Mr. Bracken
AP Chemistry

Name BRACKEN KEY
Period ____

Acid Base Comprehensive Review Packet (2011)

General Information:
What is meant by the term *spectator ion*?

What is the difference between a strong and weak acid?

What is the difference between a strong and weak base?

What is the Bronsted Lowry definition of an acid?

What is the Bronsted Lowry definition of a base?

The bicarbonate ion (HCO_3^{1-}) is an amphoteric ion. Write a reaction with water showing how it can act as a base and then show how it can react like an acid with water.

$HCO_3^- + HOH \rightleftharpoons H_2CO_3 + OH^-$
Reacting as a base with water

$HCO_3^- + HOH \rightleftharpoons H_3O^+ + CO_3^{2-}$
Reacting as an acid with water

What is an *equivalence point* of an acid-base titration experiment?

There are many acid-base indicators that can be used. What factor do chemists use to decide which indicator would be appropriate for their acid-base titration?

What is the estimated pH at the equivalence point of a titration involving a weak acid and a strong base?

(a) pH < 7.0
(b) pH = 7.0
(c) pH > 7.0

What is a buffer?

How do we know when to draw a single arrow (irreversible) or double arrow in chemical reactions?

Which is a stronger acid: $HBrO_3$ or HBrO ? Explain briefly.

MORE OXYGENS = STRONGER ACID

How would you prepare a 125 mL of 0.44 M HCl solution from concentrated 12 M HCl solution? Explain briefly and show any necessary calculations.

$(.44)(.125) = (12)(V)$

V = .0046 Liters or 4.6 mL conc. HCl added to about 50 mL H_2O then mix. Add H_2O to final volume

Use the orange sheet of Ka values to rank the following three acids in order from weakest to strongest:

butanoic ($HC_4H_7O_2$) 1.5×10^{-5}
hydrobromic acid (HBr) strong
hydrocyanic acid (HCN) 4.9×10^{-10}

HCN < $HC_4H_7O_2$ < HBr
weakest acid — strongest acid

Write the hydrolysis reaction for ammonia (NH_3).

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

Consider the above hydrolysis equation in this question. What happens to the position of the equilibrium (shift left, right, or no effect) if 6 M NaOH is added to the equilibrium system?

OH^- added shifts to the left (Le Chat Principle)

Strong Acid/Base Problems

1. What is the pH of a 0.10 M HBr solution?

$-\log(.10) = pH$ → pH = 1

2. What is the pH of a 0.15 M NaOH solution?

$-\log(.15) = pOH$ → pOH = .82 → pH = 13.18

3. What is the pH of a 0.10 M $Ca(OH)_2$ solution?

$-\log(.20) = pOH$ → pOH = .699 → pH = 13.30

Weak Acid/Base Problems

4. What is the pH of a 0.10 M HF solution?

	HF	+ H_2O ⇌	H_3O^+	+ F^-
	.10 M		0	0
	−x		+x	+x
	.10 − x		x	x

$K_a = 6.8 \times 10^{-4} = \frac{x^2}{.10 - x}$

x = .0079 → pH = 2.10

5. What is the pH of a 0.10 M pyridine (C_5H_5N) solution?

	C_5H_5N +	H_2O ⇌	$HC_5H_5N^+$	+ OH^-
	.10 M		0	0
	−x		+x	+x
	.10 − x		x	x

$K_b = 1.7 \times 10^{-9} = \frac{x^2}{.10 - x}$

$x = [OH^-] = 1.3 \times 10^{-5}$ M

pOH = 4.88 → pH = 9.11

Buffer Problems

6. What is the pH of a solution that is 0.20 M in HF and 0.30 M in NaF?

	HF +	H_2O ⇌	H_3O^+	+ F^-
	.20 M		0	.30 M
	−x		+x	+x
	.20 − x		x	.30 + x

$K_a = 6.8 \times 10^{-4} = \frac{[x][.30 + x]}{[.20 - x]}$

$x = 4.52 \times 10^{-4} = [H_3O^+]$

pH = 3.35

7. What is the pH of a solution that is 0.16 M in sodium formate ($NaCHO_2$) and 0.26 M in formic acid ($HCHO_2$)?

	$HCHO_2$ +	H_2O ⇌	H_3O^+	+ CHO_2^-
	.26 M		0	.16 M
	−x		+x	+x
	.26 − x		x	.16 + x

pH = 3.54

$K_a = 1.8 \times 10^{-4} = \frac{[x][.16 + x]}{[.26 - x]}$

$x = 2.9 \times 10^{-4} = [H_3O^+]$

Hydrolysis Problems

8. What is the pH of a 0.10 M NaCN solution?

$K_b = \frac{1\times10^{-14}}{4.9\times10^{-10}} = 2.0\times10^{-5}$

$CN^- + H_2O \rightleftharpoons HCN + OH^-$

.10 M	0	0
−x	+x	+x
.10 − x	x	x

$2.0\times10^{-5} = \frac{x^2}{[.10-x]}$

$x = [OH^-] = .0014\ M$

pOH = 2.85 pH = 11.15

9. What is the pH of a 0.25 M KNO_2 solution?

$NO_2^- + H_2O \rightleftharpoons HNO_2 + OH^-$

.25 M	0	0
−x	+x	+x
.25 − x	x	x

$K_b = \frac{1\times10^{-14}}{4.5\times10^{-4}} = 2.2\times10^{-11}$

$2.2\times10^{-11} = \frac{x^2}{[.25-x]}$

$x = [OH^-] = 2.3\times10^{-6}\ M$

pOH = 5.63 pH = 8.37

Titration Problems

10. What is the pH of a solution after 10 mL of 0.30 M HCl has been added to 15 mL of 0.30 M NH_3?

$NH_3 + H^+ \longrightarrow NH_4^+$

(.30)(.015) (.30)(.010) .0030 moles produced

.0045 moles NH_3 .0030 moles H^+

.0045 − .0030 = .0015 moles leftover NH_3

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

$\frac{.0015}{.025} = .060M$	$\frac{.0030}{.025} = .12M$	0
−x	+x	+x
.060 − x	.12 + x	x

$K_b = 1.8\times10^{-5} = \frac{[x][.12+x]}{[.060-x]}$

$x = [OH^-] = 9.00\times10^{-6}\ M$

pOH = 5.05 pH = 8.95

11. What is the pH of the resulting solution after 15 mL of 0.20 M NaOH has been added to a beaker containing 35 mL of 0.50 M benzoic acid ($HC_7H_5O_2$) ?

$HC_7H_5O_2 + OH^- \rightarrow H_2O + C_7H_5O_2^-$

(.50)(.035) (.20)(.015) .0030 moles produced

.0175 moles $HC_7H_5O_2$ .0030 moles OH^-

.0175 − .0030 = .0145 moles leftover $HC_7H_5O_2$

$HC_7H_5O_2 + H_2O \rightleftharpoons H_3O^+ + C_7H_5O_2^-$

$\frac{.0145}{.050} = .29M$	0	$\frac{.0030}{.050} = .060M$
−x	+x	+x
.29 − x	x	.060 + x

$K_a = 6.3\times10^{-5} = \frac{[x][.060+x]}{[.29-x]}$

$x = [H_3O^+] = 3.03\times10^{-4}\ M$

pH = 3.52