1st Determine the description of the contents of Each Beaker.
2nd calculate the # of moles or millimoles of each species

Beaker	contents	Description	Amount
A	30 ml of 0.2M NaOH	Strong Base	(30)(.2) = 6mmol
B	50ml 0.3M $HC_2H_3O_2$	weak Acid	(50)(.3) = 15mmol
C	50ml 0.4M NH_4Cl	Acidic Salt	(50)(.4) = 20mmol
D	60ml 0.1M HCl	Strong Acid	(60)(.1) = 6mmol
E	50ml 0.5M $NaC_2H_3O_2$	BASIC SALT	(50)(.5) = 25mmol
F	100ml 0.2M NH_3	Weak BASE	(100)(.2) = 20mmol
G	75ml 0.2M NaOH	Strong Base	(75)(.2) = 15mmol
H	37.5ml 0.2M NaOH	Strong Base	(37.5)(.2) = 7.5mmol
I	90 ml 0.2M NaOH	Strong Base	(90)(.2) = 18mmol

NH_3 $K_b = 1.8\times10^{-5}$ NH_4^+ $K_a = 5.6\times10^{-10}$

$HC_2H_3O_2$ $K_a = 1.8\times10^{-5}$ NH_3 $K_b = 1.8\times10^{-5}$

Beaker A

1) Strong Base $pOH = -\log[OH^-]$ $pH = 14 - pOH$

$= -\log[0.2]$ $pH = 13.30$

$pOH = .70$

2) Beaker C = Acidic Salt NH_4Cl $K_a = 5.6\times10^{-10}$

weak Base NH_3 ⇌ NH_4Cl

Strong Acid HCl ⇌ NH_4Cl

Strong wins ⇌ H^+

Strong spectator NH_4Cl

$NH_4 + HOH \rightleftharpoons NH_3 + H_3O^+$

weak Base, Strong Acid

$NH_4Cl + HOH \rightleftharpoons NH_3 + H_3O^+$

	NH_4Cl		NH_3	H_3O^+
I	.4M	-	0	0
C	-x		x	x
E	.4-x		x	x

$K_a = \frac{[NH_3][H_3O^+]}{[NH_4Cl]}$

$K_a = \frac{(x)(x)}{.4-x}$ Assume 5%

$(.4)(5.6\times10^{-10}) = x^2$

2) conti

$X = 1.50 \times 10^{-5}\ M = [H^+]$

$pH = -\log [H^+]$

pH = 4.82

3) Beaker F NH_3 0.2M Weak Base $K_b = 1.8 \times 10^{-5}$

$NH_3 + HOH \rightarrow NH_4^+ + OH^-$

	NH_3		NH_4^+	OH^-
I	0.2 M	-	0	0
C	$-X$		$+X$	$+X$
	$.2 - X$		$+X$	$+X$

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

$K_b = \frac{(X)(X)}{.2 - X}$ Assume 5%

$X^2 = (.2)(1.8 \times 10^{-5})$

$[OH^-] = X = 1.90 \times 10^{-3}$

$pOH = -\log [OH^-]$

$pOH = 2.72$

$pH = 14 - pOH$

pH = 11.28

4) Beaker E $NaC_2H_3O_2$ Basic Salt

$K_a = 1.8 \times 10^{-5}$ 0.5 M

$K_b K_a = K_w$

$K_b = \frac{1 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$

Weak Acid $HC_2H_3O_2$ > $NaC_2H_3O_2$

Strong Base NaOH

Strong wins $\Rightarrow OH^-$

Strong spectator ~~Na^+~~ $C_2H_3O_2$

$C_2H_3O_2^- + HOH \rightleftharpoons OH^- + HC_2H_3O_2$

Strong Base — Weak Acid

$C_2H_3O_2^- + HOH \rightleftharpoons OH^- + HC_2H_3O_2$

	$C_2H_3O_2^-$		OH^-	$HC_2H_3O_2$
I	.5 M	-	0	0
C	$-X$		$+X$	$+X$
E	$.5 - X$		$+X$	$+X$

