



Nuclear Power

Syll. Statements 8.4.1 – 8.4.11



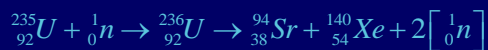
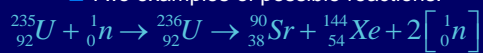
Nuclear Fuel

- Primarily involve **nuclear fission**
- **Fuel:** typically is **uranium-235**
 - Must be enriched, as the most abundant isotope of uranium found naturally is U-238
 - [Enriching Process](#)
- Before enriching
 - Natural Uranium is < 1% U-235
- After enriching:
 - Uranium is at least 3% U-235



Fission Reactions:

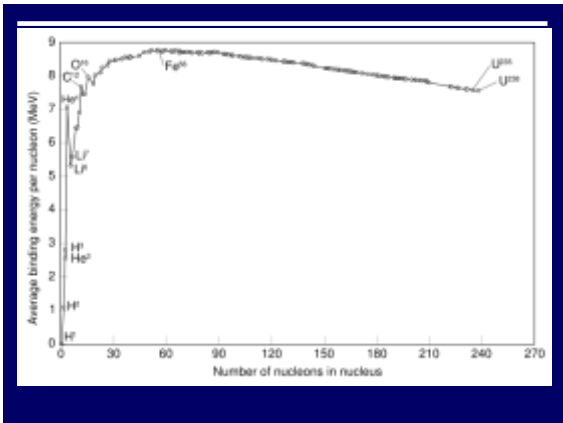
- Nuclear power plants rely on **induced fission reactions** to begin a **chain reaction** within the reactor core
- Two examples of possible reactions:



Energy released?

□ How much energy is released in one of the fission reactions that occur during chain reactions?

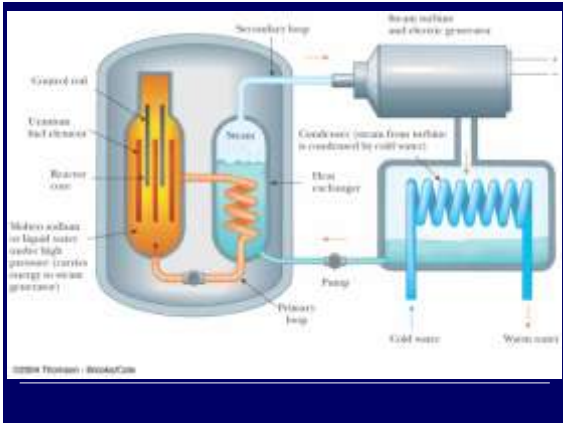
$${}_{92}^{235}\text{U} + {}_0^1\text{n} \rightarrow {}_{92}^{236}\text{U} \rightarrow {}_{38}^{94}\text{Sr} + {}_{54}^{140}\text{Xe} + 2[{}_0^1\text{n}]$$



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Nuclear Reactors

- **Moderator:** The material that surrounds the fuel rods and is used to slow down the incoming neutrons
 - **Neutrons** must have a kinetic energy of <1 eV, but are released with a KE of ~ 1 MeV during a fission reaction
- **Often**, the moderator is WATER that surrounds the fuel rods



Nuclear Reactors

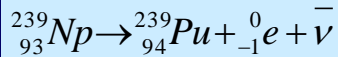
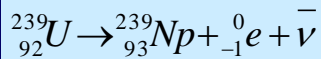
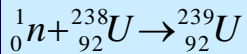
- **Control Rods**
 - A material that is able to absorb excess neutrons without becoming unstable
 - Control rods are placed in the moderator between the fuel rods whenever it is necessary to limit the number of neutrons available to impact the fuel.
 - Materials used include boron carbide, silver, indium, cadmium, and hafnium. (*according to the virtual nuclear tourist*)
- **Purpose:**
 - To ensure that the energy released in the nuclear reaction is slow and controlled

Nuclear Reactors

- Energy released in reactions:
 - Kinetic energy of neutrons released
 - Turns to Thermal energy as neutrons are slowed down in moderator
 - Coolant pulls thermal energy out of moderator, brings to heat exchanger to turn water to steam
 - Steam turns turbines, generates electricity


Plutonium

- Produced during a possible fission reaction caused by high energy (fast-moving) neutrons and Uranium-238:




Plutonium Production:

- What's the big deal?
 - Plutonium does not occur naturally
 - Uranium-238 normally not fissionable
 - High energy neutrons are able to make it fissionable
 - Plutonium IS fissionable, and can now be used as fuel in another reactor
- DISadvantage:
 - Plutonium is also used for nuclear weapons...




Nuclear Reactors--Problems

- ❑ Spent fuel and all reaction by-products are highly radioactive
- ❑ VERY long half-lives for all materials
- ❑ Possible meltdowns (significant thermal energy created during reactions...)
 - If graphite is the moderator, fires can also occur...i.e. Chernobyl, 1986
 - Increased temp. = increased pressure → steam explosions




Nuclear Meltdown

- ❑ Occurs when the temperature of the reactor core increases so significantly that the radioactive material melts and leaks from sealed containment systems into the environment
- ❑ Partial Meltdown—some of the core does not melt; the molten radioactive material does not completely enter the environment except through explosions and minor leaks
- ❑ Complete Meltdown—the entire core melts; burns through containment system; thoroughly leaks into ground below reactor



Other Nuclear Reactor Disadvantages...

- ❑ Fissionable material produced could possibly be recovered and used for weapons...
- ❑ Nuclear material (Uranium) creates Radon gas—when mining, miners are exposed to large amounts
- ❑ Mines must be closed off from direct contact with atmosphere, yet well ventilated
- ❑ Waste material from mines (excess rock that's not worth keeping because of lack of U) is still radioactive...disposal a problem




Advantages of Nuclear Energy

- High power output (enormous energy density!)
- Large reserves of nuclear fuel (i.e. Uranium ores, and already-processed enriched Uranium...)
- No greenhouse gases produced by nuclear power stations



Summary of Disadvantages

- Disposal of radioactive waste...
- "should something go wrong..."—major public health issue
- Uranium mining issues
- Nuclear weapons possibilities



Some disasters in history

- Three Mile Island: March 28, 1979
 - Partial meltdown in one of two reactors
- Chernobyl: April 26, 1986



[□ http://library.thinkquest.org/17940/texts/nuclear_disasters/nuclear_disasters.html](http://library.thinkquest.org/17940/texts/nuclear_disasters/nuclear_disasters.html)
