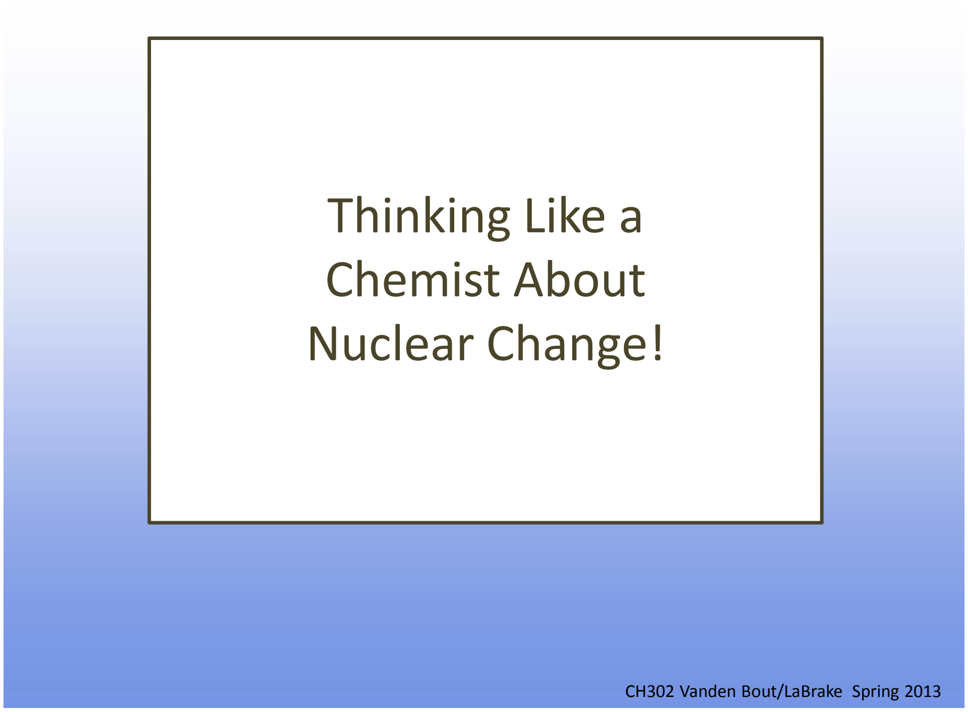
UNIT7-DAY1-LaB1230

Thursday, March 07, 2013
8:48 AM



Thinking Like a Chemist About Nuclear Change!

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IMPORTANT INFORMATION

Begin Unit 7
LM's assigned on March 19th
HW assigned on March 21st

Thank you for coming to class today!

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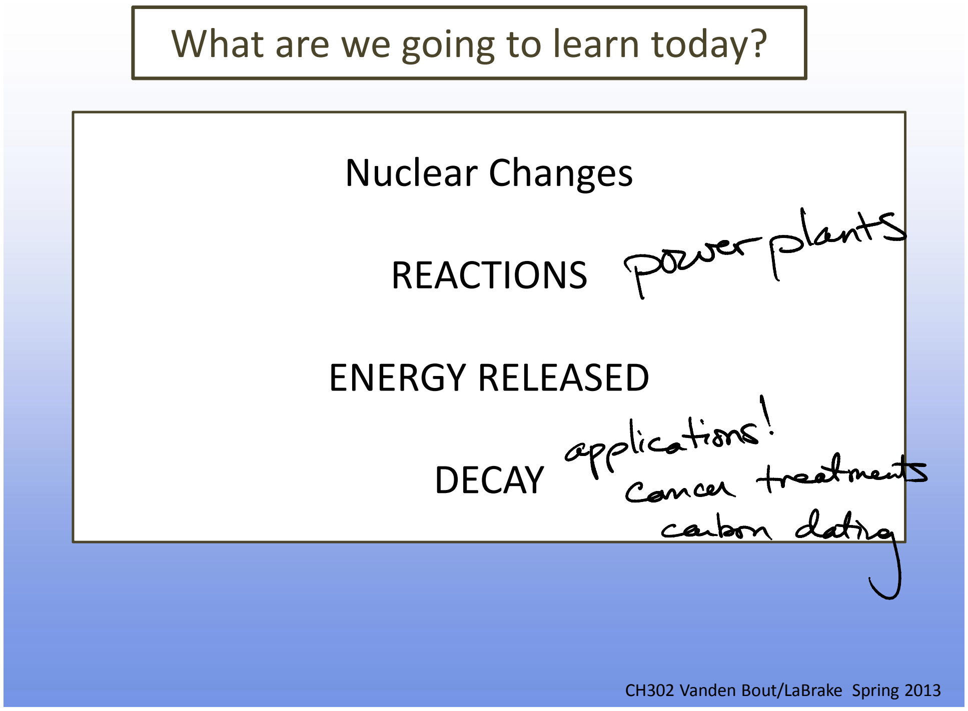


