For Example
Pour 51.0 mL of 2.00 M NaOH(aq) into 50.0 mL of 2.00 M HCl(aq)

1. Is there a Limiting Reagent ? If so, what is it?
2. What is the Theoretical Yield of water in grams?
3. If 5.85 grams of NaCl is formed, what is the % Yield ?

How are Moles determined from Molarity?

Moles of Solute = Molarity x (Volume in Liters)

Calculate the number of moles of HCl in 50.0 mL of 2.00 M HCl(aq)
Moles = M x V = (0.0500)x(2.00) = 0.100

Calculate the number of moles of NaOH in 51.0 mL of 2.00 M NaOH
Moles = M x V = (0.0510)x(2.00) = 0.102

Write & Balance Reaction

$1\ HCl_{(aq)} + 1\ NaOH_{(aq)} \rightarrow 1\ H_2O + 1\ NaCl_{(aq)}$

or

$0.1\ HCl_{(aq)} + 0.102\ NaOH_{(aq)} \rightarrow 0.1\ H_2O + 0.1\ NaCl_{(aq)}$

What is the Limiting Reagent ?	HCl(aq)
What is the Theoretical Yield of water?	0.1 mole = 1.8 grams
5.85 grams of NaCl formed, % Yield is	5.85 g NaCl = 0.1 mole Therefore 100% yield

---

Brief Review for Exam 3

Chapter 5
Thermo chemistry
Chapter 6
Electrons
Chapter 7
Size of Atoms & Ions

Chapter 5 Thermo chemistry

Units of Energy: 1 cal = 4.184 joule

Energy is constant (system + surroundings)

System = *the portion of the universe that we single out for study*

Surroundings = *everything outside the system*

The **1st Law of Thermodynamics** states that the energy of the universe is constant

$\Delta U_{universe} = \Delta U_{system} - \Delta U_{surrounding} = 0$

Energy can be **transferred** from **system** to **surroundings** (*or vice versa*) but it can't be created or destroyed

$\Delta U_{system} = \Delta U_{surrounding}$

A more useful form of the first law:

$\Delta U_{system} = q + w$

The **change** in the internal energy of a **system** is equal to the **sum** of the **heat** ….(*gained* or *lost* by the *system*)
and the **work** …………..(*done by* or *on* the *system*)

$\Delta U_{system} = q + w$

For q
+ means **system** GAINS heat (endothermic)
- means **system** LOSES heat (exothermic)

For w
+ means work done ON **system**
- means work done BY **system**

For ΔU_{sys}
+ means **system** GAINS energy
- means **system** LOSES energy

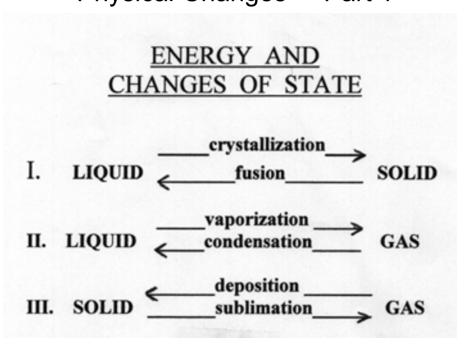
Most important concept in Chap 5

HEAT LOST = HEAT GAIN

Something is gaining Heat
While Something else looses Heat.

If you know one of these
then you know the other

Physical Changes Part 1



How much energy is involved when 1.0 grams of ice melts? *(the heat of fusion is 6.01 kJ/mole)*

$$(1.0\ g\ H_2O)\ x\ \frac{1}{18.0}\frac{mole}{g} = 0.0555\ mole$$

$$(0.0555\ mole)\ x\ \frac{6.01}{1}\frac{KJ}{mole} = 0.3338885\ KJ$$

ΔH = 0.33 kJ

Physical Changes Part 2

Energy Change ***WITHIN*** a state {***No Phase Change***}

Specific Heat: heat required to raise the temperature of one gram of a substance by one degree C

$$\text{Specific heat} = \frac{\text{Joules of heat transferred}}{(\text{grams of substance})\ x\ (\text{temperature change})}$$

$$\textit{For}\ \text{Water}: \text{S.H.} = 4.18\ \frac{\text{JOULES}}{(\text{Grams})(\Delta T)}$$

How much Energy required to heat 1.0 gram of water at 0ºC to water at 100ºC

Let UNITS solve the problem.

