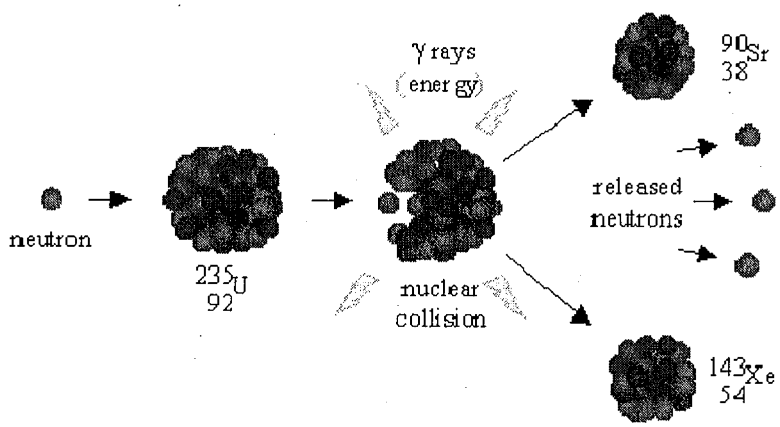
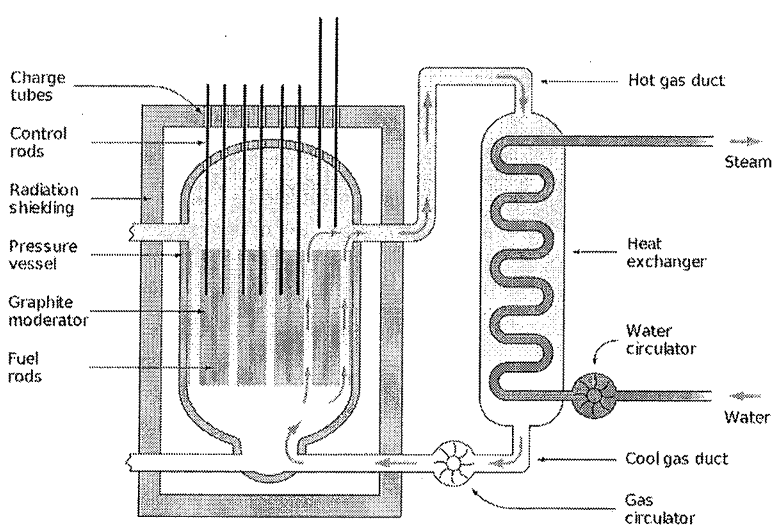
Name____ Mr. GARDNER

Unit #11: Nuclear CHEMISTRY



$$^{238}_{92}U \rightarrow \, ^{4}_{2}He + \, ^{234}_{90}Th$$

$$^{235}_{92}U + \, ^{1}_{0}n \rightarrow \begin{cases} ^{140}_{56}Ba + \, ^{93}_{36}Kr + 3\, ^{1}_{0}n \\ ^{144}_{55}Cs + \, ^{90}_{37}Rb + 2\, ^{1}_{0}n \\ ^{144}_{54}Xe + \, ^{90}_{38}Sr + 2\, ^{1}_{0}n \\ ^{146}_{57}La + \, ^{87}_{35}Br + 3\, ^{1}_{0}n \\ ^{160}_{62}Sm + \, ^{72}_{30}Zn + 4\, ^{1}_{0}n \end{cases}$$



Index

Key Terms for Nuclear Chemistry

alpha particle a helium nucleus

artificial transmutation a transmutation caused by bombarding a nucleus with a high energy particle, such as a neutron or an alpha particle

beta particles high-energy electrons whose source is an atomic nucleus

fission splitting of large nuclei into middle-weight nuclei and neutrons

fusion the constant temperature process in which particles in the solid phase gain enough energy to break away into the liquid phase; also known as melting; the reverse of the freezing process; (in nuclear chemistry) the combining of light nuclei into a heavier nucleus

gamma ray high-energy ray similar to an X ray

half-life the length of time for half of a given sample of a radioisotope to decay

positron particle identical to an electron except that it has a positive charge

radioisotope an unstable nucleus that is radioactive

tracer a radioisotope used to track a chemical reaction

transmutation the changing of a nucleus of one element into that of a different element

Some Key Objectives for the unit

- list common nuclear particles and their symbols
- balance nuclear equations
- describe types of radioactive decay
- solve half life problems
- describe uses of radioisotopes
- Describe how energy can be obtained from fusion and fission
- List parts of a fission reactor and their functions
- Indicate safety procedures in disposal of radioactive wastes

1 **Nuclear Chemistry:**

Ref. Tables N/O

2 **Nuclear Energy**

- Energy released as a result of a change in the nucleus of an atom
- Transmutation: The atomic nucleus of one element is changed into the nucleus of a different element (# of protons change, thus atomic number changes.)
- Nucleus made of Nucleons

Protons Neutrons

3 **Radioisotopes and the Band of Stability**

- an isotope that is unstable and thus radioactive (usually element above #83) (Table N)
- n/P ratios above one are often unstable
- Band of stability exists showing areas of stable/unstable isotopes

4 **Types of Particles**

- Table O
- alpha, beta, gamma, neutron, proton, positron

5 **Alpha radiation: symbol→**

- particle is 2 protons/2 neutrons= 4 amu and has a +2 charge.
- notation is similar to a Helium nucleus

He or

- least harmful radiation:
  - i- blocked by paper
  - ii- low penetrating power
  - iii- travels short distances ~3ft/1m
  - iv- speed is 1/10 of light

6 **Alpha radiation continued**

7 **Beta radiation: symbol→ β-**

- particle is basically an electron= 0 amu and has a -1 charge
- notation
-

or

-
- More dangerous than alpha
  - i- blocked by aluminum foil

ii- higher penetrating power
iii- travels about 10m
iv- speed equals that of light

8 **Beta radiation continued**

9 **Gamma radiation: symbol→**

- is not a particle (but is energy) that has no mass and no charge(photon)
- notation
-
-
- most harmful-similar to x-rays
  - i-blocked by lead (5-10cm), concrete (2-4ft) or water (10-15ft)
  - ii- travels farther than α and β
  - iii- travels at the speed of light
  - iv- causes cells to be destroyed

10 **Gamma radiation continued**

11 **Neutron, Proton, Positrons**

- Neutron mass of 1 with no charge
-
- Proton Mass of 1/charge of +1
-
- Positron Mass of 0/charge of +1
  - results when a proton converts to a neutron

12 **Positron formation**

13 **Effect of magnetic field on α, β, γ**

14 **Radioactive Decay: By transmutation**

- Natural/spontaneous transmutation
  - Particles given off
  - Happens at any time
  - Elements greater than 83 will go through a series of transmutations until they form ^{206}Pb by alpha or beta decay
  - Alpha decay: $^{226}Ra \rightarrow {}^{4}He + {}^{222}Rn$
    $^{210}Po \rightarrow {}^{206}Pb + {}^{4}He$
  - Beta decay: $^{60}Co \rightarrow {}^{0}e + {}^{60}Ni$
    $^{234}Pa \rightarrow {}^{234}U + {}^{0}e$

15 **Transmutation continued**

- Artificial transmutation

- Particles are added to an existing atom
  - ^{1}H + ^{9}Be → ^{4}He + ^{6}Li
  - ^{238}U + ^{12}C → $6(^{1}n)$ + ^{244}Cf
  - ^{249}Cf + ^{10}B → ^{257}Lr + $2(^{1}n)$
- **In nuclear equations, both mass and charge must be conserved and equal**

16 **Nuclear Humor**

17 **Half-Life**

- Time required for ½ of the atoms in a radioactive sample to decay to a stable form
- Formula to determine amount left after each half life is $(1/2)^n$, where n = the # of half lives

1→$(1/2)^1$ → 1/2	6→$(1/2)^6$ →1/64
2→$(1/2)^2$ → 1/4	7→$(1/2)^7$ →1/128
3→$(1/2)^3$ →1/8	8→$(1/2)^8$ →1/256
4→$(1/2)^4$ →1/16	9→$(1/2)^9$ →1/512
5→$(1/2)^5$ →1/32	10→$(1/2)^{10}$→1/1024

18

19 **To determine # of half-lives passed (n)**

- use the following: $\frac{\text{Total Time elapsed}}{\text{Half-Life of isotope}}$
- Ex. Phosphorus -32 has a half life of 14.3 days, How many mg are left after 57.2 days if we started with 4.0 mg?

  $\frac{57.2\text{days}}{14.3\text{ days}}$ = 4 half lives:

- 4.0mg→ 2.0mg→ 1.0mg→ 0.50mg→ 0.25mg

20 **Half Lives continued**

- Ex. How many grams of a 34.0g sample of Neon-19 will remain after 1 minute and 43.2 seconds?

  $\frac{103.2\text{sec}}{17.2\text{sec}}$ = 6 Half lives:

- 34.0g→17.0g→8.50g→4.25g→2.13g→1.06g→ 0.530g left

21 **Half Life curves**

- Shape is generally the same for all half life curves

22 **Fission/Fusion**

- Energy producing Reactions

- Mass defect= in these Rxn's, the reactants mass is slightly larger than the resulting product mass.
  - Loss represents a conversion of mass into energy → $E=MC^2$
- Fission: large unstable atom is split into smaller ones (a particle is needed to start this chain reaction)

23 **Nuclear Fission of Uranium**

- n + U → Ba + Kr +3 n + Q

24 **Fission: Products may differ**

25 **Fusion**

- 2 small nuclei combine to form 1 larger or heavier one.
  - H + H → He + Q
  -
  - 4 H → He + 2 e
    - takes place in the sun under high pressure and temperature, producing an immense amount of energy

26 **Fusion continued**

27 **Fusion: Good vs. Bad**

- Benefit: tremendous amounts of heat energy and no radioactive waste.
- Problem: high starting energy needed. Extreme high temperatures and pressures to get (+) charged protons to fuse together.

28 **Nuclear Reactors**

- Fuel sources: Uranium-235, Uranium-233, Plutonium-239
- Moderators: maintain efficiency of reaction.
  - slows down reaction
  - water, graphite and beryllium used to slow down neutrons

29 **Nuclear Reactors continued**

- Control Rods: controls fission process by adjusting # of neutrons available.
  - Cadmium/Boron used to absorb neutrons
  - Can be inserted/withdrawn along a fuel rod to control amount of neutrons available
  - in an emergency they are inserted and left to absorb all neutrons to kill reaction
- Coolant: absorbs heat energy → converted into steam and used as an energy source
  - H_2O, He, CO_2, Liquid Na and Li used
  - Work along with moderator to prevent core meltdown

30 **Nuclear Reactors continued**

- Shielding: Protection
  - Reaction occurs in water
  - Internal shield: steel lining protects walls of reactor from radiation damage
  - External shield: high density concrete for radiation containment

31 **Nuclear Reactors continued**

32 **Nuclear Medicine**

33 **Nuclear Medicine continued**

- Radioactive isotopes are used to help diagnose medical problems
  - Used as tracers for imaging
  - Material used must have a short half life to prevent additional damage to the system
    - Barium enema/swallow for digestive tract
    - Iodine for thyroid
  -
- X-rays, mri's, cat scans etc., also use radiation to result in images that can show problems

34 **Nuclear Medicine continued**

- Radiation Therapy
  - Kills cancerous cells
  - Inserted into effected region (but may also kill healthy tissue)
    - May be liquid/solid etc.
  - Breast cancer
  - Prostate cancer

35 **The End ☺**

Good Luck on the Regents Exam!!!