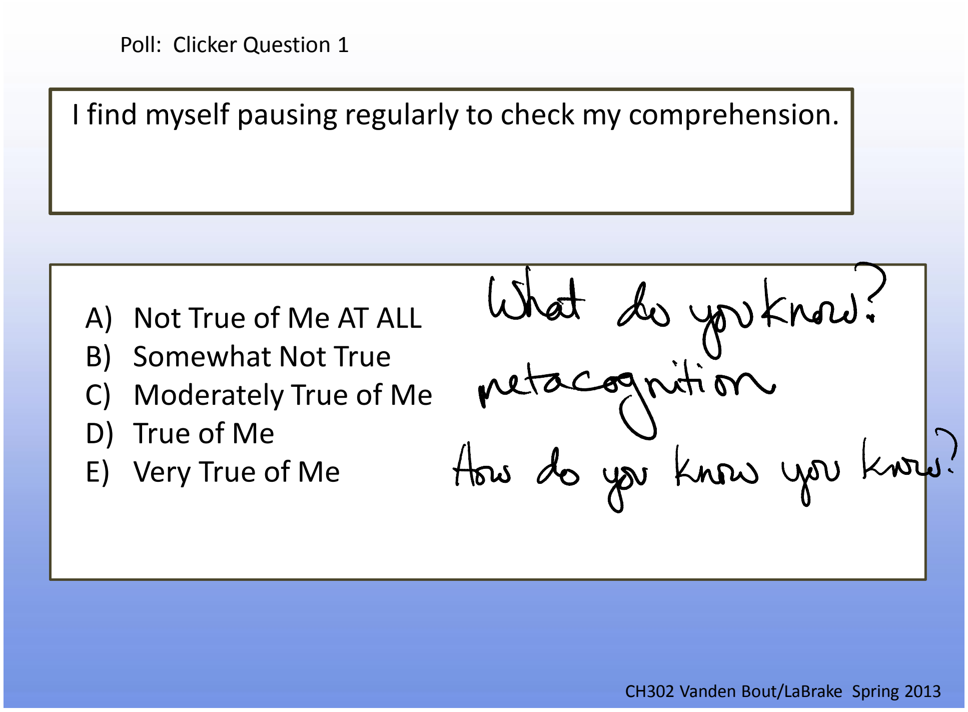
What are we going to learn today?

Nuclear Changes

REACTIONS power plants

ENERGY RELEASED

DECAY applications!
cancer treatments
carbon dating



Poll: Clicker Question 1

I find myself pausing regularly to check my comprehension.

A) Not True of Me AT ALL
B) Somewhat Not True
C) Moderately True of Me
D) True of Me
E) Very True of Me

What do you know?
metacognition
How do you know you know?

Poll: Clicker Question 2

There was a nuclear emergency in Japan. The emergency was brought on because the flow of cooling water in nuclear reactors was interrupted. Cooling water interruptions were the cause of the following incidents as well:

- A. There have been no other situations similar to the Japan situation
- B. Cooling water was the initial problem at Chernobyl
- C. Cooling water was the initial problem at 3 Mile Island
- [✓ D.] Cooling water was the problem at both Chernobyl and 3 Mile Island

Video Earthquake and Tsunami:

Poll: Clicker Question 3

Check your background knowledge!

Did a nuclear explosion occur at the Fukushima plant?

A) Yes, but only at 4 of the 6 reactors.

