ch. 17.1 common ion effect

- in essence, it's like applying Le Chatelier's principle

ex $HA \rightleftharpoons H^+ + A^-$

ch 17.2 buffer

- solution that maintains its pH due to the addition of an acid or base

composition of a buffer

- weak acid & its conjugate base

ex $CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$

weak acid — conjugate base

CH_3COONa

- weak base & its conjugate acid

ex $NH_3 + H_2O \rightleftharpoons OH^- + NH_4^+$

weak base — conjugate acid

NH_4Cl

preparation of a buffer

method 1: . mix weak acid & a salt containing its conjugate base

ex · CH_3COOH & $NaCH_3COO$

• mix weak base & a salt of its conjugate acid

ex NH_3 & NH_4Cl

method 2 : titration

ex 1 weak acid + strong base

ex CH_3COOH (excess) + $NaOH \rightleftharpoons NaCH_3COO^- + H_2O$

ex 2 weak base + strong acid

ex NH_3 (excess) + $HCl \rightleftharpoons NH_4Cl$

mechanism of a buffer

recall: acid: H donor

base: H acceptor

conjugate pair

- 2 chemicals in equilibrium
- (differ by H)
- one is an acid & the other is a base

ex acetate buffer

CH_3COOH & CH_3COO^-

add acid, i.e. H^+

H^+ + $CH_3COO^- \longrightarrow CH_3COOH$

strong acid → weak acid

add base = OH^-

OH^- + CH_3COOH → H_2O + CH_3COO^-

strong base · acid · weak base

problems

① find the pH of a 10 mM CH_3COOH & 1 M $NaCH_3COO$

method 1: use ICE table

$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$

	CH_3COOH		H_3O^+	CH_3COO^-
i)	10 mM		0	1 M
[I]			+x	+x
[C]	−x		x	1 M + x
[E]	10 mM − x			

ii) $K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$

$1.8 \cdot 10^{-5} = \frac{x\,(0.001 + x)}{0.01 - x}$

$x = -0.\cancel{0}0117,\ 0.000154$

iii) $pH = -\log[H_3O^+] = -\log(0.000154)$

$= -\log(1.54 \cdot 10^{-4}) = \boxed{3.81}$

method 2: use Henderson-Hasselbach eq

it's an approximation

$HA + H_2O \rightleftharpoons H_3O^+ + A^-$

$\log(K_a) = \log\left(\frac{[H_3O^+][A^-]}{[HA]}\right)$

$-\log K_a = -\log [H_3O^+] + \log \frac{[A^-]}{[HA]}$

$pK_a = pH - \log \frac{[A^-]}{[HA]}$ assume

$[salt]$

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

$[HA]$

$= -\log (1.8 \cdot 10^{-5}) + \log \frac{10^{-3}}{10^{-2}}$

$= \boxed{3.74}$

(2) find the pH a buffer with 10 mM NH_3 & 1 mM NH_4Cl

method 1 ; use ICE

i) $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

[I]	10 mM	1 mM	0
[C]	$-x$	$+x$	$+x$
[E]	$10\,mM - x$	$1\,mM + x$	x

ii) $K_b = \frac{[OH^-][NH_4^+]}{[NH_3]}$

$1.8 \cdot 10^{-5} = \frac{x\,(0.001 + x)}{0.01 - x}$

$x = -0.0117$ / $1.54 \cdot 10^{-4}$

iii) $pOH = -\log [OH^-] = -\log (1.54 \cdot 10^{-4})$

$= 3.81$

iv) $pH + pOH = 14$

$pH = 14 - pOH = 14 - 3.81 = \boxed{10.19}$

method 2: use HH eqn

$$B + H_2O \rightleftharpoons HB^+ + OH^-$$

ex $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

i) $-\log(K_b) = \log\left(\frac{[NH_4^+][OH^-]}{[NH_3]}\right)$

$$pOH = pK_b + \log\frac{[NH_4^+]}{[NH_3]}$$

$$= -\log(1.8\cdot 10^{-5}) + \log\left(\frac{10^{-3}}{10^{-2}}\right)$$

$$= 3.74$$

ii) $pH + pOH = 14$

$$pH + 3.74 = 14$$

$$\boxed{pH = 10.26}$$

(3) How to prepare an acetate buffer @ $pH = 5.0$?

$$pH = pK_a + \log\frac{[A^-]}{[HA]}$$

$$5.0 = -\log(1.8\cdot 10^{-5}) + \log\frac{[A^-]}{[HA]}$$

$$\frac{[A^-]}{[HA]} = 1.82$$

ex $[NaA_c] = 1.82\ mM$ or $1.82\ M$

$[HA] = 1\ mM$ or $1\ M$

"better buffer"