Class Reminders:

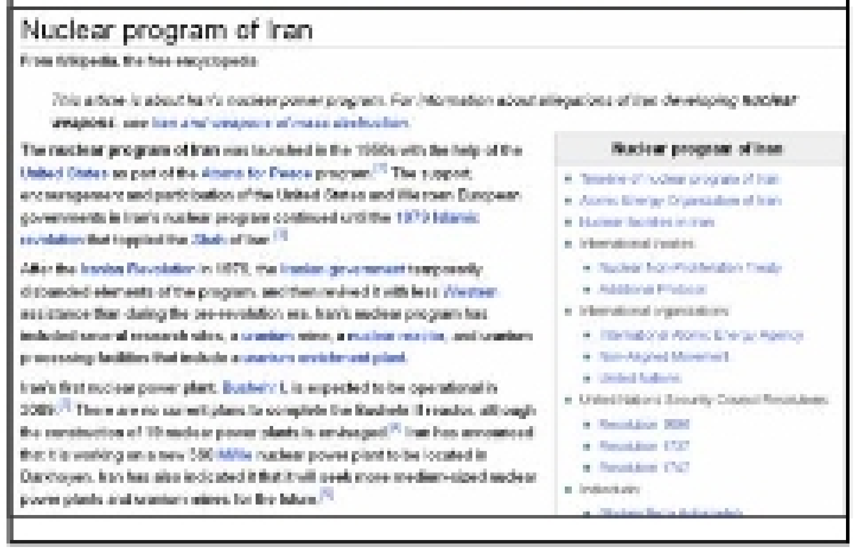
- Research Project #1 due in class on Friday, October 31
- Homework #6 now available, due next Wednesday
- Extra Credit #5 due November 7 (reminder)

Upcoming Panel Discussion: "Do we Need a "Manhattan/Apollo Project" To Solve the Energy/Climate Problem?"

Thursday, October 30
7:00 PM - 9:00 PM
CU-Boulder, Eaton Humanities Room 150
Free and Open to the Public
View Flyer: http://sciencepolicy.colorado.edu/outreach/ecc2_flyer.pdf

- Read all of Chapter 6

Question on Nuclear Energy Production in Iran…

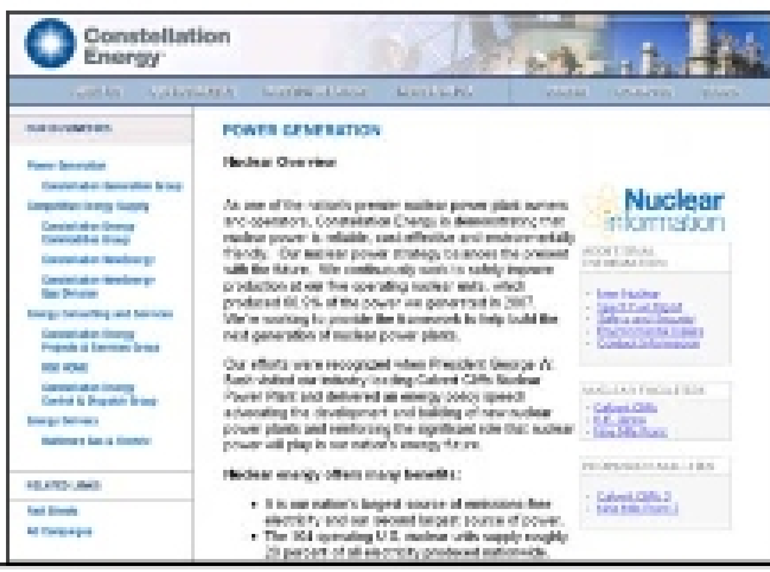

Nuclear program of Iran

From Wikipedia, the free encyclopedia

The nuclear program of Iran was launched in the 1950s with the help of the United States as part of the Atoms for Peace program.

