

Chapter 14

14.34

~~14.32~~(a) X^- , Y^- , Z^- (b) $HX < HZ < HY$ (c) HY (d) HX (e) $(2/10) \times 100\% = 20\%$

14.35

~~14.33~~

(c) represents a solution of a weak diprotic acid H_2A .
 Because K_{a2} is always less than K_{a1} , (c) + (d) represent impossible situations. (b) contains no H_2A .

14.37

~~14.35~~

(a) The weakest acid has the strongest conjugate base. HY is the weakest acid because it is the least dissociated. Therefore Y^- has the largest K_b .

(b) The strongest acid has the weakest conjugate base.
 HX is the strongest acid because it is the most dissociated.
 Therefore, X^- is the weakest base.

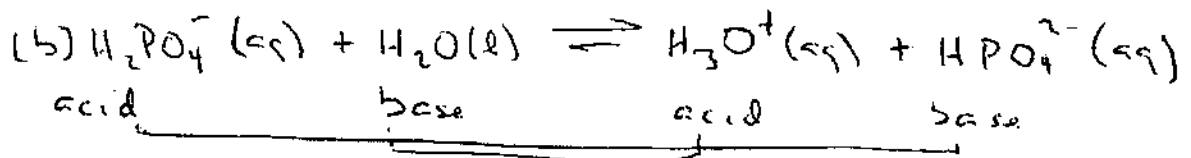
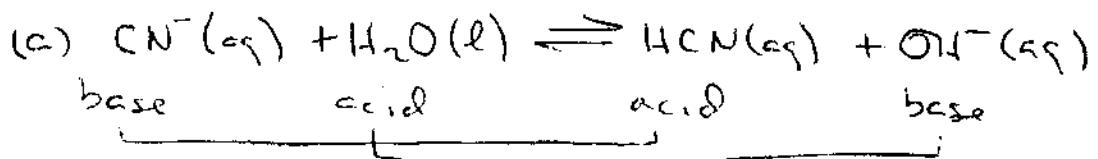
14.46

~~14.44~~(a) SO_4^{2-} (b) HSO_3^- (c) HPO_4^{2-} (d) NH_3 (e) OH^- (f) NH_2^-

14.47

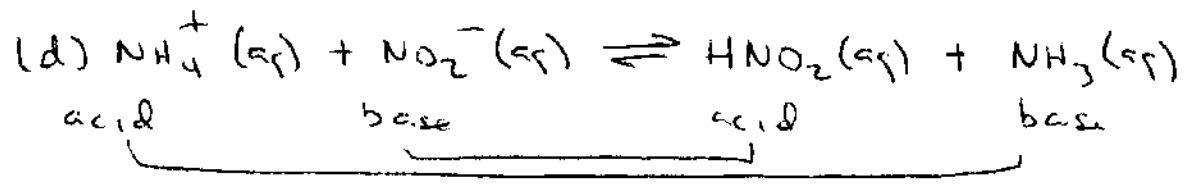
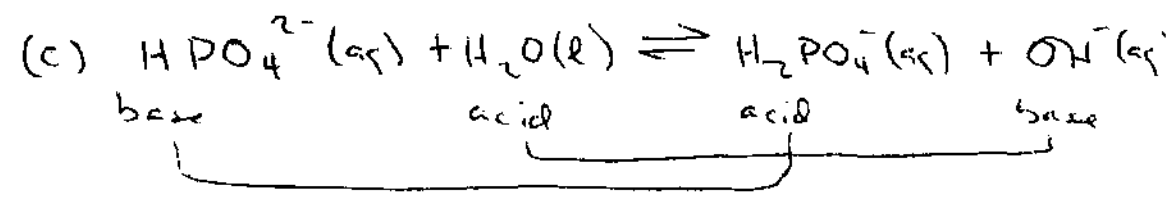
~~14.45~~(a) HSO_3^- (b) H_3O^+ (c) $CH_3NH_3^+$ (d) H_2O (e) H_2CO_3
(f) H_2

14.49

~~14.47~~

14.49

14.49 cont.



