Name ___KEY_____

AP Chemistry
What's in the Beaker? (Acid-Base)

Beaker	Contents
A	30.0 mL of 0.20 M NaOH
B	50.0 mL of 0.30 M $HC_2H_3O_2$
C	50.0 mL of 0.40 M NH_4Cl
D	60.0 mL of 0.10 M HCl
E	50.0 mL of 0.50 M $NaC_2H_3O_2$
F	100. mL of 0.20 M NH_3
G	75.0 mL of 0.20 M NaOH
H	37.5 mL of 0.20 M NaOH
I	90.0 mL of 0.20 M NaOH

Answer Choices
Strong acid
Strong base
Weak acid
Weak base
Acidic Salt
Basic Salt
Neutral Salt
Acidic Buffer
Basic Buffer

$HC_2H_3O_2$ $K_a = 1.8x10^{-5}$

NH_3 $K_b = 1.8x10^{-5}$

Questions

In the following questions, describe what would be in the beaker (using the answer choices above) when either one of the beakers above is used or a combination of the beakers above is poured together. For an extra bonus, calculate the pH of the resultant solution.

#	Question	Answer	pH
1	A	Strong base	13.30
2	C	Acidic salt	4.82
3	F	Weak base	11.28
4	E	Basic salt	9.22
5	D	Strong acid	1.00
6	B	Weak acid	2.63
7	A + D	Neutral salt	7.00
8	A + B	Acidic buffer	4.57
9	B + G	Basic salt	8.91
10	B + H	Acidic buffer	4.74
11	B + I	Strong base	12.33
12	F + D	Basic buffer	9.62
13	B + E	Acidic buffer	4.97

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What's In the Beaker – Answer Key

First – determine the contents of each beaker A –

Beaker	Contents	Quantity (moles)	Description
A	30.0 mL of 0.20 M NaOH	0.0060	Strong Base
B	50.0 mL of 0.30 M $HC_2H_3O_2$	0.015	Weak Acid
C	50.0 mL of 0.40 M NH_4Cl	0.020	Acidic Salt
D	60.0 mL of 0.10 M HCl	0.0060	Strong Acid
E	50.0 mL of 0.50 M $NaC_2H_3O_2$	0.025	Basic Salt
F	100. mL of 0.20 M NH_3	0.020	Weak Base
G	75.0 mL of 0.20 M NaOH	0.015	Strong Base
H	37.5 mL of 0.20 M NaOH	0.0075	Strong Base
I	90.0 mL of 0.20 M NaOH	0.018	Strong Base

1. **Strong Base**; pOH = -log(0.20) = 0.70; pH = 14 – 0.70 = 13.30

2. **Acidic Salt** (hydrolysis RICE table)

NH_4^+	H_2O	↔	NH_3	H_3O^+
0.40			0	0
-x			+x	+x
0.40-x ~0.40			x	x

$$K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]} = \frac{K_w}{K_b}$$

$$\frac{1\ x\ 10^{-14}}{1.8\ x\ 10^{-5}} = \frac{x^2}{0.40}$$

$$x = [H_3O^+] = 1.5\ x\ 10^{-5}$$

$$pH = -log(1.5\ x\ 10^{-5}) = 4.83$$

3. **Weak Base** (basic RICE table)

NH_3	H_2O	↔	NH_4^+	OH^-
0.20			0	0
-x			+x	+x
0.20-x ~0.20			x	x

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

$$1.8\ x\ 10^{-5} = \frac{x^2}{0.20}$$

$$x = [OH^-] = 0.0019$$

$$pOH = -log(0.0019) = 2.72$$

$$pH = 14 - 2.72 = 11.28$$

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4. **Basic Salt** (hydrolysis RICE table)

$C_2H_3O_2^-$	H_2O	↔	$HC_2H_3O_2$	OH^-
0.50			0	0
-x			+x	+x
0.50-x ~0.50			x	x

$$K_b = \frac{[HC_2H_3O_2][OH^-]}{[C_2H_3O_2^-]} = \frac{K_w}{K_a}$$

$$\frac{1\ x\ 10^{-14}}{1.8\ x\ 10^{-5}} = \frac{x^2}{0.50}$$

$$x = [OH^-] = 1.7\ x\ 10^{-5}$$

$$pOH = -log(1.7\ x\ 10^{-5}) = 4.78$$

$$pH = 14 - 4.78 = 9.22$$

5. **Strong Acid**; pH = -log(0.10) = 1.00

6. **Weak Acid** (acidic RICE table)