B) No, but experts expect a nuclear explosion to occur if the situation isn't brought under control soon

C) Yes, they all of the reactors have had nuclear explosions to varying degrees

D) No, there have been no nuclear explosions, nor do experts believe that a nuclear explosion will occur at the facility

Take a closer look at Fukushima power plant…

Images of the 6 reactors at Fukushima

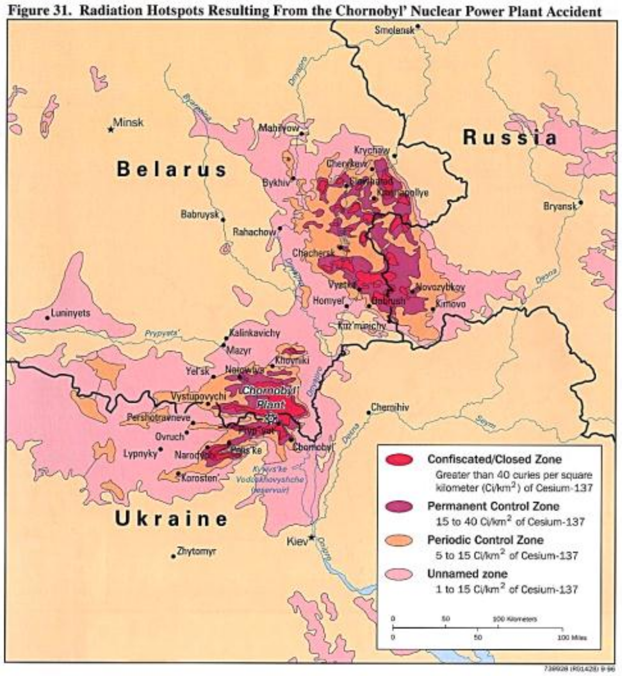
Chernobyl-What Happened: April 26, 1986

Operator error – cooling water mistake

Explosion

9 tons of nuclear material blown into sky
100 times normal background radiation

Figure 31. Radiation Hotspots Resulting From the Chornobyl' Nuclear Power Plant Accident



If a nuclear explosion would have happened at the power plant this is what it would have looked like:

Nuclear or Chemical?

Clearly a chemical explosion occurred.

massive

But, we know that nuclear change occurs and that is what produces the heat energy for the nuclear power plant.

Sort out nuclear change vs nuclear explosion vs chemical changes

Video Vlog Brother Explanation - go back & watch it should make 100% sense

Nuclear Change vs Chemical Change

1. Compare energy released upon change
2. Compare what is conserved across the change
3. Types of change and how to recognize type of change

Poll: Clicker Question 4

During Fission reactions the number and type of atoms on the left hand side of the equation is

Chemistry → A) The **same** as the number and type of atoms on the **right** hand side of the equation, it's just that the atoms have rearranged (Law of Conservation of Mass).

B) The type of **atom** on the **right** hand side is the **same**, it is just the **number of atoms** that **changes**

Nuclear → [✓ C)] The **type and number** of atoms on the **right** hand side **changes**.

D) Fission reactions don't have a left and right hand side, so this doesn't make sense

Poll: Clicker Question 4

During Fission reactions the number and type of atoms on the left hand side of the equation is

- A) The **same** as the number and type of atoms on the **right** hand side of the equation, it's just that the atoms have rearranged (Law of Conservation of Mass).

- B) The type of **atom** on the **right** hand side is the **same**, it is just the **number of atoms** that **changes**

- C) The **type and number** of atoms on the **right** hand side **changes**.

- D) Fission reactions don't have a left and right hand side, so this doesn't make sense

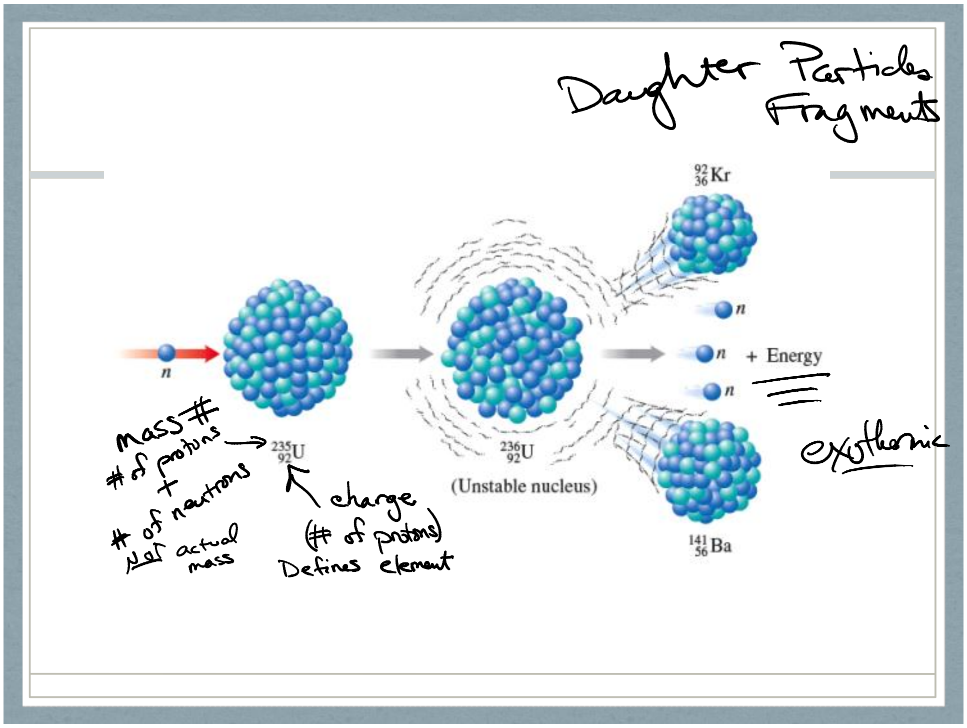
What does a nuclear reaction look like?

