Student Exploration: Nuclear Reactions

[Note to teachers and students: This Gizmo was designed as a follow-up to the Nuclear Decay *Gizmo. We recommend doing that activity before trying this one.*

Vocabulary: chain reaction, CNO cycle, catalyst, deuterium, electron volt, fission, fusion, isotope, nuclear reaction, positron, positron emission, proton-proton chain

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)
The chart to the right gives the **isotope** name, element name, number of protons, and number of neutrons of three isotopes.

Isotope	Protons	Neutrons
Hydrogen-1	1	0
Carbon-12	6	6
Uranium-235	92	143

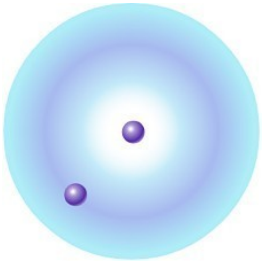
1. What do you notice about the isotope number and the sum of protons and neutrons?

   They all vary in numbers

2. The element symbol for uranium-238 is $^{238}_{92}U$. This means U-238 has a total mass of 238 and contains 92 protons. Write the element symbols for the isotopes in the table:

   Hydrogen-1 1/1 H Carbon-12 12/6 C Uranium-235 235/92 U

Gizmo Warm-up
The *Nuclear Reactions* Gizmo simulates a particle accelerator. Particle accelerators speed up atoms to very high velocities, then crash the atoms together with enough energy to cause changes called **nuclear reactions**. There are three particle beams available in this Gizmo, protons, neutrons, and helium-3 nuclei.



1. Click **Fire Proton** to engage the first particle beam.

   What happens? A positron flew out

2. Colliding particles don't always react. Click **Reset**, and then click **Fire neutron**.

   A. Does a reaction occur? no

   B. Explain: the fire neutron flew through

Activity A: **Proton-proton chain**	Get the Gizmo ready: • Click **Reset**. • Be sure **Proton-proton** is selected in the **Reaction** menu.	Proton Neutron

Introduction: All stars turn hydrogen into helium in a process called nuclear **fusion**. Stars perform this process in different ways. In stars like our sun, the **proton-proton chain** is used. This reaction requires temperatures greater than 4,000,000 K to occur.

Question: How does the process of fusion turn hydrogen into helium in stars?

1. Observe: Click **Fire proton** and observe. What happens after the proton merges into the nucleus? A gamma is released

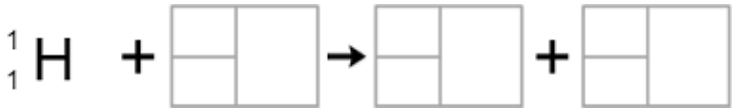
   This is a form of nuclear decay called **positron emission**. During positron emission, a proton decays into a neutron. In this process, it emits a **positron**, which is a nearly massless antimatter particle with a positive charge.

2. Observe: Click **Reset** and click **Fire proton**. Observe what happens. Many subatomic particles appear frequently in nuclear reactions. Their element symbols are given below:

Neutron Positron Electron Proton

(Neutrinos  are also produced but are beyond the scope of this Gizmo.)

Click **Reset** and click **Fire proton**. Turn on the **Write equation** checkbox. Based on what you have observed, write in the equation for this reaction in the Gizmo and below.



1/0 n to 0/1 e+ plus 1/1 H

A. Turn on **Show equation**. Was your predicted equation correct? yes

   Correct your equation if necessary. The resulting H-2 isotope is called **deuterium**.

B. Emitted energy is reported in megaelectron volts (MeV), where one MeV