C101 Exam 2
Version 01

Instructions for filling out your answer sheet:

1. Use a #2 pencil only.
2. Print your **LAST NAME** and then your **FIRST NAME** in the name field, and then blacken in the bubbles that correspond to the letters of your name. Leave a space between your last and first name; blacken in the blank circle below the blank space.
3. In the Version column, blacken in the version number of the exam.

This is Version 01 Note: You must fill in the zero and the one.

4. Fill in your IU username in the username column and then blacken in the corresponding circles.
5. Fill in only ONE answer for each multiple choice question. If multiple answers are given, no points can be awarded; therefore, make sure you erase your answers well.
6. Do not make stray marks in any other portions of the answer sheet.
7. Failure to follow the above instructions will delay the posting of your grade. If you do not bring problems to our attention within one week, we reserve the right to not make adjustments. It is your responsibility to be about entering your IU username and version number correctly.

You have two hours to complete the exam. This exam has 35 questions (30 multiple choice at 2 points each and 5 short answer for 40 points and up to 8 points bonus) for a total of 108 out of 100 points.

1. **Legibly put your whole name on the first and last page of the exam in the bank for name.**
2. **Circle you discussion AI's name.**
3. **Fill out your scantron completely with correct version number.**

Avogadro's # = 6.022×10^{23} things/mol

H 2.1																	
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	
K 0.8	Ca 1.0											Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	
Rb 0.8	Sr 1.0											Many elements have been omitted to emphasize the basic pattern of electronegativity variation.				I 2.4	
Cs 0.7	Ba 0.9																

Table 8.1 Solubility Rules

Soluble in water		
All sodium, potassium, and ammonium salts		
All acetates and nitrates		
Most halides (chlorides, bromides, iodides)	*except*	Halides of lead(II), silver(I), and mercury(I)
Most sulfates	*except*	Sulfates of calcium, barium, lead(II), and strontium
Insoluble in water		
Most phosphates, carbonates, and sulfides	*except*	Sodium, potassium, and ammonium salts; calcium sulfide
Most hydroxides	*except*	Sodium, potassium, calcium, and barium hydroxides

Oxidation State

Rule 1: The oxidation number of an element in its free (uncombined) state is zero — for example, Al(s) or Zn(s). This is also true for elements found in nature as *diatomic* (two-atom) elements and for sulfur, found as: S_8

Rule 2: The oxidation number of a *monatomic* (one-atom) ion is the same as the charge on the ion, for example:

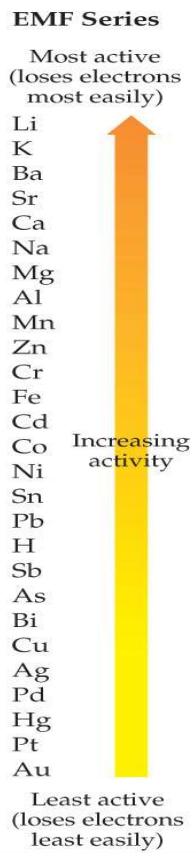
Rule 3: The sum of all oxidation numbers in a neutral compound is zero. The sum of all oxidation numbers in a *polyatomic* (many-atom) ion is equal to the charge on the ion. This rule often allows chemists to calculate the oxidation number of an atom that may have multiple oxidation states, if the other atoms in the ion have known oxidation numbers.

