Announcements – Lecture XX – Tuesday, Nov 29th

1. Lab 5 – Saturday, December 3, 1-4pm

2. Exam III – Thursday, December 8th – In Class
   Three or Four questions will be taken from Lab Owls 3 and 4.
   No questions will be taken from Lab Owl 5.

3. iClicker:
   

   Choose any letter: A-E

8.3 What Are Conjugate Acid–Base Pairs?

Arrhenius:

Acid: Produces H_3O^+ in water.

$HCl(aq) + H_2O(l) = H_3O^+ + Cl^-$

acid

Base: Produces OH^- in water.

$NH_3(aq) + H_2O(l) \Leftrightarrow NH_4^+ + OH^-$

base

Bronsted Lowry:

Acid: A proton (H^+) donor.

$HCl(aq) + H_2O(l) = H_3O^+ + Cl^-$

acid ... donates H^+ to $H_2O(l)$

Base: A proton (H^+) acceptor.

$NH_3(aq) + H_2O(l) \Leftrightarrow NH_4^+ + OH^-$

base ... accepts H^+ from $H_2O(l)$

Notice anything about $H_2O(l)$ in the two examples given above?

8.3 What Are Conjugate Acid–Base Pairs?

$HCN(aq) + NH_3(aq) \rightleftharpoons NH_4^+ + CN^-$

acid base

$NH_4^+ + CN^- \rightleftharpoons HCN(aq) + NH_3(aq)$

acid base

$HCN(aq) + NH_3(aq) \rightleftharpoons NH_4^+ + CN^-$

acid base acid* base*

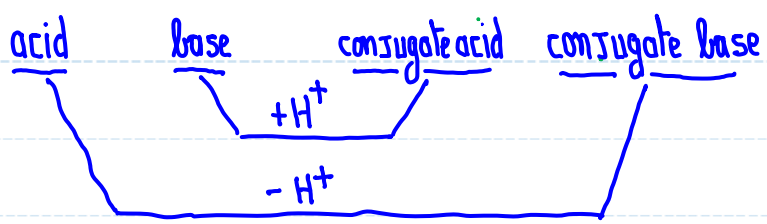
acid* = Conjugate acid.

base* = Conjugate base.

HCN/CN^- = Acid / Conjugate base pair.

NH_3/NH_4^+ = Base / Conjugate acid pair.

$HCN(aq) + NH_3(aq) \rightleftharpoons NH_4^+ + CN^-$



Acid - H^+ = its conjugate base.

Base + H^+ = its conjugate acid.

Cations behaving as acids?

Anions behaving as bases?

Hydrolysis

Cation	Anion	
Na^+	Cl^-	7.0
NH_4^+	F^-	7.6
$C_5H_5NH^+$	CN^-	10.7
	NO_2^-	7.7
	ClO^-	9.7

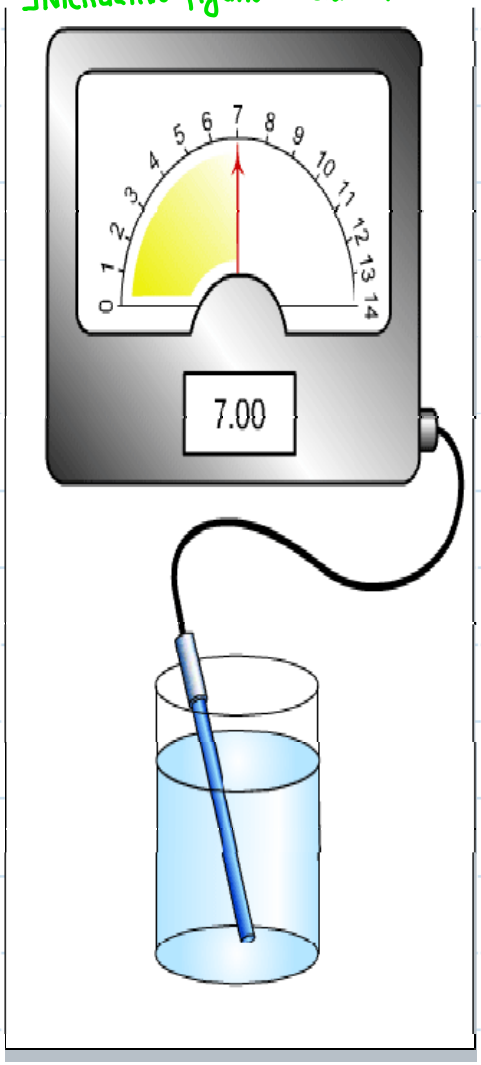
Concentration

0.01 M

Salt: NaCl

pH = 7.00

Interactive figure on class web site



Base	Conjugate acid	
Cl^-	HCl	... strong acid
F^-	HF	all weak acids
CN^-	HCN	
NO_2^-	HNO_2	
ClO^-	HClO	

