CHEM 1411 FINAL

1. 50 multiple choice questions (2 pts each)
2. 15 nomenclature questions (1 pt each)
   - final has 115 points (similar to others)
3. Key to final exam will be posted in glass case outside room 100 after exam is over

You Will Have Five (5) Grades
Exam 1, 2, 3, 4 + LAB

I will Average These Five (5) grades
{add grades & divide by five}

One Exam {1, 2, or 3} Grade Can be REPLACED By Exam 4 (Final Exam) If Necessary

No, I Do Not Drop a Grade!!!!!!!

What is my Grade?

<table>
<thead>
<tr>
<th>Average (total points / 5)</th>
<th>Letter Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>89 → up</td>
<td>A</td>
</tr>
<tr>
<td>78 → 88</td>
<td>B</td>
</tr>
<tr>
<td>67 → 77</td>
<td>C</td>
</tr>
<tr>
<td>56 → 66</td>
<td>D</td>
</tr>
<tr>
<td>0 → 55</td>
<td>F</td>
</tr>
</tbody>
</table>

What to Study?

At the end of each chapter
1. Strategies in Chemistry
2. Summary & Key Terms
   - Also
   - Old Exams
3. Web problems & Exams
30 questions from “old” material

Chap 1 - Measurements {laws, properties, & dimensional analysis
Chap 2 - Atoms, Molecules and Ions \(_{30}^{210}\text{Po}\)
Chap 3 - Stoichiometry {% yield, Limiting reagent etc
Chap 4 - Solution Stoichiometry {Molarity, Solubility, Oxidation
Chap 5 – Thermochemistry {Specific heat, Calorimetry, Hess’ Law
Chap 6 - Electron configuration, Quantum numbers, Hund’s Rule ...

20 questions from “new” material

Chap 7 - Periodic Properties of the Elements size of atoms & ions
Chap 8 - Chemical Bonding Lewis Structures / Resonance Structures
Chap 9 - Molecular Geometry { VSEPR & V.B. Models

Chapter 1

1. Intensive Properties & Extensive Properties
2. Atoms, Elements & Compounds
3. Law of Mass Conservation Explained
4. Law of definite proportions by
5. Law of multiple proportions ATOMS
6. Fundamental particles

<table>
<thead>
<tr>
<th>Name</th>
<th>Charge</th>
<th>Mass (amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proton</td>
<td>+1</td>
<td>1</td>
</tr>
<tr>
<td>Neutron</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Electron</td>
<td>-1</td>
<td>0</td>
</tr>
</tbody>
</table>

Dimensional–Analysis method for SOLVING PROBLEMS makes use of conversion factors

Use UNITS To Solve Problems !!!!!!!

**SIGNIFICANT FIGURES:** The Number Of Digits That Are KNOWN With Certainty
Density relates mass to volume.

What is the mass (in kg) of the air in a room that is 12.0 x 17.0 x 8.50 ft? Density of air = 0.936 g/L.

- How do you find mass? **From the density**!

- How do you convert ft³ to Liters?
  \[ \text{ft}^3 \rightarrow \text{in}^3 \rightarrow \text{cm}^3 \rightarrow \text{cc} \rightarrow \text{mL} \rightarrow \text{Liters} \]

  Answer: 3.45x10³ Kg

Chapter 2

- Atomic Theory of Matter by Dalton
- Atomic Structure by Rutherford
  - atomic numbers, mass numbers, and isotopes
  - notation
- The Periodic Table
  - metals, nonmetals, and metaloids
- Names and Formulas (Bonus question)

Types of Radiation

**alpha(α) beta(β) gamma(γ)**

Lead block
Radioactive substance

\[ (+) \rightarrow (\beta) \rightarrow (\gamma) \]

β-rays
γ-rays
α-rays

Photographic plate

More EXPERIMENTS

- **THOMSON’S** Experiments
  - Discovered **ELECTRONS**
- **MILLIKAN’S** Experiments
  - The **MASS OF ELECTRON**
- **RUTHERFORD’S** Experiment
  - STRUCTURE of ATOMS:
    - PROTONS and NEUTRONS
The Molecule & the Mole

