CHEM 1210
Exam 1
February 5^{th}, 2014

Name: ______________________________

You have one hour and fifty minutes to complete this exam. Answer all questions, full work must be shown to receive full credit. A formula sheet and periodic table is provided, if you do not understand a question please ask for clarification.

1) **(4 marks)** Balance the following oxidation reduction reaction occurring in acidic solution:

$BrO_4^{1-} + N_2O \rightarrow HNO_2 + Br_2$

$(14e^- + 16H^+ + 2BrO_4^{1-} \rightarrow Br_2 + 8H_2O)2$

$28e^- + 32H^+ + 4BrO_4^{1-} \rightarrow 2Br_2 + 16H_2O$

$(3H_2O + N_2O \rightarrow 2HNO_2 + 4H^+ + 4e^-)7$

$21H_2O + 7N_2O \rightarrow 14HNO_2 + 28H^+ + 28e^-$

$5H_2O + 4H^+ + 4BrO_4^{1-} + 7N_2O \rightarrow 14HNO_2 + 2Br_2$

2) **(3 marks)** For the following balanced oxidation reduction reaction:

$2CrI_3 + 27Cl_2 + 64OH^{1-} \rightarrow 54Cl^{1-} + 2CrO_4^{2-} + 6IO_4^{1-} + 32H_2O$

+3 −1 0 −1 +6 +7

a) What species is the reducing agent? CrI_3

b) How many electrons are involved in the reduction half reaction? 2e or 54e−

c) Determine the equivalent mass of CrI_3

$$432.7\,\frac{g}{mol} \times \frac{2\,mol\,CrI_3}{54\,mol\,e^-} \times \frac{1\,mol\,e^-}{1\,equiv} = 16.0\,g/equiv$$

3) **(3marks)** A 1.874 g sample of an ore that contains molybdenum is dissolved in acid, passed through a Jones reductor (which converts all molybdenum to Mo^{3+}), and then titrated with 23.76 mL of 0.1234 N $KMnO_4$, during the titration the Mo^{3+} is oxidized to MoO_2^{2+}. Determine the %(by mass) of Mo in the original ore sample.

$$\underset{+3}{Mo^{3+}} \rightarrow \underset{+6\ -4}{MoO_2^{2+}} \quad 3e^-$$

$$23.76\,mL \times 0.1234\,\frac{mequiv}{mL} \times \frac{1\,mmole^-}{1\,mequiv} \times \frac{1\,mmol\,Mo}{3\,mmole^-} \times \frac{95.94\,mg\,Mo}{1\,mmol}$$

$$= 9.376\,mg \qquad \cancel{9.3}\ \frac{93.76\,mg}{1874\,mg} \times 100 = 5.00\,\%$$

4) **Part 1** -An evacuated flask is charged with BrF_5 gas heated to 1000 K and allowed to attain equilibrium. The K_c value is determined to be 1.4×10^{-10}.

$$2BrF_5(g) \leftrightarrow Br_2(g) + 5F_2(g) \qquad K_c = 1.4 \times 10^{-10}$$

a) **(1 mark)** Determine K_p for this reaction at 1000 K.

$$K_p = K_c(RT)^{\Delta n}$$
$$= (1.4\times10^{-10})(.08206 \times 1000)^{6-2}$$
$$= 6.35 \times 10^{-3}$$

b) **(1 mark)** If the volume is reduced at constant ~~pressure~~ temp the reaction will shift:

$\leftarrow$ and the K_c will: Not change

c) **(1 mark)** ΔH = -1050 kJ for this reaction, if the temperature is reduced to 750 K the reaction will shift: $\rightarrow$ and the K_c will: $\uparrow$.

d) **(1 mark)** What is the equilibrium expression (not value) if the temperature is reduced to 45°? (The boiling points are Br_2 = 59°C, F_2 = -188°C and BrF_5 = 40.5°C)

45°C

Br_2 will be a liq.

$$K_c = \frac{[F_2]^5}{[BrF_5]^2}$$

if 45 K

no gases

$K_c = 1$

4) **Part 2** A flask was charged with 4 atm of $C_2H_4(g)$ and 2 atm of $H_2(g)$ and the equilibrium:

$$3C_2H_4(g) \rightleftharpoons C_6H_6(l) + 3H_2(g) \qquad K_p = 125$$

established.

a) **(1 mark)** In which direction did the reaction shift in order to establish equilibrium? You must show proof.

$$Q = \frac{2^3}{4^3} = .125$$

$$Q < K \quad \text{rxn} \rightarrow$$

b) **(3 marks)** What were the equilibrium pressures of all species?

	$3C_2H_4(g)$	$\rightleftharpoons$	$C_6H_6(l) +$	$3H_2(g)$
i	4			2
c	$-x$			$+x$
e	$4-x$			$2+x$

$$\frac{(2+x)^3}{(4-x)^3} = 125$$

$$\frac{2+x}{4-x} = 5$$

$$2 + x = 20 - 5x$$

$$6x = 18$$

$$x = 3$$

$P_{C_2H_4} = 4 - 3 = 1$ atm

$P_{H_2} = 2 + 3 = 5$ atm.

