

Nuclear Reactions

PowerPoint 7.3

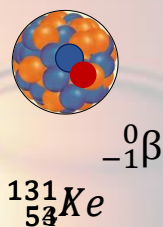
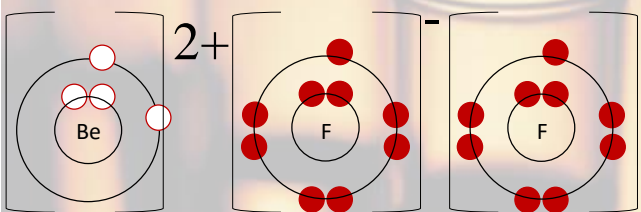
Chemical Reactions Versus Nuclear Reactions

Chemical Reactions

- Relatively small amount of energy involved
- Rearrangement of valence electrons
- Atomic nuclei are unchanged

Nuclear Reactions

- Large amounts of energy involved
- Nuclei of isotopes are changed often producing different elements
- Electrons can be produced in the nucleus



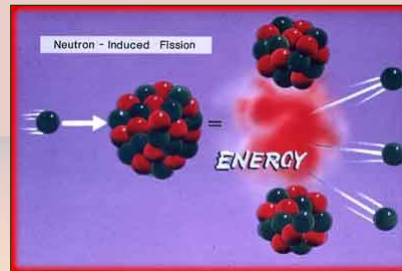
Beta decay

Review of Symbols for Subatomic Particles in Standard Atomic Notation

<u>Particle</u>	<u>Also Known As</u>	<u>Symbols</u>
Proton	H nucleus	1_1p or 1_1H
Neutron	-	1_0n
Electron	Beta particle	${}^{-1}_0e$ or ${}^{-1}_0\beta$
Alpha particle	He nucleus	${}^4_2\alpha$ or 4_2He

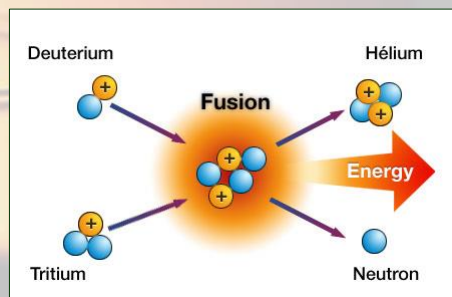
Two Types of Nuclear Reactions

1. Nuclear Fission



Both types of reactions can be *induced*.

