## Homework Set 11 Solutions

(Distributed 11/30/16; Due on 12/7/16)
Read Chapters 16 and 18 in Zumdahl and complete the listed questions from the text: Chapter 16: 9, 15, 31, $36,54,102$; Chapter $18: 4,33,56,86$; as well as the following problems:
A. Identify the Brønsted-Lowry acid, base, conjugate acid and conjugate base in the following equations:
(i) $\mathrm{HSO}_{4}^{-}(\mathrm{aq})+\mathrm{CO}_{3}^{2-}(\mathrm{aq})$ <-> $\mathrm{SO}_{4}^{2-}(\mathrm{aq})+\mathrm{HCO}_{3}^{-}(\mathrm{aq})$

Acid Base Conj. Base Conj. Acid
(ii) $\mathrm{H}_{2} \mathrm{~S}(\mathrm{aq})+\mathrm{CH}_{3} \mathrm{NH}_{2}(\mathrm{aq}) \quad<-\mathrm{HS}^{-}(\mathrm{aq})+\mathrm{CH}_{3} \mathrm{NH}_{3}{ }^{+}(\mathrm{aq})$

Acid Base Conj. Base Conj. Acid
B. What are $\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]$and $\left[\mathrm{OH}^{-}\right]$for solutions with the following pH values:

> (i) $\mathrm{pH}=9$
> $\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]=1 \times 10^{-9} \mathrm{M}$
> $\left[\mathrm{OH}^{-}\right]=1 \times 10^{-5} \mathrm{M}$
(iii) $\mathrm{pH}=5.33$
$\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]=4.68 \times 10^{-6} \mathrm{M}$
$\left[\mathrm{OH}^{-}\right]=2.14 \times 10^{-9} \mathrm{M}$
(ii) $\mathrm{pH}=4$ $\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]=1 \times 10^{-4} \mathrm{M}$ $\left[\mathrm{OH}^{-}\right]=1 \times 10^{-10} \mathrm{M}$
(iv) $\mathrm{pH}=8.04$ $\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]=9.12 \times 10^{-9} \mathrm{M}$ $\left[\mathrm{OH}^{-}\right]=1.1 \times 10^{-6} \mathrm{M}$
C. What is the pH of each of the following solutions:
(i) Lime juice : $\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]=4.64 \times 10^{-4} \mathrm{M} \quad \mathrm{pH}=3.33$
(ii) saliva $\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]=7.94 \times 10^{-7} \mathrm{M} \quad \mathrm{pH}=\mathbf{6 . 1 0}$
(iii) laundry bleach: $\left[\mathrm{H}_{3} \mathrm{O}^{+}\right]=2.51 \times 10^{-13} \mathrm{M} \quad \mathrm{pH}=\mathbf{1 2 . 6}$
D. Identify the materials being oxidized or reduced in the equations shown:
(i) $\mathrm{Cu}+2 \mathrm{Ag}^{+}---\ldots------->2 \mathrm{Ag}+\mathrm{Cu}^{2+}$

Cu is oxidized and $\mathrm{Ag}+$ is reduced $\mathrm{Cu} \rightarrow \mathrm{Cu}^{2+}$ and $\mathrm{Ag}+\rightarrow \mathrm{Ag}$
(ii) $4 \mathrm{Fe}+3 \mathrm{O}_{2}----->2 \mathrm{Fe}_{2} \mathrm{O}_{3}$

Fe is oxidized and $\mathrm{O}_{2}$ is reduced $\mathrm{Fe} \rightarrow \mathrm{Fe}^{3+}$ and $\mathrm{O}_{2} \rightarrow \mathrm{O}^{2-}$
(iii) $2 \mathrm{As}+3 \mathrm{Cl}_{2}---->2 \mathrm{AsCl}_{3}$

As is oxidized and $\mathrm{Cl}_{2}$ is reduced $\mathrm{As} \rightarrow \mathrm{As}^{3+}$ and $\mathrm{Cl}_{2} \rightarrow \mathrm{Cl}^{-}$

