

16.1 a) HX is the BL acid, NH_3 is the BL base.

b) Because NH_3 “donates” its unshared electron pair to the H from HX, making it the Lewis base. Because the H from HX “accepts” the electron pair, it is the Lewis acid.

16.3 a) HY is the stronger acid as indicated by the fact that 4 of the 6 HY molecules are dissociated, whereas on 2 of the 6 HX molecules are dissociated.

b) Because HX is the weaker acid, it will have the stronger conjugate base, making X^- a stronger base than Y^- .

c) HY and X^- are the stronger acid/base pair. As such, the reverse reaction will be favored and the equilibrium will lie to the left.

16.6 a) Because it is fully dissociated, HY is the strong acid

b) Of the 8 molecules represented for each acid, HX only has 2 molecules dissociated, making HX the weakest acid, making its K_a value the smallest.

c) Because HX has the fewest H^+ (H_3O^+) present in solution, its pH will be the highest.

16.11 Solutions of HCl and H₂SO₄ both conduct electricity, taste sour, turn litmus paper red, neutralize basic solutions and react with metals to produce hydrogen gas. They share these properties because HCl and H₂SO₄ are both strong acids. As such, they both have high H₃O⁺ concentrations, explaining their similar behaviors.

16.13 a) According to Arrhenius, an acid when dissolved in water increases the concentration of H⁺. In the BL definition, an acid is capable of donating H⁺ regardless of physical state.

b) When HCl and NH₃ react to form NH₄Cl, the HCl is the BL acid and the NH₃ is the BL base.

16.14 a) According to Arrhenius, a base when dissolved in water increases the concentration of OH⁻. In the BL definition, a base is capable of accepting H⁺ regardless of physical state.

b) A substance which doesn't contain an OH group can act as an Arrhenius base by hydrolyzing water, creating OH⁻. Ammonia is a example: $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$

- 16.25 a) weak base - CH_3COOH (weak acid)
b) weak base - H_2CO_3 (weak acid)
c) strong base - OH^- (negligible acid)
d) negligible - HCl (strong acid)
e) weak base - NH_4^+ (weak acid)

16.31 In a pure water the only source of H^+ and OH^- ions is the autoionization of water. Since autoionization produces these ions in equal number, the concentration of H^+ is not greater than OH^- . If the solution is cooled, the pH rises, indicating the solution is basic, making iii valid.



b) $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$

c) A basic solution is one in which the concentration of OH^- is greater than the concentration of H^+ , making iii valid.

$$\begin{aligned} 16.33a) \quad K_w &= [\text{H}_3\text{O}^+][\text{OH}^-] \\ 1 \times 10^{-14} &= x \cdot 0.00045\text{M} \\ \text{H}^+ &= 2.2 \times 10^{-11} \text{ M}; \text{ basic} \end{aligned}$$

$$\begin{aligned} 16.29b) \quad K_w &= [\text{H}_3\text{O}^+][\text{OH}^-] \\ 1 \times 10^{-14} &= x \cdot 8.8 \times 10^{-9}\text{M} \\ \text{H}^+ &= 1.1 \times 10^{-6} \text{ M}; \text{ acidic} \end{aligned}$$

$$\begin{aligned} 16.33c) \quad K_w &= [\text{H}_3\text{O}^+][\text{OH}^-] \\ 1 \times 10^{-14} &= x \cdot 1.0 \times 10^{-6}\text{M} \\ \text{H}^+ &= 1 \times 10^{-8} \text{ M}; \text{ basic} \end{aligned}$$

$$16.37 \text{ a) } 10^2 = 100 \quad \text{b) } 10^{0.5} = 3.16$$

16.39

[H ⁺]	[OH ⁻]	pH	pOH	acid/base
7.5×10^{-3}	1.3×10^{-12}	2.12	11.88	acidic
2.8×10^{-5}	3.6×10^{-10}	4.56	9.44	acidic
5.6×10^{-9}	1.8×10^{-6}	8.25	5.75	basic
5.0×10^{-9}	2.0×10^{-6}	8.30	5.70	basic

16.41 a) A strong acid is a substance that completely ionizes in water to release hydrogen ions (protons)

b) A 0.500M HCl solution is 0.500M in H⁺ concentration.

c) HCl, HBr, HI (HF is not)

16.42a) A strong base is a substance that completely ionizes in water to release hydroxide ions.

b) A 0.035M Sr(OH)₂ solution is 0.070M in hydroxide ion because this base is dibasic.

c) This statement is true, when we understand the term strong to represent the ability of a substance to ionize in water. This said, Mg(OH)₂ is a very effective base because it is dibasic.

