2002학년도 2학기 화학2 중간고사 풀이

1. (a) 표준상태 : 25°C (298.15K), 1 기압 5

(b) $\frac{1}{2}O_2(g) + H_2(g) \rightarrow H_2O(l)$ 10

(c) 0 KJ/mol 5

(d) 열역학 제3법칙 : 절대0도 (0K)에서 perfect crystal (결함 없는 결정)의 entropy는 0이다.

· 따라서 절대0도보다 높은 온도에서 모든 물질의 entropy는 양수이다. 10

(e) $\Delta H^\circ = \Delta H_f^\circ(Br_2(g)) + \Delta H_f^\circ(SO_2(g)) + 2\Delta H_f^\circ(H_2O(l))$

$- 2\times\Delta H_f^\circ(HBr(g)) - \Delta H_f^\circ(H_2SO_4(l))$

$= 30.91 + (-296.8) + 2\times(-285.8) - 2\times(-36.4) - (-814.0)$

$= \boxed{49.3\ (KJ/mol)}$ 10

(f) $\Delta S = S^\circ(Br_2(g)) + S^\circ(SO_2(g)) + 2\times S^\circ(H_2O(l))$

$- 2S^\circ(HBr(g)) - S^\circ(H_2SO_4(l))$

$= 245.4 + 241.8 + 2\times(69.91) - 2\times(198.59) - 156.9$

$= 72.9\ (J/K\cdot mol)$

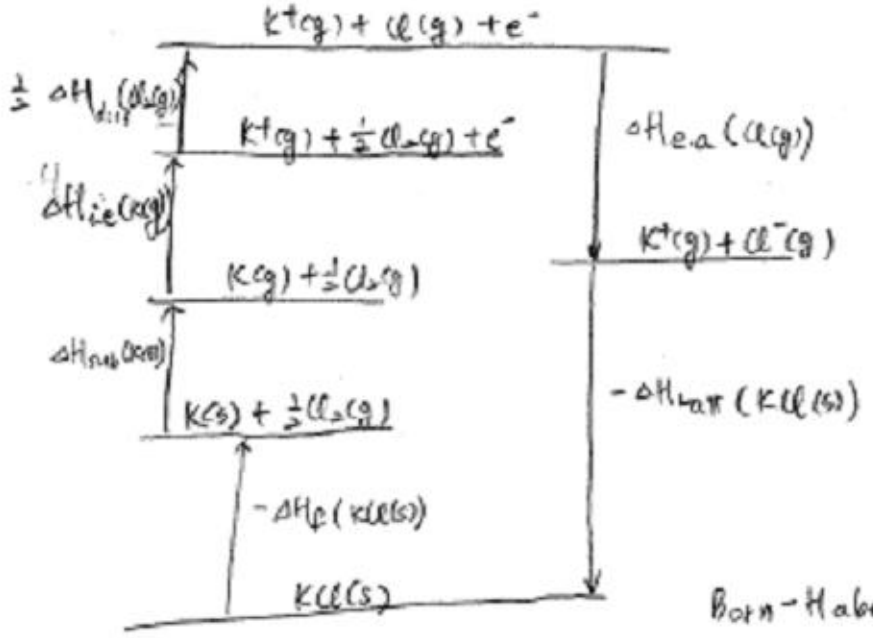
$\Delta G = \Delta H - T\Delta S$ $(150^\circ C = 423K)$

$= 49.3\ KJ/mol - 423K \times 72.9\ J/K\cdot mol$

$= \boxed{18.5\ KJ/mol}$

$\Delta G > 0$ ∴ 이 반응이 자발적 (150°C에서) 10

2. ~~30~~



Born-Haber cycle

$$0 = -\Delta H_f(KCl(s)) + \Delta H_{sub}(K(s)) + \Delta H_{ie}(K(g))$$

$$+\tfrac{1}{2}\Delta H_{diss}(Cl_2(g)) + \Delta H_{e.a}(Cl(g)) - \Delta H_{Latt}(KCl(s))$$

$$= -(-438) + 89 + 425 + \tfrac{1}{2}\times 244 + (-355) - \Delta H_{Latt}(KCl(s))$$