14.50

14.50

Strong Acids: $\text{HNO}_3 + \text{H}_2\text{SO}_4$; Strong Bases: $\text{H}^- + \text{O}^{2-}$
from data table 14.1

14.54

14.54

- If $[\text{H}_3\text{O}^+] > 1 \times 10^{-7} \text{ M}$; soln. is acidic
- $[\text{H}_3\text{O}^+] < 1 \times 10^{-7} \text{ M}$; soln is basic
- $[\text{H}_3\text{O}^+] = [\text{OH}^-] = 1 \times 10^{-7} \text{ M}$; soln. is neutral
- $[\text{OH}^-] > 1 \times 10^{-7} \text{ M}$; soln is basic
- $[\text{OH}^-] < 1 \times 10^{-7} \text{ M}$; soln is acidic

(a) $[\text{OH}^-] = \frac{K_w}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{3.4 \times 10^{-9}} = 2.9 \times 10^{-6} \text{ M}$, basic

(b) $[\text{H}_3\text{O}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{1 \times 10^{-14}}{0.01} = 1 \times 10^{-12} \text{ M}$, basic

(c) $[\text{H}_3\text{O}^+] = 1 \times 10^{-4} \text{ M}$, acidic

(d) $[\text{OH}^-] = 1.0 \times 10^{-7} \text{ M}$, neutral

(e) $[\text{OH}^-] = 1.2 \times 10^{-10} \text{ M}$, acidic

$$[\text{OH}^-] = \frac{k_w}{[\text{H}_3\text{O}^+]} \quad \& \quad [\text{H}_3\text{O}^+] = \frac{k_w}{[\text{OH}^-]}$$

(3)

14.55
~~14.53~~

(a) $[\text{OH}^-] = 4 \times 10^{-11} \text{ M}$, acidic

(b) $[\text{OH}^-] = 5.0 \times 10^{-15} \text{ M}$, acidic

(c) $[\text{H}_3\text{O}^+] = 1.8 \times 10^{-6} \text{ M}$, acidic

(d) $[\text{H}_3\text{O}^+] = 6.7 \times 10^{-12} \text{ M}$, basic

(e) $[\text{H}_3\text{O}^+] = 1.0 \times 10^{-7} \text{ M}$, neutral

14.61
~~14.57~~

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}}$$

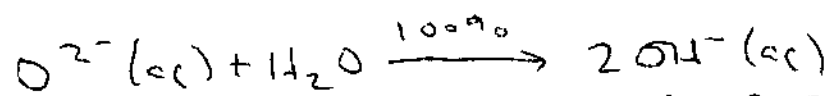
(a) $1 \times 10^{-9} \text{ M}$ (b) $1.0 \times 10^{-7} \text{ M}$ (c) 2 M

(d) $6.6 \times 10^{-16} \text{ M}$ (e) $2.3 \times 10^{-7} \text{ M}$ (f) $1.75 \times 10^{-11} \text{ M}$

14.67

~~14.65~~ (c) Na_2O , 61.98 g mol^{-1} ; 100 mL

$$\text{moles Na}_2\text{O} \Rightarrow 0.20 \text{ g Na}_2\text{O} \times \frac{1 \text{ mol Na}_2\text{O}}{61.98 \text{ g Na}_2\text{O}} = 0.0032 \text{ mol Na}_2\text{O}$$



$$\text{moles OH}^{-} = 2(0.0032 \text{ mol}) = 0.0064 \text{ mol}$$

$$[\text{OH}^{-}] = \frac{0.0064 \text{ mol}}{0.1 \text{ L}} = 0.064 \text{ M}$$

$$[\text{H}_3\text{O}^{+}] = \frac{K_w}{[\text{OH}^{-}]} = 1 \times 10^{-14} / 0.064 = 1.6 \times 10^{-13} \text{ M}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^{+}] = -\log (1.6 \times 10^{-13}) = 12.80$$

1467

14.65 cont.