Fission reaction is the type that is in the power plant, so let's take a look at that first.

After we figure out what a fission reaction is, then we'll take a look at where all that energy comes from.

What does a nuclear reaction look like?

Fission - Animation



Daughter Particles
Fragments

mass #
# of protons
+
# of neutrons
Not actual mass

charge
(# of protons)
Defines element

exothermic

Write that as an equation:

$$^{1}n + ^{235}_{92}U \rightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + 3\,^{1}_{0}n$$

Write that as an equation:

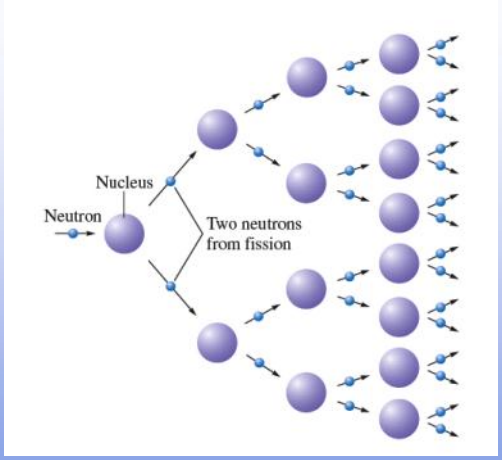
$$^{1}_{0}n + ^{235}_{92}U \rightarrow {}_{36}Kr + {}_{56}Ba + 3\,^{1}_{0}n$$

$$92 = 36 + 56$$

Are the total number of protons conserved?

[✓ A) yes] or B) no

Chain Reaction



Chemical Change vs Nuclear Change

Chemical: $4C_7H_2(NO_2)_3CH_3(s) + 25O_2(g) \rightarrow 32CO_2(g) + 10H_2O(g) + 6\,N_2(g)$

Reactants → Products

same # atoms

same type of atoms

Nuclear: $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,^{1}_{0}n$

same Type of atoms

Nuclear: $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,^{1}_{0}n$

Reactants → Products

Different atoms!

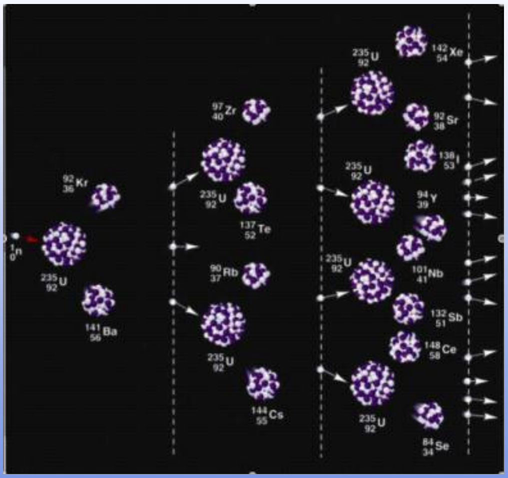
Same:
Charge
Mass #

Some fission products

Lots of them

we won't (can't) predict all the particles

Nuclear chemists can!



