University of Bahrain, Department of Chemistry
Chemy 102, Second Semester 2012-2013
2nd hour examination /27
Time : 75 min, Examiners: Layla Saleem. Ahmed Saad, & Reema Balachandra

Name ....Key.......... ID .... Sec ....

Order	Concentration–Time Relation
0	$[A] = [A]_o - kt$
1	$\ln \frac{[A]_o}{[A]} = kt$
2	$\frac{1}{[A]} = \frac{1}{[A]_o} + kt$

Arrhenius equation: $k = Ae^{-Ea/RT}$

$R = 8.314\ J\ K^{-1}\ mol^{-1}$

$K_p = K_c\,(0.0821T)^{\Delta n}$

Q1. **(1 mark)**

Which one of the following is correct for the reaction

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)\ ?$$

a. $\frac{\Delta[H_2]}{\Delta t} = \frac{\Delta[NH_3]}{\Delta t}$

b. $\frac{3\,\Delta[H_2]}{\Delta t} = -\frac{2\,\Delta[NH_3]}{\Delta t}$

c. $\frac{1}{2}\frac{\Delta[H_2]}{\Delta t} = -\frac{1}{3}\frac{\Delta[NH_3]}{\Delta t}$

d. $-\frac{1}{3}\frac{\Delta[H_2]}{\Delta t} = \frac{1}{2}\frac{\Delta[NH_3]}{\Delta t}$

e. $\frac{\Delta[H_2]}{\Delta t} = -\frac{\Delta[NH_3]}{\Delta t}$

Q2. **(1 mark)**

The rate law for a reaction is rate$=k[A]^2[B]$. If the concentration of A doubles, the rate of the reaction will do which of the following?

a) not change
b) increase by a factor of 2
c) increase by a factor of 4
d) increase by a factor of 8
e) increase by a factor of 9

Q3. ***(Show your work)*** **(3 marks)**

Use the experimental data below to determine the rate constant for the following reaction. $3A + B \rightarrow C$

Trial	[A] (mol/L)	[B] (mol/L)	Initial rate (mol/L·s)
1	0.20	0.20	0.144
2	0.40	0.20	0.288
3	0.20	0.40	0.576

$R = K[A]^m[B]^n$

(1 mark) To find m:

$\frac{R2}{R1} = \frac{0.288}{0.144} = \left(\frac{0.4}{0.2}\right)^m \Rightarrow m = 1$

(1 mark) To find n:

$\frac{R3}{R1} = \frac{0.576}{0.144} = \left(\frac{0.4}{0.2}\right)^n \Rightarrow n = 2$

To find K (1 mark)

$K = \frac{R}{[A][B]^2}$

$K = \frac{0.144}{(0.2)(0.2)^2}$

$= 18$

Q4. ***(show your work)*** **(3 marks)**

A first-order reaction has a half-life of 4.54 seconds. How much time is required for the reactant to be reduced to 6.25% of its initial concentration?

$t_{1/2} = 0.693/K$

$K = 0.693/4.54 = 0.153\ s^{-1}$

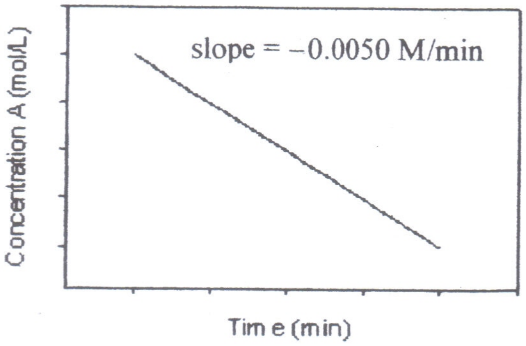
$\ln \frac{[A]_0}{[A]} = Kt$

$\ln \frac{100}{6.25} = (0.153)t$

$\therefore t = 18.12$ sec

Q5. **(1 mark)**

Use the plot below to determine the rate constant of the reaction.



