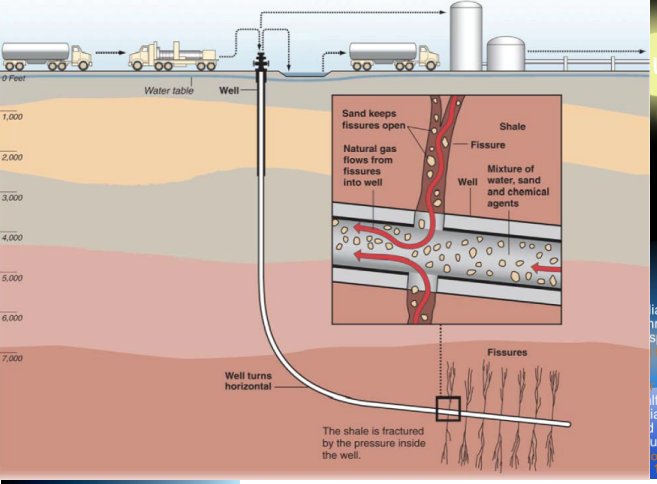
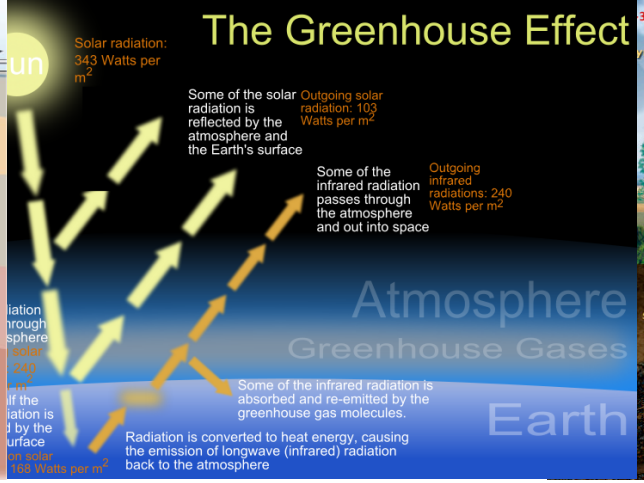
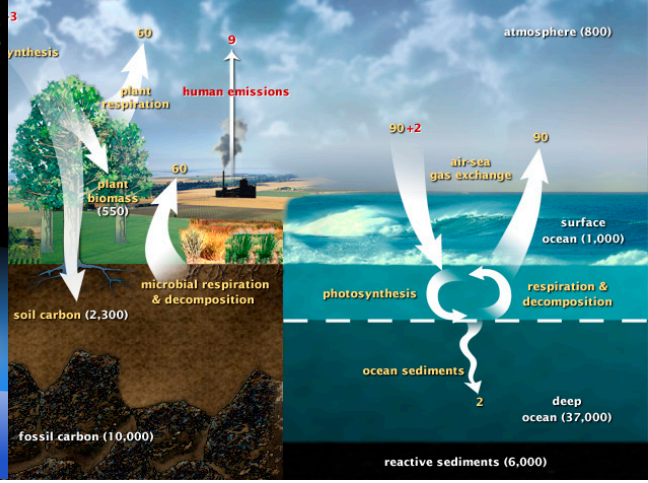


