

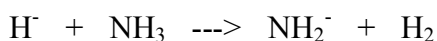
KWANTLEN UNIVERSITY COLLEGE
CHEMISTRY 1210 S-10
EXAM No. 2A
November 20, 1997

NAME: _____

Instructions: This exam contains **Five** questions. Read the exam carefully and judge your time accordingly. A thermodynamic data sheet and periodic chart are included with this exam. **Return** this exam paper with your exam booklet. **ALL CALCULATIONS MUST BE SHOWN TO RECEIVE ANY CREDIT!** Maximum Score: **62 + 4 bonus** points.

Question One: (6 MARKS)

a) The following reaction takes place in liquid ammonia as the solvent:



In this reaction ammonia acts as

- i) a Brønsted-Lowry base ii) an Arrhenius acid iii) a Lewis base
iv) a Brønsted-Lowry acid v) an Arrhenius base vi) a conjugate base

b) Choose the couple which is not a conjugate acid-base pair,

- i) HCO_3^- , CO_3^{2-} ii) H_3O^+ , H_2O iii) OH^- , O^{2-} iv) H_3PO_4 , HPO_4^{2-}
v) NH_2OH_2^+ , NH_2OH

c) What is the pH of a 0.10 M solution of $\text{Ba}(\text{OH})_2$?

- i) 13.00 ii) 13.30 iii) 0.20 iv) 0.10 v) none of these

d) What is the pH of the solution when 10.00 mL of 0.30 M HNO_3 is mixed with 10.00 mL of 0.10 M KOH ?

- i) 7.0 ii) 13.0 iii) 0.82 iv) 1.0 v) 0.70

e) Which of the following aqueous mixtures is **not** a buffer solution?

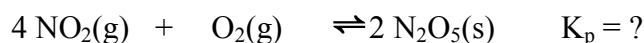
- i) NH_4Cl and NH_3 ii) HCN and NaCN iii) H_3PO_4 and NaH_2PO_4
iv) CH_3COONa and NaCl v) Na_2HPO_4 and NaH_2PO_4

Question Two: (15 MARKS)

Dinitrogen pentoxide, $\text{N}_2\text{O}_5(\text{s})$, decomposes at 25.0°C according to the equation,



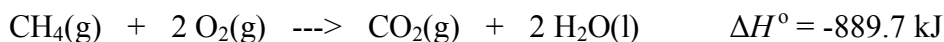
- a) Calculate K_c at 298K for this reaction. (2)
- b) Calculate K_p for the above equilibrium at 398K. (4)
- c) Find the equilibrium pressure of $\text{NO}_2(\text{g})$ at 298K when the equilibrium pressure of $\text{O}_2(\text{g})$ is 2.00 atm. (3)
- d) What happens (increase, decrease, or no change) to the mass of $\text{NO}_2(\text{g})$ and the value of K_p when, (4)
- i) $\text{O}_2(\text{g})$ is added to the flask.
 - ii) some $\text{N}_2\text{O}_5(\text{s})$ is added (assume volume does not change).
 - iii) volume is increased.
 - iv) temperature is decreased.
- e) Determine the value of K_p for the following equilibrium: (2)



- f) If excess solid N_2O_5 was injected into an evacuated 1.00L reaction vessel at 25.0°C , what would be the total pressure of this system at equilibrium? **BONUS QUESTION (4 MARKS)**

Question Three: (18 MARKS)

The combustion reaction for methane gas is given by the following thermochemical equation at 25.0°C :



- a) Determine the standard enthalpy of formation of $\text{H}_2\text{O}(\text{l})$ using the enthalpy of combustion and the following standard enthalpies of formation at 298K: (3)



- b) Calculate the work done if the above reaction was carried out at constant pressure (1.00 atm) at 25°C . (2)
- c) Calculate the change in internal energy, ΔE° , at 25°C for the above reaction. (2)

Question Three: (Continued)

d) What size sample of $\text{CH}_4(\text{g})$ (Molar mass = 16.0 g/mol) would have to be burned in a bomb calorimeter to cause a temperature rise of 5.00 °C? The total heat capacity of the calorimeter (including the water) was found to be 8.000 kJ/°C. (4)

e) Calculate the approximate enthalpy of combustion for $\text{CH}_4(\text{g})$ using the bond energies given below: (3)

C-H(413 kJ/mol); C=O(802 kJ/mol); O=O(498 kJ/mol); O-H(463 kJ/mol)

f) Give two reasons why the value of ΔH° calculated in part e) so different than the heat of combustion given above? (1)

g) Calculate ΔS° for the combustion of methane given the absolute molar entropies: (2)

$$S^\circ(\text{CH}_4(\text{g})) = 186.26 \text{ J/mol-K}$$

$$S^\circ(\text{O}_2(\text{g})) = 205.14 \text{ J/mol-K}$$

$$S^\circ(\text{CO}_2(\text{g})) = 213.74 \text{ J/mol-K}$$

$$S^\circ(\text{H}_2\text{O}(\text{l})) = 69.91 \text{ J/mol-K}$$

h) Briefly comment on the sign and magnitude of ΔS° calculated in part g) above in terms of the reaction. (1)

Question Four: (17 MARKS)

Methylamine (CH_3NH_2) is a weak base which undergoes hydrolysis as follows:



A 20.00 mL sample of 0.2000 M methylamine is titrated with 0.1000 M HCl solution.

a) Calculate the pH of the methylamine solution before any HCl is added. (3)

b) Calculate the pH after the addition of 10.00 mL of the HCl solution. (3)

c) Calculate the pH at the equivalence point. (3)

d) Calculate the pH after the addition of 50.00 mL of HCl solution. (3)

e) Which indicator methyl red ($\text{pK}_{\text{ind}} \approx 5.0$) or thymol blue ($\text{pK}_{\text{ind}} \approx 9.0$) would be most suitable for this titration? (Assume color change occurs when $\text{pH} = \text{pK}_{\text{ind}}$.) **EXPLAIN** (1)

f) Roughly sketch a titration curve (not necessarily to scale) for this titration, clearly show the following: (4)

i) units on both x and y axis and **all points calculated above**.

ii) equivalence point

iii) buffer region(s)

iv) regions or point(s) where pH is dependent **only** upon:

1) $[\text{CH}_3\text{NH}_2]$

2) $[\text{CH}_3\text{NH}_3^+]$

3) $[\text{CH}_3\text{NH}_2] / [\text{CH}_3\text{NH}_3^+]$

4) $[\text{H}^+]$

Question Five: (6 MARKS)

- a) A solution contains $1.00 \times 10^{-4} \text{ M Cu}^+$ and $2.00 \times 10^{-2} \text{ M Pb}^{2+}$. If a source of I^- is added to this solution will PbI_2 ($K_{\text{sp}} = 8.49 \times 10^{-9}$) or CuI ($K_{\text{sp}} = 1.27 \times 10^{-12}$) precipitate first? Specify the concentration of I^- necessary to begin precipitation of each compound.
- b) Calculate the % left in solution of the first ion to precipitate when the second ion just starts to precipitate.