**Part I – Intro to Chemistry**

**Measurements** - Measure each of the following using correct significant figures. Include units in your answer.

1) __________________
2) __________________
3) __________________
4) __________________
5) __________________
6) __________________
7) __________________
8) __________________
9) __________________
10) __________________
11) __________________
12) __________________

**Significant Figures and Scientific Notation**

**How many sig figs are in the following numbers?**

1) 420.0 __________________________
2) 7589 __________________________
3) 432506.43 ______________________
4) 0.000476 _______________________
5) 4.30000 x 10^{-22} __________________
6) 35.17 __________________________
7) 0.000004 _________________________
8) 8671.5 __________________________
9) 460.046 _________________________
10) 0.008000 _______________________
11) 45.00 __________________________
12) 3.1 ____________________________
13) 600 ____________________________
14) 7.0101010 ______________________

**Express your answers with the appropriate number of sig figs:**

15) 422.6 + 23.135 + 310.04= __________________
16) 123.009 + 16.001 + 22.6= __________________
17) 44.79-2.3-0.0045= __________________
18) 2.90 x 0.01733 x 920= __________________
19) (72) (4.022) / 9.03 __________________
20) (657.89)/ 32.9= __________________
21) (34.567) (89.2) (54)= __________________
22) 789.235/ 47.36= __________________
23) 0.300 x 120 x 678=

24) (350.1 -19) x 30.0=

25) 890 / 0.500=

26) 1.58 x 10^{12} / 9.44 x 10^9=

27) (3 x 10^{-3}) (3.21 x 10^5)=

28) 4.000 x 10^{15} / 6.02 x 10^{23}=

Accuracy and Precision

1) A student experimentally determined the density of copper and recorded data in the table below. The actual density of copper is 8.96 g/mL. Describe the accuracy and precision of the student’s data:

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Density of Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>4.95 g/mL</td>
</tr>
<tr>
<td>Trial 2</td>
<td>4.98 g/mL</td>
</tr>
<tr>
<td>Trial 3</td>
<td>4.98 g/mL</td>
</tr>
<tr>
<td>Trial 4</td>
<td>4.96 g/mL</td>
</tr>
</tbody>
</table>

2) Describe the accuracy and precision for the following targets:

A.  
B.  
C.  
D.  

Conversions

1) Express the following in the units asked for.
   a. Speed of light, 3x10^8 m/s, in miles per hour.
   b. Speed of sound, 740 mph, in kilometers per hour and meters/sec.
   c. Length of a C-C bond in diamond, 1.54452 Å, in cm, m, and inches (1 Å = 10^{-10} m)
   d. Temperature
      i. Liquid nitrogen -195 C, in F and K
      ii. Body Temp, 98 F, in C and K
      iii. Paper Flashpoint, 450 F, in C and K

2) A pitcher can throw a fastball that is clocked at 91.2 miles per hour. How many seconds does it take the fastball to travel from the pitcher’s mound to home plate, a distance of 18.44 meters? (hint: start with 18.44 m)

3) Assume a milliliter of water contains 20. Drops. How many drops of water are there in 2.50 gallons of water?

4) Chloroform is a liquid with a sticky sweet odor that was once used as a surgical anesthetic. If the density of chloroform is 1.49 g/mL, what is the volume in (liters) of 2.50 pounds of chloroform? (1 lb = 454g)
<table>
<thead>
<tr>
<th>Nuclear Symbol</th>
<th>Atomic Number</th>
<th>Mass Number</th>
<th># of Protons</th>
<th># of Neutrons</th>
<th># of Electrons</th>
<th>Family</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>6</td>
<td>12</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td>3</td>
<td>7</td>
<td></td>
<td></td>
<td>18</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td>17</td>
<td>35</td>
<td></td>
<td></td>
<td>28</td>
<td>Halogen</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>92</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mg</td>
<td>12</td>
<td>24</td>
<td></td>
<td></td>
<td>10</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>As</td>
<td>33</td>
<td>75</td>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Average atomic mass calculations

1) Are there more Bromine-79 atoms or more Bromine-80 atoms on earth? (Hint: look at the periodic table.) Bromine has two isotopes, Br-79 (mass 78.9183, 50.5% abundant) and Br-81 (mass 80.9163, 49.5% abundant). Calculate the average mass of bromine.

2) Calculate the atomic mass of an element if 60.4% of the atoms have a mass of 68.9257 amu and the rest have a mass of 70.9249 amu. Identify the element in the periodic table.

3) Nitrogen is made up of two isotopes, N-14 and N-15. N-14 has a mass of 14.003074 and 99.3% abundant. N-15 has a mass of 15.000108 and 0.7%. Calculate the average mass of nitrogen.

4) Chlorine is made up of two isotopes, Cl-35 and Cl-37. Cl-35 has a mass of 34.9689 and is 75.77% abundant. Cl-37 has a mass of 36.9659 and is 24.23% abundant. Calculate the average mass of chlorine.

Electron Configurations and Orbital Diagrams

Write the complete electron for the following atoms or ions.

<table>
<thead>
<tr>
<th>Symbol</th>
<th># e⁻</th>
<th>Full Electron Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Mg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Ge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Kr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Al⁺³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Fe⁺²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) Cl⁻</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) O²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Write the shorthand electron configurations for the following.

<table>
<thead>
<tr>
<th>Symbol</th>
<th># e⁻</th>
<th>Shorthand Electron Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Ag</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Se²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) N³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Na¹⁺</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Zn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Ca</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Pb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) Ti</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10) Au</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11) Ne</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Draw the orbital diagram for the following. You may use shorthand:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Orbital Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) As</td>
<td></td>
</tr>
<tr>
<td>2) Hg</td>
<td></td>
</tr>
<tr>
<td>3) Be</td>
<td></td>
</tr>
<tr>
<td>4) Ni</td>
<td></td>
</tr>
<tr>
<td>5) Cu</td>
<td></td>
</tr>
</tbody>
</table>
Which of the following “rules” is being violated in each electron configuration below? **Explain** your answer for each.

<p>| | | | | | | | | | | |</p>
<table>
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<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6)</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1s</td>
<td>2s</td>
<td>2p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7)</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td></td>
<td>↑↑</td>
<td>↑↑</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1s</td>
<td>2s</td>
<td>2p</td>
<td>3s</td>
<td>3p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8)</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↑</td>
<td>↑↑</td>
<td>↑↑</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1s</td>
<td>2s</td>
<td>2p</td>
<td>3s</td>
<td>3p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9)</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
<td>↑↓</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1s</td>
<td>2s</td>
<td>2p</td>
<td>3s</td>
<td>3p</td>
<td>3p</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Periodic Trends**

**List the following elements in order of increasing atomic radius:**

1) Al, Mg, S  
2) Sn, F, Rb  
3) Kr, Xe, He  
4) Se, O, S

**List the following elements in order of decreasing ionic radius:**

5) Pb, Pb\(^{2+}\), Pb\(^{4+}\)  
6) S, S\(^{2-}\)  
7) I, I\(^{-}\)  
8) Ti, Ti\(^{2+}\), Ti\(^{3+}\)

**List the following elements in order of increasing ionization energy:**

9) Ag, Fr, Cl  
10) Si, Ca, Cs  
11) V, Mn, Zn  
12) Cd, Zn, Hg

**List the following elements in order of decreasing electronegativity:**

13) As, Li, Rb  
14) F, Na, S  
15) Ga, B, Ba  
16) Al, Ge, Sb

**List the following elements in order of increasing metallic characteristic:**

17) O, Sr, Ag  
18) Ne, Li, C  
19) Br, Hg, Os  
20) Fr, K, Cs
For each of the following, circle all the correct elements

