Name_____

Room number _____

Seat number _____

1. (14 points) Give the appropriate name or formula for the following.

a.	mercury(II) hypobromite	**$Hg(BrO)_2$**
b.	Copper(I) cyanide	**CuCN**
c.	iron(III)iodide	**FeI_3**
d.	NH_3	**ammonia**
e.	PCl_3	**phosphorus trichloride**
f.	nitrous acid	**HNO_2**
g.	tin(II) permanganate	**$Sn(MnO_4)_2$**
h.	K_3PO_4	**potassium phosphate**
i.	sulfur tetrafluoride	**SF_4**
j.	NH_4IO_4	**ammonium periodate**
k.	ammonium hydrogen phosphate	**$(NH_4)_2HPO_4$**
l.	$Cr(HCO_3)_3$	**chromium(III) hydrogen carbonate**
m.	$KMnO_4$	**potassium permanganate**
n.	$HNO_{3(aq)}$	**nitric acid**

2. (3 points) Three successive reactions: A→ B, B → C, and C→D have yields of 80%, 90% and 68%, respectively. What is the overall percent yield for the conversion of A → D?

0.80x0.90x0.68 = 0.49, or 49%

3. (3 points) What is the molarity of a solution made by dissolving 0.75 g of C_4H_8O in enough water to make 125-mL of solution?

$$\frac{0.75\text{ g } C_4H_8O}{} \cdot \frac{1\text{ mol } C_4H_8O}{72.104\text{ g } C_4H_8O} \cdot \frac{1}{0.125\text{ L solution}} = 0.0832\text{ M } C_4H_8O$$

4. (5 points) Which compound or compounds in **EACH** of the following groups is(are) expected to be insoluble in water? Circle the compound$_{(s)}$ in each group that are insoluble. This is not a multiple-choice problem. Answer each part.

   a. CuO, $CuCl_2$, and $FeCO_3$ **carbonates are insoluble, except for NH_4+ and alkali metals. Oxides are insoluble except for NH_4+, alkali metals, Ba^{2+}, Ca^{2+}, and Sr^{2+}.**

   b. AgI, Ag_3PO_4, and $AgNO_3$ **silver compounds of phosphate and halides are insoluble. All nitrate compounds are soluble.**

   c. K_2CO_3, NiS, and KCN **sulfides are insoluble except for NH_4+, alkali metals, Ba^{2+}, Ca^{2+}, and Sr^{2+}**

5. (6 points) Consider solutions in which 0.10 mol of each of the following compounds is dissolved in 1 L of water: $Ca(NO_3)_2$, $C_6H_{12}OH$, $NaC_2H_3O_2$, HF, $Al_2(SO_4)_3$. Rank the solutions in order of increasing electrical conductivity (which ones will be the worst conductors of electricity to the best conductors of electricity), based on the number of ions in solution. Explain your choices BRIEFLY based on conductivity and electrolyte strength.

Conductivity is related to the number of ions a compound produces upon dissolving in water.

From worst to best, the order is: $C_6H_{12}OH$, HF, $NaC_2H_3O_2$, $Ca(NO_3)_2$, $Al_2(SO_4)_3$.

WHY?:

Molecules, such as $C_6H_{12}OH$, do not ionize when dissolved in water. The bonds between the atoms are stronger than the attraction of the atoms to water. This is a non-electrolyte and does not conduct electricity.

$HF_{(aq)}$ is a weak acid. Weak acids ionize, but not 100 and are considered weak electrolytes because they don't put as many ions into the solution as a stronger ionizing species like the $NaC_2H_3O_2$.

The last three compounds are strong electrolytes. They ionize completely. $NaC_2H_3O_2$ ionizes completely to form two ions for each unit, $Ca(NO_3)_2$ forms three ions per unit, and $Al_2(SO_4)_3$ forms five ions per unit. The more ions, the better the conductor.

6. (6 points) Write the molecular, ionic and net ionic equations for the reaction of a strontium hydroxide solution mixing with propionic acid, $HC_3H_5O_2$. Propionic acid forms the propionate ion ($C_3H_5O_2^-$) upon reacting with a base. Ionic salts of propionate are very soluble. Clearly label states and charges if any.

