Positives & Negatives of Nuclear Chemistry

Gallery Walk Activity

This activity allows students to ponder the pros and cons within the field of nuclear chemistry. Included are ten mini-posters (1 page each) that cover the following topics:
Chernobyl accident, Three Mile Island accident, Fukushima accident, Atomic Bomb of Hiroshima, Atomic Bomb of Nagasaki, Nuclear Power in Spacecraft, Radioisotopes in Medicine, Nuclear Submarines, Carbon Dating, Nuclear Power Plants

I set this up as a "gallery walk" around my classroom and have students take their answer sheet and silently walk around to read each poster and fill in their sheet. If you can print in color and laminate these posters, you will have a nice product to use year after year.

Afterwards, we discuss reactions to the nuclear incidents and to the ways in which nuclear energy and radioactivity are used in technology important to our everyday lives.

This could work as part of a nuclear chemistry unit, or as a way to get the point across in a one or two-period activity.

If you'd like to get your students involved in researching some of these topics in more detail, please have a look at my Nuclear Chemistry Class Blog Research Project!

Sources:
- World-nuclear.org
- education.nationalgeographic.com
- Atomicheritage.org
- PhysLink.com
- Duke-energy.com

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Chernobyl

1986

Power Plant Disaster

On April 26, 1986, the Chernobyl Nuclear Power Station in the Soviet Union (present-day Ukraine) exploded. This incident is considered the worst nuclear accident in history. Chernobyl had four nuclear reactors, each producing 1,000 megawatts of electric power. On the day of the accident, workers in Reactor 4 attempted a test of an emergency cooling procedure. The reactor experienced a huge power surge. When workers tried to shut down the reactor, it resulted in an even larger power surge. Soon after, several large explosions turned into a fireball that eventually blew off the lid of the reactor. This released enormous amounts of radioactive material into the atmosphere—several times more than that of the atomic bombs dropped on Japan during World War II.

The citizens of the nearby town of Prypyat were evacuated the day after the accident, but it was too late for the radioactive toxins to be captured. The radioactive material was spread by the wind and stretched as far as France and Italy. In addition to causing the deaths of 32 people, the Chernobyl accident had many serious and life-threatening effects. Civilians suffered from radiation sickness, and in the years following the accident, thousands of radiation-induced illnesses were identified; many people died of cancer. The explosion created a cloud of radioactive particles that fell to the ground, called fallout. The fallout drifted with the wind and entered the water cycle as rain. Radioactivity traced to Chernobyl fell as far away as Scotland and Ireland, although most fallout was detected in Belarus. Millions of hectacres of forest and farmland were contaminated, causing deformities and short-term life spans in farm animals. Although several of the units at Chernobyl remained active until 2000, the nuclear power plant is now officially shut down.

Three Mile Island

1979

Power Plant
Disaster

On March 28, 1979, the Three Mile Island nuclear power plant near Middleton, Pennsylvania, had a partial meltdown. The meltdown was linked to both human error and technical failures. The accident released minute amounts of radioactive materials into the environment, and threatened the health and safety of people living near the plant. Ultimately, state and federal officials evacuated the most at-risk populations from the area and the accident did not cause any injuries or deaths.

The incident at Three Mile Island caused many people to question the safety of nuclear energy. Since the incident, no new nuclear power plants have been built in the U.S.

Fukushima

2011

Power Plant
Disaster

On March 11, 2011, following a major earthquake, a 15-meter tsunami disabled the power supply and cooling of three Fukushima Daiichi reactors in Japan, causing a nuclear accident. All three cores largely melted in the first three days. After two weeks the three reactors were stable with water addition but no proper heat sink for removal of decay heat from the fuel.

By July they were being cooled with recycled water from the new treatment plant. Reactor temperatures had fallen to below 80ºC at the end of October, and official 'cold shutdown condition' was announced in mid-December. Apart from cooling, the basic ongoing task was to prevent release of radioactive materials, particularly in contaminated water leaked from the three units. This task became newsworthy in August 2013.

There have been no deaths or cases of radiation sickness from the nuclear accident, but over 100,000 people had to be evacuated from their homes to ensure this. Government nervousness delays their return.

