z) must be conserved on both sides of the equation.

Section A: Recall & Balancing Rules

1. Complete the sentences below regarding nuclear decay:

a) In alpha decay, the mass number (A) _____ by 4, and the atomic number (Z) _____ by 2.

b) In beta decay, the mass number (A) _____, and the atomic number (Z) _____ by 1.

c) An alpha particle is identical to a _____.

d) A beta particle is a high-energy _____.

2. Convert the following units, showing your working:

a) Convert 2.5 minutes into seconds.

b) Convert 72 hours into seconds.

c) Convert 0.000000000001 metres (1 picometre) into standard form.

Section B: Practice Calculations

Balance the following nuclear decay equations by determining the missing nuclide or particle.

3. Complete the following alpha decay equations:

a) ${}^{226}_{88}\text{Ra} \longrightarrow {}^{A}_{Z}\text{Rn} + {}^{4}_{2}\alpha$

b) ${}^{238}_{92}\text{U} \longrightarrow {}^{A}_{Z}\text{Th} + {}^{4}_{2}\alpha$

c) ${}^{A}_{Z}\text{Po} \longrightarrow {}^{206}_{82}\text{Pb} + {}^{4}_{2}\alpha$

d) ${}^{A}_{Z}\text{Th} \longrightarrow {}^{228}_{88}\text{Ra} + {}^{4}_{2}\alpha$

4. Complete the following beta decay equations:

a) ${}^{14}_{6}\mathrm{C} \longrightarrow {}^{A}_{Z}\mathrm{N} + {}^{0}_{-1}\beta$

b) ${}^{234}_{90}\mathrm{Th} \longrightarrow {}^{A}_{Z}\mathrm{Pa} + {}^{0}_{-1}\beta$

c) ${}^{A}_{Z}\mathrm{K} \longrightarrow {}^{40}_{20}\mathrm{Ca} + {}^{0}_{-1}\beta$

d) ${}^{A}_{Z}\mathrm{I} \longrightarrow {}^{131}_{54}\mathrm{Xe} + {}^{0}_{-1}\beta$

Section C: Challenge Context & Multi-step Decay

5. Plutonium-241 (${}^{241}_{94}\mathrm{Pu}$) undergoes a series of decays.

a) Plutonium-241 (${}^{241}_{94}\mathrm{Pu}$) first undergoes beta decay to form Americium (Am). Write the balanced nuclear equation for this decay.

b) The Americium isotope formed in part (a) then undergoes alpha decay to form Neptunium (Np). Write the balanced nuclear equation for this second decay.

6. A radioactive source has an initial activity of 12000 Bq. Its half-life is 6 hours.

a) Calculate the activity of the source after 18 hours. Show your working clearly, including the number of half-lives.

b) If the source from part (a) is an alpha emitter, explain why it would be less hazardous to handle after 18 hours compared to when it was first produced. Refer to the properties of alpha particles and the concept of activity in your answer.