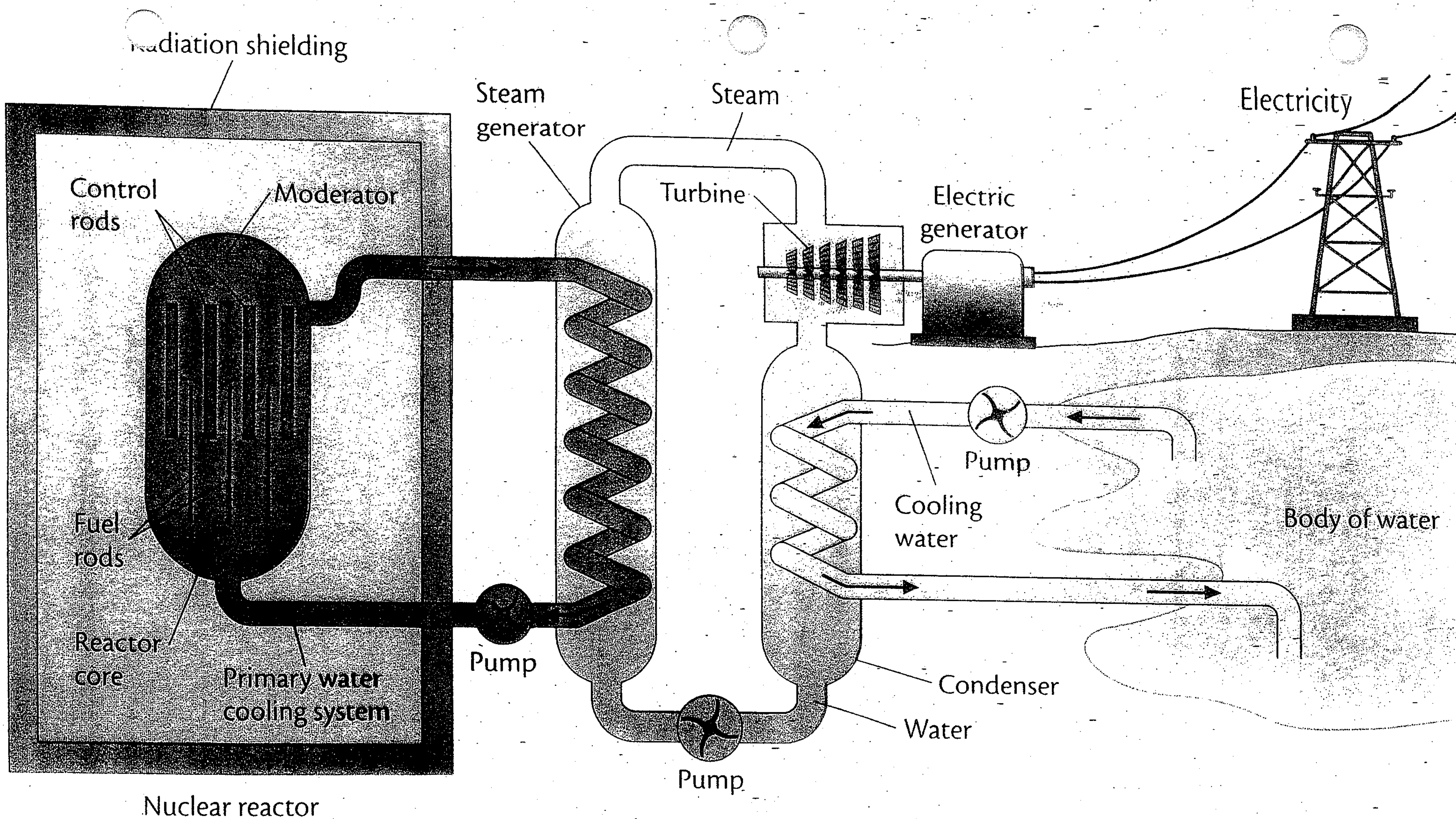


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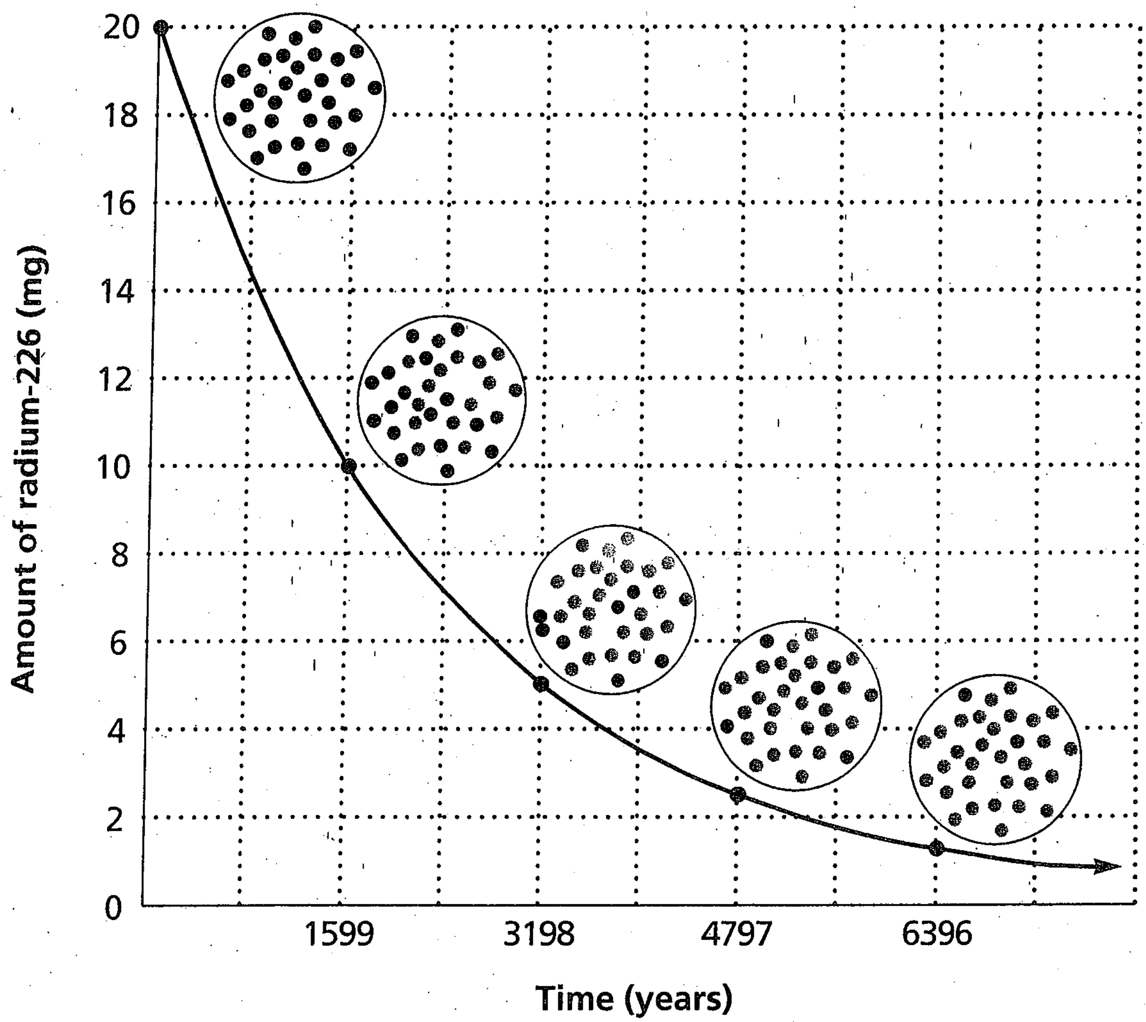
Figure 6-36, American Chemical Society,
CHEMISTRY IN THE COMMUNITY, Fourth Edition

Rate of Decay



(8)

Irradiated Food: Short on Safety?

Look out! The radura may be coming.

A radura looks innocent. Any flower would. But this is no ordinary flower. It's a symbol that you may spot on a package of fresh strawberries, or on a jar of spice. And in the future, the radura may bloom on labels of foods from chickens to clams.

A label that bears a radura informs a shopper that a food product has been irradiated. The food has most probably spent a short time on a conveyor belt that rode by a source of gamma radiation, such as cesium-137 or cobalt-60.

During that journey on the conveyer belt, the food was zapped with up to 3,000,000 rads. A *rad* is a unit of absorbed radiation dosage. To get an idea of the wallop 3,000,000 rads packs, consider that an ordinary chest X ray delivers about 20 millirads, or 20 thousandths of a rad. So 3,000,000 rads is equivalent to the radiation of 150,000,000 chest X rays!

Why expose food to such enormous doses of radiation? To preserve them and make them healthier for people to eat, say proponents of irradiating foods. These advocates of food irradiation point out that food decay is caused by microorganisms like bacteria. What's more, they say, certain serious diseases that strike human beings are caused by bacteria and other food contaminants, like salmonella bacteria in chicken and other poultry, trichina worms in pork, and hepatitis-causing viruses in shellfish.

Radiation deals death blows to both food-spoiling and disease-causing organisms. It also increases the shelf life of foods, which saves consumers money. The foods they buy simply last longer. As food irradiation supporter William McGivney puts it, ". . . irradiation offers a means to decontaminate, disinfect and retard the spoilage of the food supply." This can't be anything but a benefit to consumers, right?

Maybe not, says critic Donald B. Louria, chairman of the preventive medicine department at the New Jersey Medical School in Newark, New Jersey. In an article published in the September 1990 issue of *The Bulletin of the Atomic Scientists*, Louria states: "At dispute . . . are the quality of the FDA [Food and Drug Administration] safety assessment, the loss of nutritional value that irradiated foods undergo, the risk of environmental contamination posed by irradiation facilities, and the possible cancer-causing nature of irradiated foods."

Louria accuses the FDA of considering only five of 441 studies done to determine the safety of irradiated foods. Three of the studies "do not document the safety of food irradiation . . ." Louria insists. On the contrary, Louria reports that these studies implicated irradiated foods in the weight loss and miscarriage of test animals. Louria also pointed to studies done in India and China that, although not conclusive, hinted at a possible link between irradiated foods and the production of abnormal chromosomes in people who ate those foods.

