Final Exam Review - Answers to Written Response

Monday, June 01, 2015
1:30 PM

PART B: WRITTEN RESPONSE

Suggested Time: 40 minutes

INSTRUCTIONS: Answer the following questions in the space provided in this **Response Booklet.** You are expected to communicate your knowledge and understanding of chemical principles in a clear and logical manner. Your steps and assumptions leading to a solution must be written in this **Response Booklet**. Answers must include units where appropriate and be given to the correct number of significant figures. **For questions involving calculations, full marks will NOT be given for providing only an answer.**

1. Consider the reaction: $2Zn(s) + O_2(g) \rightarrow 2ZnO(s)$

State two different methods that would increase the rate of this reaction.
Explain each in terms of collision theory. **(4 marks)**

Method 1: crush Zn to a powder

Explanation: increase surface area

Method 2: increase Temperature

Explanation: increase # of collisions

2. Consider the equilibrium: $CO_2(g) + H_2(g) \rightleftarrows CO(g) + H_2O(g)$ $K_{eq} = 1.60$

Initially, 8.2 mol of CO and 8.2 mol of H_2O are placed in a 2.0L container and allowed to react.
Calculate the equilibrium concentrations of CO_2 and CO. **(4 marks)**

$Conc_I = \frac{8.2\ mole}{2.0L} = 4.1M$ of $[CO_2] + [H_2O]$ initial

	CO_2	+ H_2	⇌ CO	H_2O
I	0	0	4.1M	4.1M
Δ	+x	+x	−x	−x
E	x	x	4.1m − x	4.1M − x

$K_{eq} = \frac{[CO][H_2O]}{[CO_2][H_2O]}$

$1.6 = \frac{(4.1-x)(4.1-x)}{x \cdot x}$

$\therefore x^2 \times 1.6 = (4.1-x)^2$

$\sqrt{1.6} \times x = 4.1 - x$

$1.2649x = 4.1 - x$

$2.2649x = 4.1$

$x = \frac{4.1}{2.2649} = 1.81$

$\therefore [CO_2] = 1.81M$ at equil.

$[CO] = 4.1 - 1.81 = 2.29M$

3. What is the maximum $[Pb^{2+}]$ that can exist in a saturated solution of $BaSO_4$ without causing precipitate formation? **(4 marks)**

$BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{-2}$ let $x = [SO_4^{-2}]$

$K_{sp} = [Ba^{2+}][SO_4^{-2}]$

$1.1 \times 10^{-10} = x^2$

$\sqrt{1.1 \times 10^{-10}} = x$

$1.048 \times 10^{-5} M = x = [SO_4^{-2}]$

$\therefore K_{sp} = [Pb^{2+}][SO_4^{-2}]$

$[Pb^{2+}] = \frac{1.8 \times 10^{-8}}{1.048 \times 10^{-5} M}$

$[Pb^{2+}] = 1.7 \times 10^{-3} M$

4. Given the reactants:

A B B A

$H_2C_2O_4 + HCOO^- \rightleftarrows HC_2O_4^- + HCOOH$

Complete the acid-base equilibrium equation in the box above.
Determine whether reactants or products will be favoured and explain why. **(3 marks)**

since $H_2C_2O_4$ is a stronger weak acid than HCOOH the product side will be favoured.

5. Calculate the pH of a 0.30M H_2S solution. Begin by writing the equation for the predominant reaction. **(5 marks)**

$$H_2S + H_2O \rightleftharpoons H_3O^+ + HS^-$$

$$K_a = \frac{[H_3O^+][HS^-]}{[H_2S]}$$

let $x = [H_3O^+]_{EQUI.}$

Assume $[\ ]_{eq} = [H_2S]_i - x$

$$9.1 \times 10^{-8} = \frac{x \cdot x}{0.30}$$

$$x = \sqrt{0.30 \times 9.1 \times 10^{-8}}$$

$$x = 1.652 \times 10^{-4} M$$

$\therefore pH = -\log[H_3O^+]$

$pH = -\log(1.652 \times 10^{-4})$

$pH = 3.78$

6. What mass of NaOH(s) is required to just neutralize 50.0 mL of 2.0M H_2SO_4? Begin by writing the balanced equation for the neutralization reaction. **(3 marks)**

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

moles H_2SO_4 = 2.0 M × 0.050 L = 0.100 moles

$\therefore$ 2 × 0.100 moles of H^+ will be produced

$\therefore$ need 0.200 moles of NaOH

mass NaOH = 0.200 moles × 40.0 g/mole

= 8.0 g.

