THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

CHE2615 TEST 2 **SOLUTIONS**

80/80

Solution 1

(a)

i)

$$\left(\frac{dG}{d\xi}\right)_{T,P} = \Delta G^{o}_{rxn} + RT\ln\prod_{i=1}^{N} a_{i,eq}^{\nu_i} \qquad (1\ mk)$$

$$\prod_{i=1}^{N} a_{i,eq}^{\nu_i} = \frac{a_C}{a_A a_B} = \frac{P_C}{P_A P_B} = \frac{0.25\ bar}{(1\ bar)(0.5\ bar)} = 0.5\ bar \qquad (1\ mk)$$

For an ideal gas $a_i = P_i$

$$\left(\frac{dG}{d\xi}\right)_{T,P} = -10000\frac{J}{\text{mol}} + \left(8.3145\frac{J}{\text{K mol}}\right)(298.15\ K)\ln(0.5\ bar)$$

$$= -11.718\frac{KJ}{\text{mol}} \qquad (2\ mks)$$

ii)

$$\Delta G^{o} = -RT\ln K_{eq} \qquad (1\ mk)$$

$$\ln K_{eq} = -\frac{\Delta G^{o}}{RT}$$

$$\ln K_{eq} = -\frac{\left(-10000\frac{J}{\text{mol}}\right)}{\left(8.3145\frac{J}{\text{mol}\,K}\right)(298.15\ K)} = 4.0339 \qquad (1\ mk)$$

$$K_{eq} = e^{4.0339} = 56.483 \qquad (0.5\ mk)$$

$$Q = \prod_{i=1}^{N} a_{i,eq}^{\nu_i} < K_{eq}\ \{\text{reaction moves forward}\}$$

iii)

	$A(g)$	+ $B(g)$	⇌ $C(g)$
Initial press	1	0.5	0.25
Change	$-\xi$	$-\xi$	$+\xi$
Press at equilibrium	$1-\xi$	$0.5-\xi$	$0.25+\xi$

(2 mks)

Total press $1-\xi+0.5-\xi+0.25+\xi = 1.75-\xi$

$$K_{eq} = \frac{P_C}{P_A P_B} = \frac{(0.25+\xi)}{(1-\xi)(1-\xi)} = 56.483 \qquad (1.5\ mks)$$

(1 mk)

$56.483x^2 - 85.7245x + 27.9915 = 0$

a=56.483, b=-85.7245, c=27.9915.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-(-857245) \pm \sqrt{(-857245)^2 - 4(56.483)(27.9915)}}{2(56.483)}$$ (1 mk)

$$x = \frac{857245 \pm \sqrt{1024.514322}}{112.966}$$

x =1.0422 or x = 0.476 (1 mk$)

P_A = 1-0.476 = 0.5244 (0.5 mk)

P_B = 0.5 – 0.476 = 0.0244 (0.5 mk)

P_C = 0.25 – 0.476 = 0.726 (0.5 mk)

(b)

$$P = \frac{n}{V}RT$$ (1 mk)

$$0.496\ bar = (1 + \xi)\left(5.96\ x\ 10^{-3}\frac{mol}{L}\right)\left(0.08314\frac{L.bar}{K.mol}\right)(973\ K)$$ (1 mk)

$$\xi = \frac{0.496\ bar}{\left(5.96\ x\ 10^{-3}\frac{mol}{L}\right)\left(0.08314\frac{L.bar}{K.mol}\right)(973\ K)} - 1$$ (1 mk)

$\xi = 0.0288$ (1 mk)

$$K = \frac{4\xi^2\left(\frac{P}{p^o}\right)}{(1 - \xi^2)} = \frac{4(0.0288)^2(0.496)}{(1 - 0.0287^2)} = 1.64\ x\ 10^{-3}$$ (1.5 mks)

Solution 2

(a) T_1 = 25.0 °C = 298 K — 1 mark

T_2 = - 60 °C = 213 K. — 1 mark

$\ln\frac{k_1}{k_2} = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ — 2 marks

$\ln\frac{1.08\times10^7}{6.02\times10^7} = -\frac{E_a}{8.3145}\left(\frac{1}{213} - \frac{1}{298}\right)$ — 4 marks

$-1.718 = -(-1.6106)\ E_a$

= 10666.85 J/mol — 4 marks

=10.7 kJ/mol

$\frac{0.05916}{2}$ 29.58 mV

0.02958

(ii) NO — 1 mark

(iii) $O_3 + NO \rightarrow NO_2 + O_2$ — 1 mark

(iv) O_3 once and O is not used — 1 mark

(v) $R = k[O_3]$ — 1 mark

ion 4

a) $\log \gamma_{\pm} = -0.509)\text{Lmol}^{-1})^{1/2}[z_+ z_-[I^{1/2}$ **(2 mks)**

$I = 3c$

$\log \gamma_{\pm} = -0.509)\text{Lmol}^{-1})^{1/2}[2x-1_-[(3x0.00500\,\text{mol}\,\text{L}^{-1})^{1/2}$ **(2 mks)**

$\log \gamma_{\pm} = -.0.12468$

$\gamma_{\pm} = 10^{-0.12468} = 0.75045$ **(2 mks)**

b)

$\text{Red.rxn}: Hg_2Cl_2(s) + 2e^- \rightleftharpoons 2Hg(l) + 2Cl^-(aq)$

$\text{Oxd.rxn}\ Zn(s) \rightleftharpoons Zn^{2+}(aq) + 2e^-$

$\text{Cellrxn}: Hg_2Cl_2(s) + Zn(s) \rightleftharpoons 2Hg(l) + Zn^{2+}(aq) + 2Cl^-(aq)$ **(2 mks)**

