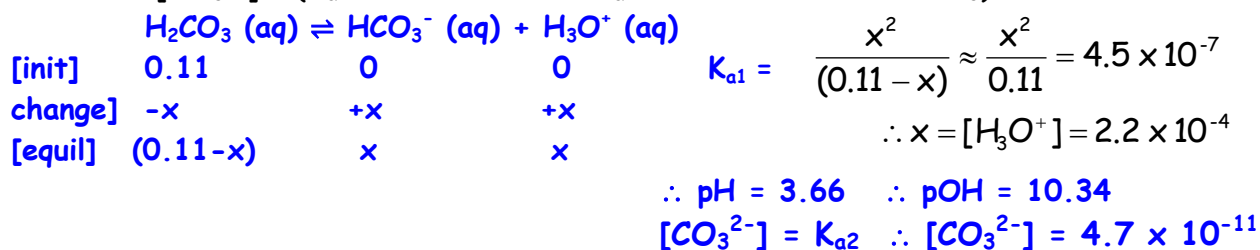


Answer all questions. Be careful to give your final answer to the correct sig. figs.

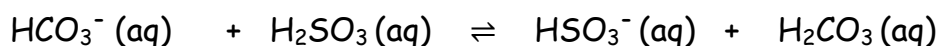
1. a) (3 points) The  $K_a$  of acetic acid ( $\text{CH}_3\text{COOH}$ ) at  $25^\circ\text{C}$  is  $1.8 \times 10^{-5}$ . What is the  $K_b$  of its conjugate base, acetate ( $\text{CH}_3\text{COO}^-$ )?

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$$

- b) (5 points) What are  $[\text{H}_3\text{O}^+]$  and  $\text{pOH}$  in a 0.11 M solution of  $\text{H}_2\text{CO}_3$ ? What is  $[\text{CO}_3^{2-}]$ ? ( $K_{a1} = 4.5 \times 10^{-7}$  and  $K_{a2} = 4.7 \times 10^{-11}$  for  $\text{H}_2\text{CO}_3$ )



- b) (3 points)  $K_c$  for the reaction below is  $1.5 \times 10^6$ . Identify each compound as the stronger acid, the stronger base, the weaker acid, or the weaker base.

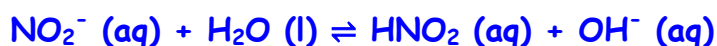


**stronger base      stronger acid      weaker base      weaker acid**

- c) (2 points) Which one of the following salts will give a basic solution when dissolved in water? Circle your choice.



(2 points) Write an equation for the reaction that occurs when the salt dissolves in water and makes the solution basic.



- d) Will a solution of the salt  $\text{NH}_4\text{F}$  be acidic, neutral or basic? ( $K_a$  for  $\text{HF}$  is  $6.8 \times 10^{-4}$ , and  $K_b$  for  $\text{NH}_3$  is  $1.8 \times 10^{-5}$ )

(2 point) Write your answer here: The solution will be acidic

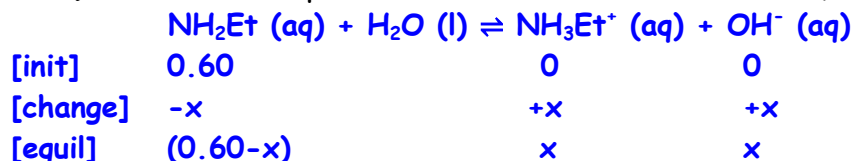
(4 points) Show how you reached your answer.

$$K_a (\text{NH}_4^+) = (1.0 \times 10^{-14}) / (1.8 \times 10^{-5}) = 5.6 \times 10^{-10}$$

$$K_b (\text{F}^-) = (1.0 \times 10^{-14}) / (6.8 \times 10^{-4}) = 1.5 \times 10^{-11}$$

Since  $K_a > K_b$ , the acid will produce more  $[\text{H}_3\text{O}^+]$  than the base will produce  $[\text{OH}^-]$ , Therefore, the solution is acidic

- e) (4 points) Calculate the pH of a 0.60 M solution of  $\text{NH}_2\text{Et}$  ( $K_b = 4.3 \times 10^{-4}$ )

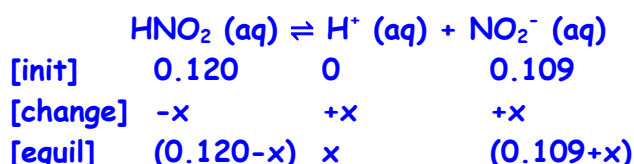


$$K_b = \frac{x^2}{(0.60 - x)} \approx \frac{x^2}{0.60} = 4.3 \times 10^{-4} \quad \therefore x = [\text{OH}^-] = 1.6 \times 10^{-2} \quad \therefore \text{pOH} = 1.80 \quad \therefore \text{pH} = 12.20$$