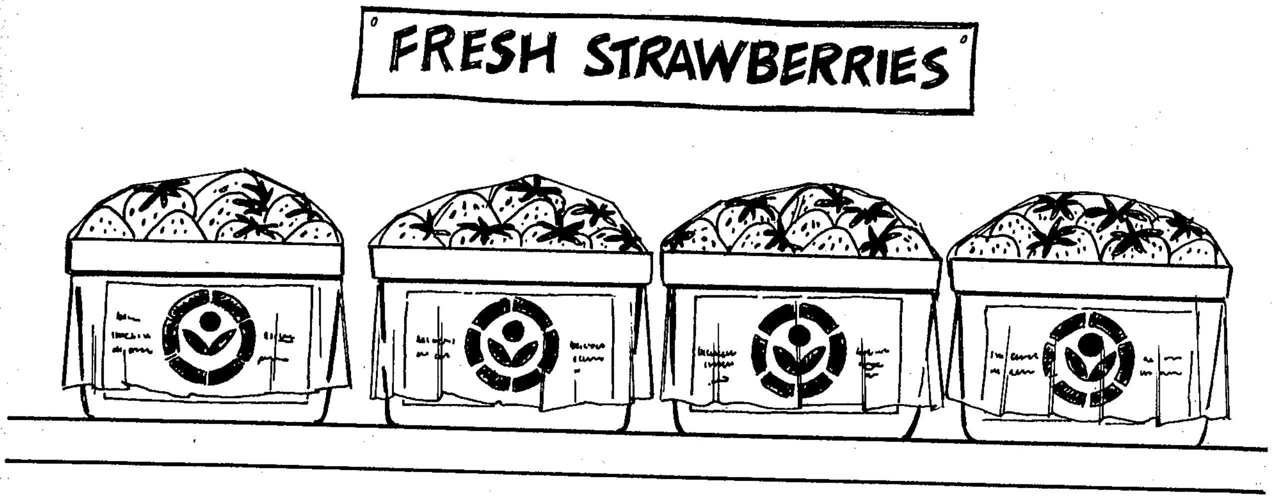
Aside from the question of safety, there is the issue of the effect of irradiation on the nutrient content of foods. Evidence exists that implicates irradiation in the destruction of vitamins E, A, C, and some B complex vitamins. Supporters of irradiation suggest this problem can easily be overcome by adding vitamins to such foods, or having people take vitamin supplements.

Critics suggest another potential hazard. Although irradiation does not make foods radioactive, it does break up some substances that occur naturally in them. Experiments show that some of these substances may cause cells to mutate. Might such mutations lead to cancers? No one seems to know the answer.

Finally, the building of many factories to irradiate foods would require the shipment of large quantities of radioactive materials across the country. Accidents might allow such materials to pollute the environment and threaten lives.

There seems to be a lot of mights, maybes, and unknowns mixed in with hard facts in this issue. Based on your knowledge of the mix, what do you think should be done?

UNIT 11



Questions

1. Foods are irradiated with
   a. alpha particles.
   b. beta particles.
   c. gamma rays.
   d. X rays.

2. Poultry products would be irradiated to rid them of
   a. hepatitis-causing viruses.
   b. salmonella bacteria.
   c. trichina worms.
   d. mold.

3. Evidence exists that irradiation of food destroys
   a. vitamin A only.
   b. B complex vitamins only.
   c. vitamin C only.
   d. vitamins A, E, C, and some B complex.

4. Describe four criticisms of the irradiation of food.

5. On a separate sheet of paper, discuss your views concerning the irradiation of foods. Include in your discussion your reaction to the various arguments in favor of and against food irradiation.

Name______________________________ Chernobyl Readings/Questions

Chernobyl Disaster's Health Impact Remains Cloudy

Stefan Lovgren
for National Geographic News April 26, 2004
http://news.nationalgeographic.com/news/2004/04/0426_040426_chernobyl.html

At 1:24 a.m. on April 26, 1986, Reactor 4 of the nuclear power plant in the Ukrainian town of Chernobyl exploded as engineers conducted a test to determine how long the plant's generators could run without power. It was the greatest technological disaster in history. Burning for ten days, the reactor released a cloud of radioactivity that some experts estimate was equivalent to that of 200 Hiroshima and Nagasaki bombs. The accident killed at least 30 plant workers, caused the hospitalization of hundreds of others, and exposed millions of people to ionizing radiation. This type of high-energy radiation can break apart molecules and atoms. But 18 years after the disaster, the true health costs of Chernobyl's radiation bomb are still unknown. Up to 2,000 children later developed thyroid cancer as a result of radiation. While some experts believe the cancer rate has peaked, others warn that it could take decades for all cancers to be detected. Thousands of other fatal illnesses have also been blamed on the disaster. Less controversially, it is widely accepted that the accident has caused great economic and psychological hardship, especially among the hundred thousand people who had to be resettled. "Eighteen years after the Chernobyl disaster, we are still unable to give an exhaustive picture of the consequences of this accident and its health implications," said Denise Adler, a radiation expert at the University of Geneva in Switzerland. "It can't be compared to any other environmental disaster."

Contaminated Rains

Chernobyl is located about 80 miles (130 kilometers) north of Kiev, the Ukrainian capital, and 7 miles (11 kilometers) south of the border with Belarus. At the time of the accident, Ukraine and Belarus were still part of the Soviet Union. Belarus was affected the most by the Chernobyl catastrophe. About 70 percent of all released radioactive substances from Chernobyl fell on its territory. Some places in western Europe and Turkey received contaminated rains, and insignificant amounts of radiation even reached the United States. In Switzerland, it is still forbidden to eat mushrooms in some mountainous parts. The secretive Soviet government at first downplayed the magnitude of the disaster. Few residents were told to evacuate the area, even though a large swath of territory soon became heavily contaminated by radionuclides—atoms that emit ionizing radiation. "The actual radiation suffered by the populations is little known," said André Giordan, the director of the Didactic Science and Epistemology Laboratory at the University of Geneva. "It is therefore very difficult to quantify the health effects of the Chernobyl accident." Poor recordkeeping and corruption also prevented the accurate registration of the 600,000 so-called liquidators—the workers who helped put out the fire and entomb the smoldering nuclear plant in the spring of 1986. Significant international efforts by the United Nations and others have been underway to better understand public and worker exposure, and the possible effects on their health.

Chronic Radiation

A report published in the journal *Nuclear Energy* last year predicted that 4,400 people would develop thyroid cancer as a result of the Chernobyl accident, leading to 1,000 premature deaths.

Most cases can be cured by surgically removing the thyroid and treating patients with tablets of thyroxin hormone for the rest of their lives. So far, only three people have died from Chernobyl-induced thyroid cancer, according to Ted Lazo, the deputy head of radiation protection at the Nuclear Energy Agency in Paris. There is no evidence yet of an increase in other cancers, such as leukemia. "This is not to say that the populations still living in contaminated territories are healthy," Lazo said. "It seems pretty clear that, in general, the health of these people has deteriorated and continues to do so." In Hiroshima and Nagasaki, it took, in some cases, 20 to 30 years to detect certain cancers. But studies of Hiroshima and Nagasaki victims may not be applicable to predicting the effects of Chernobyl. While the victims of those atomic bombs were exposed to radiation in a blinding flash, the people of Chernobyl have lived with chronic exposure—albeit at a lower dose rate—for years. The danger of such radiation is difficult to assess and is the topic of ongoing research. There are many noncancer health concerns, too. In a major study of children born in 1994 to mothers who had lived 186 miles (300 kilometers) from Chernobyl and had been exposed to radioactive fallout, researchers found never before observed "germ line" mutations: changes in the DNA of sperm and eggs. "Genetic defects may remain hidden for several generations," Adler said. "We have to expect more [of them] in the future." Fear of the effects of radiation had a significant effect. Around 200,000 women reportedly aborted fetuses after being exposed to radioactive fallout, fearing that the children would have birth defects. So far, no such birth defects have been observed.