Molecular: $Sr(OH)_{2(aq)} + 2HC_3H_5O_{2\,(aq)} \rightarrow Sr(C_3H_5O_2)_{2(aq))} + 2H_2O_{(l)}$

Ionic: $Sr^{2+}_{(aq)} + 2\,HC_3H_5O_{2(aq)} + 2OH^-_{(aq)} \rightarrow Sr^{2+}_{(aq)} + 2H_2O_{(l)} + 2C_3H_5O_2^-{}_{(aq)}$

Net ionic $HC_3H_5O_{2aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)} + C_3H_5O_2^-{}_{(aq)}$

7. When 29.5 g of methane and 45.0 g of chlorine gas undergo a reaction that has a 85.0% yield, what mass of chloromethane (CH_3Cl) forms? (The second product is $HCl_{(g)}$)

$CH_{4(g)} + Cl_{2(g)} \rightarrow CH_3Cl_{(l)} + HCl_{(g)}$

The reaction is 1:1. So which ever compound has the smaller equivalence ratio, it is the limiting reagent.

29.5 g CH_4(	**1 mol CH_4**	**= 1.84 mol CH_4**
	16.04g CH_4	

45.0 g Cl_2(g	**1 mol Cl_2(g**	**=0.635 mol Cl_2**
	70.90 g Cl_2	

Since the ratio is 1:1, chlorine is the limiting reagent.

45.0 g Cl_2	**1 mol Cl_2**	**1 mol CH_3Cl**	**50.48g CH_3Cl**	**85 g actual**	**= 27.2 g made**
	70.90 g Cl_2	**1 mol Cl_2(g**	**1 mol CH_3Cl**	**100 g theoretical**	

8. (7 points) Acenaphthoquinone is a molecule based on quinone. It is insoluble in water, but soluble in alcohol. It is used in the manufacturing of dyes, pharmaceuticals, and pesticides. Determine the empirical formula of acenaphthoquinone 79.12% C, 3.32 % H, and 17.57% O by mass.

C	**79.12 g C**	**1 mole C**	**6.5873 mol C**	**C**	**6.5873**	**5.998**
		12.011 mol		**O**	**1.098**	**1**
H	**3.32 g H**	**1 mol H**	**3.294 mol H**	**H**	**3.294**	**3.00**
		1.0079 g H		**O**	**1.098**	**1**
O	**17.57 g O**	**1 mol O**	**1.098 mol O**	**C_6H_3O**		
		15.9994 g O				

9. (5 points) You know that an unlabeled bottle contains a solution of one of the following ions: Na_3PO_4, $BaCl_2$, Rb_2CO_3, or Na_2SO_4. A friend suggests that you test perform three tests on the unknown solution. TEST 1: An equal volume sample of the unknown solution was mixed with a solution of a silver nitrate. TEST 2: An equal volume of sample of the unknown solution was mixed with a a sodium sulfate solution. TEST 3: An equal volume of sample of the unknown solution was mixed with a copper(II) chloride solution. TEST 4: An equal volume of sample of the unknown solution was mixed with a 6.0M $HCl_{(aq)}$ solution.

   i. A reaction occurs when silver nitrate solution is added to a sample of the solution from the bottle.
   ii. No reaction occurs when sodium sulfate solution is added to a sample of the solution from the bottle.
   iii. A precipitate formed when the copper(II) chloride solution is added to a sample of the solution from the bottle.
   iv. A reaction occurs when a 6.0 M $HCl_{(aq)}$ solution is added to sample.

   What anion$_{(s)}$ are present in the bottle? Explain your choice$_{(s)}$ using solubility rules.

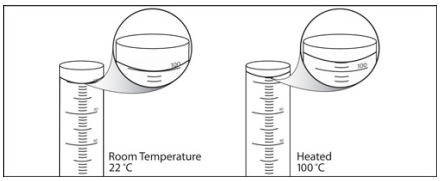
TEST 1: An equal volume sample of the unknown solution was mixed with a solution of a silver nitrate. **A reaction occurred. Silver will form solids with all of the anions present in solution. This is not a definitive test. So we move on.**

TEST 2: An equal volume of sample of the unknown solution was mixed with a a sodium sulfate solution. **No reaction occurred. Since $BaCl_2$ would have reacted with the sodium sulfate, we can eliminate $BaCl_2$, in effect, eliminating the chloride ion.**

