Kwantlen Polytechnic University
CHEM 1105

SAMPLE FINAL EXAM 2

Time allowed: 3 hours

Instructions: Ensure that the exam has **14 pages (including this cover page and attached periodic table).** There are **16 questions.** (Total Marks = 109 points). Read the exam carefully and judge your time accordingly. **ALL CALCULATIONS MUST BE SHOWN TO RECEIVE ANY CREDIT !** If you need extra space, use the back of a preceding page and clearly indicate the question number. A **periodic chart** is included on the last page of this exam.

USEFUL INFORMATION

$N_o = 6.022 \times 10^{23}$

$R = 0.0821$ L-atm/K-mol

1 atm = 760 mm Hg = 101.325 kPa = 760 torr

$0\ ^oC = 273.15$ K

$K_w = 1.0 \times 10^{-14}$ at 25.0 ^oC

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1. a) Write the formula for each of the following: **(5)**

i) chlorous acid

ii) sodium sulfate

iii) tetraphosphorus decoxide

iv) iron(III) sulphite

v) calcium hydroxide dihydrate

b) Give the proper (IUPAC) names for each of the following compounds. **(5)**

i) $(NH_4)_2S$

ii) $Al(ClO_3)_3$

iii) $Ni(CN)_2$

iv) HI(aq)

v) $Fe_2(CO_3)_3$

2. a) Complete the following table. You may refer to the periodic table provided. **(5½)**

Nuclear Symbol	Number of Protons	Number of Electrons	Number of Neutrons	Atomic Number	Mass Number
$^{27}Al^{3+}$					
		18	15		31
		36		36	84

2. (Continued)

b) Copper exists as a mixture of **two** isotopes. The major isotope (69.09%) has a mass of 62.9298 amu. Calculate the mass of the other isotope. **(2½)**

3. a) For the following equation, first balance, then write the net ionic equation: **(3)**

___ $Na_2CO_3(aq)$ + ___ $Al(NO_3)_3(aq)$ ---> ___ $Al_2(CO_3)_3(s)$ + ___ $NaNO_3(aq)$

b) Write the balanced equation for the combustion of octane, $C_8H_{18}(l)$. **(2)**

4. a) Chemical analysis of an unknown organic liquid shows that the percent by mass composition is 48.64% C, 8.16% H, and the remainder is oxygen. Determine the empirical formula for this unknown liquid. **(3)**

4. (Continued)

b) A 0.4280 g sample of the unknown liquid from part a) was vaporized in a sealed 250.0 mL container at 100.0 ^{o}C, producing a pressure of 0.708 atm. Based on these data, determine the molecular formula for the unknown. **(3)**

5. a) Determine the density of $CO_2(g)$ at 27.2 ^{o}C and 742.1 mm Hg pressure. **(2)**

b) A 1.00 L flask contains 2.00 grams each of the noble gases, helium, neon, and argon at 20.0 ^{o}C. Determine the partial pressures and the total pressure of the three gases in the flask (in atm). **(4)**

6. Consider the following reaction:

$2\ Fe(NO_3)_3(aq) + 3\ H_2S(g) \rightarrow Fe_2S_3(s) + 6\ HNO_3(aq)$

when 110.0 mL of 0.200 M $Fe(NO_3)_3$ were reacted with 1.45 g of H_2S gas, 2.15 g of Fe_2S_3 was obtained.

a) Is there a limiting reagent? If so, what is it? **(3)**

b) Determine the theoretical yield of $Fe_2S_3(s)$. **(2)**

c) Calculate the percentage yield of Fe_2S_3. **(1)**

d) Assuming the solution volume is equal to the volume of $Fe(NO_3)_3$ solution, determine the concentration (in mol/L) of HNO_3 in the final solution. This should be based on 100% yield of HNO_3. **(2)**

7. In a coffee-cup calorimeter, 100.0 mL of 1.00 *M* KOH and 100.0 mL of 1.00 *M* HCl are mixed. Both solutions were originally at 24.6 °C. After the reaction, the temperature is 31.3 °C. Assuming all solutions have a density of 1.00 g/cm^3 and a specific heat of 4.184 J/g °C, determine ΔH for the

neutralization reaction:

$$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$$

Assume that no heat is lost to the surroundings and heat gained by the calorimeter (coffee-cup, stirrer, and thermometer) is negligible. **(5)**

8. a) Given the following reactions: **(4)**

$2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$ $\quad \Delta H^o = -556$ KJ

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\quad \Delta H^o = -571.6$ kJ

$H_2O(g) \rightarrow H_2O\ (l)$ $\quad \Delta H^o = -44.0$ kJ

Calculate ΔH^o for the reaction:

$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$

8. (Continued)

b) Write the **complete** thermochemical equation that corresponds to

ΔH_f° ($NaHCO_3(s)$) = -950.81 kJ/mol. **(2)**

c) Consider the following reaction:

$4\ NH_3(g) + 7\ O_2(g) \rightarrow 4\ NO_2(g) + 6\ H_2O(l)$ $\quad \Delta H^\circ = -1396$ kJ

Given the following standard enthalpies of formation, ΔH_f° :