Life Returning

There is evidence that the Chernobyl disaster has led to increases in cardiovascular and gastrointestinal diseases, diabetes, and disorders of bone and connective tissue. Some of these diseases may be linked to stress. "A number of stresses are most likely contributing to the current degradation [of] public health," Lazo said. "Exposure to radiation and other toxic substances is a fact and probably is part of this biological and complex problem. But these are certainly not the only major contributors to public health decline. The people living in these territories feel that they and their children are, in some sense, doomed." Radiation doses in the area are still a dozen times higher than normal. Unable to make ends meet elsewhere, several hundred former residents have returned to Chernobyl, which once had a population of 120,000. Thousands more are shuttled into the so-called exclusion zone to work on the gradual powering down of the plant. Reactor 4 has been sealed. However, some experts have warned that nuclear fuel trapped in its remains could cause the structure to deteriorate, and radiation to be released once again.

End of article #1

The World's Worst Nuclear Disaster - What Happened at Chernobyl

On 26th April 1986 at 1.23 a.m.: The world's worst nuclear disaster took place at the Chernobyl nuclear power station in the northern Ukraine. 190 tons of highly radioactive uranium and graphite were expelled into the atmosphere. The result was an international ecological calamity.

"The splitting of the atom
has changed everything
except our way of
thinking and thus we drift
towards unparalleled
catastrophe"
Albert Einstein

The people of Chernobyl were exposed to radiation 90 times greater than from the Hiroshima bomb. A United Nations 1995 Report estimated that a total of 9 million people were directly or indirectly affected by the Chernobyl disaster and that *3 - 4 million of those affected were children.* Radiation specialist Professor John Gofmans assessment is that the Chernobyl accident will cause 475,000 fatal cancers world-wide, and an equal number of non-fatal cancers.

Almost 400,000 people have been forced to leave their homes as a result of the nuclear power plant explosion. According to the Belarus Ministry of Health, the incidence of thyroid cancer, which has already shown marked increase, may rise still further and could peak between the years 2005 - 2010. An area the size of England, Wales and Northern Ireland combined - over 160,000 square kilometres - is estimated to have been contaminated by the disaster. Chiefly affected are Northern Ukraine, Western Russia and the Republic of Belarus.

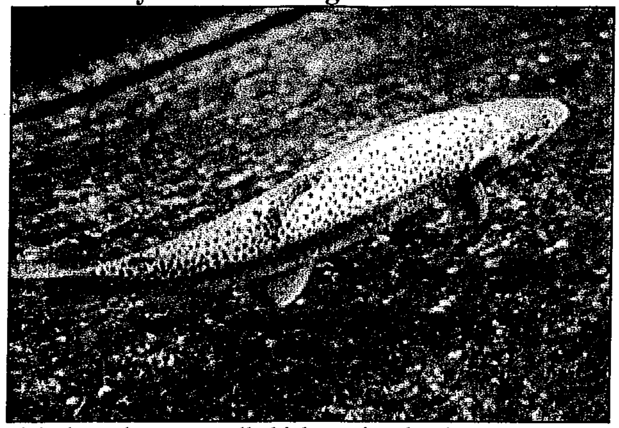
Since the accident approximately 400,000 people have been evacuated and relocated. They have become environmental refugees. The areas they have left have become a radioactive desert comprised of no-go areas covering thousands of hectares fenced off with barbed wire. Approximately 2,000 towns and villages in Belarus and the Ukraine have been evacuated. In Belarus, evacuations have been abandoned since new hot spots of contamination are being found daily. During the summer radiation is spread through forest fires. Recontamination through food and water is a constant problem in Belarus and there is no access to clean food. The people of this traditional farming area still till their fields, herd their cattle and eat their own produce.

Over 1.8 million people, including 500,000 children, live in radioactive zones in Belarus. Between 3 and 5 million people, including 2 million children, in the Ukraine live in radioactive zones. In the radioactive zone areas there are bans on children walking in forests or in rain, playing in the parks, and picking wild berries or flowers due to the high levels of radiation. Parents in these zones must check local radiation levels before allowing their children out to school.

Over 70% of the 100 million curies of radiation released into the atmosphere from Chernobyl fell on to the population of Belarus. 25% of the countrys prime farmland and forest has been subjected to radioactive contamination of varying degrees. 10% of the land is now unusable. Only 1% of the Belarussian land remains uncontaminated by international standards.

End of Article #2

Chernobyl's effects linger on



Fish showed unexpectedly high caesium levels

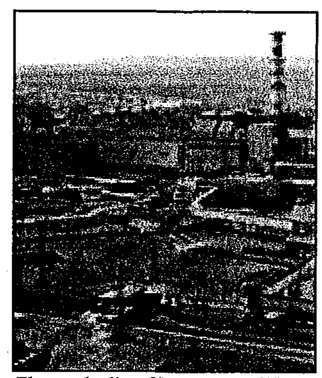
By environment correspondent Alex Kirby

Levels of radioactivity from the Chernobyl explosion in 1986 remain unexpectedly high in some parts of northern Europe, researchers have found. They say restrictions on some foods in both the United Kingdom and the former Soviet Union will have to remain in place for up to 50 years. They found that the environment is not cleaning itself as fast as previously thought, and that radioactivity can be released to the soil again after it has been absorbed. This unexpected result means that previous estimates of how long restrictions would be needed are proving wide of the mark. The researchers' findings are published in Nature. They are from the UK and the Netherlands.

Increased half-life

They found from analysis of radioactivity in fish in Norway and Cumbria, in north west England, that levels of one element, caesium 137, were higher than expected.

They also measured caesium in terrestrial vegetation and in lake water, and found that its effective ecological half-life rose from between one and four years in the first five years after Chernobyl to between six and 30 years recently. The team leader is Dr Jim Smith, of the Centre for Ecology and Hydrology, part of the UK's Natural Environment Research Council. Dr Smith said: "During the first five years after Chernobyl, concentrations of radioactive caesium in most foodstuffs and water decreased by a factor of 10, but in the last few years they have changed very little. "The environment is not cleaning itself of the pollution at the rate we previously thought. "Generally, after a nuclear accident, ecosystems have a self-cleaning capacity, and caesium becomes immobilised in the soil.



Chernobyl's effects are still felt

Restoring balance

"Now, 14 years after Chernobyl, we have found that the caesium is not completely immobilised, but can be re-released to the ecosystem." Dr Smith told BBC News Online this renewed leaking of radioactivity is not unprecedented. "With many chemical processes there can be a back reaction, when the contamination diffuses out. Here the rate of absorption is slowing, and it's being matched by diffusion.

"It's like a physical principle. Diffusion happens because of a concentration gradient, which leads to a balance between the radioactivity in the water in the soil, and that absorbed into the soil itself. "As that balance changes, the gradient levels out, and the difference between take-up and release alters." The researchers say the contamination "represents only a small health risk to consumers".


Cumbrian sheep are still contaminated

Half century

But they say restrictions on the consumption of some affected foods will be needed for years ahead. In 1986, UK Government scientists thought Cumbrian sheep should be kept out of the food chain for a matter of weeks. Dr Smith and his colleagues say the restrictions may be needed for another 10 to 15 years, 100 times longer than originally estimated. And forest berries, fungi and fish from parts of the former Soviet Union will remain restricted for another half century.

End of Article #3

Questions: Answer in complete sentences please.

1) Describe the Chernobyl accident including the events leading to the accident.

2) What are the health consequences of the disaster?

3) What are the social, economic and political consequences of the disaster?