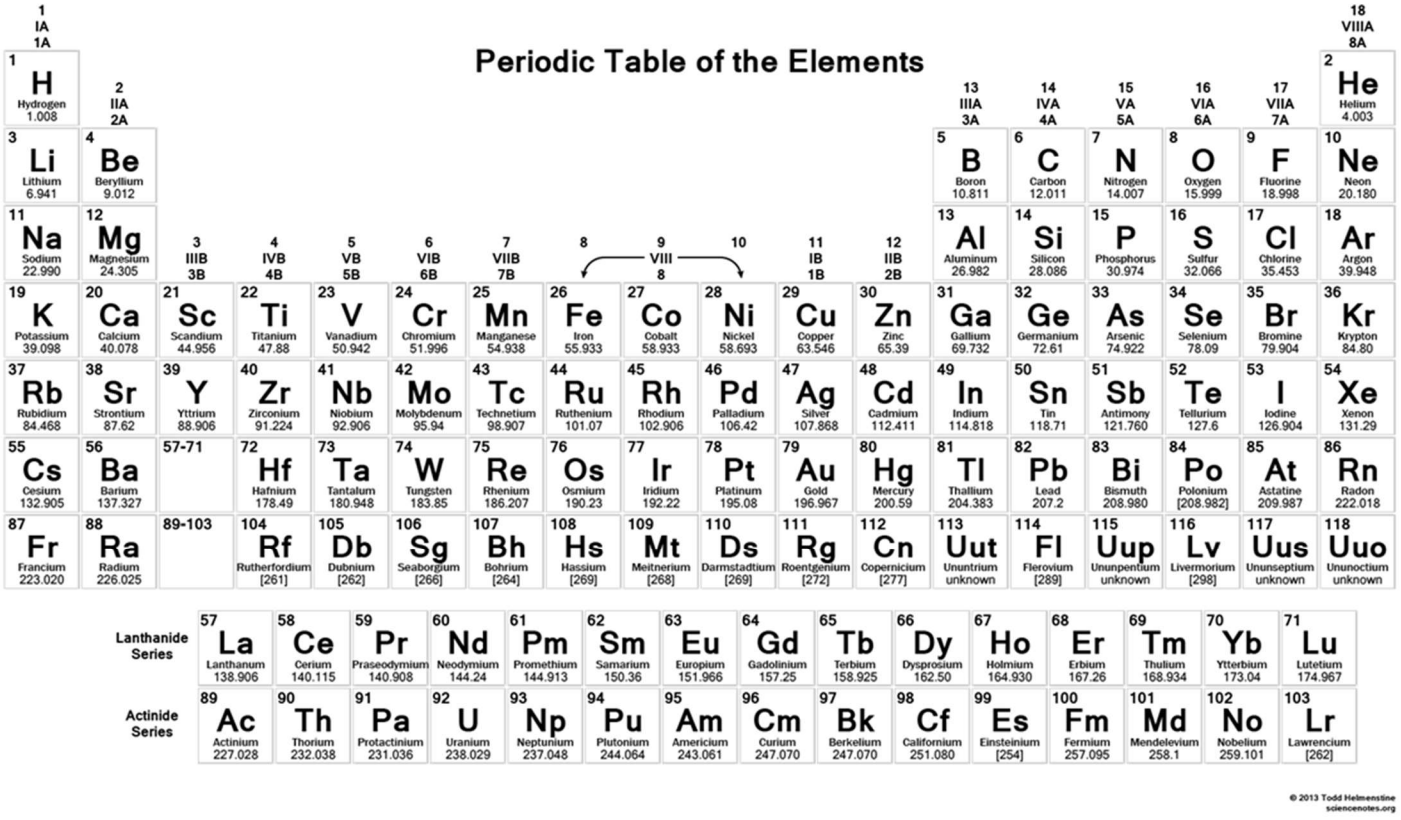
Rule 4: The oxidation number of an alkali metal (IA family) in a compound is +1; the oxidation number of an alkaline earth metal (IIA family) in a compound is +2.

Rule 5: The oxidation number of fluorine is always –1. Chlorine, bromine, and iodine usually have an oxidation number of –1, unless they're in combination with an oxygen or fluorine.

Rule 6: The oxidation state of hydrogen in a compound is usually +1. If the hydrogen is part of a *binary metal hydride* (compound of hydrogen and some metal), then the oxidation state of hydrogen is –1.

Rule 7: The oxidation number of oxygen in a compound is usually –2. If, however, the oxygen is in a class of compounds called *peroxides* (for example, hydrogen peroxide), then the oxygen has an oxidation number of –1. If the oxygen is bonded to fluorine, the number is +1



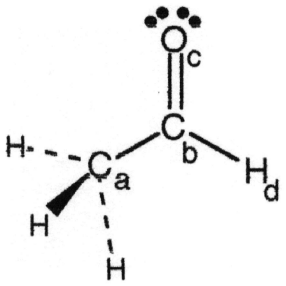


1) In a molecule having four pairs of electrons around the central atom and a pyramidal shape, how many bonding pairs of electrons does the central atom have?
   A) 1
   B) 2
   C) 3
   D) 4