(b)

$$\text{molarity HNO}_3 \Rightarrow 1.26\text{g HNO}_3 \times \frac{1\text{mol HNO}_3}{63.01\text{g}} \times \frac{1}{0.5\text{L}} =$$

0.0400M

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(0.0400\text{M}) = 1.398$$

$$(c) [\text{OH}^-] = 2(0.075\text{M}) = 0.15\text{M}$$

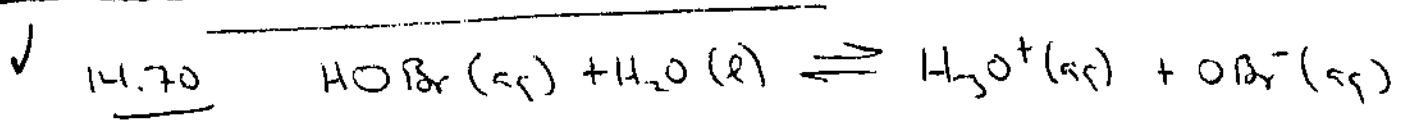
$$M_2 V_2 = M_1 V_1 \quad M_2 = \frac{M_1 V_1}{V_2} = \frac{(0.15)(40\text{mL})}{300\text{mL}} = 0.02$$

$$[\text{H}_3\text{O}^+] = \frac{K_w}{[\text{OH}^-]} = \frac{1 \times 10^{-14}}{0.02} = 5.0 \times 10^{-13}\text{M}$$

(d) Mixing equal volumes of the two strong acids results in cutting both conc. in half.

$$[\text{H}_3\text{O}^+] = 0.10\text{M} + 0.25\text{M} = 0.35\text{M}$$

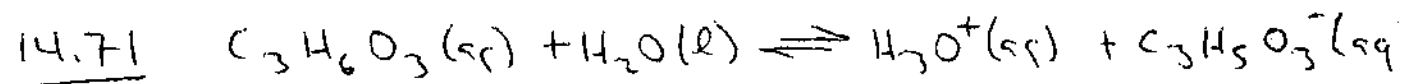
$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(0.35) = \underline{0.46}$$



start	0.040 M	-	-
Δ	-x	+x	+x
equil.	0.040 - x	x	x

$$x = [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-5.05} = 8.9 \times 10^{-6} \text{ M}$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{OBr}^-]}{[\text{HOBr}]} = \frac{x^2}{0.040 - x} = \frac{(8.9 \times 10^{-6})^2}{0.04 - (8.9 \times 10^{-6})} = 2.0 \times 10^{-9}$$



start	0.10	-	-
Δ	-x	+x	+x
equil.	0.10 - x	x	x

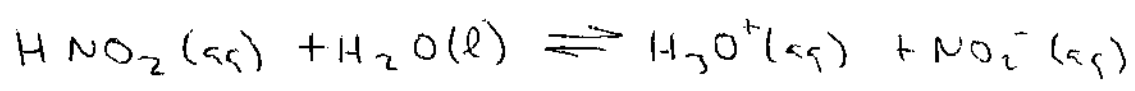
$$x = [\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-2.43} = 3.7 \times 10^{-3} \text{ M}$$

$$[\text{C}_3\text{H}_5\text{O}_3^-] = 3.7 \times 10^{-3} \text{ M}; \quad [\text{C}_3\text{H}_6\text{O}_3] = 0.10 - x = 0.10 - 3.7 \times 10^{-3} \text{ M} = 0.10$$

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{C}_3\text{H}_5\text{O}_3^-]}{[\text{C}_3\text{H}_6\text{O}_3]} = \frac{(3.7 \times 10^{-3})^2}{(0.10 - 3.7 \times 10^{-3})} = 1.4 \times 10^{-4}$$

$$\text{p}K_a = -\log K_a = -\log(1.4 \times 10^{-4}) = \underline{\underline{3.85}}$$

14.74



start	1.5	-	-
Δ	-x	+x	+x
equil.	1.5 - x	x	x

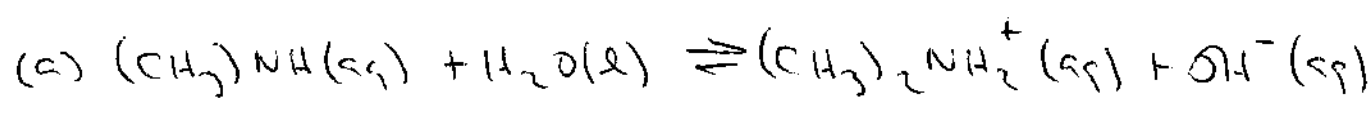
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{NO}_2^-]}{[\text{HNO}_2]} = 4.5 \times 10^{-4} = \frac{x^2}{1.5-x} \approx \frac{x^2}{1.5}$$