$k =$ 0.0050

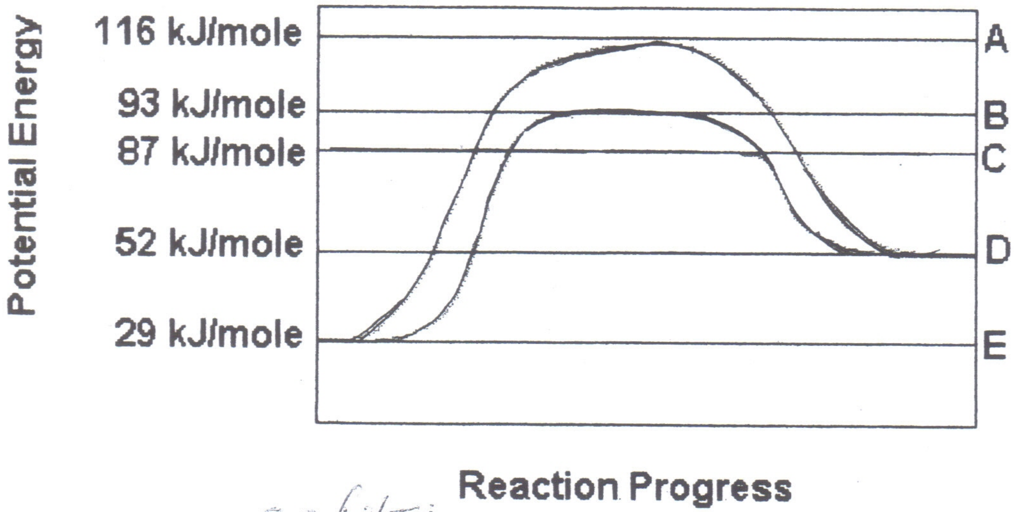
Q6. **(2 marks)**

For the second-order reaction $2A \rightarrow B$, the initial concentration of A is 1.34 *M*. If $k = 7.61 \times 10^{-4}$ L/mol·s, what is the concentration of A after 18.3 minutes?

[A] = 0.632 M

Q7. **(1 mark)**

Based on the energy profile, what is the activation energy for the catalyzed reaction?

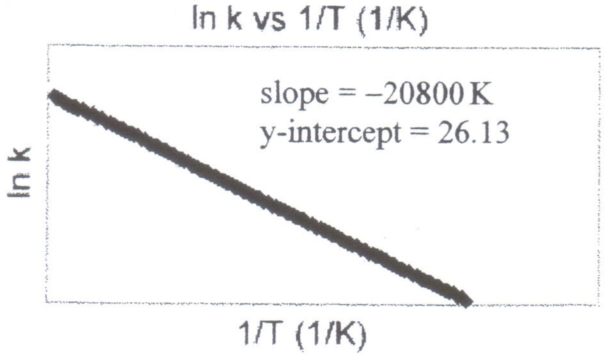


E_a = ~~93 kJ/mol.~~ 64

Q8. **(3 marks)**

Consider the first-order reaction $CH_3CH_2NO_2 \longrightarrow C_2H_2 + HNO_2$

Using the graph below, calculate the rate constant for this reaction at 40.0 °C. (show your work)



$\ln k = \ln A - \frac{E_a}{RT}$

$y = C + mx$

$\text{slope} = \frac{-E_a}{R} = -20800K$

$E_a = (20800K)(8.31 \frac{J}{K\,mol})$

$= 172848 \text{ J/mol}.$

$\ln k = 26.13 - \frac{172848 \text{ J/mol}}{(8.31 \frac{J}{K\,mol})(313K)}$

$= 26.13 - 66.45$

$\ln k = -40.32$

$k = 3.07 \times 10^{-18}$

Q9. ***(show your work)*** **(3 marks)**

At certain temperature, the equilibrium constant K for the reaction $2NOCl(g) \leftrightarrows 2NO(g) + Cl_2(g)$ is 1.9×10^{-2}. An equilibrium mixture was found to have the following partial pressures: $P_{Cl2} = 0.50$ atm; $P_{NOCl} = 0.33$ atm. Calculate the equilibrium partial pressure of NO(g).

