Energy Intro

How do we access chemical energy?

Why do combustion reactions give off energy?

Order wood, Coal, Natural Gas (methane), gasoline (C_8H_{18}), and ethanol in terms of energy content (per gram) using Table 4.3

Table 4.3 Energy Content of Fuels

Source	kJ/g
Hydrogen	140
Methane	56
Propane	51
Gasoline	48
Coal (hard)	31
Ethanol	30
Wood (oak)	14

Question

For bonds between the following pairs of atoms, in which **one** would you expect the 2nd atom of the pair to gain electrons?

a) C and N
b) O and Cl
c) Be and Na
d) Cl and S

Table 5.3 Electronegativity Values, Arranged by Group Number

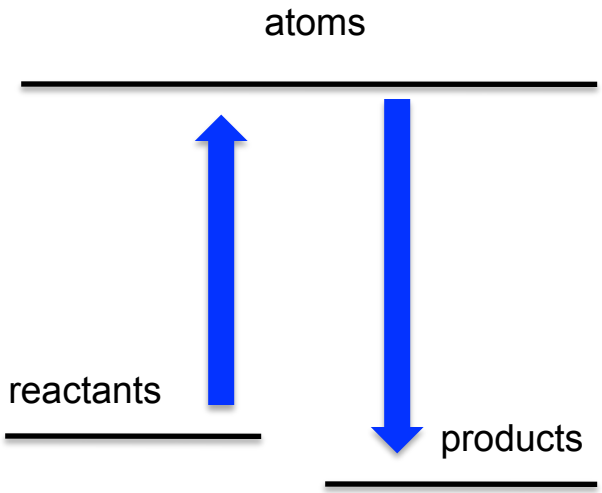
1A	2A	3A	4A	5A	6A	7A	8A
H							He
2.1							—
Li	Be	B	C	N	O	F	Ne
1.0	1.5	2.0	2.5	3.0	3.5	4.0	—
Na	Mg	Al	Si	P	S	Cl	Ar
0.9	1.2	1.5	1.8	2.1	2.5	3.0	—

Bond Energy Calcs

Is the reaction of nitrogen with hydrogen to form ammonia exothermic?

$N_2 + 3H_2 \rightarrow 2NH_3$

If – exothermic
If + endothermic



Need to know bonding
(Dot diagrams/#bonds)

Table 4.2 Bond Energies (in kJ/mol)

	H	C	N	O	S	F	Cl	Br	I
Single Bonds									
H	436								
C	416	356							
N	391	285	160						
O	467	336	201	146					
S	347	272	—	—	226				
F	566	485	272	190	326	158			
Cl	431	327	193	205	255	255	242		
Br	366	285	—	234	213	—	217	193	
I	299	213	—	201	—	—	209	180	151
Multiple Bonds									
C=C	598			C=N	616		C=O	803 in CO_2	
C≡C	813			C≡N	866		C≡O	1073	
N=N	418			O=O	498				
N≡N	946								

Source: Data from Darrell D. Ebbing, *General Chemistry,* Fourth Edition, 1993 Houghton Mifflin Co. Data originally from *Inorganic Chemistry: Principles of Structure and Reactivity,* Third Edition, by James E. Huheey, 1983, Addison Wesley Longman.

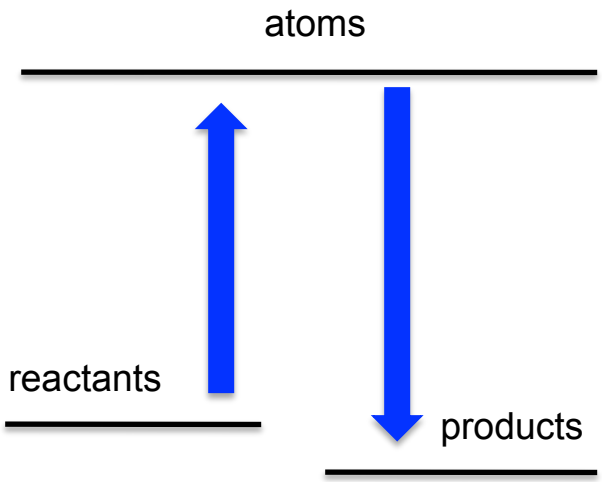
Bond Energy calcs, cont.

Is the reaction of diimide with hydrogen to form ammonia exothermic?

$N_2H_2 + 2H_2 \rightarrow 2NH_3$

What about hydrazine?

