

Assume all solutions are aqueous at 25°C.  $K_w = 1.0 \times 10^{-14}$

1. A 25.0 mL sample of 0.150 M hydrofluoric acid is titrated with a 0.100 M NaOH solution. The  $K_a$  of hydrofluoric acid is  $3.5 \times 10^{-4}$ .

a) What volume of NaOH solution is needed to neutralize the hydrofluoric acid? Show your method. (4 pts)

$$V_{\text{NaOH}} = \frac{V_A M_A}{M_B} = \frac{(25.0 \text{ mL})(0.150 \text{ M})}{0.100 \text{ M}} = 37.5 \text{ mL}$$

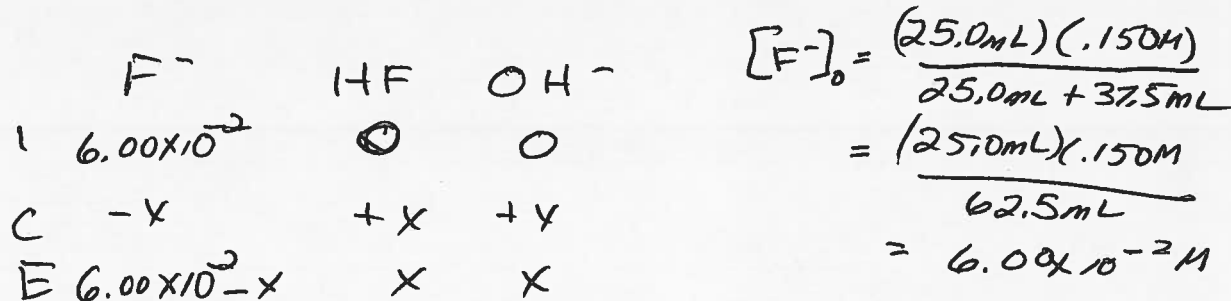
b) Will the pH at the equivalence point be greater than, less than, or equal to 7.00? (2 pt) > 7

c) Write the balanced net-ionic chemical reaction that occurs at the equivalence point, and causes the pH in part (b) above. (4 pts)



d) Calculate the pH at the equivalence point. Be sure to include an ICE equation, K expression, assumptions made, etc. (8 pts)

$$K_b = \frac{[\text{HF}][\text{OH}^-]}{[\text{F}^-]} = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{3.5 \times 10^{-4}} = 2.86 \times 10^{-11}$$



$$\frac{1.00 \times 10^{-2} - 1.3 \times 10^{-6}}{6.00 \times 10^{-2} - x} (x)(x) = 2.86 \times 10^{-11}$$

Assume  $x$  is small bc  $K$  is small

$$x^2 = 1.7 \times 10^{-12}$$

$$x = \frac{4.1 \times 10^{-3}}{1.3 \times 10^{-6}}$$

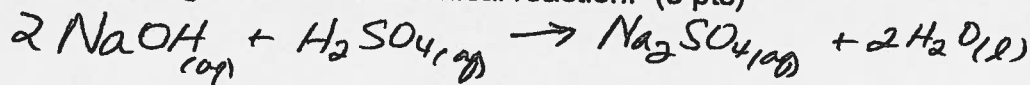
$$x = [\text{OH}^-] = 1.3 \times 10^{-6}$$

$$\text{pOH} = -\log 1.3 \times 10^{-6} = 5.88$$

$$\text{pH} = 14.00 - 5.88 = 8.12$$

Answer: pH = 8.12

2. 25.00 mL of a solution of sulfuric acid is completely neutralized by 29.80 mL of 0.5567 M NaOH. Calculate the molarity of the sulfuric acid solution. Show your work, including a balanced chemical reaction. (8 pts)



$$\text{moles NaOH} = 29.80 \text{ mL} \left( \frac{0.5567 \text{ mol}}{\text{L}} \right) = 1.659 \times 10^{-2} \text{ moles NaOH}$$

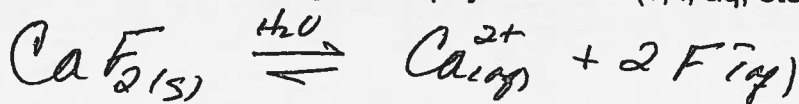
$$1.659 \times 10^{-2} \text{ mmol NaOH} \times \frac{1 \text{ mmol H}_2\text{SO}_4}{2 \text{ mmol NaOH}} = 8.295 \text{ mmol H}_2\text{SO}_4$$

$$[\text{H}_2\text{SO}_4] = \frac{8.295 \text{ mmol H}_2\text{SO}_4}{25.00 \text{ mL H}_2\text{SO}_4} = \underline{0.3318 \text{ M}}$$

Answer: 0.3318 M

3. Calculate the molar solubility of calcium fluoride in water at 25°C if the  $K_{sp}$  for calcium fluoride is  $1.5 \times 10^{-10}$ .

- a) Write the chemical reaction that corresponds to  $K_{sp}$  for calcium fluoride. Be sure to include ionic charges and physical state (s, l, aq, etc). (4 pts)



- b) Write the  $K_{sp}$  expression for calcium fluoride. (4 pts)

$$K_{sp} = [\text{Ca}^{2+}][\text{F}^{-}]^2 = 1.5 \times 10^{-10}$$

- c) Calculate the molar solubility of calcium fluoride. Clearly show your method. (6 pts)

$$\text{molar sol} = x$$

$$[\text{Ca}^{2+}] = x$$

$$[\text{F}^{-}] = 2x$$

$$1.5 \times 10^{-10} = (x)(2x)^2$$

$$1.5 \times 10^{-10} = 4x^3$$

$$3.75 \times 10^{-11} = x^3$$

$$3.3 \times 10^{-4} \text{ M} = x$$

Answer:  $3.3 \times 10^{-4} \text{ M}$