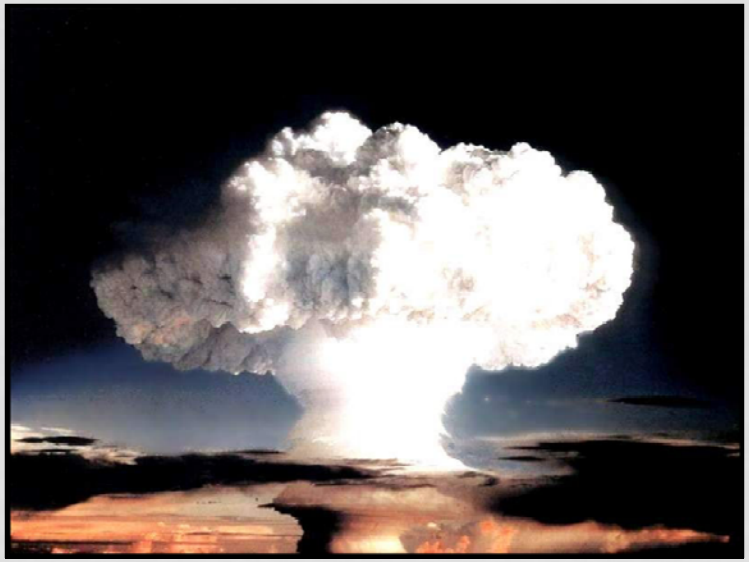


NUCLEAR REACTIONS

7.3

PREVIEW QUESTIONS

- Nuclear powerplants are safe.

PREVIEW QUESTIONS

- Nuclear powerplants are better than powerplants that burn fossil fuels.

PREVIEW QUESTIONS

- Nuclear powerplants could easily blow up

PREVIEW QUESTIONS

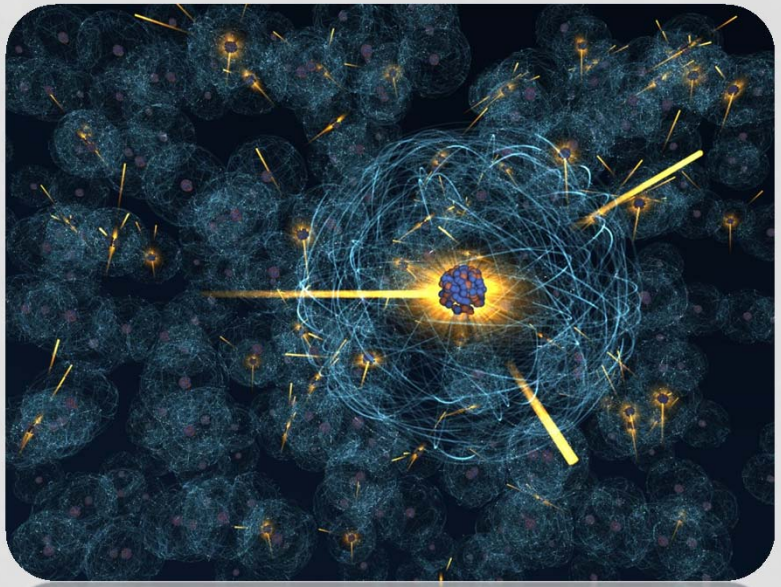
- Nuclear waste will break down in the next 10 000 years

VOCABULARY

- Chain reaction
- Fission
- Fusion
- Nuclear equation
- Nuclear reaction

NUCLEAR REACTIONS

- Nuclear fission and fusion are processes that involve extremely large amounts of energy.
  - Fission = the splitting of nuclei
  - Fusion = the joining of nuclei



See page 312

NUCLEAR REACTIONS

- Nuclear power plants can generate large amounts of electricity.
  - Ontario, Quebec and New Brunswick currently generate nuclear power.
  - Canadian-made nuclear reactors are called CANDU reactors.
    - CANDU reactors are considered safe and effective and are sold throughout the world.
- Video

The Bruce Nuclear Generating Station on the shore of Lake Huron, in Ontario

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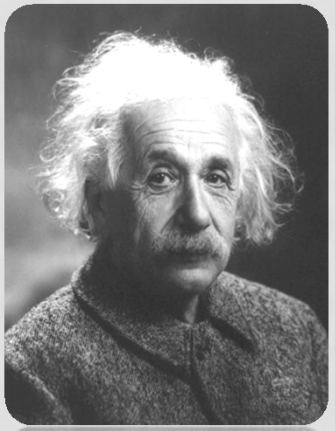
- Video
- Video 2

The Bruce Nuclear Generating Station on the shore of Lake Huron, in Ontario

NUCLEAR FISSION

- Nuclear energy used to produce power comes from fission.
  - Nuclear fission is the splitting of one heavy nucleus into two or more smaller nuclei, some sub-atomic particles, and energy.
  - A heavy nucleus is usually unstable, due to many positive protons pushing apart.
  - When fission occurs:
    1. Energy is produced.
    2. Neutrons are released.