$$= 719\ (kJ/mol) - \Delta H_{Latt}(KCl(s))$$

$$\therefore \Delta H_{Latt}(KCl(s)) = \boxed{719\ kJ/mol}$$

3. (a) $\frac{d[NOCl]}{dt} = -k[NOCl]^n$

or $\left(Rate = -\frac{d[NOCl]}{dt} = k[NOCl]^n \right)$

$Rate_1 = 6.64 \times 10^3 = k(1.0 \times 10^{16})^n$

$Rate_2 = 2.66 \times 10^4 = k(2.0 \times 10^{16})^n$

$\frac{Rate\,1}{Rate\,2} = 0.25 \left(= \frac{1}{4}\right) = \left(\frac{1}{2}\right)^n$

$\therefore n = 2$

$\therefore \frac{d[NOCl]}{dt} = -k[NOCl]^2$

$\left(or\ -\frac{d[NOCl]}{dt} = k[NOCl]^2 \right)$ 10

(b) $-\frac{d[NOCl]}{dt} = k[NOCl]^2$

$-\frac{d[NOCl]}{[NOCl]^2} = k\,dt$

$\left[\frac{1}{[NOCl]} \right]_{[NOCl]_0}^{[NOCl]} = k[t]_{t=0}^{t=t}$

$\frac{1}{[NOCl]} - \frac{1}{[NOCl]_0} = kt$ 10

$\therefore \frac{1}{[NOCl]} = kt + \frac{1}{[NOCl]_0} \left(or\ [NOCl] = \frac{[NOCl]_0}{[NOCl]_0 kt + 1} \right)$

3. cont'd

(c)

$$Rate_1 = 6.64 \times 10^3 \text{ molecules/cm}^3\cdot\text{s}$$

$$= k(1.0 \times 10^{16} \text{ molecules/cm}^3)^2$$

$$\therefore k = \frac{6.64 \times 10^3 \text{ molecules/cm}^3\cdot\text{s}}{1.0 \times 10^{32} \text{ molecules}^2/\text{cm}^6}$$

$$= \boxed{6.64 \times 10^{-29} \text{ cm}^3/\text{molecules}\cdot\text{s}} \quad (10)$$

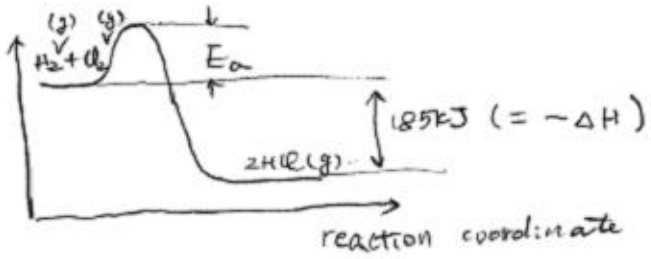
(d) $k = 6.64 \times 10^{-29} \text{ cm}^3/\text{molecules}\cdot\text{s}$

$$= 6.64 \times 10^{-29} \left(10^{-3} \text{ L} / \frac{1}{6.022 \times 10^{23}} \text{ mol}\right)$$

$$= \boxed{4.00 \times 10^{-8} \text{ (L/mol}\cdot\text{s)}}$$

$$\text{or} = \boxed{4.00 \times 10^{-8} \text{ (}^1/\text{M}\cdot\text{s)}} \quad (10)$$

4. (a)



(10)

(b) 발열반응

5

(c) $H_2(g)$와 $Cl_2(g)$의 농도 증가

온도 증가

촉매 사용

(10)

5. $aA \longrightarrow$ product (P)

