Nuclear Fission and Fusion Name ________________________

Part A: Nuclear Fission and Fusion Reactions

Nuclear Fission One very large nucleus is broken into two smaller nuclei, releasing enormous amounts of energy. Releases enormous amounts of energy.
Nuclear Fusion Two very small nuclei (or even protons) are combined to form a lesson. Releases *even more* enormous amounts of energy than nuclear fission.

Nuclear Fission Examples - Nuclear power plants use nuclear fission to produce electricity - Most nuclear bombs, including those dropped on Hiroshima and Nagasaki, use a nuclear fission chain reaction to produce a massive burst of energy. - Submarines in the US Navy run on nuclear fission reactors.
Nuclear Fusion Examples - Nuclear fusion occurs in the center of the sun, producing all the energy that makes life on earth possible. _ Nuclear fusion inside of a supernova (exploding star) produces almost all of the elements that make up our daily life, such as carbon and iron. - In the 1950s, the US government developed nuclear fusion bombs (called Hydrogen-Bombs) that are even more powerful than fission bombs. None has ever been used in wartime, only in developmental tests. - Many scientists are attempting to harness nuclear fusion to create electrical power. This is one of the “holy grails” of science. If someone solves it, they would become unbelievable rich and famous and solve many of the world’s problems in one piece, but thus far no one has come close.

A.1 Two small nuclei combine to make a large nuclei.

A.2 A large Uranium nucleus breaks into two smaller nuclei.

A.3 Which type of reaction releases more energy?

A.4 Used by nuclear power plants.

A.5 Used by the nuclear bomb that was dropped on Nagasaki during World War II.

A.6 Two protons merge to make a nucleus.

A.7 Type of reaction that occurs in the center of the sun.

Part B: Important Particles

Name (or Names)	Symbol	Description
Proton/ Hydrogen-1	${}^{1}_{1}\mathrm{H}$	Positively charged particle. Given off by beta decay.
Electron / Beta Particle	${}^{0}_{-1}\mathrm{e}$	Nearly massless negatively charged particle.
Neutron	${}^{1}_{0}\mathrm{n}$	Particle with no charge
Deuteron / Hydrogen-2	${}^{2}_{1}\mathrm{H}$	One Neutron and one proton
Tritium / Hydrogen - 3	${}^{3}_{1}\mathrm{H}$	Two neutrons and one proton
Helium-3	${}^{3}_{2}\mathrm{He}$	Two protons and one neutron.
Alpha Particle / Helium- 4	${}^{4}_{2}\mathrm{He}$	Two protons and two neutrons, given off in alpha decay
Gamma Ray	γ	Very high energy photon (electromagnetic wave), given off as extra energy in gamma decay or some reactions.
Positron	${}^{0}_{+1}\mathrm{e}$	Nearly massless positively charged particle. Just like an electron, but positive not negative.
Neutrino	${}^{0}_{0}\nu$	Nearly massless, neutral particle given off as extra energy in some reactions.
Anti-neutrino	${}^{0}_{0}\bar{\upsilon}$	Nearly massless, neutral particle, given off as extra energy in some reactions

For each of the following particles, write the symbol.

B.1 A proton

B.2 An electron

B.3 Tritium

B.4 Gamma ray

B.5 Neutrino

B.6 Alpha particle

B.7 positron

B.8 Helium 3

<u>For the following, write the name of the particle and the symbol.</u>

B.9 Highest energy electromagnetic photon.

B.10 Exactly like an electron, except positive

B.11 Tiny, nearly massless, neutral particles that are sometimes sent out of a reaction as extra energy. (two answers)

B.12 A hydrogen atom with two neutrons.

B.13 A hydrogen atom with one neutron

B.14 two protons and two neutrons.

B.15 a particle with a mass of one and no charge.

Part C: Nuclear Reactions

For each nuclide, the number on the top is the *mass*,
and the number on the bottom is the *charge*. For nuclei, it is the atomic number of the nucleus.

The masses on each side of the arrow must balance out. The changes on each side of the equation must balance out as well.

C.1 For the reaction below, fill in the empty spaces:

$$^{235}_{[\ \ ]}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{[\ \ ]}_{[\ \ ]}\mathrm{Ba} + {}^{94}_{[\ \ ]}[\quad] + 3\,{}^{1}_{0}\mathrm{n}$$

Is this a *fission reaction* or a *fusion reaction*?

C.2 For the reaction below, fill in the empty spaces:

$$^{235}_{[\ \ ]}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{139}_{[\ \ ]}[\quad] + {}^{[\ \ ]}_{[\ \ ]}\mathrm{Cs} + 3\,{}^{1}_{0}\mathrm{n}$$

Is this a *fission reaction* or a *fusion reaction*?

C.3 Fill in the empty spaces:

$$^{1}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{[\ \ ]}_{1}[\ \ \ ] + {}^{0}_{[\ \ ]}\mathrm{e} + {}^{0}_{0}\nu$$

Is the "e" particle an electron or a positron?

Is this a *fission reaction* or a *fusion reaction*?

C.4 Fill in the empty spaces:

$$4\,{}^{1}_{[\ \ ]}\mathrm{H} \rightarrow {}^{[\ \ ]}_{[\ \ ]}[\ \ \ ] + 2\,{}^{0}_{1}\mathrm{e}$$

What is the name of the particle that you figured out:

Is this a *fission reaction* or a *fusion reaction*?

C.5 Fill in the empty spaces:

$$^{2}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{[\ \ ]}_{[\ \ ]}[\ \ \ ] + \gamma$$

Is this a *fission reaction* or a *fusion reaction*?

C.6 Fill in the empty spaces:

$$^{2}_{[\ \ ]}\mathrm{H} + {}^{[\ \ ]}_{[\ \ ]}\mathrm{H} \rightarrow {}^{4}_{[\ \ ]}\mathrm{He} + {}^{[\ \ ]}_{[\ \ ]}\mathrm{n}$$

Is this a *fission reaction* or a *fusion reaction*?

(how do you calculate the energy gained…energy that was binding the atoms together is released….no mass or charge is lost)

What keys do I want to produce:
- nuclear fission is when a very large nuclei is broken apart [nuclear power plants and most atomic bombs, such as the one dropped on Hiroshima]
- nuclear fusion is when two small nuclei are combined
[the center of the sun and some atomic bombs, called an H bomb]
--- both release *enormous* amounts of energy
--- I will need to have them learn many new types of particle, such as neutrons, positrons, deuterium etc.

$$4\,{}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + 2\,{}^{0}_{+1}\mathrm{e}$$

$${}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$$

http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch23/fission.php

http://physics.tutorvista.com/modern-physics/nuclear-fusion.html

http://hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fission.html

lots of really interesting conceptual stuff here

$${}^{2}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{2}_{1}\mathrm{H} + {}^{0}_{+1}\mathrm{e} + {}^{0}_{0}\nu$$

$${}^{2}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + \gamma$$

$${}^{3}_{2}\mathrm{He} + {}^{3}_{2}\mathrm{He} \rightarrow {}^{4}_{2}\mathrm{He} + 2\,{}^{1}_{1}\mathrm{H}$$

[a larger system is broken into multiple steps]

Answers

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{139}_{56}\text{Ba} + ^{94}_{36}\text{Kr} + 3^{1}_{0}\text{n}$$

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{139}_{56}\text{Rb} + ^{94}_{36}\text{Cs} + 3^{1}_{0}\text{n}$$