7. Balance the following in acidic solution.

$$FeS + NO_2^- \rightarrow NO + SO_4^{2-} + Fe^{3+} \quad \text{(acidic)}$$

(4 marks)

$1 \times [4H_2O + FeS \rightarrow SO_4^{2-} + Fe^{3+} + 8H^+ + 9e^-]$

$9 \times [2H^+ + NO_2^- + 1e^- \rightarrow NO + H_2O]$

$FeS + 10H^+ + 9NO_2^- \rightarrow SO_4^{-2} + Fe^{3+} + 5H_2O + 9NO$

8. Consider the following overall reaction which is exothermic:

$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$

a) Complete the proposed two-step reaction mechanism. **(2 marks)**

Step 1	$NO + NO \rightarrow N_2O_2$
Step 2	$N_2O_2 + O_2 \rightarrow 2NO_2$

$2NO + O_2 \rightarrow 2NO_2$

b) Describe how adding a catalyst would affect the activation energy and ΔH for the overall reaction? **(2 marks)**

- lower activation energy
- would not change ΔH

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9 Consider the following equilibrium:

$$N_{2(g)} + O_{2(g)} \rightleftarrows 2NO_{(g)} \qquad K_{eq} = 8.1 \times 10^{-3}$$

A 2.0 L container is filled with 0.15 mol N_2, 0.15 mol O_2 and 0.050 mol NO. Does the $[NO]$ increase or decrease as equilibrium is established? Support your answer with appropriate calculations. **(4 marks)**

conc $= \frac{0.15}{2.0L} = 0.075\ M\ N_2 + O_2$

conc $= \frac{0.050}{2.0L} = 0.025\ M\ NO$

$Q = \frac{[NO]^2}{[N_2][O_2]} = \frac{(0.025)^2}{(0.075)^2}$

$Q = 0.111$

since $Q > K_{eq}$

$0.111 > 8.1 \times 10^{-3}$

$[NO]$ will decrease as reaction shifts back towards reactants.

10 Calculate the iodate ion concentration in a saturated copper (II) iodate solution at 25°C. **(3 marks)**

$K_{sp} = [Cu^{2+}][IO_3^-]^2$

$Cu(IO_3)_2 \rightleftharpoons Cu^{2+} + 2IO_3^-$

let $x = [Cu^{2+}]$

$2x = [IO_3^-]$

$6.9 \times 10^{-8} = x(2x)^2$

$= 4x^3$

$\therefore [IO_3^-] = 2x$

$= 2 \times 2.58 \times 10^{-3}$

$[IO_3^-] = 5.2 \times 10^{-3}\ M$

$\frac{4 \times 6.9 \times 10^{-8}}{4} = x^3$

$\sqrt[3]{1.725 \times 10^{-8}} = x$

$2.58 \times 10^{-3} = x$

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OVER

11. Calculate the pH of a sample of 1.5M CH_3COOH. Begin by writing the equation for the predominant equilibrium reaction. **(5 marks)**

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

initial. 1.5M 0 0

equil. $1.5 - x$ x x let $x = [H_3O^+]$

Assume $1.5 - x = 1.5M = [CH_3COOH]$

$$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$$

$$1.8 \times 10^{-5} = \frac{x \cdot x}{1.5}$$

$$x = \sqrt{1.5 \times 1.8 \times 10^{-5}}$$

$$x = 0.005196 = [H_3O^+]$$

$\therefore pH = -\log(0.005196)$

$pH = 2.28$

12 State the sequence of events that occur when a small amount of $HCl_{(aq)}$ is added to a buffer such as:

$$NH_{3(aq)} + H_2O_{(\ell)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

omit

Be sure to describe the stress, the shift and the effect on pH that occur. **(3 marks)**

H^+ react with OH^- to form H_2O removing the extra H^+ from sol. the reaction will shift to the right producing more OH^- keeping the pH relatively the same

OVER

13. **(4 marks)**

Balance the following redox equation in acidic solution:

$$TeO_4^- + In \rightarrow In_2O_3 + Te \qquad \text{(acidic)}$$

$6(TeO_4^- + 8H^+ + 7e^- \rightarrow Te + 4H_2O)$

$7(2In + 3H_2O \rightarrow In_2O_3 + 6H^+ + 6e^-)$

$6TeO_4^- + 48H^+ + 14In + 21H_2O \rightarrow 6Te + 24H_2O + 7In_2O_3 + 42H^+$

$6TeO_4^- + 14In + 6H^+ \rightarrow 6Te + 7In_2O_3 + 3H_2O$