

Exercise 14.6

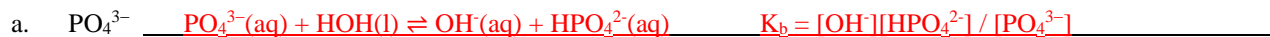
Ionization of Bases

Name: _____

Date: _____ Per: _____

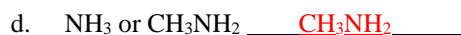
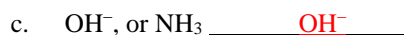
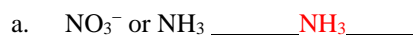
DIRECTIONS: Complete the following in the space provided.

1. Write the dissociation reaction and the corresponding K_b equilibrium expression for each of the following substances acting as bases in water.



2. Order the following bases from strongest to weakest. NO_3^- , H_2O , NH_3 , CH_3NH_2 : $\text{CH}_3\text{NH}_2, \text{NH}_3, \text{H}_2\text{O}, \text{NO}_3^-$

3. Which is the stronger base?



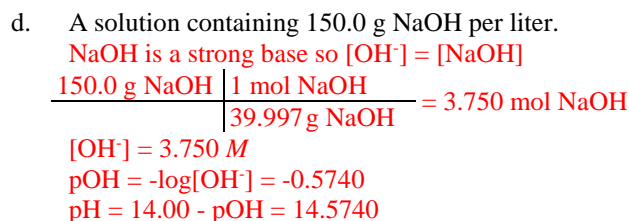
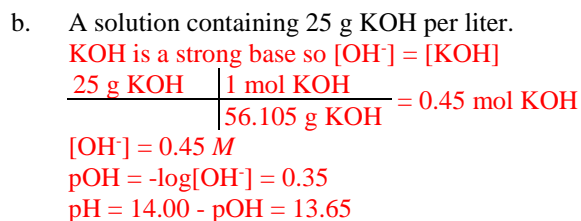
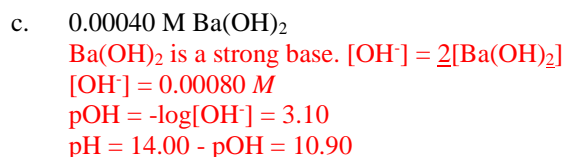
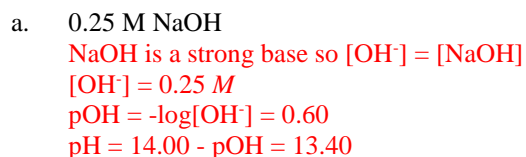
4. Thallium(I) hydroxide is a **strong base** used in the synthesis of some organic compounds. Calculate the pH of a solution containing **2.48 g TIOH per liter**.

$$\frac{2.48 \text{ g TIOH}}{221.387 \text{ g TIOH}} \left| \frac{1 \text{ mol TIOH}}{1 \text{ mol TIOH}} \right. = 0.0112 \text{ mol TIOH}$$

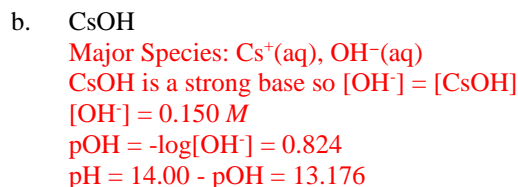
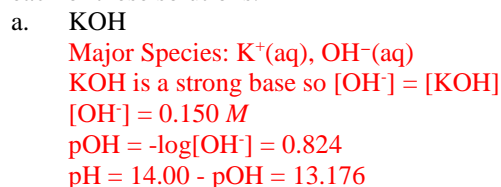
Since TIOH is a strong base, it dissociates completely – the concentration of OH^- will equal the concentration of the compound from which it dissociates.

$$0.0112 \text{ mol} / 1 \text{ L} = 0.0112 \text{ M OH}^- \quad \text{pOH} = -\log[\text{OH}^-] = -\log(0.0112) = 1.951 \quad \text{pH} = 14.000 - \text{pOH} = \boxed{12.049}$$

5. Calculate $[\text{OH}^-]$, pOH and pH for each of the following:



6. What major species are present in 0.150 M solutions of each of the following bases? Calculate the $[\text{OH}^-]$ and the pH of each of these solutions.



