Nuclear Power Generation

Nuclear power is controversial. On the plus side, it does not emit carbon dioxide fumes that contribute to global warming. It is 'clean' energy. On the negative side, it does create potentially dangerous radioactive waste that needs to be contained for a very long time. There is also the fear of 'nuclear meltdown'.

Over 50% of Canada's electrical power is produced in nuclear power generating plants (Pickering). We use CANDU (Canadian Deuterium Uranium reactors) that are very safe. CANDU reactors contain fissionable fuel. That is to say, fuel that is radioactive and will undergo a fission (nuclear decomposition) reaction. Typically we use U-235. (Uranium-233, Plutonium-239 and thorium-232 are also fissionable).

Missing Mass?

Oddly, if we add up the know masses of the protons, neutrons and electrons of a given atom and compare it to the actual measured mass of the atom, there appears to be missing mass.

For example: Lithium-7 or Li-7 has a measured mass of 7.016 u (7.016 atomic units)

The total of 3(protons) + 4(neutrons) + 3(electrons) = 7.058 u

The actual Li-7 has less mass than it should!

Where did the missing mass (called 'mass defect') go? It is in the energy that binds the nucleus together. Remember Einstein determined that mass and energy are equivalent.

$$E = mc^2$$

So we have really, the **LAW OF CONSERVATION OF MASS-ENERGY**

Mass can transform into energy and energy into mass, such that the total mass-energy in an isolated system remains constant.

When U-235 decays (see p. 337 for some of the possible decay products), the bond energy/mass defect is released as energy and lots of it.

Nuclear Fuel

A CANDU reactor will use U-235 which releases neutrons as it decays. These neutrons then nudge more U-235 which also radioactively decay and so on and so on…. This causes a chain reaction to occur with lots of energy released!

Canada is a great source of uranium. We supply rods of uranium that are 99.27% U-238 (stable) and 0.72% U-235 (radioactive).

3 C's of Safety

● Containment – Reaction chamber is encased with enough concrete etc. to prevent any escape of damaging radiation. Waste is encased and often buried deep underground in old mine shafts.

●Control – Need to control the rate of reaction so it does not get out of control (meltdown). If our electricity fails, control rods drop into the reactor to slow/stop the reaction. No meltdown! Control rods are made of cadmium that absorb the neutrons (that nudge a uranium atom to react). .

●Cooling – water takes excess heat away (prevent meltdown).

Personal Safety

Workers wear badges that record the amount of radiation they are exposed to. All precautions are taken to reduce exposure but this badge monitors what exposure actually occurs.

Generating Electricity.

Simply put, the heat energy generated when uranium radioactively decays is used to heat water and create steam. This pressurized steam is used to turn a turbine which causes electrons to move. Voila! You have generated electricity.

Bond energy of uranium → electrical energy.