CHM1025 Final Exam Review

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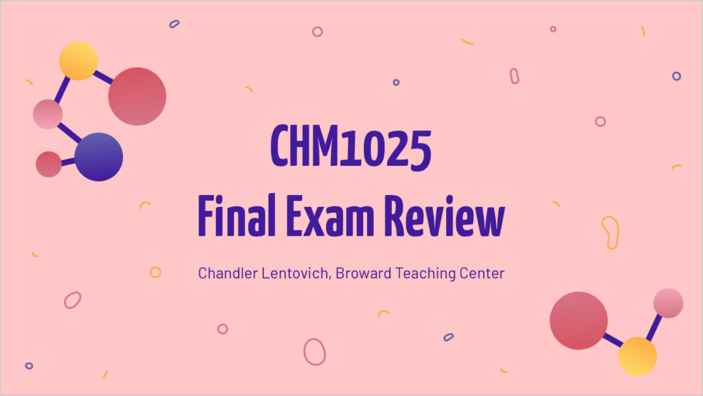
CHM1025
Final Exam...



CHM1025
Final Exam Review

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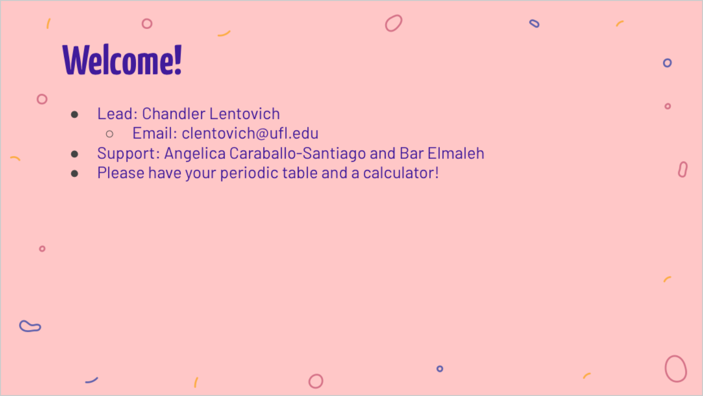

Welcome!

- Lead: Chandler Lentovich
    - Email: clentovich@ufl.edu
- Support: Angelica Caraballo-Santiago and Bar Elmaleh
- Please have your periodic table and a calculator!

Limiting Reagent

What is limiting reagent?

- Two reagents react, you need to find out how much of each reacted
- There will be less of one reagent available to react, this will be your limiting reagent
- Use dimensional analysis to:
  - Determine how much of each reagent reacts
    - Determine limiting reagent
  - Use limiting reagent to determine how much product is formed

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Consider the following reaction: $4NH_3 + 5O_2$ -> $4NO + 6H_2O$. If 3.25 g NH_3 are allowed to react with 3.50 g O_2, how many grams of NO are formed?

$$3.25\ \cancel{g\ NH_3} \cdot \frac{1\ \cancel{mol\ NH_3}}{17.03\ \cancel{g\ NH_3}} \cdot \frac{4\ mol\ NO}{4\ \cancel{mol\ NH_3}} = 0.191\ mol\ NO$$

$$3.50\ \cancel{g\ O_2} \cdot \frac{1\ \cancel{mol}\ O_2}{32\ g\ \cancel{O_2}} \cdot \frac{4\ mol\ NO}{5\ \cancel{mol}\ O_2} = 0.0875\ mol\ NO$$

↑ LR

↑ max amount possible

$$0.0875\ mol\ NO \cdot \frac{30\ g}{1\ mol\ NO} = \boxed{2.625\ g\ NO}$$

Consider the following reaction: $N_2 + 3H_2 \rightarrow 2NH_3$. If you use 30g of N_2 and 10 g of H_2, what is the mass of the excess reagent?

$$30\,g\,\cancel{N_2}\cdot\frac{1\,mol\,\cancel{N_2}}{28\,\cancel{g}\,N_2}\cdot\frac{3\,\cancel{mol}\,H_2}{1\,\cancel{mol}\,\cancel{N_2}}\cdot\frac{2.016\,g\,H_2}{1\,\cancel{mol}\,H_2}=6.48\,g\,H_2$$

$$10\,g\,H_2-6.48\,g\,H_2=\boxed{3.52\,g\text{ excess }H_2}$$

$$10\,g\,\cancel{H_2}\cdot\frac{1\,\cancel{mol}\,H_2}{2.016\,g\,\cancel{H_2}}\cdot\frac{1\,\cancel{mol}\,\cancel{N_2}}{3\,\cancel{mol}\,H_2}\cdot\frac{28\,g\,N_2}{1\,\cancel{mol}\,N_2}=46.3\,g\,N_2\text{ needed}$$

*we only have 30 g N_2, we can't react w/ 46.3 g N_2 *

- N_2 will not be the excess reagent, do dimensional analysis using N_2

Redox Reactions

Finding Oxidation Numbers

- Oxidation number
  - The hypothetical charge of an atom if all of its bonds to different atoms were fully ionic
- Group 1 metals: always +1
- Group 2 metals: always +2
- Oxygen: usually -2
- Hydrogen: usually +1
- Halogens: usually -1
- Elements by themselves= 0!

oxidation numbers in a molecule MUST add up to 0 unless you have an ion (need to add up to charge of the ion

What is the oxidation number of each atom in Fe_2O_3?