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>N</td>
<td>P</td>
<td>As</td>
</tr>
<tr>
<td>22</td>
<td>O</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>23</td>
<td>K</td>
<td>Ca</td>
<td>Ga</td>
</tr>
<tr>
<td>24</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
</tr>
<tr>
<td>25</td>
<td>Cl</td>
<td>Br</td>
<td>I</td>
</tr>
<tr>
<td>26</td>
<td>Cl</td>
<td>Br</td>
<td>I</td>
</tr>
<tr>
<td>27</td>
<td>Te</td>
<td>I</td>
<td>Xe</td>
</tr>
<tr>
<td>28</td>
<td>Na</td>
<td>K</td>
<td>Rb</td>
</tr>
<tr>
<td>29</td>
<td>Cu$^{+1}$</td>
<td>Cu$^{+2}$</td>
<td>Cu$^{+3}$</td>
</tr>
<tr>
<td>30</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
</tr>
<tr>
<td>31</td>
<td>H</td>
<td>Li</td>
<td>Na</td>
</tr>
<tr>
<td>32</td>
<td>Hg</td>
<td>Tl</td>
<td>Pb</td>
</tr>
<tr>
<td>33</td>
<td>Pb</td>
<td>Bi</td>
<td>Te</td>
</tr>
<tr>
<td>34</td>
<td>B</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>35</td>
<td>Ca</td>
<td>Ge</td>
<td>Se</td>
</tr>
<tr>
<td>36</td>
<td>Sb</td>
<td>Te</td>
<td>Sr</td>
</tr>
<tr>
<td>37</td>
<td>Br</td>
<td>Br$^{-1}$</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>K</td>
<td>Ti</td>
<td>Cu</td>
</tr>
<tr>
<td>39</td>
<td>Na</td>
<td>K</td>
<td>Li</td>
</tr>
<tr>
<td>40</td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
</tr>
<tr>
<td>41</td>
<td>N</td>
<td>O</td>
<td>F</td>
</tr>
<tr>
<td>42</td>
<td>Li</td>
<td>Be</td>
<td>B</td>
</tr>
<tr>
<td>43</td>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
</tr>
<tr>
<td>44</td>
<td>H</td>
<td>H$^{+1}$</td>
<td>H$^{-1}$</td>
</tr>
<tr>
<td>45</td>
<td>Cu</td>
<td>Zn</td>
<td>Cd</td>
</tr>
</tbody>
</table>

46) Why does atomic radius decrease as you move left to right on the periodic table?

47) Why does atomic radius increase as you move top to bottom on the periodic table?

48) Why does ionization energy increase as you move left to right on the periodic table?

49) Why does ionization energy decrease as you move top to bottom on the periodic table?

50) Why does electronegativity increase as you move left to right on the periodic table?

51) Why does electronegativity decrease as you move top to bottom on the periodic table?
### Part III – Bonding and Nomenclature

*Indicate if the following are Acids (A), Ionic Compounds (I), or Molecular Compounds (M), indicate the name or formula, AND determine the molar mass of each substance (don’t forget to include units).*

<table>
<thead>
<tr>
<th>A, I, or M</th>
<th>Name or formula</th>
<th>Molar mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>KBr</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>H₃P</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>FeO</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Fe₂O₃</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>CuCl₂</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>NO₂</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>CO</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>O₂</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>C₂H₆</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Al₂(SO₄)₃</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>HF</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>NaOH</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>FeCrO₄</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Pb₃(PO₄)₂</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>H₃CO₃</td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>P₂O₅</td>
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</tr>
<tr>
<td>17.</td>
<td>H₂O</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Ca(ClO₃)₂</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>(NH₄)₂O</td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Zn(HCO₃)₂</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>SnBr₄</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>HClO</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>Lithium oxide</td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Aluminum sulfide</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>Perchloric acid</td>
<td></td>
</tr>
<tr>
<td>26.</td>
<td>Calcium chloride</td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>Lead (IV) oxide</td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>Copper (II) iodide</td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>Hydroiodic acid</td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>Mercury (II) hydroxide</td>
<td></td>
</tr>
<tr>
<td>31.</td>
<td>Dinitrogen pentaoxide</td>
<td></td>
</tr>
<tr>
<td>32.</td>
<td>Carbon tetrahydride</td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>Dihydrogen monoxide</td>
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<tr>
<td>34.</td>
<td>Ammonium chloride</td>
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</tr>
<tr>
<td>35.</td>
<td>Hydrocyanic acid</td>
<td></td>
</tr>
<tr>
<td>36.</td>
<td>Sulfurous acid</td>
<td></td>
</tr>
<tr>
<td>37.</td>
<td>Copper (I) sulfate</td>
<td></td>
</tr>
<tr>
<td>38.</td>
<td>Sodium phosphate</td>
<td></td>
</tr>
<tr>
<td>39.</td>
<td>nickel(II) nitrate</td>
<td></td>
</tr>
<tr>
<td>40.</td>
<td>Hydrogen gas</td>
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<tr>
<td>41.</td>
<td>lithium chromate</td>
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<tr>
<td>42.</td>
<td>potassium permanganate</td>
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<tr>
<td>43.</td>
<td>silver perchlorate</td>
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<tr>
<td>44.</td>
<td>silver sulfide</td>
<td></td>
</tr>
<tr>
<td>45.</td>
<td>nickel(II) hydroxide</td>
<td></td>
</tr>
</tbody>
</table>
**Lewis Structures:** Complete the following table. STAR any molecules that have resonance.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>Total Valence Electrons</th>
<th>Lewis Structure</th>
<th>Do all atoms have an octet or duet?</th>
<th># of Single Bonds, # of Double Bonds, # of Triple Bonds</th>
<th># of unshared pairs of electrons on the Central atom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) H₂O</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2) N₂</td>
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<tr>
<td>3) NH₃</td>
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<tr>
<td>4) CO₃²⁻</td>
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<tr>
<td>5) CF₄</td>
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<tr>
<td>6) CH₃Cl</td>
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<tr>
<td>7) SO₃</td>
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</tr>
</tbody>
</table>
**VSEPR:** Determine the VSEPR geometry and bond angle for the structures in Part D of the homework packet. Redraw the structure considering VSEPR geometry.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>VSEPR Geometry</th>
<th>Bond Angle</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) H₂O</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) N₂</td>
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<tr>
<td>3) NH₃</td>
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<tr>
<td>4) CO₃⁻²</td>
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<td>5) CF₄</td>
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<td>6) CH₃Cl</td>
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<tr>
<td>7) SO₃</td>
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</tbody>
</table>
**Polarity:** Answer the following questions and determine the electronegativity difference and determine what type of bond (polar or nonpolar) exists between the following pairs of atoms:

1) Polar bonds have an electronegativity difference _________________________
2) Nonpolar bonds have an electronegativity difference ______________________
3) Ionic bonds have an electronegativity difference _________________________

<table>
<thead>
<tr>
<th>Atoms</th>
<th>Electronegativity Difference</th>
<th>Polar or Nonpolar Bond</th>
</tr>
</thead>
<tbody>
<tr>
<td>H and I</td>
<td></td>
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<tr>
<td>Se and S</td>
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<tr>
<td>Se and F</td>
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<tr>
<td>S and O</td>
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<tr>
<td>H and Br</td>
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<tr>
<td>C and H</td>
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<tr>
<td>Se and H</td>
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<tr>
<td>H and Cl</td>
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<tr>
<td>I and Br</td>
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<tr>
<td>Si and Cl</td>
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<tr>
<td>Cl and O</td>
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<tr>
<td>S and Cl</td>
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<tr>
<td>I and Cl</td>
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<tr>
<td>Cl and Br</td>
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<tr>
<td>P and O</td>
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</tbody>
</table>
**Concepts and Vocabulary:** Answer the following questions using your notes and/or other resources.

1) What is a chemical bond?

2) Why do atoms form bonds?

3) How are types of bonds determined?

4) Fill out the following chart.

<table>
<thead>
<tr>
<th>Type of Bond</th>
<th>Types of elements involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metallic</td>
<td></td>
</tr>
<tr>
<td>Covalent</td>
<td></td>
</tr>
<tr>
<td>Acid</td>
<td></td>
</tr>
</tbody>
</table>

5) What type of bond involves a “sea of electrons”? _________________________

6) What is the octet rule?