2) In a molecule having three pairs of electrons around a central atom and a trigonal planar shape, how many lone pairs of electrons does the central atom have?
   A) 2
   B) 0
   C) 1
   D) 3

3) What is the steric number of the central atom in boron trichloride? (draw dot structure if needed)
   A) 1
   B) 2
   C) 3
   D) 4

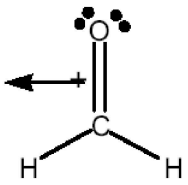
4) Which of the following chlorine–containing compounds is **not** polar?
   A) CH_2Cl_2
   B) CCl_4
   C) HCl
   D) $CHCl_3$



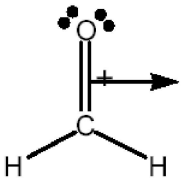
5) In the drawing of acetaldehyde, CH_3CHO (above), the largest partial **negative** charge (δ–) occurs on
   A) atom (a).
   B) atom (b).
   C) atom (c).
   D) atom (d).

6) Which of the three phases of matter (solid, liquid, or gas) has particles that are fast–moving and independent of each other?
   A) gas
   B) solid
   C) liquid
   D) All of the above feature loose arrangements of particles.

7) Which best indicates the direction of the dipole moment in formaldehyde, $H_2C{=}O$?



(1)



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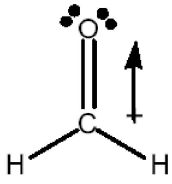

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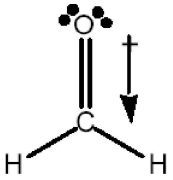
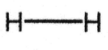


(4)

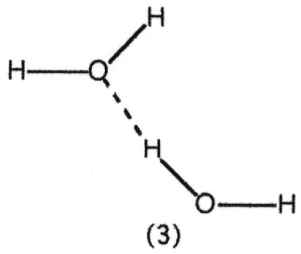
A) drawing (1)
B) drawing (2)
C) drawing (3)
D) drawing (4)

8) Which drawing best represents hydrogen bonding?



(1)

(2)



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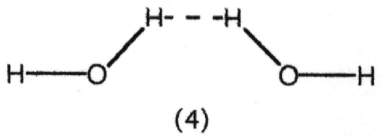


(4)

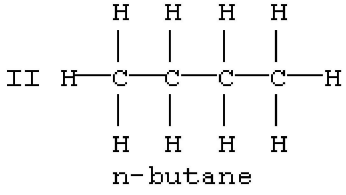
A) drawing (1)
B) drawing (2)
C) drawing (3)
D) drawing (4)

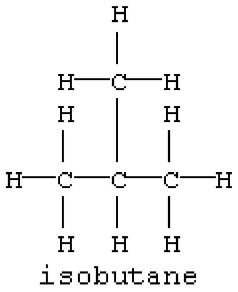
9) Which of the following statements about London forces is correct?
A) London forces occur between polar and nonpolar molecules.
B) London forces are relatively weakly attractive.
C) London forces are also called dispersion forces.
D) All the above statements are true.

10) Which substance in **each** of the following pairs is expected to have the larger London dispersion forces (LDF)?

Set I: Br_2 or I_2 **Set II**: n–butane or isobutane (structures below)

I Br_2 or I_2

II 

or 

A) Br_2 in set I and isobutane in set II
B) I_2 in set I and isobutane in set II
C) Br_2 in set I and n–butane in set II
D) I_2 in set I and n–butane in set II

11) Which of the following chemical substances would you expect to exhibit hydrogen bonding?
A) CH_3OH
B) HF
C) NH_3
D) all of the above

12) Which of the following will have the lowest boiling point?
A) $HOCH_2–CH_2OH$
B) CH_3CH_3
C) CH_3CH_2OH
D) CH_3OCH_3

13) Which process absorbs (requires) energy?
A) bond formation
B) bond breaking
C) both A and B
D) none of the above

14) Which of the following equations has 1:2:1:1 as the coefficient ratio when balanced?
A) $Zn + HCl \rightarrow H_2 + ZnCl_2$
B) $H_2SO_4 + KOH \rightarrow K_2SO_4 + H_2O$
C) $CH_4 + O_2 \rightarrow CO_2 + H_2O$
D) $NaOH + HCl \rightarrow NaCl + H_2O$