$K_b = \frac{X^2}{.5}$ Assume 5%

$(.5)(5.6 \times 10^{-10}) = X^2$

$[OH^-] = X = 1.67 \times 10^{-5}$

$pOH = -\log [OH^-]$

$pOH = 4.78$

$pH = 14 - pOH$

pH = 9.22

5) Beaker D 0.10M HCl — $pH = -\log[H^+]$

Strong Acid — $pH = -\log[.10]$

$pH = 1.00$

6) Beaker B 0.30M $HC_2H_3O_2$

Weak acid $K_a = 1.8 \times 10^{-5}$ — $HC_2H_3O_2 + HOH \rightleftharpoons H^+ + C_2H_3O_2^-$

$K_a = \frac{[H^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$

	$HC_2H_3O_2$		H^+	$C_2H_3O_2^-$
I	.30	–	0	0
C	−x		x	x
E	.30 − x		x	x

$1.8 \times 10^{-5} = \frac{(x)(x)}{.30 - x}$ assume $< 5\%$

$x = 2.32 \times 10^{-3} = [H^+]$ — $pH = -\log[H^+]$

$pH = 2.63$

7) Beaker A + D — A → 30mL 0.20M NaOH 6 mmol Strong Base

D → 60mL 0.10M HCl 6 mmol Strong Acid

$NaOH + HCl \rightleftharpoons NaCl + HOH$

	6 mmol	6 mmol	0	0
I				
C	−x	−y	+y	+x
	0	0	6	6

$x = 6$

Neutral Salt

$pH = 7.0$

8) Beaker A + B — A → 30 mL 0.20 NaOH 6 mmol Strong Base

B → 50 mL 0.30 M $HC_2H_3O_2$ 15 mmol weak acid

$NaOH + HC_2H_3O_2 \rightarrow HOH + NaC_2H_3O_2$

	6 mmol	15 mmol	–	0
I				
C	−x	−y		+x
	0	9 mmol		6

$x = 6$

4/7

8) cont.

In Beaker - water, weak acid, BASIC SALT

⇒ Buffer! $K_a = 1.8\times10^{-5}$ $HC_2H_3O_2$

$[H^+] = K_a \frac{[Acid]}{[Base]}$ Acid / CB

$= (1.8\times10^{-5})\left(\frac{9\text{mmol}}{6\text{mmol}}\right)$

$[H^+] = 2.7\times10^{-5}$

values from ICE Table!

$pH = -\log[H^+]$

pH = 4.57

9) Beaker B+G B → 50.0mL 0.30 M $HC_2H_3O_2$ 15mmol

G → 75.0mL 0.20 M NaOH 15mmol

$NaOH + HC_2H_3O_2 \rightleftharpoons H_2O + NaC_2H_3O_2$

I	15mmol	15mmol	–	0
C	−x	−x		+x
	0	0		15

Y=15

In Beaker = BASIC SALT + H_2O

Strong Base NaOH

Weak Acid $HC_2H_3O_2$ → $NaC_2H_3O_2$

Strong wins ⇌ OH^-

Strong spectator Na^+ $C_2H_3O_2^-$

$C_2H_3O_2^- + HOH = HC_2H_3O_2 + OH^-$

	15mmol	–	0 0
	−x		+x +x
	15.0−x		x x

Assume 5%

$K_a = 1.8\times10^{-5}$

$K_b = \frac{K_w}{K_a} = \frac{1\times10^{-14}}{1.8\times10^{-5}}$

$K_b = 5.6\times10^{-10}$

$K_b = \frac{(x)(x)}{.12}$

$(.12)(5.6\times10^{-10}) = x^2$

$[OH^-] = x = 8.20\times10^{-6}$

$pOH = -\log[OH^-]$

$pOH = 5.09$

* New Total Volume

50 + 75 = 125mL

$\frac{15.0\text{ mmol}}{125\text{ mL}} = .12\text{ M}$

$pH = 14 - pOH$

pH = 8.91

10) Beaker B+H Beaker B 50mL 0.3M $HC_2H_3O_2$ 15mmol
Beaker H 37.5mL 0.20M NaOH 7.5mmol

