

General Chem. 102
Second Exam

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

1 atm=760 mmHg, $K=^{\circ}\text{C} + 273$, $R=8.314 \text{ J/mol}\cdot\text{K}=0.08206 \text{ L}\cdot\text{atm/mol}\cdot\text{K}$

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

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

ANSWER SHEET

- | | | | | | | | | | | | |
|----|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-----|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| 1. | a | b | c | d | <input checked="" type="radio"/> e | 9. | a | <input checked="" type="radio"/> b | c | d | e |
| 2. | a | <input checked="" type="radio"/> b | c | d | e | 10. | a | b | c | d | <input checked="" type="radio"/> e |
| 3. | a | <input checked="" type="radio"/> b | c | d | e | 11. | <input checked="" type="radio"/> a | b | c | d | e |
| 4. | <input checked="" type="radio"/> a | b | c | d | e | 12. | a | b | <input checked="" type="radio"/> c | d | e |
| 5. | a | b | c | <input checked="" type="radio"/> d | e | 13. | a | <input checked="" type="radio"/> b | c | d | e |
| 6. | <input checked="" type="radio"/> a | b | c | d | e | 14. | a | b | c | <input checked="" type="radio"/> d | e |
| 7. | a | b | <input checked="" type="radio"/> c | d | e | 15. | <input checked="" type="radio"/> a | b | c | d | e |
| 8. | a | b | c | <input checked="" type="radio"/> d | e | 16. | a | b | <input checked="" type="radio"/> 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 $2.5 \times 10^{-3} \text{ s}^{-1}$ 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



is:



Which of the following statements is correct?

- a) The rate law is : rate = $k[\text{NO}_2][\text{CO}]$
- (b)** The rate law is : rate = $k[\text{NO}_2]^2$
- c) The rate law is : rate = $k[\text{NO}_3][\text{CO}]$
- d) The rate law is : rate = $k[\text{NO}_2]^2[\text{CO}]$
- 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:



- a) 0.833 b) 0.344 c) 0.640 d) 1.00 e) 0.429

5. For the reaction system



The equilibrium constant expression; K_c , is:

- a) $K_c = \frac{[CaCl_2 \cdot 2H_2O]}{[CaCl_2][H_2O]^2}$ b) $K_c = \frac{1}{2[H_2O]}$ c) $K_c = [H_2O]^2$
 d) $K_c = \frac{1}{[H_2O]^2}$ e) $K_c = \frac{[CaCl_2 \cdot 2H_2O]}{[H_2O]^2}$

6. For the reaction:



$K_c = 9.7 \times 10^{-4}$ at 25 °C, calculate K_p ?

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

7. The equilibrium reaction



has $K_c = 0.0400$ at 25°C . If 0.800 mol $\text{NO}_{1(g)}$ and 0.800 mol $\text{CO}_{2(g)}$ are introduced into an empty 2.00 L flask at this temperature. Determine the molar equilibrium concentration of $\text{NO}_{1(g)}$?

- 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



Which of the following statements is correct?

- a) If 2.0 moles of $\text{NO}_{2(g)}$ and 1.2 moles of $\text{N}_2\text{O}_{4(g)}$ 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 $\text{NO}_{2(g)}$.
- d) Adding a catalyst will increase the amount of $\text{N}_2\text{O}_{4(g)}$.
- e) Increasing the temperature will decrease the value of K_c .

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

- a) 5.00 b) 3.96 c) 4.77 d) 3.81 e) 7.00

10. Given for the diprotic acid H_2X , $K_{a1} = 2.1 \times 10^{-6}$, $K_{a2} = 4.9 \times 10^{-12}$. 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) 2.8×10^{-9}

11. Given: $K_a(\text{CH}_3\text{COOH}) = 1.8 \times 10^{-5}$, $K_a(\text{HCOOH}) = 1.7 \times 10^{-4}$
 $K_a(\text{HNO}_2) = 4.5 \times 10^{-4}$, $K_a(\text{HF}) = 7.1 \times 10^{-4}$

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

- a) $\text{CH}_3\text{COO}^- > \text{HCOO}^- > \text{NO}_2^- > \text{F}^-$
b) $\text{HCOO}^- > \text{CH}_3\text{COO}^- > \text{NO}_2^- > \text{F}^-$
c) $\text{CH}_3\text{COO}^- > \text{F}^- > \text{NO}_2^- > \text{HCOO}^-$
d) $\text{CH}_3\text{COO}^- > \text{NO}_2^- > \text{HCOO}^- > \text{F}^-$
e) $\text{F}^- > \text{NO}_2^- > \text{HCOO}^- > \text{CH}_3\text{COO}^-$
12. Consider acid strength in aqueous solution, which of the following orders of acid strength is correct?

