Chapter 1: conversion problems, metric system, significant figures, accuracy, precision
Chapter 2: History of Chemistry, Laws: Conservation of Mass, Definite Proportion, Multiple Proportions, Dalton's Atomic Theory, Avogadro's Hypothesis, Atomic Structure, Thomson, Millikan, Rutherford,
naming compounds
Chapter 3: Atomic Masses (amu's), grams to moles, percent composition, empirical/molecular formulas, Stoichiometry, balancing equations, limiting reagents, theoretical yield, percent yield.
Chapter 4: stoichiometry, solubility rules, precipitation reactions, assigning oxidation states (helpful for figuring out sulfate, sulfites, etc for naming of compounds), acid base reactions, REDOX reactions, Half-Rxn method for balancing REDOX rxns.
Chapter 5: gas Laws, pressure, kinetic theory of gases, Grahams Law, Temperature of a gas, root mean square velocity of a gas. Vapor pressure correction
Chapter 6: work/enthalpy, calorimetry, Hess's Law, standard enthalpies of formation, energy sources, global warming
Chapter 7: quantum numbers, electron rules, periodic trends,
Chapter 8: Lewis dots, formal charge, resonance, isoelectronic
Chapter 9: sigma and pi bonding, hybridization, local electron model (Lewis Dot Theory with mixing of atomic orbitals to create hybrids - hybridization), failure of L.E. model (use resonance to "fudge"), Molecular Orbital Theory (M.O. Theory) – use atomic orbitals and create sigma and pi molecular orbitals.   Ultimately, combine MO theory with local model – allow mixing and allow hybridization and get better overall explanation of bonding. Understand how MO theory explains the delocalization of pi orbitals . Calculate Bond order, determine magnetism (para or diamagnetism)

sp   bonding in two directions $H-C{\equiv}C-H$ Carbon is sp hybridized (180°)
sp^2   bonding in three directions BH_3 (no lone pair, just a three orbitals at 120°
sp^3   bonding in four directions CH4 or NH3 (remember, NH3 has a lone pair in
          4th direction)   tetrahedral angles of 109.5°
dsp^3 bonding in 5 directions – trigonal bipyramidal – three at 120° to each other in same
          plane, the 4th and 5th at the top and bottom e.g. XeO_3F_2
d^{2}sp^3 bonding in six directions - octahedral e.g. PF_6^{-1}

Units – be able to convert within metric

Name	abrev	# in one meter	# meters
Picometer	pm	10^{12}	10^{-12}
Nanometer	nm	10^9	10^{-9}
Micrometer	µm	10^6	10^{-6}

also called a "micron"

Name	abrev	# in one meter	# meters
Millimeter	mm	10^3	10^{-3}
Meter	m	10^0	10^0
Kilometer	km	10^{-3}	10^3
Megameter	Mm	10^{-6}	10^6
Gigameter	Gm	10^{-9}	10^9
Terameter	Tm	10^{-12}	10^{12}

We also use centi and deci

Name	abrev	# in one meter	# meters
Centimeter	cm	10^2	10^{-2}
Decimeter	dm	10^1	10^{-1}

Please note that all of these units work with other measures than meters:
e.g. joules (kilojoules, Megajoules, microjoules   or watts – kilowatts, Megawatts
even computer memory – kilobytes, Megabytes, Gigabytes

Mass and Volume – see previous density problems.

1 ml is defined as the volume of a 1cm by 1 cm by 1 cm or 1 cm^3
(1 ml = 1 cm^3)
Calculate the volume of an object – length times width time heights for an orthogonal
   object (all right angles, like a cube or shoebox)
   3 cm x 5 mm x 2 cm
   convert mm to cm then multiply   (3cm x 0.5 cm x 2 cm) = 3 cm^3
   How many liters?   3 cm3(1 ml /1cm^3)(1L/10^3 ml)

Temperature Scales: Celsius Kelvin and Fahrenheit

Celsius	0	100
Kelvin	273.15	373.15

Fahrenheit   32   212

Know how to convert between all of the above: e.g. if Temp is 55 F what is it in C? what
    is it in K?