5) **(2 marks)** You have collected samples of two bases for use in the lab, one is 0.100 M NaOH and the other is 0.100 M CH_3NH_2 (methylamine). Unfortunately you forgot to label the beakers and when you get to your benchtop you do not know which beaker contains which base. Describe clearly how you could quickly and safely determine which beaker contains which base.

measure the pH

0.100 M NaOH should have a pH ~13

0.100M CH_3NH_2 will have a pH < 13 since it is a weak base.

6) A 20.00 mL sample of 0.075 M nicotinic acid, $HC_6H_4NO_2$, is titrated with 0.050 M NaOH. The K_a for nicotinic acid is 1.4×10^{-5}.

Determine:

a) **(1 mark)** The volume of NaOH to reach the equivalence point.

$$\frac{20.00\text{mL} \times 0.075\text{M}}{0.050\text{ M}} = 30.\text{ mL}$$

b) **(2 marks)** The pH of the original acid solution.

assume x is small $.075 - x \approx .075$ ✓

$$HA + H_2O \rightleftharpoons A^- + H_3O^+$$

	HA	A^-	H_3O^+
	.075	0	0
	−x	+x	+x
	.075−x	x	x

$$\frac{x^2}{.075} = 1.4 \times 10^{-5}$$

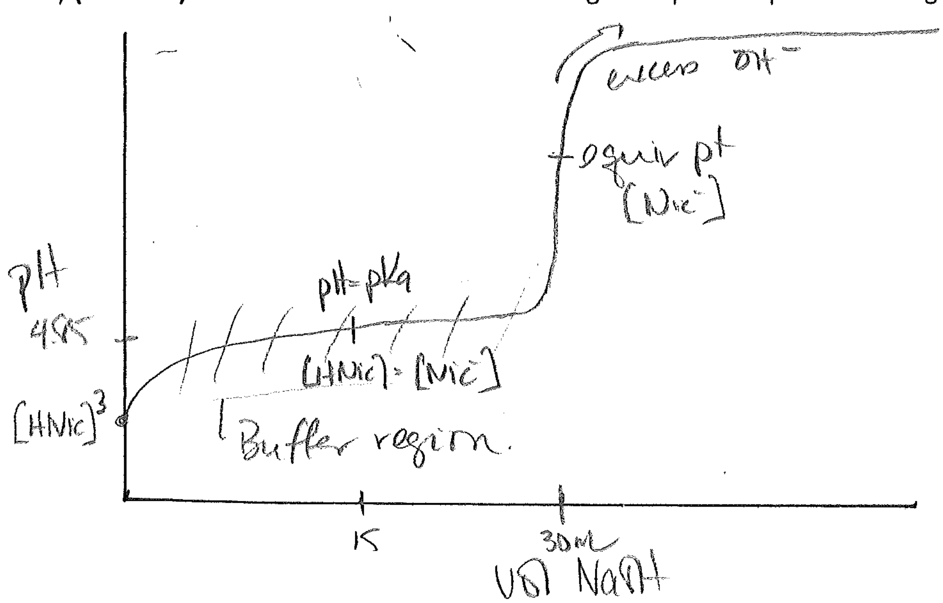
$$x = 1.02 \times 10^{-3}$$

pH = 2.99

c) **(1 mark)** The pH half way to the equivalence point.

$$pH = pKa = -\log(1.4 \times 10^{-5}) = 4.85$$

d) **(3 marks)** Sketch the titration curve labelling all important points and regions.



7) **(2 marks)** Determine the pH of a solution prepared by combining 300.0 mL of 0.125 M HClO (aq) with 200.0 mL of 0.0750 M NaClO. The K_a for HClO is 4.0 x 10^{-8}

$$HClO + H_2O \rightleftharpoons ClO^- + H_3O^+$$

assume x is small

$\frac{300 \times .125}{500}$		$\frac{200 \times .075}{500}$	0
$-x$		$+x$	$+x$
$\frac{3}{5}(.125) - x$		$\frac{2}{5}(.075) + x$	x

$$\frac{(x)\left(\frac{2}{5} \cdot .075\right)}{\left(\frac{3}{5} \cdot .125\right)} = 4.0 \times 10^{-8}$$

$x = 1 \times 10^{-7}$ $\quad$ pH = 7.00

8) **(3 marks)** For each of the following solutions indicate if you expect the solution to be acidic, basic or neutral:

a) 10.0 mL of a 0.10 M sodium acetate solution: Basic

b) Water at 10°C with a pH of 7.27 Neutral

c) 10.0 mL of 0.10 M NH_3 and 10.0 mL of 0.10 M HCl: Acidic