Hiroshima

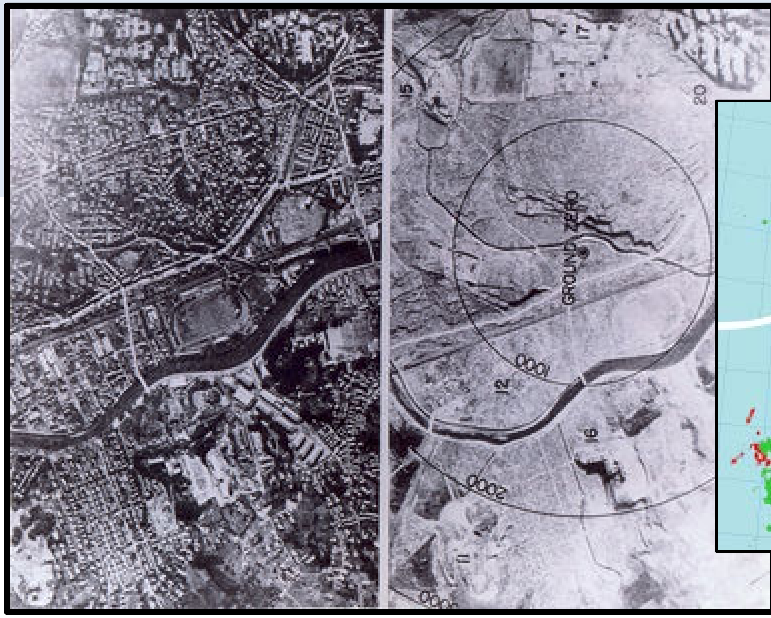
1945

Atomic Bomb

On August 6, 1945, the United States dropped its first atomic bomb on the city of Hiroshima, Japan. The bomb was known a "Little Boy", a uranium gun-type bomb that exploded with about thirteen kilotons of force. At the time of the bombing, Hiroshima was home to 280,000-290,000 civilians as well as 43,000 soldiers. Between 90,000 and 166,000 people are believed to have died from the bomb in the four-month period following the explosion. The U.S. Department of Energy has estimated that after five years there were perhaps 200,000 or more fatalities as a result of the bombing, while the city of Hiroshima has estimated that 237,000 people were killed directly or indirectly by the bomb's effects, including burns, radiation sickness, and cancer.

Nagasaki

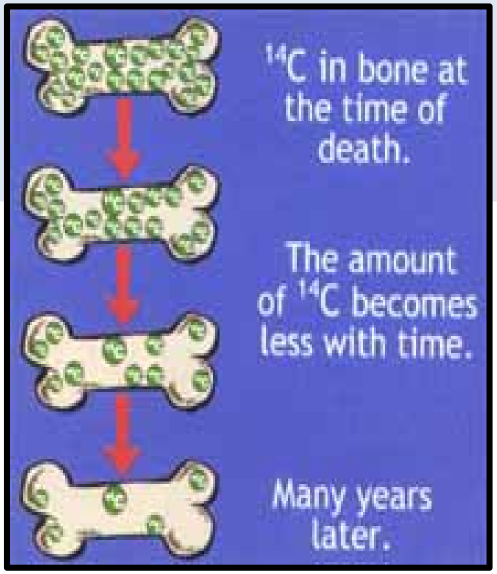
1945



Atomic Bomb

Three days after the United States dropped an atomic bomb on Hiroshima, Japan, a second atomic bomb was dropped on Nagasaki, Japan on August 9th; it was a 21-kiloton plutonium device known as "Fat Man". On the day of the bombing, an estimated 263,000 were in Nagasaki, including 240,000 Japanese residents, 9,000 Japanese soldiers, and 400 prisoners of war. Prior to August 9, Nagasaki had been the target of small scale bombing by the United States. Though the damage from these bombings was relatively small, it created considerable concern in Nagasaki and many people were evacuated to rural areas for safety, thus reducing the population in the city at the time of the nuclear attack. It is estimated that between 40,000 and 75,000 people died immediately following the atomic explosion, while another 60,000 people suffered severe injuries. Total deaths by the end of 1945 may have reached 80,000.