15) Which of the following reactions is a decomposition reaction?
A) $CaCl_2 + H_2O \rightarrow CaCl_2 \cdot 2H_2O$
B) $KClO_3 \rightarrow KCl + O_2$
C) $HCl + NaOH \rightarrow NaCl + H_2O$
D) $Mg + HCl \rightarrow H_2 + MgCl_2$

16) Which ions are **not** spectator ions in the following precipitation equation? (use solubility rules!)

$$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$$

A) Na^+ and Cl^-
B) Ag^+ and Cl^-
C) Ag^+ and NO_3^-
D) Na^+ and NO_3^-

17) If the following ions Ca^{2+}, NO_3^-, Na^+ and SO_4^{2-} are placed in a test tube, the precipitate formed is _____.

A) $CaSO_4$
B) $NaNO_3$
C) $Ca(NO_3)_2$
D) Na_2SO_4

18) The net ionic equation for the following acid base neutralization reaction is _____.

$$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O\ (l)$$

A) $H^+\ (aq) + OH^-\ (aq) \rightarrow H_2O\ (l)$
B) $2K^+\ (aq) + SO_4^{2-}\ (aq) \rightarrow K_2SO_4\ (aq)$
C) $K^+\ (aq) + OH^-(aq) \rightarrow KOH\ (aq)$
D) $2H^+\ (aq) + SO_4^{2-}\ (aq) \rightarrow H_2SO_4\ (aq)$

19) What is the mass, in grams, of 1.000 mole of diphosphorus pentoxide?

A) 46.98 g
B) 239.03 g
C) 61.96 g
D) 142.0 g

20) 0.3 moles of a certain calcium compound weigh 93 g. This compound may be _____.

A) calcium chloride
B) calcium phosphate
C) calcium sulfate
D) calcium nitrate

21) The mass, in grams, of **oxygen** present in 11.7 g of $Al_2(CO_3)_3$ is _____. $MM_{Al2(CO3)3} = 234$ g/mol

A) 4.05 g
B) 7.20 g
C) 8.10 g
D) 14.4 g

22) 4 moles of nitrogen reacts with excess oxygen. If this reaction produces 2 moles of nitrogen dioxide, the percent yield is _____.

$$N_2 + 2\ O_2 \rightarrow 2\ NO_2$$

A) 50%
B) 12.5%
C) 100%
D) 25%

23) The maximum number of moles of water that could be produced from 0.5 moles of C_3H_8O is _____.

$$2\ C_3H_8O + 9\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O$$

A) 4
B) 0.5
C) 2
D) 8

24) Which reactant is present in excess if 40.0 g of CaO react with 1.5 mol of H_2O?

$$CaO + H_2O \rightarrow Ca(OH)_2$$

A) CaO
B) H_2O
C) $Ca(OH)_2$
D) None of the above, the amounts exactly balance.

25) What is the oxidation state of manganese in the compound $KMnO_4$?

A) +2
B) −4
C) +4
D) +7

26) Which atom in the compound $KClO_3$ has a negative oxidation state?

A) oxygen
B) potassium
C) both chlorine and oxygen
D) both potassium and chlorine

27) Identify the compound that contains bromine with a +3 oxidation state.

A) $NaBrO_2$

B) $NaBrO_4$

C) NaBrO

D) $NaBrO_3$

28) Which of the following is true for the following reaction?

$$Mg + O_2 \rightarrow 2\ MgO$$

A) Magnesium is oxidized.
B) Oxygen is reduced.
C) The oxidation state of magnesium in MgO is +2.
D) All of the above are true.

29) What is oxidized in the following chemical process?

$$Fe(s) + Cu(NO_3)_{2(aq)} \rightarrow Fe(NO_3)_{2(aq)} + Cu(s)$$

A) NO_3^- (aq)
B) Fe (s)
C) Cu (s)
D) Cu^{+2} (aq)

30) In the following reaction, is the carbon in methane, CH_4, oxidized or reduced and how many electrons does each carbon atom gain or lose?

$$CH_4 + 2O_2 \rightarrow 2H_2O + CO_2$$

A) Carbon is reduced and gains 4 electrons
B) Carbon is oxidized and loses 8 electrons
C) Carbon is oxidized and gains 4 electrons
D) Carbon is reduced and loses 8 electrons
E) Noneof the above.