- a) $\text{H}_2\text{O} > \text{H}_2\text{S}$ b) $\text{HClO}_3 > \text{HClO}_4$ c) $\text{H}_2\text{SO}_3 > \text{H}_2\text{SeO}_3$
d) $\text{H}_3\text{PO}_3 > \text{H}_3\text{PO}_4$ e) $\text{H}_3\text{PO}_4 > \text{HClO}_4$

13. Calculate the % ionization of NH_3 in 0.020 M aqueous NH_3 solution, $K_b(\text{NH}_3) = 1.8 \times 10^{-5}$

- 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
 $K_a(\text{HNO}_2) = 7.1 \times 10^{-4}$

- 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 CH₃COOH and 0.60 mol CH₃COONa. Assume no volume change. K_a (CH₃COOH) = 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:



When 1.00 mol of CS₂ and 3.00 mol of Cl₂ are placed in a 2.00 L container and allowed to react. At equilibrium, the mixture was found to contain 0.360 mol of CCl₄. Calculate the equilibrium constant K_c ?

Answer: ()

①

$$E_a = 65 \text{ kJ/mol}$$

$$k_1 = 2.5 \times 10^{-3} \text{ s}^{-1}$$

$$T_1 = 25 \text{ }^\circ\text{C}$$

$$T_2 = 37 \text{ }^\circ\text{C}$$

$$k_2 = ?$$

$$\ln \frac{k_1}{k_2} = \frac{E_a}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

$$\ln(2.5 \times 10^{-3}) - \ln k_2 = \frac{65 \times 10^3 \text{ J/mol}}{8.314 \text{ J/mol} \cdot \text{K}} \left(\frac{1}{37+273} - \frac{1}{25+273} \right)$$

$$\ln(2.5 \times 10^{-3}) - \ln k_2 = 7818.14 \left(\frac{1}{310} - \frac{1}{298} \right)$$

$$\ln(2.5 \times 10^{-3}) - \ln k_2 = -1.015$$

$$\begin{array}{r} -5.99 \\ +5.99 \end{array} - \ln k_2 = -1.015$$

$$-\ln k_2 = -4.976$$

$$k_2 = 6.9016 \text{ s}^{-1}$$

2) (c) The activation energy of Reaction is always positive whether the Reaction ~~is~~ endothermic or exothermic.

3) (b) Always we write the law from slow Rxn.

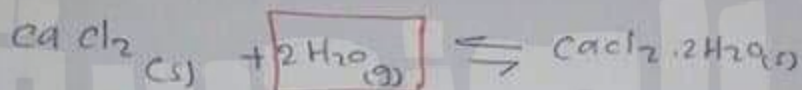


$$\text{rate} = k [\text{NO}_2]^2$$

4) First we divide the $k_c \rightarrow \frac{1}{k_c}$ (we get opposite direction) then we take the square root

a) $\frac{1}{1.44} = 0.694 \xrightarrow{\text{sq. root}} \boxed{0.833}$

5) equilibrium constant, k_c include just the gaseous and aqueous materials,

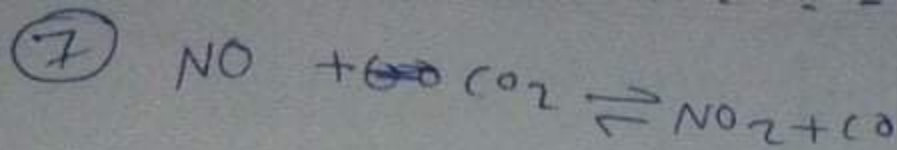


d) $k_c = \frac{1}{[\text{H}_2\text{O}]^2}$

6) $k_p = k_c (RT)^{\Delta n}$, $4\text{NO}_2 \rightleftharpoons 2\text{N}_2\text{O} + 3\text{O}_2$

$$= 9.7 \times 10^{-4} \left(\frac{0.0821 \text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times (25+273) \text{K} \right)^{5-4}$$

a) $= 2.37 \times 10^{-2}$



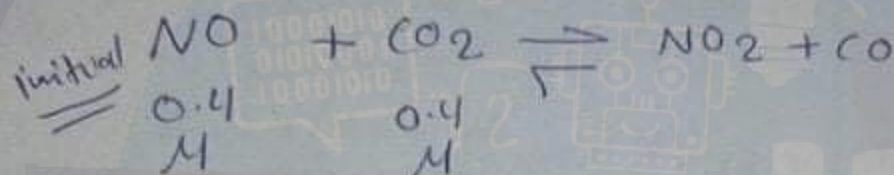
$$K_c = 0.04$$

0.8 NO mole

0.8 mol CO_2

$$V = 2 \text{ L}$$

molar equm. concn $\text{NO} = 1$

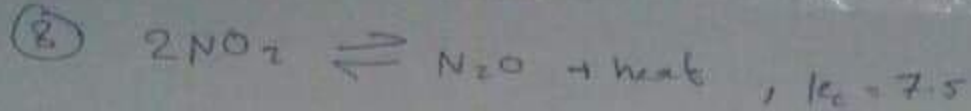


$$(0.4 - x) \quad (0.4 - x) \quad + x \quad + x$$

$$0.04 = \frac{x^2}{(0.4)^2} \quad , \text{ neglect } +ve (-x)$$

$$x = 0.08 \text{ M}$$

$$\boxed{[\text{NO}] \text{ at equilibrium} = 0.4 - 0.08 = 0.32 \text{ } \textcircled{C}}$$



