Unit 4.1 Summary

- interaction of light and matter
  - need to understand the relationships between wavelength, frequency and energy
  - need to understand how light can break chemical bonds
- reactivity of ozone
  - Chapman cycle (establishment of steady state concentrations)
  - production of persistent radicals and their interactions with ozone
  - understand the function of catalysts
  - role of CFCs and related materials in ozone depletion
- environmental, biological and political effects of ozone depletion

Unit 4.2 Summary

- energy balance: all of our energy comes from the sun
  - greenhouse effect vs enhanced greenhouse effect
- “global climate change” is a better descriptor of the whole ‘experiment’ we’re currently undertaking with the Earth
  - remember: the planet will be fine no matter what happens
- molecular shapes tell us what molecular vibrations are operative
  - start with Lewis (dot) structures, then consider that electron pairs repel each other
  - infrared radiation
  - there must be a change in dipole for a vibration to contribute to warming
- mass and the mole
  - use balanced chemical equations and unit analysis to determine things like the amount of carbon put into the atmosphere
- carbon cycle
  - natural forcings vs anthropogenic forcings
- data collection and interpretation:
  - difference between correlation and causation
  - scientific arguments about theories versus legal/political coverage of the issues

Unit 4.3a Summary

- Concepts
  - definitions of redox terms
    - oxidation: a compound loses electron(s)
    - reduction: a compound gains electron(s)
  - determination of oxidation state
  - combustion is a redox reaction: check out the oxidation states of the reactants and products
  - galvanic cells and batteries
    - cathode (+): where the reduction takes place
    - anode (-): where the oxidation takes place
    - V = I*R Voltage = Current * Resistance
  - biological redox
    - reactive oxygen species (hydroxyl, superoxide, peroxide)
    - effects on proteins, DNA
  - thermite reaction: exploiting the propensity of some metals (e.g. Aluminum) to oxidize very easily

Unit 4.3b Summary

- Concepts
  - macronutrients
    - fats
    - Proteins
    - carbohydrates
  - Vitamins (hydrophilic, hydrophobic)
  - Minerals (macro: P, S, Cl, Mg, Ca)
  - Essential
    - Amino acids
    - Fats
  - 21 EJ to feed the world (44 GJ/person)
  - Nitrogen cycle (range of oxidation states)
  - Need nitrogen for fertilizer to feed the world

Ozone Layer

What's ozone & where is it?

O_3, it's in the stratosphere (15-30 km above surface)

What's light?

radiant energy (waves)

radio, microwave, IR (heat), visible, UV, x-ray, Gamma rays

What do O_2 and O_3 do for us in Stratosphere?

Shield us from UVB & UVC by absorbing light & breaking O-O bonds

Why is UV radiation bad for us?

Breaks bonds in us & other living beings

What do sunscreens do?

Absorb & scatter UV radiation

What causes Ozone layer destruction?

$Cl^{\bullet}$ reactions… with O_3 convert O_3 to O_2

Where do $Cl^{\bullet}$ come from?

Freons (CFCs ($CFCl_3$ and CF_2Cl_2))

Ozone Layer, cont.

What do CFCs do for us?

Inert, non-toxic refrigerants

What have we/are we doing about them?

Replace with more reactive molecules with C-H bonds

Ultimately replace them with molecules that don't contain Cl

Global Warming

What is it?

Enhanced greenhouse effect (more energy absorbed than emitted)

What type of light is involved?

IR

Which molecules are the major players?

CO_2 & CH_4 & N_2O (so far)

What happens to the molecules?

They absorb IR energy & vibrate and then emit IR light

Carbon Cycle

What puts Carbon in the atmosphere?

- Respiration
- Deforestation
- CO_2 evaporation from the oceans
- Burning fossil fuel

What takes Carbon out of the atmosphere?

- Reforestation
- Photosynthesis
- CO_2 dissolving in oceans

How much are we talking about?

- 3-4 Gt C/year addition to atmosphere
- Gt=gigatonne (a billion metric tons (10^9),
  2200 billion pounds (2.2×10^{12})

What are the major greenhouse gases?

CO_2, CFCs, CH_4, N_2O

What type of light (radiation) is involved?

IR (Infrared, radiant heat)

What makes something a major greenhouse gas?

Concentration
Lifetime (connected to concentration & reactivity)
Light Absorption efficiency

What are important factors in climate models?

Albedo-ratio of reflected to incident radiation on a surface-depends upon what's on the surface.

Soot & smoke limit incoming light

Photosynthesis dependent upon CO_2 concentration & temperature

Equilibrium: $CO_2 + H_2O \rightleftharpoons H_2CO_3$

Product favored by pressure, higher concentration in deep ocean

What can we do about global warming?

Reduce CO2 emissions by reducing our use of fossil fuels

What are the major fossil fuels?

Coal
Oil
Natural gas

Where is the energy used?