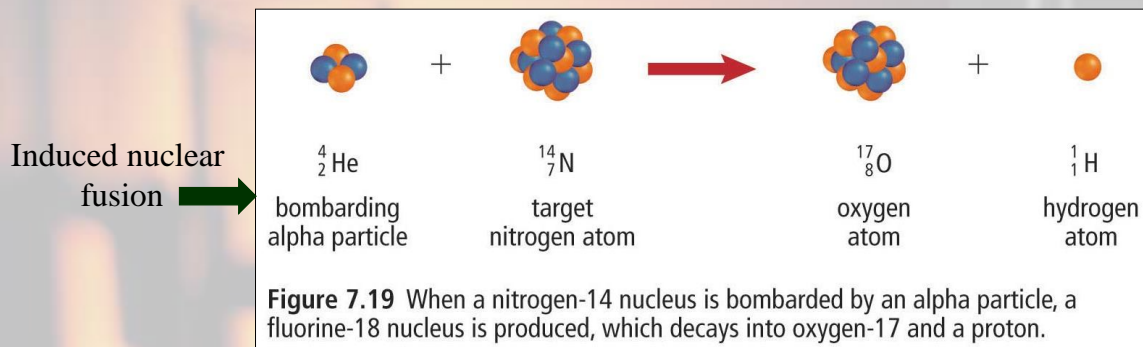
2. Nuclear Fusion



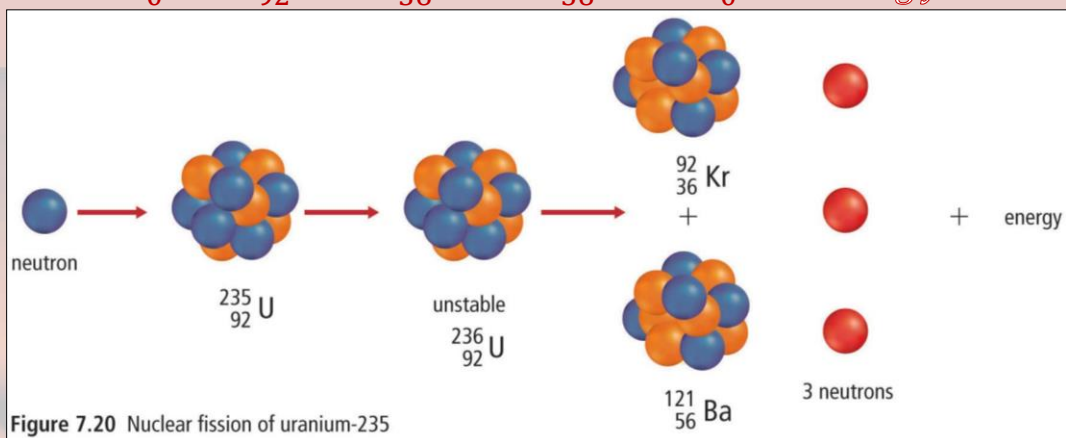
Induced Nuclear Reactions

Naturally occurring nuclear reactions are generally caused by unstable nuclei. \longrightarrow α , β , and γ decay

Scientists can also cause nuclei of isotopes to become unstable, causing an immediate nuclear reaction. \longrightarrow **Induced Nuclear Reaction**

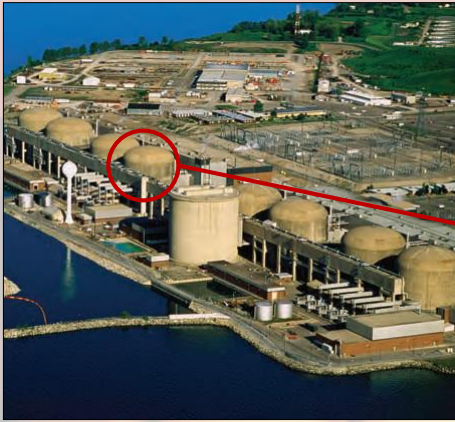


A More Common Induced Nuclear Reaction The Induced Nuclear Fission of U-235

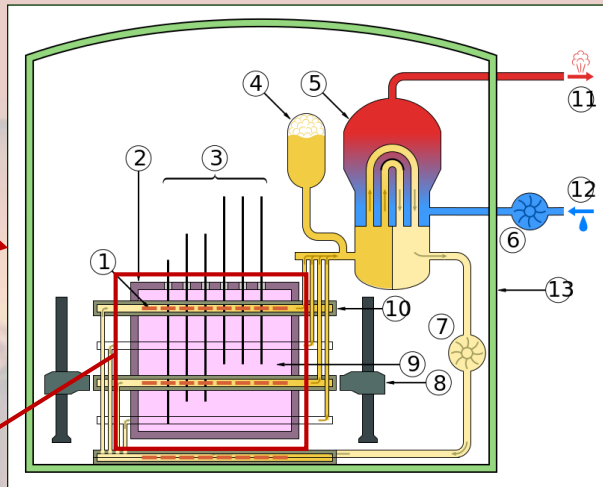


- This is a nuclear reaction that is commonly utilized to produce nuclear power in Canada, in CANDU reactors.

