Form 1 (White)

CHEM 101 Exam 2

Page 1

October 12, 2001 **Name**__________________________________

Section ________________________________

This exam consists of 7 pages. When the exam begins make sure you have one of each. Print your name at the top of each page now The last page is blank and you may tear if off and use it for scratch paper. Show your work on calculations, this is the only way partial credit can be given. Be sure to include units on calculations, and give answer to the correct number of significant figures. When a blank is not provided make sure you place a box around the correct answer. The exam is 100 points and 50 minutes.

Page	**Points**
2	_____
3	_____
4	_____
5	_____
6	_____
7	_____
Total	_____

If anything confuses you or is not clear, raise your hand and ask!

USEFUL INFORMATION

Avogadro's number = 6.022×10^{23}
R = 0.082057 L atm mol^{-1} K^{-1}
R = 8.3145 J mol^{-1} K^{-1}
1 atm = 760 torr
K = $^{o}C + 273.15$

Ideal Gas Law:	PV=nRT; P = (d/M)RT
Average Kinetic Energy:	$(KE)_{avg} = (3/2)RT$
Root-mean-square velocity:	$u_{rms} = [3RT/M]^{1/2}$
Effusion rate:	$r(1)/r(2) = [M_m(2)/M_m(1)]^{1/2}$

Points

8 1) A 3.664 g sample of a monoprotic (one acidic proton) is dissolved in 0.120 L of water. 20.7 mL of a 0.1578 M NaOH solution is required for complete neutralization in a titration. Calculate the concentration (molarity) and molar mass of the acid.

Neutralization: mol acid = mol base

mol base = (0.0207 L)(0.1578 mol/L) = 0.00327 mol OH^-

mol acid = 0.00327 mol

Concentration of acid = (mol acid)//(vol H_2O) = (0.00327 mol)/(0.120 L) = 0.0272 M

Molar mass of acid = (g acid)/(mol acid) = (3.664 g)/(0.00327 mol) = 1120 g/mol

12 2) A test for alcohols (and one you are likely to do in organic chemistry) is the chromic acid test. In this test an alcohol is treated with chromic anhydride ion, $HCrO_4^-$, which is orange. If the reaction turns an opaque blue-green an alcohol was present. Balance the redox reaction under acidic conditions.

(orange) (opaque blue-green)

$CH_3OH(l) + HCrO_4^-(aq) \rightarrow CH_2O(l) + Cr^{3+}(aq)$

Oxidation # **(-2)** **(+6)** **(0)** **(+3)**

Oxidation: **$(CH_3OH \rightarrow CH_2O + 2H^+ + 2e^-)$** **x 3**

Reduction: **$(3e^- + 7H^+ + HCrO_4^- \rightarrow Cr^{3+} + 4H_2O)$** **x 2**

Balanced Reaction: **$3CH_3OH + 6e^- + 14H^+ + 2HCrO_4^- \rightarrow 3CH_2O + 6H^+ + 6e^- + 2Cr^{3+} + 8H_2O$**

$3CH_3OH + 8H^+ + 2HCrO_4^- \rightarrow 3CH_2O + 2Cr^{3+} + 8H_2O$

Identify the oxidizing agent ___**$HCrO_4^-$**_____

Identify the reducing agent ___**CH_3OH**______

Points

12 3) Qualitative analysis (QA) is an important way of determining what ions are in solution. You will do experiments using QA next semester in the laboratory. One of the critical aspects of QA is using selective precipitation to determine if certain ions are present. To prove to yourself it works you do the following experiment. In a beaker you dissolve equal amounts of $AgNO_3$, $Pb(NO_3)_2$, and $Ca(NO_3)_2$. To this mixture you add excess HCl and a precipitate is formed which you filter and label precipitate 1. To the leftover solution you add excess H_2S and another precipitate is formed. You filter and label it precipitate 2. Finally, you add excess $(NH_4)\ CO_3$ to the solution that remains after the first two filtrations and a precipitate is formed that you label 3.

a) Write down the net ionic reaction that resulted in precipitate 1. Underline the precipitate.