$N_2H_4 + H_2 \rightarrow 2NH_3$



Need to know bonding
(Dot diagrams/#bonds)

Table 4.2 Bond Energies (in kJ/mol)

	H	C	N	O	S	F	Cl	Br	I
Single Bonds									
H	436								
C	416	356							
N	391	285	160						
O	467	336	201	146					
S	347	272	—	—	226				
F	566	485	272	190	326	158			
Cl	431	327	193	205	255	255	242		
Br	366	285	—	234	213	—	217	193	
I	299	213	—	201	—	—	209	180	151
Multiple Bonds									
C=C	598			C=N	616		C=O	803 in CO_2	
C≡C	813			C≡N	866		C≡O	1073	
N=N	418			O=O	498				
N≡N	946								

Source: Data from Darrell D. Ebbing, *General Chemistry,* Fourth Edition, 1993 Houghton Mifflin Co. Data originally from *Inorganic Chemistry: Principles of Structure and Reactivity,* Third Edition, by James E. Huheey, 1983, Addison Wesley Longman.

Energy content

Energy content of fuels

The text (p. 166) gives the equation for combusting glucose as giving off 2800 kJ, What is the energy content of glucose per gram?

Table 4.3 Energy Content of Fuels

Source	kJ/g
Hydrogen	140
Methane	56
Propane	51
Gasoline	48
Coal (hard)	31
Ethanol	30
Wood (oak)	14

Unit 2.2 Summary

- Balancing chemical reactions leads to insight on pollution
  - e.g. complete vs incomplete combustion
  - e.g. catalytic conversion of CO to CO_2

- atomic structure and periodicity
  - composition of atoms: protons, neutrons, electrons
  - groups have the same number of valence electrons and similar properties
  - atomic reactivity based on achieving the same number of valence electrons as the noble gas in that atom's group
- Lewis (dot) structures
  - atoms make (covalent) bonds to satisfy the octet rule (most of the time)

- mass and the mole
  - mole is a counting unit, just like dozen…only a lot bigger: Avogadro's # is 6.02×10^{23}
  - use balanced chemical equations and unit analysis to determine things like the amount of carbon put into the atmosphere

Air Pollution

What's in air?

What are the major pollutants that we talked about?

Where do/did they come from?

What's matter?

What have we/are we/can we do?

Balanced Chemical Equations

Table 1.8 Characteristics of Chemical Equations

Always Conserved

Identity of atoms in reactants = Identity of atoms in products

Number of atoms in reactants = Number of atoms in products

Mass of all reactants = Mass of all products

May Change

Number of molecules in reactants vs. Number of molecules in products

Physical states (*s*, *l*, or *g*) of reactants vs. physical states of products

Ethanol (C_2H_6O) reacts with oxygen to form carbon dioxide and water
Write the balanced chemical equation for this.

Atoms are made up of three elementary particles:

