Balancing and Predicting Nuclear Equations Workshop

Information: Nuclear reactions and ionizing radiation

A **nuclear reaction** is a change in the composition of the nucleus of an atom. This is not normally considered a chemical reaction, and does not depend on what molecule the atom might be in.

There are three types of nuclear reactions: fusion, fission, and radioactivity. Fusion (combining of nuclei into larger nuclei, such as in stars and the sun) and fission ("splitting the atom," such as in a nuclear reactor) do not concern us much in chemistry.

Some isotopes are radioactive, meaning that their nuclei break down ("decay") and give off particles, "rays," or both. There is no simple way to predict which isotopes are radioactive.

Table 1: Some types of ionizing radiation produced in nuclear reactions

Type of Radiation	Symbol	Mass Number	Charge	Relative penetrating ability	Shielding required	Biological hazard
Alpha particle	α, $^{4}_{2}He$	4	2+	very low	clothing	none unless inhaled
Beta particle	β, $^{0}_{-1}e$	0	1−	low	heavy cloth, plastic	mainly to eyes, skin
Gamma ray	γ, $^{0}_{0}\gamma$	0	0	very high	lead or concrete	whole body
Neutron	$^{1}_{0}n$	1	0	very high	water, lead	whole body
Positron	β^+, $^{0}_{1}e$	0	1+	low	heavy cloth, plastic	mainly to eyes, skin

Balancing Nuclear Equations Practice

1. Complete the following nuclear equations in order to balance them. Identify the type of nuclear change represented by the equation.

Type of Nuclear Change

$^{235}_{92}U \rightarrow {}^{4}_{2}He + {}^{231}_{90}Th$ — alpha decay

$^{240}_{95}Am + {}^{4}_{2}He \rightarrow {}^{243}_{97}Bk + {}^{1}_{0}n$ — nuclear fusion / bombardment

$^{142}_{61}Pm + {}^{0}_{-1}e \rightarrow {}^{142}_{60}Nd$ — electron capture

${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{142}_{56}Ba + {}^{91}_{36}Kr + 3\,{}^{1}_{0}n$ — nuclear fission → typically triggered by a neutron

${}^{6}_{3}Li + {}^{1}_{0}n \rightarrow {}^{4}_{2}He + {}^{3}_{1}H$ — nuclear fission

makes smaller nuclei

2. Write balanced nuclear equations for each process.

a). The alpha decay of radon-198. $^{198}_{86}Rn \rightarrow {}^{4}_{2}He + {}^{194}_{84}Po$ (can also say "α")

b). The beta decay of uranium -237. $^{237}_{92}U \rightarrow {}^{0}_{-1}e + {}^{237}_{93}Np$

I mean the electron here.

IF I mean "positron" I will say so

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c). Positron emission from silicon-26. $^{26}_{14}Si \longrightarrow {}^{0}_{+1}\bar{e} + {}^{26}_{13}Al$

d). Sodium-22 undergoes electron capture. $^{22}_{11}Na + {}^{0}_{-1}\bar{e} \longrightarrow {}^{22}_{10}Ne$

3. Write the overall nuclear equation for the decay of Po-210 if it undergoes 2 consecutive alpha decays followed by a beta decay followed by another alpha decay. (Note: it actually occurs stepwise, but this is a good lesson on how to put coefficients into nuclear equations.) 3 alpha particles

$^{210}_{84}Po \longrightarrow 3\ {}^{4}_{2}He + {}^{0}_{-1}\bar{e} + {}^{198}_{79}Au$

(3 alpha particles)

4. Write a balanced nuclear equation for the conversion of carbon-13 to carbon-14.

$^{1}_{0}n + {}^{13}_{6}C \longrightarrow {}^{14}_{6}C$

5. Write a balanced nuclear equation for the electron capture of thorium-235.

$^{235}_{90}Th + {}^{0}_{-1}e \longrightarrow {}^{235}_{89}Ac$

6. Write a balanced nuclear equation for the beta decay of selenium-75.

$^{75}_{34}Se \longrightarrow {}^{0}_{-1}e + {}^{75}_{35}Br$

7. Write a balanced nuclear equation for the positron emission of rubidium-81.

$^{81}_{37}Rb \longrightarrow {}^{0}_{+1}\bar{e} + {}^{81}_{36}Kr$

8. Write the balanced nuclear equation for the alpha particle bombardment of einsteinium-238. One of the reaction products is a neutron.

$^{238}_{99}Es + {}^{4}_{2}He \longrightarrow {}^{1}_{0}n + {}^{241}_{101}Md$

9. Write a balanced nuclear equation for the conversion of uranium-238 into californium-246 by bombardment with carbon-12.

$^{238}_{92}U + {}^{12}_{6}C \longrightarrow {}^{246}_{98}Cf + 4\ {}^{1}_{0}n$

4 neutrons

10. Write a balanced nuclear equation for the alpha particle bombardment of plutonium-239. The reaction products include a hydrogen atom and 2 neutrons.

$^{239}_{94}Pu + {}^{4}_{2}He \longrightarrow {}^{1}_{1}H + 2\ {}^{1}_{0}n + {}^{240}_{95}Am$

2 neutrons