CHEM 1215
Exam III
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November 10, 1999

Name _____

TA's Name _____

Lab Section _____

INSTRUCTIONS:

1. This examination consists of a total of 7 different pages. The last page includes a periodic table and a solubility table. All work should be done in this booklet.

2. PRINT your name, TA's name and your lab section number now in the space at the top of this sheet. DO NOT SEPARATE THESE PAGES.

3. Answer all questions that you can and whenever called for show your work clearly. Your method of solving problems should pattern the approach used in lecture. You do not have to show your work for the multiple choice (if any) or short answer questions.

4. No credit will be awarded if your work is not shown in problems 3, 5 - 7 and 8.

5. Point values are shown next to the problem number.

6. Budget your time for each of the questions. Some problems may have a low point value yet be very challenging. If you do not recognize the solution to a question quickly, skip it, and return to the question after completing the easier problems.

7. Look through the exam before beginning; plan your work; then begin.

8. Relax and do well.

	Page 2	Page 3	Page 4	Page 5	TOTAL
SCORES	_____ (29)	_____ (34)	_____ (23)	_____ (14)	_____ (100)

(9) 1. Write the chemical formula(s) of the product(s) and balance the following reactions. Identify all products phases as either (g)as, (l)iquid, (s)olid or (aq)ueous.

a) $H_2SO_{4(aq)} + Mg(OH)_{2(aq)} \rightarrow \mathbf{MgSO_4(aq) + 2H_2O(l)}$

b) $N_{2(g)} + \mathbf{2}O_{2(g)} \rightarrow \mathbf{2NO_2(g)}$

c) $Al(NO_3)_{3(aq)} + \mathbf{3}NaOH_{(aq)} \rightarrow \mathbf{Al(OH)_3(s) + 3NaNO_3(aq)}$

(8) 2. Write the balanced ionic and balanced net ionic chemical equations for the reactions a) and c) in Problem 1. (Remember to include the correct charges on all ions and the phase of each species.)

1a)

Ionic equation:

$$\mathbf{2H^+(aq) + SO_4^{2-}(aq) + 2OH^-(aq) + Mg^{2+}(aq) \rightarrow Mg^{2+}(aq) + SO_4^{2-}(aq) + 2H_2O(l)}$$

Net Ionic equation:

$$\mathbf{2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)}$$

1c)

Ionic equation:

$$\mathbf{Al^{3+}(aq) + 3NO_3^-(aq) + 3OH^-(aq) + 3Na^+(aq) \rightarrow 3Na^+(aq) + 3NO_3^-(aq) + Al(OH)_3(s)}$$

Net Ionic equation:

$$\mathbf{Al^{3+}(aq) + 3OH^-(aq) \rightarrow Al(OH)_3(s)}$$

(12)3a. Determine the empirical formula of a compound that is 69.8% carbon, 11.7% hydrogen, and 18.6% oxygen by mass.

$$\mathbf{69.8\ g\ C\left(\frac{1\ mol\ C}{12.0\ g\ C}\right) = 5.82\ mol\ C}$$

$$\mathbf{11.7\ g\ H\left(\frac{1\ mol\ H}{1.01\ g\ H}\right) = 11.6\ mol\ H}$$

$$\mathbf{18.6\ g\ O\left(\frac{1\ mol\ O}{16.00\ g}\right) = 1.16\ mol\ O}$$

$$\mathbf{\left(\frac{5.82\ mol\ C}{1.16}\right) : \left(\frac{11.6\ mol\ H}{1.16}\right) : \left(\frac{1.16\ mol\ O}{1.16}\right)}$$

5.00 C : 10.0 H : 1.0 O = 5 C : 10 H : 1 O

$C_5H_{10}O$

b) If the molar mass of this compound is 172 g mol^{-1}, determine the molecular formula.

$$\mathbf{Empirical\ mass \cdot n = molecular\ mass \qquad n = \left(\frac{molecular\ mass}{Empirical\ mass}\right) = \left(\frac{172}{86}\right) = 2}$$

Molecular formula = $(C_5H_{10}O)_2 = C_{10}H_{20}O_2$

(22)4. Complete the following table

Formula	*M*, Molar Mass $\left(\frac{g}{mol}\right)$	*m*, Mass of sample (g)	*n*, Moles of sample (mol)	*N*, Number of atoms, molecules, or formula units
SO_3	**80**	4.13×10^{-2}	**5.16×10^{-4}**	**3.11×10^{20} molecules**
$Na_2C_2O_4$	**134**	**186**	1.39	**8.37×10^{23} formula units**
unknown	**95.8**	9.41×10^{2}	**9.82**	5.91×10^{24} atoms
$KPtCl_3(C_2H_4)$	369	7.03×10^{-4}	**1.91×10^{-6}**	**1.15×10^{18} formula units**

Provide the symbol of the unknown element

Mo

(12) 5. Calculate the following,

c) the mass, in grams, of a single atom of mercury.

$$\left(\frac{200.6\ g}{1\ mol}\right)\left(\frac{1\ mol}{6.02 \times 10^{23}\ atom}\right) = 3.33 \times 10^{-22}\ \frac{g}{atom}$$

d) the number of molecules of water in 1.0 mol of the hydrate $CuSO_4 \cdot 5H_2O$.

$$1.0\ mol\ CuSO_4 \cdot 5H_2O \left(\frac{5\ mol\ H_2O}{1\ mol\ CuSO_4 \cdot 5H_2O}\right)\left(\frac{6.02 \times 10^{23}\ molecule}{1\ mol}\right)$$

$$= 3.01 \times 10^{24}\ molecules$$

c) the number of CH_4 molecules and the number of hydrogen atoms in 9.22 g of methane, CH_4.