Joules = (Specific Heat)x(grams)x(change in Temp)
= (4.18) x (1.0) x (100) = 418 Joules
= 4.2×10^2 Joules

What is delta H ?

CHEMICAL REACTIONS Part 1

Reactants → Products +/-*ENERGY*

Determination of Heats of Reaction

Using

THE DIRECT METHOD

EXPERIMENTAL

Go to Lab and use a Calorimeter

EXPERIMENTAL

Two (2) types of Calorimeters

In Both Types

Heat LOST = Heat GAINED

1. ***OPEN*** { to the atmosphere

&

2. ***CLOSED*** {to the atmosphere

(mainly for gas reactions)

1.435 g of naphthalene ($C_{10}H_8$)was burned in a constant volume bomb calorimeter. The temperature of the water rose from 20.17 to 25.84 °C. If the mass of the water was exactly 2000 g and the heat capacity of the calorimeter was 1.80kJ/°C find the heat of combustion

Write and balance reaction

$1\ C_{10}H_8 + 12\ O_2 \rightarrow 10\ CO_2 + 4\ H_2O +$ HEAT

Heat Lost by Chemical Reaction = *Heat Gain by 1. Water + 2. Calorimeter*

HEAT LOST = HEAT GAIN

1. ***Heat Gain by Water*** = S. H. x grams x Temp

$q_{water} = (4.184)(2000)(25.84 - 20.17) = 4.74 \times 10^4$ J

2. ***Heat Gain by Calorimeter*** = Heat Cap x Temp Change

$q_{Calorimeter} = (1800)(25.84 - 20.17) = 1.02 \times 10^4$ J

Total Heat Gained = Water + Calorimeter

$= 4.74 \times 10^4 + 1.02 \times 10^4 = 5.76 \times 10^4$ J

$1\ C_{10}H_8 + 12\ O_2 \rightarrow 10\ CO_2 + 4\ H_2O \quad \Delta H = ??$

Heat lost by 1.435 g of naphthalene = 5.76×10^4 J

MW of naphthalene ($C_{10}H_8$) = 128.2 g / mol

1.435 g / (128.2 g / mol) = 0.01119 mole

How much heat for 1 mole of naphthalene ?

5.76×10^4 J / 0.01119 mole = 5.1458895×10^6 J/mol

Heat of combustion of naphthalene

$\Delta H = -5.15 \times 10^3$ kJ/mole

CHEMICAL REACTIONS Part 2

Determination of Heats of Reaction

Using

THE INDIRECT METHOD

MATHEMATICAL

Using HESS'S Law:

ENTHALPY CHANGES ARE ADDITIVE

Example 1: Calculate the heat given off for reaction

$N_2(gas) + 3\ H_2(gas) \rightarrow 2\ NH_3\ (gas)$

Given: ΔH_f for NH_3 (gas) = -46.19 kJ / mole

ΔH_f for N_2(gas) = ?

ΔH_f for H_2(gas) = ?

Therefore heat given off = 46.19 kJ x 2 = **92.38kJ**

Example 2: Calculate the heat of vaporization of CS_2

Given ΔH_f for CS_2 (liq) = 88 kJ / mole

and ΔH_f for CS_2 (gas) = 117 kJ / mole

(1) $C + 2\ S \rightarrow CS_2$ (liq) = 88 kJ

(2) $C + 2\ S \rightarrow CS_2$ (gas) = 117 kJ

(3) CS_2 (liq) $\rightarrow C + 2\ S$ = - 88 kJ

Add equations (2) and (3)

CS_2 (liq) $\rightarrow$ CS_2 (gas) ΔH_{vao} = 117 – 88 = 29kJ

Example 3: Calculate [using Hess' Law] the heat of reaction for $CO(g) + \frac{1}{2}\ O_2(g) \rightarrow CO_2(g)$

What DATA Do You Need From Table ?