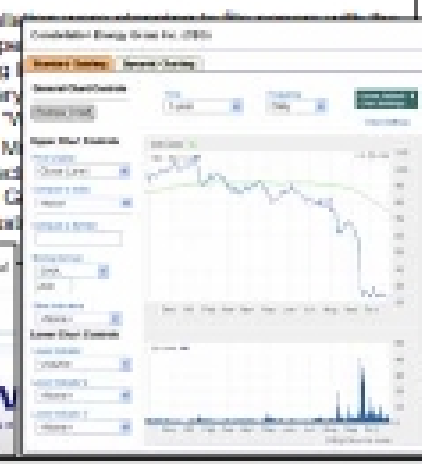
Nuclear program of Iran

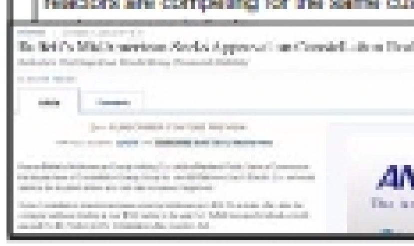
What is the future of nuclear energy?



What is the future of nuclear energy?

"EDF is concerned that Mr. Buffett's ownership of Constellation, through Berkshire Hathaway Inc., could jeopardize a joint venture the French company has with Constellation to construct nuclear plants in the U.S. using nuclear technology developed by Paris-based Areva SA.
Mr. Abel said MidAmerican and Constell…
U.S. Nuclear Regulatory Commission, pe…
permission to transfer nuclear-operating …
MidAmerican. He added his team is "very…
Constellation's nuclear plans and said, "V…
One reason for EDF's concern may be M…
General Electric Co. stake. General Elect…
designs in partnership with Hitachi Ltd. G…
reactors are competing for the same cus…





Three Mile Island

Advantages:

- No CO_2 emissions → Small impact on global warming
- No SO_2, CO, NOx, particulates, etc.
- Basically (air) pollution free.

- Less radiation leakage in normal operation than coal burning.
- Safety record in US better than fossil fuels (despite 3 Mile Island).

- Uranium relatively abundant, relatively inexpensive.
- Quantity needed to mine is relatively small (compared to coal).

Recall "R/P" = resource amount / current production rate
~ "simple time to end"

It is about R/P ~ 150 years for Uranium fuel.
"Breeder" reactor technology would extend that to 1000's of years.

Clicker Question

How long will our (US) Uranium reserves last if we ramp up nuclear energy to cover all our electrical needs, using present reactor technology?

A) 30 years
B) 300 years
C) 1000 years
D) 5000 years
E) Even longer than that.

Using current extraction technologies, about 30 years.
R/P ~ 150 but we only get about 20% of electrical from nuclear.
If we can figure out how to efficiently get U from sea water, there's quite a bit there, the supply would last 100's of years then. (It'd be more expensive than it is now, but by less than a factor of 10, so this may happen some day!)
Breeder reactors may be necessary.

Disadvantages:

- Public fears
- "New" technology, hard to understand, unknown risks

- Catastrophic failure can have severe consequences
- Radioactive waste disposal (how and where?)

- Nuclear weapon proliferation (fuel and waste can be reprocessed for bombs).

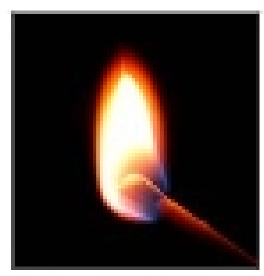
- Reactor construction costs more than coal burning plant (in the USA currently). Decommissioning is expensive.

Nuclear Physics

What are atoms? What are nuclei?

Atoms are made of a central nucleus (composed of protons and neutrons). These protons and neutrons are bound together by the strong force (also called the nuclear force).

In "orbit" around the nucleus are electrons. These electrons have a negative electrical charge and are thus attracted ("bound") to the nucleus (which has positive charge) by the electric force.



Chemical Reactions involve atomic electrons.

Typical energy per reaction ~ 10^{-18} Joules (or 10 eV)

Nuclear Reactions involve the nucleus.

Typical energy per reaction ~ 10^{-11} Joules (or 200 MeV)

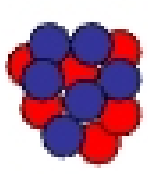
Nine orders of magnitude difference in energy !