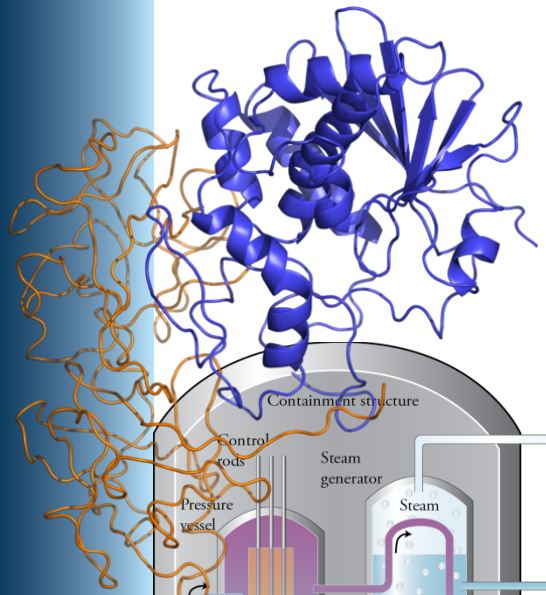


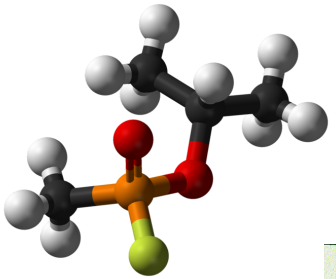


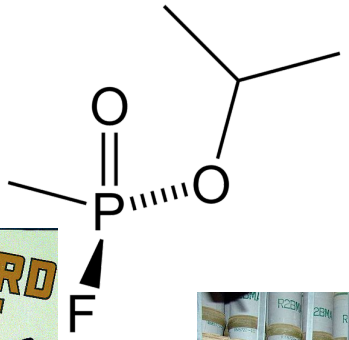
ECPR 8510

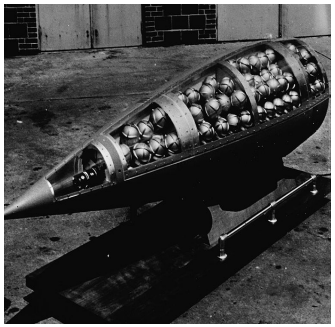
Math-Science Review for IEP & NPTS

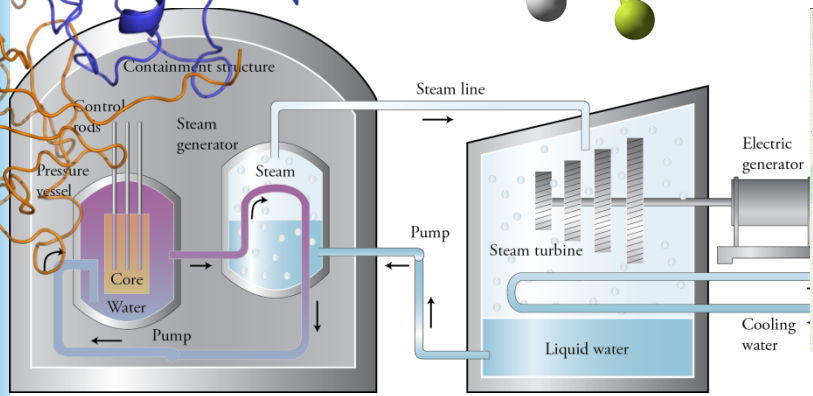
Instructor: Mark Bishop











Math-Science Review for IEP & NPTS

- The course provides a math and science foundation for students taking courses in both the International Environmental Policy (IEP) and Nonproliferation and Terrorism Studies (NPTS) programs.
- The following slides provide brief descriptions of some of the topics you might see in these programs, and they show you the sorts of math- and science-related questions you might need to be able to answer.

What do you want to know?

- Some short-lived radioactive isotopes are found in nature because they are part of a radioactive decay series that starts with a very long-lived isotope.
  - What does it mean to be radioactive?
  - What's an isotope?
  - What's a radioactive decay series?

What do you want to know?

- The radioactive emissions called alpha particles, beta particles, and gamma rays are all ionizing radiation.
  - What are the sources of these radioactive emissions?
  - What are alpha particles, beta particles, and gamma rays?
  - What does it mean to ionize something?
  - What are the consequences of the formation of ions in living organisms, including us?

What do you want to know?

- The $LD_{50/30}$ expressed as a biological dose of radiation is 4-5 Sieverts (Sv).
  - What does $LD_{50/30}$ mean?
  - What's a biological dose?
  - What's a Sievert?

What do you want to know?