Table 2.1 Properties of Subatomic Particles

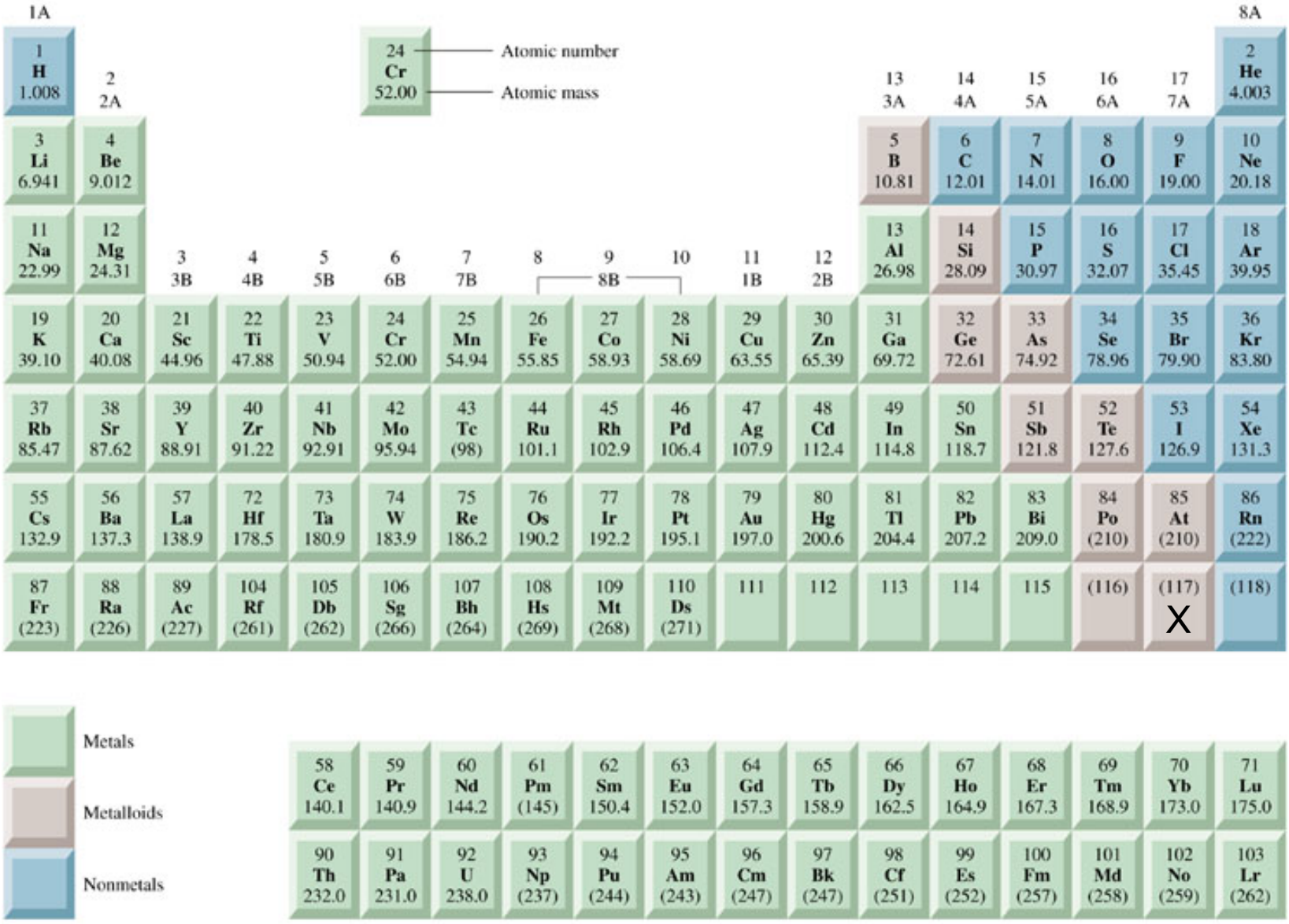
Particle	Relative Charge	Relative Mass	Actual Mass, kg
proton	+1	1	1.67×10^{-27}
neutron	0	1	1.67×10^{-27}
electron	−1	0*	9.11×10^{-31}

Protons & neutrons are in the nucleus (small and dense)
& electrons take up most of the space of atoms but are very light & difficult to describe
Atoms have same # of protons as electrons (zero net charge)

How many protons/electrons are in an atom of Si?

What is the element with 17 protons?

The Periodic Table



Draw the Lewis structure for:

Br

As

Mg

Te

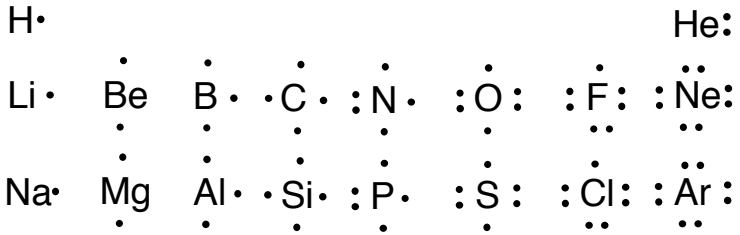
Si

Lewis Dot diagrams

Basic procedure:

1. Determine # outer/valence electrons for each atom (chapter 2)
2. Arrange outer/valence electrons so each atom has noble gas configuration (chapter 2)
3. Electrons repel (but are attracted to protons) so want to be as far apart as possible (chapter 3)

4 pairs of electrons: tetrahedral
3 pairs of electrons: trigonal planar
2 pairs of electrons: linear



Methanol (CH_4O)

Acetic Acid (CH_3COOH)

Methyl amine (CH_3NH_2)

Acetamide (CH_3CONH_2)