31)

a. (8 points)	H_2O	CO_2
Dot Structure Draw net dipoles if dipoles do not cancel out. note: electronegativty values: H=2.1, O=3.5, C=2.5		
electron geometry		
molecular shape		
bond angles (circle)	~180 ~120 ~109.5	~180 ~120 ~109.5
Polar or nonpolar (circle)	polar nonpolar	polar nonpolar
types of intermolecular forces (circle ALL that apply)	london dispersion dipole–dipole hydrogen bonding ion–dipole	london dispersion dipole–dipole hydrogen bonding ion–dipole

b. (2 points) Consider the molecules H–Cl and H–F. Electronegativty values: H=2.1, Cl=3.0, F=4.0

Which of the two molecules has a larger dipole moment?	
Which gas has stronger intermolecular forces?	
Which compound has the higher boiling point?	
Which compound experiences hydrogen bonding?	

c. (**BONUS** 3 points) Draw one central water molecule surrounded by 4 other water molecules with dotted lines to indicate hydrogen bonding. Be sure each of your water molecules are correctly drawn with the correct number of bonds and lone pairs on the central atom.

32) (8 points total) Chemical Equations

a) (2 pts) Balance the followling equation

____Li(s) + ____N_2(g) → ____Li_3N(s) Type of Reaction: _____

b) (2 pts) Predict products and balance the following equation

____C_5H_{12} + ____O_2 → _____ + _____ Type of Reaction:_____

c) (4 points) Use the solubilty rules to answer the following questions. Show all states (l), (g), (s), (aq). Aqueous solutions of magnesium chloride and potassium sulfide are combined. If a reaction occurs, write the molecular,and the net ionic equations. If a reaction does not occur, write NR (no reaction).

Molecular:

Net ionic:

d) (**2 points bonus**) You need calcium sulfate but there is none available. Using any other ionic compounds, propose an exchange precipitatin reaction for the synthesis of calcium sulfate. Show the balanced equation for your proposed reaction including all states: (l), (g), (s), (aq).

_____ + _____ → _____ + _____

33) (6 points) Answer the following conversion questions.

a) How many grams of silver are there in 4.0×10^{22} atoms of silver?

b) How many moles of sulfur dioxide are in 40.0 mg of sulfur dioxide?

c) How many grams of caffeine ($C_8H_{10}N_4O_2$, MM=194 g/mol) would you need to get 4.00×10^{23} **carbon** atoms?

34) (8 points) Nitrogen gas and hydrogen gas react to form ammonia gas. (**show all work for full credit)**.

a) What is the balanced chemical equation?

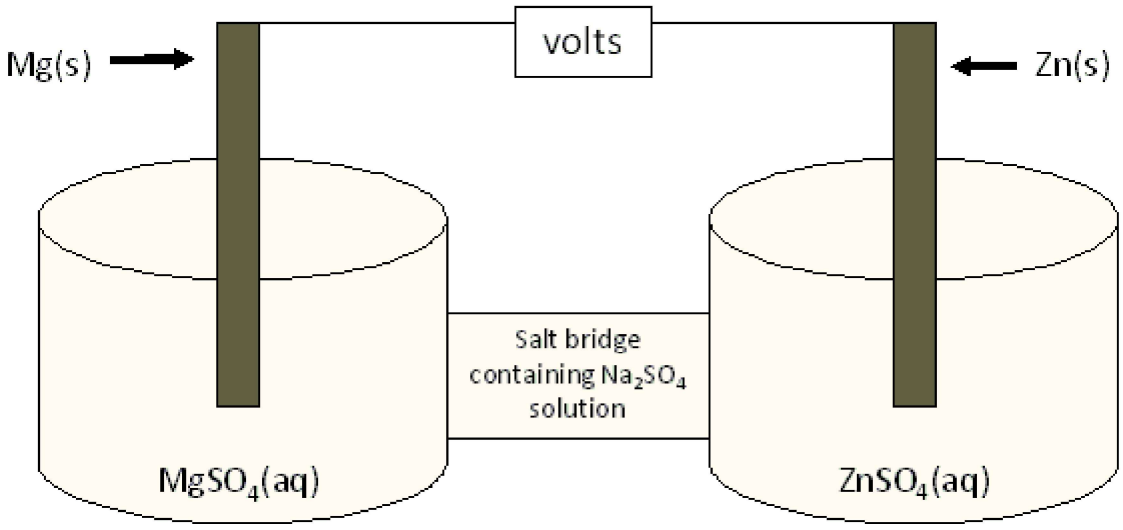
b) What is the theoretical yield of ammonia in grams, when 12.0 g N_2 reacts with 4.00 g H_2? (circle answer)

c) The limiting reactant is: _____The excess reactant is: _____

d) If 11.3 g of ammonia is actually produced, what is the percent yield of this reaction?

e) (3 points bonus) What amount, in grams, of excess reactant is left–over at the end of the reaction?