**Mole:** A counting unit for objects such as atoms, molecules, ions, …

A mole represents $6.02 \times 10^{23}$ objects

**Molecule:** A chemical combination of two or more atoms. For example $C_6H_{12}O_6$

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PERIODIC TABLE

Divided Into

PERIODS …..ROWS and

GROUPS……..COLUMNS

I. METALS
II. METALLOIDS
III. NONMETALS

---

Chapter 3 Interpretation of Chemical Reactions

- Chemical Equations
- Formula Weights
- Avogadro’s number and the Mole
- Empirical Formulas
- Limiting Reactants
- Stoichiometry

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CHEMICAL REACTIONS
( YOU Need To KNOW )

- NEUTRALIZATION (Acid + Base)
  [MUST KNOW ARRHENIUS Acids/Bases]
- PRECIPITATION REACTIONS
  [MUST KNOW SOLUBILITY RULES]
- OXIDATION REDUCTION (Redox)
  [MUST KNOW OXIDATION “RULES”]
Stoichiometry & Balancing Equations

The fat stored in the hump of a camel is a source of both energy and water. Calculate the mass of water in grams produced by metabolism of 5.599 kg of fat (C\(_{57}H_{110}O_6\))

\[
\text{C}_{57}\text{H}_{110}\text{O}_6 + \text{O}_2 \rightarrow 57 \text{CO}_2 + 55 \text{H}_2\text{O}
\]

Answer 345.6 grams

Use Molecular Weight
To Convert  **Grams to Moles**
or
To Convert  **Moles to Grams**
Use AVOGADRO’S Number
For NUMBER of Atoms
Or NUMBER of Molecules

---

**Empirical / Molecular Formulas**

Determine the empirical formula of a compound that has (by mass)
21.7% C ; 9.6% O ; and 68.7% F.

- answer \( \text{C}_3\text{OF}_6 \)

Determine the molecular formula of the compound if its molar mass = 166

- Answer: same as empirical formula

---

**Grams, moles, molecules & atoms**

A sample of acetaminophen (C\(_8\)H\(_9\)O\(_2\)N) has \(6.02 \times 10^{23}\) atoms of Hydrogen. What is the mass in grams of the sample?

How many atoms of H in one mole of C\(_8\)H\(_9\)O\(_2\)N ?

\(9 \times (6.02 \times 10^{23})\) atoms of H

Therefore have 1/9 of a mole of acetaminophen

What is the molecular weight of acetaminophen ?

151 grams / mole

---
Chapter 4
1. Reactions in Aqueous Solutions & Solution Stoichiometry
2. Molarity is a CONVERSION FACTOR
3. Solubility Rules
4. Oxidation Rules

Solution Stoichiometry

A solution of 285 mL of 1.35 M KOH is mixed with a solution of 100 mL of 0.500 M NiSO$_4$.

Is there a limiting reagent? If so, what is it?

How many grams of the precipitate form?

Write and Balance Reaction

KOH(aq) + NiSO$_4$ (aq) $\rightarrow$ ?????????

moles of reactants and products = ?

<table>
<thead>
<tr>
<th>TABLE 4.1 Solubility Guidelines for Common Ionic Compounds in Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble Ionic Compounds</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Compounds containing NO$_3^-$</td>
</tr>
<tr>
<td>C$_2$H$_5$OH$^-$</td>
</tr>
<tr>
<td>Cl$^-$</td>
</tr>
<tr>
<td>Br$^-$</td>
</tr>
<tr>
<td>I$^-$</td>
</tr>
<tr>
<td>SO$_4^{2-}$</td>
</tr>
<tr>
<td>Insoluble Ionic Compounds</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>Compounds containing S$^{2-}$</td>
</tr>
<tr>
<td>CO$_3^{2-}$</td>
</tr>
<tr>
<td>PO$_4^{3-}$</td>
</tr>
<tr>
<td>OH$^-$</td>
</tr>
</tbody>
</table>
**MUST KNOW OXIDATION “RULES”**

What is the oxidation number?
What is oxidized?
What is causing oxidation?
What is reduced?
What is causing reduction?

**Chapter 5 Thermochemistry**

**HEAT LOST = HEAT GAIN**

Something is gaining Heat
While Something else looses Heat.

Two (2) Ways to express heat

1. \( q \) heat liberated or required
2. \( H \) Enthalpy (\( \Delta H \) Change in Enthalpy)

**Energy Changes Involved**

1. From One Phase To Another
   - Phase Changes | Gas/Liquid/Solid

2. WITHIN One Phase
   - Specific Heat

**HEATS OF REACTIONS**

1. **DIRECT METHOD**
   - EXPERIMENTAL → Calorimeter
   - \( Heat \, LOST = Heat \, GAINED \)

2. **INDIRECT METHOD** → HESS’S Law
Calorimetry

The heat of combustion of glucose is 15.57 kJ/g. A 2.03 g sample of glucose is burned in a bomb calorimeter. The temperature of the calorimeter and the water increased from 20.3 to 22.6 °C.

If the calorimeter contained 2.77 kg of water, what is the heat capacity of the calorimeter in kJ/°C?

Heat Liberated = Heat absorbed by Water
By Chemical Reaction + Heat absorbed by calorimeter

(15.57) x (2.03) kJ = (4.184)(2.77)(2.3) + calorimeter
Heat absorbed by calorimeter in kJ/°C = ????

STANDARD ENTHALPIES OF FORMATION

THE STANDARD ENTHALPY OF FORMATION (ΔHf) OF ANY ELEMENT IN ITS MOST STABLE FORM IS ZERO (BY DEFINATION)

Using Hess’s Law Calculate the standard enthalpy of formation of acetylene (C2H2) from the following combustion reactions

The combustion of ΔH
C(graphite) -393.5 kJ
Hydrogen -285.5 kJ
Acetylene -1299.4 kJ
Calculate \( \Delta H \) for
\[
2 \text{C(graphite)} + \text{H}_2(\text{gas}) \rightarrow \text{C}_2\text{H}_2(\text{gas})
\]
\[
\text{C(graphite)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) \quad \Delta H = -393.5 \text{kJ}
\]
\[
\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O} \quad \Delta H = -285.5 \text{kJ}
\]
\[
\text{C}_2\text{H}_2(\text{g}) + \frac{5}{2} \text{O}_2(\text{g}) \rightarrow 2 \text{CO}_2(\text{g}) + \text{H}_2\text{O} \quad \Delta H = -1299.4 \text{kJ}
\]
\[
2 \text{CO}_2(\text{g}) + \text{H}_2\text{O} \rightarrow \text{C}_2\text{H}_2(\text{gas}) + \frac{5}{2} \text{O}_2(\text{g}) \quad \Delta H = +1299.4 \text{kJ}
\]
answer \( \Delta H = +226.6 \text{kJ} \)

Chapter 6

1. Quantum numbers
2. Orbital diagrams
3. Electron configuration
4. Electromagnetic radiation
5. Energy, wavelength, frequency

Aufbau Principle:
Lower energy orbitals fill first.

Orbitals only hold two electrons, and each should have different spin.

<table>
<thead>
<tr>
<th>1S</th>
<th>2S</th>
<th>2P</th>
<th>3S</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>(↑)</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>He</td>
<td>(↑↓)</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Li</td>
<td>(↑↑)</td>
<td>(↑)</td>
<td>( )</td>
</tr>
<tr>
<td>Be</td>
<td>(↑↓)</td>
<td>(↑↓)</td>
<td>( )</td>
</tr>
<tr>
<td>B</td>
<td>(↑↓)</td>
<td>(↑↓)</td>
<td>(↑)</td>
</tr>
<tr>
<td>C</td>
<td>(↑↓)</td>
<td>(↑↓)</td>
<td>(↑)(↑)(↑)</td>
</tr>
<tr>
<td>N</td>
<td>(↑↓)</td>
<td>(↑↓)</td>
<td>(↑)(↑)(↑)</td>
</tr>
</tbody>
</table>

Hund’s Rule
How many UNPAIRED electrons in

<table>
<thead>
<tr>
<th>Element</th>
<th>Electron Configuration</th>
<th>How many e⁻?</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>He</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Be</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>0</td>
<td>[1s² 2s² 2p⁶ 3s²]</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0</td>
<td>[1s² 2s² 2p⁶]</td>
</tr>
<tr>
<td>Al</td>
<td>1</td>
<td>[Ne] 2s² 3p¹</td>
</tr>
<tr>
<td>Al³⁺</td>
<td>0</td>
<td>[Ne]</td>
</tr>
<tr>
<td>Cr</td>
<td>6</td>
<td>[Ar] 4s¹ 3d⁵</td>
</tr>
<tr>
<td>Cr³⁺</td>
<td>1</td>
<td>[Ar] 4s² 3d¹</td>
</tr>
</tbody>
</table>