the Reaction between $k_p = k_c (RT)^{\Delta n}$

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

$$k_p = 2.77 \text{ is constant}$$

the Reaction between

and it is Reversible

$$k_c = \frac{k_p}{(RT)^{\Delta n}}, \quad k_p, k_i, \Delta n \text{ are constant}$$

9) Increasing the temperature will decrease the value of k_c

9



initial 0.4

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

$$K_a = \frac{[\text{H}^+][\text{ocl}^-]}{[\text{Hocl}]}$$

$$3 \times 10^{-8} = \frac{x^2}{0.4-x}$$

← we can neglect it

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

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

$$\text{pH} = -\log[\text{H}^+]$$

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

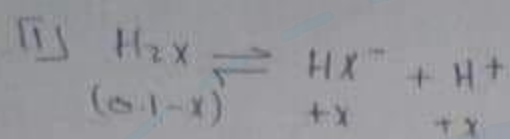
$$\text{pH} = 3.96$$

10

10) diprotic mean we must deprotonate the H twice time.

$$[H_2X] = 0.1M, \quad K_{a1} = 2.1 \times 10^{-6}$$

$$K_{a2} = 4.9 \times 10^{-12}$$

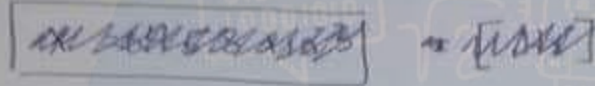


$$K_{a1} = \frac{x^2}{0.1-x}$$

we can neglect it

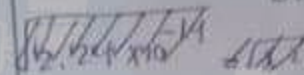
$$2.1 \times 10^{-6} = \frac{x^2}{0.1} \Rightarrow 0.21 \times 10^{-6}$$

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



$$K_{a2} = \frac{x^2}{(0.458 \times 10^{-4} - x)}$$

$$4.9 \times 10^{-12} = \frac{x^2}{0.458 \times 10^{-4}}$$

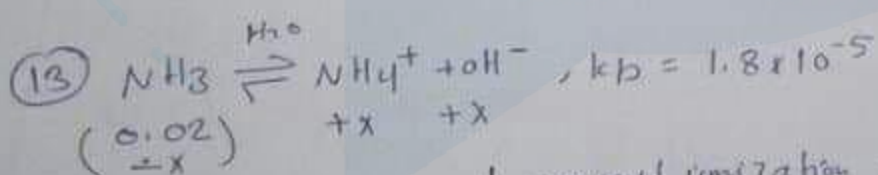


$$x = 1.498 \times 10^{-7}$$

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

11) Because of $K_a \uparrow \rightarrow$ the strength of Acid \uparrow , But the Conjugate base \downarrow so, $HF > HNO_2 > HCOOH > CH_3COOH$ as Acid
 $F^- < NO_2^- < HCOO^- < CH_3COO^-$ as Base (a)

12) (e) Because more (H) atoms, more strength of Acid.
 NO. (H) in $H_3PO_4 >$ NO. (H) in $HClO_4$



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

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

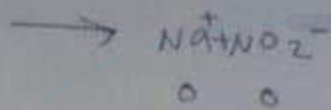
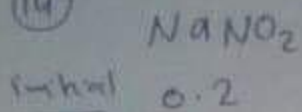
$$0.036 \times 10^{-5} = x^2$$

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

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

$$= 3.0 \quad (b)$$

(14)



$$K_a \times K_b = K_w$$

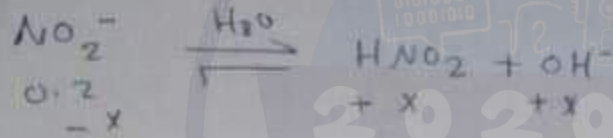
$$7.1 \times 10^{-4} K_b = 1 \times 10^{-14}$$

At the end 0

0.2 0.2

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

SiHx
 NaNO_2 give basic effect "Kb"