35) (8 points) Here is a diagram of a battery made from magnesium and zinc:



a) In the diagram above, label the **anode** and **cathode** and **draw an arrow** above the voltmeter to show the direction of the electron flow.

b)Write the net ionic equation for the spontaneous reaction that occurs in this battery.

c) In which half cell does reduction take place? (circle one)

Reduction occurs in the Mg half cell or Reduction occurs in the Zn half cell

d) Into which half cell will the sulfate ions in the salt bridge flow? (circle one)

the Mg half cell or the Zn half cell

e) Over time, which electrode will increase in mass? (circle one) Mg electrode or Zn electrode

Printed Name:_____ Circle Discussion AI: Amir OR Kristen

Q31_____/10
Q32_____/8
Q33_____/6
Q34_____/8
Q35_____/8

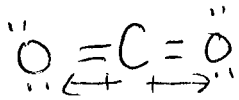
Total handgrade: _____/40 (48 points possible)

Answer Key
Testname: F18 C101 E2

1) C
2) B
3) C
4) B
5) C
6) A
7) C
8) C
9) D
10) D
11) D
12) B
13) B
14) A
15) B
16) B
17) A
18) A
19) D
20) B
21) B
22) D
23) C
24) B
25) D
26) A
27) A
28) D
29) B
30) B
31)
32)
33)
34)
35)

4pts 4pts

31) a. (8 points)

	H_2O	CO_2
Dot Structure Draw net dipoles if dipoles do not cancel out. note: electronegativty values: H=2.1, O=3.5, C=2.5		 no net dipole
electron geometry	tetrahedral	linear
molecular shape	bent	linear
bond angles (circle)	~180 ~120 ~109.5	~180 ~120 ~109.5
Polar or nonpolar (circle)	polar nonpolar	polar nonpolar
types of intermolecular forces (circle ALL that apply)	london dispersion dipole-dipole hydrogen bonding ion-dipole	london dispersion dipole-dipole hydrogen bonding ion-dipole

1pt for dot structure

½ pt for net dipole

½ pt

½ pt

½ pt

½ pt

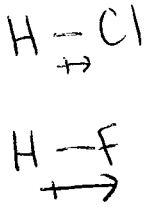
½ pt each / 2

4 pts

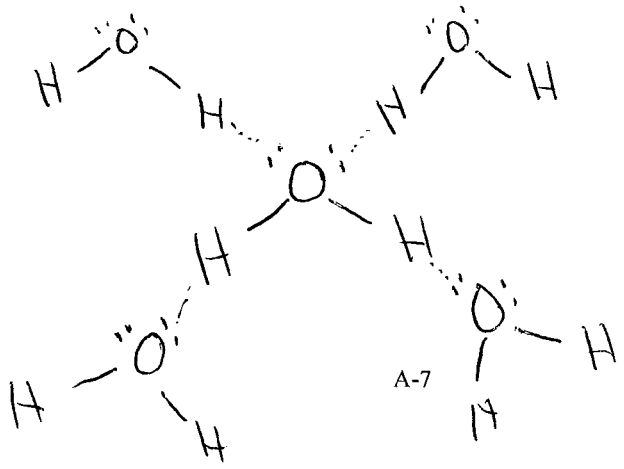
b. (2 points) Consider the molecules H–Cl and H–F. Electronegativty values: H=2.1, Cl=3.0, F=4.0

Which of the two molecules has a larger dipole moment?	H–F
Which gas has stronger intermolecular forces?	H–F
Which compound has the higher boiling point?	H–F
Which compound experiences hydrogen bonding?	H–F

½ pt each



c. (**BONUS** 3 points) Draw one central water molecule surrounded by 4 other water molecules with dotted lines to indicate hydrogen bonding. Be sure each of your water molecules are correctly drawn with the correct number of bonds and lone pairs on the central atom.