↑ overall charge = 0

- O is usually -2

$2(Fe) + 3(-2) = 0$

↓

$2(Fe) - 6 = 0$

$+6 \quad +6$

↓

$\frac{2(Fe)}{2} = \frac{6}{2}$ → $Fe = +3$, $O = -2$

What is the oxidation number of each atom in H_2CO_3?

↑ overall charge of 0

$2(H) + 1(C) + 3(O) = 0$

↓

$2(+1) + 1(C) + 3(-2) = 0$

↓

$2 + 1(C) - 6 = 0$

$1(C) - 4 = 0$

$+4 \quad +4$

↓

$\frac{1(C)}{1} = \frac{4}{1}$ → $C = 4$, $H = +1$, $O = -2$

How Oxidation Numbers Relate to Redox

- Loss of electrons: oxidation
  - Charge gets more positive
- Gain of electrons: reduction
  - Charge gets more negative
- Remember: LEO the lion goes GER!
  - (Loss of Electrons=Oxidation, Gain of Electrons=Reduction)

In the reaction, $2HCl + Zn \rightarrow H_2 + ZnCl_2$, which reactant is oxidized and which reactant is reduced?

+1 -1 0 0 +2 $2(-1)=-2$

LEO
GER

H: $+1 \rightarrow 0$ REDUCED (oxidizing agent)

Cl: $-1 \rightarrow -1$ NO CHANGE

Zn: $0 \rightarrow +2$ OXIDIZED (reducing agent)

In the reaction, $Au + 4H^+ + NO_3^- + 4Cl^- \rightarrow AuCl_4 + 2H_2O + NO$, which reactant is the oxidizing agent?

$Au + 4H^+ + NO_3^- + 4Cl^- \rightarrow AuCl_4 + 2H_2O + NO$

0 +1 -1 +4 -1 +1 -2 +2 -2

$1(N)+3(-2)=-1$
$1(N)-6=-1$
$+6 \quad +6$
$\frac{1(N)}{1} = \frac{+5}{1}$
$N=+5, O=-2$

Au: $0 \rightarrow +4$ Oxidized (red. ag.) Cl: $-1 \rightarrow -1$ NO CHANGE

H: $+1 \rightarrow +1$ NO CHANGE

$\boxed{N: +5 \rightarrow +2 \text{ reduced (ox. ag.)}}$

O: $-2 \rightarrow -2$ NO CHANGE

LEO
GER

Balancing Redox Reactions

- Half reaction method
  - Balance each species individually
  - Electrons are included
  - Ensure that electrons lost= electrons gained
  - Combine half reactions

Balance $MnO_4^- + SO_3^{2-} \to MnO_2 + SO_4^{2-}$ using the half reaction method

$$MnO_4^- \longrightarrow MnO_2$$

$1(Mn)+4(-2)=-1$

$Mn=+7$

$O=-2$

$1(Mn)+2(-2)=0$

$Mn=+4$

$O=-2$

$$\underset{\uparrow \atop +7}{MnO_4} + \underline{3}\,\underset{\uparrow \atop -3}{e^-s} \to \underset{\uparrow \atop +4}{MnO_2}$$

$$+7 \quad -3 \quad = \quad +4$$

$$SO_3^{2-} \longrightarrow SO_4^{2-}$$

$1(S)+3(-2)=-2$

$S=+4$

$O=-2$

$1(S)+4(-2)=-2$

$S=+6$

$O=-2$

$$\underset{\uparrow \atop +4}{SO_3^{2-}} \longrightarrow \underset{\uparrow \atop +6}{SO_4^{2-}} + \underline{2}\,\underset{\uparrow \atop -2}{e^-s}$$

$$+4 \quad = \quad +6 \quad -2$$

---

make sure our electrons are equal

$2(MnO_4 + 3e^-s \to MnO_2)$ | $3(SO_3^{2-} \to SO_4^{2-} + 2e^-s)$

$2MnO_4 + 6e^-s \to 2MnO_2$ | $3SO_3^{2-} \to 3SO_4^{2-} + 6e^-s$

$2MnO_4 + \cancel{6e}^-s + 3SO_3^{2-} \rightarrow 2MnO_2 + 3SO_4^{2-} + \cancel{6e}^-s$