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- c. NH_3
Major Species: $\text{NH}_3(\text{aq})$, $\text{NH}_4^+(\text{aq})$, $\text{OH}^-(\text{aq})$
Weak Base, so need K_b to find pH
- d. Pyridine ($\text{C}_5\text{H}_5\text{N}$)
Major Species: $\text{C}_5\text{H}_5\text{N}(\text{aq})$, $\text{C}_5\text{H}_5\text{NH}^+(\text{aq})$, $\text{OH}^-(\text{aq})$
Weak Base, so need K_b to find pH

7. What are the major species present in the following mixtures of bases?

- a. 0.050 M NaOH and 0.050 M KOH $\text{Na}^+(\text{aq})$, $\text{K}^+(\text{aq})$, $\text{OH}^-(\text{aq})$
- b. 0.050 M NaOH and 0.50 M NH_3 $\text{Na}^+(\text{aq})$, $\text{OH}^-(\text{aq})$, $\text{NH}_3(\text{aq})$, $\text{NH}_4^+(\text{aq})$
- c. 0.0010 M $\text{Ba}(\text{OH})_2$ and 0.020 M NaOH $\text{Ba}^+(\text{aq})$, $\text{Na}^+(\text{aq})$, $\text{OH}^-(\text{aq})$

8. For the reaction of hydrazine (N_2H_4) in water, $\text{H}_2\text{NNH}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{NNH}_3^+(\text{aq}) + \text{OH}^-(\text{aq})$, K_b is 3.0×10^{-6} . Calculate the concentrations of all species and the pH of a 2.0 M solution of hydrazine in water.

| | | | | | | | |
|---|-------------------------------------|---|--------------------------------|----------------------|---------------------------------------|---|--------------------------|
| R | $\text{H}_2\text{NNH}_2(\text{aq})$ | + | $\text{H}_2\text{O}(\text{l})$ | \rightleftharpoons | $\text{H}_2\text{NNH}_3^+(\text{aq})$ | + | $\text{OH}^-(\text{aq})$ |
| I | 2.0 | | N/A | | 0 | | 0 |
| C | -x | | N/A | | +x | | +x |
| E | 2.0-x | | N/A | | x | | x |

K_b is small enough to disregard the change in concentration of H_2NNH_2

$$K_b = \frac{[\text{H}_2\text{NNH}_3^+][\text{OH}^-]}{[\text{H}_2\text{NNH}_2]} \rightarrow 3.0 \times 10^{-6} = \frac{x^2}{2.0} \rightarrow x = 0.0024 = [\text{OH}^-]$$

$$\text{pOH} = -\log[\text{OH}^-] = -\log[0.00240] = 2.620$$

$$\text{pH} = 14.000 - \text{pOH} = \boxed{11.380}$$

9. Calculate the $[\text{OH}^-]$, $[\text{H}^+]$, and pH of 0.20 M solutions of each of the following amines.

a. Ethylamine ($K_b = 5.6 \times 10^{-4}$)

| | | | | | | | |
|---|--------|---|--------------------------------|----------------------|--------------------------|---|--------------------------|
| R | B(aq) | + | $\text{H}_2\text{O}(\text{l})$ | \rightleftharpoons | $\text{BH}^+(\text{aq})$ | + | $\text{OH}^-(\text{aq})$ |
| I | 0.20 | | N/A | | 0 | | 0 |
| C | -x | | N/A | | +x | | +x |
| E | 0.20-x | | N/A | | x | | x |

K_b is small enough to disregard the change in concentration of the initial base.

$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} \rightarrow 5.6 \times 10^{-4} = \frac{x^2}{0.20} \rightarrow x = 0.011 = [\text{OH}^-]$$

$$\text{pOH} = -\log[\text{OH}^-] = -\log[0.011] = 1.96$$

$$\text{pH} = 14.000 - \text{pOH} = \boxed{12.04}$$

b. Diethylamine ($K_b = 1.3 \times 10^{-3}$)

| | | | | | | | |
|---|--------|---|--------------------------------|----------------------|--------------------------|---|--------------------------|
| R | B(aq) | + | $\text{H}_2\text{O}(\text{l})$ | \rightleftharpoons | $\text{BH}^+(\text{aq})$ | + | $\text{OH}^-(\text{aq})$ |
| I | 0.20 | | N/A | | 0 | | 0 |
| C | -x | | N/A | | +x | | +x |
| E | 0.20-x | | N/A | | x | | x |

K_b is small enough to disregard the change in concentration of the initial base.