3 pts if correct

1 pt if partial correct

0 pt if wrong

32) (8 points total) Chemical Equations

a) (2 pts) Balance the followling equation

1pt for balance + products

$\_6\_ Li(s) + \_1\_ N_2(g) \rightarrow \_2\_ Li_3N(s)$ Type of Reaction: synthesis (or combination)

b) (2 pts) Predict products and balance the following equation

1pt for type of rxn

$\_1\_ C_5H_{12} + \_8\_ O_2 \rightarrow \_5CO_2\_ + \_6H_2O$ Type of Reaction: combustion

c) (4 points) Use the solubilty rules to answer the following questions. Show all states (l), (g), (s), (aq). Aqueous solutions of magnesium chloride and potassium sulfide are combined. If a reaction occurs, write the molecular,and the net ionic equations. If a reaction does not occur, write NR (no reaction).

Molecular:

2pts [$MgCl_{2(aq)} + K_2S_{(aq)} \rightarrow MgS_{(s)} + 2KCl_{(aq)}$

Net ionic:

2pts [$Mg^{2+}_{(aq)} + S^{2-}_{(aq)} \rightarrow MgS_{(s)}$

-1/2 for wrong formulas
-1/2 for not balanced
-1/2 for not showing states

d) (**2 points bonus**) You need calcium sulfate but there is none available. Using any other ionic compounds, propose an exchange precipitatin reaction for the synthesis of calcium sulfate. Show the balanced equation for your proposed reaction including all states: (l), (g), (s), (aq).

Ca (any soluble anion) $_{(aq)} + $ (any sol cation) $SO_4{}_{(aq)} \rightarrow CaSO_4{}_{(s)} + \_\_\_\_$

2 pts correct
1 pt if have correct product w/ state + right idea

33) (6 points) Answer the following conversion questions.

a) How many grams of silver are there in 4.0×10^{22} atoms of silver?

$$4.0\times10^{22}\ \text{atoms Ag} \left| \frac{1\ \text{mol Ag}}{6.022\times10^{23}\ \text{Ag atoms}} \right| \frac{107.9\ \text{g Ag}}{1\ \text{mol Ag}} = \boxed{7.2\ \text{g Ag}}$$

b) How many moles of sulfur dioxide are in 40.0 mg of sulfur dioxide?

SO_2

$$40.0\ \text{mg } SO_2 \times \frac{1\ \text{g } SO_2}{1000\ \text{mg}} \times \frac{1\ \text{mol } SO_2}{64\ \text{g } SO_2} = 6.25\times10^{-4}\ \text{mol } SO_2$$

c) How many grams of caffeine ($C_8H_{10}N_4O_2$, MM=194 g/mol) would you need to get 4.00×10^{23} **carbon** atoms?

$$4.00\times10^{23}\ \text{C atoms} \left| \frac{1\ \text{molecule } C_8H_{10}N_4O_2}{8\ \text{C atoms}} \right| \frac{1\ \text{mol } C_8H_{10}N_4O_2}{6.022\times10^{23}\ \text{molecules}} \left| \frac{194\ \text{g}}{1\ \text{mol } C_8H_{10}N_4O_2} \right| = \boxed{16.1\ \text{g caffeine}}$$

34) (8 points) Nitrogen gas and hydrogen gas react to form ammonia gas. **(show all work for full credit).**

a) What is the balanced chemical equation?

$$N_2 + 3H_2 \rightarrow 2NH_3$$

b) What is the theoretical yield of ammonia in grams, when 12.0 g N_2 reacts with 4.00 g H_2? (circle answer)

$$12.0\,g\,N_2 \left|\frac{1\,mol\,N_2}{28\,g\,N_2}\right|\frac{2\,mol\,NH_3}{1\,mol\,N_2}\left|\frac{17\,g\,NH_3}{1\,mol\,NH_3}\right. = 14.57\,g\,NH_3 = \text{theoretical yield}$$

$$4.00\,g\,H_2 \left|\frac{1\,mol\,H_2}{2\,g\,H_2}\right|\frac{2\,mol\,NH_3}{3\,mol\,H_2}\left|\frac{17\,g\,NH_3}{1\,mol}\right. = 22.7\,g\,NH_3$$

c) The limiting reactant is: N_2 The excess reactant is: H_2

d) If 11.3 g of ammonia is actually produced, what is the percent yield of this reaction?