$\underline{Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)}$

(will accept $Pb^{2+} + 2Cl^- \rightarrow PbCl_2(s)$ except that it is soluble in acidic medium)

b) Write down the net ionic reaction that resulted in precipitate 2. Indicate the precipitate.

$\underline{Pb^{2+}(aq) + S^{2-}(aq) \rightarrow PbS(s)}$

(will accept $Ag^+(aq) + S^{2-}(aq) \rightarrow Ag_2S(s)$)

c) Write down the net ionic reaction that resulted in precipitate 3. Indicate the precipitate.

$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

12 4) A 1.00 g sample of metal X (that is known to form X^{2+} ions) was added to HCl. Immediately bubbles of H_2 gas are seen evolving from the mixture. After all the metal had reacted, the H_2 gas was collected in a 750. mL container and found to have a pressure of 1.34 atm at 298 K.

a) Balance (by inspection) the net ionic reaction for this reaction?

$\_\_\_X(s) + \underline{\ 2\ }H^+(aq) \rightarrow \_\_\_X^{2+}(aq) + \_\_\_H_2(g)$

b) Is the reaction in a) a redox reaction? (Circle one) **YES** NO

c) Calculate the molar mass of the metal X. What is the identity of X?

mol of $H_2(g)$ = PV/RT = (1.34 atm)(0.750 L)/[(0.082057 L atm/mol K)(298 K)] =
= 0.0411 mol $H_2(g)$

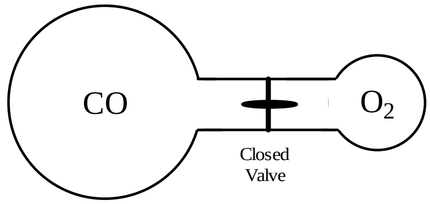
0.0411 mol $H_2(g)$ x 1 mol X(s)/1 mol $H_2(g)$ = 0.0411 mol X(s)

Molar mass of X(s) = 1.00 g X(s)/0.0411 mol X(s) = 24.3 g/mol

X(s) is Magnesium

Points

14 5) Carbon monoxide, CO(g), reacts with molecular oxygen, O_2(g), to give carbon dioxide, CO_2(g). Initially CO and O_2 are separated as shown below with the conditions as given.



2.00 L at 0.500 atm — 1.00 L at 1.00 atm

When the valve is opened, the reaction quickly goes to completion.

a) Write a balanced chemical reaction for this process.

_**2**_CO(g) + ____O_2(g) → _**2**_CO_2(g)

b) Determine what gases remain at the end of the reaction and calculate their partial pressures. The temperature for the reaction is 25 ^{o}C.

Calculate moles and determine limiting reagent then calculate moles remaining.
mol CO = (0.500 atm)(2.00 L)/(0.082057 L atm/mol K)(25 + 273.15 K) = 0.0409 mol CO
mol O_2 = (1.00 atm)(1.00 L)/(0.082057 L atm/mol K)(25 + 273.15 K) = 0.0409 mol O_2
***Limiting reagent*: 0.0409 mol CO x 1 mol O_2/2 mol CO = 0.0204 mol O_2 – thus CO is limiting**
mol CO_2 produced = 0.0409 mol CO x 2 mol CO_2/2 mol CO = 0.0409 mol CO_2

Moles after reaction: mol CO = 0, mol O_2 = (0.0409 - 0.0204) = 0.0205, mol CO_2 = 0.0409
P(CO) = <u>0.00 atm</u>
P(O_2) = (0.0205 mol)(0.082057 L atm/mol K)(25 + 273.15 K)/(2.00 L + 1.00L) = <u>0.167 atm</u>
P(CO_2) = (0.0409 mol)(0.082057 L atm/mol K)(25 + 273.15 K)/(2.00 L + 1.00L) = <u>0.333 atm</u>

c) What is the total pressure at the end of the reaction?

