General Chem. 102
Second Exam

Time: 60 min.
Date: 8/5/2012

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1 atm=760 mmHg , K=°C + 273 , R=8.314 J/mol.K=0.08206 L.atm/mol. K

$\ln\frac{k_1}{k_2}=\frac{E_a}{R}\left(\frac{1}{T_2}-\frac{1}{T_1}\right)$, $K_p=K_c\ (RT)^{\Delta n}$, $pH = pK_a + \log\ [base]/[acid]$

$K_w=1.0\times10^{-14}$

* * *

ANSWER SHEET

1. a b c d [✓ e]
2. a [✓ b] ~~c~~ d e
3. a [✓ b] c d e
4. [✓ a] b c d e
5. a b c [✓ d] e
6. [✓ a] b c d e
7. a b [✓ c] d e
8. a b c [✓ d] ~~e~~
9. a [✓ b] c d e
10. a b c ~~d~~ [✓ e]
11. [✓ a] b c d e
12. a b [✓ c] d e
13. a [✓ b] c d e
14. a b c [✓ d] e
15. [✓ a] b c d e
16. a b [✓ c] d e

Good Luck

Circle the *correct* answer for each of the following questions and put (x) on the *corresponding choice* on the *front page*:

1. Given that E_a for a certain reaction is 65 kJ/mol,and the rate constant is $2.5 \times 10^{-3}\ s^{-1}$ at 25.0 °C,what is the rate constant(in s^{-1}) at 37.0 °C?

a) 9.4×10^{-3} b) 5.9×10^{-3} c) 2.5×10^{-3} d) 8.1×10^{-3} [✓ e) 6.9×10^{-3}]

2. Which of the following statements is correct?

a) For an endothermic reaction, the activation energy of the reverse reaction is always greater than the activation energy of the forward reaction.

[✓ b)] The activation energy of a reaction is negative if the reaction is exothermic.

c) The activation energy of a reaction is always positive whether the reaction is endothermic or exothermic.

d) The activation energy of a reaction depends on the temperature of that reaction.

e) If the activation energy of the forward reaction is 95 kJ/mol, and ΔH of the reaction is 25 kJ/mol, then the activation energy of the reverse reaction is – 70 kJ/mol.

3. The proposed mechanism for the reaction

$$NO_2 + CO \rightarrow NO + CO_2$$

is:

$NO_2 + NO_2 \rightarrow NO_3 + NO$ slow
$NO_3 + CO \rightarrow NO_2 + CO_2$ fast

Which of the following statements is correct?

a) The rate law is : rate = $k[NO_2][CO]$

[✓ b)] The rate law is : rate = $k[NO_2]^2$

c) The rate law is : rate = $k[NO_3][CO]$

d) The rate law is : rate = $k[NO_2]^x[CO]^y$

e) NO_3 is a catalyst

4. For the reaction $A_2 + 2B \rightleftharpoons 2AB$, $K_c = 1.44$
Calculate K_c for the reaction:

$$AB \rightleftharpoons B + \frac{1}{2}A_2$$

[✓ a) 0.833] b) 0.344 c) 0.640 d) 1.00 e) 0.429

5. For the reaction system

$$CaCl_{2(s)} + 2H_2O_{(g)} \rightleftharpoons CaCl_2.2H_2O_{(s)}$$

The equilibrium constant expression; K_c , is:

a) $K_c = \frac{[CaCl_2.2H_2O]}{[CaCl_2][H_2O]^2}$ b) $K_c = \frac{1}{2[H_2O]}$ c) $K_c = [H_2O]^2$

[✓ d) $K_c = \frac{1}{[H_2O]^2}$] e) $K_c = \frac{[CaCl_2.2H_2O]}{[H_2O]^2}$

6. For the reaction:

$$4NO_{2(g)} \rightleftharpoons 2N_2O_{(g)} + 3O_{2(g)}$$

$K_c = 9.7\times10^{-4}$ at 25 °C, calculate K_p?