TEST 3: An equal volume of sample of the unknown solution was mixed with a copper(II) chloride solution. **A ppt formed with the addition of copper(III) chloride. Copper will form ppt with phosphates and carbonates. So still not definitive, but we know we don't have chloride**

TEST 4: An equal volume of sample of the unknown solution was mixed with a 6.0M $HCl_{(aq)}$ solution. **The addition of acid caused a reaction. We know that acids react with carbonate to form a gas, while the other ions will not. This eliminates sulfate (no gas, need sulfite for that), phosphate, and chloride was eliminated in test 2.**

The anion is carbonate.



10. (6 points) The figure shows the meniscus of two identical solutions at two temperatures in identical flasks. Liquid 1 is at 22°C and liquid 2 is at 100°C. The level of the meniscus of Liquid 1 is 100.0-mL, while the level of the meniscus in Liquid 2 is 102.0-mL.
    a. Does the molarity of the solution change with the change in temperature? Explain and support your answer.

The molarity does change. Molarity is the ratio of moles of a solute to the volume of the solution. When the solution is warmed, the material expands, so the volume increases. Since molarity and volume are inversely proportional, as volume increases, the molarity must decrease.

    b. Does the molality of the solution change with the change in temperature? Explain and support your answer.

Molality is not dependent on temperature. Molality is the ratio of the moles of solute to the mass of solvent. Mass and moles are not temperature related. The molarity will stay constant.

11. (10 Points) In a combustion analysis of 23.2g sample of aspartame containing carbon, hydrogen, and oxygen was burned in excess oxygen and yielded 52.8 g of CO_2 and 21.6 g of water. Determine the empirical formula of the compound. A sample of 0.00829 g aspartame contains 0.000 0357 mole of aspartame. What is the molecular formula?

52.8 g CO_2	1 mol CO_2	1 mol C	= 1.20 mol C
	44.01 g CO_2	1 mol CO_2	

1.20 mol C	12.01 g C	=14.44 g C
	1 mol C	

21.6 g H_2O	1 mol H_2O	2 mol H	= 2.40 mol H
	18.02 g H_2O	1 mol H_2O	

2.40 mol H	1.008 g H	= 2.42g H
	1 mol H	

23.2 g -14.44 g- 2.415 g = 6.34 g oxygen

6.34 g O_x	1 mol O_x	=0.396 mol O_x
	16.00g O_x	

Mol C	1.20 mol C	3 C
Mol O	0.396mol O	1 O_x

MolH	2.397 mol H	6.0H
Mol O	0.396 mol O	1 O_x

Empirical formula is C_3H_6O, empirical formula mass is 58.08 g/ mol
0.00829 g aspartame/0.000 0357 mole of aspartame = 232g/ mol aspartame

there are 4 empirical formulae units in 1 molecular formula: $C_{12}H_{24}O_4$

12. (10 points) Suppose you have 5.00g of powdered magnesium metal, 1.00L of 2.00 M potassium nitrate solution, and 1.00L of 2.00 M silver nitrate solution.
    a. Which one of the solutions will react with the magnesium powder? Explain your choice.
    b. What volume of solution is needed to completely react with the magnesium metal?
    c. What is the net ionic equation that describes this reaction?
    d. What is the molarity of the magnesium ion in the resulting solution.

The magnesium metal will react with the silver ions in the silver nitrate solution. Magnesium is an active metal and will transfer electrons to any cation below it in solution. Since silver metal is not active, the cation is very reactive and will oxidize the magnesium metal. Potassium metal is more active the magnesium metal, so the potassium cation can not oxidize the magnesium metal. It is a poor reducing agent.

Mg

5.00g Mg	**1 mol Mg**	**2 Ag^+**	**$AgNO_3$**	**1L**	**= 0.205 L**
	24.305 g Mg	**1Mg^{2+}**	**1Ag^+**	**2.00 mol $AgNO_3$**	

$Mg_{(s)}+2Ag^+ \rightarrow Mg^{2+}_{(aq)}+2Ag^+_{(aq)}$

This is a limiting reagent problem (but, you did not have to solve for the limiting reagent. I did it below by equivalence, so you can see that there are more moles of silver than there are moles of Mg. All the magnesium reacted! The solid was converted to ions.

