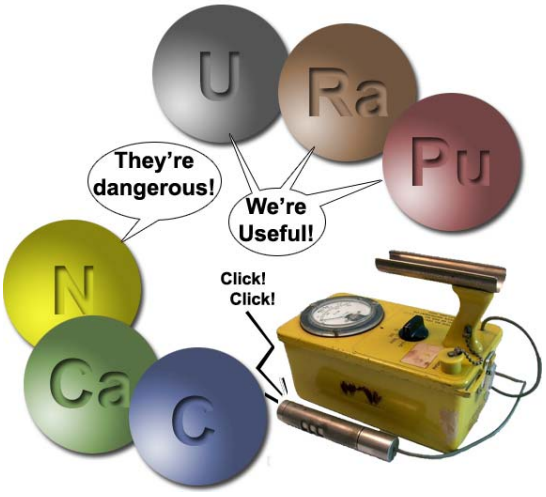
Uses of Radiation

Radiation is both useful and dangerous. The danger is caused by the fact that radioactive emissions are high energy and can ionize atoms they contact. Ionizing radiation damages cells causing burns, rashes, or cancer. Damage to reproductive cells can cause genetic defects. As a result it is important to be able to detect radiation. The tool used for detecting radiation is a Geiger counter. A Geiger counter is a hollow negatively charged cylinder filled with argon gas. It has a positive wire in the center and a thin window through which radiation passes. The radiation ionizes the argon gas. The ions are attracted to the electrodes where they create an electric pulse which is amplified to an audible click.

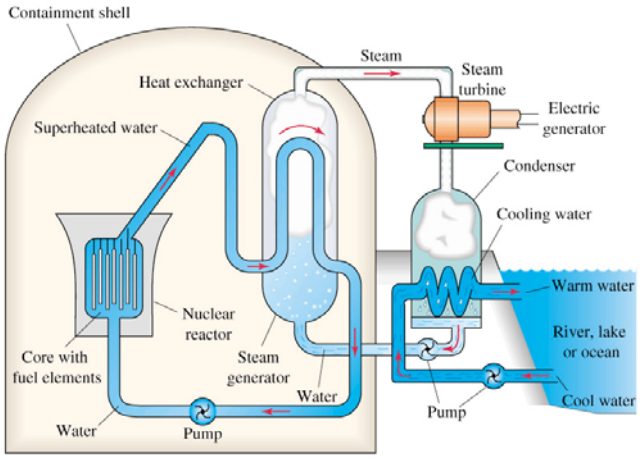


Xenophobia among atoms.

Radioactive isotopes, or radioisotopes, of different elements have a wide variety of uses depending on their chemical activity, their radioactive properties, and their half-lives. Radioisotopes can be used as tracers because radioactivity has no effect on chemical behavior. P-31 in fertilizer is used to trace uptake of phosphorus by plants. C-14 is used to map the path of carbon in metabolic processes. Radioisotopes with short half lives that concentrate in certain organs are administered as tracers. Tc-99 is used for location of tumors. I-131 is used for detection and treatment of thyroid disturbances because the thyroid gland uses iodine. Some cancer therapies depend on radiation because malignant cells are more sensitive to radioactivity than normal cells. Gamma radiation from cobalt 60 can be aimed at cancerous tumors. Gamma radiation can also destroy bacteria, yeasts, molds, and insect eggs, so it is used in food preservation. Radiation intensity decreases as radiation passes through matter, so it can be used to measure the thickness of industrial products.

Radioactive dating depends on the characteristic of radioactive substances known as half-life. Carbon dating is used to measure the age of fossils of living things fro the not too distant past. Carbon-14 is radioactive and has a half life of 5,730 years. Carbon dioxide in the air contains carbon-14. Plants take in carbon dioxide and make carbohydrates as long as they are alive. Animals eat plants as long as they are alive. Each gram of carbon in a living organism emits about 15 disintegrations per minute (dpm). As soon as an organism dies, it stops taking in carbon, so its amount of C-14 begins to decrease as does the number of dpm. A reading of 7 dpm/g of carbon indicates an age of about 5700 y. Uranium dating is useful for measuring the age of very old rocks. Uranium-238 is radioactive and has a half life of 10^9 years. Uranium-238 is found in igneous rock and decays into lead-206. After the rock cools, the amount of uranium-238 in the rock begins to decrease and the amount of lead begins to increase. The fraction of uranium left can be determined by comparing its mass to the mass of the lead. Then the number of half lives elapsed and the age can be determined.

One of the more important uses of radioactivity is nuclear energy. A **Nuclear reactor (fission reactor)** converts nuclear energy into heat energy which can then be used to generate electricity. The fuel for a nuclear reactor is usually U-235. It is found in the core. A nuclear reactor needs a moderator, a substance that slows neutrons down without absorbing them, in order to increase the chance of collision between the neutrons and the U-235 nuclei. Hydrogen, deuterium, water, heavy water, beryllium and graphite are used as moderators. The coolant keeps the system from overheating. Control rods made of boron or cadmium steel absorb neutrons controlling the rate of fission. Shielding provides protection from radiation damage.



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Answer the questions that follow based on your reading and on your knowledge of chemistry.

1. Why is radiation dangerous? _____

2. How is it possible to tell if dangerous radiation is leaking into the environment from a radioactive source? _____

3. Phosphorous is used by living things to make DNA, RNA, and ATP:
   a. Does radioactive phosphorous influence the functioning of these compounds? Explain. _____
   b. Explain how scientists showed that viruses hijacked cells with their DNA or RNA and not with their protein. _____

4. Radiation is more readily absorbed by actively growing cells. How is this both useful and dangerous? _____

5. Why is uranium better for radioactive dating of older things than carbon–14? If living things don't absorb uranium, how might uranium be used to find the age of very old fossils? _____

6. How do nuclear power plants provide energy? _____

7. Based on your understanding of radioactivity, what are some pontential problems associated with nuclear energy? _____