속도법칙식 $\quad \frac{d[P]}{dt} = k[A]$

$\therefore -\frac{d[A]}{dt} = k[A]$

$\frac{d[A]}{[A]} = -k\,dt$

$\left[\ln[A]\right]_{[A]_0}^{[A]} = \left[-kt\right]_{t=0}^{t=t}$

$\ln\frac{[A]}{[A]_0} = -kt$

$t = t_{1/2}$ (반감기 of/m) $\quad [A] = \frac{1}{2}[A]_0$

$\therefore \ln\frac{\frac{1}{2}[A]_0}{[A_0]} = -kt_{1/2}$

$\therefore \boxed{t_{1/2} = \frac{1}{k}\ln 2}$ 30

6. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

$K = \frac{[NH_3]^2}{[N_2][H_2]^3} = 1.3\times10^{-2} \equiv A$

(a) $K = \frac{[NH_3]}{[N_2]^{1/2}[H_2]^{3/2}} = (A)^{1/2} = 0.11$ 5

(b) $K = \frac{[N_2][H_2]^3}{[NH_3]^2} = \frac{1}{A} = 77$ 5

(c) $K = \frac{[N_2]^{1/2}[H_2]^{3/2}}{[NH_3]} = \frac{1}{(A)^{1/2}} = 8.8$ 5

(d) $K = \frac{[NH_3]^4}{[N_2]^2[H_2]^6} = A^2 = 1.7\times10^{-4}$ 5

7. $H_2(g) + I_2(g) \rightarrow 2HI(g)$

(a) $K_p = \dfrac{P_{HI}^2}{P_{H_2} P_{I_2}} = \dfrac{\left(\frac{n_{HI}}{V}\right)^2 R^2 T^2}{\left(\frac{n_{H_2}}{V}\right)RT \times \left(\frac{n_{I_2}}{V}\right)RT}$

$= \dfrac{C_{HI}^2}{C_{H_2} C_{I_2}} = K_c = \boxed{50}$

(b) $H_2(g) + I_2(g) \rightarrow 2HI$ 부피 = 10 L

처음 1g 127g

↓ ↓

0.5 mol 0.5 mol

반응한 $(0.5-x)$ mol $(0.5-x)$ mol $2x$ mol

∴ 전체 기체 mol 수 $= (0.5-x) + (0.5-x) + 2x = 1$ mol

$P_{total} = P_{H_2} + P_{I_2} + P_{HI}$

$= \dfrac{n_{H_2} + n_{I_2} + n_{HI}}{V} RT \quad \left(= \dfrac{n_{H_2}}{V}RT + \dfrac{n_{I_2}}{V}RT + \dfrac{n_{HI}}{V}RT\right)$

$= \dfrac{1 \text{ mol}}{10 \text{ L}} \times 0.08206 \text{ L·atm/mol·K} \times (448 + 273) \text{K}$

$= \boxed{5.92 \text{ atm}}$

(c) $K = \dfrac{C_{HI}^2}{C_{H_2} C_{I_2}} = \dfrac{n_{HI}^2}{n_{H_2} n_{I_2}} = \dfrac{(2x)^2}{(0.5-x)(0.5-x)}$

$= \left(\dfrac{2x}{0.5-x}\right)^2 = 50$

$\dfrac{2x}{0.5-x} = \sqrt{50}$ ∴ $(2+\sqrt{50})x = 0.5\sqrt{50}$

∴ $x = \dfrac{0.5\sqrt{50}}{2+\sqrt{50}} = 0.39$ mol

(c) cont'd

$\therefore n_{HI} = 2x = 0.78 \text{ mol}$

$n_{H_2} = 0.5 - x = 0.11 \text{ mol}$

$n_{I_2} = 0.5 - x = 0.11 \text{ mol}$

$\therefore P_{H_2} = \frac{n_{H_2}}{n_{total}} P_{total} = \frac{0.11 \text{ mol}}{1 \text{ mol}} \times 5.92 \text{ atm} = \boxed{0.65 \text{ atm}}$

$P_{I_2} = P_{H_2} = \boxed{0.65 \text{ atm}}$ 15

$P_{HI} = P_{total} - P_{I_2} - P_{H_2} = 5.92 \text{ atm} - (0.65 \text{ atm}) \times 2 = \boxed{4.62 \text{ atm}}$

(d) from (c)

$n_{H_2} = 0.11 \text{ mol}$

$n_{I_2} = 0.11 \text{ mol}$

$n_{HI} = 0.78 \text{ mol}$ 15

(e)

$Mass_{H_2} = n_{H_2} \times \text{molecular weight}$

$= 0.11 \text{ mol} \times 2 \text{ g/mol} = \boxed{0.22 \text{ g}}$

$Mass_{I_2} = 0.11 \text{ mol} \times 254 \text{ g/mol} = \boxed{27.9 \text{ g}}$ 15