4) What are the environmental consequences of the disaster?

5) What are some lessons learned from the power plant disaster?

Name________________________________ Period_________

Day___________

NOVA: The Dirty Bomb

Please answer the following questions in complete sentences.

1) What is a dirty bomb.

2) How long does it take for radiation sickness to occur after an exposure at a high dose?.

3) Why were team members allowed only 40 seconds to work near the radioactive material in Georgia?

4) Unless all radioactive material is cleaned up after an explosion, how long could it remain?

5) Why was the little girl buried in a lead coffin sealed with concrete?

16

September 7, 2004

Dirty bomb called almost inevitable

Authorities haven't put an end to availability of radioactive material.

San Francisco Chronicle

A flood of radioactive sources, from discarded cancer treatment machines advertised on the Internet to misplaced industrial gadgets that turn up in junkyards, have yet to be corralled by U.S. authorities three years after the Sept. 11, 2001, terrorist attacks, experts say — and could easily be exploited by terrorists seeking to make a dirty bomb.

The material is so abundant and easy to obtain, the experts say, that it is almost inevitable that a U.S. city will be the target of a bomb salted with radioactive waste.

And if a terrorist attaches ordinary chemical explosives to stolen radioactive sources, then detonates the bomb in or over a city — spreading a "hot" plume over a huge urban area — the consequences could be devastating.

Despite efforts by emergency preparedness and military agencies to prepare for such an attack — including a simulated dirty bomb "attack" in Los Angeles on Aug. 5-6 — a real-life, devastating attack could cause property losses far in excess of Sept. 11 and have unforeseeable health effects, analysts warn.

The list of woe includes:

■ "There are more than 2 million radioactive sources in the U.S. (that are) used for medical procedures, research and industrial processes," noted Rep. Edward J. Markey, D-Mass., in a statement late last year. "In the past five years, the Nuclear Regulatory Commission reported that nearly 1,500 radioactive sources have been reported lost or stolen in the U.S., but less than half of them have been found."

■ The Internet provides a potential route for the irresponsible to obtain deadly radioactive sources, Markey warned in mid-August. As an example of what he called the "atomic eBay," he cited a recent online offer by a hospital in Beirut to give away — for free — a used cancer therapy machine, containing a highly radioactive cobalt-60 source, to anyone who would pay to remove it.

■ Because radioactive grains can "chemically bind to asphalt, concrete and glass," in the words of Jaime M. Yassif of the Federation of American Scientists, some cleanups might require the use of exotic new tools such as concrete-eating bacteria. Just locating all contaminants could be nearly impossible, given the ease with which they're absorbed by soil and disappear into cracks in wood and pavement.

While there's disagreement over how many people would be killed in a dirty-bomb assault — perhaps thousands, perhaps a few, perhaps nobody if people evacuated quickly enough to safe sites — the economic impact could be cataclysmic.

Name ______________________ Period __________ Date __________

Unit 6

C.4 BUILDING SKILLS SUPPLEMENT

Write a balanced equation for each of the following nuclear reactions.

Example: Oxygen-16 plus a neutron results in the formation of another element and the release of an alpha particle.

$$^{16}_{8}O + ^{1}_{0}n \rightarrow ^{13}_{6}C + ^{4}_{2}He$$

1. Boron-10 plus a neutron results in the formation of another element and the release of an alpha particle.

   ____

2. Beryllium-9 plus a proton results in the formation of another element and the release of an alpha particle.

   ____

3. Einsteinium-253 plus an alpha particle results in the formation of another element and the release of a neutron.

   ____

4. Lithium-7 plus a proton results in the formation of another element and the release of a neutron.

   ____

5. Plutonium-241 plus another particle results in the formation of plutonium-242 and the release of gamma rays.

   ____

6. Argon-40 plus an alpha particle produces another element and the release of a neutron.

   ____

7. Einsteinium-252 was bombarded by a berylium-9 atom, producing a new element and three neutrons.

   ____

8. Plutonium-239 can be produced by bombarding uranium-238 with an alpha particle. Some neutrons are released.

   ____

(18)

9. Uranium-235 is bombarded with a neutron to produce tellurium-137, another element, and two neutrons.

10. On the sun, three steps are needed to create helium from hydrogen (nuclear fusion). In the third step, two helium-3 atoms react to form helium-4 and two hydrogen atoms. (Since the atomic mass of the helium-4 is less than that of the four hydrogen atoms used to make it, the difference in mass accounts for the energy released from the sun.)

Name______________________________ Period___________

Date______________________________ Take Home QUIZ

Using Table N from your reference table, complete the following. Show all work where applicable

Please place all answers in space provided to the left of each number. Failure to do so will result in the loss of 5 points.

_______ 1) At the end of 12 days, ¼ of an original sample of a radioactive element remains. What is the half life of the element?

_______ 2) What is the number of hours required for potassium-42 to undergo 3 half life periods?

_______ 3) After 3 half life periods, 12.5g of an original sample of radioisotope remains unchanged. What was the mass of the original sample?

_______ 4) How many grams of a 32-gram sample of ^{32}P will remain after 71.5 days?

_______ 5) The amount of C-14 contained in an object has been reduced to 25% of what it was in the original sample. Calculate the age of the object (from this dating method).

_______ 6) If 1/8 of the mass of the original sample of a radioisotope remains unchanged after 4800 years, the isotope could be A) H-3 B) K-42 C) Sr-90 D) Ra-226

_______ 7) Which of the following radioisotopes has the shortest half-life?
A) ^{14}C B) ^{3}H C) ^{37}K D) ^{32}P

_______ 8) What is the total mass of Rn-222 remaining in an original 160mg sample after 19.1 days

_______ 9) How much of a 15mg sample of ^{16}N would be left after 50.4 seconds?

_______ 10) This question requires you to make up your own ½ life question. In the space provided please write out a sample question similar to those above from an element not yet used here (Use Table N). You must also show solution to the problem as well. If I like it, it might even show up on a future exam☺

