Energy Intro

How do we access chemical energy?

Why do combustion reactions give off energy?

Order wood, Coal, Natural Gas (methane), gasoline (C₈H₁₈), and ethanol in terms of energy content (per gram) using Table 4.3

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Table 4.3	Energy Conten	t of Fuels	
So	urce	kJ/g	
Ну	drogen	140	
Me	ethane	56	
Pro	opane	51	
Ga	soline	48	
Co	al (hard)	31	
Eth	nanol	30	
Wo	ood (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

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Tabl	e 5. 3		Electronegativity Values, Arranged by Group Number											
1A	2A	3A	4A	5A	6A	7A	8A							
Н							Не							
2.1							_							
Li	Be	В	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?

$$N_2 + 3H_2 \rightarrow 2NH_3$$

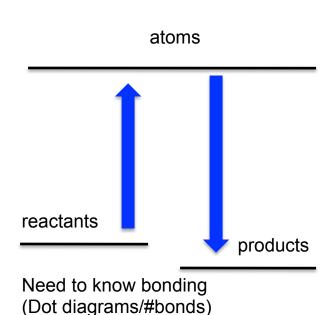
If – exothermic

If + endothermic

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Table	4.2	Bo	nd En	ergies (in	ı kJ/m	ol)			
	Н	C	N	0	S	F	Cl	Br	I
Single I	Bonds								
Н	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	e Bonds								
C = C	598			C=N	616		C=O	803 is	n CO ₂
C≡C	813			$C \equiv N$	866		C≡O	1073	
N=N	418			0=0	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.



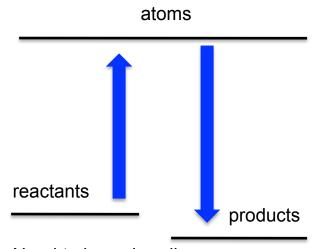
Bond Energy calcs, cont.

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)

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

H (4.2 Bond Energies (in kJ/mol)					
	C	N	O	S F		Cl	Br	I	
ds									
36									
16 3	56								
91 2	85	160							
67 3	36 2	201	146						
47 2	72	_	_	226					
66 4	85 2	272	190	326	158				
31 3	27 1	193	205	255	255	242			
66 2	85	_	234	213	_	217	193		
99 2	.13	—	201		—	209	180	151	
onds									
98			C=N	616		C=O	803 in	CO_2	
13			$C \equiv N$	866		C≡O	1073		
18			0=0	498					
46									
	36 16 31 27 28 29 20 20 20 20 20 20 20 20 20 20	36 16 356 91 285 67 336 47 272 66 485 31 327 66 285 99 213 onds 98 13 18	36 16 356 91 285 160 67 336 201 47 272 — 66 485 272 31 327 193 66 285 — 99 213 — onds 98 13 18	36 16 356 91 285 160 67 336 201 146 47 272 — — 66 485 272 190 31 327 193 205 66 285 — 234 99 213 — 201 onds 98 13 C≡N C≡N C≡N O=O	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	36 16 356 91 285 160 67 336 201 146 47 272 — — 226 66 485 272 190 326 158 31 327 193 205 255 255 242 66 285 — 234 213 — 217 99 213 — 201 — 209 onds 98 C=N 616 C=O C≡N 866 C≡O 18 O=O 498	36 16 356 91 285 160 67 336 201 146 47 272 — — 226 66 485 272 190 326 158 31 327 193 205 255 255 242 66 285 — 234 213 — 217 193 99 213 — 201 — 209 180 onds 98 C=N 616 C=O 803 in 6 C=N 866 C=O 1073 0=O 498	

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?

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Table 4.3	Energy Content	of Fuels	
So	urce	kJ/g	
Ну	drogen	140	
Me	ethane	56	
Pro	opane	51	
Ga	soline	48	
Co	oal (hard)	31	
Eti	nanol	30	
We	ood (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 CO₂
- 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 x 10²³
 - 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

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

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 (C₂H₆O) reacts with oxygen to form carbon dioxide and water Write the balanced chemical equation for this.

