Henri Becqueral

Marie Curie

Radiation

Type	Comments	Particle	Equation
Alpha			
Beta			
Gamma			
Positron Emission			
Electron Capture			

The Band of Stability

Isotopes that are stable

Number of Protons	Number of Neutrons	Number of Known Stable Nuclei	Examples

1. $^{235}U \rightarrow$ ____ + ^{4}He

2. $^{234}Th \rightarrow$ ____ + e

3. $^{239}Pa \rightarrow$ ____ + ^{4}He

4. $^{220}Rn \rightarrow$ ____ + ^{4}He

5. $^{240}Pu \rightarrow$ ____ + ^{4}He

6. $^{27}Al + {}^{4}He \rightarrow$ ____ + ^{1}n

7. $^{7}Li +$ ____ $\rightarrow 2\ ^{4}He$

8. $^{239}Pu +$ ____ $\rightarrow {}^{242}Cm + {}^{1}n$

9. $^{14}C \rightarrow {}^{14}N +$ ____

10. $^{14}N + {}^{4}He \rightarrow$ ____ + ^{1}H

Uranium 238 decays by the following series of steps. Where does it end?

α, β, β, α, α, α, α, α, β, β, α, β, β, α

Why do nuclides decay the way they do?

Measurement of Radiation

Effects of Radiation and its Units

Somatic Damage

Genetic Damage

RAD

REM

Biological Effect

1.

2.

3.

4.

Biological Doses

0-25 REM

25-50 REM

50-100 REM

100-200 REM

200-500 REM

500 REM

Kinetics of Radioactive Decay

Half Life

Carbon Dating

1) Copper 64 is used in the form of copper acetate to study brain tumors. It has a half-life of 12.8 hours. If you begin with a sample containing 15.0 mg of copper 64 how much of the sample is left after 2 days and 16 hours?

2) One of thee worst spills of a radioactive substance occurred in 1984. Cobalt 60 was exposed in large quantities on a highway in the United States. If cobalt 60 has a half-life of 5.3 years how much of a 10.0 mg sample will still be present after 21.2 years? What about 100 years?

3) Iodine 131 is an isotope used to treat thyroid problems. It was discovered by Glenn Seaborg. If it has a half-life of 8.05 days how long will it take to decay to 5% of its original sample?

4) A Bulgarian archeology dig unearthed a chariot made of wood. It was carbon 14 dated and showed an activity of 11.2 disintegrations per gram per minute. How old is the chariot?

5) There is an isotope of gold whose mass is 198. It has a half-life of 2.7 days. How long will it take of 50.0 mg of it to decay to 48.7 mg?

Nuclear Energy

Albert Einstein
1905 was a really good year.

Nuclear Binding Energy and the Mass Defect

Mass of the Proton	Mass of the Neutron	Mass of the Electron

1 amu = $1.6605655 \times 10^{-27}$ kg

Lets look at Hydrogen and Helium

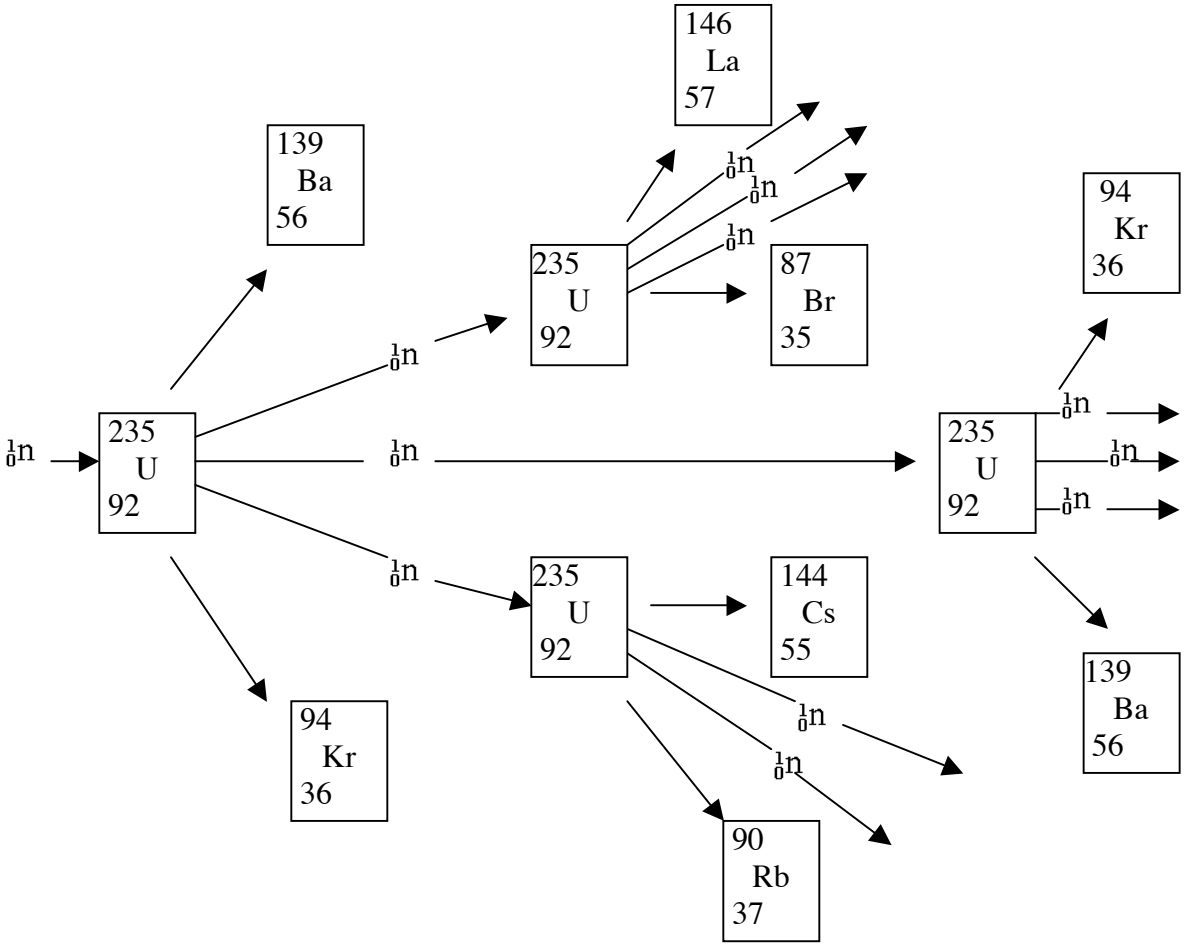
Calculate the nuclear binding energy per nucleon for Nitrogen 14. Its mass is 14.00307 amu.

Calculate the nuclear binding energy per nucleon for Boron 11. Its mass is 11.00931 amu.

Binding Energy Diagram

1939 Otto Hahn, Lise Meitner, Fritz Strassman
We find a new type of reaction. A chain reaction!

Fission



What is the critical mass?