7) Explain how an ionic bond is formed.

8) Ionic bonding are held together by an ________________________  ________________________ of ________________________.

9) What is the 3D structure called that ionic compounds form? _________________

10) List 5 properties of ionic compounds:
    a. ____________________________________________________________
    b. ____________________________________________________________
    c. ____________________________________________________________
    d. ____________________________________________________________
    e. ____________________________________________________________

11) How are covalent bonds formed?

12) List 2 ways ionic and covalent bonds are different:
13) List 5 properties of covalent bonds:
   a.  
   b.  
   c.  
   d.  
   e.  

14) Why do covalent molecules have lower melting and boiling points than ionic compounds?

15) How do you know how many valence electrons an element has? ____________________________________________

16) What are 3 exceptions to the octet rule? ______________________________________________________________

17) List the 7 diatomic molecules?

18) Fill out the chart below:

<table>
<thead>
<tr>
<th>Type of Bond</th>
<th># of electron pairs involved</th>
<th># of electrons involved</th>
<th>Strength (1 being strongest; 3 being weakest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
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<td></td>
<td></td>
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<tr>
<td>Double</td>
<td></td>
<td></td>
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<tr>
<td>Triple</td>
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</tr>
</tbody>
</table>

19) What repels more: Bonding pairs or Lone pairs? (circle your answer)

20) What are electron domains? _______________________________________________________________________

21) How many electron domains would a central atom that has one single bond, one double bond, and one lone pair have? _______________________________________________________________________

22) What does the word polar mean?

23) What is a polar bond?

24) What is a nonpolar bond?

25) What do the following symbols mean? δ+ __________ δ− __________

26) How is the polarity of a bond determined? _______________________________________________________________________

27) Draw a dipole moment: ___________________________________________________________________________ which direction does the arrow point? __________

28) What is a net dipole?

29) What type of molecules have no net dipole? __________________________________________________________

30) Is water polar or nonpolar? _______________________________________________________________________

31) List 2 properties that polarity effects:
Part IV – The Mole and Chemical Compounds

Percent Composition - Determine the percent composition of each element in the substances listed below. Write your answers in the tables provided. Show ALL of your work for credit.

1) A 14.80g sample contains 3.83g of iron and 10.97 g bromine.
   \[
   \% \text{ Fe} = \frac{3.83}{14.80} \times 100 = \ldots \\
   \% \text{ Br} = \frac{10.97}{14.80} \times 100 = \ldots
   \]

2) A 9.14g sample contains 4.77 g of carbon, 1.19 g of hydrogen, and 3.18g of oxygen.
   \[
   \% \text{ C} = \frac{4.77}{9.14} \times 100 = \ldots \\
   \% \text{ H} = \frac{1.19}{9.14} \times 100 = \ldots \\
   \% \text{ O} = \frac{3.18}{9.14} \times 100 = \ldots
   \]

3) A 2.85g sample contains 0.82 g of magnesium, 0.41 g of carbon, and 1.62g of oxygen.
   \[
   \% \text{ Mg} = \frac{0.82}{2.85} \times 100 = \ldots \\
   \% \text{ C} = \frac{0.41}{2.85} \times 100 = \ldots \\
   \% \text{ O} = \frac{1.62}{2.85} \times 100 = \ldots
   \]

4) \(\text{CaC}_2\text{O}_4\)
   \[
   \% \text{ Ca} = \frac{40}{124} \times 100 = \ldots \\
   \% \text{ C} = \frac{24}{124} \times 100 = \ldots \\
   \% \text{ O} = \frac{32}{124} \times 100 = \ldots
   \]

5) \(\text{Al}_2(\text{SO}_4)_3\)
   \[
   \% \text{ Al} = \frac{54}{385} \times 100 = \ldots \\
   \% \text{ S} = \frac{12}{385} \times 100 = \ldots \\
   \% \text{ O} = \frac{240}{385} \times 100 = \ldots
   \]

6) \((\text{NH}_4)_3\text{PO}_4\)
   \[
   \% \text{ N} = \frac{28}{160} \times 100 = \ldots \\
   \% \text{ H} = \frac{12}{160} \times 100 = \ldots \\
   \% \text{ P} = \frac{30}{160} \times 100 = \ldots \\
   \% \text{ O} = \frac{128}{160} \times 100 = \ldots
   \]

7) How many grams of oxygen can be produced form the decomposition of 100.0 g of \(\text{KClO}_3\)?

8) How much iron can be recovered from 25.0g of \(\text{Fe}_2\text{O}_3\)?

9) How much silver can be produced from 125 g of \(\text{Ag}_2\text{S}\)?

Mole conversions - Answer the following questions, be sure to include units. Show ALL work for credit.

1) How many atoms are contained in 3.46 moles of magnesium?

2) What mass would 4.50L of helium gas be at STP?

3) Convert 256.3 g of \(\text{Na}_2\text{CO}_3\) to atoms of Na.
4) How many molecules of bromine gas (Br₂) are in 15 L of bromine gas?

5) What is the mass of 12.4 molecules of carbon tetrachloride?

6) How many moles of carbon dioxide would be in 8.93 L of carbon dioxide?

7) How many moles are contained in 0.43 g of Al₂O₃?

8) The volume of 42.1 g of carbon dioxide is ________________________________.

9) What is the volume in liters of 9.31 \times 10^{21} molecules of nitrogen gas (N₂)?

**Empirical Formula**- Determine the empirical formula for the following. Show ALL work for credit.

1) Determine the empirical formula from the molecular formulas:
   a. C₆H₆
   b. C₂H₆
   c. C₃H₈
   d. Fe₃(CO)₉
   e. C₆H₄O₂
   f. N₂H₄
   g. CaBr₂
   h. C₆H₁₂O₆
   i. C₆H₅O
   j. Na₂SO₄
   k. C₆H₅N
   l. LiCl

2) Determine the empirical formula from the percent composition for each of the following:
   a. 40.68% carbon, 5.13% hydrogen, and 54.19% oxygen
   b. 22.1% aluminum, 25.4% phosphorous, and 52.5% oxygen
   c. 43.64% phosphorous and the remainder oxygen
3) An analysis of an unknown sample was found to contain 97.56g of carbon, 4.878g of hydrogen, 52.03g of oxygen, and 45.53g of nitrogen. Find the empirical formula for this substance.

Molecular Formulas- Determine the molecular formula for the following. Show ALL work for credit.

1) A compound is 79.08% carbon, 5.54% hydrogen, and 15.38% nitrogen. What is the molecular formula of this substance if the molar mass is 273.36 g/mol?

2) A compound found to be 40.0% carbon, 6.7% hydrogen, and 53.5% oxygen. Its molar mass is 60.00 g/mol. What is its molecular formula?

3) A compound is 64.9% carbon, 13.5% hydrogen, and 21.6% oxygen. Its molar mass is 74.14g/mol. What is its molecular formula?

4) If the empirical formula of a compound is NO$_2$ and its molar mass is 92.00 g/mole, what is its molecular formula?

