Exam 2: Name

1. **(5 points)** Capsaicin is the pungent component of various species of *Capsicum,* including red and green chili peppers, especially *c. annum* and is the active component of *paprika.* It has several actions in the body when ingested, such as stimulation of the formation of endorphins in the brain and increased salivation when eating spicy food. The formula of capsaicin is $C_{18}H_{27}O_3N$. A sample of capsaicin contains 6.79 $x10^{20}$ molecules of capsaicin.

a.	How many moles of capsaicin does the sample contain?	
b.	How many atoms of hydrogen does the sample contain?	
c.	What is the molecular mass of capsaicin? Use the following values: C-12.011 amu; H-1.0079 amu; N-14.00672 amu; O-15.9994 amu	
d.	What is the mass of this sample in grams?	

a. How many moles of capsaicin does the sample contain?

$$\mathbf{6.79\ X10^{20}\ C_{18}H_{27}O_3N} \times \frac{\mathbf{1\ mol\ C_{18}H_{27}O_3N}}{\mathbf{6.022x10^{23}\ C_{18}H_{27}O_3N}} = \mathbf{0.00113\ mol\ C_{18}H_{27}O_3N}$$

b. How many atoms of hydrogen does the sample contain?

$$\mathbf{6.79\ X10^{20}\ C_{18}H_{27}O_3N} \times \frac{\mathbf{27\ H\ atoms}}{\mathbf{1\ mol\ C_{18}H_{27}O_3N}} = \mathbf{1.83x10^{24}\ H\ atoms}$$

c. What is the molecular mass of capsaicin? Use the following values: C-12.011 amu; H-1.0079 amu; Cl-35.453 amu; O-15.9994 amu

305.412 amu

d. What is the mass of this sample in grams?

$$\mathbf{= 0.00113\ mol\ C_{18}H_{27}O_3N} \times \frac{\mathbf{305.412\ g\ C_{18}H_{27}O_3N}}{\mathbf{1\ mol\ C_{18}H_{27}O_3N}} = \mathbf{0.345\ g\ C_{18}H_{27}O_3N}$$

2. **(4 points**) Suppose you were marooned on a tropical island and had to make a primitive barometer using sea water (density = 1.10 g/mL). What height would the water reach in your sea water barometer when a mercury barometer would reach 77.5 cm? d (Hg) = 13.6g/mL.

$P_{(Hg)} \times d_{(Hg)} = P_{seawater} \times d_{seawater}$
77.5cm Hg x 13.6 g/mL = $P_{seawater}$ x 1.10 g/ml
P = 958 $cm_{seawater}$, 9.58 x 10^3mm, 9.58m,

3. **(7 points)** Cacodyl, a compound containing arsenic has an over powering, noxious, garlicy smell. It undergoes spontaneous combustion with dry air. It was reported in 1842 by the German chemist Robert Wilhelm Bunsen. To quote Bunsen, " the smell of this compound produces instantaneous tingling of the hands and feet, and even giddiness and insensibility." The composition of cacodyl is 22.88% C, 5.76 % H and 71.36 % As.
    a. Determine its empirical formula.
    b. A sample of 2.699×10^{-5} g of cacodyl represents 1.285×10^{-7} moles of cacodyl. What is the molecular formula of cacodyl

C	**22.88 g C**	**1 mole C**	**1.905 mol C**	**C**	**1.905**	**2**
		12.011 mol		**As**	**0.9525**	**1**
H	**5.76 g H**	**1 mol H**	**= 5.714 mol H**	**H**	**5.714**	**6**
		1.0079 g H		**As**	**0.9525**	**1**
As	**71.36 g As**	**1 mol As**	**= 0.9525 mol As**	**C_2H_6As**		
		74.922 g As				

2.699×10^{-5} g of cacodyl	**210.04 g/mol**	**210.04 g/mol**	2
1.285×10^{-7} moles of cacodyl		**104.98**	

$C_4H_{12}As_2$

4. **(10 points)** Give the appropriate name or formula for the following.