P(total) = P(CO) + P(O_2) + P(CO_2) = 0.00 atm + 0.167 atm + 0.333 atm = <u>0.500 atm</u>

d) What is the mole fraction of CO_2 after the reaction is complete?

X(CO_2) = P(CO_2)/P(total) = 0.333 atm/0.500 atm = <u>0.666</u>

Points

25 6) Nitrogen is the gas used to inflate air bags required in automobiles. Air bags contain sodium azide, NaN_3. The azide ion is N_3^-. When a sensor detects a sudden deceleration, it activates an electrical heater which initiates the decomposition of the sodium azide.

a) Balance the air bag reaction (do it by inspection).

__**2**__$NaN_3(s)$ → __**2**__$Na(s)$ + __**3**__$N_2(g)$

Is this reaction a redox reaction? Circle one. **Yes** No

b) If the air bag is 13.6 L and bag needs to be inflated to 2.00 atm at 25.0 °C, how many grams of NaN_3 are necessary if you assume the reaction goes to completion? How many grams of Na are produced?

mol N_2 = PV/RT = (2.00 atm)(13.6 L)/[(0.082057 L atm mol^{-1} K^{-1})(25.0 + 273.15 K)] = 1.11 mol

1.11 mol N_2 x (2 mol NaN_3)/(3 mol N_2) = 0.740 mol NaN_3
0.740 mol NaN_3 x (65.010 g NaN_3/1 mol) = <u>48.1 g NaN_3</u>

1.11 mol N_2 x (2 mol Na)/(3 mol N_2) = 0.740 mol Na x (22.9898 g Na/mol) =<u>17.0 g Na</u>

c) If the minimum pressure to which the bag can be inflated to be functional is 1.35 atm, what is the minimum temperature which will allow the airbag to be functional?

$P_1/T_1 = P_2/T_2 \rightarrow T_2 = T_1(P_2/P_1)$ = 298 K(1.35 atm/2.00 atm) = <u>201 K</u>

Points

d) Na metal is undesirable, especially if the air bag tears. Thus, an additional reaction to remove the Na with KNO_3 is initiated after the air bag is inflated. The balanced reaction is shown below.

$$10Na(s) + 2KNO_3(aq) \rightarrow K_2O(s) + 5Na_2O(s) + N_2(g)$$

Is this a redox reaction? Circle one. **Yes** No

e) What pressure of N_2(g) is produced by this reaction using your result in b). (If you did not get b) assume you have 0.200 g of Na).

0.740 mol Na x 1 mol N_2/10 mol Na = 0.0740 mol N_2
P = nRT/V = (0.0740 mol)(0.082057 L atm mol^{-1} K^{-1})(298 K)/(13.6 L) = 0.133 atm N_2

***IF* 20.0 g Na x (1 mol Na/22.9898 g) = 0.870 mol Na x 1 mol N_2/10 mol Na = 0.0870 mol N_2**
P = nRT/V = (0.0870 mol)(0.082057 L atm mol^{-1} K^{-1})(298 K)/(13.6 L) = 0.156 atm N_2

10 7) You have two identical flasks at the same temperature. One contains 6.0474 g of H_2(g) and the other contains 84.042 g of N_2(g). In the blank provided determine whether the property listed for H_2(g) is less than, equal to, or greater than that same property in N_2(g). An example is given below. Show work for partial credit.

	Mass:	H_2(g)	is less than	N_2(g)
a)	Pressure:	H_2(g)	**is equal to**	N_2(g)
b)	Average Kinetic Energy:	H_2(g)	**is equal to**	N_2(g)
c)	Density:	H_2(g)	**is less than**	N_2(g)
d)	RMS velocity:	H_2(g)	**is greater than**	N_2(g)
e)	Rate of Effusion:	H_2(g)	**is greater than**	N_2(g)