[✓ a) 2.4×10^{-2}] b) 8.8×10^{-6} c) 1.9×10^{-3} d) 4.1×10^{-2} e) 1.4×10^{-4}

7. The equilibrium reaction

$$NO_{(g)} + CO_{2(g)} \rightleftharpoons NO_{2(g)} + CO_{(g)}$$

has $K_c = 0.0400$ at 25 °C. If 0.800 mol $NO_{(g)}$ and 0.800 mol $CO_{2(g)}$ are introduced into an empty 2.00 L flask at this temperature. Determine the molar equilibrium concentration of $NO_{(g)}$?

a) 0.0400 b) 0.167 [✓ c) 0.333] d) 0.0833 e) 0.250

For the following reaction, $K_c = 7.5$ at 40 °C

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} + \text{heat}$$

Which of the following statements is correct?

a) If 2.0 moles of $NO_{2(g)}$ and 1.2 moles of $N_2O_{4(g)}$ were mixed in a 5.0 L container then the mixture is at equilibrium.
b) Increasing the temperature will not affect the value of K_c ✗
c) Increasing the pressure by decreasing the volume will increase the amount of $NO_{2(g)}$
[✓ d) Adding a catalyst will increase the amount of $N_2O_{4(g)}$.] ✓
e) Increasing the temperature will decrease the value of K_c

9. Calculate the pH of 0.40 M aqueous solution of HOCl (K_a=3.0×10^{-8})

a) 5.00 [✓ b) 3.96] c) 4.77 d) 3.81 e) 7.00

10. Given for the diprotic acid H_2X, $K_{a1} = 2.1\times10^{-6}$, $K_{a2} = 4.9\times10^{-12}$
Calculate the concentration of X^{2-} in 0.10 M aqueous solution of H_2X.

a) 4.9×10^{-11} b) 2.1×10^{-6} c) 1.8×10^{-10} d) 4.9×10^{-12} [✓ e) $2.8\times10^{[illegible]}$]

11. Given: K_a (CH_3COOH) = 1.8×10^{-5}, K_a ($HCOOH$) = 1.7×10^{-4}
K_a (HNO_2) = 4.5×10^{-4}, K_a (HF) = 7.1×10^{-4}

Which of the following is the correct order of base strength in aqueous solution?

[✓ a) $CH_3COO^- > HCOO^- > NO_2^- > F^-$]
b) $HCOO^- > CH_3COO^- > NO_2^- > F^-$
c) $CH_3COO^- > F^- > NO_2^- > HCOO^-$
d) $CH_3COO^- > NO_2^- > HCOO^- > F^-$
e) $F^- > NO_2^- > HCOO^- > CH_3COO^-$

12. Consider acid strength in aqueous solution, which of the following orders of acid strength is correct?

a) $H_2O > H_2S$ b) $HClO_3 > HClO_4$ [✓ c) $H_2SO_3 > H_2SeO_3$]
d) $H_3PO_3 > H_3PO_4$, e) $H_3PO_4 > HClO_4$

13. Calculate the % ionization of NH_3 in 0.020 M aqueous NH_3 solution, $K_b(NH_3) = 1.8\times10^{-5}$

a) 5.3 [✓ b) 3.0] c) 7.5 d) 1.3 e) 50.

14. Calculate the pH of 0.20 M $NaNO_2$ aqueous solution
K_a (HNO_2) = 7.1×10^{-4}

a) 8.52 b) 7.00 c) 8.72 [✓ d) 8.22] e) 9.03

15. Calculate the pH of a buffer that contains 0.40 M HCOOH and 0.82 M HCOONa. K_a (HCOOH) = 1.7×10^{-4}

[✓ a) 4.08] b) 4.37 c) 3.47 d) 3.77 e) 3.17

16. Calculate the **pH change** when 0.20 mol HCl are added to 1.00 L buffer solution that contains 0.60 mol CH_3COOH and 0.60 mol CH_3COONa. Assume no volume change. K_a (CH_3COOH) = 1.8×10^{-5}

a) 4.74 b) 0.30 [✓ c) -0.30] d) 0.15 e) -0.15

Bonus

17. Consider the equilibrium reaction:

$$CS_{2(g)} + 3Cl_{2(g)} \rightleftharpoons S_2Cl_{2(g)} + CCl_{4(g)}$$

When 1.00 mol of CS_2 and 3.00 mol of Cl_2 are placed in a 2.00 L container and allowed to react. At equilibrium, the mixture was found to contain 0.360 mol of CCl_4. Calculate the equilibrium constant K_c?