a) mercury(II) hypobromite **$Hg(BrO)_2$**

b) $ZnCrO_4$ **zinc chromate**

c) Xenon tetrafluoride **XeF_4**

d) $CoCl_2$ **cobalt(II) chloride**

e) $Hg_2(CN)_2$ **mercury(I) cyanide**

f) Copper(I) cyanide **CuCN**

g) P_2S_5 **diphosphorus pentasulfide**

h) zinc sulfite **$ZnSO_3$**

i) $Mg(HSO_3)_2$ **magnesium hydrogensulfate**

j) $AgMnO_4$ **silver permanganate**

5. **(5 points)** A standard solution is prepared for the analysis of fluoxymesterone [FXM] ($C_{20}H_{29}FO_3$), an anabolic steroid. 25.00 g is dissolved in enough water to give a total volume of 500.00mL of solution. A 5.00mL sample of this stock solution is diluted to a final volume of 650. mL. What is the final solution in terms of molarity for the fluoxymesterone. The molar mass of fluoxymesterone is 336.43 g $C_{20}H_{29}FO_3$= 1 mole $C_{20}H_{29}FO_3$

Mol $_{FXM}$	**10.0 g FXM**	**1 mol FXM**	**0.074309 mol FXM stock**	**M $_{FXM}$**	**0.074309 mol FXM stock**	**0.1486 47M_{FXM}**
		336.43 g FXM			**0.500 00L**	

M $_{FXM\ dilute}$	**0.1486 M_{FXM}**	**5.00 mL**	**0.00114M FXM**
	650. mL		

6. **(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 this solution
   b. The mole fraction of 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**	

7. **(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: $\mathbf{Sr(OH)_{2(aq)} + 2HC_3H_5O_{2\,(aq)} \rightarrow Sr(C_3H_5O_2)_{2(aq))} + 2H_2O_{\,(l)}}$
Ionic: $\mathbf{Sr^{2+}_{\,(aq)} + 2\,HC_3H_5O_{2(aq)} + 2OH^-_{\,(aq)} \rightarrow Sr^{2+}_{\,(aq)} + 2H_2O_{\,(l)} + 2C_3H_5O_2^-{}_{\,(aq)}}$
Net ionic $\mathbf{HC_3H_5O_{2aq)} + OH^-_{\,(aq)} \rightarrow H_2O_{\,(l)} + C_3H_5O_2^-{}_{\,(aq)}}$

8. **(5 points)** Acrylonitrile, C_3H_3N, is used to make acrylics. It can be made from propylene, C_3H_6, and nitric oxide, NO.

$$4\ C_3H_6 + 6\ NO \rightarrow 4\ C_3H_3N + 6\ H_2O + N_2$$

How many grams of acrylonitrile are obtained from 2.50 g of nitric oxide?
[NO = 30.01 amu; C_3H_3N = 53.064 amu]

2.50 g NO	**1 mol NO**	**4 mol C_3H_3N**	**53.06 g C_3H_3N**	**=2.95 g C_3H_3N**
	30.0 g NO	**6 mol NO**	**1 mol C_3H_3N**	

9. **(4 points)** A child's balloon is filled with He to a volume of 5.00L at a temperature of 25.0°C. As the balloon rises in the atmosphere, lifting the child to new heights, the volume of the balloon increases by 20.5%. What is the temperature of the He gas in the balloon in °C?

25.0 + 273.15K [298.15K]	**6.025L** [5.00Lx0.205+5.00L]	**= 359.27K**
	5.00L	

359.27K– 273.15=86.12K x(1˚C/K)= 86 ˚C

10. **(10 points)** A sample of an organic compound containing C, H, and O, which weights 1.213 g gives 3.06 g of CO_2 and 0.536 g of H_2O in combustion. Determine the empirical formula for this compound

3.06 g CO_2	1 mol CO_2	1 mol C	= 0.06953 mol C
	44.01 g CO_2	1 mol CO_2	
0.06953 mol C	12.01 g C	=0.83505 g C	
	1 mol C		
0.536 g H_2O	1 mol H_2O	2 mol H	= 0.05949 mol H
	18.02 g H_2O	1 mol H_2O	
0.09820 mol H	1.008 g H	=0.05997 g H	
	1 mol H		

1.213 g – (0.08305g C+0.05997gH) = 0.31798 g oxygen

0.31798 g O_x	1 mol O_x / 16.00g O_x	=0.01987 mol O_x

Mol C	0.06953 mol C	3.5 C
Mol O	0.09187 mol O_x	1 O_x
MolH	0.05949 mol H	3.0 H
Mol O	0.09187mol O_x	1 O_x