$2MnO_4 + 3SO_3^{2-} \rightarrow 2MnO_2 + 3SO_4^{2-}$ ← end of e^-s part, need to make sure atoms are equal

$Mn = 2$

$+2H^+ \rightarrow O = 8 + 9 = 17$ ← one more O

$S = 3$

$Mn = 2$

$O = 4 + 12 = 16$ $+H_2O$

$S = 3$

$$\boxed{2H^+ + 2MnO_4 + 3SO_3^{2-} \rightarrow 2MnO_2 + 3SO_4^{2-} + H_2O}$$

Titration

Titration

- You will have an acidic/basic solution
- You want it to become neutral, so you add base (acidic solution) or acid (basic solution)
- Titration stops when the solution is neutral

↑

$H^+ = OH^-$

$83\,\text{mL} \cdot \frac{1\,\text{L}}{1000\,\text{mL}} = 8.3\times10^{-2}\,\text{L}$

$235\,\text{mL} \cdot \frac{1\,\text{L}}{1000\,\text{mL}} = 0.235\,\text{L}$

It takes 83 mL of a 0.45 M NaOH solution to neutralize 235 mL of an HCl solution. What was the initial concentration of the HCl solution?

$\frac{0.45\,\text{mol}}{1\,\text{L}} \cdot 8.3\times10^{-2}\,\text{L} = 3.74\times10^{-2}\,\text{mol NaOH} \cdot \frac{1\,\text{mol OH}^-}{1\,\text{mol NaOH}} = 3.74\times10^{-2}\,\text{mol OH}^-$

↑ definition of neutrality

$3.74\times10^{-2}\,\text{mol H}^+$

neutrality: $H^+ = OH^-$

$3.74\times10^{-2}\,\text{mol H}^+ \cdot \frac{1\,\text{mol HCl}}{1\,\text{mol H}^+} = \frac{3.74\times10^{-2}\,\text{mol HCl}}{0.235\,\text{L}} = \boxed{0.16\,\text{M HCl}}$

$0.038\,\text{L}$

1:1

It takes 38 mL of 0.75 M NaOH solution to completely neutralize a 0.092 M solution of sulfuric acid (H_2SO_4). What was the initial volume of the sulfuric acid solution, in mL?

diprotic

definition of neutrality

$\frac{0.75\,\text{mol OH}^-}{1\,\cancel{\text{L}}} \cdot 0.038\,\cancel{\text{L}}\,\text{OH}^- = 0.0285\,\text{mol OH}^- = 0.0285\,\text{mol H}^+$

$\frac{0.0285\,\text{mol H}^+}{} \cdot \frac{1\,\text{mol H}_2\text{SO}_4}{2\,\text{mol H}^+} = \frac{0.01425\,\text{mol H}_2\text{SO}_4}{?\,\text{L}} \times \frac{0.092\,\text{mol}}{1\,\text{L}}$

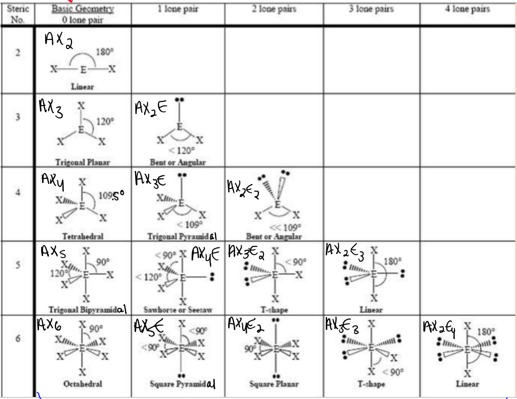
$(0.01425)(1) = (0.092)(x)$

$0.155\,\text{L}$ or $\boxed{155\,\text{mL}}$

$0.01425\,\cancel{\text{mol H}_2}\text{SO}_4 \cdot \frac{1\,\text{L H}_2\text{SO}_4}{0.092\,\cancel{\text{mol H}_2\text{SO}_4}} = 0.155$ or $155\,\text{mL}$

Molecular Geometry

electron geometry



Steric No.	Basic Geometry 0 lone pair	1 lone pair	2 lone pairs	3 lone pairs	4 lone pairs
2	AX_2 180° Linear				
3	AX_3 120° Trigonal Planar	AX_2E < 120° Bent or Angular			
4	AX_4 109.5° Tetrahedral	AX_3E < 109° Trigonal Pyramidal	AX_2E_2 << 109° Bent or Angular		
5	AX_5 90° 120° Trigonal Bipyramidal	AX_4E < 90° < 120° Sawhorse or Seesaw	AX_3E_2 < 90° T-shape	AX_2E_3 180° Linear	
6	AX_6 90° Octahedral	AX_5E < 90° < 90° Square Pyramidal	AX_4E_2 90° Square Planar	AX_3E_3 < 90° T-shape	AX_2E_4 180° Linear

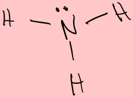
molecular geometry

What is the molecular geometry of NH_3?