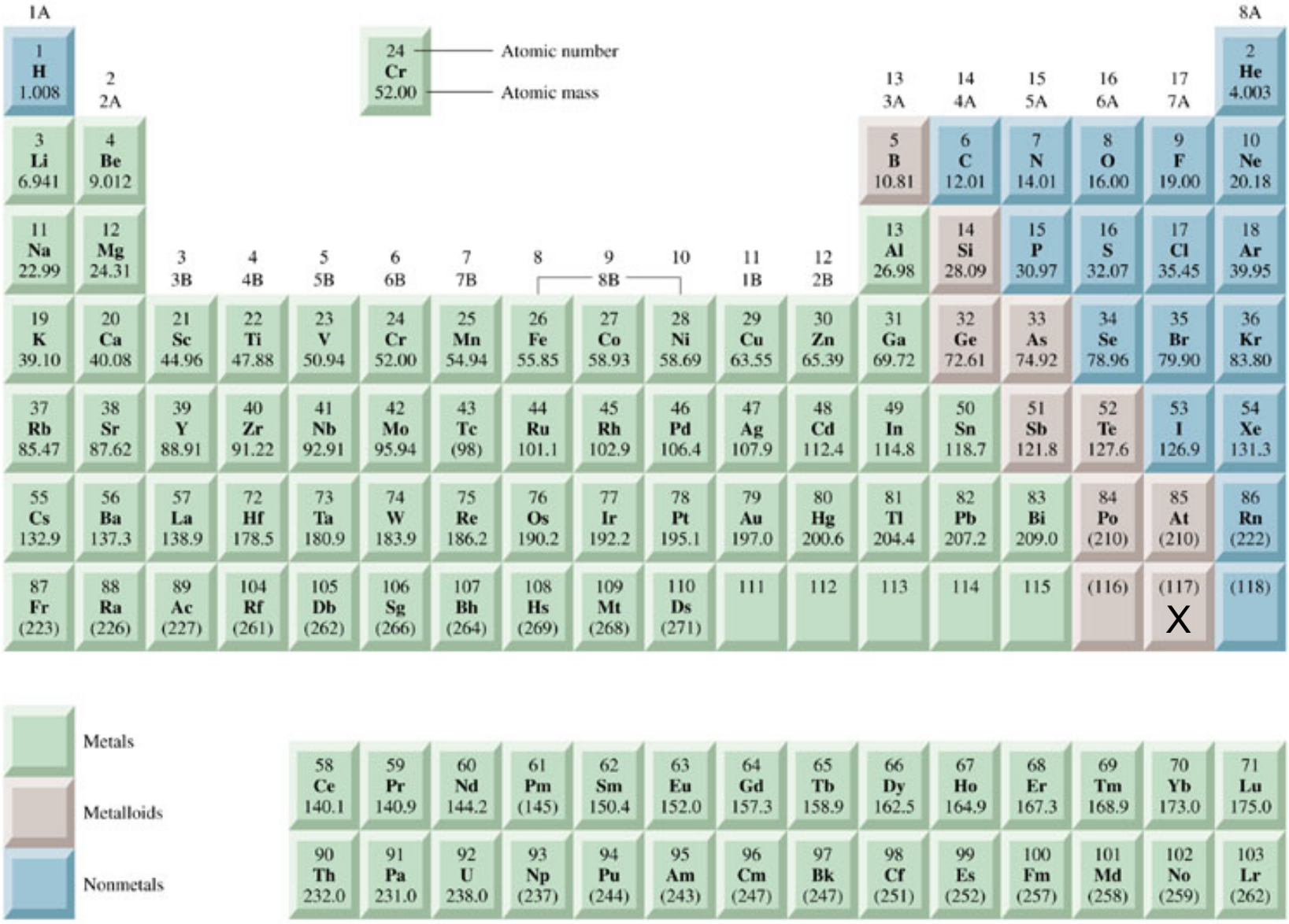
Molar mass, factor-label/unit conversions

What's the molar mass of:

N_2O freon-12 (CF_2Cl_2)

ethanol (C_2H_6O) glucose ($C_6H_{12}O_6$) water (H_2O)

The Periodic Table



Water Solutions & Acids & Bases

- Concepts water
  - electronegativity ➔polar bonds ➔ polar molecules (sometimes)
  - hydrogen bonding: effects on melting and boiling points; effects on solubility
  - ions and ionic compounds
    - anions (-)
    - cations (+)
    - polyatomic ions

    Compounds neutral (no net charge)
    so subscripts are chosen to have zero net charge
  - concentration terms
    - ppm = mg solute /L H_2O
    - ppb = µg solute /L H_2O
    - molarity (M) = mol solute/L solution grams ➔ moles

- Concepts Acids & Bases
  - definitions of acids and bases
    - acids produce hydronium ion [H_3O^+] when dissolved in aqueous solutions
    - bases produce hydroxide ion [OH^-] when dissolved in aqueous solutions
  - acid-base equilibria and neutralization
    - acid + base → salt + water
    - [H_3O^+] * [OH^-] = 1 x 10^{-14} (a constant)
  - definition of pH
    - pH = -log[H_3O^+] [H_3O^+]=10^{-pH}

Where does our drinking water come from?