Need to multiple until whole (X2!)
Empirical formula $C_7H_6O_2$

11. **(6 points)** 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 $HCl_{(g)}$)

These steps were not asked for, yet need to be done to solve the answer

Write the balanced equation (phase was not important):

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

Find the limiting reactant. Normally I use the equivalence method, but this problem is asking for the mass of product formed, so that is how I set up the problem. I calculated each starting reagent for the product mass; the compound that produced the smallest amount of product is the LR and the problem is solved

29.5 g $CH_{4(}$	**1 mol** $CH_{4(}$ / **16.04g** CH_4	**1 mol** CH_3Cl / **1 mol** $CH_{4(}$	**50.48g** CH_3Cl / **1mol** CH_3Cl	**85.0g act** / **100 g theo**	**= 78.9g** CH_3Cl

45.0 g $Cl_{2(g}$	**1 mol** $Cl_{2(g}$ / **70.90 g** $Cl_{2(g}$	**1 mol** CH_3Cl / **1 mol** $Cl_{2(g}$	**50.48g** CH_3Cl / **1 mol** CH_3Cl	**85.0gact** / **100 g theo**	**=27.2 g** CH_3Cl

Since chlorine produced the smallest amount of product, it is the limiting reactant, and the amount of chloromethane made is 27.1 g.

You could also have solved for the problem using equivalences. The ratio would have shown that chlorine gas is the LR, and then you would have solved for the mass accordingly.

29.5 g $CH_{4(}$	**1 mol** $CH_{4(}$ / **16.04g** CH_4	**= 1.84/1**
45.0 g $Cl_{2(g}$	**1 mol** $Cl_{2(g}$ / **70.90 g** $Cl_{2(g}$	**=0.635/1 smaller equivalence means LR**

45.0 g $Cl_{2(g}$	**1 mol** $Cl_{2(g}$ / **70.90 g** $Cl_{2(g}$	**1 mol** CH_3Cl / **1 mol** $Cl_{2(g}$	**50.48g** CH_3Cl / **1 mol** CH_3Cl	**85.0gact** / **100 g theo**	**=27.2 g** CH_3Cl

12. **(6 points)** When iron metal is reacted with potassium permanganate in acid, the following reaction occurs.

$5\mathbf{Fe}_{(s)} + 3\ K\mathbf{Mn}O_{4(aq)} + 24\ HCl_{(aq)} \rightarrow 3\mathbf{Mn}Cl_{2(aq)} + 5\ \mathbf{Fe}Cl_{3(aq)} + 12\ H_2O_{(l)} + 3\ KCl_{(aq)}$

(a) **(4 points)** Oxidation number of the element in bold. Show your thought process, or work.

Fe	Mn in MnO_4	Mn in $MnCl_2$	Fe in $FeCl_3$
Since the #protons = the #electrons, $Nox_{Fe}=0$	**Permangante is -1 because K^+. $Nox_{Mn}+4\ Nox_O= -1$ $Nox_{Mn}=-4(-2)+ -1$ $Nox_{Mn} = 7$**	**Mn is 2+ because each Cl^- $Nox_{Mn}+2\ Nox_{Cl}=0$ $Nox_{Mn}=-2(-1)+ 0$ $Nox_{Mn} = 2+$**	**Fe is 3+ because each Cl^- $Nox_{Fe}+3\ Nox_{Cl}=0$ $Nox_{Fe}=-3(1-)+ 0$ $Nox_{Mn} = 3+$**

(b) **(0.5 point)** The reactant that contains the oxidized element and identity of that element: **The reactant that contains the oxidized element is iron because the oxidation number (Nox) changes from 0 to 3+ indicating electrons were lost**

(c) (0.5point) The reactant that contains the reduced element and identity of that element: **The reactant that contains the reduced element is $KMnO_4$ and the element reduced is manganese in the $KMnO_4$. The oxidation number (Nox) changes from 7 to 2+ indicating electrons were gained**

(d) (0.5 point) The compound that is the oxidizing agent: **The oxidizing agent is the permanganate ion; it facilitated oxidation (removal of electrons)of the iron metal.**

(e) **(0.5 point)** The compound that is the reducing agent**: The reducing agent is the iron; it acted as a source of electrons for the manganese.**

Notes: Oxidizing and reducing agents can't be products. They are, by their nature, reactants.