Fusion

1939 Einstein Writes a Letter to Roosevelt (not really)
Leo Szilard/ Enrico Fermi/ Eugene Wigner/ and many others

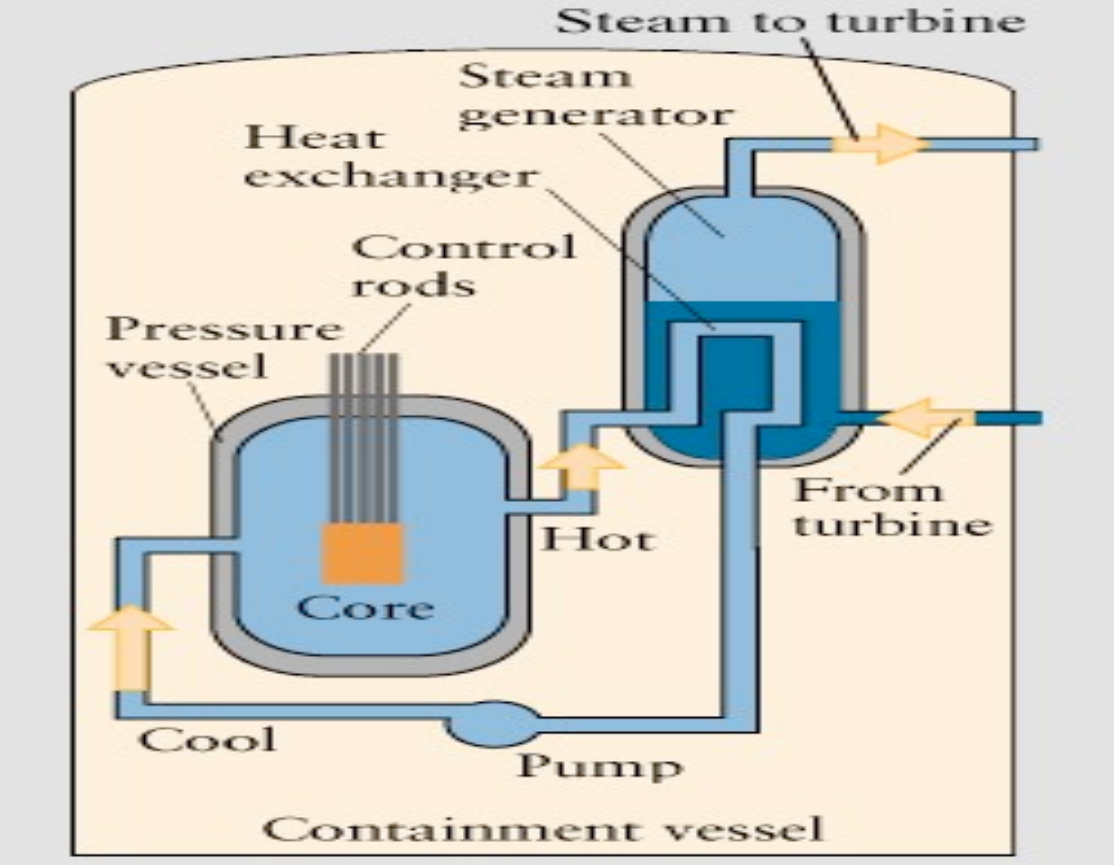
Robert Oppenheimer

Los Alamos

How does it work?

Peaceful Uses of Nuclear Power

Power Plants



Transuranium Elements

Ernest Rutherford and the first step

Glenn Seaborg and the Berkeley Group

From the 1989 AP Exam

The carbon isotope of mass 12 is stable. The carbon isotopes of mass 11 and mass 14 are unstable. However, the type of radioactivity decay is different for these two isotopes. Carbon–12 is not produced in either case.

a) Identify a type of decay expected for carbon–11 and write the balanced nuclear reaction for that decay process.

b) Identify the type of decay expected for carbon–14 and write the balanced nuclear reaction for that decay process.

c) Gamma rays are observed during the radioactive decay of carbon–11. Why is it unnecessary to include the gamma rays in the radioactive decay equation of (a)?

d) Explain how the amount of carbon–14 in a piece of wood can be used to determine when the tree died.

From the 1991 AP Exam

Explain each of the following in terms of nuclear models.

a) The mass of an atom of ^{4}He is less than the sum of the masses of 2 protons, 2 neutrons, and 2 electrons.

b) Alpha radiation penetrates a much shorter distance into a piece of material than does beta radiation of the same energy.

c) Products from a nuclear fission of a uranium atom such as ^{90}Sr and ^{137}Ce are highly radioactive and decay by emission of beta particles.

d) Nuclear fusion requires large amounts of energy and to get started, whereas nuclear fission can occur spontaneously, although both processes release energy.