Radioactive Decay Worksheet

Alpha decay: nucleus spontaneously emits an alpha particle (symbol: α particle), which is 2 p+ and 2 n (or also the same as a Helium (He) atom).

Result: atomic number decreases by 2 (lost 2 p+)

Result: atomic mass decreases by 4 (lost 2 p+ and 2n = 4 amu)

Beta decay: neutron in nucleus spontaneously emits a beta particle (symbol: β particle), which is essentially an electron trapped in a neutron. The neutron, therefore, turns itself into a proton.

Result: atomic number increases by 1 (gained 1 p+)

Result: atomic mass stays same (no mass lost or gained: β particle or electrons have no mass)

Beta or electron capture: proton in nucleus captures a beta particle (symbol: β particle), which is essentially an electron that can become part of a neutron. The proton, therefore, turns itself into a neutron.

Result: atomic number decreases by 1 (lost 1 p+)

Result: atomic mass stays same (no mass lost or gained: β particle or electrons have no mass)

1. Fill in the missing isotope or emitted particle

a) $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He$

b) $^{216}_{84}Po \rightarrow ^{216}_{85}At + ^{0}_{-1}e$

c) $^{234}_{90}Th \rightarrow ^{234}_{91}Pa + ^{0}_{-1}e$

d) $^{215}_{84}Po \rightarrow ^{211}_{82}Pb + ^{4}_{2}He$

e) $^{210}_{83}Bi \rightarrow ^{210}_{84}Po + ^{0}_{-1}e$

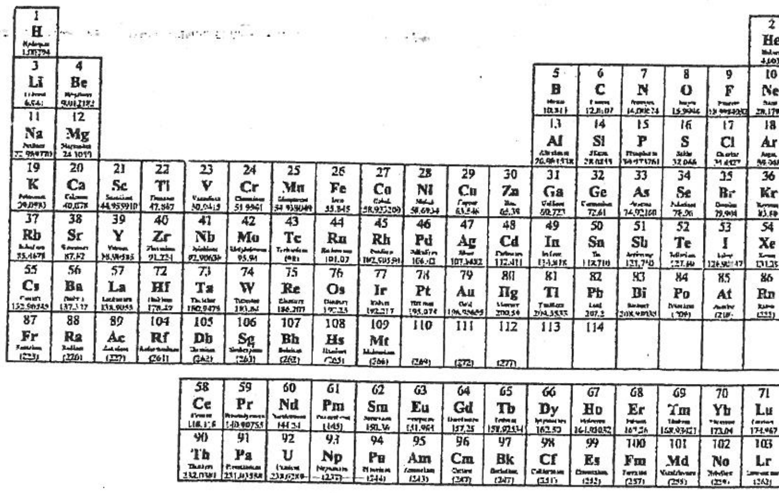
f) $^{220}_{86}Rn \rightarrow ^{216}_{84}Po + ^{4}_{2}He$

g) $^{238}_{92}U + ^{2}_{1}H \rightarrow ^{231}_{91}Pa + 2^{1}_{0}n$

h) $^{238}_{93}Np \rightarrow ^{238}_{94}Pu + ^{0}_{-1}e$

i) $^{240}_{96}Cf + ^{16}_{8}O \rightarrow ^{252}_{104}Rf + 4^{1}_{0}n$

The Periodic Table of the Elements



Example

Original	alpha decay	beta decay	alpha decay	beta capture	beta decay	alpha decay
85	83	84	82	81	82	80
At	Bi	Po	Pb	Tl	Pb	Hg
Astatine	Bismuth	Polonium	Lead	Thallium	Lead	Mercury
210	206	206	202	202	202	198

Complete this table

Original	beta decay	alpha decay	beta capture	alpha decay	alpha decay	beta decay
90	91	89	88	86	84	85
Th	Pa	Ac	Ra	Rn	Po	At
Thorium						
232	232	228	228	224	220	220

Complete this table

Original	beta capture	alpha decay	alpha decay	beta capture	alpha decay	beta decay
92	91	89	87	86	84	85
U	Pa	Ac	Fr	Rn	Po	At
Uranium						
238	238	234	230	230	226	226

1. Polonium 214 (m_{Po} = 213.995186 u) decays by alpha radiation (m_α = 4.002602 u) to Lead 210 (m_{Pb} = 209.984173 u). How much energy is released as the alpha particle leaves the nucleus? (**7.83 MeV**)

$$\begin{array}{r} 213.995186 \\ -\ 4.002602 \\ -209.984173 \\ \hline \Delta m = 0.008411\ u \end{array} \ (931.5\ MeV) = \boxed{7.83\ MeV}$$

2. Determine the symbol ${}^{A}_{Z}?$ for the parent nucleus whose α decay produces the same daughter as the β^- decay of thallium ${}^{208}_{81}Tl$.

$\beta^-: {}^{208}_{81}Tl \rightarrow {}^{0}_{-1}e + {}^{208}_{82}Pb$

$\alpha: {}^{4}_{2}He + {}^{208}_{82}Pb \rightarrow \boxed{{}^{212}_{84}Po}$

3. How much energy is released when tritium (${}^{3}_{1}H$ m = 3.016049 u) decays by β^- emission to ${}^{3}_{2}He$ (m = 3.016029 u)? (**18.6 keV**)

$$\begin{array}{r} 3.016048 \\ -\ 3.016028 \\ \hline 0.00002\ u \end{array} \ (931.5) = 0.01863\ MeV = \boxed{18.6\ keV}$$

4. Does ${}^{11}_{6}C$ m = 11.011434 u decay by β^- to become ${}^{11}_{7}N$ m = 11.011334 u or β^+ to become ${}^{11}_{5}B$ m = 11.009306 u? What is the energy released?

(${}^{11}_{7}N$: unstable ∴ ${}^{11}_{5}B$ is daughter)

$$\begin{array}{r} 11.011434 \\ -\ 11.009306 \\ \hline 0.002128 \end{array} \ (931) = \boxed{1.98\ MeV}$$

5. Berkelium 247 (m = 247.070299 u) decays to Americium 243 (m = 243.061373u) through α decay. Assuming that Berkelium was originally at rest and that energy and momentum are conserved, find the speed of the α particle (~~5.285×10^6 m/s~~)

$\sum \vec{p}_i = 0 = \sum \vec{p}_f \therefore p_\alpha = p_{Am}$

$m_\alpha v_\alpha = m_{Am} v_{Am}$

$$\begin{array}{r} 247.070298 \\ -\ 243.061373 \\ -\ 4.002602 \\ \hline \Delta m = 0.006324 \end{array}$$

$E = 2.47\ MeV = 3.97 \cdot 10^{-13}\ J$ ← KE_{tot}

$KE_{tot} = KE_\alpha + KE_{Am}$

$= \frac{1}{2}(m_\alpha v_\alpha^2 + m_A v_A v_A)$

$= \frac{1}{2}\left(m_\alpha v_\alpha^2 + m_\alpha v_\alpha \left(\frac{m_\alpha v_\alpha}{m_A}\right)\right)$

$= \frac{1}{2} m_\alpha v_\alpha^2 \left(1 + \frac{m_\alpha}{m_A}\right)$

$\rightarrow v_\alpha = \sqrt{\dfrac{2KE_{tot}}{m_\alpha\left(1 + \frac{m_\alpha}{m_A}\right)}}$

$= \boxed{1.08 \cdot 10^7\ m/s}$