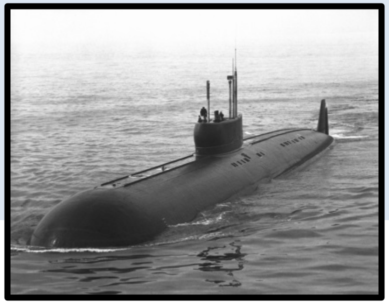
Carbon Dating



Radio carbon dating determines the age of ancient objects by means of measuring the amount of carbon-14 that is left in an object. A man named Willard F. Libby pioneered it at the University of Chicago in the 1950s. In 1960, he won the Nobel Prize for Chemistry. This is now the most widely used method of age estimation in the field of archaeology.

Certain chemical elements have more than one type of atom. Different atoms of the same element are called isotopes. Carbon has three main isotopes. They are C-12, C-13, and C-14. Carbon-14 is radioactive and it is this radioactivity which is used to measure age. Half of the available atoms of Carbon-14 in a dead organism decay into Nitrogen-14 over a period of 5,730 years. For example, This means that given a statistically large sample of carbon 14, we know that if we sit it in a box, go away, and come back in 5730 years, half of it will still be carbon 14, and the other half will have decayed.

So, if we have a box, and we don't know how old it is but we know it started with 100 C-14 atoms (this is figured out by the overall ratio of C-14 to C-12 atoms within Earth's atmosphere), and we open it and find only 50 C-14 atoms, we could say, 'Aha! It must be 1 Carbon-14 half-life (or 5730 years) old!' This is the basic idea behind carbon dating.



Nuclear Submarines

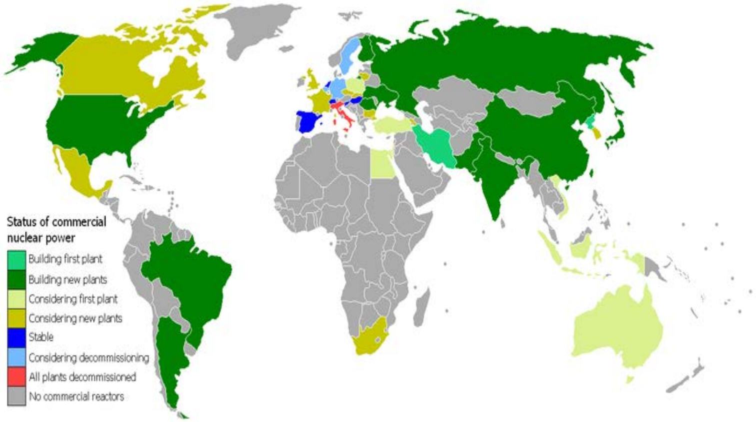
Nuclear power is particularly suitable for vessels which need to be at sea for long periods without refueling, or for powerful submarine propulsion. Work on nuclear marine propulsion started in the 1940s, and the first test reactor started up in USA in 1953. The first nuclear-powered submarine, USS Nautilus, put to sea in 1955. This marked the transition of submarines from slow underwater vessels to warships capable of sustaining 20-25 knots submerged for weeks on end.

By 1962 the US Navy had 26 nuclear submarines operational and 30 under construction. Nuclear power had revolutionized the Navy. The technology was shared with Britain, while French, Russian and Chinese developments proceeded separately. At the end of the Cold War, in 1989, there were over 400 nuclear-powered submarines operational or being built. Russia and the USA had over one hundred each in service, with UK and France less than twenty each and China had six. The total today is understood to be about 120, including new ones commissioned. Most or all are fuelled by high-enriched uranium.

In the future, constraints on fossil fuel use in transport may bring marine nuclear propulsion into more widespread use. So far, exaggerated fears about safety have caused political restrictions.

Nuclear Power Plants

In a nuclear-fueled power plant – much like a fossil-fueled power plant – water is turned into steam, which in turn drives turbine generators to produce electricity. The difference is the source of heat. At nuclear power plants, the heat to make the steam is created when uranium atoms split – called fission. There is no combustion in a nuclear reactor.