Video explaining Nuclear Fission



Albert Einstein's famous equation $E = mc^2$ illustrates the energy found in even small amounts of matter

See pages 313 - 314

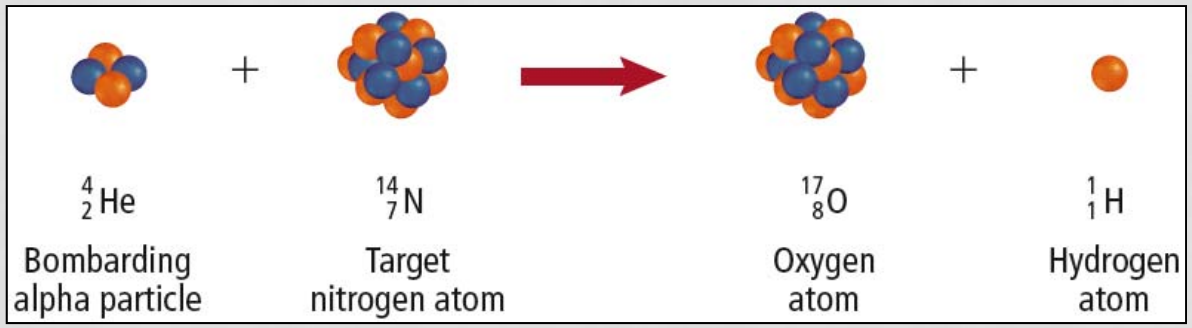
NUCLEAR FISSION

- Nuclear reactions are different than chemical reactions.
  - In chemical reactions, mass is conserved, and energy changes are relatively small.
    - There are no changes to the nuclei in chemical reactions.
  - In nuclear reactions, the actual nucleus of atoms changes.
    - Protons, neutrons, electrons, and/or gamma rays can be lost or gained.
    - Small changes of mass = huge changes in energy

See pages 313 - 314

NUCLEAR EQUATIONS FOR INDUCED NUCLEAR REACTIONS

- Natural radioactive decay consists of the release of alpha, beta and gamma radiation.
  - Scientists can also create nuclear reactions by smashing nuclei with alpha, beta and gamma radiation.



$$^{4}_{2}\alpha + {}^{14}_{7}\mathrm{N} \rightarrow {}^{17}_{8}\mathrm{O} + {}^{1}_{1}p$$

or

$$^{4}_{2}\mathrm{He} + {}^{14}_{7}\mathrm{N} \rightarrow {}^{17}_{8}\mathrm{O} + {}^{1}_{1}\mathrm{H}$$

See pages 314 - 315

NUCLEAR EQUATIONS FOR INDUCED NUCLEAR REACTIONS

- The rules for writing these equations are the same as earlier nuclear equations
  - Mass numbers must equal on both sides of the equation
  - Charges must equal on both sides of the equation

Table 7.9 Subatomic particles in nuclear reactions

Particle (symbol)	Also known as
proton ($_1^1p$)	hydrogen-1 nucleus ($_1^1H$)
neutron ($_0^1n$)	---
helium nucleus ($_2^4He$)	alpha particle ($_2^4\alpha$)
electron ($_{-1}^0e$)	beta particle ($_{-1}^0\beta$)

See pages 314 - 315

NUCLEAR FISSION OF URANIUM-235

- It is much easier to crash a neutral a neutron than a positive proton into a nucleus to release energy.
  - Most nuclear fission reactors and weapons use this principle.
  - A neutron, ${}_{0}^{1}n$, crashes into an atom of stable uranium-235 to create unstable uranium-236, which then undergoes radioactive decay.