- Because of the uranium content of the granite in the U.S. Capitol Building, radiation levels inside the building are ≈0.85 mSv/yr, which is close to the regulatory limit. What biological dose of radiation would a person who works 8 hours a day, five days a week, and 50 weeks a year absorb over a 20-year career in the capitol building?
  - Why is uranium radioactive?
  - What's the most efficient and reliable way to do this calculation?

What do you want to know?

- Iodine-131 has a half-life of 8.0197 days. If we start with 37 GBq (or 1 curie) of I-131, how much is left after 14 days?
  - What does the 131 in iodine-131 describe?
  - What's half-life?
  - What does the G in 37 GBq represent?
  - What does the Bq in 37 GBq represent?
  - How do you do this calculation?

What do you want to know?

- Binding energy per nucleon generally increases from small atoms to atoms with a mass number around 56. Therefore, fusing small atoms to form medium-sized atoms (***nuclear fusion***) releases energy. Binding energy per nucleon generally decreases from atoms with a mass number around 56 to larger atoms. Therefore, splitting large atoms to form medium-sized atoms (***nuclear fission***) also releases energy.
  - What's energy and binding energy?
  - What's a nucleon?
  - What are fission and fusion?

What do you want to know?

- To get a sustained chain reaction, the percentage of fissile ^{235}U must be increased over what is found in nature, in part because the unfissionable ^{238}U absorbs too many neutrons.
  - What's a chain reaction?
  - What do the symbols ^{235}U and ^{238}U represent?
  - What does fissile mean?

What do you want to know?

- The spinning of a gas centrifuge used to enrich uranium creates a strong centrifugal force so that the heavier gas molecules containing ^{238}U move toward the outside of the cylinder and the lighter gas molecules rich in ^{235}U collect closer to the center. The bottom of the rotating cylinder can be heated, producing convection currents that move the ^{235}U up the cylinder, where it can be collected.
  - What is a centrifuge?
  - What is centrifugal force?
  - What's a convection current?

What do you want to know?

- Ozone gas, a form of the element oxygen, is a pollutant in the lower atmosphere and a protectant in the upper atmosphere. In the lower atmosphere, it is created in a series of chemical reactions that involve two forms of energy, heat and radiant energy.
  - *What's the nature of gases?*
  - *What are chemical elements?*
  - *What are chemical reactions?*
  - *What are heat and radiant energy, and why do they speed chemical changes?*

What do you want to know?

- At ozone concentrations from 0.116 to 0.404 ppm, sensitive people experience severe respiratory symptoms and impaired breathing. An Air Quality Index (AQI) is used to indicate the level of risk from ozone. An AQI of 100 for ozone corresponds to an ozone level of 0.075 parts per million (averaged over 8 hours).
  - *What are concentration units?*
  - *What does ppm mean?*
  - *How would you convert from ppm to an AQI rating?*

What do you want to know?

- The average temperature of the earth is increasing. Most scientists believe the increase in temperature is caused by an increase of certain gases in the atmosphere that trap energy that would otherwise escape into space. These gases, called greenhouse gases, include the chemical compounds carbon dioxide, methane, nitrous oxide, chlorofluorocarbons (CFCs), and the ozone.
  - *What form of energy is trapped by greenhouse gases?*
  - *What is it about the greenhouse gases that causes this problem?*
  - *What are chemical compounds?*

What do you want to know?

- The increased acidity of rain leads to many problems. For example, the acids in acid rain react with the calcium carbonate in marble statues and buildings, causing them to dissolve. (Marble is compressed limestone, which is composed of calcium carbonate, $CaCO_3(s)$.)

  $$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

  - *What are acids?*
  - *What information is given in chemical formulas?*
  - *What information is provided by chemical equations?*

What do you want to know?

- The first poison gas used by the Germans in the first world war was the element chlorine, Cl_2, which is made up of molecules with two atoms of chlorine per molecule.
  - *What makes one element different from another?*
  - *What's the internal structure of the atoms of elements, and how does this internal structure affect the interactions between atoms?*
  - *What are molecules?*
  - *Why is chlorine described with the chemical formula Cl_2?*
  - *What holds the chlorine atoms in chlorine molecules together?*

What do you want to know?