$$\%\text{ yield} = \frac{\text{act}}{\text{theor}} \times 100 = \frac{11.3\,g\,NH_3}{14.57\,g\,NH_3} \times 100 = 77.5\%$$

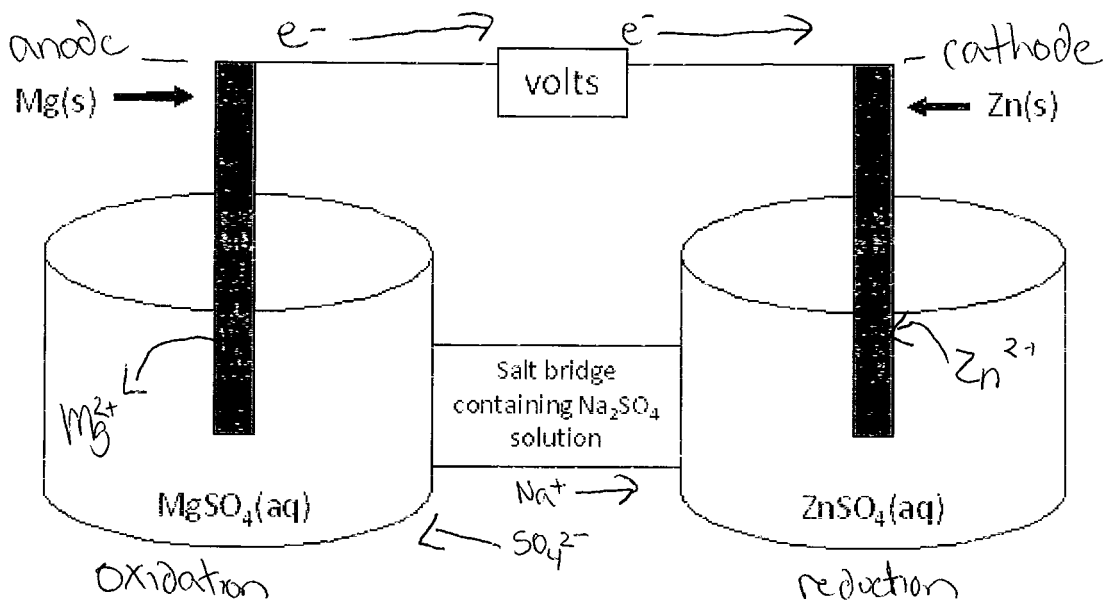
e) (3 points bonus) What amount, in grams, of excess reactant is left-over at the end of the reaction?

$$12.0\,g\,N_2 \left|\frac{1\,mol\,N_2}{28\,g\,N_2}\right|\frac{3\,mol\,H_2}{1\,mol\,N_2}\left|\frac{2\,g\,H_2}{1\,mol\,H_2}\right. = 2.57\,g\,H_2 \text{ used up}$$

$$4.00\,g\,H_2 - 2.57\,g\,H_2 = 1.43\,g\,H_2 \text{ leftover}$$

Mg is higher than Zn on activity series

35) (8 points) Here is a diagram of a battery made from magnesium and zinc:



a) In the diagram above, label the **anode** and **cathode** and **draw an arrow** above the voltmeter to show the direction of the electron flow.

1pt each

b)Write the net ionic equation for the spontaneous reaction that occurs in this battery.

2pts $Mg_{(s)} + Zn^{2+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + Zn_{(s)}$

c) In which half cell does reduction take place? (circle one)

1pt each

Reduction occurs in the Mg half cell or (Reduction occurs in the Zn half cell)

d) Into which half cell will the sulfate ions in the salt bridge flow? (circle one)

(the Mg half cell) or the Zn half cell

e) Over time, which electrode will increase in mass? (circle one) Mg electrode or (Zn electrode)

Printed Name:_____ Circle Discussion AI: Amir OR Kristen

Q31_____/10
Q32_____/8
Q33_____/6
Q34_____/8
Q35_____/8

Total handgrade: _____/40 (48 points possible)