$HC_2H_3O_2 + NaOH \rightarrow HOH + NaC_2H_3O_2$

	I	15mmol	7.5mmol	0
x=7.5	C	-x	-x	x
		-7.5	-7.5	7.5
	E	7.5 mmol	0	7.5 mmol

In Beaker → Weak Acid, Basic Salt, H_2O
→ Buffer $K_a = 1.8\times10^{-5}$ $HC_2H_3O_2$

$[H^+] = K_a \frac{\text{Acid}}{\text{Base}}$
$= (1.8\times10^{-5}) \frac{7.5\ \text{mmol}}{7.5\ \text{mmol}}$
$[H^+] = 1.8\times10^{-5}$

$pH = -\log[H^+]$
$\boxed{pH = 4.74}$

11) Beaker B+I Beaker B 50mL 0.30M $HC_2H_3O_2$ 15 mmol
Beaker I 90mL 0.20M NaOH 18 mmol

$HC_2H_3O_2 + NaOH \rightarrow HOH + NaC_2H_3O_2$

	I	15mmol	18mmol	0	0
x=15	C	-x	-x	+	x
		-15	-15		15
		0	3 mmol		15 mmol

In Beaker strong Base, Basic salt, water ⇒ Strong Base, Basic Salt

PH is dictated By the Strong Component
New Volume = 50mL + 90mL = 140mL

6/7

11) Cont.

3 mmol NaOH in Beaker w/ volume = 140ml

$\frac{3\ mmol}{140ml} = 0.021\ M$

$pOH = -\log[OH^-]$ $\quad pH = 14 - pOH$

$pOH = 1.68$ $\quad$ **pH = 12.32**

12) Beaker F+D

Beaker F 100ml 0.20M NH_3 weak Base 20 mmol

Beaker D 60ml 0.10M HCl strong Acid 6 mmol

$NH_3 + HCl \rightarrow NH_4^+ + Cl^-$

NH_4Cl ← acidic salt

	20mmol	6mmol	0	
x=6	-x	-x	x	NH_4^+ $K_a = 5.6\times10^{-10}$
	-6	-6	6	NH_3 $K_b = 1.8\times10^{-5}$
	14mmol	0	6mmol	$K_b > K_a$
	Weak Base		Acidic salt	∴ Basic Buffer in Beaker

$[H^+] = K_a \frac{[Acid]}{[Base]}$

$= 5.6\times10^{-10}\left(\frac{6mmol}{14mmol}\right)$

$= 2.4\times10^{-10}$

$pH = -\log[H^+]$

pH = 9.62

or $[OH^-] = K_b \frac{Base}{Acid}$

$= (1.8\times10^{-5})\left(\frac{14}{6}\right)$

$[OH^-] = 4.2\times10^{-5}$

$pOH = 4.38$

$pH = 14 - pOH$

pH = 9.62

7/7

13) Beaker B+E

Beaker B 50mL 0.30M $HC_2H_3O_2$ 15mmol

Beaker E 50mL 0.50M $NaC_2H_3O_2$ 25mmol

Weak Acid

↓ Basic salt

In Beaker Acidic Buffer

$[H^+] = K_a \frac{Acid}{Base}$ $K_a = 1.8 \times 10^{-5}$ $HC_2H_3O_2$

$= 1.8 \times 10^{-5} \left(\frac{15\,mmol}{25\,mmol}\right)$

$= 1.08 \times 10^{-5}$

$pH = -\log [H^+]$

$\boxed{pH = 4.97}$