$HC_2H_3O_2$	H_2O	↔	$C_2H_3O_2^-$	H_3O^+
0.30			0	0
-x			+x	+x
0.30-x ~0.30			x	x

$$K_a = \frac{[HC_2H_3O_2][H_3O^+]}{[C_2H_3O_2^-]}$$

$$1.8\ x\ 10^{-5} = \frac{x^2}{0.30}$$

$$x = [H_3O^+] = 0.0023$$

$$pH = -log(0.0023) = 2.63$$

7. Strong Base + Strong Acid (equal moles) = **Neutral Salt** pH = 7.00

8. Strong Base + Weak Acid = Invader Problem; Use a stoichiometry table

OH^-	$HC_2H_3O_2$	↔	$C_2H_3O_2^-$	H_2O
0.0060	0.015		0	
-0.0060	-0.0060		+0.0060	
0	0.0090		0.0060	
Acidic Buffer				

$$pH = -\log(1.8\ x\ 10^{-5}) + log\left(\frac{0.0060}{0.0090}\right) = 4.57$$

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What's in the Beaker? (Acid-Base)

9. Weak Acid + Strong Base = Invader Problem; Use a stoichiometry table

$HC_2H_3O_2$	OH^-	↔	$C_2H_3O_2^-$	H_2O
0.015	0.015		0	
-0.015	-0.015		+0.015	
0	0		0.015	
Basic Salt				

Total Volume = 50.0 + 75.0 = 125.0 mL

Set Up a hydrolysis RICE Table

$C_2H_3O_2^-$	H_2O	↔	$HC_2H_3O_2$	OH^-
0.12			0	0
-x			+x	+x
0.12-x ~0.12			x	x

$$K_b = \frac{[HC_2H_3O_2][OH^-]}{[C_2H_3O_2^-]} = \frac{K_w}{K_a}$$

$$\frac{1\ x\ 10^{-14}}{1.8\ x\ 10^{-5}} = \frac{x^2}{0.12}$$

$$x = [OH^-] = 8.2\ x\ 10^{-6}$$

$$pOH = -log(8.2\ x\ 10^{-6}) = 5.09$$

$$pH = 14 - 5.09 = 8.91$$

10. Weak Acid + Strong Base = Invader Problem; Use a stoichiometry table

$HC_2H_3O_2$	OH^-	↔	$C_2H_3O_2^-$	H_2O
0.015	0.0075		0	
-0.0075	-0.0075		+0.0075	
0.0075	0		0.0075	
Acidic Buffer				

$$pH = -\log(1.8\ x\ 10^{-5}) + log\left(\frac{0.0075}{0.0075}\right) = 4.74$$

11. Weak Acid + Strong Base = Invader Problem; Use a stoichiometry table

$HC_2H_3O_2$	OH^-	↔	$C_2H_3O_2^-$	H_2O
0.015	0.018		0	
-0.015	-0.015		+0.015	
0	0.003		0.015	
Strong Wins!				

Total Volume = 50.0 + 90.0 = 140.0 mL

$$[OH^-] = \frac{0.003\ mol}{0.140\ L} = 0.021\frac{mol}{L}$$

$$pOH = -\log(0.021) = 1.67$$

$$pH = 14 - 1.67 = 12.33$$

12. Weak Base + Strong Acid = Invader Problem; Use a stoichiometry table

NH_3	H_3O^+	↔	NH_4^+	H_2O
0.020	0.0060		0	
-0.0060	-0.0060		+0.0060	
0.014	0		0.0060	
Basic Buffer				

$$pOH = -\log(1.8\ x\ 10^{-5}) + log\left(\frac{0.0060}{0.014}\right) = 4.38$$

$$pH = 14 - 4.38 = 9.62$$

12. Weak Acid + Acidic Salt = Acidic Buffer

$$pH = -\log(1.8\ x\ 10^{-5}) + log\left(\frac{0.025}{0.015}\right) = 4.97$$