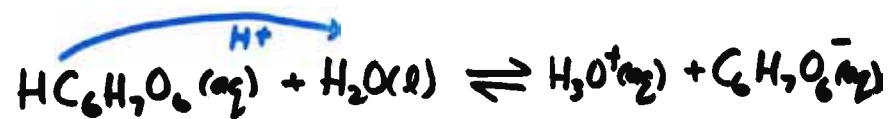


How can we measure  $K_a$  from pH?

ex: pH of a 0.20M soln of  $\text{HC}_6\text{H}_7\text{O}_6(\text{aq})$  @ 25°C,  $\text{pH} = 2.40$   
 What's its  $K_a$ ?



I	0.20M	—	≈ 0	0
C	-x	—	+x	+x
E	(0.20-x)	—	(x)	(x)

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{C}_6\text{H}_7\text{O}_6^-]}{[\text{HC}_6\text{H}_7\text{O}_6]_{\text{eq}}}$$

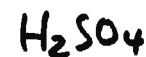
?

$$K_a = \frac{(x)(x)}{0.20-x}$$

$$\Rightarrow K_a = \frac{(4.0 \times 10^{-3})^2}{0.20 - 4.0 \times 10^{-3}} = 8.1 \times 10^{-5}$$

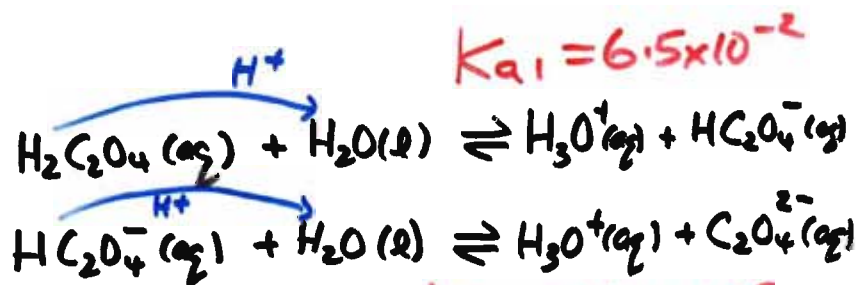
$\text{pH} = -\log_{10} [\text{H}^+]$   
 $[\text{H}^+] = 10^{-\text{pH}}$   
 2sf.  $x = 10^{-2.40}$   
 $= 4.0 \times 10^{-3}$

Monoprotic acid      1  $\text{H}^+$ /molecule: HCl  
 Diprotic acid      2  $\text{H}^+$ /molecule:



Polyprotic acid      > 1  $\text{H}^+$ /molecule

ex: oxalic acid:  $\text{H}_2\text{C}_2\text{O}_4$



$$K_{a1} = 6.5 \times 10^{-2}$$

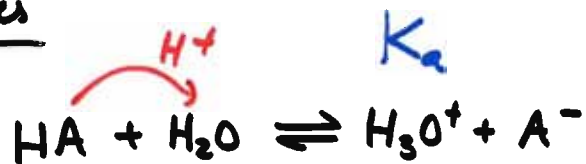
$$K_{a2} = 6.1 \times 10^{-5}$$

in general:  $K_{a1} > K_{a2} > K_{a3} > \dots$

→ successively smaller

## Weak Bases

acids,  
HA



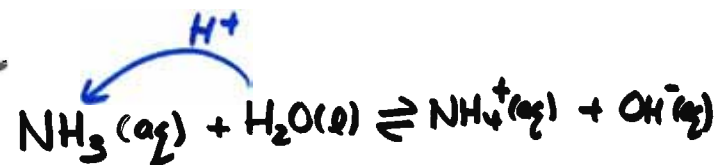
weak base,  
B



$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]_{\text{eq}}}$$

ex: Ammonia is a weak base,  
 $K_b = 1.8 \times 10^{-5}$  @ 25°C.  
What's pH of a 0.50 M soln?

## ICE-Chart



I	0.50M	—	0	≈ 0
C	-x	—	+x	+x
E	(0.5-x)	—	(x)	(x)

$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]_{\text{eq}}}$$

PH?

$$1.8 \times 10^{-5} = \frac{(x)(x)}{0.5-x}$$

Assume:  $x \ll 0.5$

$$1.8 \times 10^{-5} \approx \frac{(x)(x)}{0.50}$$
$$\Rightarrow \sqrt{(1.8 \times 10^{-5})(0.5)} = \sqrt{x^2} = x$$

$$\Rightarrow x = 3.0 \times 10^{-3}$$

Check Assumption: 5% rule.

< 5% dissociated ✓

$$\% \text{ dissoci.} = \frac{[\text{OH}^-]_{\text{eq}} \times 100}{[\text{B}]_0}$$

$$= \frac{3 \times 10^{-3} \text{ M} \times 100}{0.50 \text{ M}}$$

$$= 0.6\% \quad \checkmark$$

$$\Rightarrow [\text{OH}^-] = 3.0 \times 10^{-3} \text{ M} \quad \text{2sf.}$$

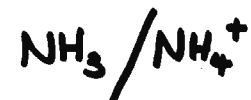
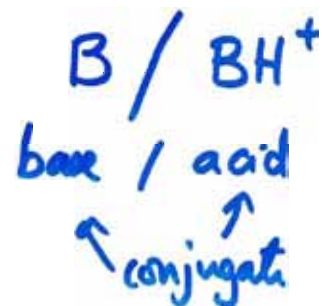
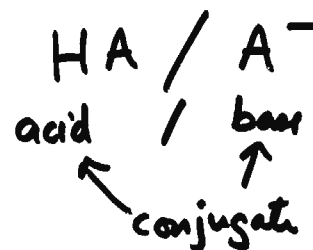
$$\text{pOH} = -\log_{10} [\text{OH}^-]$$

$$= 2.52$$

$$\Rightarrow \text{pH} = 14.00 - \text{pOH} = 11.48$$

$$\Rightarrow \text{pH} + \text{pOH} = 14.00 \quad (25^\circ\text{C}) \quad \text{BASIC}$$

## Conjugate ACID-BASE pairs



K<sub>a</sub> and K<sub>b</sub> for conj. pairs are related!

$$\boxed{K_a \cdot K_b = K_w}$$

at any temp

ex. HCN  
hydrocyanic  
acid

$$K_a = 4.9 \times 10^{-10}$$

@ 25°C

$$K_a \cdot K_b = K_w$$

CN<sup>-</sup>  
cyanide

$$K_b = \frac{K_w}{K_a}$$
$$= \frac{1.0 \times 10^{-14}}{4.9 \times 10^{-10}}$$
$$= 2.0 \times 10^{-5}$$