Also, using your common sense, analyze temperatures and see if they make sense:
e.g. circle the following temperatures that are "bogus" (incorrect)
human body temperature: 98.6°C
boiling point water: 100°C
freezing point of water   32°K
room temperature   290°K

(human body temperature and freezing point of water are bogus)

Naming Chemicals   You need to know how to name and recognize the names of
    common chemical compounds:

See Table 2.5 page 67 of Zumdahl (Common Polyatomic Ions)

Ates, Ites, and Ides - see previous reviews

Thermal chemistry   - system and surroundings

If you ADD heat or work to a system, the work and/or heat is positive.
If you remove heat or work from a system, the work and/or heat is negative.

$\Delta E = q + w$ q= heat   w = work = $-P\Delta V$

q < 0 exothermic   or w < 0   e.g. a gas expands in the system - it does work on the
    surroundings and hence the work is negative.

If you have to put heat into a system or if you have to put work into a system, the heat
    and work are positive (i.e. you boil water, you put heat into the system   or if you have
    to compress a balloon, you have the surroundings doing work on the system)
A gas releases 2.500 * 10^3kJ of heat to the surroundings while the surroundings then
perform 15.2 J of work on the gas. What is the change in internal energy of the gas ?

The gas is the system – it releases means exothermic, heat, q, is -2.5kj

The surroundings perform work on the system – so the system is receiving work, meaning the work is positive + 15.2 J   delta E = q + w = -2500 + 15.2 = -2385 joules

Heat capacity – how much energy does it take to heat 250 ml of water from 20C to 100C
Heat capacity of water is 4.184 J/(°g)   use density of water = 1g/ml (or 1 g/cm3)

250 ml *(1g/ml) = 250 grams water   250 g*4.184 J/°/g =   about 1000 J/degree (I'm being lazy and rounding 4.184 to 4)

you have a delta T of 100-20 = 80 degrees

so 1000 j/degree*80 degrees = 80,000 joules or 80 kjoules

in one step   250 ml(1 g/ml)(4.184 J/°/g)(80°)(1 kj/1000 j) = 80 kjoules

KNOW the solubility Rules (six total) page 152 table 4.1

Write a net ionic equation to illustrate a solubility rule that has a precipitation:
e.g.   Most sulfates soluble EXCEPT the +2 ones (Pb^{+2} Hg^{+2} Ca^{+2} Sr^{+2} Ba^{+2})
(it's easier to write a net ionic for the precipitating ones)
$Ba^{+2}(aq) + SO_4^{-2}(aq)$ = $BaSO_4(s)$
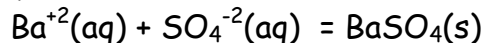
Chapter 7 Atom Structure

The 4 Quantum numbers (n, l, m_l and m_s)
   Know each and what they mean
   n = principal quantum number – relates to **size** and **energy**
   l = azimuthal quantum number – relates to **shape** (s, p, d, f)   l = 0, 1,…, n-1
   m_l = magnetic quantum number – relates to **direction** of orbital (px, py,pz)
     m_l = –l, -l+1, …0…l-1, l
   ms = spin quantum number – relates to electron **spin**

Advanced Lewis Dots (resonance and formal charge)
Periodic trends
Meaning of isoelectronic
See suggested chapter 8 homework problems at top for examples

Chapter 8 Bonding

Know Ionic vs covalent vs polar covalent

Identify dipoles in a structure (CH4 ?　NH3?　CO2

Calculate if a bond is polar or not by subtracting electronegativities

Calculate enthalpy of a reaction by looking

Know the fundamental acids and bases:

Strong acids: H_2SO_4 HNO_3 HCl　H_3PO_4, $HClO_4$ (Sulfuric　Nitric　Hydrochloric, perchloric)

Some weak Acids:　acetic HCH_3COO or CH_3COOH　or $HC_2H_3O_2$　the corresponding anion is acetate　CH_3COO^- or $C_2H_3O_2^-$

Organic acids: ROOH　C=O-OH

Strong Bases: alkali hydroxides (Li, Na, K, Rb, and CsOH) and some alkaline earth hydroxides ($Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_{2)}$

Other bases: ammonia NH_3

some practice problems – see next page for answers:

acid/base

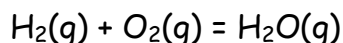200. mL of 0.0250 M HCl　how much 0.0500 M NaOH needed to neutralize?