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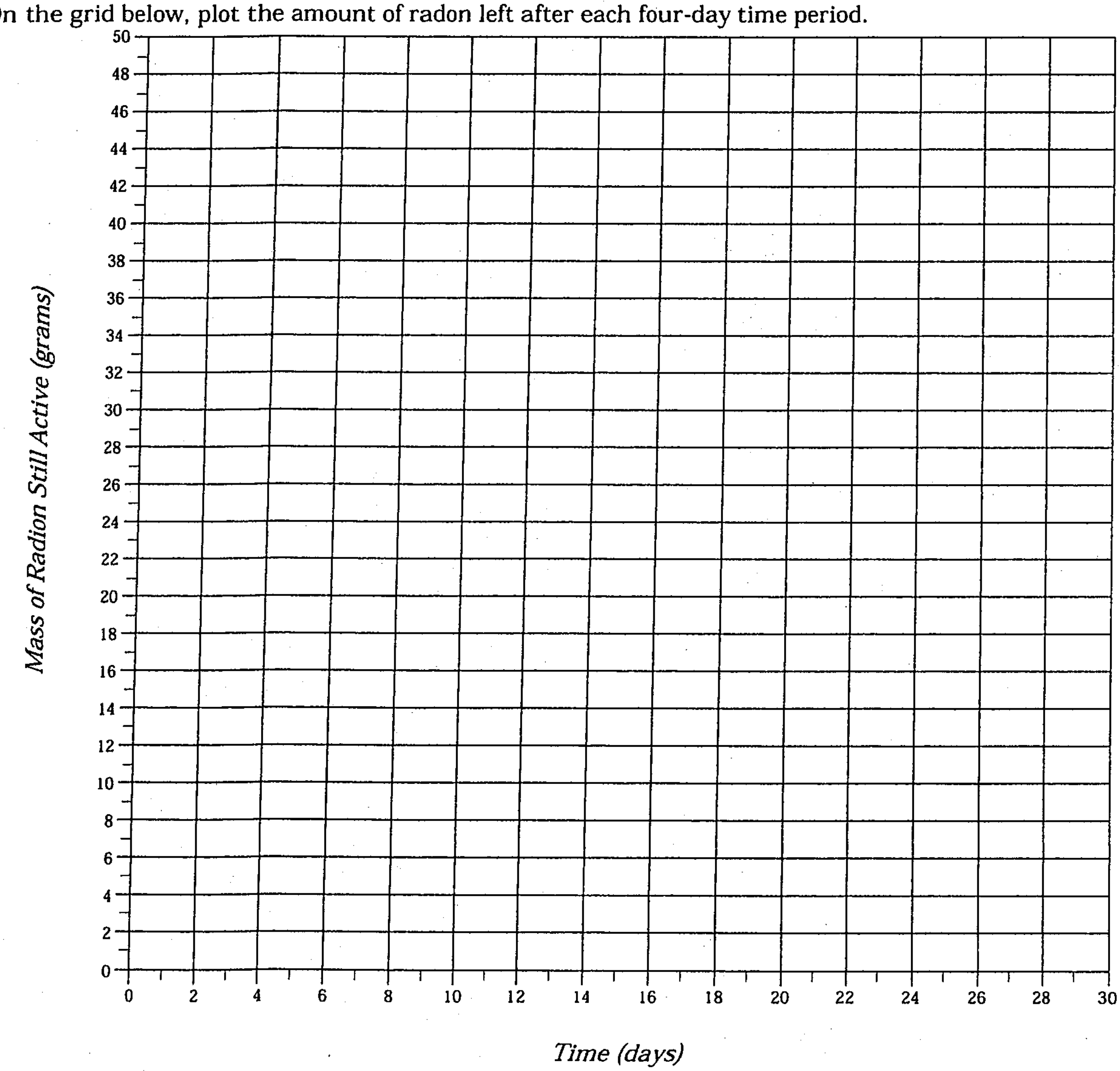
Name:

Half-Life of Radon

$^{222}_{86}Rn$ is the first decay product of $^{226}_{88}Ra$. Radon's activity is much greater than that of its parent. It is the heaviest of all gases (atomic mass = 222), with a density of almost 10 g/L. Like radium, it is hazardous to handle and should be used with adequate protective shielding.

Assume you have an initial sample of radon with a mass of 48 g. Assume the half-life of radon is about four days. On the grid below, plot the amount of radon left after each four-day time period.



Questions

1. How many grams of radon would be present after 4 days?
2. How many grams of radon would be present after 12 days?
3. How many grams of radon would be present after 24 days?
4. If 8 g of radon are left, what is the time elapsed?
5. How many grams of radon would be present after 6 days?

A student taking data on the beta decay of a radioactive isotope obtained the following set of data:

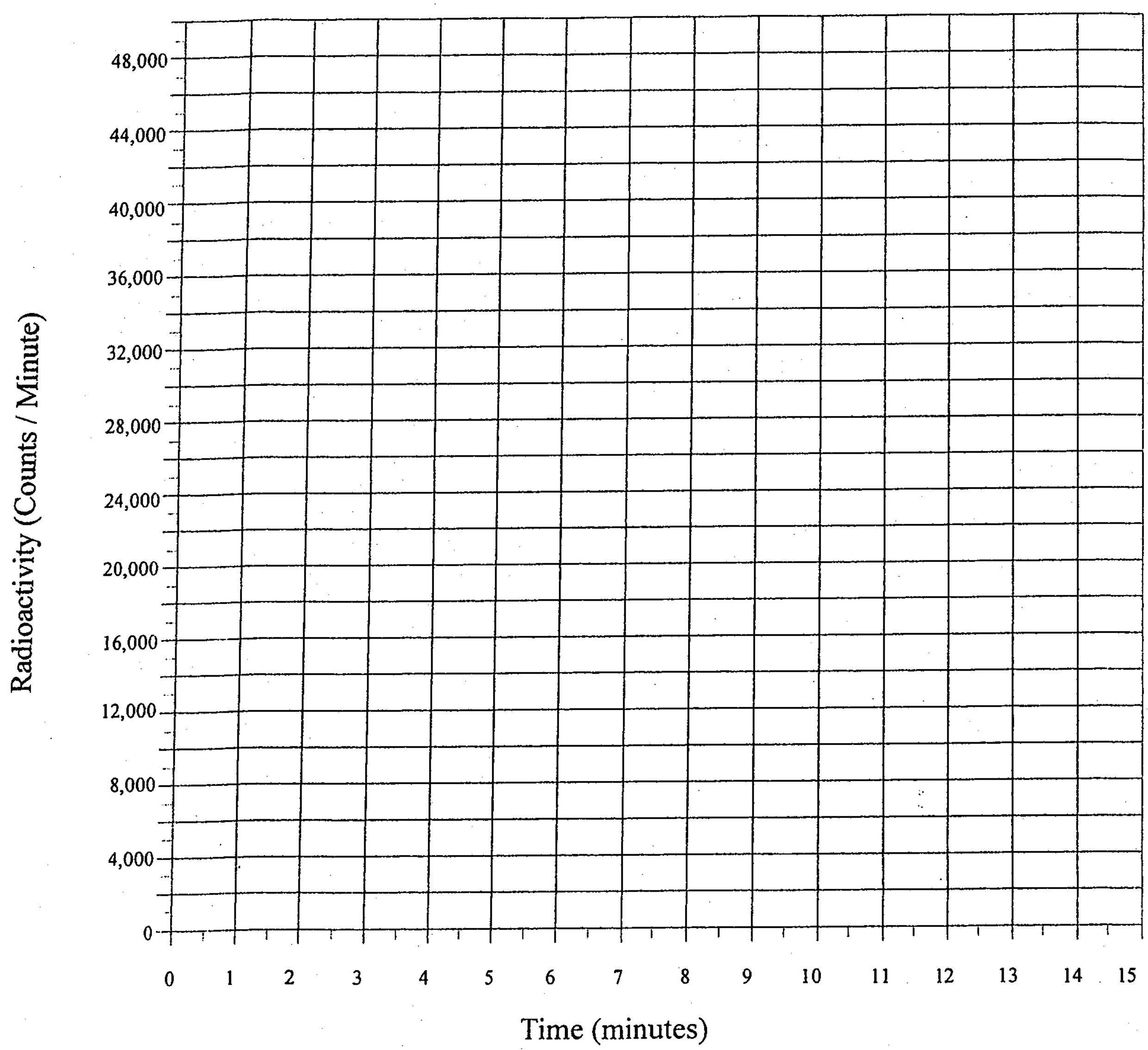
Radioactive Decay Data

Radioactivity (Counts/Minute)	Time (minutes)
43,200	0
35,830	1
29,705	2
24,458	3
20,430	4
16,500	5
14,045	6
11,640	7
9,655	8
8,010	9
6,645	10
3,138	12
2,718	14
2,356	15

1. Plot the radioactivity vs. time on the attached graph. Draw a best-fit curve.

2. From the graph, determine the half-life of this radioisotope.

Radioactive Decay
Radioactivity(counts/minute) vs. Time (minutes)