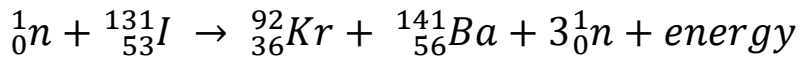
Canadian Deuterium Uranium Reactors, CANDU Reactors



A CANDU reactor in Pickering, Ontario



Inside a CANDU nuclear reactor



CANDU Reactors are great, But

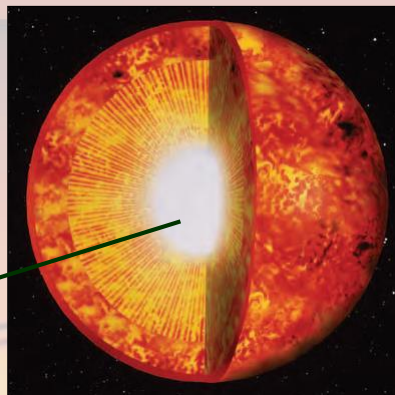
- Nuclear materials, U-235, are only useable for approximately 15 years.
- Eventually, the nuclear waste left over is stored in above-ground storage tanks.
- While the radioactivity of used fuel bundles decreases significantly with time, the bundles ***remain hazardous for many thousands of years*** and must be isolated from the natural living environment



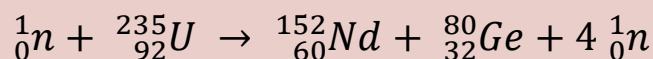
Nuclear Fusion

Fusion is the process in which two low mass nuclei join together to make a more massive nucleus.

Fusion occurs naturally in the extremely high-temperature and high-pressure cores of stars like the Sun.



Key Points for Nuclear Reaction Equations



- The total masses before and after the reaction are the same.
 - Law of conservation of mass
 - In the reaction above,
 - mass number on the left = $1 + 235 = 236$
 - mass number on the right = $152 + 80 + (4 \times 1) = 236$
- The net charge before and after the reaction is the same.
 - Law of conservation of charge
 - In the reaction above,
 - charge on the left = $0 + 92 = 92$
 - charge on the right = $60 + 32 + (4 \times 0) = 92$

Provincial Exam Question

Question

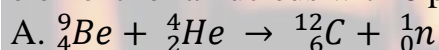
Which reaction occurs when an alpha particle is captured by a beryllium-9 nucleus?

- A. ${}^9_4\text{Be} + {}^4_2\text{He} \rightarrow {}^{12}_6\text{C} + {}^1_0\text{n}$
 B. ${}^9_4\text{Be} + {}^4_2\text{He} \rightarrow {}^{12}_6\text{C} + {}^0_1\text{n}$
 C. ${}^9_4\text{Be} + {}^4_2\text{He} \rightarrow {}^{12}_{12}\text{Mg} + {}^0_1\text{n}$
 D. ${}^9_4\text{Be} + {}^4_2\text{He} \rightarrow {}^{12}_6\text{Mg} + {}^1_0\text{n}$

Answer

The total mass on the left is $9 + 4 = 13$.

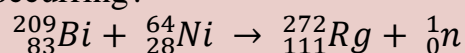
Options A and D have a total mass of 13 on the right, but only A shows the correct element for a nucleus with 6 protons, therefore the answer is



Provincial Exam Question

Question

What type of reaction is occurring?



- A. fusion
 B. fission
 C. beta decay
 D. alpha decay

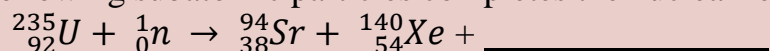
Answer

Bi and Ni have joined to form a larger isotope, Rg. Even though a neutron is expelled, two smaller isotopes joining together to form a larger isotope is fusion, therefore the answer is A.

Provincial Exam Question

Question

Which of the following subatomic particles completes the nuclear reaction below?



- A. one proton
- B. two protons
- C. one neutron
- D. two neutrons

Answer

The total mass on the left is $235 + 1 = 236$, therefore the mass on the right must also be 236. The mass of whatever is missing must be $236 - 94 - 140 = 2$.

The total charge on the left is 92, therefore the total charge on the right must also be 92. The mass of whatever is missing must be $92 - 38 - 54 = 0$.

The option that has a mass of 2 and a charge of 0 is D.

Summary

Induced nuclear reactions can be caused by bombarding nuclei with high-energy particles causing them to become unstable.

Types of nuclear reactions

- **fission**, utilized in CANDU reactors, nuclear bombs, and other applications
- **fusion**, occurring in stars and, maybe one day, on earth to produce energy