Why are H through F REACTIVE? While Ne is NOT REACTIVE (ie Stable)

**ELECTRON CONFIGURATION PREDICTS STABILITY**

| Element   | Electron configurations | Stability
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>He (2e)</td>
<td>1S²</td>
<td>Stable</td>
</tr>
<tr>
<td>Li (3e)</td>
<td>1 S² 2 S¹</td>
<td>REACTIVE</td>
</tr>
<tr>
<td>Li⁺(2e)</td>
<td>[He]</td>
<td>Stable</td>
</tr>
<tr>
<td>Mg (12e)</td>
<td>1S² 2S² 2P⁶ 3S²</td>
<td>REACTIVE</td>
</tr>
<tr>
<td>Mg²⁺(10e)</td>
<td>[Ne]</td>
<td>Stable</td>
</tr>
</tbody>
</table>

**QUANTUM NUMBERS (Four)**

\[
n \ell \ m \ s
\]

\[
n = 1, 2, 3, 4, 5, 6, \text{ or } 7
\]

\[
\ell = n-1, \ n-2, \ldots
\]

\[
m = -\ell \ \text{to} \ +\ell
\]

\[
S = +\frac{1}{2} \ \text{or} \ -\frac{1}{2}
\]
Identify the GROUP of elements that corresponds to each of the following generalized electron configurations

[noble gas] ns² np⁵  Halogens (Group 17)
[noble gas] ns² (n-1)d²  Group 4

**RELATIONSHIP BETWEEN**

\[ C = \lambda \times \nu \]

**UNITS** Solve Problems!!

\[ \frac{meters}{sec} = \text{meters} \times \frac{1}{sec} \]

**Electromagnetic Radiation**

The amount of energy depends on the frequency (\( \nu \))

\[ E = h \nu \]

*Where h is a constant*

**Chapter 7**

7.2 Effective Nuclear Charge
7.3 Size of Atoms & Ions
7.4 Ionization
7.5 Electron Affinity
Periodic Trends

- Arises from the Periodic patterns in **ELECTRON CONFIGURATIONS**.
- Elements in the same **GROUP** have the same number of **VALENCE** electrons
- **VALENCE** electrons = electrons in the outermost orbital

In an isoelectronic series

Ionic size decreases with an increasing nuclear charge

(See Text page 269)

<table>
<thead>
<tr>
<th>Ion</th>
<th>Group</th>
<th>Charge</th>
<th>Ionic Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>H+</td>
<td>1A</td>
<td>1.24</td>
<td>0.68</td>
</tr>
<tr>
<td>Li+</td>
<td>2A</td>
<td>1.09</td>
<td>0.56</td>
</tr>
<tr>
<td>Be2+</td>
<td>2A</td>
<td>1.23</td>
<td>0.52</td>
</tr>
<tr>
<td>B3+</td>
<td>3A</td>
<td>1.37</td>
<td>0.72</td>
</tr>
<tr>
<td>C4+</td>
<td>4A</td>
<td>1.40</td>
<td>0.71</td>
</tr>
<tr>
<td>N5+</td>
<td>5A</td>
<td>1.45</td>
<td>0.76</td>
</tr>
<tr>
<td>O6+</td>
<td>6A</td>
<td>1.50</td>
<td>0.82</td>
</tr>
<tr>
<td>F7+</td>
<td>7A</td>
<td>1.55</td>
<td>0.85</td>
</tr>
</tbody>
</table>

**IONIZATION ENERGY**
Energy required to “get rid” of an electron

Na → Na⁺ + e⁻

**ELECTRON AFFINITY**
Energy change accompanying addition of an electron

Cl + e⁻ → Cl⁻

**ELECTRONEGATIVITY**
The ability of one atom in a molecule to attract electrons to itself “a tug of war”

H δ⁺ → F δ⁻

Chapter 8  Basic Concepts of Chemical Bonding

 Ionic
 Polar Covalent  Two Extremes
 Covalent

A difference in electronegativity forms a polar covalent bond

Hδ⁺ → Fδ⁻

the molecule, HF has a di pole
DISCRIPTION OF ELECTRONS
1. How Many Electrons?
2. Electron Configuration
3. Orbital Diagram
4. Quantum Numbers
5. LEWIS SYMBOLS

Drawing Lewis Structures
1. What TYPE of Bonds Will be Formed
   Ionic? Covalent? or Polar Covalent?
2. The LEAST Electronegative atom is in the center
3. COUNT Number of Valence electrons Adding or Subtracting e− For IONS
4. Draw a SINGLE Bond between central atom and Each of surrounding atoms
5. Complete the OCTETS Of ALL Atoms

DRAW THE LEWIS STRUCTURE FOR
Cyanide Ion  CN−
How many valence electrons? C N
   4 + 5 + 1 = 10
First draw a bond between the C and N
   C − N
Next, eight (8) electrons around each atom
   C − N
Count electrons. Correct number? Now what?