$NH_3(g)$	-45.9 kJ/mol
$H_2O(l)$	-286 kJ/mol

Determine ΔH_f° for $NO_2(g)$ in kJ/mol. **(3)**

9. a) Write the equilibrium constant expression for

$2\ NH_3(g) + 2\ CH_4(g) + 3\ O_2(g) \rightleftarrows 2\ HCN(g) + 6\ H_2O(l)$ **(2)**

$\mathbf{K_c}$ **=**

9. (Continued)

b) Give the balanced equation for the equilibrium system which would have the following expression for K_c: (Indicate the physical state of all species in your equation) **(3)**

$$\mathbf{K_c} = \frac{[Br_2(aq)]^2}{[O_2(aq)]\ [HBr(aq)]^4}$$

c) For the following equilibrium system at 500 °C

$$2\ NOCl(g) \rightleftarrows 2\ NO(g) + Cl_2(g) \qquad K_c = 4.4 \times 10^{-4}$$

What is the value of K_c for the following reaction at 500 °C?

$$NO(g) + \tfrac{1}{2}\ Cl_2(g) \rightleftarrows NOCl(g)$$ **(2)**

$\mathbf{K_c}$ =

d) Consider the equilibrium system,

$$2\ N_2(g) + 6\ H_2O(l) \rightleftarrows 4\ NH_3(g) + 3\ O_2(g) \qquad \Delta H = +1530.4\ kJ$$

using Le Chatelier's principle, predict the effect (i.e. increase, decrease, or no change) on the moles of N_2 and the value of K_c when: (write I, D, or NC) **(5)**

	moles of $\mathbf{N_2}$	$\mathbf{K_c}$
i) O_2 is removed	_____	_____
ii) NH_3 is added	_____	_____
iii) volume of container is increased	_____	_____
iv) temperature is increased	_____	_____
v) water is added (assume volume does not change)	_____	_____

10. At a high temperature, 0.600 moles of methane, CH_4, was placed in a 10.00 L reaction vessel and allowed to attain the following equilibrium,

$2\ CH_4(g) \rightleftarrows C_2H_2(g) + 3\ H_2(g)$

At equilibrium the concentration of acetylene, C_2H_2, was measured to be 0.026 mol/L. Determine the following:

a) the equilibrium concentration of $CH_4(g)$ and $H_2(g)$. **(3)**

b) the numerical value of K_c. **(1)**

11. **a)** Which of the following acids will have the strongest conjugate base?

HCN ($K_a = 4.9 \times 10^{-10}$); HCO_3^- ($K_a = 4.8 \times 10^{-11}$); NH_4^+ ($K_a = 5.6 \times 10^{-10}$)

Identify the base and give the value of its $\mathbf{K_b}$. **(3)**

11. (Continued)

b) Indicate if the classification, in aqueous solutions, of the species listed below is true (T) or false (F) **(4)**

HI : strong acid _____ NH_3 : strong base _____

HCN : weak acid _____ $H_2PO_4^-$: amphiprotic _____

LiOH : strong base _____ PO_4^{3-} : amphiprotic _____

NO_3^- : strong base _____ SO_4^{2-} : weak base _____

12. **a)** Calculate the $[OH^-]$, pOH, $[H_3O^+]$, and pH of a 2.50×10^{-4} *M* solution of $Ba(OH)_2$. **(2)**

b) If 20.00 mL of 0.2500 *M* HNO_3 solution is mixed with 20.00 mL of a 0.1000 *M* $Ca(OH)_2$ solution, what will be the resulting pH? The neutralization reaction is

$2\ HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2\ H_2O(l)$ **(3)**

13. **a)** Calculate the pH and percent ionization of a 0.100 *M* aqueous solution of formic acid, HCOOH. ($K_a = 1.9 \times 10^{-4}$) **(4)**

b) Calculate the pH of a 0.500 *M* sodium formate, NaHCOO, solution. **(3)**

c) Determine the pH of a buffer solution prepared by combining 0.200 L of 0.250 *M* formic acid with 0.200 L of 0.250 *M* sodium formate, NaHCOO, solution. **(3)**

13. (Continued)

d) Determine the pH of the solution that results when 500.0 mL of water is added to the buffer solution made in part **c)** above. **(2)**

14. Assign an oxidation number to sulfur in each of the following species: **(2)**

$S_2O_3^{2-}$ _____ **b)** HSO_3^- _____ **c)** H_2S _____ **d)** SO_4^{2-}_____

15. **a)** Balance the following redox equation in acidic conditions:

$ClO_3^-(aq) + SO_2(g) \text{ ----> } Cl_2(g) + SO_4^{2-}(aq)$ **(4)**

b) Give the formula of the oxidizing agent. _____ **(1)**

c) Which species is oxidized? _____ **(1)**

16. Reserpine, a natural product, has been used as a tranquilizer. The boiling point of a solution of 3.00g of reserpine dissolved in 20.0g of chloroform is 0.893 ^oC higher than the boiling point of pure chloroform. Determine the molar mass of reserpine. The boiling point elevation constant, K_b, for chloroform is 3.63 $^oC/m$. **(4)**