

- 8 1. Which of the following will create a buffer solution when equal volumes of each solution are mixed? Circle all that apply—there may be more than one correct answer.

- ~~(a)~~ 0.20 M HNO₃ + 0.10 M H₂CO₃
 (b) 0.20 M HCO₂H + 0.10 M NaHCO₂
 (c) 0.20 M HF + 0.20 M CaF₂
 ✗(d) 0.10 M HNO₃ + 0.30 M NaCH₃CO₂

- 8 2. Identify each of the following solutions as acidic, basic, or pH neutral:

- a. NH₄NO₃ acidic basic neutral
 b. KNO₃ acidic basic neutral
 c. H₃PO₄ acidic basic neutral
 d. K₂S acidic basic neutral

- 6 3. Which of the following acid-base pairs would be used to create a buffer of pH = 4.62, and which species would be present in higher concentration? Circle the acid-base pair used.

Weak Acid	Conjugate Base	K _a	pK _a
HC ₂ O ₄ ⁻	C ₂ O ₄ ²⁻	6.4 × 10 ⁻⁵	4.19
H ₂ PO ₄ ⁻	HPO ₄ ²⁻	6.2 × 10 ⁻⁸	7.21
HCO ₃ ⁻	CO ₃ ²⁻	4.8 × 10 ⁻¹¹	10.32

Circle one of these: pH > pKa so

The conjugate acid will be in higher concentration than the conjugate base.

6 The conjugate base will be in higher concentration than the conjugate acid.

4. The value of K_a for phenol (a weak acid, C₆H₅OH) is 1.1 × 10⁻¹⁰.

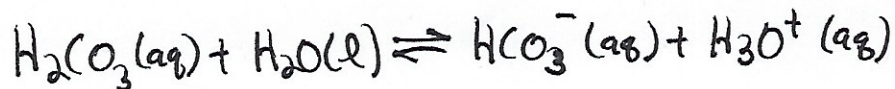
What is the value of K_b, for its conjugate base, C₆H₅O⁻? 9.1 × 10⁻⁵

What is pKa? 9.96

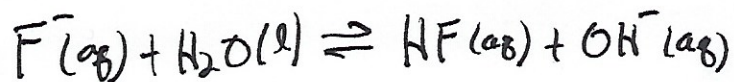
In what form will phenol exist at pH = 7: C₆H₅OH or C₆H₅O⁻

pH < pKa so

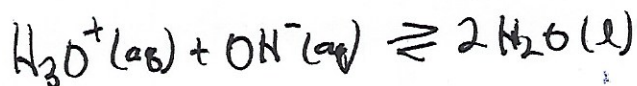
- 9 5. Write the chemical reaction equation described by the K_a value for H_2CO_3 .



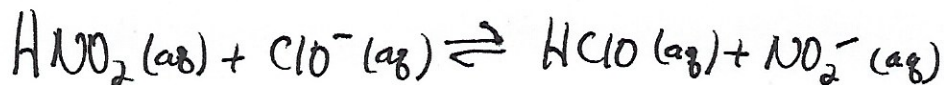
Write the chemical reaction equation described by the K_b value for NaF .



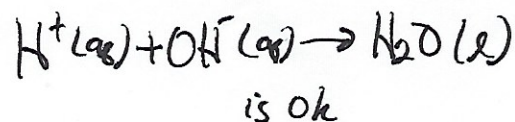
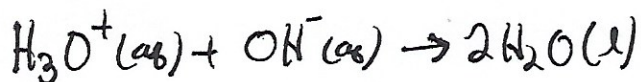
Write the chemical equation described by K_w .



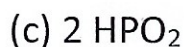
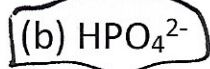
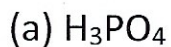
- 6 6. Write the net-ionic equation for the acid-base reaction between HNO_2 and ClO^- :



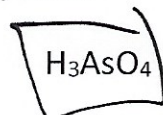
Write the net-ionic equation for the acid-base reaction between HCl and KOH :



- 4 7. What is the conjugate base of $H_2PO_4^-$? *uses H^+*



- 4 8. Which of the following acids has the largest K_a value?



