

**CHEM 101-080 Fall 2004**  
**Problem-Solving Session 6 - Answer Key**  
**Chapters 12 and 13**  
**November 22, 2004**

**Ch. 12: Acids, Bases, and Salts**

<b>Group</b>	<b>Problem No. p. 382</b>	<b>Solution</b>
1	7 (a-c)	(a) $\text{NO}_3^-$ , (b) $\text{HSO}_4^-$ , (c) $\text{PO}_4^{3-}$
2	7 (d-f)	(d) $\text{CH}_3^-$ , (e) $\text{OH}^-$ , (f) $\text{NH}_2^-$
3	8 (a-c)	(a) $\text{CH}_3\text{NH}_3^+$ , (b) $\text{H}_2\text{PO}_4^-$ , (c) $\text{HNO}_3$
4	8 (d-f)	(d) $\text{OH}^-$ , (e) $\text{H}_2\text{CN}^+$ , (f) $\text{H}_3\text{O}^+$

<b>Group</b>	<b>Problem No. p. 382</b>	<b>Solution</b>
1	9 (a,b)	See page 2
2	9 (c,d)	"
3	10 (a,b)	"
4	10 (c,d)	"

<b>Group</b>	<b>Problem No.</b>	<b>Solution</b>
1	14	See 10d.
2	14	$\text{HCO}_3^- (\text{aq}) + \text{H}_2\text{O} (\text{l}) \rightarrow \text{H}_3\text{O}^+ (\text{l}) + \text{CO}_3^{2-} (\text{g})$
3	113	$\text{NaHCO}_3 (\text{aq}) + \text{HC}_2\text{H}_3\text{O}_2 (\text{aq}) \rightarrow \text{NaC}_2\text{H}_3\text{O}_2 (\text{aq}) + \text{H}_2\text{CO}_3 (\text{aq})$
4	113	$\text{H}_2\text{CO}_3 (\text{aq}) \rightarrow \text{H}_2\text{O} (\text{l}) + \text{CO}_2 (\text{g})$

Solutions to Problems 9 and 10 - p. 382

<b>9a</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	HClO <sub>4</sub>	ClO <sub>4</sub> <sup>-</sup>
<b>CP2</b>	H <sub>2</sub> O	OH <sup>-</sup>

<b>9b</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	HSO <sub>4</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>
<b>CP2</b>	HClO	ClO <sup>-</sup>

<b>9c</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	NH <sub>3</sub>	NH <sub>2</sub> <sup>-</sup>
<b>CP2</b>	H <sub>2</sub> O	OH <sup>-</sup>

<b>9d</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	NH <sub>4</sub> <sup>+</sup>	NH <sub>3</sub>
<b>CP2</b>	H <sub>3</sub> O <sup>+</sup>	H <sub>2</sub> O

<b>10a</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	HCN	CN <sup>-</sup>
<b>CP2</b>	H <sub>3</sub> O <sup>+</sup>	H <sub>2</sub> O

<b>10b</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	HClO <sub>4</sub>	ClO <sub>4</sub> <sup>-</sup>
<b>CP2</b>	HNO <sub>3</sub>	NO <sub>3</sub> <sup>-</sup>

<b>10c</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	H <sub>2</sub> S	HS <sup>-</sup>
<b>CP2</b>	NH <sub>4</sub> <sup>+</sup>	NH <sub>3</sub>

<b>10d</b>	<b>Acid</b>	<b>Base</b>
<b>CP1</b>	H <sub>2</sub> CO <sub>3</sub>	HCO <sub>3</sub> <sup>-</sup>
<b>CP2</b>	H <sub>3</sub> O <sup>+</sup>	H <sub>2</sub> O

<b>Group</b>	<b>What is the <math>[H^+]</math> and pH in a 0.060 M solution of the following acids? Assume the second ionization (if it exists) is only 50% complete.</b>	<b>Solution</b>
1	HCl	0.060 M, pH = 1.22
2	HNO <sub>3</sub>	0.060 M, pH = 1.22
3	H <sub>2</sub> SO <sub>4</sub>	0.090 M, pH = 1.05
4	H <sub>3</sub> PO <sub>4</sub>	0.090 M, pH = 1.05

<b>Group</b>	<b>What is the pH that corresponds to each concentration?</b>	<b>Solution</b>
All	$[H^+] = 0.55 \text{ M}$	0.26
	$[OH^-] = 0.55 \text{ M}$	13.7
	$[H^+] = 0.0001 \text{ M}$	4
	$[H^+] = 10^{-4} \text{ M}$	4
	$[OH^-] = 10^{-8} \text{ M}$	6
	$[OH^-] = 0.00146 \text{ M}$	11.2