- Exposure to chlorine in air with about 1000 ppm Cl_2 can be lethal. Because there are a million milligrams per kilogram, the number of milligrams of chlorine per kilogram of air can be described as parts per million (ppm).
  - *What are the units used in the International System of Measurement?*
  - *How can you convert from one unit to another?*

What do you want to know?

- The Germans interpreted the Hague Convention of 1899 as banning projectiles used ***solely*** to deliver poison gas, so to get around the commitment that they made when they signed this agreement, the Germans developed projectiles that contained chemical explosives that could distribute both shrapnel and poison gases. Chemical explosives, such as TNT, oxidize very quickly, releasing large amounts of gas and energy. Some of the potential energy of the reacting chemicals is converted into kinetic energy of the gaseous products, causing a rapid increase in temperature. This leads to very high gas pressures that can send shrapnel and gases out from the projectile at very high velocity.
  - *What makes a compound explosive?*
  - *What is oxidation?*
  - *What creates gas pressure?*
  - *What are energy, potential energy, and kinetic energy?*
  - *What's happening when the temperature of a system increases?*

What do you want to know?

- During WW I, the blockade of sea ports where the Germans received their supplies led to a shortage of nitrates from Chile. Nitrates were needed to produce the chemical explosives TNT and nitroglycerine. Nitrates are ionic compounds that contain the polyatomic ion nitrate, NO_3^-.
  - *What are ionic compounds?*
  - *What are ions, and how do they differ from atoms and molecules?*
  - *What are polyatomic ions?*
  - *How are polyatomic ions named?*

What do you want to know?

- In 1914, the French used a tear gas against the Germans. There is some debate as to whether they used the organic compound xylyl bromide, C_8H_9Br, or another organic compound called ethyl 2-bromoacetate, $CH_2BrCO_2C_2H_5$.
  - *What's an organic compound?*
  - *How are organic compounds described?*

What do you want to know?

- The chemical weapon sulfur mustard was first used in WW I. It attaches to the guanine nucleotide of DNA, disrupting cell division and function. This can lead to cellular death or cancer.
  - What is a nucleotide?
  - What is DNA?

What do you want to know?

- The chemical weapon hydrogen cyanide disrupts cellular respiration by inhibiting an enzyme (cytochrome oxidase) in mitochondria.
  - What is cellular respiration?
  - What is an enzyme?

What do you want to know?

- Among other things, the neurotransmitter acetylcholine stimulates nerve cells that cause muscle contractions.
- Normally, acetylcholine is broken down in the active site of the enzyme called acetylcholinesterase.
- The chemical weapon sarin forms a covalent bond to a serine side chain in the active site of the enzyme acetylcholinesterase, deactivating it.
- If acetylcholinesterase is deactivated, the acetylcholine levels remain high, and the muscle and nerve cells are over-stimulated.
  - What are neurotransmitters, active sites, and side chains?
  - What triggers the firing of nerve and muscle cells?

Schedule

- Mon-Fri, January 6-17, 9:00am-1:00pm

General Information

Email

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Web Sites

http://preparatorychemistry.com

http://webassign.net

http://institutebishop.org

WebAssign

- We will use a WebAssign package that includes an electronic text/tools/homework bundle.
- You sign up at http://webassign.net
- The instructions for signing up are at http://institutebishop.org/WebAssign_Tools.pdf

Textbook: *An Introduction to Chemistry – Atoms First* by Mark Bishop

- The WebAssign electronic homework system includes an electronic version of the text.
- Loaner textbooks are available
- If you want a textbook to keep after the course is over, you can purchase one at

http://preparatorychemistry.com/Bishop_Payment_MIIS.htm

- Online versions of the text and study guide can be found at

http://preparatorychemistry.com/Bishop_Atoms_First.htm

Grading

- Although this is a no-credit course, completing all of the WebAssign assignments with 70% or higher will be considered successful completion of the course.