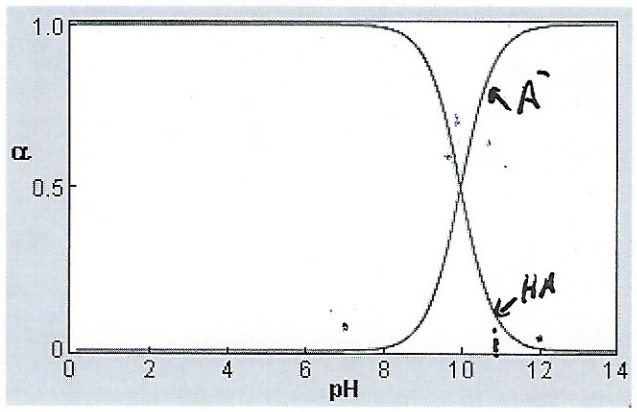
8 9. Write the formulas of common strong acids:

- HCl
- HBr
- HI
- HNO₃
- HClO₄
- H₂SO₄

Write the formulas of common strong bases:

- NaOH
- LiOH is ok
- KOH
- Ca(OH)₂
- Ba(OH)₂

8 10. Consider the alpha plot below, which is for an acid-base system HA/A⁻.



a. At pH = 11, which species is present in greater concentration?

HA or A⁻ or about the same amount of each

b. What is pK_a of HA? ~~1.7 × 10⁻¹⁰~~ 10.0

c. What is K_a of HA? 1 × 10⁻¹⁰

d. If this acid-base pair were a pH indicator, would it be suitable for the titration of NH₄⁺ with NaOH?

Yes or No

pK_a of NH₄⁺ is 9.25. The pK_a of the indicator must be significantly above pK_a acid titrated.

11. Calculate the following for a solution that has a pH of 4.68?

[H₃O⁺] = 2.1 × 10⁻⁵ mol/L

[OH⁻] = 4.8 × 10⁻¹⁰ mol/L

pOH = 9.32

9
25
22
19

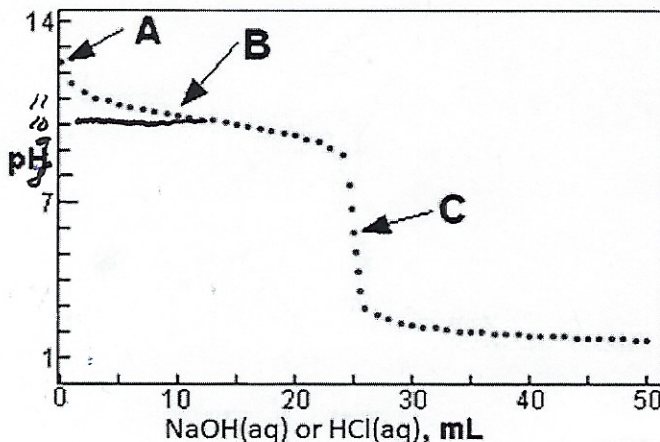
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12. Consider the titration curve below involving a weak acid ($C_2H_7NH^+$) and a weak base (C_2H_7N).

a. Which does this titration represent? Circle it.

weak acid being titrated with NaOH or

weak base being titrated with HCl



b. What is the approximate value of K_a for the acid

form ($C_2H_7NH^+$) of the studied acid-base pair?

$K_a = \text{not } 10^{-10.1} = 7.9 \times 10^{-11}$

For the questions below, answer with $C_2H_7NH^+$, C_2H_7NH , H_3O^+ and/or OH^- . More than one is allowed.

c. What acid-base species is/are mainly in solution at point A? C_2H_7N

d. What acid-base species is/are mainly in solution at point B? $C_2H_7NH^+$ and C_2H_7N

e. What acid-base species is/are mainly in solution at point C? $C_2H_7NH^+$

6

13. To what extent does each of the following reaction progress?

- | | | | |
|--|----------------|------------------|--------------|
| a) $NH_3 + HCl \rightarrow NH_4^+ + H_2O$ | <50% | between 50 – 90% | <u>~100%</u> |
| b) $CH_3CO_2H + F^- \rightarrow HF + CH_3CO_2^-$ | <u><50%</u> | between 50 – 90% | ~100% |
| c) $HNO_3 + KOH \rightarrow H_2O + KNO_3$ | <50% | between 50 – 90% | <u>~100%</u> |

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13. What is the pH of a 0.00248 M solution of $Ba(OH)_2$?
 $[OH^-] = 0.00496$, $[H_3O^+] = 2.02 \times 10^{-12}$, $pH = -\log(2.02 \times 10^{-12}) = 11.695$

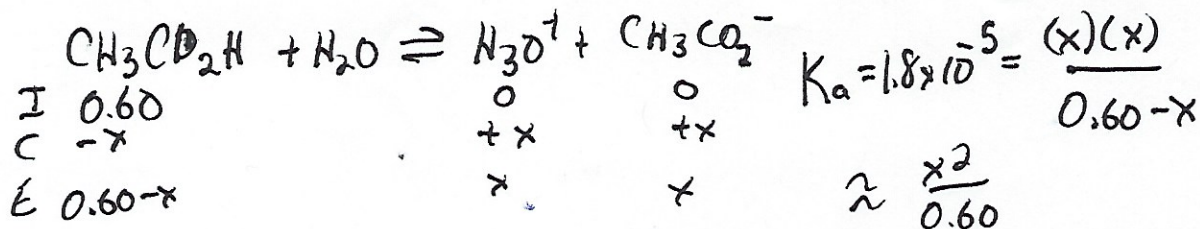
What is the pH of a 4.8×10^{-4} M solution of HNO_3 ?
 $[H_3O^+] = 4.8 \times 10^{-4}$ M, $pH = 3.32$

What is the pH of a 3.0 M solution of HCl?
 $[H_3O^+] = 3.0$ M, $pH = -\log(3.0) = -0.48$

It is possible to have negative pH values.