$$x = 0.026 \text{ M} = [\text{H}_3\text{O}^+] = [\text{NO}_2^-]$$

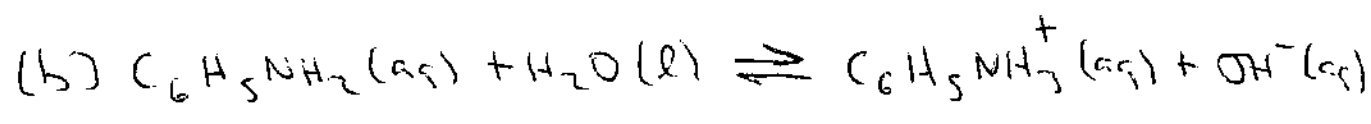
$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(0.026 \text{ M}) = 1.59$$

$$\% \text{ dissociation} = \frac{[\text{NO}_2^-]}{[\text{HNO}_2]_i} \times 100 = \frac{0.026}{1.5} \times 100 = 1.7\%$$

14.82

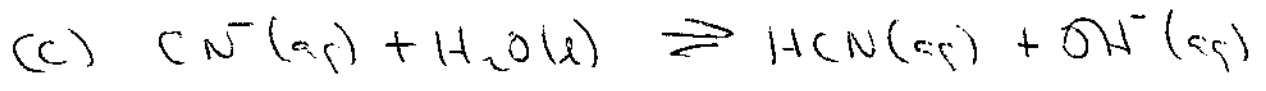


$$K_b = \frac{[(\text{CH}_3)_2\text{NH}_2^+][\text{OH}^-]}{[(\text{CH}_3)_2\text{NH}]}$$



$$K_b = \frac{[\text{C}_6\text{H}_5\text{NH}_3^+][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{NH}_2]}$$

14.87 cont.



$$K_b = \frac{[\text{HCN}][\text{OH}^-]}{[\text{CN}^-]}$$

14.84

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-9.5} = 3.16 \times 10^{-10} \text{ M}$$

$$[\text{OH}^-] = \frac{K_w}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{3.16 \times 10^{-10}} = 3.16 \times 10^{-5} \text{ M}$$

	$\text{C}_{17}\text{H}_{19}\text{NO}_3(aq)$	$+$	$\text{H}_2\text{O}(l)$	\rightleftharpoons	$\text{C}_{17}\text{H}_{20}\text{NO}_3^+(aq)$	$+$	$\text{OH}^-(aq)$
start	7.0×10^{-4}						
Δ	$-x$				$+x$		$+x$
equil.	$7.0 \times 10^{-4} - x$				x		x

$$x = [\text{OH}^-] = 3.16 \times 10^{-5} \text{ M}$$

$$K_b = \frac{[\text{C}_{17}\text{H}_{20}\text{NO}_3^+][\text{OH}^-]}{[\text{C}_{17}\text{H}_{19}\text{NO}_3]} = \frac{x^2}{7.0 \times 10^{-4} - x} = \frac{(3.16 \times 10^{-5})^2}{(7.0 \times 10^{-4}) - (3.16 \times 10^{-5})}$$

$$= 1.49 \times 10^{-6}$$

$$\text{p}K_b = -\log K_b = -\log(1.49 \times 10^{-6} \text{ M}) = \underline{5.8}$$

14.93 (a) $\text{Fe}(\text{NO}_3)_3$; Fe^{+3} acidic cation; NO_3^- neutral anion
soln is acidic

(b) $\text{Ba}(\text{NO}_3)_2$; Ba^{+2} , neutral cation; NO_3^- neutral anion
soln is neutral

(c) NaOCl ; Na^+ , neutral cation; OCl^- basic anion
soln is basic

(d) NH_4I ; NH_4^+ , acidic cation; I^- neutral anion,
soln is acidic

(e) NH_4NO_2 ; for NH_4^+ ; $K_a = 5.6 \times 10^{-10}$; for NO_2^-
 $K_b = 2.2 \times 10^{-11}$
since $K_a > K_b$; the soln is acidic