5) The empirical formula for a compound of CH$_2$ has a molar mass of 70.00 g/mole. What is the molecular formula?
Part V – Chemical Reactions and Equations

Balancing Equations and Types of Reactions - Balance the following (in Part D use the blanks to the right to identify the following reactions):

1) ___ Mg + ____ Zn(NO_3)_2 \rightarrow ____ Zn + ____ Mg(NO_3)_2

2) ___ NH_3 \rightarrow ____ N_2 + ____ H_2

3) ___ MgO \rightarrow ____ Mg + ____ O_2

4) ___ K + ____ Cl_2 \rightarrow ____ KCl

5) ___ Al + ____ O_2 \rightarrow ____ Al_2O_3

6) ___ HI \rightarrow ____ H_2 + ____ I_2

7) ___ C_2H_6 + ____ O_2 \rightarrow ____ CO_2 + ____ H_2O

8) ___ Li_2S + ____ AlP \rightarrow ____ Al_2S_3 + ____ Li_3P

9) ___ K_2S + ____ PbO_2 \rightarrow ____ K_2O + ____ PbS_2

10) ___ C_6H_14 + ____ O_2 \rightarrow ____ CO_2 + ____ H_2O

11) ___ CaO + ____ H_2O \rightarrow ____ Ca(OH)_2

12) ___ Al + ____ CuSO_4 \rightarrow ____ Al_2(SO_4)_3 + ____ Cu

13) ___ Cu + ____ S_8 \rightarrow ____ Cu_2S

14) ___ K + ____ H_2O \rightarrow ____ KOH + ____ H_2

15) ___ Br_2 + ____ NaF \rightarrow ____ F_2 + ____ NaBr

16) ___ Li + ____ CuCO_3 \rightarrow ____ Cu + ____ Li_2CO_3

17) Lithium metal reacts with hydrochloric acid to produce lithium chloride and hydrogen gas.

18) Mercury (II) oxide decomposes to produce mercury and oxygen gas.

19) Magnesium hydroxide decomposes to produce magnesium oxide and water.

20) Copper reacts with chlorine gas to produce copper (II) chloride.

21) Silver Sulfate reacts with sodium bromide to yield sodium sulfate and silver bromide.

22) Aluminum reacts with iron (III) oxide to yield aluminum oxide and iron.

23) Carbon tetrahydride burns in oxygen gas to produce carbon dioxide and water.

24) Aluminum sulfate reacts with calcium hydroxide to produce aluminum hydroxide and calcium sulfate.

Predicting the products from words - In each of the following examples: (a) State what type of reaction is expected, and (b) Write the balanced equation for those reactions.

25) aluminum reacts with hydrochloric acid

26) solutions of calcium hydroxide and nitric acid are mixed

27) a strip of magnesium is placed in a solution of zinc nitrate

28) zinc chloride reacts with hydrosulfuric acid

29) barium nitrate reacts with sodium chromate

30) sodium bromide undergoes electrolysis

31) propane is completely burned in the presence of excess oxygen
32) iron(III) hydroxide reacts with phosphoric acid
33) sodium plus nitric acid
34) zinc reacts with oxygen
35) solutions of mercury(I) nitrate and sodium carbonate are mixed
36) magnesium plus hydrochloric acid
37) lead(II) nitrate and sodium iodide
38) chromium(II) perchlorate and sodium sulfide
39) ethylene glycol (C$_2$H$_6$O$_2$) is burned in oxygen

**Stoichiometry**

1) Lithium perchlorate decomposes to produce lithium chloride and oxygen gas. What volume of oxygen gas can be produced if 100.0 g of lithium perchlorate decompose at STP?

2) Hydrogen gas and chlorine gas combine in a synthesis reaction. If 43g of product are produced, how many grams of hydrogen gas was used?

3) When 0.46 g of antimony III oxide reacts with carbon to produce antimony metal and carbon monoxide gas, determine the mass of antimony metal produced.

4) How many gram of carbon monoxide must react with oxygen to produce 10.0L of carbon dioxide?

5) When hydrogen peroxide decomposes, it produces liquid water and oxygen gas. What mass of hydrogen peroxide must decompose to produce 0.77g of liquid water?

6) When lithium nitride reacts with water, lithium hydroxide and ammonia gas (NH$_3$) are produced. Determine the mass of lithium hydroxide produced when 0.38 g of lithium nitride reacts with water.

7) 0.29 g Sodium iodide reacts with chlorine gas in a single replacement reaction. How much is produced of the new sodium salt made?
8) Ethane gas ($C_2H_6$) is burned in oxygen gas. What volume of oxygen gas is needed to react with 45.0g of ethane gas?

9) Sodium bicarbonate decomposes to produce sodium carbonate, carbon dioxide and water. What mass of each product can be made with 15.0 g of sodium bicarbonate?

Limiting and Excess Reactant

1) How much water can be produced when 5.87g of magnesium hydroxide reacts with 12.84g of hydrosulfuric acid to produce liquid water and magnesium sulfide.

2) How much Ca(OH)$_2$ will be produced when 43.25g of calcium carbide (CaC$_2$) reacts with 33.71g of liquid water to produce calcium hydroxide and acetylene (C$_2$H$_2$).

3) Identify the limiting reactant when 19.9 g of CuO are exposed to 2.02 g of H$_2$ to produce copper metal and water.  How many grams of copper metal would be produced? How much is left of the excess reactant after the reaction is complete?

6) In a synthesis reaction between 3.44g of Cesium metal and 0.901 L of oxygen 2.83g of product results. What is the percent yield for this reaction?

7) Tetraantimony hexoxide reacts with carbon to produce antimony and carbon monoxide. If a mixture of 36.5g of tetraantimony hexoxide and 27.1g carbon produces 17.3g of antimony, what is the percent yield?

8) What is the percent yield for the reaction of 45.9g of sodium bromide with 33.3L chlorine gas, which produces 12.8g of the sodium chloride and an unmeasured amount of bromine gas?
Part VI - Matter and Energy

1) Model a substance in its solid, liquid, and gaseous phase below. Write the name of the phase change on the appropriate arrow.

Heating Curve and Q

1) What is the freezing point of the substance? ____________________________
2) What is the boiling point of the substance? ____________________________
3) What is the melting point of the substance? ____________________________
4) What letter represents the range where the solid is increasing in temperature? _________________
5) What letter represents the range where the liquid is increasing in temperature? _________________
6) What letter represents the range where the gas is increasing in temperature? ___________________
7) What letter represents the melting of the solid? ________________________________
8) What letter represents the vaporization of the liquid? _____________________________
9) What letter(s) show a change in potential energy? ______________________________
10) What letter(s) show a change in kinetic energy? ______________________________
11) What letter represents condensation? ________________________________________
12) What letter represents crystallization? ________________________________________

1) How much energy (in calories and in Joules) will it take to raise the temperature of 75.0 g of water from 20.0 to 55.0 °C? (specific Heat = 1 cal / (g °C) and 4.184 J / (g °C) )

2) 350 J are released as ice (specific Heat = 2.1 J/(g °C) ) cools from -5.0 °C to -32 °C. What is the mass of ice?

3) By January, the 3.0 kg of water in the birdbath in the backyard has frozen to a temperature of -7.0°C. As the season changes, how much heat must be added to the water to make it a comfortable 25°C for the birds? (c_{water} = 4.184 J/(g °C) (c_{ice} = 2.1 J/(g °C) (ΔH_{fus} of water = 3.35 x 10^5 J/kg) )

4) Consider a 0.63-kg sample of metal at room temperature of 20°C. The addition of 6.42 x 10^5 J increases its temperature to its melting point (782°C). An additional 5.94 x 10^4 J causes the sample to completely liquefy. (a) What is the specific heat capacity of the sample? (b) What is the heat of fusion of the metal?

5) How much energy would be required to melt 10.0 g of ice (Specific Heat = 2.1 J/(g °C) ) at 0 °C, warm the resulting liquid (Specific Heat = 4.184 J/(g °C) ) to 100 °C, and change it to steam at 100 °C? (ΔH_{fus} of water = 3.35 x 10^5 J/kg); ΔH_{vap} = 2.3 x 10^6 J/kg)

6) How many grams of steam could be condensed at 100 °C with the removal of 307 kJ of energy? ΔH_{vap} = 2.3 x 10^6 J/kg.
Hess’s Law- Include units and show ALL WORK!

