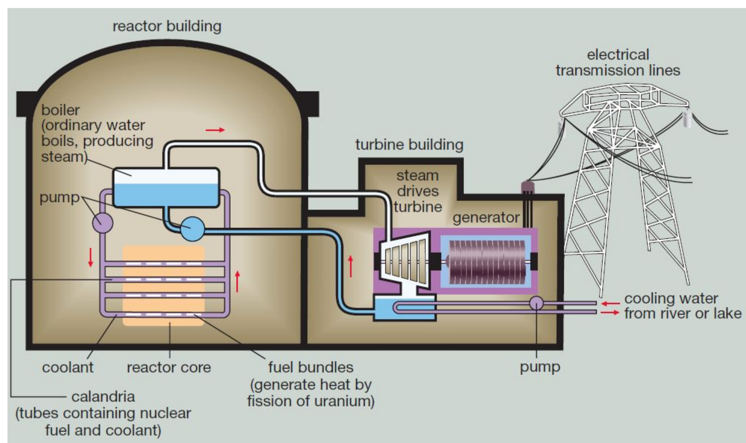
Science 30	Unit D: Energy and the Environment
Lesson 10 - Controlling Nuclear Energy	84 mins

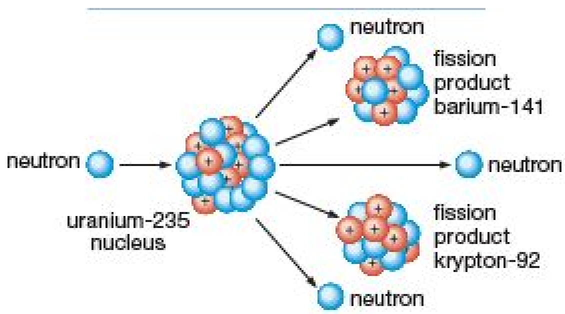
Shielding Radiation

More energy a particle has the more protection is needed. **Geiger counter**: a device that detects and measures the intensity of ionizing radiation	Weakest → Strongest Alpha* Beta* Gamma* Thinnest Shield Needed … Thickest Shield Needed Biggest … Smallest *All ionizing radiation

Nuclear Energy in Canada

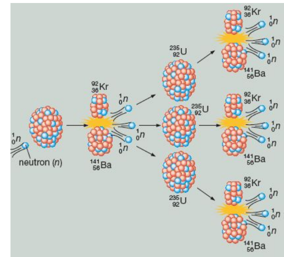
CANDU Reactor - Canadian Deuterium Uranium Reactor; a nuclear reactor technology developed in Canada and now operating in Canada and six other countries **intranuclear potential energ**y: energy stored within the nucleus of atoms	

Nuclear Fission

nuclear fission: a nuclear reaction in which a large nucleus splits into smaller nuclei or particles with the simultaneous release of energy Nuclear Fission of Uranium-235 	$${}^{235}_{92}U + {}^{1}_{0}n \rightarrow 3\,{}^{1}_{0}n + {}^{92}_{36}Kr + {}^{141}_{56}Ba$$

Controlling the Fission Reaction

- Uranium-235 requires neutrons to start a reaction.
- Uranium-235 also produces more neutrons as the reaction continues allowing for more reactions (chain reaction)
- Number of neutrons produced needs to be controlled to prevent a “meltdown” (an out of control series of fission reactions)
- CANDU uses heavy water (D_2O) to moderate the reaction



moderator: a substance of low molecular mass capable of reducing the speed of neutrons during the operation of a nuclear reactor

heavy water: water composed of two atoms of the heavier isotopes of hydrogen and one atom of oxygen

- The second method of controlling the reaction is to have the fuel be controlled, in a nuclear reactor that means having the fuel rods being able to be moved in and out of the reactor to ensure less or more fuel is available.

DRAW

Mass-Energy Equivalence - E = mc^2

- In nuclear reactions mass is being converted into energy at an amazing rate
- Einstein’s formula can show us the amounts

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

ΔE = change in energy

Δm = change in mass
= mass of products − mass of reactants

c = speed of light $(3.00 \times 10^8 \text{ m/s})$

1g of mass = 9 x 10^{13} J or 90 TJ

In the fission of 1 mol of beryllium-8, the mass of the products is determined to be 2.29 x 10^{-5} kg less than the mass of the reactants. Calculate the change in energy that corresponds with this change in mass. Identify whether this reaction is exothermic or endothermic.