Stoichiometry/gases

Oxalic acid decomposes to form CO_2 gas:　$H_2C_2O_4 \rightarrow 2CO_2 + 2H^+$

How many grams of acid need to be decomposed to make 44.8 liters CO_2 at STP?

$Ca_3N_2 + H_2O = NH_3 + CaO$　how many grams Ca_3N_2 to make 11.2 liters NH_3 at STP?

Stoichiometry/Limiting example

$H_2(g) + O_2(g) = H_2O(g)$

1) balance the reaction. If 1 liter of H_2 and 1 liter O_2 react at 1.00 atm and 400.K, how many liters of $H_2O(g)$ will they make?

2) if that water is cooled to 27°C, what volume will it have?

3) Calculate the change in internal energy for the condensation of this steam at 400.K to liquid at 27°C. The heat for this process will involve a few steps – You will have to calculate the heat change from cooling the steam from 400.K to 373K (the heat capacity of steam is 2.0J/(K*g), then the heat of condensation using the latent heat of condensation of water which is 2.26kJ/g (the latent heat is the heat released when a gas condenses to a liquid – it is the opposite of the heat required to convert a liquid to a gas), then you have to cool this liquid water from 373K to 27°C - its heat capacity is 4.184 J/(g*K).

ANSWER KEY:

acid/base
200. mL of 0.0250 M HCl   how much 0.0500 M NaOH needed to neutralize?

M means molarity – it is a concentration not a number of moles.

It is a measure of the number of moles contained in 1 liter – moles solute per L solution.

So write 0.0250 M HCl as   <u>0.0250 mol HCl</u>   so you can set up units to cancel
                            L soln

<u>(0.0250 mol HCl</u>)0.200L HCl soln = 0.00500 mol HCl
(L HCl soln)

now relate the number of moles of HCl to the number of moles NaOH

$H^+ + OH^- = H_2O$ so there is a 1 to 1 ratio between them

<u>(0.0250 mol HCl</u>)(0.200L HCl soln)(1 mol NaOH)(<u>1 L NaOH</u>   )= 0.100 L NaOH
(L HCl soln)   (1 mol HCl)   (0.0500 mol NaOH)

Stoichiometry/gases
Oxalic acid decomposes to form CO_2 gas: $H_2C_2O_4 \rightarrow 2CO_2 + 2H^+$

How many grams of acid need to be decomposed to make 44.8 liters CO_2 at STP?

STP = 273.15K, 1 atm, (either use pv=nRT to calculate or 22.4 L/mole, the molar volume of an ideal gas at STP)

22.4 L/mol and 44.8 L CO_2 at STP means we have 2.00 mol CO_2 gas

(2.00 mol CO_2)(1 mol $H_2C_2O_4$)(90.0 g $H_2C_2O_4$) = 90.0 g oxalic acid needed
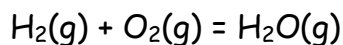   (2 mol CO_2)   (1 mol $H_2C_2O_4$)

$Ca_3N_2 + H_2O = NH_3 + CaO$ how many grams Ca_3N_2 to make 11.2 liters NH_3 at STP?

Balance first, $Ca_3N_2 + 3H_2O = 2NH_3 + 3CaO$

Ca_3N_2 molar mass = 3*40.0 * 2*14.0 = 148 g/mol

11.2 L NH_3 (1 mol NH_3) (1 mol Ca_3N_2)(148 g Ca_3N_2) = 24.7 g Ca_3N_2
              (22.4 L NH_3)(3 mol CaO)(1 mol Ca_3N_2)

Stoichiometry/Limiting example

$H_2(g) + O_2(g) = H_2O(g)$

1) balance the reaction. If 1 liter of H_2 and 1 liter O_2 react at 1.00 atm and 400.K, how many liters of $H_2O(g)$ will they make?

