General Chemistry Review

Helping you remember what you learned, oh, so long ago.

Topics – (Until we run out of time)

- The mole
  - Stoichiometry
  - Limiting Reactants
- Solution Chemistry
  - Molarity
  - Dilution
  - Stoichiometry
- Gases
  - Gas Laws
  - Stoichiometry
- Thermochemistry
  - Using Thermochemical Equations
  - Measuring heat change
- Equilibria
  - Equilibrium constants
  - Le Châtelier's Principle
- Electrochemistry
  - Redox reactions
  - Volteic cells
  - Electrolysis

THE MOLE

The Mole (simply a number)

- Mole – number of atoms in 12.00 grams of ^{12}C.
- 1 mole = 6.022×10^{23} of anything.
- Molar mass: mass of one more of a substance.
  - Applies to element as well as compounds.
  - Used to convert between mass and moles.

MAIN–GROUP ELEMENTS | TRANSITION ELEMENTS | MAIN–GROUP ELEMENTS

- Metals (main-group)
- Metals (transition)
- Metals (inner transition)
- Metalloids
- Nonmetals

Period	IA (1)	IIA (2)	IIIB (3)	IVB (4)	VB (5)	VIB (6)	VIIB (7)	VIIIB (8)	VIIIB (9)	VIIIB (10)	IB (11)	IIB (12)	IIIA (13)	IVA (14)	VA (15)	VIA (16)	VIIA (17)	VIIIA (18)
1	1 H 1.008																	2 He 4.003
2	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
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	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
5	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
6	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 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)						

INNER TRANSITION ELEMENTS

6	Lanthanides	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
7	Actinides	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (242)	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 (260)

Gram to Mole Conversion

- How many moles of silver atoms are in 15.0 grams of silver?
  Molar mass of Ag = 107.87 g/mol

- How many grams of SO_3 are in 4.0 moles SO_3?

Mole to Mole conversions

- Using balanced chemical equations to convert between substances.
- For the balanced equation: $H_2 + Cl_2 \rightarrow 2\ HCl$, How many moles of HCl will be produced when 2.5 moles Cl_2 reacts with an excess of H_2.

Combining the conversions

- How many grams of HCl would be produced when 4.5 grams of Cl_2 reacts with an excess of H_2? (In other words, what is the theoretical yield…)

Limiting Reactant

- If given measured information about both reactants…
- Work the problem twice and determine which produces the least amount of product.
- What is the theoretical yield of NaCl if 2.5 g Na reacts with 3.5 g Cl_2?

Limiting reactant

- How many grams of SO_3 will be produced if 3.0 moles of SO_2 reacts with 35.0 grams of O_2?

SOLUTION CHEMISTRY

Solution – a homogeneous mixture

- Molarity = moles of solute per liters of solution

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

- What is the molarity of a solution prepared by dissolving 5.0 grams of NaOH in enough water to prepare 250.0 mL of solution?

Molarity as a conversion factor

- How many grams of sodium sulfate (Na_2SO_4) is contained in 2.0 L of a 0.105 M solution?

Dilution: $M_1V_1 = M_2V_2$

- Solution of high concentration diluted by adding water to a solution of lower concentration.
- What is the molarity of a solution prepared by dissolving 15.0 mL of 8.0 M HCl with 85.0 mL of water?

Molarity and Stoichiometry

- $M \times V$ = moles…a new road to moles
- What mass of NaCl is required to react with 25.0 mL of 0.105 M $AgNO_3$.
  $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$

GASES

Gases

- Molecules very far apart (vast amount of empty space).
- No defined volume or shape.
- Pressure = force/area
- Common units: atm and mmHg (torr)
- 1 atm = 760 mmHg (torr)

Ideal gas equation

- PV=nRT (R=0.08206 L·atm/mol·K)
- What is the volume occupied by 5.0 grams of CO_2 at 25 °C and 3.5 atm.

Gas Laws (Changing conditions)

- Relationships can be derived from PV=nRT

- P,V relationship – inverse proportion (Boyle's Law)
- V,T relationship – direct proportion (Charles's Law)
- V, n relationship – direct proportion (Avogadro's Law.)

Change of conditions

- What is the volume of a gas at 300 °C if the gas occupies 150 mL at 150 °C?

Gases and stoichiometry

- What volume of H_2 at STP is produced at STP if 5.0-g of Na is dropped in water?
  $Na(s) + H_2O(l) \rightarrow NaOH(aq) + H_2(g)$
- Handy conversion factor at STP: Molar volume of a gas.
- 22.4 L/mol

Heat exchange in chemical reactions

THERMOCHEMISTRY

Thermochemical Equaitons

- Heat – transfer of thermal energy
- Thermochemical equation – gives balanced reaction and enthalpy (heat at constant P).

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g) \quad \Delta H^{\circ}_{rxn} = -802.3\ kJ$

- Can be used to convert between kJ ←→ mol

Using a thermochemical equation

- How much heat is liberated during the combustion of 30.0-g of methane.