Answer:( )

①

$E_a = 65\ kJ/mol$

$K_1 = 2.5 \times 10^{-3}\ s^{-1}$

$T_1 = 25\ C°$

$T_2 = 37\ C°$

$K_2\ ?$

$$\ln \frac{K_1}{K_2} = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln(2.5\times10^{-3}) - \ln K_2 = \frac{65\times10^{3}\ J/mol}{8.314\ J/mol\cdot K}\left(\frac{1}{37+273} - \frac{1}{25+273}\right)$$

$$\ln(2.5\times10^{-3}) - \ln K_2 = 7818.14\left(\frac{1}{310} - \frac{1}{298}\right)$$

$$\ln(2.5\times10^{-3}) - \ln K_2 = -1.015$$

$$\begin{array}{l} -5.99 - \ln K_2 = -1.015 \\ +5.99 \end{array}$$

$$e^{-\ln K_2} = e^{-4.976}$$

$$\boxed{K_2 = 6.9016\ s^{-1}}$$

② ⓒ The activation energy of Reaction is always positive whether the Reaction is endothermic OR exothermic

③ ⓑ Always we write the law from Slow Rxn

$$NO_2 + NO_2 \longrightarrow NO_3 + NO$$

$$\text{rate} = k[NO_2]^2$$

④ first we divid the $K_c \rightarrow \frac{1}{K_c}$ (we get opposite direction) then we take the square root

ⓐ

$$\frac{1}{1.44} = 0.694 \xrightarrow{\text{S. root}} \boxed{0.833}$$

⑤ equilibrium constant, K_c include just the gases and Aquias materials,

$$CaCl_{2(s)} + \boxed{2H_2O_{(g)}} \rightleftharpoons CaCl_2 \cdot 2H_2O_{(s)}$$

ⓓ

$$K_c = \frac{1}{[H_2O]^2}$$

⑥

$$K_p = K_c(RT)^{\Delta n} \quad , \quad 4NO_2 \rightleftharpoons 2N_2O + 3O_2$$

$$= 9.7\times10^{-4}\left(0.0821\,\frac{\text{atm}\cdot L}{mol\cdot K} \times (25+273)\,K\right)^{5-4}$$

ⓐ

$$= 2.37\times10^{-2}$$

⑦ $NO + \cancel{CO}\, CO_2 \rightleftharpoons NO_2 + CO$

$K_c = 0.04$

0.8 NO mole

0.8 mol CO_2

V = 2L

molar equlm concentn NO ?!

initial

$$NO + CO_2 \rightleftharpoons NO_2 + CO$$

0.4 M 0.4 M

$(0.4 - x)$ $(0.4 - x)$ $+x$ $+x$

$$0.04 = \frac{x^2}{(0.4)^2}$$, neglict the $(-x)$

$x = 0.08$ M

$\boxed{[NO] \text{ at equlbm} = 0.4 - 0.08 = 0.32}$ ⓒ

⑧ $2NO_2 \rightleftharpoons N_2O + heat$, $K_c = 7.5$

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

$K_p = 7.5(313 \times 0.082)^{-1}$

$K_p = 2.77$ is constant

the Reaction between T and K_c , is Reversible

$\underline{\boxed{K_c}} = \frac{K_p}{(R\boxed{T})^{\Delta n}}$, K_p, R, Δn are constant

ⓔ Increasing the temperature will decrease the value of K_c

⑨ $HOCl \rightleftharpoons H^+ + OCl^-$

initial 0.4 · ·

At equilibrium $(0.4 - x)$ $+x$ $+x$

$K_a = \frac{[H^+][OCl^-]}{[HOCl]}$

$3 \times 10^{-8} = \frac{x^2}{0.4 - \underline{\underline{x}}}$ ← we can neglect it

$\sqrt{1.2 \times 10^{-8}} = \sqrt{x^2}$

$1.09 \times 10^{-4} = x = [H^+]$

$pH = -\log[H]^+$

$= -\log(1.09 \times 10^{-4})$

$\boxed{pH = 3.96}$ ⓑ

⑩ dipiotic mean we must dissosiate the H twice time.

$[H_2X] = 0.1M$, $Ka_1 = 2.1 \times 10^{-4}$ 6

$Ka_2 = 4.9 \times 10^{-12}$

[1] $H_2X \rightleftharpoons HX^- + H^+$

$(0.1-x)$ $+x$ $+x$

$Ka = \frac{x^2}{0.1-x}$ ← we can neglibit

$2.1 \times 10^{-6} = \frac{x^2}{0.1} \Rightarrow 0.21 \times 10^{-6}$

[illegible] $x = [XH^-] = 4.58 \times 10^{-4} M$

$\boxed{[illegible]}$ = [illegible]

[2] $HX^- \rightleftharpoons H^+ + X^{-2}$

$(0.458 \times 10^{-2} - x)$ $+x$ $+x$

$Ka_2 = \frac{x^2}{(0.458 \times 10^{-2} - x)}$

$4.9 \times 10^{-12} = \frac{x^2}{0.458 \times 10^{-3}}$

[illegible]

[illegible]

$[X^{-2}] = 4.73 \times 10^{-7} M$

⑪ Becaus of Ka↑ → the strength of Acid↑, But the Conjugate base↓ so, $HF > HNO_2 > HCOOH > CH_3COOH$ as Acid

$F^- < NO_2^- < HCOO^- < CH_3COO^-$ as Base ⓐ

⑫ ⓔ Becas more (H) atoms, more strength of Acid.