$$9.22\ g\ CH_4 \left(\frac{1\ mol\ CH_4}{16\ g}\right)\left(\frac{6.02 \times 10^{23}\ molecule\ CH_4}{1\ mol}\right) = 3.47 \times 10^{23}\ molecules$$

$$3.47 \times 10^{23}\ molecules \left(\frac{4\ atoms\ H}{1\ molecule\ CH_4}\right) = 1.39 \times 10^{24}\ H\ atoms$$

(13) 6. For the reaction

$$P_{4(s)} + 10Cl_{2(g)} \rightarrow 4PCl_{5(g)}$$

Calculate how many grams of chlorine that must react to produce 32.5 g of PCl_5. (Assume phosphorus is in excess.)

$$\mathbf{32.5\ g\ PCl_5}\left(\frac{\mathbf{1\ mol\ PCl_5}}{\mathbf{208\ g}}\right)\left(\frac{\mathbf{10\ mol\ Cl_2}}{\mathbf{1\ mol\ PCl_5}}\right)\left(\frac{\mathbf{70.9\ g\ Cl_2}}{\mathbf{1\ mol\ Cl_2}}\right) = \mathbf{27.7\ g\ Cl_2}$$

(10) 7. Calculate the mass of silver produced when 3.22 g of Zn react with 4.35 g of $AgNO_3$.

$$Zn_{(s)} + 2AgNO_{3(aq)} \rightarrow 2Ag_{(g)} + Zn(NO_3)_{2(aq)}$$

$$\mathbf{3.22\ g\ Zn}\left(\frac{\mathbf{1\ mol}}{\mathbf{65.4\ g}}\right) = \mathbf{0.049\ mol\ Zn}$$

$$\mathbf{4.35\ g\ AgNO_3}\left(\frac{\mathbf{1\ mol}}{\mathbf{170.0\ g}}\right) = \mathbf{0.026\ mol\ AgNO_3}$$

$(\text{moles Zn})_o$	$(\text{moles } AgNO_3)_{required}$	$(\text{moles } AgNO_3)_o$	Conclusion
0.049 mol	0.098 mol	0.026 mol	$AgNO_3$ limiting, Zn excess

$$\mathbf{0.049\ mol\ Zn}\left(\frac{\mathbf{2\ mol\ AgNO_3}}{\mathbf{1\ mol\ Zn}}\right) = \mathbf{0.098\ mol\ AgNO_3}$$

$$\mathbf{0.026\ mol\ AgNO_3}\left(\frac{\mathbf{2\ mol\ Ag}}{\mathbf{2\ mol\ AgNO_3}}\right)\left(\frac{\mathbf{107.9\ g}}{\mathbf{1\ mol\ Ag}}\right) = \boxed{\mathbf{2.81\ g\ Ag}}$$

(14) 8. Acetonitile, C_2H_3N, is an important nonaqueous solvent. The compound reacts with O_2 according to the equation,

$$4C_2H_3N_{(g)} + 15O_{2(g)} \rightarrow 8CO_{2(g)} + 6H_2O_{(g)} + 4NO_{2(g)}$$

47.6 g of acetonitile are added to an amount of oxygen. After the reaction occurs 28.4 grams of H_2O and 48.4 g of NO_2 are produced. Answer each of the following,

a) the mol of H_2O produced?

$$\mathbf{28.4\ g\ H_2O \left(\frac{1\ mol\ H_2O}{18\ g}\right) = 1.58\ mol\ H_2O}$$

b) the mass of CO_2 produced?

$$\mathbf{1.58\ mol\ H_2O \left(\frac{8\ mol\ CO_2}{6\ mol\ H_2O}\right)\left(\frac{44.0\ g\ CO_2}{1\ mol\ CO_2}\right) = 92.7\ g\ CO_2}$$

c) Could O_2 be the limiting reagent or is it in excess in this reaction? Explain. (You may use a calculation to support your answer.)

$$\mathbf{1.58\ mol\ H_2O \left(\frac{4\ mol\ C_2H_3N}{6\ mol\ H_2O}\right)\left(\frac{41.0\ g\ C_2H_3N}{1\ mol\ C_2H_3N}\right) = 43.2\ g\ C_2H_3N}$$

Since we began with 47.8 g of C_2H_3N and only 43.2 g reacted, the acetonitrile must be in excess, therefore oxygen is the limiting reagent.

(5) 9. THIS IS EXTRA CREDIT. DO NOT ATTEMPT UNTIL AFTER YOU ARE THROUGH DOING THE FIRST 9 QUESTIONS.

A 2.24 gram sample of an unknown metal reacts with HCl to produce 0.0808 g of H_2 gas. Identify the metal assuming all of it reacts. (Show ALL your work!)

$$\mathbf{X}_{(s)} + \mathbf{2HCl}_{(aq)} \rightarrow \mathbf{H_2(g)} + \mathbf{XCl_2(aq)}$$

$$\mathbf{0.0808\ g\ H_2}\left(\frac{\mathbf{1\ mol\ H_2}}{\mathbf{2.02\ g}}\right)\left(\frac{\mathbf{1\ mol\ X}}{\mathbf{1\ mol\ H_2}}\right) = \mathbf{0.04\ mol\ X}$$

$$\left(\frac{\mathbf{2.24\ g\ X}}{\mathbf{0.04\ mol\ X}}\right) = \mathbf{56}\ \frac{\mathbf{g}}{\mathbf{mol}} \quad \mathbf{probably\ Fe}$$

Periodic Table of the Elements

	IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
1	1 **H** 1.008																	2 **He** 4.00
2	3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)									

Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinides	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Solubility Table

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, $*Pb^{2+}$
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
CrO_4^{2-}	insoluble	except Group IA, IIA and NH_4^+
^-OH	insoluble	except Group IA, $*Ca^{2+}$, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble