Nuclear transmutation

Nuclear transmutation: → is used to converting one element into another.

- ✓ Differs from radioactive decay in that the former is brought about by the collision of two particles.

Rutherford experiment: → He bombarded a sample of nitrogen with α particles, the following reaction took place.

$$^{14}_{7}N + ^{4}_{2}\alpha \rightarrow ^{17}_{8}O + ^{1}_{1}P$$

Note that

In the parentheses the bombarding particle is written first, followed by the ejected particle.

So, this reaction can be abbreviated as:

$$^{14}_{7}N(\alpha, p)^{17}_{8}O$$

Example

Write the balanced equation for the nuclear reaction $^{56}_{26}\text{Fe}(\text{d}, \propto)^{54}_{25}\text{Mn}$, where d represesnts the deuterium nucleus (That is, $^{2}_{1}\text{H}$)

Solution

The abbreviation tells us that when iron 56 is bombarded with a deuterium nucleus, it produces the manganese 54 nucleus plus an α particle, thus the equation for this reaction is:

$$^{56}_{26}\text{Fe} + ^{2}_{1}\text{H} \rightarrow ^{4}_{2}\propto + ^{54}_{25}\text{Mn}$$

Transuranium elements

Transuranium elements: → element with atomic number greater than 92.

Neptunium (Z=93) was first prepared in 1940 since then, 23 other transuranium elements have been synthesized.

The transuranium elements and the reactions through which they are formed.

Atomic Number	Name	Symbol	Preparation
93	Neptunium	Np	$^{238}_{92}U + ^{1}_{0}n \longrightarrow ^{239}_{93}Np + ^{0}_{-1}\beta$
94	Plutonium	Pu	$^{239}_{93}Np \longrightarrow ^{239}_{94}Pu + ^{0}_{-1}\beta$
95	Americium	Am	$^{239}_{94}Pu + ^{1}_{0}n \longrightarrow ^{240}_{95}Am + ^{0}_{-1}\beta$
96	Curium	Cm	$^{239}_{94}Pu + ^{4}_{2}\alpha \longrightarrow ^{242}_{96}Cm + ^{1}_{0}n$
97	Berkelium	Bk	$^{241}_{95}Am + ^{4}_{2}\alpha \longrightarrow ^{243}_{97}Bk + 2^{1}_{0}n$
98	Californium	Cf	$^{242}_{96}Cm + ^{4}_{2}\alpha \longrightarrow ^{245}_{98}Cf + ^{1}_{0}n$
99	Einsteinium	Es	$^{238}_{92}U + 15^{1}_{0}n \longrightarrow ^{253}_{99}Es + 7^{0}_{-1}\beta$
100	Fermium	Fm	$^{238}_{92}U + 17^{1}_{0}n \longrightarrow ^{255}_{100}Fm + 8^{0}_{-1}\beta$
101	Mendelevium	Md	$^{253}_{99}Es + ^{4}_{2}\alpha \longrightarrow ^{256}_{101}Md + ^{1}_{0}n$
102	Nobelium	No	$^{246}_{96}Cm + ^{12}_{6}C \longrightarrow ^{254}_{102}No + 4^{1}_{0}n$
103	Lawrencium	Lr	$^{252}_{98}Cf + ^{10}_{5}B \longrightarrow ^{257}_{103}Lr + 5^{1}_{0}n$
104	Rutherfordium	Rf	$^{249}_{98}Cf + ^{12}_{6}C \longrightarrow ^{257}_{104}Rf + 4^{1}_{0}n$
105	Dubnium	Db	$^{249}_{98}Cf + ^{15}_{7}N \longrightarrow ^{260}_{105}Db + 4^{1}_{0}n$
106	Seaborgium	Sg	$^{249}_{98}Cf + ^{18}_{8}O \longrightarrow ^{263}_{106}Sg + 4^{1}_{0}n$
107	Bohrium	Bh	$^{209}_{83}Bi + ^{54}_{24}Cr \longrightarrow ^{262}_{107}Bh + ^{1}_{0}n$
108	Hassium	Hs	$^{208}_{82}Pb + ^{58}_{26}Fe \longrightarrow ^{265}_{108}Hs + ^{1}_{0}n$
109	Meitnerium	Mt	$^{209}_{83}Bi + ^{58}_{26}Fe \longrightarrow ^{266}_{109}Mt + ^{1}_{0}n$
110	Darmstadtium	Ds	$^{208}_{82}Pb + ^{62}_{28}Ni \longrightarrow ^{269}_{110}Ds + ^{1}_{0}n$
111	Roentgenium	Rg	$^{209}_{83}Bi + ^{64}_{28}Ni \longrightarrow ^{272}_{111}Rg + ^{1}_{0}n$

Note that

- Although light elements are generally not radioactive, they can be made so by bombarding their nuclei with appropriate particles.

Example

- Tritium $^{3}_{1}H$, is prepared according to the following bombardment.

$$^{6}_{3}Li + ^{1}_{0}n \rightarrow ^{3}_{1}H + ^{4}_{2}\alpha$$

- Tritium decays with the emission of β particles.

$$^{3}_{1}H \rightarrow ^{3}_{2}He + ^{0}_{-1}\beta \quad t_{1/2} = 12.5yr$$

❖ Many synthetic isotopes are prepared by using neutron as projectiles why?

✓ Because neutrons carry no charged and therefore are not repelled by the targets – the nuclei.

If the projectiles charged particles "protons, α particles"?!

So, they must have considerable kinetic energy to overcome the electrostatic repulsion between themselves and the target nuclei.

A particle accelerator: → uses electric and magnetic fields to increase the kinetic energy of charged species so that a reaction will occur.

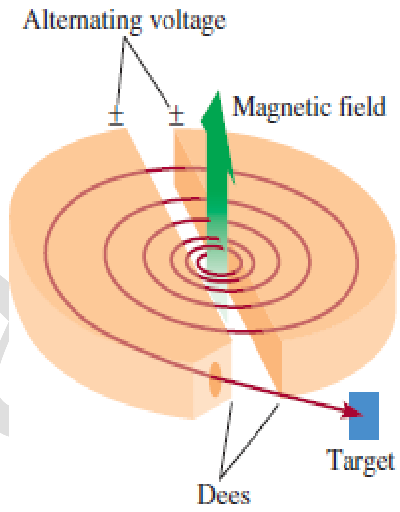

Figure show: The particle (an ion) to be accelerated starts at the center and is forced to move in a spiral path through the influence of electric and magnetic fields until it emerges at a high velocity.
The magnetic fields are perpendicular to the plane of the Dees (so-called because of their shape), which are hollow and serve as electrodes.

- It's now possible to accelerate particles to a speed well above 90 percent of the speed of light.

This is according to Einstein's theory of relativity: It is impossible for a particle to move at the speed of light, the only exception is the photon, which has a zero rest mass.

Choose

1) ……..is used to converting one element into another.

A) Radio activity
B) Half-life time
C) Nuclear transmutation
D) None of them

2) This reaction ${}^{14}_{7}N + {}^{4}_{2}\propto \rightarrow {}^{17}_{8}O + {}^{1}_{1}P$ can abbreviate as.

A) ${}^{14}_{7}N(p,\propto){}^{17}_{8}O$
B) ${}^{14}_{7}N(\propto,p){}^{17}_{8}O$
C) ${}^{17}_{8}O(\propto,p){}^{14}_{7}N$
D) ${}^{17}_{8}O(p,\propto){}^{14}_{7}N$

3) The balanced equation for the nuclear reaction ${}^{56}_{26}Fe(d,\propto){}^{54}_{25}Mn$ is….

A) ${}^{56}_{26}Fe + {}^{4}_{2}\propto \rightarrow {}^{2}_{1}H + {}^{54}_{25}Mn$
B) ${}^{56}_{26}Fe + {}^{4}_{2}\propto + {}^{2}_{1}H \rightarrow {}^{54}_{25}Mn$
C) ${}^{56}_{26}Fe + {}^{2}_{1}H \rightarrow {}^{4}_{2}\propto + {}^{54}_{25}Mn$
D) none of them

4) Elements with atomic number greater than 92 are called…….

A) Transmutation element
B) Transuranium element
C) Inert element
D) Both B and C

5) Transuranium element, it's the element with atomic number greater than……

A) 42
B) 93
C) 85
D) 92

6) Many synthetic isotopes are prepared by using………. as projectiles.

A) proton
B) Neutron
C) electron
D) positron

7) Which isotope, when bombarded with oxygen-18, yields the artificial isotope seaborgium-263 plus 4 neutrons?

A) nobelium-245
B) radium-259
C) californium-249
D) nobelium-249

8) Which isotope, when bombarded with nitrogen-15, yields the artificial isotope dubnium-260 plus 4 neutrons?

A) californium-245
B) thorium-257
C) nobelium-245
D) californium-249

9) In the following reaction, identify X.

$^{252}_{98}Cf(^{10}B,\ 5n)X$.

A) $^{257}_{103}Lr$
B) $^{247}_{93}Np$
C) $^{247}_{98}Cf$
D) $^{257}_{93}Lr$

10) In the following reaction, identify X.

$$^{10}_{5}B\,(X,\,\alpha)\,^{7}_{3}Li$$

A) α
B) n
C) p
D) β

11) In the following reaction, identify X.

$$^{238}_{92}U\,(15n,\,X)\,^{253}_{99}Es$$

A) 7β
B) 3α
C) 4n
D) 15p