NO. (H) in H_3PO_4 > NO. (H) H_2ClO_4

⑬ $NH_3 \overset{H_2O}{\rightleftharpoons} NH_4^+ + OH^-$, $kb = 1.8 \times 10^{-5}$

$(0.02 - x)$ $+x$ $+x$

$kb = \frac{x^2}{(0.02-x)}$

$1.8 \times 10^{-5} = \frac{x^2}{(0.02-x)}$

$0.036 \times 10^{-5} = x^2$

$[OH]^- = 0.6 \times 10^{-3}$

percent ionization $= \frac{0.0006}{0.02} \times 100\%$

$\boxed{= 3.0}$ ⓑ

⑭ $NaNO_2 \longrightarrow Na^+ + NO_2^-$

initial 0.2 $\quad 0 \quad 0$

At the end 0 $\quad 0.2 \quad 0.2$

$$NO_2^- \underset{}{\overset{H_2O}{\rightleftharpoons}} HNO_2 + OH^-$$

0.2 $-x$ $\quad +x \quad +x$

$$0.14 \times 10^{-10} = \frac{x^2}{0.2 - x}$$

$$\sqrt{0.028 \times 10^{-10}} = \sqrt{x^2}$$

$$\boxed{x = 0.1673 \times 10^{-5} = [OH^-]}$$

$K_a \times K_b = K_w$

$7.1 \times 10^{-4}\, K_b = 1 \times 10^{-14}$

$K_b = 0.14 \times 10^{-10}$

$NaNO_2$ give basic effect "K_b"

$pOH = -\log[OH^-]$

$pOH = 5.77$

$pOH + pH = 14$

$\boxed{pH = 8.22}$ ⓓ

⑮ $HCOONa \longrightarrow HCOO^- + Na^+$

$0.82 \xrightarrow[\text{Conc. in dessoiation}]{} 0.82 \quad 0.82$

$HCOOH \rightleftharpoons HCOO^- + H^+$

$(0.4 - x) \quad (0.82 + x) \quad x$

$1.7 \times 10^{-4} = \frac{(0.82 + x) * x}{0.4 - x}$ ← neglect.

$0.68 \times 10^{-4} = 0.82\underline{x} + \underline{x}^2$

$[X] = [H]^+ = 0.169M$

$pH = -\log [H]^+$

$\boxed{pH = 4.08}$

⑯ **Befor adding Hcl "PH"**

$CH_3COONa \longrightarrow CH_3COO^- + Na^+$

$\frac{0.6\,mol}{1\,L} \xrightarrow[\text{conc}]{} 0.6M \quad 0.6M$

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$\frac{0.6\,mol}{1\,L} - x \quad (0.6+x) \quad x$

" from salt. "
we have 2 source of this ion is
salt / weak acid

$$1.8\times10^{-5} = \frac{(0.6+x)\,x}{0.6-x}$$

$0.108\times10^{-4} = 0.6x + x^2$

$[x] = [H^+] =$

$PH_1 = -\log[H]^+$

$$\boxed{PH_2 - PH_1 = -0.3}$$

After Adding Hcl "PH"
0.2M

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

$(0.6+0.2) - x \quad (0.6 - 0.2 + x) \quad (+x)$

$(0.8-x) \quad 0.4+x \quad x$

$$1.8\times10^{-5} = \frac{(0.4+x)\,x}{(0.8-x)}$$

$1.44\times10^{-5} = 0.4x + x^2$

$x = [H]^+ =$

$pH_2 = -\log[H^+] =$

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⑰ $CS_2 + 3Cl_2 \rightleftharpoons S_2Cl_2 + CCl_4$

$-x \quad -3x \quad +x \quad +x$

the value of $x = 0.18M$

$(0.5-0.18) \quad 1.5-(3*0.18) \rightleftharpoons 0.18 \quad 0.18$

$$K_c = \frac{(0.18)^2}{(0.32)(0.96)}$$

$$\boxed{K_c = 0.10546}$$

1 $CS_2 \xrightarrow{2L}$ 0.5 M

3 $Cl_2 \xrightarrow{2L}$ 1.5 M

At equlbm:

$CCl_4 = \frac{0.36\,mol}{2} = 0.18\,M$

$= [S_2Cl_2] = 0.18M$