Solution

$\Delta m = 2.29 \times 10^{-5}$ kg

$c = 3.00 \times 10^8$ m/s

$\Delta E = ?$

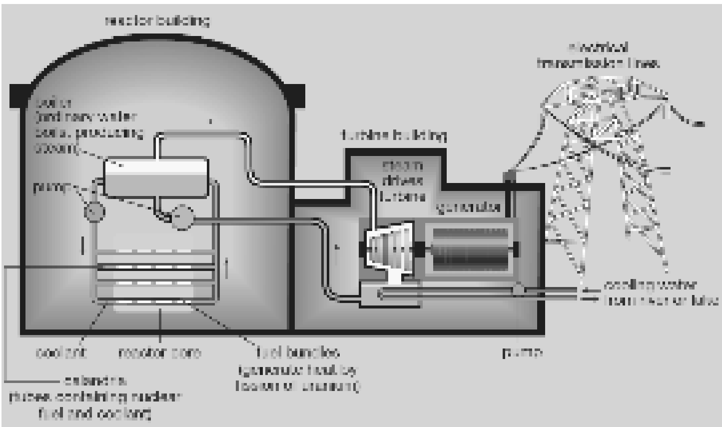
$$\begin{aligned}\Delta E &= \Delta mc^2 \\ &= (2.29 \times 10^{-5}\ \text{kg})(3.00 \times 10^8\ \text{m/s})^2 \\ &= 2.06 \times 10^{12}\ \text{kg}\cdot\text{m}^2/\text{s}^2 \\ &= 2.06 \times 10^{12}\ \text{J}\end{aligned}$$

Science 30 - Lesson 46 - Unit D - Controlling Nuclear Energy

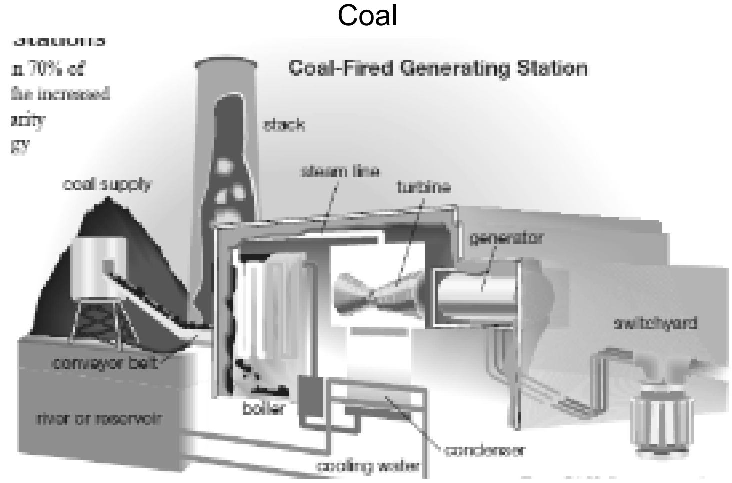
Name: ________________________________

Use the following information to answer the next question

CANDU



Coal



1) Compare these two methods of producing electricity by considering the following:
    i) energy source
    ii) form of energy in energy source
    iii) reaction used to release energy from the energy source
    iv) list of energy transformations for water during the process
    v) method of converting kinetic energy into electrical energy

2) The fission of uranium-235 can produce many different products. The following equations show one product of the fission of uranium-235. Use a balanced nuclear reaction to determine the unknown product, ${}^{A}_{Z}X$, in each reaction.
    a) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow 3{}^{1}_{0}n + {}^{A}_{Z}X + {}^{137}_{53}I$

    b) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow 3{}^{1}_{0}n + {}^{A}_{Z}X + {}^{90}_{35}Br$

3) Use the “Masses of Subatomic Particles and Radiation” table from the Science Data Booklet to calculate the change in mass between the products and the reactants. Identify whether this reaction is exothermic or endothermic.

$$^{1}_{0}n \rightarrow \, ^{0}_{-1}e + \, ^{1}_{1}p$$

4) The fission of uranium-235 that occurs in a CANDU reactor involves the following reaction.

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

Calculate the change in mass between the reactants and the products for this reaction and the corresponding energy change.