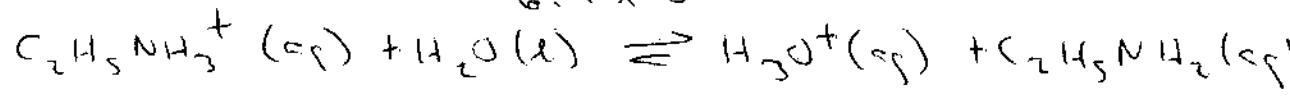
(f) $(\text{CH}_3\text{NH}_3)\text{Cl}$, CH_3NH_3^+ is acidic cation; Cl^-
is a neutral anion; soln is acidic

14.94

(a) $(C_2H_5NH_3)NO_3$; $C_2H_5NH_3^+$, acidic cation;
 NO_3^- neutral anion

$C_2H_5NH_3^+$, $K_b = 6.4 \times 10^{-4}$ $C_2H_5NH_3^+$; $K_a = \frac{k_w}{K_b} =$

$\frac{1.0 \times 10^{-14}}{6.4 \times 10^{-4}} = 1.56 \times 10^{-11}$



start	0.1	-	-
Δ	-x	+x	+x
equil.	0.1-x	x	x

$K_a = \frac{[H_3O^+][C_2H_5NH_2]}{[C_2H_5NH_3^+]} = 1.56 \times 10^{-11} = \frac{x^2}{0.1-x} \approx \frac{x^2}{0.1}$

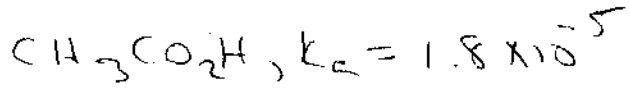
solve for x $\rightarrow x = 1.25 \times 10^{-6} M = [H_3O^+] = [C_2H_5NH_2]$
 $pH = -\log[H_3O^+] = 5.90$

$[C_2H_5NH_3^+] = 0.1 - x = 0.10 M$; $[NO_3^-] = 0.1 M$

$[OH^-] = \frac{k_w}{[H_3O^+]} = \frac{1.0 \times 10^{-14}}{1.25 \times 10^{-6} M} = 8 \times 10^{-9} M$

14.94 cont. next pg

(b) $\text{Na}(\text{CH}_3\text{CO}_2^-)$: Na^+ , neutral cation ; CH_3CO_2^- , basic anion



$$\text{CH}_3\text{CO}_2^- \text{ , } k_b = \frac{k_w}{k_a} = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$$

	$\text{CH}_3\text{CO}_2^- (\text{aq})$	$+ \text{H}_2\text{O}$	\rightleftharpoons	$\text{CH}_3\text{CO}_2\text{H} (\text{aq})$	$+ \text{OH}^- (\text{aq})$
start	0.1			-	-
D	-x			+x	+x
equil.	0.1 - x			x	x

$$k_b = \frac{[\text{CH}_3\text{CO}_2\text{H}][\text{OH}^-]}{[\text{CH}_3\text{CO}_2^-]} = \frac{x^2}{0.1 - x} = 5.6 \times 10^{-10} \approx \frac{x^2}{0.1}$$

$x = 7.5 \times 10^{-6} \text{ M} = [\text{CH}_3\text{CO}_2\text{H}] = [\text{OH}^-]$
 $[\text{CH}_3\text{CO}_2^-] = 0.1 - x = 0.1 \text{ M}$; $[\text{Na}^+] = 0.1 \text{ M}$

$$[\text{H}_3\text{O}^+] = \frac{k_w}{[\text{OH}^-]} = \frac{1 \times 10^{-14}}{7.5 \times 10^{-6}} = 1.3 \times 10^{-9} \text{ M}$$

$$\text{pH} = -\log [\text{H}_3\text{O}^+] = 8.89$$

(c) NaNO_3 ; Na^+ neutral cation & NO_3^- neutral anion

$$[\text{Na}^+] = [\text{NO}_3^-] = 0.1 \text{ M}$$

$$[\text{H}_3\text{O}^+] = [\text{OH}^-] = 1 \times 10^{-7} \text{ M} \text{ , } \text{pH} = 7.0$$

14.96

(a) $\text{PH}_3 < \text{H}_2\text{S} < \text{HCl}$; since electronegativity increases from P to Cl

(b) $\text{NH}_3 < \text{PH}_3 < \text{AsH}_3$; X-H bond strength decreases from N to As (down a group)

(c) $\text{HBrO} < \text{HBrO}_2 < \text{HBrO}_3$; acid strength increases w/ increased # of O atoms.