1.00 L	**2.00 mol $AgNO_3$**	**= 2.00 mol Ag^+**	**2.00 mol Ag^+**	**= 1.00**
	1.00 L		**2 mol Ag^+**	**1.00**

5.00 g Mg	**1 mol Mg**	**0.2057 mol Mg**	**= 0.205 mol Mg^{2+}**	**0.205 mol Mg^{2+}**	**=**	**0.205 M Mg^{2+}**
	24.305 g Mg			**1.00L**		

13. (6 point) A student mixed 200.0 mL of 6.00 M $Al(NO_3)_3$, 400.0 mL of 1.00 M $NaNO_3$, 400.0mL of 0.500M $Ba(NO_3)_2$ and enough water to make 2000.0 mL of solution. What is the molarity of the nitrate ion (NO_3^-) in the final solution?

200.0 mL solution	**6.00 mol** $Al(NO_3)_3$,	**3 mol** NO_3^-	**= 3600 mmol** NO_3^-
	1L solution	**1 mol** $Al(NO_3)_3$,	

400.0 mL solution	**1 mol** $NaNO_3$,	**1 mol** NO_3^-	**= 400. mmol** NO_3^-
	1L solution	**1 mol** $NaNO_3$,	

400.0 mL solution	**0.500 mol** $Ba(NO_3)_2$	**2 mol** NO_3^-	**= 400.mmol** NO_3^-
	1L solution	**1 mol** $Ba(NO_3)_2$	

[400. +400.+3600]mmol NO_3^-**=4400 mmol** NO_3^-
[Na^+] = 4300 mmol NO_3^-**2000.0 mL =2.20 M** NO_3^-

14. (6 points) A sulfuric acid solution containing 571.6 g of H_2SO_4 per liter of solution has a density of 1.329 g/cm^3. [MW= 98.086 g/mol]
Calculate the:

a. Mass percentage of H_2SO_4 in this solution
b. The mole fraction of H_2SO_4 in this solution
c. The molarity of H_2SO_4 of this solution

Mass percentage of this solution

571.6 g H_2SO_4	**1 mL H_2SO_4 sol'n**	**100**	**= 43.01 % H_2SO_4**
1000 mL	**1.329 g H_2SO_4 sol'n**		

The mole fraction of this solution

43.01 g H_2SO_4	**1 mol H_2SO_4**	**0.43856 mol H_2SO_4**
	98.086 g H_2SO_4	

56.99 g H_2O	**1 mol H_2O**	**3.1626 mol H_2O**
	18.02 g H_2O	

0.43856 mol H_2SO_4 **0.1218**

0.43856 mol H_2SO_4 + 3.163 mol H_2O

The molarity of H_2SO_4 of this solution

571.6 g H_2SO_4	**1 mol H_2SO_4**	**= 5.828 M H_2SO_4**
1 L	**98.086 g H_2SO_4**	

15. (5 points) Rust stains can be removed by washing a surface of a piece of steel with a dilute solution of oxalic acid ($H_2C_2O_4$).

The reaction is $Fe_2O_{3(s)} + 6\ H_2C_2O_{4(aq)} \rightarrow 2\ Fe(C_2O_4)_3^{3-}{}_{(aq)} + 3\ H_2O_{(l)} + 6\ H^+{}_{(aq)}$.

What mass of rust can be removed from the surface of steel by 1.0L of a 1.14M solution of oxalic acid?

1.0L $H_2C_2O_{4(aq)}$	**1.14 mol** $H_2C_2O_{4(aq)}$	1 mol $Fe_2O_{3(s)}$	159.69 g $Fe_2O_{3(s)}$	= 30. g $Fe_2O_{3(s)}$
	1 L $H_2C_2O_{4(aq)}$	**6 mol** $H_2C_2O_{4(aq)}$	**1 mol** $Fe_2O_{3(s)}$+	

16. (5 points) You have 0.954 g of an unknown acid H_2A, which reacts with NaOH according to the reaction below.

$$H_2A_{(aq)} + 2\ NaOH_{(aq)} \rightarrow Na_2A_{(aq)} + H_2O_{(l)}$$

If 36.04 mL of 0.509 M NaOH is required to titrate the acid to the equivalence point, what is the molar mass of the acid?