$$16.47a) \text{pH} = -\log [\text{H}^+] = -\log[8.5 \times 10^{-3}] = 2.07$$

$$d) \frac{10.0\text{mL} \mid 1 \text{ liter} \mid 0.100 \text{ mol HBr} \mid 1 \text{ mol H}^+}{1000\text{mL} \mid 1 \text{ liter} \mid 1 \text{ mol HBr}} = 0.00100 \text{ mol H}^+$$

$$\frac{20.0\text{mL} \mid 1 \text{ liter} \mid 0.200 \text{ mol HCl} \mid 1 \text{ mol H}^+}{1000\text{mL} \mid 1 \text{ liter} \mid 1 \text{ mol HCl}} = 0.00400 \text{ mol H}^+$$

$$M = \frac{\text{Moles}}{\text{Liters}} = \frac{0.00100 \text{ mol H}^+ + 0.00400 \text{ mol H}^+}{0.0300 \text{ L}} = 0.167M$$

$$\text{pH} = -\log [\text{H}^+] = -\log[0.167M] = 0.778$$

$$16.48a) \text{pH} = -\log [\text{H}^+] = -\log[0.0167] = 1.77$$

$$c) \quad M_1V_1 = M_2V_2$$

$$1.00M \times 15.00\text{mL} = M_2 \times 500.0\text{mL}$$

$$M_2 = 0.03000 \text{ M}$$

$$\text{pH} = -\log [\text{H}^+] = -\log[0.03000 \text{ M}] = 1.5239$$

$$16.49a) \quad 1.5 \times 10^{-3}M \text{ Sr(OH)}_2 = 3.0 \times 10^{-3}M \text{ OH}^-$$

$$\text{pOH} = -\log [\text{OH}^-] = -\log[3.0 \times 10^{-3}M] = 2.5$$

$$\text{pH} + \text{pOH} = 14 \quad \text{pH} = 14 - \text{pOH} = 14 - 2.5 = 11.5$$

d)

$$\frac{5.00\text{mL}}{1000\text{mL}} \left| \frac{1 \text{ liter}}{1000\text{mL}} \right| \frac{0.105 \text{ mol KOH}}{1 \text{ liter}} \left| \frac{1 \text{ mol OH}^-}{1 \text{ mol KOH}} \right| = 5.25 \times 10^{-4}\text{mol OH}^-$$

$$\frac{15.0\text{mL}}{1000\text{mL}} \left| \frac{1 \text{ liter}}{1000\text{mL}} \right| \frac{9.5 \times 10^{-2} \text{ mol Ca(OH)}_2}{1 \text{ liter}} \left| \frac{2 \text{ mol OH}^-}{1 \text{ mol Ca(OH)}_2} \right| = 0.0029\text{mol OH}^-$$

$$M = \frac{\text{Moles}}{\text{Liters}} = \frac{5.25 \times 10^{-4}\text{mol OH}^- + 0.0029\text{mol OH}^-}{0.0200 \text{ L}} = 0.171M$$

$$\text{pOH} = -\log [\text{OH}^-] = -\log[0.171M] = 0.767$$

$$\text{pH} + \text{pOH} = 14 \quad \text{pH} = 14 - \text{pOH} = 14 - 0.767 = 13.233$$

$$16.50a \quad 0.182 \text{ M KOH} = 0.182 \text{ M OH}^-$$

$$\text{pOH} = -\log [\text{OH}^-] = -\log[0.182\text{M}] = 0.740$$

$$\text{pH} + \text{pOH} = 14 \quad \text{pH} = 14 - \text{pOH} = 14 - 0.740 = 13.260$$

&c

$$M_1V_1 = M_2V_2$$

$$0.0105\text{M} \times 10.0\text{mL} = M_2 \times 500.0\text{mL}$$

$$M_2 = 2.1 \times 10^{-4} \text{ M Ca(OH)}_2 = 4.2 \times 10^{-4}\text{M OH}^-$$

$$\text{pOH} = -\log [\text{OH}^-] = -\log[4.2 \times 10^{-4}\text{M}] = 3.38$$

$$\text{pH} + \text{pOH} = 14 \quad \text{pH} = 14 - \text{pOH} = 14 - 3.38 = 10.62$$

$$16.51 \quad \text{pH} + \text{pOH} = 14$$

$$\text{pOH} = 14 - \text{pH}$$

$$\text{pOH} = 14 - 11.50 = 2.50$$

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

$$2.50 = -\log x$$

$$x = 0.00316M$$