Caused by Uranium

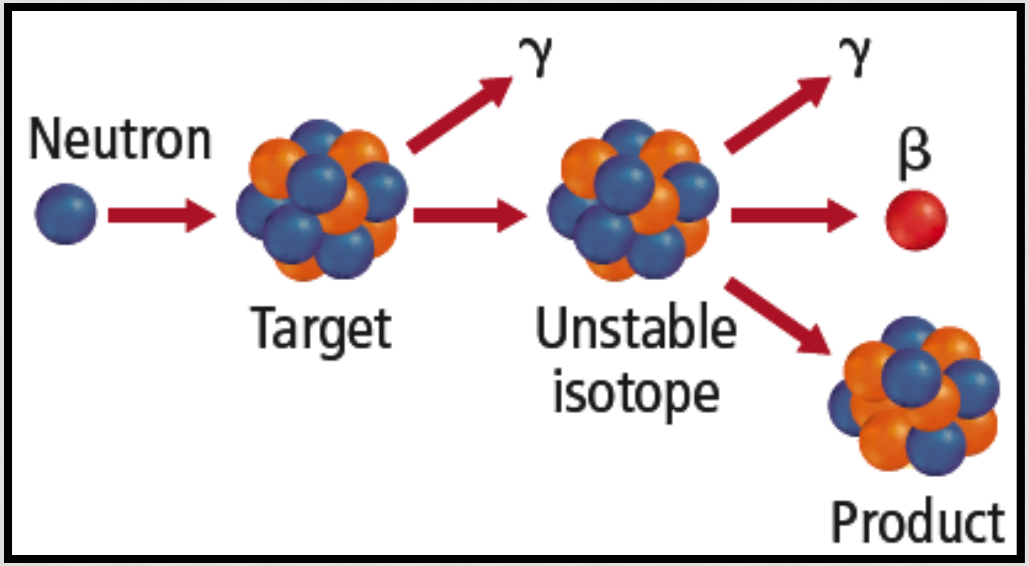
See pages 316 - 317

NUCLEAR FISSION OF URANIUM-235

- After several steps, atoms of krypton and barium are formed, along with the release of three neutrons and huge quantities of energy.

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

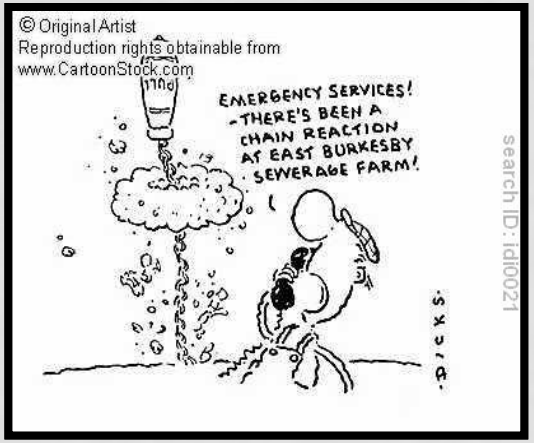
The induced nuclear fission of uranium-235. This nuclear reaction is the origin of nuclear power and nuclear bombs.



See pages 316 - 317

CHAIN REACTIONS

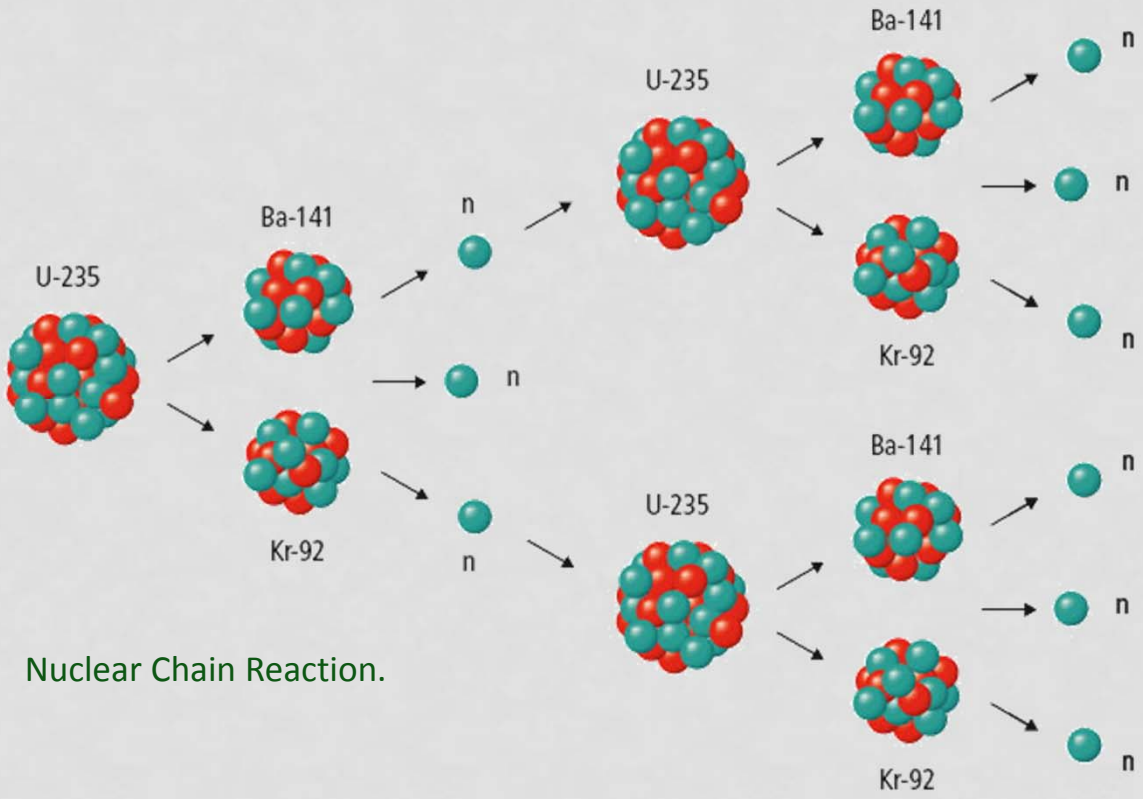
- Once the nuclear fission reaction has started, it can keep going.
  - The neutrons released in the induced reaction can then trigger more reactions on other uranium-235 atoms.
  - This chain reaction can quickly get out of control.
    - Fermi realized that materials that could absorb some neutrons could help to control the chain reaction.
  - Nuclear reactors have complex systems to ensure the chain reaction stays at safe levels.



