Artificial Transmutation

**Aim:** How can we differentiate between artificial and natural transmutation?

Do Now

Which nuclear equation represents a natural transmutation?

1. $\frac{9}{4}\text{Be} + \frac{1}{1}\text{H} \rightarrow \frac{6}{3}\text{Li} + \frac{4}{2}\text{He}$
2. $\frac{27}{13}\text{Al} + \frac{4}{2}\text{He} \rightarrow \frac{30}{15}\text{P} + \frac{1}{0}\text{n}$
3. $\frac{14}{7}\text{N} + \frac{4}{2}\text{He} \rightarrow \frac{17}{8}\text{O} + \frac{1}{1}\text{H}$
4. $\frac{235}{92}\text{U} \rightarrow \frac{231}{90}\text{Th} + \frac{4}{2}\text{He}$

**Artificial transmutation:** an artificially induced nuclear reaction caused by the bombardment of a nucleus with particles or other small nuclei.
# How are they different?

<table>
<thead>
<tr>
<th>Natural transmutation</th>
<th>VS</th>
<th>Artificial transmutation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always has one nuclear reactant.</td>
<td></td>
<td>Always has two or more nuclear reactants.</td>
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<tr>
<td>Spontaneous process. - This decay occurs naturally without assistance</td>
<td></td>
<td>Non-spontaneous process. - This decay must be forced to occur and will not happen naturally.</td>
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<tr>
<td>$^{235}\text{U} \rightarrow ^{231}\text{Th} + ^{4}\text{He}$</td>
<td></td>
<td>Fission and fusion are artificial transmutation.</td>
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<tr>
<td></td>
<td></td>
<td>Fission= to split large nuclei apart</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fusion= to combine small nuclei together</td>
</tr>
</tbody>
</table>

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## Fission and Fusion; Forms of Artificial Transmutation

**Aim:** What are the differences between fission and fusion?
Fission reaction: an artificial transmutation that takes place when a neutron bombards a heavy radioisotope nucleus (Pu-239 or U-235) to produce smaller nuclei.

Products of fission: tremendous quantities of energy, smaller dangerous radioisotopes (waste) and neutrons.
Little Boy

An atom bomb is an uncontrolled fission chain reaction that releases the nuclear binding energy of millions of uranium-235 atoms.

Plutonium-239 can also be used.

Fat Man

Nuclear Power
- Uses a controlled fission chain reaction to produce energy.
- Control rods moderate the speed of neutrons being released to react with uranium atoms.
Fusion: an artificial transmutation that combines two small hydrogen nuclei to make a larger nucleus and energy.

Tremendous amounts of heat and pressure are required for fusion to occur in order to overcome the repelling forces of the nuclei.

Fusion produces more energy than fission and leaves no radioactive waste.
Mass Defect

**Mass defect** - when a small amount of mass is **lost** and converted to energy because the release of nuclear binding energy is a very powerful process.

Mass defect occurs in fission and in fusion.

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**Chernobyl**

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Hydrogen Bomb

- Hydrogen bomb (H-Bomb): Uncontrolled fusion reaction started by fission with uranium.

H Bomb Tests 1:22