TABLE 5.3 Standard Enthalpies of Formation, ΔH_f°, at 298 K

Substance	Formula	ΔH_f° (kJ/mol)	Substance	Formula	ΔH_f° (kJ/mol)
Acetylene	$C_2H_2(g)$	226.7	Hydrogen chloride	$HCl(g)$	−92.30
Ammonia	$NH_3(g)$	−46.19	Hydrogen fluoride	$HF(g)$	−268.6
Benzene	$C_6H_6(l)$	49.0	Hydrogen iodide	$HI(g)$	25.9
Calcium carbonate	$CaCO_3(s)$	−1207.1	Methane	$CH_4(g)$	−74.8
Calcium oxide	$CaO(s)$	−635.5	Methanol	$CH_3OH(l)$	−238.6
Carbon dioxide	$CO_2(g)$	−393.5	Propane	$C_3H_8(g)$	−103.85
Carbon monoxide	$CO(g)$	−110.5	Silver chloride	$AgCl(s)$	−127.0
Diamond	$C(s)$	1.88	Sodium bicarbonate	$NaHCO_3(s)$	−947.7
Ethane	$C_2H_6(g)$	−84.68	Sodium carbonate	$Na_2CO_3(s)$	−1130.9
Ethanol	$C_2H_5OH(l)$	−277.7	Sodium chloride	$NaCl(s)$	−410.9
Ethylene	$C_2H_4(g)$	52.30	Sucrose	$C_{12}H_{22}O_{11}(s)$	−2221
Glucose	$C_6H_{12}O_6(s)$	−1273	Water	$H_2O(l)$	−285.8
Hydrogen bromide	$HBr(g)$	−36.23	Water vapor	$H_2O(g)$	−241.8

From Enthalpy of Formation Table

Substance	Formula	ΔH_f (kJ/mol)
Carbon dioxide	CO_2	- 393.5
Carbon monoxide	CO	- 110.5

Write & Balance FORMATION Reactions

1. $C_{(s)} + \frac{1}{2}\ O_2(g) \rightarrow CO(g)$ ΔH = - 110.5 kJ
2. $C_{(s)} + O_2(g) \rightarrow CO_2(g)$ ΔH = - 393.5 kJ

ΔH_f From Table

WRITE AND BALANCE REACTIONS

Formation of CO (g) is :

1. $C_{(s)} + \frac{1}{2}\ O_2(g) \rightarrow CO(g)$ ΔH = - 110.5 kJ

Formation of CO_2(g) is :

2. $C_{(s)} + O_2(g) \rightarrow CO_2(g)$ ΔH = - 393.5 kJ

Want $CO\ (g) + \frac{1}{2}\ O_2(g) \rightarrow CO_2(g)$

1. $C_{(s)} + \frac{1}{2}\ O_2(g) \rightarrow CO(g)$ ΔH = - 110.5 kJ

REWRITE Eq 1

1b. $CO\ (g) \rightarrow C_{(s)} + \frac{1}{2}\ O_2(g)$ ΔH = + 110.5 kJ

also

2. $C_{(s)} + O_2(g) \rightarrow CO_2(g)$ ΔH = - 393.5 kJ

$CO(g) \rightarrow C_{(s)} + \frac{1}{2} O_2(g) \quad \Delta H = + 110.5\ kJ$
$C_{(s)} + O_2(g) \rightarrow CO_2(g) \quad \Delta H = - 393.5\ kJ$

Add Equations To Get :

$$CO(g) + \frac{1}{2} O_2(g) \rightarrow CO_2(g)$$

Add ΔH 's To Get :

$\Delta H = + 110.5\ kJ - 393.5\ kJ = -283\ kJ$

Do you like M&M candy? A pound contains 96 g fat, 320 g carbohydrate and 21 g protein

How many calories in a 1.5 oz serving (42 g)

1st Calculate the fuel value in a pound of M&M's

Values from table 5.4

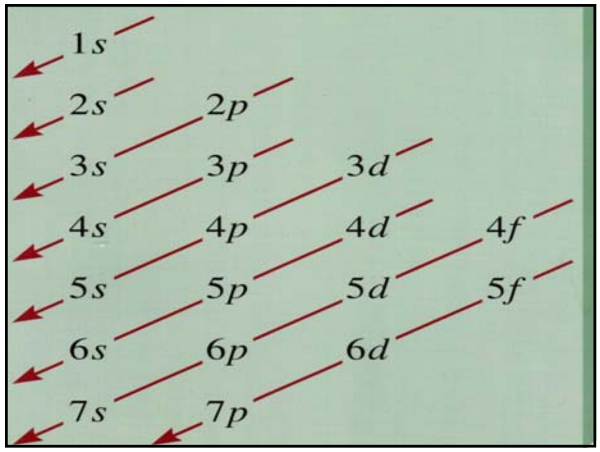
96 g fat x 9 kcal/g	=	864 kcal
320 g carbohydrate x 4 kcal/g	=	1280 kcal
21 g protein x 4 kcal/g	=	84 kcal
Total fuel value in one pound of M&M	=	2228 kcal

$$2228\ \frac{kcal}{lb}\ x\ \frac{1}{453.6}\frac{lb}{g}\ x\ \frac{42\ g}{serving} = 206$$