$2\,NOCl \rightleftharpoons 2\,NO + Cl_2$

$$K = \frac{(P_{NO})^2 (P_{Cl_2})}{(P_{NOCl})^2} = \frac{(P_{NO})^2 (0.5)}{(0.33)^2} = 1.9 \times 10^{-2}$$

$$(P_{NO})^2 = \frac{(1.9 \times 10^{-2})(0.33)^2}{(0.5)} = 0.00414$$

$\therefore P_{NO} = 0.064$ atm

Q10. **(1 mark)**

For which reaction will $K_p = K_c$?

A) $S(s) + O_2(g) \leftrightarrows SO_2(g)$
B) $2\,HgO(s) \leftrightarrows Hg(l) + O_2(g)$
C) $CaCO_3(s) \leftrightarrows CaO(s) + CO_2(g)$
D) $H_2CO_3(s) \leftrightarrows H_2O(l) + CO_2(g)$
E) $2\,H_2O(l) \leftrightarrows 2\,H_2(g) + O_2(g)$

Q11. **(1 mark)**

Consider the following equilibria:

$A(g) + B(g) \leftrightarrows AB(g) \quad K_1 = 0.24$
$AB(g) + A(g) \leftrightarrows A_2B(g) \quad K_2 = 3.8$

Calculate the equilibrium constant for the reaction
$2\,A(g) + B(g) \leftrightarrows A_2B(g)$

A) 4.0 B) 0.91 C) 3.6 D) 16 E) 0.63

Q12. **(1 mark)**

For the reaction $I_2(g) + Br_2(g) \leftrightharpoons 2\ IBr(g)$, K = 110.7 at certain temperature. If the reaction mixture contains $P_{I2} = 0.41$ atm, $P_{Br2} = 0.27$ atm, and $P_{IBr} = 0.5$ atm, which one of these statements is *true*?

A) The reaction will shift in the direction of products.
B) The reaction will shift in the direction of reactants.
C) The reaction quotient will decrease.
D) The equilibrium constant will increase.
E) The system is at equilibrium.

Q13. **(1 mark)**

For the following reaction at equilibrium in a reaction vessel, which one of the changes below would cause the equilibrium to shift to the *left*?

$$2NOBr(g) \leftrightharpoons 2NO(g) + Br_2(g), \quad \Delta H^\circ_{rxn} = 30\ kJ/mol$$

A) Increase the temperature.
B) Remove some NO.
C) Add more NOBr.
D) Compress the gas mixture into a smaller volume.

Q14. ***(show your work)*** **(3 marks)**

For the following reaction, K = 21.1 at 127° C.

$$A_{(g)} + B_{(g)} \leftrightarrow 2\ C_{(g)}$$

If a reaction contains initially 0.5 atm of both A and B, what are the equilibrium partial pressures of A, B and C at the same temperature?

$$A + B \rightleftharpoons 2C$$
P_o: 0.5, 0.5, 0
ΔP: $-x$, $-x$, $+2x$ (1 mark)
P_{eq}: $(0.5-x)$, $(0.5-x)$, $2x$

$$K = \frac{(2x)^2}{(0.5-x)^2} = 21.1$$

$$\frac{2x}{0.5-x} = \sqrt{21.1}$$

(1 mark)

$x = 0.348$

$P_A = P_B = 0.5 - 0.348 = 0.152$ atm

$P_C = 2(0.348) = 0.697$ atm (1 mark)

Q15. ***(show your work)*** **(2 marks)**

For the system :

$$H_{2(g)} + I_{2(g)} \leftrightarrows 2\,HI_{(g)} \qquad \Delta H = -9.4 \text{ kJ}$$

K = 62.5 at 800 K. What is the equilibrium constant at 606 K?

$$\ln \frac{K_2}{K_1} = \frac{\Delta H}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\ln \frac{62.5}{K_1} = \frac{-9.4 \times 10^3 \text{ J}}{8.31 \frac{\text{J}}{\text{mol.K}}}\left[\frac{1}{606} - \frac{1}{800}\right]$$

$$\ln 62.5 - \ln K_1 = -0.453$$

$$\ln K_1 = 4.588$$

$$K_1 = 98.3$$