1) Calculate the heat of reaction for: $\text{PbCl}_2(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{PbCl}_4(\text{l}) \ \Delta H = ?$

Given the following:
- $\text{Pb}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{PbCl}_2(\text{s}) \ \Delta H = -359.40 \text{ kJ}$
- $\text{Pb}(\text{s}) + 2 \text{Cl}_2(\text{g}) \rightarrow \text{PbCl}_4(\text{l}) \ \Delta H = -329.30 \text{ kJ}$

2) From the following heats of reaction: $2 \text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{SO}_3(\text{g}) \ \Delta H = -196.00 \text{ kJ}$
- $2 \text{S}(\text{s}) + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{SO}_3(\text{g}) \ \Delta H = -790.00 \text{ kJ}$

Calculate the heat of reaction for: $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g}) \ \Delta H = \ ? \text{ kJ}$

3) Given the following equations: $4 \text{NH}_3(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{NO}(\text{g}) + 6 \text{H}_2\text{O}(\text{l}) \ \Delta H^* = -1170 \text{ kJ}$
- $4 \text{NH}_3(\text{g}) + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{N}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{l}) \ \Delta H^* = -1530 \text{ kJ}$

Using these two equations, determine the heat of formation, $\Delta H_f$, for nitrogen monoxide. $\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}(\text{g})$

4) From the following heats of reaction: $2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{g}) \ \Delta H = -483.6 \text{ kJ}$
- $3 \text{O}_2(\text{g}) \rightarrow 2 \text{O}_3(\text{g}) \ \Delta H = +284.6 \text{ kJ}$

Calculate the heat of the reaction for: $3 \text{H}_2(\text{g}) + \text{O}_3(\text{g}) \rightarrow 3 \text{H}_2\text{O}(\text{g})$
5) Given the following data:  

\[ \text{N}_2(g) + \text{O}_2(g) \rightarrow 2 \text{NO}(g) \quad \Delta H = +180.7 \text{kJ} \]

\[ 2 \text{NO}(g) + \text{O}_2(g) \rightarrow 2 \text{NO}_2(g) \quad \Delta H = -113.1 \text{kJ} \]

\[ 2 \text{N}_2\text{O}(g) \rightarrow 2 \text{N}_2(g) + \text{O}_2(g) \quad \Delta H = -162.3 \text{kJ} \]

Use Hess’s law to calculate \( \Delta H \) for the following reaction: \( \text{N}_2\text{O}(g) + \text{NO}_2(g) \rightarrow 3 \text{NO}(g) \)

6) Given the following data:  

\[ \text{H}_2(g) + \frac{½}{2} \text{O}_2(g) \rightarrow \text{H}_2\text{O}(l) \quad \Delta H = -285.8 \text{kJ} \]

\[ 2 \text{N}_2\text{O}_5(g) + 2 \text{H}_2\text{O}(l) \rightarrow 4 \text{HNO}_3(l) \quad \Delta H = -153.2 \text{kJ} \]

\[ \frac{½}{2} \text{N}_2(g) + 3/2 \text{O}_2(g) + \frac{½}{2} \text{H}_2(g) \rightarrow \text{HNO}_3(g) \Delta H = -174.1 \text{kJ} \]

Use Hess’s law to calculate \( \Delta H \) for the following reaction: \( 2 \text{N}_2(g) + 5 \text{O}_2(g) \rightarrow 2 \text{N}_2\text{O}_5(g) \)

7) Given the following data:  

\[ \text{C}(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g) \quad \Delta H = -393.5 \text{kJ} \]

\[ \text{H}_2(g) + \frac{½}{2} \text{O}_2(g) \rightarrow \text{H}_2\text{O}(g) \quad \Delta H = -285.8 \text{kJ} \]

\[ \text{C}_5\text{H}_{12}(g) + 8 \text{O}_2(g) \rightarrow 5 \text{CO}_2(g) + 6 \text{H}_2\text{O}(g) \quad \Delta H = -3536 \text{kJ} \]

Use Hess’s law to calculate \( \Delta H \) for the following reaction: \( 5 \text{C}(s) + 6 \text{H}_2(g) \rightarrow \text{C}_5\text{H}_{12}(g) \)

8) Given the following data:  

\[ \text{CO}(g) + \text{SiO}_2(s) \rightarrow \text{SiO}(g) + \text{CO}_2(g) \quad \Delta H = +520.9 \text{kJ} \]

\[ 3 \text{SiO}_2(s) + 2 \text{N}_2\text{O}(g) + \text{8 CO}(g) \rightarrow 8\text{CO}_2(g) + \text{Si}_3\text{N}_4(s) \quad \Delta H = -461.1 \text{kJ} \]

Use Hess’s law to calculate \( \Delta H \) for the following reaction: \( 5 \text{CO}_2(g) + \text{Si}_3\text{N}_4(s) \rightarrow 3 \text{SiO}(g) + 2 \text{N}_2\text{O}(g) + 5 \text{CO}(g) \)
Heat of Formation

1) The standard enthalpy of formation of propane, \( \text{C}_3\text{H}_8 \), is -103.6 kJ/mole. Calculate the heat of combustion of \( \text{C}_3\text{H}_8 \). The heats of formation of \( \text{CO}_2(g) \) and \( \text{H}_2\text{O}(l) \) are -394 kJ/mole and -285.8 kJ/mole respectively. Diatomic molecules have a heat of formation of 0 kJ/mole. \( \text{C}_3\text{H}_8 + 5\text{O}_2 \rightarrow 3\text{CO}_2 + 4\text{H}_2\text{O} \)

2) The standard enthalpy of formation of propyne, \( \text{C}_3\text{H}_4 \), is +185.4 kJ/mole. Calculate the heat of combustion of \( \text{C}_3\text{H}_4 \). The heats of formation of \( \text{CO}_2(g) \) and \( \text{H}_2\text{O}(l) \) are -394 kJ/mole and -285.8 kJ/mole respectively. \( \text{C}_3\text{H}_4 + 4\text{O}_2 \rightarrow 3\text{CO}_2 + 2\text{H}_2\text{O} \)

3) The standard enthalpy of formation of ethanol, \( \text{C}_2\text{H}_5\text{OH} \), is -277.7 kJ/mole. Calculate the heat of combustion of \( \text{C}_2\text{H}_5\text{OH} \). The heats of formation of \( \text{CO}_2(g) \) and \( \text{H}_2\text{O}(l) \) are -394 kJ/mole and -285.8 kJ/mole respectively. \( \text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} \)

Stoichiometry

1) If 245 L of chlorine gas reacts with excess phosphorous trichloride, what amount of energy is released?
   \( \text{PCl}_3(g) + \text{Cl}_2(g) \rightarrow \text{PCl}_5(g) \) \( \Delta H = -87.9 \text{ kJ} \)

2) If 300.0 kJ of energy is absorbed, what volume of oxygen gas is produced?
   \( \text{SO}_3(g) \rightarrow \text{SO}_2(g) + \text{O}_2(g) \) \( \Delta H = 197.9 \text{ kJ} \)

3) How many kilojoules are given off when 8.32g of Mg react?
   \( \text{Mg}(s) + \text{O}_2(g) \rightarrow \text{MgO}(s) \) \( \Delta H = -1,213 \text{ kJ} \)

4) Glucose is the main fuel metabolized in animal cells: \( \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} \) \( \Delta H = -2,799 \text{ kJ} \)
   How much energy is given off when 100.0 g of \( \text{C}_6\text{H}_{12}\text{O}_6 \) react?
5) Given the thermochemical equation: \[ \text{____Al(s)} + \text{____Fe}_2\text{O}_3(s) \rightarrow \text{____Al}_2\text{O}_3(s) + \text{____Fe(s)} \Delta H = -850.2 \text{ kJ} \]
How much energy is given off when 288 g of Fe are produced?

6) Given the thermochemical equation: \[ \text{____CO}_2(g) \rightarrow \text{____CO(g)} + \text{____O}_2(g) \Delta H = 566 \text{ kJ} \]. How much energy is absorbed when 85.2 g of CO2 are reacted?