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g) \quad \Delta H^{\circ}_{rxn} = -802.3\ kJ$

Measurements of heat changes

- q = mass × specific heat × change in temp.
- $q = m \times s \times \Delta T$
- What is the specific heat of an unknown metal if 25.0-g of the metal at 100.0 °C is placed in 100.0-g of water at 25.0 °C and the final temperature reached is 28.0 °C? The specific heat of water is 4.184 J/(g·°C.)

EQUILIBRIA

Dealing with reversible reactions

- For any reaction:
  $aA(g) + bB(g) \rightleftharpoons cC(g) + dD(g)$
- An equilibrium expression can be created:

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

- Only include gases or aqueous substance.
- That is, leave out solids and liquids
- Can replace concentrations with pressures (in atm.)

Le Châtelier's Principle

- When a system at equilibrium is disturbed, the system shifts in a direction that minimizes the disturbance.
  - Concentration
  - Pressure (or volume)
  - Temperature

Change in concentration

- Add a substance, makes more (must be gas or aqueous to matter.)
- $CH_3OH\ (g) \rightleftharpoons CO(g) + 2\ H_2(g)$
- Add more CO, rxn. shifts ______________
- Remove some H_2, rxn. shifts _____________

Change in pressure

- Increase pressure (by decreasing volume), shifts to try to bring down the pressure
  - Shifts towards the side with fewer moles of gas.
- $CH_3OH\ (g) \rightleftharpoons CO(g) + 2\ H_2(g)$
- If the above system is at equilibrium and the pressure is increased,
  System will shift to the ___________________

Change in temperature

- Must know if reaction is
  - endothermic (positive ΔH) or
  - exothermic (negative ΔH)
- If exothermic, put heat in as a product.
- If endothermic, put heat in as a reactant.

- Raising the temperature is adding heat .
- Lowering the temperature is removing heat.

Change in temperature

- For the reaction:
  $CH_3OH\ (g) \rightleftharpoons CO(g) + 2\ H_2(g)$ ΔH^o=128.1 kJ
- What conditions of temperature will shift the reaction to produce more products?

The study of the connections between chemical energy and electrical energy.

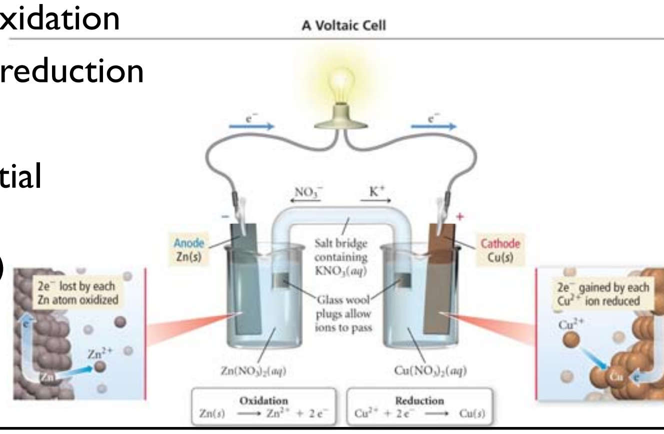
ELECTROCHEMISTRY

Redox reactions

- Electron transfer reaction.
- Noted by a change in oxidation states.
- $2\ Al(s) + 3\ Cu(NO_3)_2(aq) \rightarrow 2\ Al(NO_3)_3 + 3\ Cu(s)$
- LEO says GER
  - Loss of electrons, oxidation
  - Gain of electrons, reduction

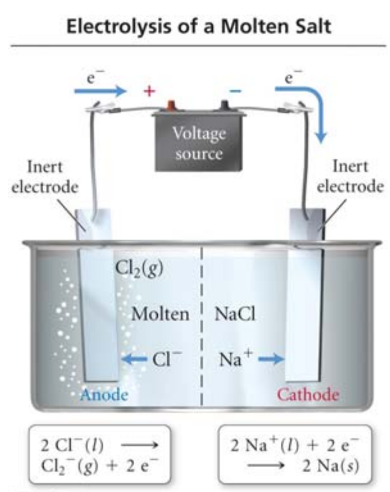
Voltaic cells

- Redox reaction is separated into half reactions so that the transferred electrons must travel across a wire. (Electrical energy)
- Anode – oxidation
- Cathode –reduction
- Cell Potential
  EMF (E)
  Voltage (V)



Electrolytic Cells

- Consumes electrical energy to drive an nonspontaneous reaction.
- Amps = Coulombs/seconds
- Faraday's constant (F)
  F = 96,500 C/mol



Electrolysis Stoichiometry

- Gold can be plated out of a solution containing Au^{3+} according to the half reaction:
  $Au^{3+}(aq) + 3\,e^{-} \rightarrow Au(s)$
  what mass of gold (in grams) is plated by a 25-minute flow of 5.5 A current?