There are two types of nuclear reactors:

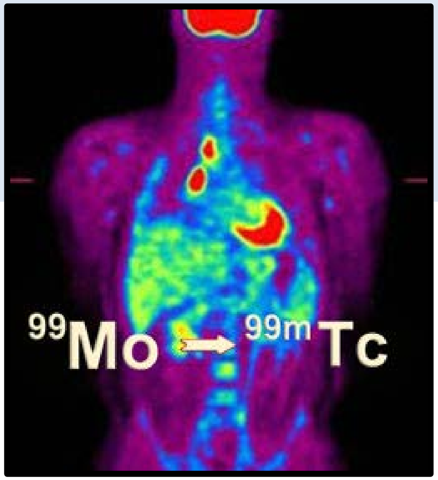
Pressurized Water Reactor

Pressurized Water Reactors (also known as PWRs) keep water under pressure so that it heats, but does not boil. This heated water is circulated through tubes in steam generators, allowing the water in the steam generators to turn to steam, which then turns the turbine generator. Water from the reactor and the water that is turned into steam are in separate systems and do not mix.

Boiling Water Reactor

In Boiling Water Reactors (also known as BWRs), the water heated by fission actually boils and turns into steam to turn the turbine generator. In both PWRs and BWRs, the steam is turned back into water and can be used again in the process.

Radioisotopes in Medicine



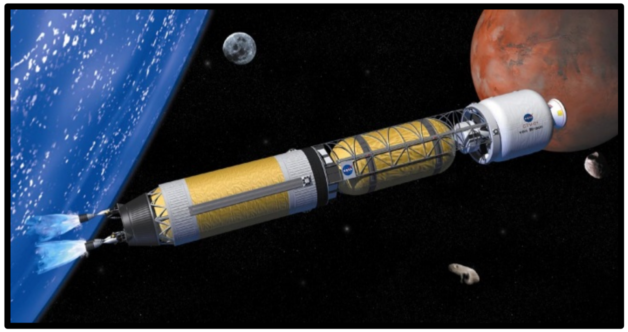
Nuclear medicine uses radiation to provide diagnostic information about the functioning of a person's specific organs, or to treat them. Diagnostic procedures using radioisotopes are now routine. Radiotherapy can be used to treat some medical conditions, especially cancer, using radiation to weaken or destroy particular targeted cells.

Tens of millions of nuclear medicine procedures are performed each year, and demand for radioisotopes is increasing rapidly. Sterilization of medical equipment is also an important use of radioisotopes.

Nuclear medicine is a branch of medicine that uses radiation to provide information about the functioning of a person's specific organs or to treat disease. In most cases, the information is used by physicians to make a quick, accurate diagnosis of the patient's illness. The thyroid, bones, heart, liver and many other organs can be easily imaged, and disorders in their function revealed. In some cases radiation can be used to treat diseased organs or tumors. Five Nobel Laureates have been involved with the use of radioactive tracers in medicine.

Over 10,000 hospitals worldwide use radioisotopes in medicine, and about 90% of the procedures are for diagnosis. The most common radioisotope used in diagnosis is Technetium-99, with some 40-45 million procedures per year.

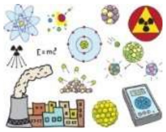
Nuclear Power in Space



For more than fifty years, radioisotope thermoelectric generators (RTGs) have been the United States' main power source in space.

RTGs offer many benefits; they are relatively safe and maintenance-free, resilient under harsh conditions, and can operate for decades. Unlike solar cells, nuclear power systems function independently of sunlight, which is necessary for deep space exploration. Nuclear reactors are especially beneficial in space because of their lower weight-to-capacity ratio than solar cells. Therefore, nuclear power systems take up much less space than solar power systems. Compact spacecraft are easier to orient and direct in space when precision is needed. Estimates of nuclear power, which can power both life support and propulsion systems, suggest that use of these systems can effectively reduce both cost and increase mission length.

Dozens of spacecraft have been sustained by nuclear power, some of which have been operating for more than 30 years!



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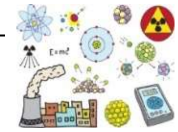

Positives & Negatives in the History of Nuclear Chemistry

WHAT? Name of Incident or Use	WHEN? Date of Occurrence or Founding (if applicable)	WHO/WHERE? Location of Occurrence or Who Uses / Where Technology is Used	HOW? List a Few Facts About the Incident or the Technology	Is this a *Positive or Negative* Facet of Nuclear Chemistry?

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