Nuclear Notation

Z = "atomic number" = # of protons

N = "neutron number" = # of neutrons

A = N+Z = "atomic mass number"



Example = Carbon

Z = 6 protons
N = 6 neutrons
A = 12 protons + neutrons

$$^{A}_{Z}U_{N} \Rightarrow {}^{12}_{6}C_{6}$$

Note there are other "isotopes" of carbon. These have similar chemical properties (same electron configuration), but just a different number of neutrons in the nucleus.

Discoveries

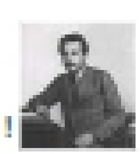
The basic pieces of the atom were discovered in the early 20th century.

1897 – Discovery of the electron

1911 – Discovery of the nucleus (i.e. proton)

1932 – Discovery of the neutron

On the same time scale in history, radioactivity was discovered.



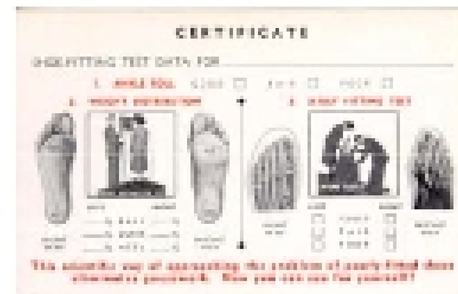
Also, in 1905 Einstein related mass to energy $E=mc^2$!

X-Ray!

At the time, there were many strange phenomena observed. They did not know what these things really were (e.g. particles, light, other…).

Interesting names (α particle, β ray, X-ray, …)

X-ray's to see how well the bones in your foot fit into that new shoe.



Marie Curie discovered "radium" (a new element at that time, and it was naturally radioactive or unstable).

In 1938, Lise Meitner discovered that Uranium nuclei spontaneously fission (split into smaller pieces).

Interestingly she did not get the Nobel Prize for this discovery. It went to Otto Hahn?

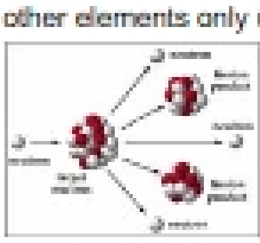
Another notable item is that the radiation many of these people were using was also killing them. Health impact were not understood at the time.

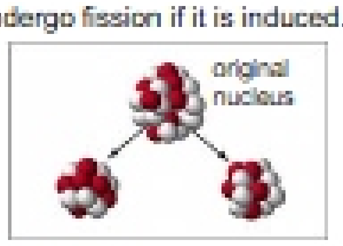
Clicker Question

Fission!

Some isotopes of elements are inherently unstable and will just spontaneously split after some amount of time.

Some other elements only undergo fission if it is induced.



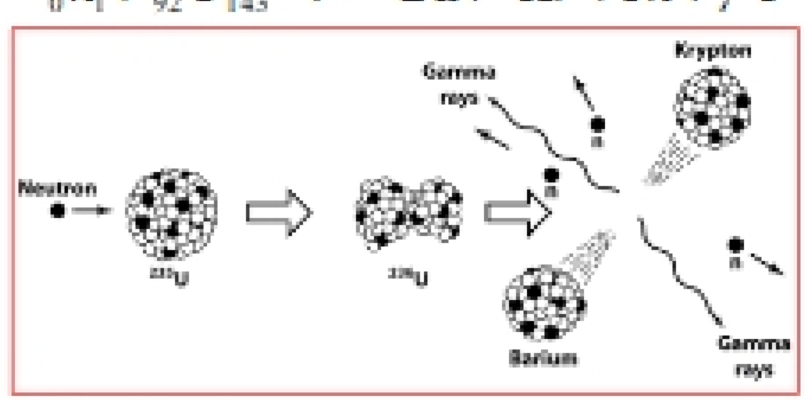


Which of the following are true?

A) The left figure is of spontaneous fission
B) The right figure is of spontaneous fission
C) Both figures are induced fission
D) Both figures are spontaneous fission

Induced Fission

$$ {}^{1}_{0}n_{1} + {}^{235}_{92}U_{143} \Rightarrow {}^{144}Ba + {}^{89}Kr + 3n + \gamma's $$



Neutron = n
Gamma rays = γ = photons or electromagnetic energy (light).