$H_2 + 1/2O_2 = H_2O$ (you can convert to moles but why bother? Remember Avogadro's
                  Hypothesis?)

Have   Need
1 L H_2 (0.5 L O_2) = 0.5 L O_2 so 1 L H_2 needs 0.5 L O_2 to react with. We have 1 L O_2
      (1 L H_2)   so O_2 is in excess – we are limited by the H_2
1 L O_2

1 L H_2(1 L H_2O) = 1 L H_2O
      (1 L H_2)

2) if that water is cooled to 27°C, what volume will it have?

If it is cooled to 20°C it will liquefy. The density of water at that temperature is 1.00 g/mL.   1 L H_2O.

But we need to know how much water we had in the first place. At 400.K we had 1 L of $H_2O(g)$ – use pv=nRT to find moles   n = pv/(RT) = 1.00*1.00/(R*400.) = 0.0305 moles H_2O

0.0305 mol H_2O(<u>18.0 g H_2O</u>) (<u>1.00 mL H_2O</u>) = 0.548 mL liquid H_2O
                    (1 mol H_2O) (1.00 g H_2O)

3) Calculate the change in internal energy for the condensation of this steam at 400.K to liquid at 27°C. The heat for this process will involve a few steps – You will have to calculate the heat change from cooling the steam from 400.K to 373K (the heat capacity of steam is 2.0J/(K*g), then the heat of condensation using the latent heat of condensation of water which is 2.26kJ/g (the latent heat is the heat released when a gas condenses to a liquid – it is the opposite of the heat required to convert a liquid to a gas), then you have to cool this liquid water from 373K to 27°C - its heat capacity is 4.184 J/(g*K).

ΔE = q + w   Let's do w first to build up your confidence.

w = -pΔV = -p(V_2-V_1) = -1.00atm(0.548 mL – 1.00L)

need to convert mL to L   w = -1.00atm(0.000548L -1.00L) = +1.00L*atm

w = 1.00L*atm need to convert to J (101.3 J/(1 L*atm)   1.00L*atm(<u>101.3 J</u>) = 101 J
                                                                            (1 L*atm)

Should the sign of w be positive? A gas is becoming a liquid, so you can think of the surroundings doing work to the system by "squeezing the gas" into a liquid. So, yes, it should be positive

The steam we do in three parts:
a) cool steam from 400.K to 373K - use steam's heat capacity for this = 2.0 J/(g*K)
b) condense steam to water at 373K - use the latent heat for this = 2260 J/g
c) cool liquid water from 373.K to 300K - use water's heat capacity for this = 4.18 J/(g*K)

1) q_1 = 0.548g(2.0J/(g*K))*(T_2-T_1) = 0.548g(2.0J/(g*K))*(373-400.)K = -29.6 J

2) q_2 = 2260 J/g*0.548g = 1240 J

3) q_3 = 0.548g(4.184J/(g*K))*(T_2-T_1) = 0.548g(4.184J/(g*K))*(300-373) = -167 J

first do q = 2.26kJ/g (0.548 g H_2O) = 1.24 kJ

What should the signs be? The signs for the q1 and q3 are clearly negative – they are cooling off so heat must leave the system.

Q2 is also negative. When a gas condenses to a liquid, does it release heat or require heat to drive the process? It is exothermic. Since exo, then heat leaves the system and goes to the surroundings, so the heat should be negative.

So qtotal = q1 +q2 + q3 = -29.6 + -1240J + -167 = - 1440 J

ΔE = q + w = -1440J + 101J = -1340 J or -1.34 kJ

WHEW!!!

Please notice the astonishingly large heat associated with condensing steam.

Cooling the steam by 27°C required 30 J be removed

Cooling the liquid by 73°C required 170 J be removed

CONDENSING (with no temperature change, just going from gas to solid) required a whopping 1240 J. This is why steam burns can be so bad – a huge amount of heat is released by the steam to your skin when the steam condenses.