<b>Group</b>	<b>Problem No. p. 383</b>	<b>Solution</b>
1	24	0.55 M
2	25	$0.55 \times 0.030 = 0.017 \text{ M}$
3	28	5 %
4	29	$4.4 \times 10^{-2} \%$

<b>Group</b>	<b>Problem No. p. 383</b>	<b>Solution</b>
1	34a	$\text{HNO}_2 + \text{NaOH} \rightarrow \text{NaNO}_2 + \text{H}_2\text{O}$
2	34b	$\text{H}_2\text{CO}_3 + 2\text{CsOH} \rightarrow \text{Cs}_2\text{CO}_3 + 2\text{H}_2\text{O}$
3	34c	$\text{H}_2\text{S} + \text{Ba}(\text{OH})_2 \rightarrow \text{BaS} + 2\text{H}_2\text{O}$
4	34c	

<b>Group</b>	<b>Problem No. p. 384</b>	<b>Solution</b>
1	74a,b	SA, SA
2	74c,d	WA, SB
3	74e,f	N, WB
4	74g,h	WA, SA

Group	Problem No. p. 385	Solution
1	82a	$\text{OH}^-$
2	82b	$\text{NH}_3$
3	82c	$\text{H}_2\text{O} + \text{OH}^-$ ( $\text{H}_2\text{O}$ cancels)
4	82d	$\text{H}_3\text{O}^+$

Group	Problem No. p. 385	Solution
1	93	Both are fully-ionized
2		
3	95	$\text{HCO}_3^- \rightarrow \text{H}^+ + \text{CO}_3^{2-}$
4		Add $\text{H}^+$ : $\text{CO}_3^{2-} + \text{H}^+ \rightarrow \text{HCO}_3^-$ Add $\text{OH}^-$ : $\text{HCO}_3^{2-} + \text{OH}^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$

Group	Problem No. p. 385	Solution
All	116	<p>A: <math>\frac{0.150 \text{ mol NaOH}}{2.50 \text{ l}} = 0.0600 \text{ M NaOH}</math>  <math>0.0600 \text{ M OH}^- \Rightarrow p\text{OH} = 1.22 \Rightarrow p\text{H} = 12.78</math></p> <p>B: <math>\frac{0.150 \text{ mol HCl}}{2.50 \text{ l}} = 0.0600 \text{ M HCl}</math>  <math>0.0600 \text{ M H}^+ \Rightarrow p\text{H} = 1.22</math></p> <p><b>A+B: Neutral because mols <math>\text{OH}^-</math> = mols <math>\text{H}^+</math></b></p>

## Ch. 13: Oxidation-Reduction Reactions

Group	Problem No. p. 416	Solution
1	18a	(1) $Sn^{2+} \rightarrow SnO_2$ (2) $2H_2O + Sn^{2+} \rightarrow SnO_2$ (3) $2H_2O + Sn^{2+} \rightarrow SnO_2 + 4H^+$ (4) $2H_2O + Sn^{2+} \rightarrow SnO_2 + 4H^+ + 2e^-$
2	18b	$2H_2O + CH_4 \rightarrow CO_2 + 8H^+ + 8e^-$
3	18c	$e^- + Fe^{3+} \rightarrow Fe^{2+}$
4	18d	$6H_2O + I_2 \rightarrow 2IO_3^- + 12H^+ + 10e^-$

Group	Problem No. p. 416	Solution
1	19a	(1) $P_4 \rightarrow H_3PO_4$ (2) $P_4 \rightarrow 4H_3PO_4$ (3) $16H_2O + P_4 \rightarrow 4H_3PO_4$ (4) $16H_2O + P_4 \rightarrow 4H_3PO_4 + 20H^+$ (5) $16H_2O + P_4 \rightarrow 4H_3PO_4 + 20H^+ + 20e^-$
2	19b	$6e^- + 6H^+ + ClO_3^- \rightarrow Cl^- + 3H_2O$
3	19c	$5H_2O + S_2O_3^{2-} \rightarrow 2SO_4^{2-} + 10H^+ + 8e^-$
4	19d	$4e^- + 6H^+ + NO_3^- \rightarrow NH_4^+ + 3H_2O$