Sr Xe
Se Zr
Te Cs
Rb Sb
I Ce
Y

Look Close

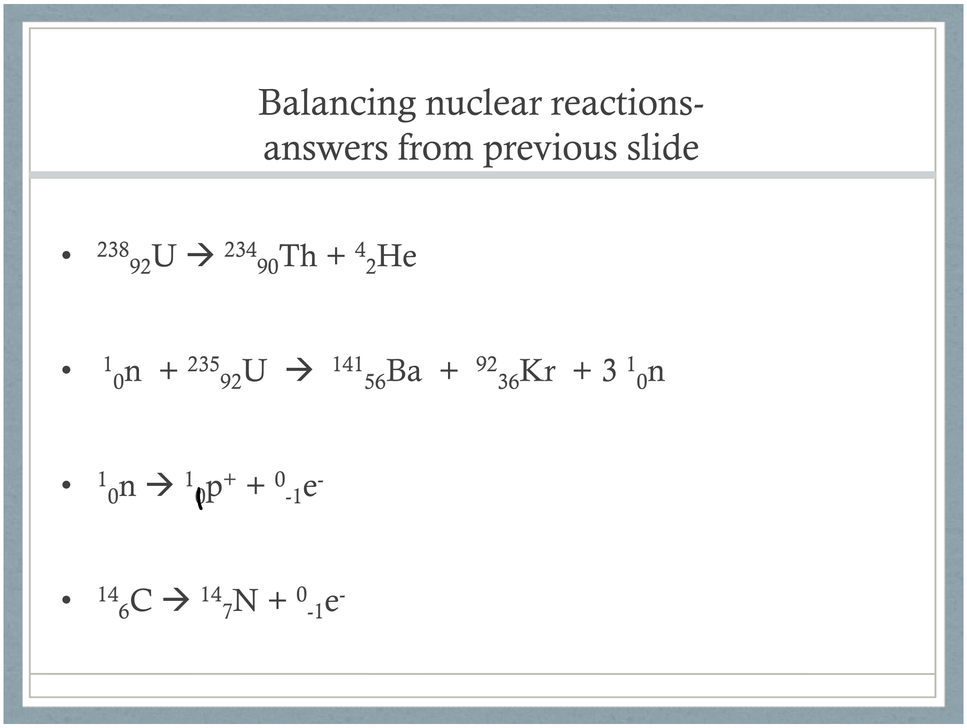
$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\ ^{1}_{0}n$

- Has the total number of protons changed across the following nuclear change?
- A) yes
- B) no
- Has the total number of neutrons changed across the nuclear change?
- A) yes
- B) no

Nuclear Change: Mass number & Nuclear charge - CONSERVED

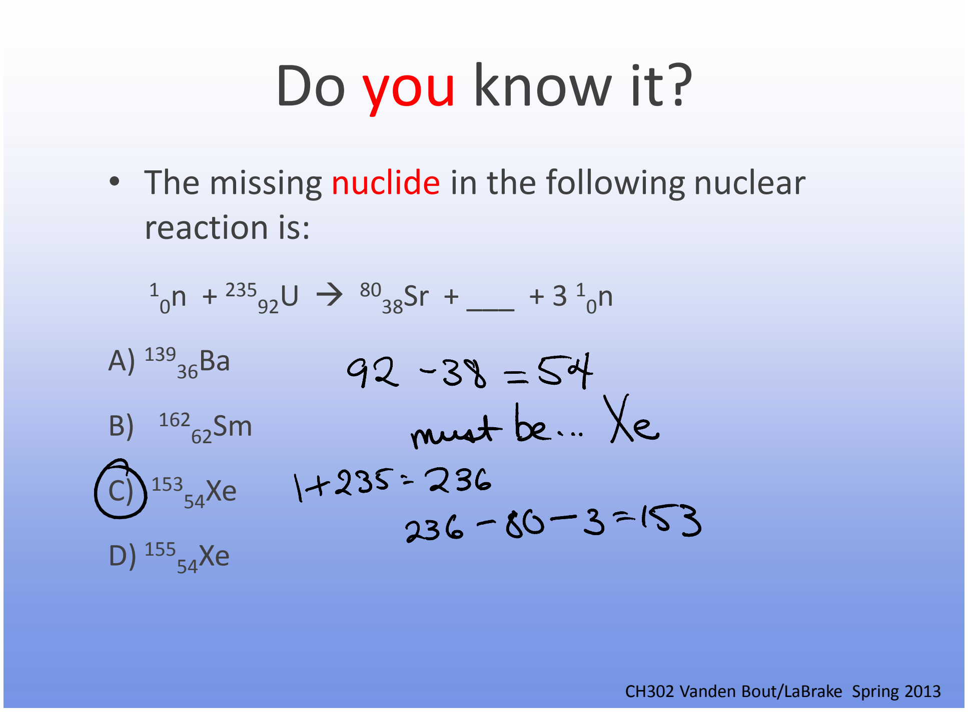
- $^{238}_{\underline{92}}U \rightarrow ^{234}_{90}Th + \underline{^{4}_{2}He}$ alpha particle
- $^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + \underline{3\ ^{1}_{0}n}$
- $^{1}_{0}n \rightarrow ^{1}_{1}p^{+} + \underline{^{0}_{-1}e}$ Beta particle
- $^{14}_{6}C \rightarrow \cancel{1}\ ^{0}_{-1}e^{-} + \underline{^{14}_{7}N}$