$Mass_{HI} = 0.78 \text{ mol} \times 128 \text{ g/mol} = \boxed{99.8 \text{ g}}$

8. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

(a) $\longrightarrow$ (정반응) 5

(b) $\longleftarrow$ (역반응) 5

(c) $\longrightarrow$ (정반응) 5

(d) 무변화 5

(e) $\longleftarrow$ (역반응) 5

(f) $\longrightarrow$ (정반응) 5

9. (a) $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$

처음 0.1M

평형 $(0.1-x)$ M $\quad x$ M $\quad x$ M

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = \frac{x^2}{0.1-x} \simeq \frac{x^2}{0.1} = 1.8\times10^{-5}$$

$0.1 - x \simeq 0.1$

$x^2 = 1.8\times10^{-6}$

$\therefore x = [H_3O^+] = (1.8\times10^{-6})^{1/2} = 1.3\times10^{-3}$ M (1.34×10^{-3})

5 $\therefore pH = -\log[H_3O^+] = \boxed{2.9}$ (2.87)

9. cont'd

(b)

$NaOH \longrightarrow Na^+ + OH^-$

$0.1\,M \times 40\,mL = 4\,mmol$ → 100% 해리 → $4\,mmol$ $4\,mmol$

$CH_3COOH + OH^- \longrightarrow H_2O + CH_3COO^-$

반응전 $0.1\,M$ $50\,mL$ $4\,mmol$

$= 5\,mmol$

반응후 $1\,mmol$ $0\,mol$ $4\,mmol$ $4\,mmol$

$CH_3COOH + H_2O \longrightarrow H_3O^+ + CH_3COO^-$

처음 $1\,mmol$ 0 $4\,mmol$

평형 $(1-x)\,mmol$ $x\,mmol$ $(4+x)\,mmol$

전체 부피 $= 90\,mL$

$$\therefore K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = \frac{\frac{4+x}{90} \cdot \frac{x}{90}}{\frac{1-x}{90}} = 1.8 \times 10^{-5}$$

$$\therefore \frac{(4+x)x}{1-x} = 1.8 \times 10^{-5} \times 90 = 1.6 \times 10^{-3}$$

($4+x \approx 0$, $1-x \approx 0$)

$$\therefore x = 4.0 \times 10^{-4}$$

$$\therefore [H_3O^+] = \frac{x\,mmol}{90\,mL} = \frac{4.0 \times 10^{-4}}{90}\,M = 4.5 \times 10^{-5}\,M$$

$$\therefore pH = -\log[H_3O^+] = \boxed{5.3} \quad (5.346)$$

10

(c) $NaOH \longrightarrow Na^+ + OH^-$

$0.1M \times 50ml = 5mmol$ $\quad 5mmol \quad 5mmol$

$CH_3COOH + OH^- \longrightarrow H_2O + CH_3COO^-$

반응전 $\quad 5mmol \quad 5mmol$

반응후 $\quad 0 \quad 0 \quad 5mmol \quad 5mmol$

$CH_3COO^- + H_2O \longrightarrow CH_3COOH + OH^-$

처음 $\quad 5mmol \quad 0 \quad 0$

평형 $\quad (5-x)mmol \quad x\,mmol \quad x\,mmol$

$$K_b = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]} = \frac{K_w}{K_a} = \frac{10^{-14}}{1.8\times10^{-5}} = 5.6\times10^{-10}$$

전체부피 100ml

$$\therefore K_b = \frac{\frac{x}{100}\cdot\frac{x}{100}}{\frac{5-x}{100}} = 5.6\times10^{-10}$$

$$\therefore \frac{x^2}{5-x} = 5.6\times10^{-8}$$

$5-x \approx 0$

$$\therefore x = 5.3\times10^{-4}$$

$$\therefore [OH^-] = \frac{x\,mmol}{100\,ml} = 5.3\times10^{-6}$$

$$\therefore pOH = -\log[OH^-] = 5.3$$

$$\therefore pH = 14 - pOH = \boxed{8.7}\ (8.72)$$ (O)