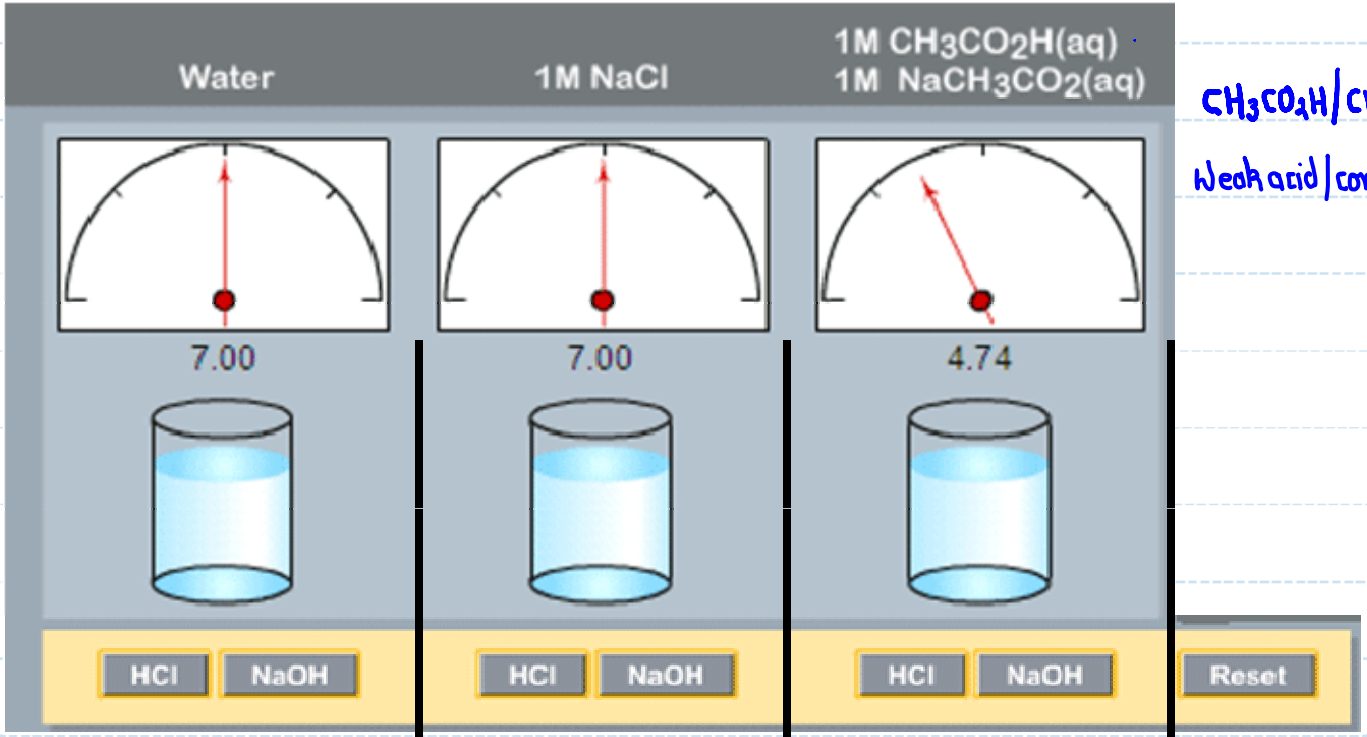
$CN^-(aq) + H_2O(l) \rightleftharpoons HCN(aq) + OH^-(aq)$

Pools!

pH Up ... sodium carbonate ... Washing Soda

↳ $CO_3^{2-} + H_2O(l) \rightleftharpoons HCO_3^- + OH^-$

8.10 What Are Buffers?



$CH_3CO_2H/CH_3CO_2^-$

Weak acid/conjugate base

pH	7.00	7.00	4.74	Initial
pH	1.04	1.04	4.65	Add H_3O^+
pH	12.96	12.96	4.83	Add OH^-

Large pH changes

Small pH changes.

8.10 What Are Buffers? – How Do They Resist Drastic pH Changes

Addition of Strong Acid – H_3O^+

1M CH_3CO_2H / 1M $CH_3CO_2^-$

weak acid — conjugate base

→ SA + WB = 100%

H_3O^+

$$H_3O^+ + CH_3CO_2^- = H_2O(l) + CH_3CO_2H(aq)$$

Buffer base — Buffer acid

OVERALL CHANGES:

$[CH_3CO_2^-]$: ↓ ... reacts with the added H_3O^+.

$[CH_3CO_2H]$: ↑ ... product of the reaction that removed H_3O^+.

$[H_3O^+]$: ↑ ... not by much ... a result of the $[CH_3CO_2H]$↑.

pH : ↓ ... not by much.

8.10 What Are Buffers? – How Do They Resist Drastic pH Changes

Addition of Strong Base – OH^-

1M CH_3CO_2H / 1M $CH_3CO_2^-$

weak acid — conjugate base

WA + SB = 100%

OH^-

$$OH^- + CH_3CO_2H(aq) = H_2O(l) + CH_3CO_2^-$$

Buffer acid — Buffer base

OVERALL CHANGES:

$[CH_3CO_2H]$: ↓ ... Reacts with the added OH^-.

$[CH_3CO_2^-]$: ↑ ... product of the reaction that removed the OH^-.

$[OH^-]$: ↑ ... not by much ... a result of the $[CH_3CO_2^-]$ ↑.

pH: ↑ ... not by much.

8.10 What Are Buffers? – How Do They Resist Drastic pH Changes

A buffer solution made from HF and KF has a pH = 2.84.
Addition of OH- will cause –

1. Increase significantly
2. Increase slightly
3. Decrease significantly
4. Decrease slightly
5. Increase
6. Decrease

a)  pH ? 2 Adding base will cause the solution to become more basic.

b)  pOH ? 4 $[OH^-]\uparrow$: $pOH = -\log_{10}[OH^-]$ will ↓

c)  [HF] ? 6 $HF(aq) + OH^- = H_2O(l) + F^-$

Buffer acid Buffer base

d)  $\frac{[F^-]}{[HF]}$? 5 See c). [HF]↓, $[F^-]\uparrow$