you
can
fill in
1 blank
spot



Balancing nuclear reactions- answers from previous slide

- $^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He$
- $^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\ {}^{1}_{0}n$
- $^{1}_{0}n \rightarrow {}^{1}_{1}p^{+} + {}^{0}_{-1}e^{-}$
- $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e^{-}$



Do you know it?

- The missing nuclide in the following nuclear reaction is:

$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{80}_{38}Sr +$ ____ $+ 3\ {}^{1}_{0}n$

A) $^{139}_{36}Ba$

B) $^{162}_{62}Sm$

[✓ C)] $^{153}_{54}Xe$

D) $^{155}_{54}Xe$

92 - 38 = 54

must be... Xe

1+235=236

236 - 80 - 3 = 153

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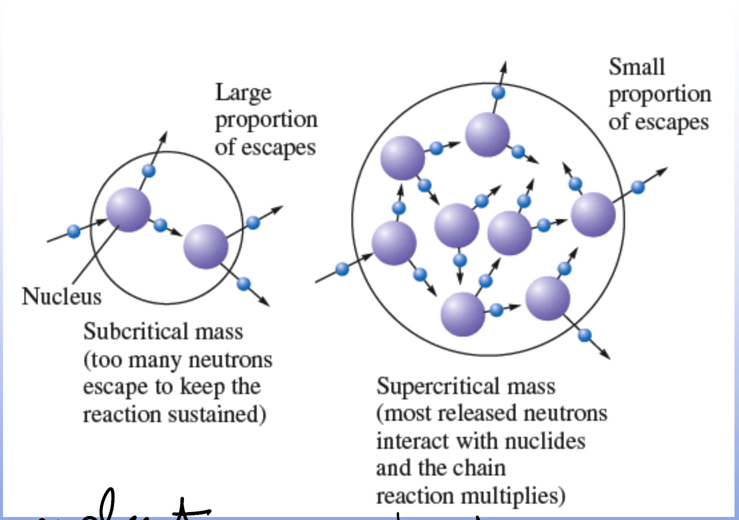

powerplant
low density

bomb
squeeze it in!

How Does Fission Produce Energy?

1) Different combination of proton/neutron

$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\,^{1}_{0}n + \text{energy}$ (E)

What is lower in energy? Products

Real mass of Reactants & Products

Mass is LOST

Nuclear fission was published in *Nature* in 1939.
Fission (splitting up) was taken from biology.

energy

mass in kg

$\boxed{kg\frac{m^2}{s^2} = J}$

$$E = mc^2$$

Nuclear fission was published in *Nature* in 1939.
Fission (splitting up) was taken from biology.

energy

mass in kg

kg

$$E = mc^2$$

speed of light

$\frac{m}{s}$

- This equation dates from the early years of the 20th century and is one of the many contributions of Albert Einstein (1879–1955).
- The symbol *c* represents the speed of light:

3.0×10^8 m/s

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How Does Fission Produce Energy?

Energy is released because **the sum of the masses of the fragments is less than the original mass**.

This 'missing' mass (about 0.1 percent of the original mass) has been converted into energy according to Einstein's E=mc^2 equation.

~0.1%

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How Does Fission Produce Energy?

Know
mass of neutron
mass of proton
mass of electron

It looks like mass is conserved.