13. **(3 points)** You know that an unlabeled bottle contains one of the following: $Hg_2(NO_3)_2$, $BaCl_2$, or $MnSO_4$. A friend suggests that you test three portions of the bottle with 1) a sodium chloride solution, 2) a sodium sulfate solution, and 3) a sodium hydroxide solution.

i. No reaction occurs when sodium chloride 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 sodium hydroxide solution is added to a sample of the solution from the bottle.

What cation(s) are present in the bottle? Explain your choice(s) using solubility rules.

Although mercury(I) ions will form a solid when reacted with chloride, barium and manganese ions will not (both are soluble chloride compounds; there is no mercury(I) ions in the solution. There is also no barium ions in solution because barium sulfate would have formed with reaction ii, and no solid was evidenced. This leaves the last reaction with hydroxide. A solid does form. Based on solubility rules all hydroxides are insoluble except for group 1 A, barium ions, strontium ions, and ammonium. Since mercury(I) was ruled out in the first test, and barium hydroxide is considered a strong base, the only ion left is manganese.

14. (**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.

$C_6H_{12}OH < HF < NaC_2H_3O_2 < Ca(NO_3)_2 < Al_2(SO_4)_3$

Electrical conductivity improves with the ability of a compound to release ions into a solution. Molecules have no conductivity and are non-electrolytes; weak acids are poor electrolytes; soluble ionic compounds are strong electrolytes. $C_6H_{12}OH$ is a molecule. It is an alcohol and does not breakup in solution. HF is a weak acid and is partially ionized, producing less than 0.10 mol of hydrogen ions and fluoride ions each. $NaC_2H_3O_2$, $Ca(NO_3)_2$, $Al_2(SO_4)_3$ are strong electrolytes, and produces 0.10 mol of each ion, with $NaC_2H_3O_2$ producing 0.20mol ions, $Ca(NO_3)_2$ producing 0.30 mols of ions, and $Al_2(SO_4)_3$ producing 0.40 moles of ions.

15. **(8 points)** A sample of nitrogen gas is at STP. (STP is a pressure of 1 atm, 0°C) The volume of the container is **decreased** while keeping the temperature constant. Use kinetic-molecular theory to explain whether each of the following would increase, decrease, or remain constant and WHY. More importantly, explain the cause(s) for this change in **pressure** using concepts from the kinetic-molecular theory. Please answer clearly and thoroughly using complete sentences. No credit **without an explanation.**

The average KE **there is no change, KE is proportional to temperature. Since temperature is constant, the KE should also be constant.**

the average speed **average speed is proportional to KE. Since KE is proportional to temperature and temperature is constant, the average speed should not change either.**

the frequency of the collisions **the frequency of the collisions should increase because the volume is decreasing. (this alone is not enough of an explanation). This means the path that the particles can travel before a collision with the walls of the container has shortened. A shorter path means more collisions.**

the frequency of collisions per unit area: **the frequency per unit area should also increase with decreasing volume, since the surface area for the collision is decreasing there are more collisions in a smaller area.**

The pressure of the gas **the pressure of the gas should increase. Pressure is a function of force/unit area and the number of collisions /unit area. Since the force is constant (KE is constant!), the pressure is dependent on the number of collisions with the wall of the container. When the number of collisions increases and the area decreases, the overall effect is the pressure must increase when the volume decreases**

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 sol'n	**1L sol'n**	**0.509 mol NaOH**	**1 mol H_2A**	**= 0.009172 mol acid in sample**
	1000 mL sol'n	**1.00L**	2 mol NaOH	

Molar mass is the grams of sample/moles of sample

0.954 g sample	**= 104g H_2A / mol H_2A**
0.009172 mol acid in sample	

17. (5 point) A student mixed 200.0 mL of 6.00 M Na_3PO_4, 300.0 mL of 1.00 M NaCl, 400.0mL of 0.500M Na_2CO_3 and enough water to make 2000.0 mL of solution. What is the molarity of the sodium ion (Na^+) in the final solution?