7) \( \text{NaHCO}_3 \) decomposes when exposed to heat. What mass of \( \text{NaHCO}_3 \) is decomposed by 256 kJ?
\[ \text{____NaHCO}_3(s) \rightarrow \text{____Na}_2\text{CO}_3(s) + \text{____CO}_2(g) + \text{H}_2\text{O(ℓ)} \Delta H = 91.5 \text{ kJ} \].

**Reaction Diagrams**

1) Answer the following questions based on the potential energy diagram shown:
   a. This graph represents an *(endothermic / exothermic)* reaction. *(circle your answer)*
   b. Label the reactants, products, and activated complex.
   c. Draw a dashed line on the diagram to indicate a potential energy curve for the reaction if a catalyst is added.
   d. Determine the heat of reaction, \( \Delta H \), (enthalpy change) for this reaction. ____________________________
   e. Determine the activation energy, \( E_a \) for this reaction.
   f. How much energy is required for this reaction to occur? ____________________________
   g. What is the \( \Delta H \) for the reverse reaction? ____________________________
   h. What is the activation energy for the reverse reaction? ____________________________

2) Answer the following questions based on the potential energy diagram shown here:
   a. This graph represents an *(endothermic / exothermic)* reaction. *(circle your answer)*
   b. Label the reactants, products, and activated complex.
   c. Draw a dashed line on the diagram to indicate a potential energy curve for the reaction if a catalyst is added.
   d. Determine the heat of reaction, \( \Delta H \), (enthalpy change) for this reaction. ____________________________
   e. Determine the activation energy, \( E_a \) for this reaction.
   f. How much energy is required for this reaction to occur? ____________________________
   g. What is the \( \Delta H \) for the reverse reaction? ____________________________
   h. What is the activation energy for the reverse reaction? ____________________________
Part VII - Gases

1) List the 5 parts of the Kinetic Molecular Theory.
   a.
   b.
   c.
   d.
   e.

Ideal Gas Law

1) If I have 4.0 moles of gas at a pressure of 5.6 atm and a temperature of 25°C, what is the volume of the gas?

2) If I have an unknown quantity of gas at a pressure of 1.2 atm, a volume of 31 liters, and a temperature of 87 °C, how many moles of gas do I have?

3) If I contain 3.00 moles of gas in a container with a volume of 60.0 liters and at a temperature of 400. K, what is the pressure inside the container?

4) If I have 77 grams of oxygen gas at a temperature of 67 °C in a volume of 88.89 liters, what is the pressure of the gas?

5) If a sample of gas neon gas occupies a volume of 25 liters at a pressure of 0.50 atm and a temperature of 300. K, what is the mass of the sample?

Gas Stoichiometry

1) How many liters of ozone (O$_3$) can be destroyed at 220.0 K and 0.550 atm if 258 g of chlorine gas react with it?

   \[ \text{____Cl}_2(g) + \text{____O}_3(g) \rightarrow \text{____ClO}(g) + \text{____O}_2(g) \]

2) What mass of aluminum is consumed along with excess HCl if 8.90 L liters of hydrogen gas is collected at 300.0 K and 1.25 atm according to the following equation?

   \[ \text{____Al(s)} + \text{____HCl(aq)} \rightarrow \text{____AlCl}_3(aq) + \text{____H}_2(g) \]
3) Propane (C₃H₈) burns in oxygen in a combustion reaction. What volume of carbon dioxide is produced, at STP, when 2.8L of oxygen are consumed? ____C₃H₈ (g) + ____O₂ (g) \rightarrow ____H₂O (g) + ____CO₂ (g)

4) How many liters of oxygen gas are consumed if 3.00 g of hydrogen gas to produce water at STP? ____H₂ (g) + ____O₂ (g) \rightarrow ____H₂O (g)

5) What volume of hydrogen gas is needed to react with excess nitrogen in order to produce 27.0 g of liquid ammonia at a 415 K and 0.800 atm? ____H₂ (g) + ____N₂ (g) \rightarrow ____NH₃ (l)

Part VIII - Solutions

Solubility Curves- Answer the following questions using the solubility curve below. Include units!

1) What mass of each solute will dissolve in 100mL of water at the following temperatures?
   a. KNO₃ at 70°C = __________________
   b. NaCl at 100°C= __________________
   c. NH₄Cl at 90°C= __________________
   d. KClO₃ at 10°C= __________________
   e. Which of the above three substances is most soluble in water at 15°C?

2) Which of the substances (if any) on the solubility curve gases? How do you know?

3) Which compound is most soluble at 20 ºC?

4) Which is the least soluble at 40 ºC?

5) Which substance is least soluble at 10 ºC?

6) How much NH₄Cl can be dissolved in 200 g of H₂O at 50°C? __________________

7) How much NaCl can be dissolved in 500 g of H₂O at 100°C? __________________

8) How much NH₃ can be dissolved in 300 g of H₂O at 20°C? __________________

9) A mass of 15 g of KClO₃ is dissolved in 100 g of water at 40 ºC. The solution is heated to 80ºC. How many more grams of potassium chlorate must be added to make the solution saturated? __________________

10) A mass of 80 g of KNO₃ is dissolved in 100 g of water at 50 ºC. The solution is heated to 70ºC. How many more grams of potassium nitrate must be added to make the solution saturated?

_________________________
11) A mass of 70 g of NaNO₃ is dissolved in 100 g of water at 10 ºC. The solution is heated to 35 ºC. How many more grams of sodium nitrate must be added to make the solution saturated? 

12) A solution of KCl is saturated in 100 g of water at 80 ºC. The solution is cooled to 60 ºC to become supersaturated. How much excess KCl is dissolved in solution?

13) A solution of NaNO₃ is saturated in 100 g of water at 40 ºC. The solution is cooled to 20 ºC to become supersaturated. How much excess NaNO₃ is dissolved in solution?

14) On a solubility curve, the points on the curve indicate a __________________________ solution.

15) Values on the graph __________________________ a curve represent unsaturated solutions.

Label the following solutions as saturated, unsaturated, or super saturated. If unsaturated, write how much more solute can be dissolved in the solution.

16) A solution that contains 70g of NaNO₃ at 30 ºC (in 100 mL H₂O): ______________________________ 

17) A solution that contains 50g of NH₄Cl at 50 ºC (in 100 mL H₂O): ______________________________

18) A solution that contains 70g of KI at 0 ºC (in 100 mL H₂O): ________________________________

19) A solution that contains 20g of KClO₃ at 50 ºC (in 100 mL H₂O): ______________________________

20) A solution that contains 20g of NH₃ at 80 ºC (in 100 mL H₂O): ______________________________

Molarity and Making Solutions- Answer the following questions. Show ALL WORK and include units!

1) What is the molarity of a solution with a volume of 6.700 L that contains 1.200 moles of calcium chloride?

2) How many moles of cesium acetate are dissolved in 890. mL of a 0.900 M solution?

3) What is the volume of a 0.450 M solution that contains 0.290 moles of chloric acid.

4) What is the molarity that was made by dissolving 250. g of hydrobromic acid in 675 mL of solution?

5) What mass of nickel (I) chloride is dissolved in 500.0 mL of a 1.25 M solution?

6) What is the volume of a solution with a molarity of 0.725 M that was made with 35.0 g of ammonium fluoride?

7) What mass of potassium acetate is dissolved in 25.0 mL of a 0.110 M solution?
8) Your teacher asks you to prepare 500 mL of a 2.75 molar solution of NaCl for a lab. Write a step-by-step procedure describing how you would carry out this task.

9) Your teacher asks you to prepare 250 mL of a 0.35M solution of HC₂H₃O₂ for an upcoming lab. Write a step-by-step procedure describing how you would carry out this task.

**Dilutions** Answer the following questions. Show ALL WORK and include units.

1) What is a dilution?

2) Describe the step-by-step process of diluting 0.50L of a 1.0M solution of NaCl to a 0.50M solution of NaCl.