Chemical Rxn
10-100 kJ
~10^4

$${}^1_0n \rightarrow {}^1_1p^+ + {}^0_{-1}e^-$$

$\Delta m = 1.394 \times 10^{-30}$ kg

$E = (1.394 \times 10^{-30})(3 \times 10^8)^2$

$E = 1.255 \times 10^{-13}$ J per 1 neutron

LOTS of

Upon a spontaneous nuclear change a small amount of mass is converted to kinetic energy and is carried off by the products of the reaction, in this example the proton and the electron. Increase of KE

$_0n \rightarrow {}_1p^{+} + {}_{-1}e$

E = (1.3 x10)(3 x10)

E = 1.255 x10^-13 J per 1 neutron

LOTS of energy

Upon a spontaneous nuclear change a small amount of mass is converted to kinetic energy and is carried off by the products of the reaction, in this example the proton and the electron. Increase of KE on a microscopic scale is perceived as thermal energy.

What about 1 mole?

7.56x10^10 J/mole

Chemical changes vs Nuclear changes

- Chemical – atoms rearrange, but do not change atomic identity.
- Nuclear – nuclear change, change in atomic identity likely across nuclear change, matter converted to energy or energy converted to matter.

$E = mc^2$

Calculate the amount of energy released when 1.0 Kg of U-235 undergoes fusion

need actual mass from table

$^1_0n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^1_0n$

neutrons

undergoes fusion

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3\ ^{1}_{0}n$$

actual mass is NOT just total neutrons & total protons

1 kg 0.1%

$$\Delta E = \Delta mc^2$$

0.001 × 1 kg

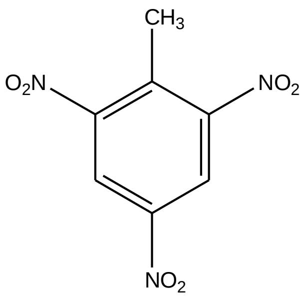
$$\Delta E = (0.001\ kg)(3 \times 10^8\ \tfrac{m}{s})^2$$

$$\Delta E = 9 \times 10^{13}\ J$$

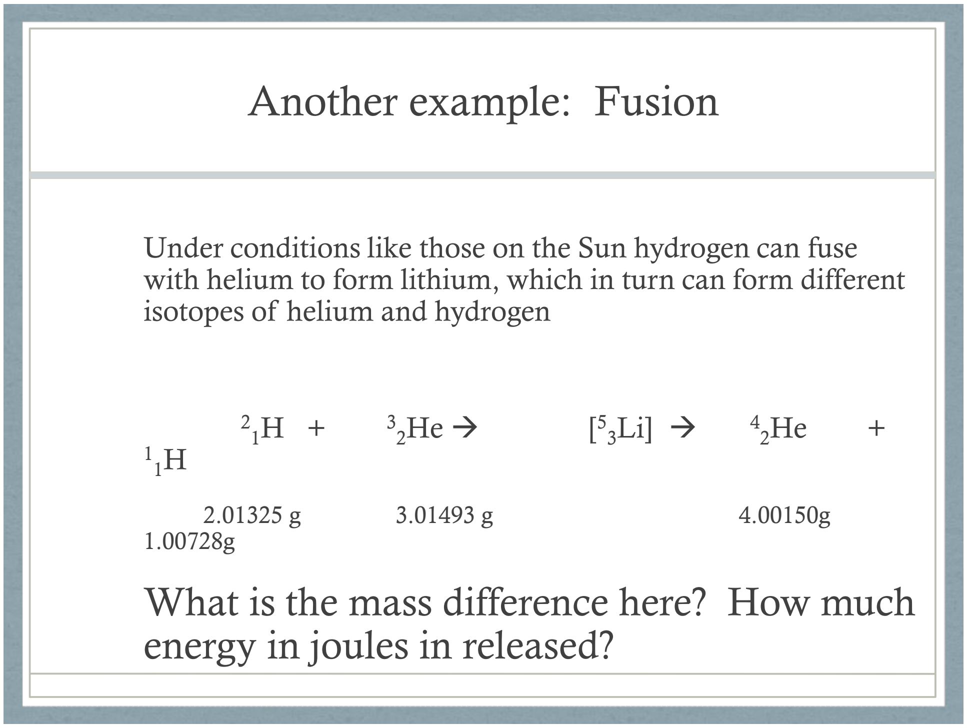
from 1 kg

TNT
(discovered in 1863 by Alfred Nobel)

trinitro toluene



1 kg of U-235, where only about 0.1% mass is converted to energy is equivalent to 33,000 tons of TNT