200.0 mL solution	**6.00 mol Na_3PO_4**	**3 mol Na+**	**= 3600 mmol Na+**
	1L solution	**1 mol Na_3PO_4**	
300.0 mL solution	**1 mol NaCl,**	**1 mol Na+**	**= 300. mmol Na+**
	1L solution	**1 mol NaCl**	
400.0 mL solution	**0.500 mol Na_2CO_3**	**2 mol Na+**	**= 400.mmol Na+**
	1L solution	**1 mol Na_2CO_3**	

[400. +300.+3600]mmol Na^+ =4300 mmol Na^+
[Na^+] = 4300 mmol Na^+/2000.0 mL =2.15 M Na^+

18. (6 points) Use the activity series to decide if an observable reaction can be expected when the follow actions are performed. If a reaction occurs, write out the balanced molecular equation showing the expected products with correct phases on all species. In one or two sentences describe why the reaction occurred. If a reaction does not occur, write NR. In one or two sentences describe why the reaction did not occur.

a) Copper wire is placed in hydrochloric acid.

No reaction, copper is below hydrogen in the activity series. Hydrogen ions cannot oxidize copper; copper can't act a source of electrons because it is less active than hydrogen.

b) Solid lead pellets are dropped into a solution of copper(II) sulfate.

Reaction, copper is below lead in the activity series. Lead metal is acting as a source of electrons for the copper(II) ions. This means copper can oxidize lead; it is the reducing agent.

$Pb_{(s)}+CuSO_{4(aq)}\rightarrow Cu_{(s)}+PbSO_{4(s)}$ solubility chart

c) Tin foil (a thin sheet of metal made of tin) is placed in a solution of iron(II)sulfate.

No reaction, tin is below iron in the activity series. Iron(II) does not have electrons to give; it can't oxidize tin. Tin is less active than iron.

19. **(10 points)** A precipitate forms when aqueous sodium sulfide is mixed with aqueous copper(II) chloride.
    (a) Calculate the mass of the precipitate that forms when 75.0 mL of 1.50 M sodium sulfide is mixed with 100.0 mL 0.500 M copper(II) chloride.
    (b) Calculate the moles of all the dissolved ions at the end of the reaction (this includes spectator and excess ion(s))
    (c) What is the final volume of the solution?
    (d) Calculate the individual concentrations of all dissolved ions at the end of the reaction.

Unspoken: you need a balanced equation and to find the limiting reagent! Personally, I like the ionic equation for these problems.

$Na_2S_{(aq)} + CuCl_{2(aq)}$

$2Na^+_{(aq)} + S^{2-}_{(aq)} + Cu^{2+}_{(aq)} + 2Cl^-_{(aq)} \rightarrow 2Na^+_{(aq)} + 2Cl^-_{(aq)} + CuS_{(s)}$

75.0 mL sol'n	**1.50 mol Na_2S / 1 L sol'n**	**=112.5 mmol Na_2S; 225. mmol Na^+ 112.5 mmol S^{2-}**
100.0 mL sol'n	**0.500 mol $CuCl_2$ / 1 L sol'n**	**50.0 mmol $CuCl_2$; 50.0 mmol Cu^{2+} ; 100. mmCl^-**

Since the product is based on the moles of S^{2-} and Cu^{2+}, the smallest moles will be the limiting reagent. We can see from the moles that theCu^{2+} is the limiting reagent because we need 50. mmol Cu^{2+} to react with 112.5 mmol S^{2-}. The most moles CuS made is 50.0 mmoles CuS.

50.0 mmol Cu^{2+}	**1 mol Cu^{2+} / 1000 mmol Cu^{2+}**	**1 mol CuS / 1 mol Cu^{2+}**	**95.62 g CuS / 1 mol CuS**	**4.78 g CuS**

(e) Identify the spectator ions.

$Na^+_{(aq)} + Cl^-_{(aq)} +$

(f) Identify the excess ion

$S^{2-}_{(aq)}$started with 112.5. mmol $S^{2-}_{(aq)}$, used 50.0 mmol, 62.5 mmol $S^{2-}_{(aq)}$ remain

(g) What is the total volume of the mixture?

75.0 mL + 100.0 mL = 175.0 mL

(h) Calculate the individual concentrations of all dissolved ions at the end of the reaction.

225. mmol Na^+	**= 1.29MNa^+**	**Spectator ion**
175 mL **100. mmCl^-**	**=0.571 M Cl^-**	**Spectator ion**
175 mL **62.5 mmol S^{2-}**	**0.357 M S^{2-}**	**Excess**
175 mL		