Chapter 6

ELECTRONS

1. HOW MANY ARE THERE ?
2. ELECTRON CONFIGURATION
3. ORBITAL DIAGRAM
   - HUND'S Rule
4. QUANTUM NUMBERS (FOUR)
   - PAULI Principle



Review

	Number of electrons	Electron Configuration
H	(1)	$1S^1$
He	(2)	$1S^2$
Li	(3)	$1S^2\ 2S^1$
Be	(4)	$1S^2\ 2S^2$
B	(5)	$1S^2\ 2S^2\ 2P^1$
C	(6)	$1S^2\ 2S^2\ 2P^2$

ORBITAL DIAGRAMS

	1S	2S	2P	3S
H	(↑)			
He	(↑↓)			
Li	(↑↓)	(↑)		
Be	(↑↓)	(↑↓)		
B	(↑↓)	(↑↓)	(↑)( ) ( )	
C	(↑↓)	(↑↓)	(↑)(↑)( )	***NOTE!***

P 6.62 How many unpaired electrons in each of the following atoms ?

(a) C	(a)2 unpaired
(b) Cl	(b) 1unpaired
(c) Ti	(c) 2 unpaired
(d) Ga	(d) 1 unpaired
(e) Rh	(e) 3 unpaired
(f) Po	(f) 2 unpaired

QUANTUM NUMBERS
Each electron is assigned FOUR

1. The Principal Quantum Number, **n**
   n = 1, 2, 3, 4, 5, 6, or 7
2. The Angular Momentum Quantum Number ℓ
   ℓ = n – 1, n – 2, ….
3. The Magnetic Quantum Number, m_ℓ
   m = - ℓ to + ℓ
4. The Spin Quantum Number S
   S = + ½ or - ½

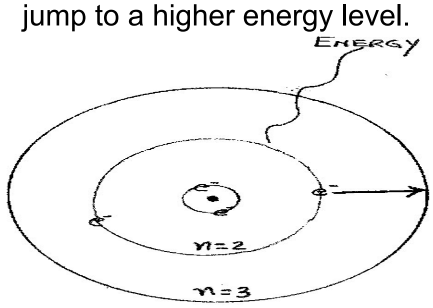
Quantum Numbers

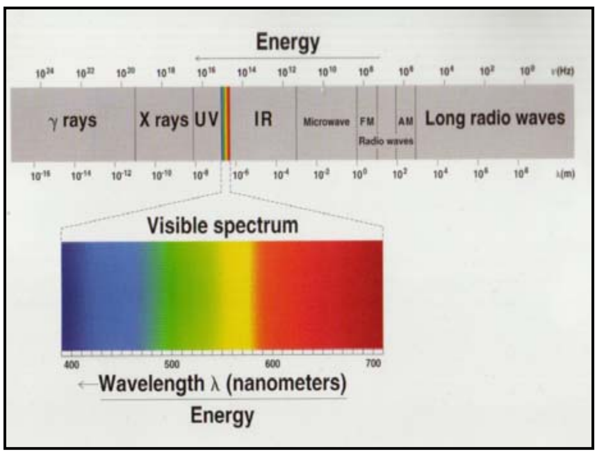
N (7)	$1s^2$		$2s^2$		$2p^3$		
	(↑↓)		(↑↓)		(↑)	(↑)	(↑)
n	= 1	1	2	2	2	2	2
ℓ	= 0	0	0	0	1	1	1
m	= 0	0	0	0	-1	0	+1
s	= ½	- ½	½	- ½	½	½	½

P6.56 What is the maximum number of electrons in an atom that can the following quantum numbers

(a) n = 2 m = ½	(a) 0
(b) n = 5 ℓ = 3	(b) 14
(c) n = 4 ℓ = 3 m = -3	(c) 2
(d) n = 4 ℓ =1 m = 1	(d) 2

If an atom absorbs energy, an electron in a lower energy level will jump to a higher energy level.