How much water is there in the world?

What fraction of the world's water is available for use?

How much do we use?

What Physical Properties of Water did we talk about?

Molarity (M)

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{L of solution}}$$

One reagent bottle on the shelf in a laboratory is labeled 12 M H_2SO_4 & another bottle on the shelf in a laboratory is labeled 12 M HCl.

How does the number of moles of H_2SO4 in 100 mL of 12 M H_2SO4 solution compare with the number of moles of HCl in 100 mL of 12 M HCl solution?

How does the number of grams of H_2SO4 in 100 mL of 12 M H_2SO4 solution compare with the number of grams of HCl in 100 mL of 12 M HCl solution?

What do we know about Ionic compounds?

What is the formula for calcium bromide?

What's the rule for solvation?

How can we purify salt water?

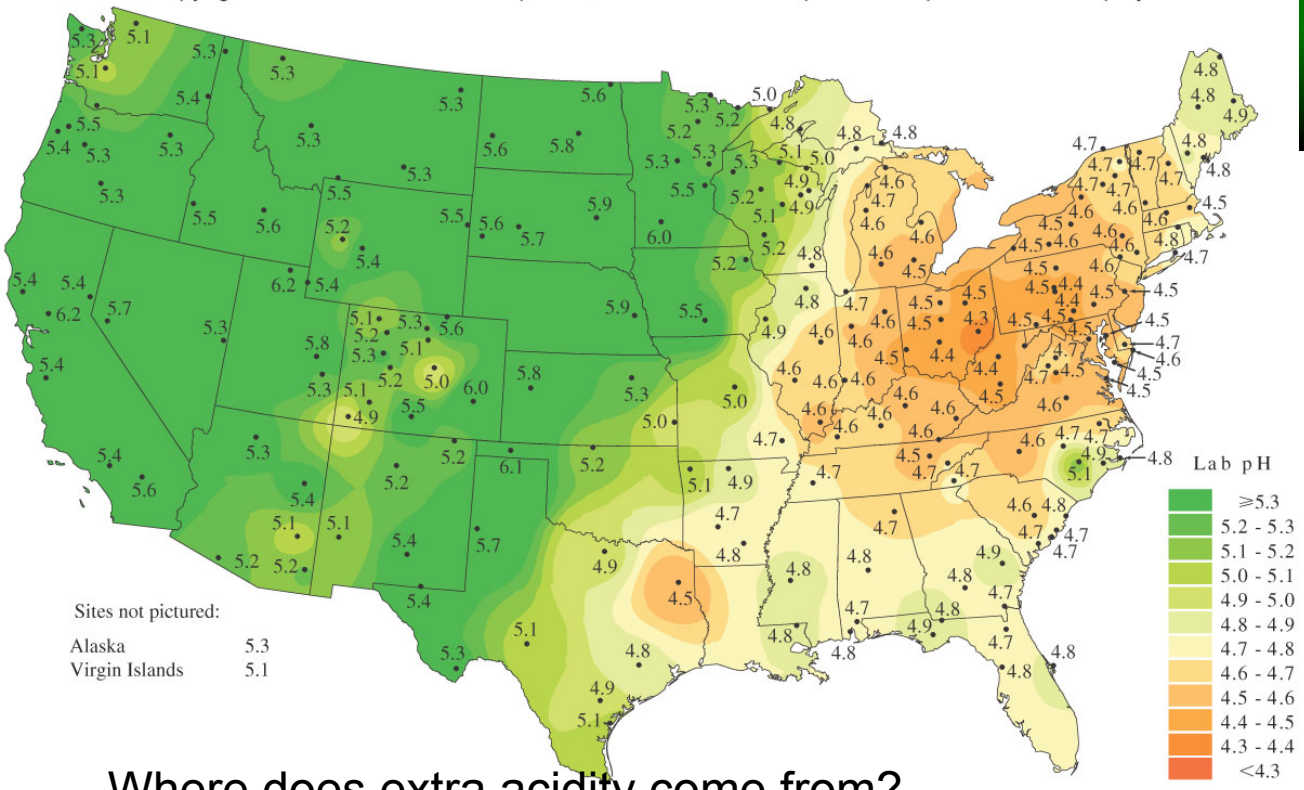
What do we know about acids?

What do we know about bases?

What is neutralization?

What’s pH & why do we care?

Is rain normally acidic?



Where does extra acidity come from?

Where does most of the SO_2 come from?

Where does most of the NO_2 come from?