University of Bahrain, Department of Chemistry
Chemy 102, First Semester 2013-2014, 3rd hour examination
Time : 75 min

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Q1 (1 mark)

The reaction $2H_2O_2\,(aq) \longrightarrow 2H_2O + O_2\,(g)$ is believed to take place by a two-step path:

$$H_2O_2\,(aq) + I^-\,(aq) \longrightarrow H_2O + IO^-\,(aq)$$

$$H_2O_2\,(aq) + IO^-\,(aq) \longrightarrow H_2O + O_2\,(g) + I^-\,(aq)$$

The catalyst in this reaction is I^-

Q2 (1 mark)

The rate law for the reaction $2NO_2 + O_3 \rightarrow N_2O_5 + O_2$ is rate = $k[NO_2][O_3]$. Which one of the following mechanisms is consistent with this rate law?

A) $NO_2 + NO_2 \rightarrow N_2O_4$ (*fast*)
$N_2O_4 + O_3 \rightarrow N_2O_5 + O_2$ (*slow*)

B) $NO_2 + O_3 \rightarrow NO_5$ (*fast*)
$NO_5 + NO_5 \rightarrow N_2O_5 + {}^5/_2O_2$ (*slow*)

C) $NO_2 + O_3 \rightarrow NO_3 + O_2$ (*slow*)
$NO_3 + NO_2 \rightarrow N_2O_5$ (*fast*)

D) $NO_2 + NO_2 \rightarrow N_2O_2 + O_2$ (*slow*)
$N_2O_2 + O_3 \rightarrow N_2O_5$ (*fast*)

Q3 (1 mark)

The following mechanism has been suggested for the reaction

$H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$

$H_2O_2 + I^- \rightarrow HOI + OH^-$
$OH^- + H^+ \rightarrow H_2O$
$HOI + H^+ + I^- \rightarrow I_2 + H_2O$

Identify all intermediates included in this mechanism.

A) H^+ and I^-
B) H^+ and HOI
C) HOI and OH^-
D) HOI only
E) H_2O and OH^-

Q4 (2 marks)

Given the equilibrium constants for the following reactions

$2C_2H_2\ (g) + 2H_2\ (g) \leftrightarrows 2C_2H_4\ (g)$ $\mathbf{K} = 2.92\times10^{49}$

$C_2H_6\ (g) \leftrightarrows C_2H_4\ (g) + H_2\ (g)$ $\mathbf{K} = 1.96\times10^{-18}$

What is **K** for the reaction $C_2H_2\ (g) + 2H_2\ (g) \leftrightarrows C_2H_6\ (g)$?

a) 3.6×10^{53} b) 1.66×10^{21} c) 2.8×10^{42} d) 9.4×10^{-8} e) 1.1×10^{7}

Q5 (2.5 marks)

Consider the following reaction at 1000 K

$FeO\ (s) + CO\ (g) \leftrightarrows Fe\ (s) + CO_2\ (g)$ $K = 0.259$

What is the equilibrium partial pressure of CO_2 at 1000 K if the initial partial pressures are $P_{CO} = 1.000$ atm and $P_{CO_2} = 0.500$ atm ? *Show your work*

Since $Q = 0.5 > K$, then reaction goes backward to achieve equilibrium.

	$FeO\ (s) + CO\ (g) \leftrightarrows Fe\ (s) + CO_2\ (g)$	
P_o / atm	1.00	0.500
ΔP / atm	$+x$	$-x$
P_{eq} / atm	$1.00 + x$	$0.500-x$

$(0.500-x)/(1.00+x) = 0.259 \Rightarrow x = 0.191$ atm

$\therefore P_{CO_2} = 0.500-x = 0.309$ atm

Q6 (1 mark)

Consider the equilibrium $COCl_2\ (g) \leftrightarrows CO\ (g) + Cl_2\ (g)$ $\Delta H > 0$

Which of the following effects will shift the equilibrium to the right?

I- The amount of CO is decreased.
II- The amount of Cl_2 is increased.
III- The temperature is increased.
IV- The volume is decreased.

a) II and IV b) I, III and IV c) II only d) IV only e) I and III

Q7 (2.5 marks)

A mixture consists initially of only N_2 and H_2 was allowed to come to equilibrium at a given temperature $N_2\,(g) + 3H_2\,(g) \leftrightarrows 2NH_3\,(g)$.
The mixture at equilibrium contains 2.0 atm of N_2, 3.0 atm of H_2, and 1.5 atm of NH_3. What was the initial pressure of H_2? *Show your work*

	$N_2\,(g)$ +	$3H_2\,(g)$ $\leftrightarrows$	$2NH_3\,(g)$
P_o / atm	$P_o(N_2)$	$P_o(H_2)$	0
ΔP / atm	$-x$	$-3x$	$+2x$
P_{eq} / atm	2.0	3.0	1.5

$P_{eq}(NH_3) = 1.5 = 2x \Rightarrow x = 0.75$ atm

$P_o(H_2) - 3x = 3.0 \Rightarrow P_o(H_2) = 5.25$ atm

Q8 (2 marks)

Arrange the following 0.1*M* aqueous solutions in order of increasing pH
$FeCl_3$, $LiClO_4$, $Ba(OH)_2$, HNO_3 , NH_4CN [$K_a\ NH_4^+ = 5.6\times10^{-10}$, $K_b\ CN^- = 1.7\times10^{-5}$]

HNO_3 < $FeCl_3$ < $LiClO_4$ < NH_4CN < $Ba(OH)_2$
(lowest pH) (highest pH)

Q9 (1 mark)

What is the pOH of 0.501 *M* HBr?
a) 14.82 b) – 0.823 c) 12.2 d) 0.823 e) 13.7

Q10 (2.5 marks)

The pH of 0.400 *M* $NaNO_2$ is 8.42, what is K_b for NO_2^-? *Show your work*

pH = 8.42 $\Rightarrow$ $[H^+] = 3.80\times10^{-9}$ M & $[OH^-] = 2.63\times10^{-6}$ M

$$NO_2^-\,(aq) + H_2O \leftrightarrows HNO_2\,(aq) + OH^-\,(aq)$$

$[\ ]_o$ / M	0.400	0	0
$\Delta[\ ]$ / M	$-x$	$+x$	$+x$
$[\ ]_{eq}$ / M	$0.400-x$	x	x

$$K_b = [\,x^2/(0.400-x)] \approx x^2 / 0.400 = (2.63\times10^{-6})^2 / 0.400$$

$$\therefore K_b = 1.73\times10^{-11}$$

Q11 (2 marks)

Classify each salt of the following as acidic, basic, or neutral in an aqueous solution.

$Ba(CN)_2$ basic

$NiBr_2$ acidic

NH_4NO_3 acidic

KI neutral