Acid Rain
-Sources of acids NO_x/SO_2; (Coal combustion, Power plants, automobile exhaust)
-Source Regions of Pollution (Midwest, PA)
-Regions affected by acid rain (Adirondacks, Scandinavia)
-Why do areas like Rochester not have problems? (carbonate soils/cation exchange capacity)
-Woods vs. Panther Lake
-What has already been done to curb the sources? (low sulfur coal) What likely needs to be done? (NOx from autos)
-Are there solutions for lakes that have been acidified?
-The role of Aluminum

Chemical Weathering
-Reactions that control soil weathering
-Weathering byproducts
-Carbonate weathering
-The role of CO_2 in the carbonate cycle (know these reactions or at least how to manipulate them)
-What is the role of pH?
-How do CO_2 concentrations vary in shallow soils? What controls these concentrations? How does this control pH?

RedOx Reactions (pg. 362-366 in Fetter)
-Eh-pH diagrams (slide 23 RedOx) Fence Diagrams
Example question: How does Eh change after a respiration reaction?
-Microbial activity
-RedOx profiles in groundwaters (know reaction orders and characteristic byproducts)
    -oxidations rxns/respiration (CO_2)
    -Nitrate reducing (N_2)
    -Iron reducing ($Fe^{3+} \rightarrow Fe^{2+}$)
    -Sulfate reduction (H_2S)
    -Methanogenesis (CH_4)

Arsenic
-What was the problem in Bangladesh?
-Source of arsenic? Natural? Anthropogenic? (volcanic from Himalayas)
-How was Bangladesh studied?
-Bangladesh paper
    -what reactions control release of arsenic (breakdown by reduction of FeOOH; Arsenate→arsenite. What other evidence supports this conclusion (methane, ammonia, correlation of Fe to As)
    -what is an oxyanions?
    -How are oxyanions important for the Bangladesh scenario?
    -What role does Eh and pH play? Reducing iron which raises pH and forms arsenite; increase in pH also increase desorption of oxyanions. Arsenite is more mobile and toxic than arsenate (slide 9 RedOx)

-What type of microbial rxns are likely most important? (Fe reducing bacteria)
-Why is arsenic such a big problem is Bangladesh?
-What are a few solutions? (drilling deeper or within the phreatic zone)
-What other locations may be susceptible to similar problems? Chesapeake Bay? China Sea?
-What causes the high concentrations of ionic species in the flood plain? Salinity induced flocculation

Heavy metal transport
-The role of pH? The role of oxidation state? Ionic radius? (Slide 4/8 in RedOx)
-Know the exchange rxns for cations and oxyanions (pH dependence) (slide 5/6 RedOx)
-Where are heavy metals and oxyanions usually found in soils? (clays/organic material)
-What affects the Kd values? Why? (pH)
-What replaces trace metals (H^+)/oxyanions (OH^-) on clay surfaces?

Lead and Mercury
-What factors control transport in the environment
-Name pathways for migration in biological material wet and dry deposition to water? → bacterial methylation → fish consumption (bioaccumulation: fish Minamata, Japan)
-Where is it stored in fish? (fatty tissue)
-Name common sources of each (anthropogenic and naturally occurring)
Mercury volcanic, power plants, battery plants industry, coal burning
Lead: Hydrothermal and volcanic processes; coal burning, lead solder, lead pipes, lead paint

Stable Isotopes
-Stable isotope basics
-Why does fractionation occur?
-Rayleigh fractionation of water
-What happens to the isotopic concentration of cloud mass and rain after several rain events? Changes in elevation? Changes in temperature?
-How can this be used in hydrology? (Determining source and ages of groundwaters)
-How can carbon isotopes be used at Yucca Mt

Yucca Mountain/Radioactive isotopes
-What factors control how dangerous radioisotopes are? (half-life and energy of decay)
-What is the need for Yucca Mt. or similar facilities? (old on site containment, leaks)
-How does the US compare with other nations (France (above ground pyramid)/Sweden (uranium mines) in dealing with radioactive waste?
-What are some other possible solutions? (deep sea burial, salt domes, Columbia River basalts? How does Yucca compare to these? What are the problems with each?
-What questions have been raised about Yucca Mt? (aquifer carbonates, tectonic activity, volcanism, seismic activity, long term rainfall/climate)
-What are the major radioactive isotopes that need to be contained? What is there most likely method of transport/

-What isotopic techniques discussed in class have been used to answer some of these questions? (Stable carbon and oxygen isotopes, cosmogenic helium) How have some of these questions been resolved? Which questions remain? What geological factor likely provides the greatest threat?

Sample Question:
Oxidation-Reduction
a). Discuss the role of ferric iron in the mobility of trace metals.
b). It what chemical state would iron appear in most soils?
c). How does iron hydroxide adsorb both metal cations and oxyanions? Draw diagrams to describe both reactions and list a few examples of trace metals that are likely to appear in each state.
d). What is the dominant factor controls whether an oxyanion (or cation) or adsorbed on iron hydroxides or found in solution?
e). How do bacteria affect oxidation potential? Name a few examples of bacteria by the process involved.
f). Why are certain waters oxidizing and others reducing? Rank the following waters from most oxidizing to most reducing: Phreatic water, lake waters, fifty year old groundwater, pore water from a coastal marsh.