(d) $CH_3COOH + OH^- \longrightarrow CH_3COO^- + H_2O$

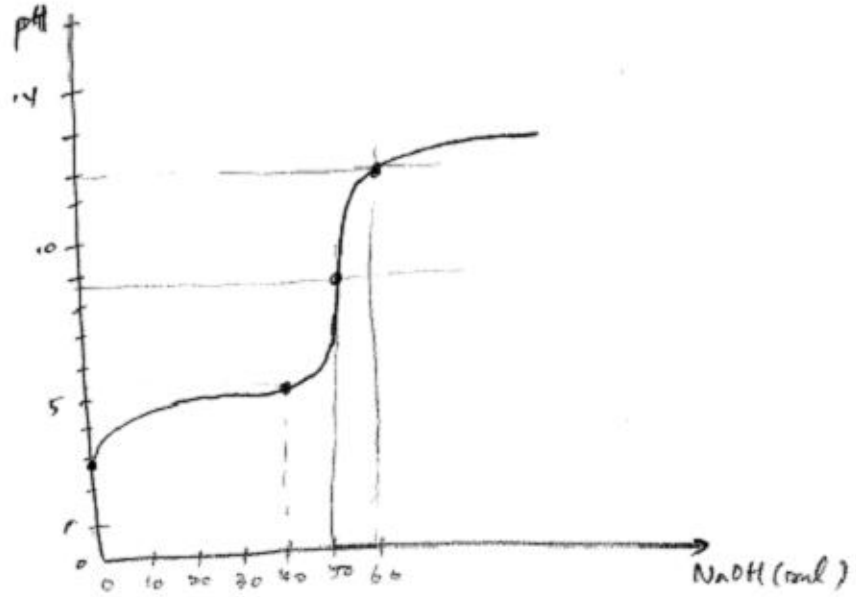
반응전 $\quad 5mmol \quad 6mmol$

반응후 $\quad 0 \quad 1mmol \quad 5mmol \quad 5mmol$

$$\therefore [OH^-] = \frac{1mmol}{110ml} = 9.1\times10^{-3}\,M$$

$$\therefore pOH = 2.0 \quad \therefore pH = 12.0 \quad (11.96)$$ (O)

(e)



10.

$$NaCH_3COO(aq) \rightleftharpoons Na^+(aq) + CH_3COO^-(aq)$$

0.1 M

$\longrightarrow$ 0.1 M 0.1 M

$$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$$

初 0.1M

平衡 (0.1-x) M x M x M

$$K_b = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]} = \frac{K_w}{K_a} = \frac{10^{-14}}{1.8\times10^{-5}} = 5.6\times10^{-10}$$

$$\therefore K_b = \frac{x^2}{0.1-x} = 5.6\times10^{-10}$$

($0.1-x \simeq 0$)

$$\therefore x = [OH^-] = (5.6\times10^{-11})^{1/2} = \boxed{7.5\times10^{-6}\ M}$$

$$\therefore pOH = -\log[OH^-] = 5.1$$

$$\therefore pH = 14 - pOH = \boxed{8.9}\ (8.87)$$

11.

(a) $pH = 7$ 5

(b) $NaOH \longrightarrow Na^+(aq) + OH^-(aq)$

0.01 mol → 0.01 mol 0.01 mol

$$[OH^-] = \frac{0.01\ mol}{1\ L} = 0.01\ M$$

$$\therefore pOH = -\log[OH^-] = 2$$

$$\therefore \boxed{pH = 12}$$ 5

(c) Henderson - Hasselbalch eq.

$$pH = pK_a + \log \frac{[Base]}{[Acid]}$$

$$= pK_a + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

$$= -\log(1.8 \times 10^{-5}) + \log \frac{0.25}{0.1}$$ 10

$$= \boxed{5.1} \quad (5.14)$$

(d)

CH_3COOH	+ OH^-	→ CH_3COO^-	+ H_2O
$0.1\ M \times 1\ L$	0.01 mol	0.25 mol	
$= 0.1$ mol			
0.09 mol		0.26 mol	0.01 mol

$$\therefore pH = pK_a + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

$$= -\log(1.8 \times 10^{-5}) + \log \frac{0.26}{0.09}$$

$$= \boxed{5.2} \quad (5.21).$$ 10