EXAM 2A (Chemistry 102) KEY
NAME: PRINT _____ Sign _____

1-3) The reaction: $2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$ is proposed to occur in a 3-step mechanism: (15pts)

Step 1). $2\,NO(g) \rightarrow N_2O_2(g)$ $\quad K_1 = \frac{[N_2O_2]}{[NO]^2}$

Step 2). $N_2O_2(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$ $\quad K_2 = \frac{[N_2O][H_2O]}{[N_2O_2][H_2]}$

Step 3). $N_2O(g) + H_2(g) \rightarrow H_2O(g) + N_2(g)$ (5pts)

What would be the rate law for the reaction if

a) The first step were the RDS (slowest)
b) The second step were the RDS(slowest)
c) The third step were the RDS(slowest)

a) $Rate = k[NO]^2$

(b) $Rate = k[N_2O_2][H_2]$ (2pts)

$Rate = kK_1[NO]^2[H_2]$ (4pts)

$Rate = k^*[NO]^2[H_2]$ (5pts)

(c) $Rate = k[N_2O][H_2]$ (2pts)

$Rate = \frac{kK_2[N_2O_2][H_2]^2}{[H_2O]}$ (3pts)

$Rate = \frac{kK_2K_1[NO]^2[H_2]^2}{[H_2O]}$ (4pts)

$Rate = k^*[NO]^2[H_2]^2/[H_2O]$ (5pts)

4-5) For the reaction, $H_2(g) + I_2(g) \rightarrow 2\,HI(g)$, $K_c = 50.5$ at 1495 K. (10pts)

If the initial concentrations of H_2, I_2, and HI are 0.5 M, 0.2 M, and 1.5 M respectively,

a) which direction will the reaction proceed in reaching equilibrium?
b) what are the equilibrium concentrations of each component?

$Q = 22.5$ $\quad Q < K \rightarrow$ Right

$[H_2] = 0.4262$

$[I_2] = 0.1262$

$[HI] = 1.648$

$x = 0.0738$

6-7) Calculate the pH of a 2.72 millimolar solution of nitrous acid (HNO_2 $K_a = 4.5 \times 10^{-4}$)
Hints: (what does millimolar mean and does the solution meet the $100K_a$ rule?) (10pts)

100 Ka rule not met (+3)

$\frac{x^2}{2.72 \times 10^{-3} - x} = 4.5 \times 10^{-4}$ (+3) $\quad pK_a = 3.347$

$x = 9.04 \times 10^{-4} = [H_3O^+]$

$\frac{-4.5 \times 10^{-3} + \sqrt{(4.5 \times 10^{-4})^2 + 4.1(2.72 \times 10^{-3})}}{2}$ $\quad pH_{exact} = 3.04$ (+2)

$pH_{approx} = 2.96$

$\frac{-4.5 \times 10^{-3} + 0.002258}{2}$ (+2)

$= 9.04 \times 10^{-4}$

all or nothing

8) Hydroxylamine, $HONH_2$, is a weak base. Write the K_b expression for hydroxylamine. (5pt)

a) $K_b = [NH_2+][OH-]/[HONH_2]$
b) $K_b = [H+][ONH_2-]/[HONH_2]$
c) $K_b = [HONH_3^+][OH-]/[HONH_2]$
d) $K_b = [HONH_2]/ [HONH_3+][OH-]$
e) $K_b = [HONH_3^+][OH-]/[H_2O][HONH_2]$

9) The following reactions all have $K_c < 1$. (5pt)

i) $CH_3C_6H_5O^-$ (aq) + **HCOOH** (aq) <==> $HCOO^-$ (aq) + $CH_3C_6H_5OH$ (aq)
ii) $HClO_2$ (aq) + $CH_3C_6H_5O$- **(aq)** <==> ClO_2^- (aq) + $CH_3C_6H_5OH$ (aq)
iii) **HCOOH** (aq) + ClO_2^- (aq) <==> $HClO_2$ (aq) + $HCOO^-$ (aq)

ARRANGE ALL of substances based on their relative strength.

$CH_3C_6H_5OH$ (aq)	4	**1) strongest base**
HCOOH (aq)	6	**2) intermediate base**
$HClO_2$(aq)	5	**3) weakest base**
ClO_2^- (aq)	2	**4) strongest acid**
$CH_3C_6H_5O^-$ (aq)	3	**5) intermediate acid**
$HCOO^-$ (aq)	1	**6) weakest acid**

Back (work) + 2 points

all or nothing

10) IDENTIFY the conjugate acid-base pairs (5pt):

$CH_3NH_3^+ + OH^- \Leftrightarrow CH_3NH_2 + H_2O$
A B CB CA

$CH_3COOH + (CH_3)_2NH \Leftrightarrow CH_3COO^- + (CH_3)_2NH_2^+$
A B C.B C.A

$NH_4^+ + F^- \Leftrightarrow HF + NH_3$
A/ B CA CB

$NO_3^- + HNO_2 \Leftrightarrow HNO_3 + NO_2^-$
B A CA CB

$CH_3CH_2NH_3^+ + F^- \Leftrightarrow CH_3CH_2NH_2 + HF$
A B CB CA

11) The pOH of an aqueous solution was found to be 4.10. **(5pt)**

The pH of this solution is $14 - 4.1 = 9.9$

The hydronium concentration is __ M. 1.26×10^{-10}

The hydroxide ion concentration is __ 7.94×10^{-5}

The solution is Basic or Acidic __ Basic

20

4 if they miss sig fr

12) Write a net ionic equation to show that Pyridine, C_5H_5N, behaves as a Bronsted-Lowry base in WATER. (5pt)

$$C_5H_5N + H_2O \rightleftharpoons C_5H_5NH^+ + OH^-$$

BL base BL acid ⇔ BL acid BL base

13) Why is it impossible to make a NaOH solution with a pOH= 7.82? (5pts)

all or nothing

~~pOH = 7.82~~ pH = 6.18 still acidic and cannot make ~~acidic~~ basic solution with ~~SB~~ acid