Cyanide Ion  CN−
How many valence electrons? 10
Reduce electrons by putting in a double bond
   C = N
Count electrons. 12
Correct number? No!
Now what?
Cyanide Ion  CN⁻

How many valence electrons? 10
Reduce electrons by putting in a triple bond
|C≡N| ?
Count electrons. Correct number?

\[ [:C≡N:]^→ \]

Resonance In Nitrate Ion

In Nitrate Ion \([\text{NO}_3^-]\) the extreme possibilities have one double and two single bonds
\[ \begin{array}{c}
  \text{N} \\
  \text{O}  \quad \text{O} \\
\end{array} \quad \begin{array}{c}
  \text{N} \\
  \text{O}  \quad \text{O} \\
\end{array} \quad \begin{array}{c}
  \text{N} \\
  \text{O}  \quad \text{O} \\
\end{array} \]

The resonance structure has three identical bonds of intermediate character.

Molecular Shapes

There are five fundamental geometries for molecules
1. 2 Bonds  Linear...vs Bent
2. 3 Bonds  Trigonal Planar vs pyramid
3. 4 Bonds  Tetrahedral
4. 5 Bonds  Trigonal bipyramidal
5. 6 Bonds  Octahedral

Chap 9  Molecular Geometry
Two (2) Theories

1. Valence Shell Electron Pair Repulsion  (VSEPR) THEORY
2. The Valence Bond  (VB) THEORY
Electron **pairs** on the central atom are called **ELECTRON DOMAINS**

Single, double or triple bonds all count as **One ELECTRON DOMAIN**

The atom **A** *(which violates the octect rule)* in this molecule, has **four (4)** electron domains

**VSEPR Theory**

**THE GEOMETRY OF A MOLECULE IS DETERMINED BY THE REPULSIVE INTERACTION OF ELECTRONS PAIRS IN THE VALENCE SHELL OF ITS CENTRAL ATOM**

AB₄ Molecules Such as CCl₄ are Tetrahedral Carbon TetraChloride

AB₃E *(Molecules With UnPaired Electrons On the Central Atom)* Such as NH₃, are Not Planar
AB₂E₂ (Molecules With UnPaired Electrons On the Central Atom) Such as H₂O are Bent

VALENCE BOND THEORY
VALENCE SHELL ORBITALS
HYBRIDIZE
THE ORIENTATION OF ALL HYBRID VALENCE SHELL ORBITALS DETERMINES THE GEOMETRY OF THE MOLECULE

Hybridized MOLECULAR ORBITALS

SP  Linear  180° angles
SP²  Flat triangle  120° angles
SP³  Tetrahedral  109° angles

SP³ HYBRIDIZATION

Methane, CH₄  4 bond pairs
Ammonia, NH₃  3 bond pairs
Water, H₂O  2 bond pairs
**Draw Lewis Structure of $C_3F_6O$**

$C_3 F_6 O$

Number of valence e$^-$: $3(4) + 6(7) + 1(6) = 60$

![Bonding structure](image)

Does each carbon have 4 bonds?
Does each fluorine have 1 bond?
Does oxygen have 2 bonds?

**Determine Geometry of $C_3F_6O$ by VSEPR Theory & VB Theory**

![Bonding structure](image)

**Name the following**

- $K_2SO_4$ : potassium sulfate
- $Ba(OH)_2$ : barium hydroxide
- $FeCl_3$ : iron(III) chloride
- $NH_4Br$ : ammonium bromide
- $Cr_2O_3$ : chromium(III) oxide
- $Co(NO_3)_2$ : cobalt(II) nitrate

**Write the chemical formulas for:**

- potassium sulfide: $K_2S$
- magnesium sulfate: $MgSO_4$
- silver sulfide: $Ag_2S$
- lead(II) nitrate: $Pb(NO_3)_2$