

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

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

$$R = 0.0821 \text{ L-atm/K-mol}$$

$$1 \text{ atm} = 760 \text{ mm Hg} = 101.325 \text{ kPa} = 760 \text{ torr}$$

$$0 \text{ }^\circ\text{C} = 273.15 \text{ K}$$

$$K_w = 1.0 \times 10^{-14} \text{ at } 25.0 \text{ }^\circ\text{C}$$

Page	
1	
2	
3	
4	
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6	
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9	
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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) $(\text{NH}_4)_2\text{S}$

ii) $\text{Al}(\text{ClO}_3)_3$

iii) $\text{Ni}(\text{CN})_2$

iv) $\text{HI}(\text{aq})$

v) $\text{Fe}_2(\text{CO}_3)_3$

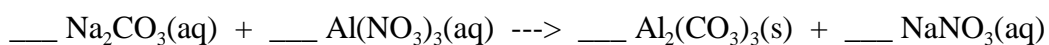
2. a) Complete the following table. You may refer to the periodic table provided. (5½)

Nuclear Symbol	Number of Protons	Number of Electrons	Number of Neutrons	Atomic Number	Mass Number
$^{27}\text{Al}^{3+}$					
		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)



- b) Write the balanced equation for the combustion of octane, C₈H₁₈(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)

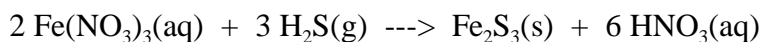
4. (Continued)

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 °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 CO₂(g) at 27.2 °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 °C. Determine the partial pressures and the total pressure of the three gases in the flask (in atm). **(4)**

6. Consider the following reaction:



when 110.0 mL of 0.200 M $\text{Fe}(\text{NO}_3)_3$ 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)

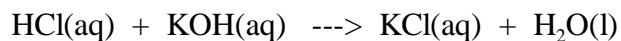
b) Determine the theoretical yield of $\text{Fe}_2\text{S}_3(\text{s})$. (2)

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

d) Assuming the solution volume is equal to the volume of $\text{Fe}(\text{NO}_3)_3$ 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)

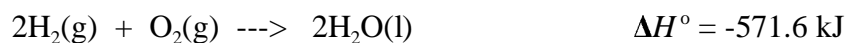
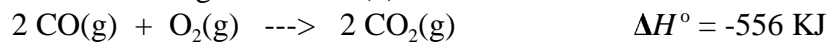
7. In a coffee-cup calorimeter, 100.0 mL of 1.00 M KOH and 100.0 mL of 1.00 M HCl are mixed. Both solutions were originally at 24.6 °C. After the reaction, the temperature is 31.3 °C. Assuming all solutions have a density of 1.00 g/cm³ and a specific heat of 4.184 J/g °C, determine ΔH for the

neutralization reaction:

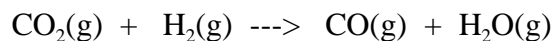


Assume that no heat is lost to the surroundings and heat gained by the calorimeter (coffee-cup, stirrer, and thermometer) is negligible. (5)

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



Calculate ΔH° for the reaction:

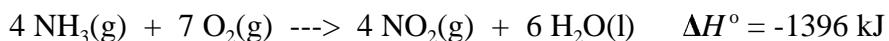


8. (Continued)

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

$$\Delta H_f^\circ (\text{NaHCO}_3(\text{s})) = -950.81 \text{ kJ/mol. (2)}$$

c) Consider the following reaction:

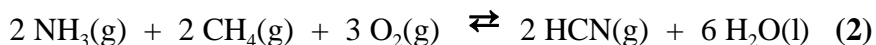


Given the following standard enthalpies of formation, ΔH_f° :

$\text{NH}_3(\text{g})$	-45.9 kJ/mol
$\text{H}_2\text{O}(\text{l})$	-286 kJ/mol

Determine ΔH_f° for $\text{NO}_2(\text{g})$ in kJ/mol. (3)

9. a) Write the equilibrium constant expression for



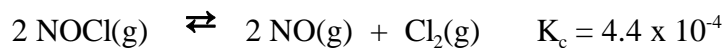
$$K_c =$$

9. (Continued)

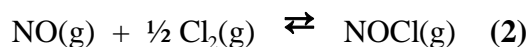
b) Give the balanced equation for the equilibrium system which would have the following expression for K_c : (Indicate the physical state of all species in your equation) (3)

$$K_c = \frac{[\text{Br}_2(\text{aq})]^2}{[\text{O}_2(\text{aq})] [\text{HBr}(\text{aq})]^4}$$

c) For the following equilibrium system at 500 °C

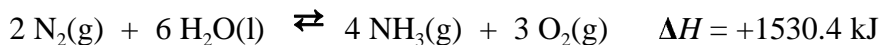


What is the value of K_c for the following reaction at 500 °C?



$$K_c =$$

d) Consider the equilibrium system,



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 N_2	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,

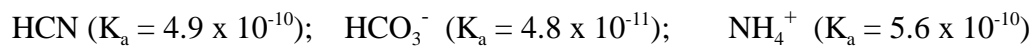


At equilibrium the concentration of acetylene, C_2H_2 , was measured to be 0.026 mol/L. Determine the following:

a) the equilibrium concentration of $\text{CH}_4(\text{g})$ and $\text{H}_2(\text{g})$. (3)

b) the numerical value of K_c . (1)

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



Identify the base and give the value of its 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 _____

NH₃ : strong base _____

HCN : weak acid _____

H₂PO₄⁻ : amphiprotic _____

LiOH : strong base _____

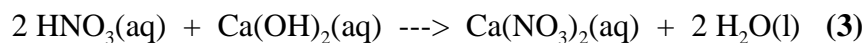
PO₄³⁻ : amphiprotic _____

NO₃⁻ : strong base _____

SO₄²⁻ : weak base _____

12. a) Calculate the [OH⁻], pOH, [H₃O⁺], and pH of a 2.50 x 10⁻⁴ M solution of Ba(OH)₂. (2)

b) If 20.00 mL of 0.2500 M HNO₃ 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



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)

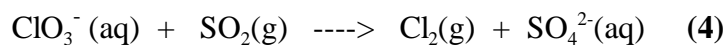
13. (Continued)

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)



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



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 °C 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 °C/m. (4)