0.2
-x

+x +x

$$\text{pOH} = -\log[\text{OH}^-]$$

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

$$= \frac{x^2}{0.2-x}$$

* $\text{pH} = 14 - \text{pOH}$

$$\text{pOH} = 4.77$$

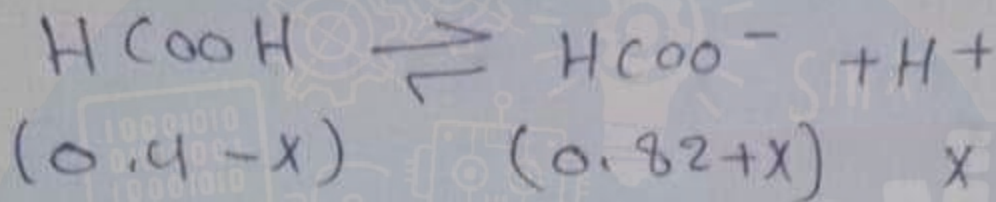
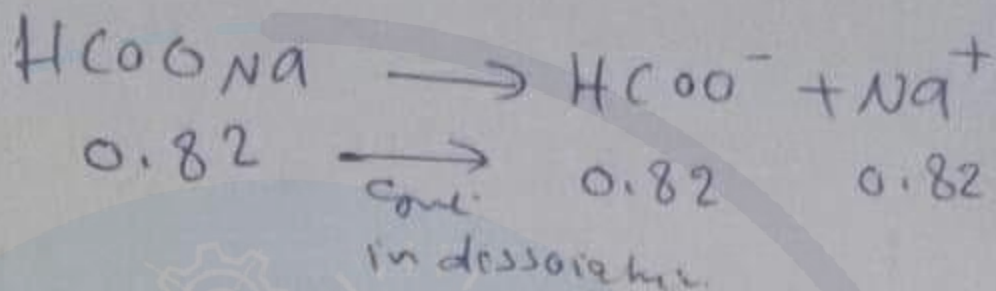
$$\sqrt{0.028 \times 10^{-10}} = \sqrt{x^2}$$

$$\text{pOH} + \text{pH} = 14$$

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

$$\text{pH} = 8.22 \quad \text{(d)}$$

15



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

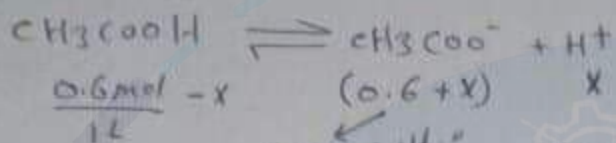
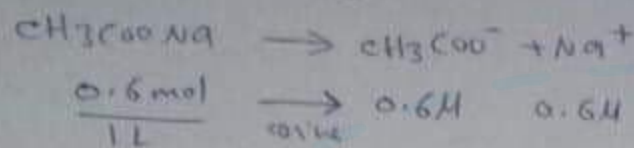
$$0.68 \times 10^{-4} = 0.82x + x^2$$

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

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

$$pH = 4.08$$

16) Before adding HCl "pH"



"from salt" we have 2 source of this ions
salt weak acid

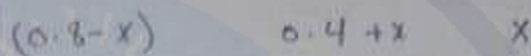
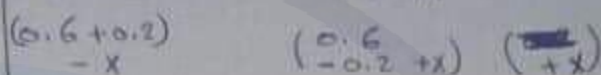
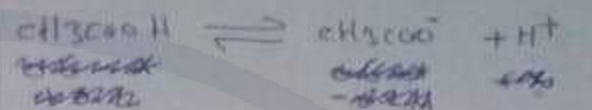
$$1.8 \times 10^{-5} = \frac{(0.6 + x) x}{0.6 - x}$$

$$0.108 \times 10^{-4} = 0.6x + x^2$$

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

$$\text{pH}_1 = -\log [H^+]^+$$

After Adding HCl "pH"



$$1.8 \times 10^{-5} = \frac{(0.4 + x) x}{(0.8 - x)}$$

$$1.44 \times 10^{-5} = 0.4x + x^2$$

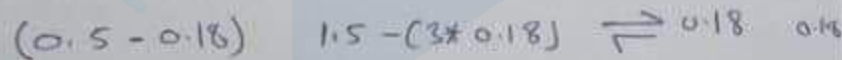
$$x = [H^+]^+$$

$$\text{pH}_2 = -\log [H^+] =$$

$$\text{pH}_2 - \text{pH}_1 = -0.3$$

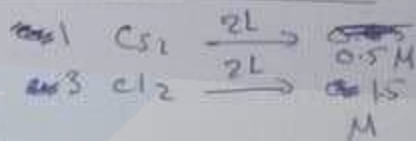


the value of $x = 0.18 \text{ M}$



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

$$K_c = 0.10546$$



At equilibrium:

$$\text{CCl}_4 = \frac{0.36 - 0.18}{2} = 0.09 \text{ M}$$

$$= [\text{S}_2\text{Cl}_2] = 0.18 \text{ M}$$