## Problems from Zumdahl:

## Chapter 16:

9.(a) $\mathrm{HF}=$ acid; $\mathrm{H}_{2} \mathrm{O}=$ base $\mathrm{F}-=$ conjugate base $\mathrm{H}_{3} \mathrm{O}+=$ conjugate acid
(b) $\mathrm{CN}-$ = base; $\mathrm{H}_{2} \mathrm{O}=$ acid; $\mathrm{HCN}=$ conjugate acid; $\mathrm{OH}-=$ conjugate base
(c ) $\mathrm{HCO}_{3}{ }^{-}=$base; $\mathrm{H}_{2} \mathrm{O}=$ acid; $\mathrm{H}_{2} \mathrm{CO}_{3}=$ conjugate acid; $\mathrm{OH}^{-}=$base
15. (a) $\mathrm{HSO}_{3}-+\mathrm{H}_{2} \mathrm{O}-\cdots--->\mathrm{SO}_{3}{ }^{2-}+\mathrm{H}_{3} \mathrm{O}^{+}$
(b) $\mathrm{CO}_{3}{ }^{2-}+\mathrm{H}_{2} \mathrm{O}----->\mathrm{HCO}_{3}^{-}+\mathrm{OH}-$
(c ) $\mathrm{H}_{2} \mathrm{PO}_{4}^{-}+\mathrm{H}_{2} \mathrm{O}----->\mathrm{HPO}_{4}^{2-}+\mathrm{H}_{3} \mathrm{O}^{+}$
(d) $\mathrm{C}_{2} \mathrm{H}_{3} \mathrm{O}_{2}^{-}+\mathrm{H}_{2} \mathrm{O}----->\mathrm{HC}_{2} \mathrm{H}_{3} \mathrm{O}_{2}+\mathrm{OH}^{-}$
31. (a) $\left[\mathrm{H}^{+}\right]=4.3 \times 10^{-11} \mathrm{M}$; basic
(b) $\left[\mathrm{H}^{+}\right]=1.1 \times 10^{-5} \mathrm{M}$; acidic (c_[ $\left.\mathrm{H}^{+}\right]=2.3 \times 10^{-9} \mathrm{M}$; basic
(d) $\left[\mathrm{H}^{+}\right]=1.6 \times 10^{-3} \mathrm{M}$; acidic
36. (a) $\left[\mathrm{OH}^{-}\right]=6.03 \times 10^{-4} \mathrm{M}$
(b) $\left[\mathrm{OH}^{-}\right]=4.21 \times 10^{-6} \mathrm{M}$
(c ) $\left[\mathrm{OH}^{-}\right]=8.04 \times 10^{-4} \mathrm{M}$
54. (a) 5.358
(b) 3.64
(c) 5.97
(d) 0.480
102. (a) $[\mathrm{H}+]=3.9 \times 10^{-6} \mathrm{M}$
(b) $\left[\mathrm{H}^{+}\right]=1.1 \times 10^{-2} \mathrm{M}$
(c) $[\mathrm{H}+]=1.2 \times 10^{-12} \mathrm{M}$
(d) $\left[\mathrm{H}^{+}\right]=7.8 \times 10^{-11} \mathrm{M}$

Chapter 18:
4. (a) Na is oxidized; nitrogen is reduced
(b) Mg is oxidized; Cl is reduced
(c ) Al is oxidized; Br is reduced
(d) Mg is oxidized; Cu is reduced
33. Zn is oxidized; $\mathrm{H}+$ is reduced
56.Cd $+2 \mathrm{OH}^{-}------->\mathrm{Cd}(\mathrm{OH})_{2}+2 \mathrm{e}^{-}$(oxidation)
$\mathrm{NiO}_{2}+2 \mathrm{H}_{2} \mathrm{O}+2 \mathrm{e}^{-}------>\mathrm{Ni}(\mathrm{OH})_{2}+2 \mathrm{OH}^{-}$(reduction)
86.(a) Al is oxidized; H is reduced
(b) H is reduced; I is oxidized
(c) Cu is oxidized; H is reduced.