See page 318

CHAIN REACTIONS

- An uncontrolled chain reaction can result in a violent nuclear explosion.
  - Nuclear bombs are created using this concept.

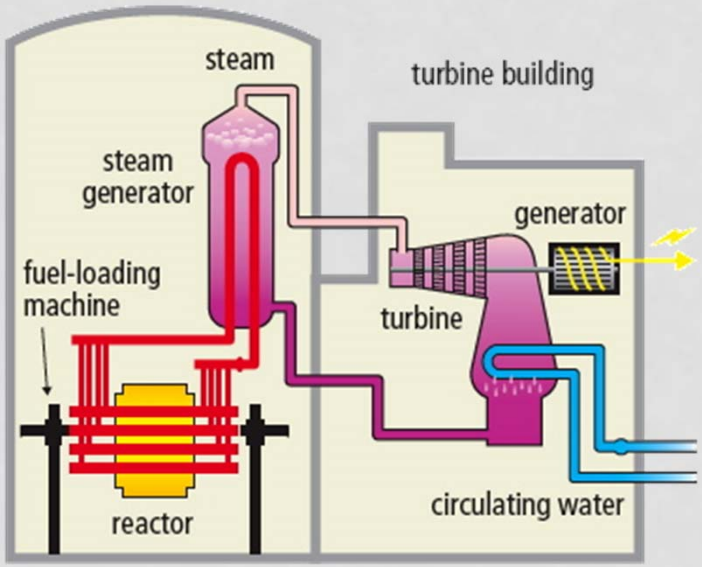


Nuclear Chain Reaction.

See page 318

CANDU REACTORS AND HAZARDOUS WASTE

- Canada's nuclear research into the safe use of nuclear reactions has resulted in the creation of CANDU reactors.
  - CANDU reactors are found in various countries around the world.
    - Canada, South Korea, China, India, Argentina, Romania and Pakistan
  - The reactors are known to be safe and easy to shut down in an emergency.
    - Heat energy produced turns electricity-generating turbines.
- CANDU Reators



Inside a CANDU reactor.

See pages 319 - 320

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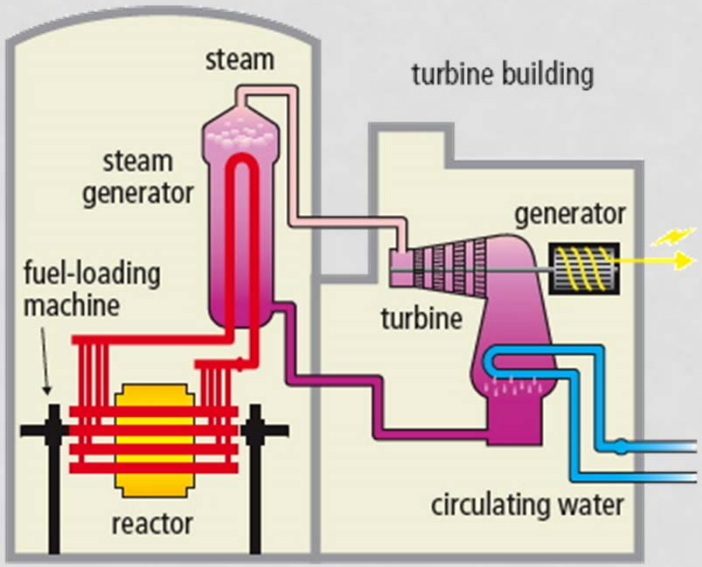


Inside a CANDU reactor.