Residential/commercial (heating/cooling lights)
Industrial (making stuff)
Transportation

Redox

- Concepts
  - definitions of redox terms
    - oxidation: a compound loses electron(s)
    - reduction: a compound gains electron(s)
  - determination of oxidation state/charge (oxygen takes electrons)
  - combustion is a redox reaction: check out the oxidation states of the reactants and products

    $C_nH_m \rightarrow nCO_2 + H_2O$

    $O_2 \rightarrow H_2O$
  - galvanic cells and batteries
    - cathode (+): where the reduction takes place
    - anode (-): where the oxidation takes place
    - V = I*R Voltage = Current * Resistance
  - biological redox
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  - thermite reaction: exploiting the propensity of some metals (e.g. Aluminum) to oxidize very easily

What is a galvanic cell?

A galvanic cell is a device that converts the energy released in a spontaneous chemical reaction into electrical energy

What is a battery?

A battery is a device consisting of one or more galvanic cells that produces a direct current by converting chemical energy into electrical energy

What is a electrolytic cell?

A electrolytic cell is a device that converts electrical energy into chemical energy (a battery running backwards)

What is the chemistry of galvanic & electrolytic cells

$Ox \rightarrow Ox^{n+} + ne^-$ oxidized

$Red^{n+} + ne^- \rightarrow Red$ reduced

Electrons are shuttled through an external circuit
Electricity is the flow of electrons from one region to another, driven by a difference in potential energy

What are anodes and cathodes?

The anode is electrode where the oxidation takes place, it is the source of electrons for the external circuit

The cathode is electrode where the reduction takes place, it receives the electrons from the external circuit

When we say a 9 volt battery what are we saying?

The Voltage is the difference in electrochemical potential between the two electrodes (how far downhill the reaction is). Cells are connected in series to increase the potential difference & voltage

1 eV=96.5 kJ/mol

In the following reaction which species is being oxidized? Ni^{2+}

$2Ni(OH)_2(s) + Cd(OH)_2(s) \rightarrow Cd(s) + 2\ NiO(OH)(s) + 2\ H_2O(l)$

In the above reaction which species is being reduced? Cd^{2+}

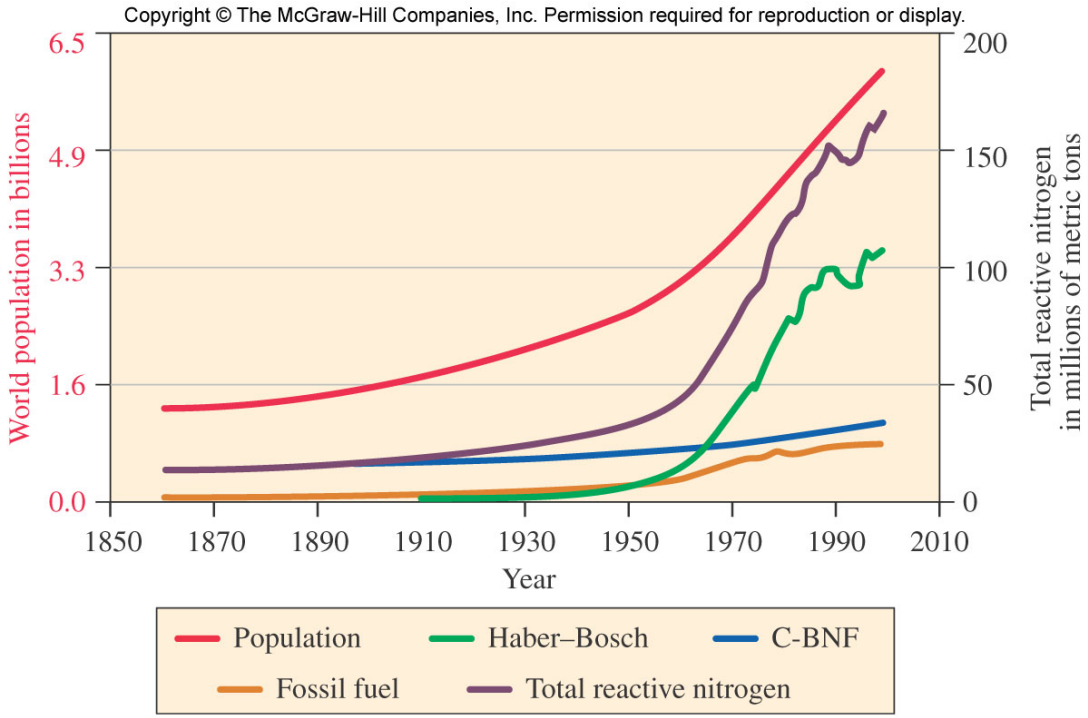
Oxygen more electronegative than most, we say it takes electrons from almost all other elements so O^{2-}, OH^-, other polyatomic anions we've seen

Nitrogen cycle

What is reactive nitrogen?

Nitrogen containing molecules that aren't N_2
examples include:
NO, NO_2, N_2O, NO_2^-, NO_3^-, HNO_3, NH_3, NH_4^+

What are man-made/man-caused sources of reactive nitrogen?