36.04 mL $NaOH_{(aq)}$	1 L	0.509 mol $NaOH_{(aq)}$	1 mol $H_2A_{(aq)}$	= 0.0091722 mol $H_2A_{(aq)}$
	1000 mL	1 L $NaOH_{(aq)}$	**2 mol** $NaOH_{(aq)}$	

0.954 g $H_2A_{(aq)}$	= 104. g $H_2A_{(aq)}$
0.0091722 mol $H_2A_{(aq)}$	**1 mol** $H_2A_{(aq)}$

17. (10 points) A precipitate forms when aqueous sodium sulfide is mixed with aqueous copper(II) chloride. Calculate the mass of the precipitate that forms when 75.0 mL of 1.50 M sodium sulfide is mixed with 100.0 mL of 0.500 M copper(II) chloride. Hint: Write the equation for the reaction.

$CuCl_{2(aq)} + Na_2S_{(aq)} \rightarrow 2NaCl_{(aq)} + CuS_{(s)}$

$$\frac{\mathbf{0.1000\ L}}{} \left| \frac{\mathbf{0.500\ mol}\ CuCl_2}{\mathbf{1.00\ L}} \right. = \mathbf{0.0500\ mol}\ CuCl_2 \qquad \frac{\mathbf{0.0500\ mol}\ CuCl_2}{\mathbf{1\ mol}\ CuCl_2} \qquad \frac{\mathbf{= 0.05}}{\mathbf{1.00}}$$

$$\frac{\mathbf{0.0750L}}{} \left| \frac{\mathbf{1.50\ mol}\ Na_2S}{\mathbf{1.00L}} \right. = \mathbf{0.1125\ mol}\ Na_2S \qquad \frac{\mathbf{0.1125\ mol}\ Na_2S}{1\ mol\ Na_2S} = \frac{\mathbf{0.1125\ mol}\ Na_2S}{1\ mol\ Na_2S}$$

Copper(II) chloride is the limiting reagent

$$\frac{\mathbf{0.1000\ L}}{} \left| \frac{\mathbf{0.500\ mol}\ CuCl_2}{\mathbf{1.00\ L}} \right. \left| \frac{1\ mol\ CuS}{\mathbf{1\ mol}\ CuCl_2} \right. \left| \frac{95.62g\ CuS}{\mathbf{1\ mol}\ CuS} \right. = 0.478\ g\ CuS$$

18. EC (5 points) Consider the following data for five hypothetical elements: Q, W, X, Y, and Z.

   a. W^{2+} ions are reduced by the metal 'Q', but W^{2+} is not reduced by the metal 'Z'
   b. Z^{2+} ions will oxidize the metal 'W', but Z^{2+} ions will not oxidize metal X
   c. The metal 'Y' is oxidized by Q^{2+} ions

   a. Rank the elements from most reactive to least reactive based on the following reactions

Most reactive — Least reactive

Y	Q	W	Z	X

Writing the equations is very helpful

a) $W^{2+}_{(aq)} + Q_{(s)} \rightarrow W_{(s)} + Q^{2+}_{(aq)}$
b) $W^{2+}_{(aq)} + Z_{(s)} \rightarrow NR$
c) $Z^{2+}_{(aq)} + W_{(s)} \rightarrow W^{2+}_{(aq)} + Z_{(s)}$
d) $Z^{2+}_{(aq)} + X_{(s)} \rightarrow NR$
e) $Y_{(s)} + Q^{2+}_{(aq)} \rightarrow Y^{2+}aq) + Q_{(s)}$

W is reduced by Q. Therefore, Q is a more active metal than W. Q gives up electrons to W.
Q>W
Z will not give its electrons to W. Z is a less active metal than W. It is not able to reduce the ions of W to a metal. This is confirmed by the next statement. Z ions can remove electrons from W metal.
W>Z
Z is more active than X for the same reasoning that W is more active than Z.
Z>X
Y is more active than Q, giving electrons to the Q ions.
Y>Q

Y			
Q	**Q**		
	W	**W**	
		Z	**Z**
			X