3) In question number 2, during the dilution, what happened to...
   a. The concentration? Increase – Decrease – Remain the same
   b. The volume of the solution? Increase – Decrease – Remain the same
   c. The amount of solvent? Increase – Decrease – Remain the same
   d. The amount of solute? Increase – Decrease – Remain the same

4) Model the solution on the molecular level from number 2 before and after the dilution. Include a key if necessary.

<table>
<thead>
<tr>
<th>BEFORE</th>
<th>AFTER</th>
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<tbody>
<tr>
<td>• • •</td>
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<td></td>
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</tbody>
</table>

**KEY**

5) If 45 mL of water is added to 250mL of a 0.75 M K₂SO₄ solution, what will the molarity of the diluted solution be?
6) If water is added to 175mL of a 0.45 M KOH solution until the volume is 250 mL, what will the molarity of the diluted solution be?

7) How much 0.075 M NaCl solution can be made by diluting 450 mL of 9.0 M NaCl?

8) If 550mL of a 3.50 M KCl solution are set aside an allowed to evaporate until the volume of the solution is 275 mL, what will the molarity of the solution be?

9) How much water would need to be added to 750 mL of a 2.8 M HCl solution to make a 1.0M solution?

10) If I add water to 100 mL of a 0.15 M NaOH solution until the final volume is 150 ML, what will the molarity of the diluted solution be?

11) How much 0.05 M HCl solution can be made by diluting 250 mL of a 10 M HCl solution?

12) I have 345 mL of a 1.5 M NaCl solution. If I boil the water until the volume of the solution is 250 mL, what will the molarity of the solution be?

13) How much water would I need to add to 500 mL of a 1.0 M KCl solution to make a 2.4 M solution?

14) How much of a 5.00 M stock solution of copper (II) sulfate is needed to make 500.0 mL of a 0.35M solution?

15) If 6.0L of a 1.50 M AgNO₃ solution is set aside an allowed to evaporate until the volume of the solution is 4.2L, what will the molarity of the solution be?
Solution Stoichiometry- Answer the following questions. Show ALL WORK and include a balanced equation and units!

1) If 10.0 mL of a 2.25 M sodium carbonate solution reacts with excess iron (III) chloride solution, what mass of iron (III) carbonate precipitates out of solution? 

\[
\text{FeCl}_3(aq) + \text{Na}_2\text{CO}_3(aq) \rightarrow \text{Fe}_2(\text{CO}_3)_3(s) + \text{NaCl}(aq)
\]

2) A chemist reacts 75.0 mL of 0.200 molar iron (III) chloride solution completely with an excess of 0.250 M sodium carbonate solution. What volume of sodium carbonate solution is needed?

3) What volume of 0.20 M AgNO\textsubscript{3} will be needed to react completely with 25.0 mL of 0.50 M potassium phosphate?

4) What mass of precipitate is produced from the above reaction?

5) What mass of precipitate should result when 0.550 L of 0.500 mol/L aluminum nitrate solution is mixed with 0.240 L of 1.50 mol/L sodium hydroxide solution?

6) If 25.0 mL of 0.750 M Copper (II) sulfate solution is mixed with excess sodium chloride solution, what is the theoretical yield of copper (II) chloride (sodium sulfate is the other product)?

7) What is the limiting reactant if 0.50 L of 0.50 M Copper (II) sulfate solution is mixed with 0.50 L of 0.50 mol/L sodium chloride solution?
Part IX - Acids and Bases

1) When describing an acid or a base, what do the terms strong and weak mean?

2) In your own words, what is the difference between Arrhenius’s definition and Bronsted-Lowry’s definition of acids and bases?

3) What type of substances are strong electrolytes?

4) What type of substances are weak electrolytes?

5) What is an amphoteric substance? Given an example of one.

6) Write the reaction for the auto ionization of water:

7) Explain why NH₃ is considered a Bronsted-Lowry base, but not an Arrhenius base.

8) What happens to the charge of a substance if it gains a proton (H⁺)?

9) What happens to the charge of a substance if it loses a proton (H⁺)?

10) When an acid (gains/loses) a proton, it becomes the conjugate (acid/base). (circle the correct answers)

11) When a base (gains/loses) a proton, it become the conjugate (acid/base). (circle the correct answers)

Conjugate Acid-Base Pairs

<table>
<thead>
<tr>
<th>Acid</th>
<th>Conjugate Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₃O⁺</td>
<td>OH⁻</td>
</tr>
<tr>
<td>HCl</td>
<td>H₂PO₃⁻</td>
</tr>
</tbody>
</table>

For the following equations, label the Bronsted-Lowry acid/base AND label the conjugate acid and conjugate base.

12) H₂C₂H₃O₂ + H₂O ⇔ H₂O⁺¹ + C₂H₂O₂⁻¹

13) HCO₃⁻ + H₂O ⇔ H₂CO₃ + OH⁻¹

14) HNO₃ + SO₄²⁻ ⇔ HSO₄⁻¹ + NO₃⁻¹

15) HF + H₂O ⇔ F⁻ + H₃O⁺¹

16) HNO₂ + H₂O ⇔ H₀⁺¹ + NO₂⁻¹

17) H₂O + S²⁻ ⇔ HS⁻¹ + OH⁻¹
18) \[ \text{CN}^{-1} + \text{HC}_2\text{H}_3\text{O}_2 \leftrightarrow \text{C}_2\text{H}_3\text{O}_2^{-1} + \text{HCN} \]

19) \[ \text{NH}_3 + \text{H}_2\text{O} \leftrightarrow \text{NH}_4^{+1} + \text{OH}^{-1} \]

20) \[ \text{OH}^{-1} + \text{NH}_4^{+1} \leftrightarrow \text{H}_2\text{O} + \text{NH}_3 \]

21) \[ \text{HSO}_4^{-1} + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{O}^{+} + \text{SO}_4^{2-} \]

**pH:** Using your knowledge of pH and pOH and the equations below answer the following questions. Show all work!

<table>
<thead>
<tr>
<th>pH</th>
<th>Formulas</th>
<th>pOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ pH = -\log[H_3O^{+1}] ]</td>
<td>[ [H_3O^{+1}] = 10^{-pH} ]</td>
<td>[ pOH = -\log[OH^{-1}] ]</td>
</tr>
<tr>
<td>[ pH + pOH = 14 ]</td>
<td>[ [OH^{-1}] = 10^{-pOH} ]</td>
<td></td>
</tr>
</tbody>
</table>

1) What is the pH of a 0.0235 M H\(_2\)SO\(_4\) solution?

2) What is the pOH of a 0.0235 M HCl solution?

3) What is the pH of a 6.50 x 10\(^{-3}\) M Ca(OH)\(_2\) solution? (Hint: this is a basic solution)

4) What is the [H\(_3\)O\(^+\)] of a 6.2 x 10\(^{-5}\) M Ba(OH)\(_2\) solution?

5) A solution with an H\(_3\)O\(^+\) concentration of 1.00 x 10\(^{-7}\) M is said to be neutral. Why?

6) Dr. Pepper has a [H\(^+\)] = 1.4 x 10\(^{-5}\) M. What is its pH?

7) Fill in the chart below:

<table>
<thead>
<tr>
<th>[H(_3)O(^+)]</th>
<th>[OH(^-)]</th>
<th>pH</th>
<th>pOH</th>
<th>Acidic, Basic, or Neutral?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 1.5 x 10(^{-3}) M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 4.2 x 10(^{-9}) M</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>8.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td></td>
<td></td>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g.</td>
<td>4.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. 2.0 x 10(^{-6}) M</td>
<td></td>
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</tbody>
</table>
Part X - Reaction Rates and Equilibrium

1) List 5 factors that affect the rate of a reaction:
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________
   d. __________________________________________
   e. __________________________________________

2) What is a reversible reaction?

3) Using the collision theory explain why the rate of a reaction increases when pressure is increased.

4) The process of milk spoiling is a chemical reaction. Using your knowledge of rates of chemical reactions and collision theory, explain why we keep milk in the refrigerator.