Group	Problem No. p. 416	Solution
1,2	21a	$\text{Mn}^{2+} + \text{BiO}_3^- \rightarrow \text{MnO}_4^- + \text{Bi}^{3+}$ <p><i>Note : omit <math>\text{H}^+</math> and <math>\text{H}_2\text{O}</math>...these are generated by balancing.</i></p> <p><i>Balance the Mn – based half – reaction (oxidation).</i></p> <p>(1a) <math>\text{Mn}^{2+} \rightarrow \text{MnO}_4^-</math></p> <p>(1b) <math>4\text{H}_2\text{O} + \text{Mn}^{2+} \rightarrow \text{MnO}_4^-</math></p> <p>(1c) <math>4\text{H}_2\text{O} + \text{Mn}^{2+} \rightarrow \text{MnO}_4^- + 8\text{H}^+</math></p> <p>(1d) <math>4\text{H}_2\text{O} + \text{Mn}^{2+} \rightarrow \text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-</math></p> <p><i>Balance the Bi – based half – reaction (reduction).</i></p> <p>(2a) <math>\text{BiO}_3^- \rightarrow \text{Bi}^{3+}</math></p> <p>(2b) <math>\text{BiO}_3^- \rightarrow \text{Bi}^{3+} + 3\text{H}_2\text{O}</math></p> <p>(2c) <math>6\text{H}^+ + \text{BiO}_3^- \rightarrow \text{Bi}^{3+} + 3\text{H}_2\text{O}</math></p> <p>(2d) <math>2\text{e}^- + 6\text{H}^+ + \text{BiO}_3^- \rightarrow \text{Bi}^{3+} + 3\text{H}_2\text{O}</math></p> <p><i>Scale (1d) by a factor of 2, scale (2d) by a factor of 5, then add.</i></p> $2(4\text{H}_2\text{O} + \text{Mn}^{2+} \rightarrow \text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-)$ $+ 5(2\text{e}^- + 6\text{H}^+ + \text{BiO}_3^- \rightarrow \text{Bi}^{3+} + 3\text{H}_2\text{O})$ <hr/> $8\text{H}_2\text{O} + 2\text{Mn}^{2+} \rightarrow 2\text{MnO}_4^- + 16\text{H}^+ + 10\text{e}^-$ $+ 10\text{e}^- + 30\text{H}^+ + 5\text{BiO}_3^- \rightarrow 5\text{Bi}^{3+} + 15\text{H}_2\text{O}$ <p><i>Write as a single reaction :</i></p> $10\text{e}^- + 30\text{H}^+ + 8\text{H}_2\text{O} + 2\text{Mn}^{2+} + 5\text{BiO}_3^-$ $\rightarrow 5\text{Bi}^{3+} + 2\text{MnO}_4^- + 15\text{H}_2\text{O} + 16\text{H}^+ + 10\text{e}^-$ <p><i>Combine and cancel "like" terms ...the result is :</i></p> $14\text{H}^+ + 2\text{Mn}^{2+} + 5\text{BiO}_3^- \rightarrow 5\text{Bi}^{3+} + 2\text{MnO}_4^- + 7\text{H}_2\text{O}$
3,4	21b	$4\text{H}_2\text{O} + 2\text{IO}_3^- + 5\text{SO}_2 \rightarrow 5\text{SO}_4^{2-} + \text{I}_2 + 8\text{H}^+$

Group	Problem No. p. 416	Solution
1,2	25a	$\text{ClO}_2 \rightarrow \text{ClO}_2^- + \text{ClO}_3^-$ <p><i>Note 1: Omit <math>\text{OH}^-</math> and <math>\text{H}_2\text{O}</math> ...these are generated by balancing.</i></p> <p><i>Note 2: Add coefficient to left side to get two half – reactions.</i></p> <p>(1) <i>Balance as in acidic solution :</i></p> $\text{H}_2\text{O} + 2\text{ClO}_2 \rightarrow \text{ClO}_2^- + \text{ClO}_3^- + 2\text{H}^+$ <p>(2) <i>For each <math>\text{H}^+</math> ion, add a hydroxide ion (add to both sides):</i></p> $2\text{OH}^- + \text{H}_2\text{O} + 2\text{ClO}_2 \rightarrow \text{ClO}_2^- + \text{ClO}_3^- + 2\text{H}^+ + 2\text{OH}^-$ <p>(3) <i>Combine <math>\text{H}^+</math> and <math>\text{OH}^-</math> into water :</i></p> $2\text{OH}^- + \text{H}_2\text{O} + 2\text{ClO}_2 \rightarrow \text{ClO}_2^- + \text{ClO}_3^- + 2\text{H}_2\text{O}$ <p>(4) <i>Combine and cancel "like" terms ...the result is :</i></p> $2\text{OH}^- + 2\text{ClO}_2 \rightarrow \text{ClO}_2^- + \text{ClO}_3^- + \text{H}_2\text{O}$
3,4	25c	$2\text{OH}^- + 3\text{BrO}^- + 2\text{Cr}(\text{OH})_4^- \rightarrow 2\text{CrO}_4^{2-} + 3\text{Br}^- + 5\text{H}_2\text{O}$