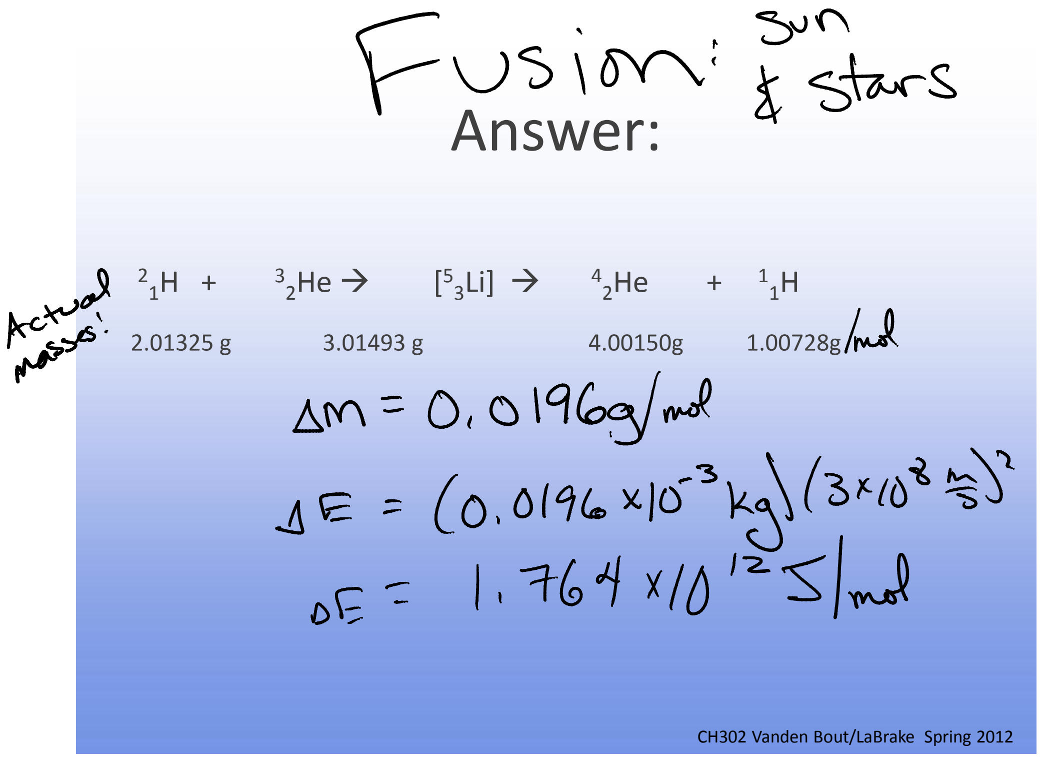
Another example: Fusion

Under conditions like those on the Sun hydrogen can fuse with helium to form lithium, which in turn can form different isotopes of helium and hydrogen

$^{2}_{1}H + {}^{3}_{2}He \rightarrow [{}^{5}_{3}Li] \rightarrow {}^{4}_{2}He + {}^{1}_{1}H$

2.01325 g 3.01493 g 4.00150g 1.00728g

What is the mass difference here? How much energy in joules in released?



Fusion: sun & stars

Answer:

Actual masses!

$^{2}_{1}H + {}^{3}_{2}He \rightarrow [{}^{5}_{3}Li] \rightarrow {}^{4}_{2}He + {}^{1}_{1}H$

2.01325 g 3.01493 g 4.00150g 1.00728g/mol

$$\Delta m = 0.0196 g/mol$$

$$\Delta E = (0.0196 \times 10^{-3} kg)(3 \times 10^{8} \tfrac{m}{s})^2$$

$$\Delta E = 1.764 \times 10^{12} J/mol$$

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What happened at Fukushima?

- Nuclear reactor was shut down too fast.
- Control rods came down, but the reactor was still very hot.
- Power went out. Cooling water stopped flowing. Reactor got hotter and hotter, uranium fuel melted, housing of fuel rods melts, reaction continues to produce enormous amount of heat, breaks down water to H_2 gas, which is very explosive.
- Fission products are mostly unstable and undergo radioactive decay

What did we learn today?

Nuclear change is different than chemical change:
    “mass” is not conserved
    type of atom is not conserved

    “mass” + “energy” is conserved
    charge is balanced across the change

Identify and balance nuclear change

$E=mc^2$