See pages 319 - 320

CANDU REACTORS AND HAZARDOUS WASTE

- Hazardous wastes produced by nuclear reactions are problematic.
  - Some waste products, like fuel rods, can be re-used.
  - Some products are very radioactive, however, and must be stored away from living things.
    - Most of this waste is buried underground or stored in concrete.
    - It will take 20 half-lives (thousands of years) before the material is safe.

See pages 319 - 320

NUCLEAR FUSION

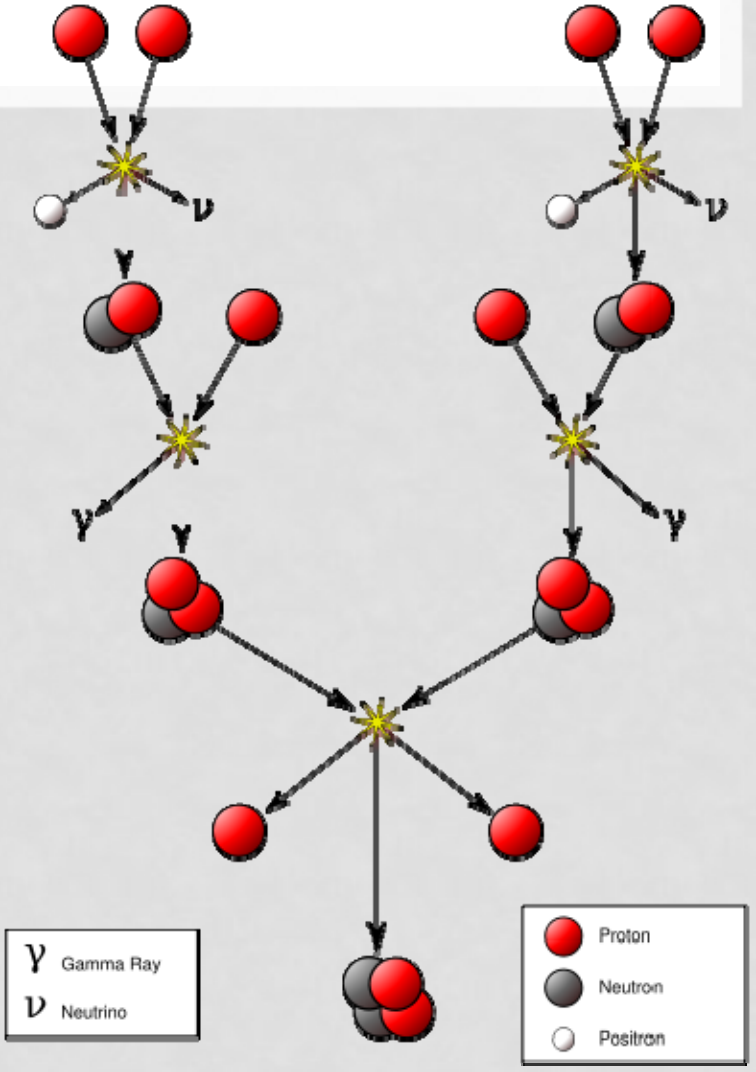
- Nuclear fusion = joining of two light nuclei into one heavier nucleus.
  - In the core of the Sun, two hydrogen nuclei join under tremendous heat and pressure to form a helium nucleus.
  - When the helium atom is formed, huge amounts of energy are released.

$$ {}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}n + \text{energy} $$

See pages 320 - 321

NUCLEAR FUSION

- Scientists cannot yet find a safe, manageable method to harness the energy of nuclear fusion.
  - So-called "cold fusion" would occur at temperatures and pressures that could be controlled.



The fusion of hydrogen nuclei

See pages 320 - 321

SUMMARY

- Nuclear reactions involve the splitting of heavy nuclei (fission) or the joining together of lightweight nuclei (fusion), both of which can release large amounts of energy.
- Radioactive decay, fission, and fusion reactions can be symbolized using nuclear equations.