RELATIONSHIP BETWEEN C λ and ν

C = λ x ν

UNITS Solve Problems !!

$$\frac{meters}{\text{sec}} = \text{meters} \times \frac{1}{\text{sec}}$$

If λ = 1000 meters (AM Radio) what is the frequency (ν) of radiation ?

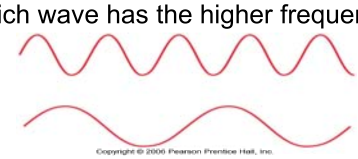
UNITS Solve Problems !!

C = λ x ν

$$3.00x10^8 \frac{meters}{\text{sec}} = 1000 \text{ meters} \times ? \frac{1}{\text{sec}}$$

$$\nu = \frac{C}{\lambda} = \frac{3.00\text{x}10^8}{1000} \frac{m/s}{m} = 3.00 \text{ x } 10^5 \text{ sec}^{-1}$$

Which wave has the higher frequency?



The lower wave has a longer wavelength (greater distance between peaks).

Since λ x ν = C (a constant)

The lower wave has the smaller frequency value

The upper one has the higher frequency

Relationship Between Energy wavelength (λ) and frequency (ν)

E ∝ ν (directly)

E ∝ 1 / λ (inversely)

What frequency of electromagnetic radiation has enough energy to break a C– H bond (bond enthalpy is 413 kJ/mol)

$E = h\ \nu$ *or* $\nu = E / h$

$\nu = E / h = 413 \text{ kJ/mol} / 6.627 \times 10^{-34} \text{ J-s/photon}$

$\nu = E / h = 413 \times 10^3 \text{ J/mol} / 6.627 \times 10^{-34} \text{ J-s/photon}$

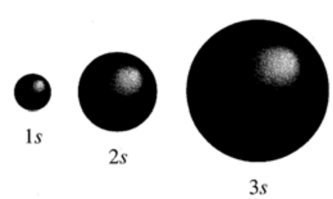
$\nu = 62.32 \times 10^{37} \text{ photon/mol-sec}$

$\nu = 62.32 \times 10^{37} \text{ photon/mol-sec} / 6.02 \times 10^{23} \text{ photon/mol}$

$\nu = 1.032 \times 10^{15} \text{ sec}^{-1}$

7.3 SIZES OF ATOMS

As the principal quantum number increases the size of the orbital increases



7.3 SIZES OF ATOMS

BUT !!

As we move **ACROSS** a period, {left to right} atoms become **SMALLER**

WHY ?

the principal quantum number remains constant, but the nuclear charge increases

Which of the following **ATOMS** is largest

Na or K	K
S or O	S
Na or Cl	Na
Na , Mg , Al	Na
N , O , F	N

P7.18 Using only the periodic table, arrange the following atoms in increasing radius

(a) Cs K Rb	K < Rb < Cs
	4/1 5/1 6/1
(b) In Te Sn	Te < Sn < In
	5/16 5/50 5/13
(c) P Cl Sr	Cl < P < Sr
	3/17 3/15 5/2

Which of the following is largest

Na^+ or K^+	K^+
Na^+ , Na or K^+	K^+
Na^+ or Mg^{2+}	Na^+
S^{2-} or O^{2-}	S^{2-}
S^{2-}, S or O^{2-}	S^{2-}
O^{2-} or F^-	O^{2-}

Problem 7.24 Select the ions or atoms that are isoelectronic with each other

(a) K^+ Rb^+ Ca^{+2}	(a) K^+ Ca^{+2}	18e
(b) Cu^+ Ca^{2+} Sc^{3+}	(b) Ca^{2+} Sc^{3+}	18e
(c) S^{2-} Se^{2-} Ar	(c) S^{2-} Ar	18e
(d) Fe^{2+} Co^{3+} Mn^{2+}	(d) Fe^{2+} Co^{3+}	24e

7.3 In an ISOELECTRONIC series Ionic size DECREASES with INCREASING nuclear charge

-- Increasing nuclear charge →

O^{2-} < F^- < Ne < Na^+ < Mg^{2+} < Al^{3+}

--- Decreasing ionic radius →