14) What volume of a 0.279 M hydrochloric acid solution is required to titrate to equivalence 26.0 mL of a 0.125 M potassium hydroxide solution? And what is the resulting pH 5 points −1 if no units

all or nothing

$$\frac{(0.125)(.026)}{0.279} = 11.6 \text{ ml of HCl}$$

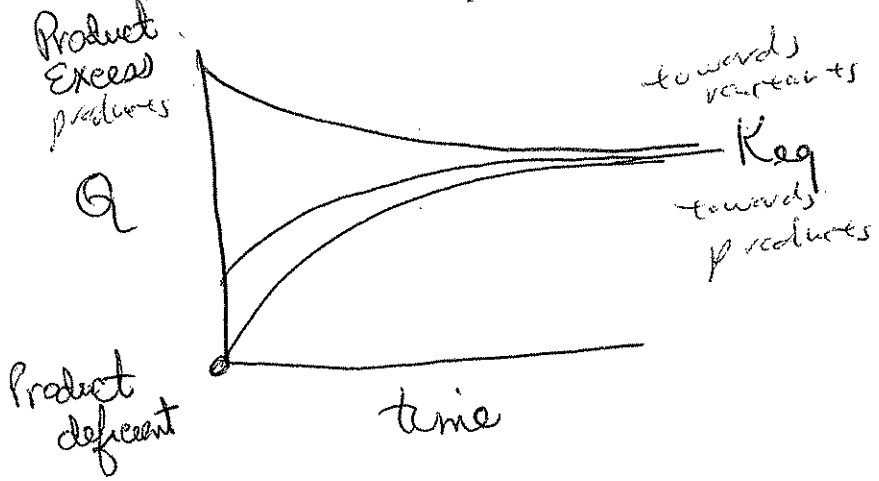
pH = 7.0

15-16) Draw a rough graph involving Q(Reaction Quotient) and time and explain how it relates to the direction of a reaction and equilibria. (10pt)

$aA + bB + cC + dD$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$Q \rightarrow K$ with time



reactants at least two lines
−3 if not at zero
explanation 5 points

25

PROBLEM (17-20) (20 pts)

The Reaction: $3Cl_{2\,(gas)} + N_{2(gas)} <==> 2\,NCl_{3(gas)}$
is found to be **EXOTHERMIC** and have a $K^{p}_{eq} = 7.1 \times 10^{-3}$ atmospheres @ 257 C

a) Discuss ways that one can use Le Chatelier's principle (to include EACH of the following: Reactants/Products, Temperature and Pressure) to produce the maximum quantity of NCl_3. (5pts)

(1) Add Cl_2 and or N_2
(2) Remove NCl_3
(3) Keep temperature low but not too low are never reach K
(4) Increase Pressure to force to right.

b) If one began with only Cl_2 and N_2 gases at partial pressures of 0.25 atm and 0.50 atm respectively; what would be the final pressure of NCl_3. SETUP only (5pts)

+4 pts

$3Cl_2 + N_2 \rightleftharpoons 2NCl_3$
$0.25-3x \quad 0.5-x \quad 2x$

$$\frac{(2x)^2}{(0.25-3x)^3(0.5-x)} = 7.1\times10^{-3}$$

Solve for x the $[NCl_3] = 2x$

c) Calculate (K^{c}_{eq}) for the above reaction (5pts)

$\Delta n = 2-4 = -2$

$K_p = K_c(RT)^{\Delta n}$

$$K_c = \frac{7.1\times10^{-3}}{[(.0821)(530)]^{-2}} = 13.43$$

Got sign wrong → 3.75×10^{-6} +3
Got T wrong C → 3.16 +3

d) Under what conditions is the Equilibrium Constant with Pressure (K^{p}_{eq}) EQUAL to the Equilibrium Constant for Concentration (K^{c}_{eq}) (5pts)

If $\Delta n = 0$ where Coef of product = coef of reactants
$c+d = a+b$

21) What concentration of Calcium hydroxide (it all dissolves) is needed to give an aqueous solution with a pH of 10.73

$pOH = 3.27$ $\quad [OH^-] = 5.37\times10^{-4}$

$Ca[OH]_2 = \frac{1}{2}[OH] = 2.69\times10^{-4}\,M$

Forgot to divide by 2 or multiplied by 2 (+3)

22) 35.0 ml of 0.12M Sulfuric Acid is mixed with 22.0 ml of 0.12M Sodium Hydroxide; what would be the final pH? *(Assume volumes are additive)*

$0.035\times2\times.12 = .0084$ moles of H_3O^+
$0.022\times.12 = 0.00264$ moles of OH^- (+2)

$$\frac{0.00576 \text{ moles of } H_3O^+}{.057\,L} = 0.101\,M$$ (+2)

$pH = 0.995$ (+1)

Forgot 2 for Sulfuric but all else correct
$pH = 1.56$ (+3)