$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} \rightarrow 1.3 \times 10^{-3} = \frac{x^2}{0.20} \rightarrow x = 0.016 = [\text{OH}^-]$$

$$\text{pOH} = -\log[\text{OH}^-] = -\log[0.016] = 1.80$$

$$\text{pH} = 14.000 - \text{pOH} = \boxed{12.20}$$

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c. Triethylamine ($K_b = 4.0 \times 10^{-4}$)

| | | | | | | | |
|---|--------|---|---------------------|---|----------------------|---|----------------------|
| R | B(aq) | + | H ₂ O(l) | ⇌ | BH ⁺ (aq) | + | OH ⁻ (aq) |
| I | 0.20 | | N/A | | 0 | | 0 |
| C | -x | | N/A | | +x | | +x |
| E | 0.20-x | | N/A | | x | | x |

K_b is small enough to disregard the change in concentration of the initial base.

$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} \rightarrow 4.0 \times 10^{-4} = \frac{x^2}{0.20} \rightarrow x = 0.0089 = [\text{OH}^-]$$

$$\text{pOH} = -\log[\text{OH}^-] = -\log[0.0089] = 2.05$$

$$\text{pH} = 14.000 - \text{pOH} = \boxed{11.95}$$

(These weren't on your worksheet, but they're good practice.)

10. Calculate the percent ionization in each of the following solutions.

a. 0.010 M NH₃

| | | | | | | | |
|---|----------------------|---|---------------------|---|-----------------------------------|---|----------------------|
| R | NH ₃ (aq) | + | H ₂ O(l) | ⇌ | NH ₄ ⁺ (aq) | + | OH ⁻ (aq) |
| I | 0.010 | | N/A | | 0 | | 0 |
| C | -x | | N/A | | +x | | +x |
| E | 0.010-x | | N/A | | x | | x |

 K_a of NH₄⁺ = 5.6 × 10⁻¹⁰, so K_b of NH₃ = 1.8 × 10⁻⁵*K_b is small enough to disregard the change in concentration of [NH₃].*

$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} \rightarrow 1.8 \times 10^{-5} = \frac{x^2}{0.010} \rightarrow x = 4.24 \times 10^{-4} = [\text{OH}^-] \rightarrow \frac{4.24 \times 10^{-4}}{0.010} \times 100 = \boxed{4.2\%}$$

b. 0.10 M hydroxylamine ($K_a = 9.333 \times 10^{-7}$)

| | | | | | | | |
|---|------------------------|---|---------------------|---|--------------------------------------|---|----------------------|
| R | NH ₂ OH(aq) | + | H ₂ O(l) | ⇌ | NH ₃ OH ⁺ (aq) | + | OH ⁻ (aq) |
| I | 0.10 | | N/A | | 0 | | 0 |
| C | -x | | N/A | | +x | | +x |
| E | 0.10-x | | N/A | | x | | x |

 K_a of NH₃OH⁺ = 9.333 × 10⁻⁷, so K_b of NH₂OH = 1.072 × 10⁻⁸*K_b is small enough to disregard the change in concentration of [NH₂OH].*

$$K_b = \frac{[\text{NH}_3\text{OH}^+][\text{OH}^-]}{[\text{NH}_2\text{OH}]} \rightarrow 1.072 \times 10^{-8} = \frac{x^2}{0.10} \rightarrow x = 3.27 \times 10^{-5} = [\text{OH}^-] \rightarrow \frac{3.27 \times 10^{-5}}{0.10} \times 100 = \boxed{0.033\%}$$

c. 0.10 M methylamine

| | | | | | | | |
|---|--------------------------------------|---|---------------------|---|---|---|----------------------|
| R | CH ₃ NH ₂ (aq) | + | H ₂ O(l) | ⇌ | CH ₃ NH ₃ ⁺ (aq) | + | OH ⁻ (aq) |
| I | 0.10 | | N/A | | 0 | | 0 |
| C | -x | | N/A | | +x | | +x |
| E | 0.10-x | | N/A | | x | | x |

 K_a of CH₃NH₃⁺ = 2.29 × 10⁻¹¹, so K_b of CH₃NH₂ = 4.37 × 10⁻⁴*K_b is small enough to disregard the change in concentration of [CH₃NH₂].*

$$K_b = \frac{[\text{CH}_3\text{NH}_3^+][\text{OH}^-]}{[\text{CH}_3\text{NH}_2]} \rightarrow 4.37 \times 10^{-4} = \frac{x^2}{0.10} \rightarrow x = 0.00661 = [\text{OH}^-] \rightarrow \frac{0.00661}{0.10} \times 100 = \boxed{6.61\%}$$