Atoms are made up of three elementary particles:

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Table 2.1	Properties of S	Subatomic Particle	es
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

1A																	8A
1 H 1.008	2 2A				24 — Cr 52.00 -		Atomic n		13 3A	14 4A	15 5A	16 6A	17 7A	2 He 4.003			
3 Li 6.941	4 Be 9.012						5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18					
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8	- 8B -	10	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 C1 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 TI 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Ds (271)	111	112	113	114	115	(116)	(117) X	(118)
	Metals																
				58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
	Metalloi	ds					93	94	95	96	97			_			
	Nonmet	als		90 Th 232.0	91 Pa 231.0	92 U 238.0	Np (237)	Pu (244)	Am (243)	Cm (247)	Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

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 Na· Mg Al··Si·:P·:S::Cl::Ar:

Methanol (CH<sub>4</sub>O) Acetic Acid (CH<sub>3</sub>COOH)
```

Methyl amine (CH₃NH₂) Acetamide (CH₃CONH₂)

Molar mass, factor-label/unit conversions

What's the molar mass of: N_2O freon-12 (CF_2CI_2)

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

The Periodic Table

1 H 1.008	2 2A				24 — Cr 52.00		Atomic n	13 3A	14 4A	15 5A	16 6A	17 7A	2 He 4.003				
3 Li 6.941	4 Be 9.012	1												7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8	- 8B -	10	11 1B	12 2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 C1 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 1 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 TI 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Ds (271)	111	112	113	114	115	(116)	(117) X	(118)
	1																
	Metallo	ids		58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
	Nonmet	als		90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)

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 (-)

Compounds neutral (no net charge)

cations (+)

so subscripts are chosen to have zero net charge

- polyatomic ions
- concentration terms
 - ppm = mg solute /L H₂O
 - ppb = μ g solute /L H₂O
 - molarity (M) = mol solute/L solution grams → moles
- Concepts Acids & Bases
 - definitions of acids and bases
 - acids produce hydronium ion [H₃O⁺] 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 = $-\log[H_3O^+]$ [H₃O⁺]=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)

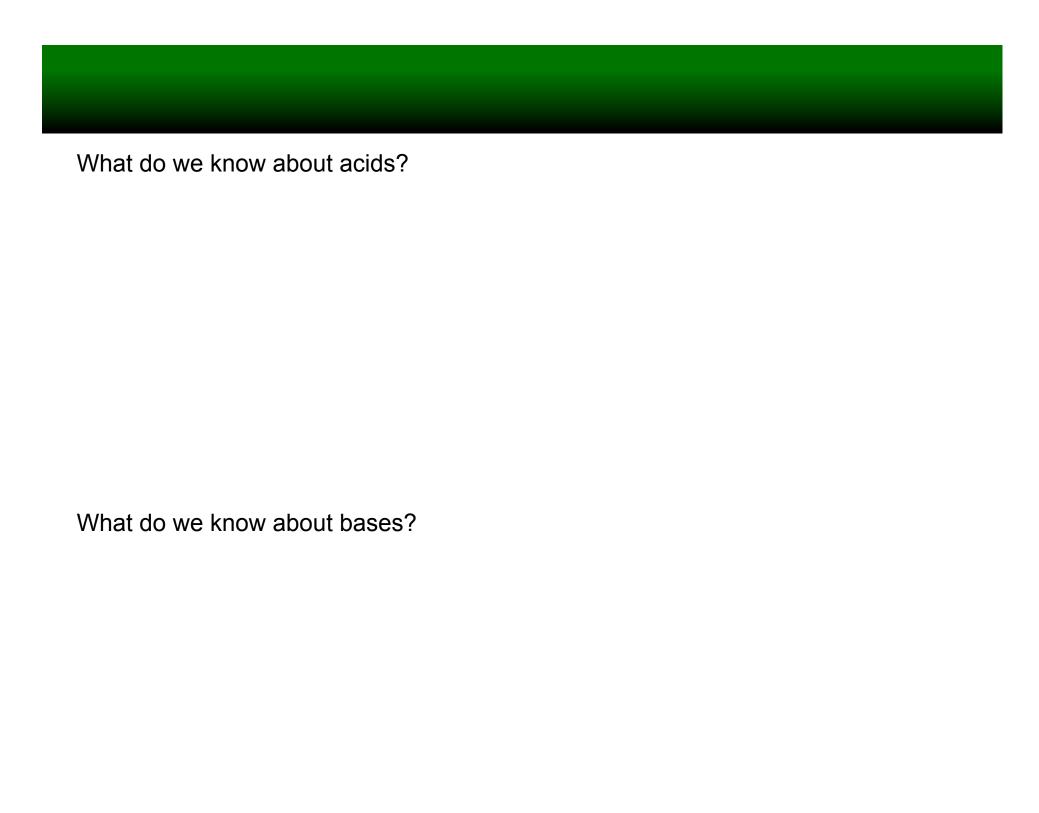
$$Molarity = \frac{moles of solute}{L of solution}$$

One reagent bottle on the shelf in a laboratory is labeled 12 M H₂SO₄ & another bottle on the shelf in a laboratory is labeled 12 M HCl.

How does the number of moles of H₂SO4 in 100 mL of 12 M H₂SO4 solution compare with the number of moles of HCl in 100 mL of 12 M HCl solution?

How does the number of grams of H₂SO4 in 100 mL of 12 M H₂SO4 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 is neutralization?

What's pH & why do we care?