5) It has been observed that more gas station fires occur on hot days than on cold days. Explain this phenomenon using your knowledge of collision theory.

6) What is chemical equilibrium?

7) What is equal at chemical equilibrium?

8) What is constant at chemical equilibrium?

9) At the macroscopic level a system at equilibrium appears to be unchanging. Is it also unchanging at the molecular level? Explain.
10) True or False: At equilibrium the amount of reactants is equal to the amount of products. __________________
11) What is the formula for writing an equilibrium expression?

12) What do brackets [ ] indicate? _________________________________
13) What are the units of K? _____________________________________
14) What does a large K value (K>1) indicate?
15) What does a small K value (K<1) indicate?

Calculating Reaction Rates

16) Use the data below to calculate the average rate of decomposition of H₂O₂ between 0 and 43,200 seconds.

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>[H₂O₂] (mol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>21,600</td>
<td>0.500</td>
</tr>
<tr>
<td>43,200</td>
<td>0.250</td>
</tr>
</tbody>
</table>

17) Using the rate of decomposition calculated above, and the following chemical equation, calculate the rate of production of oxygen in mol/L’s and in mol/L·min. 2H₂O₂ → 2H₂O + O₂

18) Consider the general reaction aA +bB → cC and the following average rate data, determine the coefficients (a, b, and c) for the reaction.

- ∆A/∆t = 0.0080 mol/L·s
- ∆B/∆t = 0.0120 mol/L·s
- ∆C/∆t = 0.0160 mol/L·s

Equilibrium Constant expressions and Calculations involving K

1. Write the equilibrium expressions for each of the following reversible reactions:
   a. O₃ (g) + NO(g) ⇌ O₂(g) + NO₂(g)
   b. 2CO(g) + O₂(g) ⇌ 2CO₂(g)
   c. NH₄NO₃(s) ⇌ N₂O(g) + 2H₂O(l)
   d. 2H₂O(g) ⇌2H₂(g) + O₂(g)
   e. 2N₂H₄(g) + 2NO₂(g) ⇌ 3N₂(g) + 4H₂O(g)
   f. 2NbCl₆(g) ⇌ NbCl₃(g) + NbCl₅(g)
   g. 2NaHCO₃(s) ⇌ Na₂CO₃(s) + H₂O(g) + CO₂(g)
   h. C₆H₆(l) ⇌ C₆H₆(g)

2. Consider the reversible reaction PCl₅(g) ⇌PCl₃(g) + Cl₂(g). What is the equilibrium constant if the equilibrium concentrations are as follows: PCl₅ is 0.0096 mol/L, PCl₃ is 0.0247 mol/L and Cl₂ is 0.0247 mol/L?
3. At 1000°C, a 1.00 L container has an equilibrium mixture consisting of 0.102 mol of ammonia, 1.03 mol of nitrogen, and 1.62 mol of hydrogen. Calculate the $K_c$ for the equilibrium system. $\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g)$.

4. At a given temperature, the $K_c$ for the reaction $\text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{HI}(g)$ is 54.3. If the concentration of both $\text{H}_2$ and $\text{I}_2$ at equilibrium are $4.79 \times 10^{-4} \text{M}$, find the concentration of HI.

5. If the system described in number 4 (above) were to contain an equilibrium mixture consisting of $1.83 \times 10^{-3} \text{M} \text{H}_2$, $3.13 \times 10^{-3} \text{M} \text{I}_2$, and $1.77 \times 10^{-2} \text{M} \text{HI}$, what would be the value of the equilibrium constant?

6. Acetic acid dissociates in water. If $K_c = 1.80 \times 10^{-5}$ and the equilibrium concentrations of acetic acid is $0.09986 \text{M}$, what is the concentration of $\text{H}^+(aq)$ and $\text{C}_2\text{H}_3\text{O}_2(aq)$? $\text{HC}_2\text{H}_3\text{O}_2(aq) \rightleftharpoons \text{H}^+(aq) + \text{C}_2\text{H}_3\text{O}_2(aq)$

7. At 60.2°C the equilibrium constant for the reaction $\text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g)$ is $8.75 \times 10^{-2}$. At equilibrium at this temperature a vessel contains $\text{N}_2\text{O}_4$ at a concentration of $1.72 \times 10^{-2} \text{M}$. What concentration of NO$_2$ does it contain?

LeChatelier’s Principle

1) State Le Chatelier’s Principle: ____________________________________________________________

2) Predict which way the following equilibrium systems will shift when the total pressure is increased. (Note: some may have no shift)
   a. $\text{N}_2 (g) + \text{O}_2 (g) \leftrightarrow 2\text{NO} (g)$  
   b. $2\text{SO}_2 (g) + \text{O}_2 (g) \leftrightarrow 2\text{SO}_3 (g)$  
   c. $4\text{NH}_3 (g) + 5\text{O}_2 (g) \leftrightarrow 4\text{NO} (g) + 6\text{H}_2\text{O} (g)$

3) $\text{N}_2\text{O}_4 (g)$ is a colorless gas and $\text{NO}_2 (g)$ is a dark brown gas. Use Le Chatelier’s principle to explain why a flask filled with $\text{NO}_2 (g)$ and $\text{N}_2\text{O}_4 (g)$ will get darker when heated. Use the equation: $\text{N}_2\text{O}_4 (g) + \text{heat} \leftrightarrow 2\text{NO}_2 (g)$
4) List at least 3 ways to increase amount of oxygen gas in the following reaction.

\[ \text{H}_2\text{O}_2 (aq) \leftrightharpoons \text{H}_2 (g) + \text{O}_2 (g) \quad \Delta H = +187.00 \text{ kJ} \]

a. ______________________________________________________________________________________

b. ______________________________________________________________________________________

c. ______________________________________________________________________________________

5) What does it mean if a reaction shifts towards the products?

_________________________________________________________________________________________

6) Complete the following chart by writing left, right, or none for the equilibrium shift. Write decrease, increases, or remains the same for the concentrations of reactants and products.

\[
\text{Ca}^{2+}(aq) + \text{SO}_4^{2-}(aq) + 10.6 \text{ kcal} \leftrightharpoons \text{CaSO}_4(s)
\]

(Remember that pure solids and liquids do not affect equilibrium values.)

<table>
<thead>
<tr>
<th>Stress</th>
<th>Equilibrium Shift</th>
<th>Amount of CaSO₄(s)</th>
<th>[Ca²⁺]</th>
<th>[SO₄²⁻]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Add CaSO₄(s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Add CaCl₂ (adds Ca²⁺)</td>
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<tr>
<td>3. Add MgSO₄ (adds SO₄²⁻)</td>
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<td></td>
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<tr>
<td>4. Remove SO₄²⁻</td>
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</tr>
<tr>
<td>5. Increase temperature</td>
<td></td>
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<td></td>
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<tr>
<td>6. Decrease temperature</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7. Increase Pressure</td>
<td></td>
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<tr>
<td>8. Decrease Pressure</td>
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</tbody>
</table>

\[
12.6 \text{ kcal} + 2\text{HCl (aq)} \leftrightharpoons \text{H}_2(g) + \text{Cl}_2(g)
\]

<table>
<thead>
<tr>
<th>Stress</th>
<th>Equilibrium Shift</th>
<th>[H₂]</th>
<th>[Cl₂]</th>
<th>[HCl]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Add H₂</td>
<td>Left</td>
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<td>decreases</td>
<td>increases</td>
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<tr>
<td>2. Add Cl₂</td>
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<tr>
<td>3. Add HCl</td>
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<tr>
<td>4. Remove H₂</td>
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<tr>
<td>5. Remove Cl₂</td>
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<tr>
<td>6. Remove HCl</td>
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<tr>
<td>7. Increase Temperature</td>
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<td>8. Decrease Temperature</td>
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<tr>
<td>9. Increase Pressure</td>
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<tr>
<td>10. Decrease Pressure</td>
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</tbody>
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