Student Worksheet: Writing Nuclear Equations

Part A. Complete each of the following by identifying . ${}^{A}_{Z}X$

1. ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{A}_{Z}X$

2. ${}^{222}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{A}_{Z}X$

3. ${}^{A}_{Z}X + {}^{0}_{-1}e \rightarrow {}^{54}_{24}Cr$

4. ${}^{54}_{26}Fe + {}^{1}_{0}n \rightarrow {}^{1}_{1}H + {}^{A}_{Z}X$

5. ${}^{238}_{92}U + {}^{12}_{6}C \rightarrow {}^{246}_{98}Cf + 4\,{}^{A}_{Z}X$

6. ${}^{A}_{Z}X + {}^{4}_{2}He \rightarrow {}^{245}_{97}Bk + {}^{1}_{1}H + 2{}^{1}_{0}n$

7. ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{139}_{56}Ba + {}^{A}_{Z}X + 3{}^{1}_{0}n$

8. ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{A}_{Z}X + {}^{1}_{0}n$

Part B. Write balanced equations for each of these reactions:

1. Alpha emission of ${}^{214}_{84}Po$
2. Beta emission of ${}^{210}_{83}Bi$
3. Neutron emission of ${}^{107}_{47}Ag$

Name: ______________________________

Nuclear Chemistry Review - 2002

1) Which particle is given off when $^{32}_{15}P$ undergoes a transmutation reaction?

A) a beta particle B) an alpha particle C) a positron D) a neutron

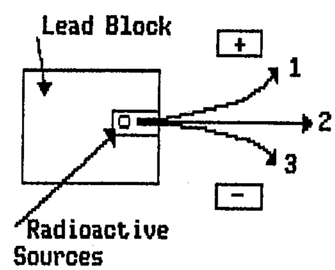
2) The structure of an alpha particle is the same as a

A) hydrogen nucleus B) neon atom C) lithium atom D) helium nucleus

3) Which species has a negative charge?

A) a beta particle B) an alpha particle C) an aluminum ion D) a lithium ion

4) The diagram below represents radiation passing through an electric field.



The arrow marked 2 would *most* likely represent

A) a proton B) an alpha particle C) a beta particle D) gamma radiation

5) In the equation $^{228}_{90}Th \longrightarrow\ ^{224}_{88}Ra + X$, which particle is represented by the letter *X*?

A) an alpha particle B) a positron C) a neutron D) a beta particle

6) At the end of 12 days, $\frac{1}{4}$ of an original sample of a radioactive element remains. What is the half-life of the element?

A) 48 days B) 24 days C) 6 days D) 3 days

7) What is the total mass of a 10. gram sample of ^{42}K that will remain unchanged after 12.4 hours?

A) 7.5 g B) 2.5 g C) 10. g D) 5.0 g

8) An original sample of a radioisotope had a mass of 10 grams. After 2 days, 5 grams of the radioisotope remains unchanged. What is the half-life of this radioisotope?

A) 2 days B) 5 days C) 1 day D) 4 days

9) A radioactive isotope has a half-life of 10 years. What fraction of the original mass will remain unchanged after 50 years?

A) $\frac{1}{8}$ B) $\frac{1}{2}$ C) $\frac{1}{32}$ D) $\frac{1}{16}$

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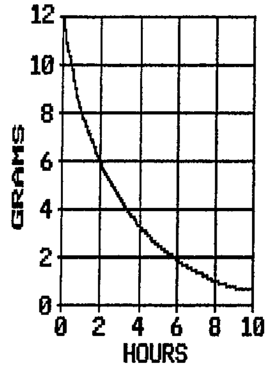
10) The graph below represents the decay of a radioactive isotope. What is the half-life of this isotope?



A) 2 hours B) 1 hour C) 3 hours D) 6 hours

11) According to the *Selected Radioisotopes* chemistry reference table, a product of the radioactive decay ${}^{226}_{88}\text{Ra}$ is

A) ${}^{0}_{-1}\text{e}$ B) ${}^{230}_{90}\text{U}$ C) ${}^{226}_{89}\text{U}$ D) ${}^{4}_{2}\text{He}$

12) Given the reaction:

$${}^{27}_{13}\text{Al} + {}^{4}_{2}\text{He} \longrightarrow {}^{30}_{15}\text{P} + {}^{1}_{0}\text{n}$$

This reaction is described as

A) fusion
B) beta decay
C) fission
D) artificial transmutation

13) The atoms of some elements can be made radioactive by

A) bombarding them with high-energy particles
B) placing them in a magnetic field
C) heating them to a very high temperature
D) separating them into their isotopes

14) Given the transmutation:

$${}^{1}_{0}\text{n} + {}^{235}_{92}\text{U} \longrightarrow {}^{141}_{56}\text{Ba} + X + 3\,{}^{1}_{0}\text{n}$$

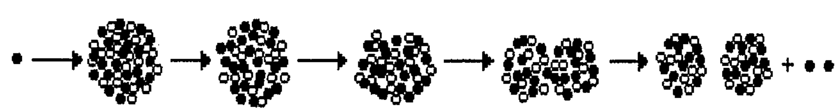
The element X has an atomic number of

A) 89 B) 93 C) 36 D) 92

15) When a uranium nucleus breaks up into fragments, which type of nuclear reaction occurs?

A) fission B) redox C) fusion D) replacement

16) The diagram below shows a nuclear reaction in which a neutron is captured by a heavy nucleus.



Which type of reaction is illustrated by the diagram?

A) an endothermic fission reaction
B) an exothermic fusion reaction
C) an endothermic fusion reaction
D) an exothermic fission reaction

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17) The equation $^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{4}_{2}He$ represents

A) fusion
B) alpha decay
C) beta decay
D) fission

18) Which pair of nuclei can undergo a fusion reaction?

A) hydrogen-2 and hydrogen-3
B) potassium-40 and cadmium-113
C) uranium-238 and lead-208
D) zinc-64 and calcium-44

19) The radioactive isotope I-131 is used in

A) controlling speeds of neutrons
B) controlling fission reactions
C) geologic dating
D) medical diagnosis

20) During which process would the ratio of uranium-238 to lead-206 be used?

A) diagnosing thyroid disorders
B) treating cancer patients
C) detecting brain tumors
D) dating geologic formations

21) Which radioisotope is used for diagnosing thyroid disorders?

A) cobalt-60
B) lead-206
C) uranium-238
D) iodine-131

22) Radiated food can be safely stored for a longer time because radiation

A) prevents air oxidation
B) cause bacteria to mutate
C) kills bacteria
D) prevents air reduction

23) Which two characteristics do radioisotopes have that are useful in medical diagnosis?

A) short half-lives and slow elimination from the body
B) long half-lives and slow elimination from the body
C) long half-lives and quick elimination from the body
D) short half-lives and quick elimination from the body

24) A radioactive-dating procedure to determine the age of a mineral compares the mineral's remaining amounts of isotope ^{238}U and isotope

A) ^{206}Bi
B) ^{214}Pb
C) ^{214}Bi
D) ^{206}Pb

25) A radioisotope is called a tracer when it is used to

A) kill cancerous tissue
B) determine the age of animal skeletal remains
C) kill bacteria in food
D) determine the way in which a chemical reaction occurs

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Have you studied today? You can only blame yourself for the efforts you put into your work.

Remember…You get out of it what you put into it!

Nuclear Chem Mr. Gardner