22

10 14. What is the pH of a 0.60 M solution of acetic acid?



$$x \approx \frac{x^2}{0.60}$$

$$x = \sqrt{1.8 \times 10^{-5} \times 0.60} =$$

$$[\text{H}_3\text{O}^+] = \frac{1.08 \times 10^{-5} \text{ M}}{0.00329 \text{ M}}$$

$$\text{pH} = -\log(0.00329 \text{ M}) = 2.48$$

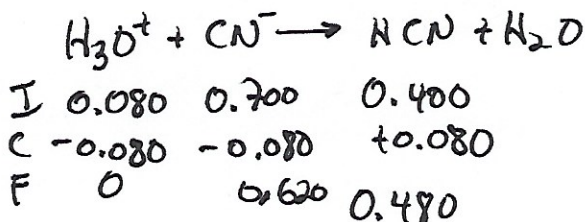
10 15. a) What is the pH of a buffer composed of 1.00 L of 0.400 M HCN and 0.700 M CN⁻?

$$K_a = 4.0 \times 10^{-10} \quad \text{p}K_a = 9.400$$

$$\text{pH} = 9.400 + \log\left(\frac{0.700 \text{ M}}{0.400 \text{ M}}\right) = 9.400 + 0.243 = \underline{9.643}$$

b) What is the pH of this buffer after 0.080 mol HCl have been added?

0.080 mol H₃O⁺ reacts to convert CN⁻ to HCN



new concentrations:

$$[\text{HCN}] = 0.480$$

$$[\text{CN}^-] = 0.620$$

$$\text{pH} = 9.400 + \log\left(\frac{0.620 \text{ M}}{0.480 \text{ M}}\right)$$

$$= 9.400 + 0.111$$

$$= \underline{9.511}$$

- 10 16. What mass of NH_4Cl must be added to a 0.380 M solution of NH_3 to make a buffer of $\text{pH} = 8.93$?

1L of 1L of

$$\text{p}K_a(\text{NH}_4^+) = -\log(5.6 \times 10^{-10}) = 9.252$$

$$8.93 = 9.252 + \log \frac{[\text{NH}_3]}{[\text{NH}_4^+]}, \quad -0.322 = \log \frac{[\text{NH}_3]}{[\text{NH}_4^+]}$$

$$\frac{[\text{NH}_3]}{[\text{NH}_4^+]} = 10^{-0.322} = 0.477 \quad \leftarrow \text{ratio needed for buffer, now solve for } [\text{NH}_4^+]$$

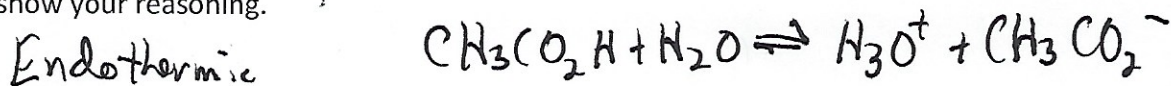
$$[\text{NH}_4^+] = \frac{[\text{NH}_3]}{0.477} = \frac{0.380 \text{ M}}{0.477} = 0.797 \text{ M } \text{NH}_4^+$$

$$0.797 \text{ mol } \text{NH}_4\text{Cl} \times \frac{53.45 \text{ g } \text{NH}_4\text{Cl}}{\text{mol}} = 42.6 \text{ g}$$

42.6 g NH_4Cl

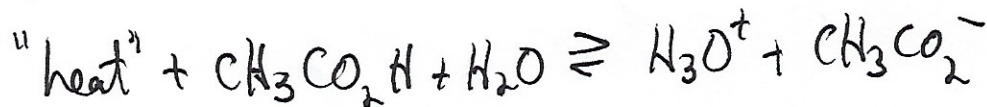
- 6 17. As temperature rises, the pH of a solution of acetic acid decreases. Is the ionization reaction of acetic acid endothermic, exothermic, or can you not tell from this information?

You must show your reasoning.



as $T \uparrow$, rxn shifts \Rightarrow , as evidenced by pH decrease

\therefore rxn must absorb heat



as $T \uparrow$, rxn shifts \Rightarrow , $[\text{H}_3\text{O}^+] \uparrow$, and $\text{pH} \downarrow$

134 pts
total