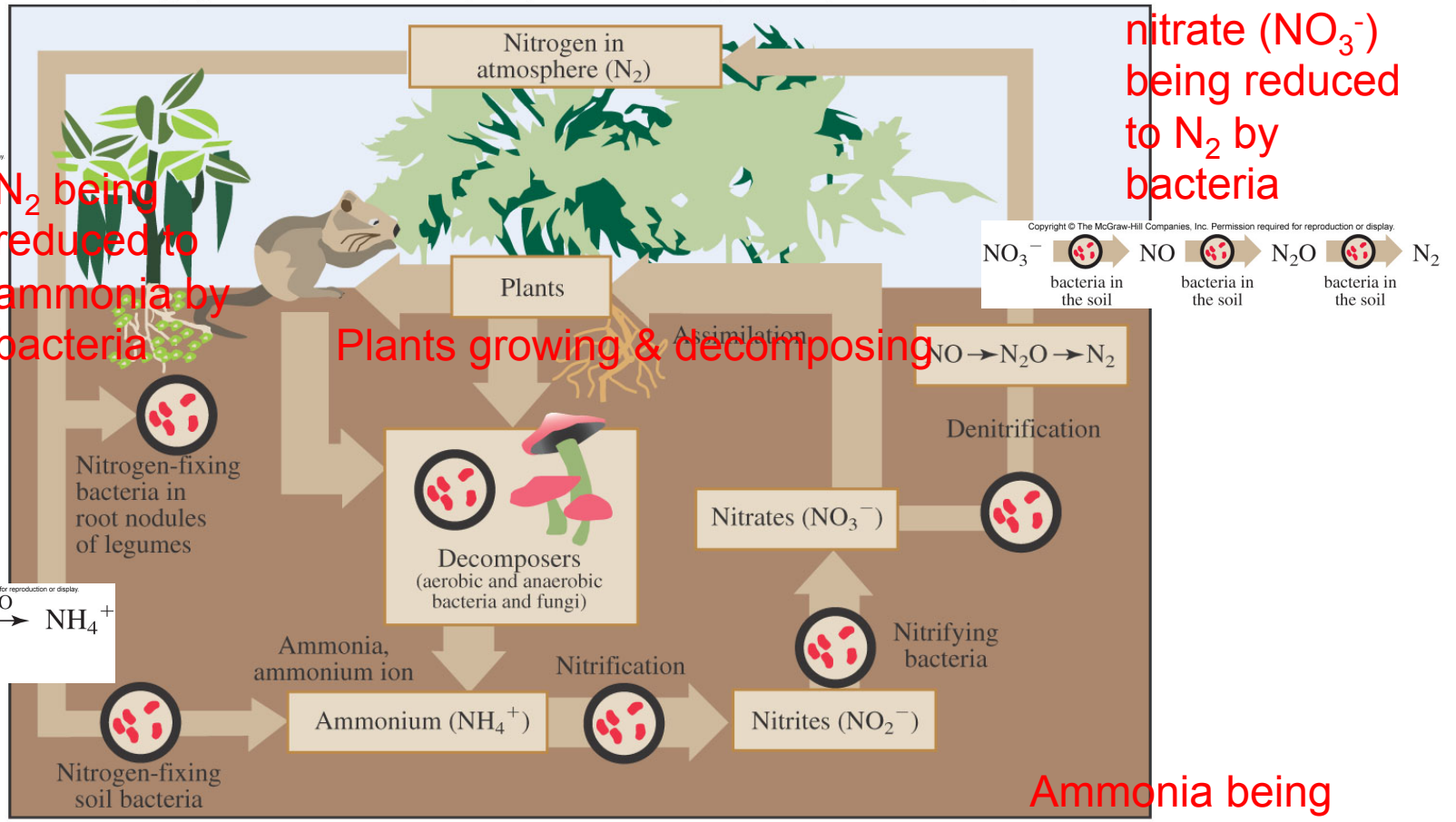
Haber-Bosch process:

$$N_2(g) + 3\,H_2(g) \xrightarrow{\text{Fe cat}} 2\,NH_3(g)$$

C-BNF=reactive nitrogen created from cultivation of legumes, rice, and sugarcane

What is the Nitrogen cycle?

N_2 being reduced to ammonia by bacteria



Plants growing & decomposing

nitrate (NO_3^-) being reduced to N_2 by bacteria

$NO_3^- \xrightarrow{\text{bacteria in the soil}} NO \xrightarrow{\text{bacteria in the soil}} N_2O \xrightarrow{\text{bacteria in the soil}} N_2$

$N_2 \xrightarrow[\text{nitrogen fixation}]{} NH_3 \xrightarrow{H_2O} NH_4^+$

$NH_4^+ \xrightarrow[\text{bacteria in the soil}]{} NO_2^- \xrightarrow[\text{bacteria in the soil}]{} NO_3^-$

Ammonia being oxidized to nitrate (NO_3^-) by bacteria