$N: 5e^-s$

$H: 1e \times 3 = 3e^-s$

total: 8 valence e^-s



$8e^-s - 6 = 2e^-$

$\boxed{AX_3E\text{: trigonal pyramidal}}$

What is the molecular geometry of SF_6?

S = 6 e^-s

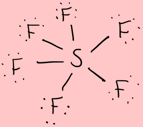
F = 7 e^-s x 6 = 42

42 + 6 = 48 valence e^-s

In bonds: 48 − (6·2) = 36

Each F gets 6 e^-s x 6 Fs = 36

↑ will use the rest of the electrons



AX6: Octahedral

Naming

Ionic Compounds

- Cation, then anion
- Normal ending for cation, -ide ending for anion
- Remember: polyatomic anion names may not adhere to this, use THEIR name
    - Ex. sulfate ion
- Transitions metals' charge indicated in name
    - Determine using deductive reasoning with anion
    - Ex. $FeCl_2$ is iron (II) chloride

↑ +2 ↑ −1x2 = −2 ↑ 2+

Covalent Compounds

- Name non-metal furthest to the left by its elemental name
- Name the other non-metal by its elemental name and -ide ending
- Use prefixes to indicate the number of that element in the molecule
    - 1-mono, 2-di, 3-tri, 4-tetra, 5-penta, 6-hexa, 7-hepta, 8-octa, 9-nona, 10-deca-
- If mono is the first prefix, you do not need to include it
- Example: N_2O_4 is dinitrogen monoxide

What is the molecular formula of iron (III) oxide?

$Fe^{3+} O^{2-} \rightarrow Fe_2O_3$

What is the molecular formula of carbon tetrachloride?

↑
4

CCl_4

Empirical vs. Molecular Formula

Empirical vs. Molecular Formula

- Empirical formula Fe_2O_3
  - The simplest formula that shows the combination of atoms
  - No associated molar mass
- Molecular formula
  - Variant of empirical formula
  - Must be given molar mass in order to determine

molar mass: 319.38

-we know molar mass of $Fe_2O_3 = 159.69$ g/mol

$\frac{319.38}{159.69} = 2 \leftarrow$ Need to multiply every number in empirical formula by 2 → molecular formula = Fe_4O_6

A compound is 40.3% carbon, 6.7% hydrogen, and 53% oxygen by mass, and has

a molar mass of 60.05 g/mol. What is it's molecular formula?

pretend you have 100g of substance, now all percents are masses

$40.3 \cancel{g C} \cdot \frac{1 mol C}{12.01 \cancel{g C}} = 3.36 mol C \div 3.31 = 1.02$

$6.7 \cancel{g H} \cdot \frac{1 mol H}{1.008 \cancel{g H}} = 6.65 mol H \div 3.31 = 2.00$

$53 \cancel{g O} \cdot \frac{1 mol O}{16 \cancel{g O}} = 3.31 mol O \div 3.31 = 1$

$\}$ CH_2O

↑ empirical formula

↑ divide all by smallest number so one of the atoms has a coefficient of 1

molar mass: 60.05 g/mol

Empirical formula: $CH_2O = 30.03$ g/mol ← half substance's molar mass

Need to multiply everything by 2 to get molecular formula

$2(CH_2O) \rightarrow \boxed{C_2H_4O_2}$ ← molecular formula

Specific Heat

Specific Heat (c)

- Characteristic of a substance
  - Not dependent on total mass!
- Amount of heat per unit mass required to raise the temperature by 1ºC
- Equation: $\overset{\text{heat (energy)}}{q}=\overset{\text{mass}}{m}\overset{\text{specific heat}}{c}\Delta t \leftarrow$ change in temperature
  - Question types
    - Can be asked about q, m, or Δt, and you will be given c and 2 variables
    - Can be asked to find c, given 2 variables (one of them being q)

Given that the specific heat of water is 4.184 J/g*C, if a water sample increases 3ºC when given 50 J of heat, how much water was in the sample, in grams?

$$q=mc\Delta t$$

$$\downarrow$$

$$\frac{q}{c\Delta t}=m$$

$$\downarrow$$

$$\frac{(50\,\cancel{J})}{(4.184\frac{\cancel{J}}{g\cdot\cancel{C^\circ}})(3^\circ\cancel{C})}=\boxed{3.98\text{ g }H_2O}$$

$q=50\text{ J}$

$m=\,?$

$c=4.184\frac{J}{g\cdot C^\circ}$

$\Delta t=3^\circ C$

$$\overbrace{\frac{1}{\frac{1}{g}}=1\times\frac{g}{1}}^{\text{units do check out}}=g$$