$E_{cell} = E^{\circ}_{cell} - \frac{0.05916}{2}\log(a_{Zn^{2+}})^1(a_{Cl^-})^2$ **(2 mks)**

c)

$a_{ZnCl_2} = (m\gamma_+)^1(2m\gamma_-)^2 = 4m^3\gamma_{\pm}^3$ **(2 mks)**

$E_{cell} = E^{\circ}_{cell} = \frac{0.05916}{2}\log 4m^3\gamma_{\pm}^3$ **(2 mks)**

$E^{\circ}_{cell} = [0.2676 - (-0.7628)]]V = 1.0304\,V$ **(1 mks)**

$E_{cell} = 1.0304 - \frac{0.05916}{2}\log 4(0.00500)^3(0.75045)^3$ **(2 mks)**

$E_{cell} = 1.0304\,V + 0.19745\,V$ **(2 mks)**

$E_{cell} = 1.2278\,V$ **(2 mks)**

$56.483x^2 - 85.7245x + 27.9915 = 0$ **(1 mk)**

a=56.483, b=-85.7245, c=27.9915.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-(-857245) \pm \sqrt{(-857245)^2 - 4(56.483)(27.9915)}}{2(56.483)}$$ **(1 mk)**

$$x = \frac{857245 \pm \sqrt{1024.514322}}{112.966}$$

x =1.0422 or x = 0.476 **(1 mk)**

P_A = 1-0.476 = 0.5244 **(0.5 mk)**

P_B = 0.5 – 0.476 = 0.0244 **(0.5 mk)**

P_C = 0.25 – 0.476 = 0.726 **(0.5 mk)**

b)

$$P = \frac{n}{V}RT$$ **(1 mk)**

$$0.496\ bar = (1 + \xi)\left(5.96\ x\ 10^{-3}\frac{mol}{L}\right)\left(0.08314\frac{L.bar}{K.mol}\right)(973\ K)$$ **(1 mk)**

$$\xi = \frac{0.496\ bar}{\left(5.96\ x\ 10^{-3}\frac{mol}{L}\right)\left(0.08314\frac{L.bar}{K.mol}\right)(973\ K)} - 1$$ **(1 mk)**

$\xi = 0.0288$ **(1 mk)**

$$K = \frac{4\xi^2\left(\frac{P}{P^o}\right)}{(1 - \xi^2)} = \frac{4(0.0288)^2(0.496)}{(1 - 0.0287^2)} = 1.64\ x\ 10^{-3}$$ **(1.5 mks)**

Solution 2

(a) T_1= 25.0 °C = 298 K **1 mark**

T_2= - 60 °C = 213 K. **1 mark**

$\ln\frac{k_1}{k_2} = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ **2 marks**

$\ln\frac{1.08\times10^7}{6.02\times10^7} = -\frac{E_a}{8.3145}\left(\frac{1}{213} - \frac{1}{298}\right)$ **4 marks**

$-1.718 = -(-1.6106)\ E_a$

= 10666.85 J/mol **4 marks**

=10.7 kJ/mol

(b) $\ln [A]_t = \ln[A]_o + \lambda_g t_g$ **2 marks**

$\lambda_g = \frac{\ln 2}{t_g} = \frac{0.693}{50} = 0.01386$ **2 marks**

$\ln [A]_t = \ln 1 + 0.01386 \times 70$ **2 marks**

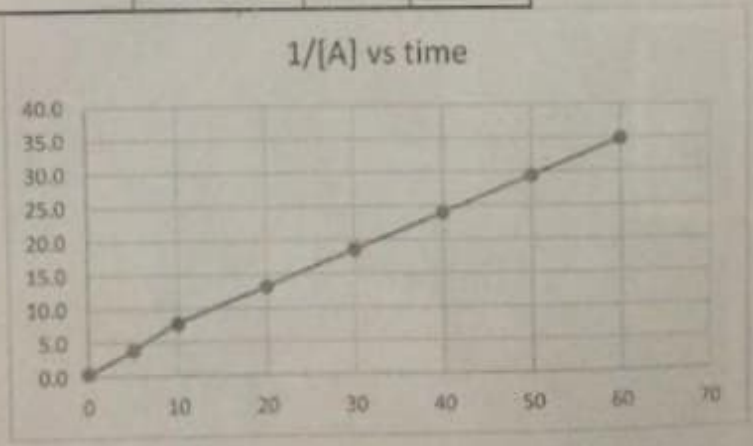
$\ln \frac{[A]_t}{[A]_o} = 0.9702$

$\frac{[A]_t}{[A]_o} = 2.64$ **2 marks**

Solution 3

(a) Table **4 marks**

Time (minutes)	$[NO_2]$ (M)	ln[A]	1/[A]
0	2.4	0.88	0.4
5	2.60E-01	-1.35	3.8
10	1.28E-01	-2.06	7.8
20	7.58E-02	-2.58	13.2
30	5.38E-02	-2.92	18.6
40	4.17E-02	-3.18	24.0
50	3.40E-02	-3.38	29.4
60	2.87E-02	-3.55	34.8



$r = k[A]^2$

Graph: Axis label, Units an title **2 marks**
Chosen correctly and Data plotted correctly **3 marks**

Straight line graph is second order. Hence, the order of reaction is 2. **2 marks**

Slope = k = 0.56449502 **2 marks**
Units = $dm^3mol^{-1}s^{-1}$

(b) (i) NO_2 **1 mark**