14.4
(from chemicdalelements.com)

Isotope	Half Life	Isotope	Half Life
U-230	20.8 days	Pu-236	2.87 years
U-231	4.2 days	Pu-237	45.2 days
U-232	70.0 years	Pu-238	87.7 years
U-233	159,000.0 years	Pu-239	24,100.0 years
U-234	247,000.0 years	Pu-240	6560.0 years
U-235	7.0004×10^8 years	Pu-241	14.4 years
U-236	2.34×10^7 years	Pu-242	375,000.0 years
U-237	6.75 days	Pu-243	4.95 hours
U-238	4.47×10^9 years	Pu-244	8.0×10^7 years
U-239	23.5 minutes	Pu-245	10.5 hours
U-240	14.1 hours	Pu-246	10.85 days

IV. More Advanced Reactors

A. *breeder reactors*

1) a *U-235 fission rxn*. (reaction)
2) *uses U-238 to absorb extra neutrons; becomes Pu-239*
3) *almost all naturally occurring U is U-238*; this makes good use of it since it is nonfissionable
4) meltdowns would be very serious since Pu-239 has a long half-life
5) France and Japan—only countries with commercial breeder reactors
   *1 g Pu = 1 ton oi*l that would be burned to produce power
6) U.S. has small, military breeders

B. fusion reactors

1) **fusion**—the joining of nuclei of two smaller atoms to form one larger atom
   - stars are nuclear reactors (sun converts H to He)
2) comments from chemist and researcher Edmund Storms:
(http://home.netcom.com/~storms2/)

- "*hot fusion*—deuterium fusion, done in plasma; results in equal quantities of tritium and neutrons
- *cold fusion* process occur in a unique solid structure without significant energy being applied; produces mainly helium with very few neutrons and occasional tritium [could theoretically run at room temp.]
  - LENR (Low Energy Nuclear Reaction), CANR (Chemically Assisted Nuclear Reaction), Condensed Matter Nuclear Science (CMNS)

Both methods [of fusion] produce large amounts of energy as heat. Therefore, both methods have the potential to provide clean energy using an essentially infinite source of fuel, although the 'cold fusion' energy is cleaner than that resulting from 'hot fusion.' As of 2005, 'hot fusion' has not achieved a controlled and sustained reaction even though over 15 billion dollars and 50 years have been applied. On the other hand, the 'cold fusion' process is not yet sufficiently well understood to be completely reproducible after about 200 million dollars and 16 years have been applied to its study."

From Wikipedia:
The field and the name "cold fusion" started in 1989 when chemists Stanley Pons of the University of Utah and Martin Fleischmann of the University of Southampton reported the production of excess heat in an electrolytic cell containing D2O "that could only be explained by a nuclear process." …A National Cold Fusion Institute was established in 1989 by the state of Utah, and eventually published a paper showing that cold fusion produces tritium, which is proof that it is a nuclear process. Their results were replicated by

some laboratories and not by others. Nevertheless, several influential physicists rejected the claims because the nuclear signatures were not consistent with those known to occur from the claimed reaction. This attitude was communicated to the general scientific profession and, even now, many professional chemists and physicists still do not believe this phenomenon exists. A few people even take the extreme position that this is an example of pseudoscience.

3) procedure
   a) "heavy hydrogen" isotopes *deuterium (D; H-2)* and *tritium (T; H-3)* are used in a *d-t reaction*
      - *T does not occur in nature* and is made in the lab - radioactive
      - *D can be extracted from seawater* – heavy but not radioactive
   b) fusion requires 3,000,000 °C as well as high pressure—usually *ignited by a fission reaction*!
4) problems
   a) would use too much energy to get started
   b) how to contain the hydrogen at such high temps without the structure itself disintegrating
5) possible techniques
   a) Tokamak design, using a magnetic field
   b) laser fusion, using frozen hydrogen
   c) Z machine, using electricity
6) ITER: International Thermonuclear Explosion Reactor
   a) international project involving China, the European Union and Switzerland, Japan, the Republic of Korea, the Russian Federation, and the U.S.
   b) to be built in France
   c) hydrogen plasma at over 100 million °C
   d) will produce 500 MW of fusion power
   e) technically ready to start construction and the first plasma operation is expected in 2016

14.5

V. The Future of Nuclear Power

A. Opposition, more than ever
   1) many countries phasing it out (China, Japan, S. Korea, India still developing it)
   2) fear of accidents
   3) distrust of bureaucratic procedures and safety regulations
   4) cost: most expensive method of energy generation to produce and maintain
   5) short life of equipment
   6) nuclear waste disposal issues
   7) addressing our needs: nuclear power produces electricity, not fuel like oil used for transportation

B. rebirth and revitalization?
   8) use more small ALWR reactors with safety protocols
   9) phase out custom-built large reactors
   10) put new reactors on the sites of old reactors
   11) revisit guidelines for proving sites safe for 100,000 years
   12) strong leadership