2. a) (8 points) What is the pH of a buffer solution prepared from adding 60.0 mL of 0.22 M nitrous acid ( $\text{HNO}_2$ ) solution to 50.0 mL of 0.24 M sodium nitrite ( $\text{NaNO}_2$ ) solution? ( $K_a$  for  $\text{HNO}_2$  is  $7.1 \times 10^{-4}$ ).

$$[\text{HNO}_2] = \frac{(60.0\text{mL})(0.22\text{M})}{110.0\text{mL}} = 0.120\text{M} \text{ (extra sig. fig.)}$$

$$[\text{NO}_2^-] = \frac{(50.0\text{mL})(0.24\text{M})}{110.0\text{mL}} = 0.109\text{M}$$



$$K_a = \frac{x(0.109 + x)}{(0.120 - x)} \approx \frac{0.109x}{0.120} = 7.1 \times 10^{-4} \quad \therefore x = 7.82 \times 10^{-4}$$

$$\therefore [\text{H}^+] = x = 7.82 \times 10^{-4} \text{ M} = 7.8 \times 10^{-4} \text{ M (sig. figs.)}$$

$$\therefore \text{pH} = -\log(7.8 \times 10^{-4})$$

$$\text{pH} = 3.11$$

$$\text{OR} \quad \text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

$$\text{pH} = 3.15 + (-0.04)$$

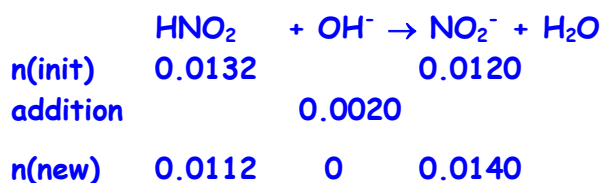
$$\text{pH} = 3.11$$

- b) (12 points) What is the new pH if 10.0 mL of a 0.20 M solution of NaOH is added?

$$n(\text{HNO}_2) = mv = (0.120 \text{ M})(110.0 \times 10^{-3} \text{ L}) = 0.0132 \text{ mol}$$

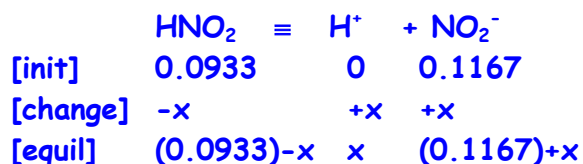
$$n(\text{NO}_2^-) = mv = (0.109 \text{ M})(110.0 \times 10^{-3} \text{ L}) = 0.0120 \text{ mol}$$

$$n(\text{OH}^-) \text{ added} = mv = (0.20 \text{ M})(10.0 \times 10^{-3} \text{ L}) = 0.0020 \text{ mol}$$



$$\text{new } [\text{HNO}_2] = \frac{0.0112\text{mol}}{120 \times 10^{-3}} = 0.0933\text{M}$$

$$\text{new } [\text{NO}_2^-] = \frac{0.0140}{120 \times 10^{-3}} = 0.1167\text{M}$$



$$\text{OR use } \text{pH} = \text{p}K_a + \log \frac{[\text{base}]}{[\text{acid}]}$$

or the version with moles

$$\text{pH} = \text{p}K_a + \log \frac{n(\text{base})}{n(\text{acid})}$$

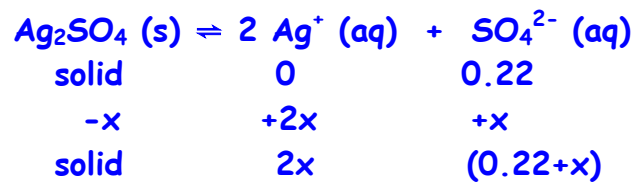
$$\therefore \text{pH} = 3.15 + 0.097$$

$$\therefore \text{pH} = 3.25$$

$$K_a = \frac{x(0.1167 + x)}{(0.0933 - x)} \approx \frac{0.1167x}{0.0933} = 7.1 \times 10^{-4}$$

$$\therefore x = [\text{H}^+] = 5.67 \times 10^{-4} \quad \therefore \text{pH} = 3.25 \text{ (now rounded to 2 decimal places because 0.20 M above was 2 sig, figs)}$$

3. (5 points) What is the molar solubility of  $\text{Ag}_2\text{SO}_4$  in a 0.22 M solution of  $\text{Na}_2\text{SO}_4$ ?  $K_{\text{sp}}$  for  $\text{Ag}_2\text{SO}_4$  is  $1.5 \times 10^{-5}$ .



$$K_{\text{sp}} = 1.5 \times 10^{-5} = [\text{Ag}^+]^2[\text{SO}_4^{2-}] = (2x)^2 (0.22+x) \approx (4x^2)(0.22)$$
$$\therefore x^2 = \frac{(1.5 \times 10^{-5})}{4(0.22)} \quad \therefore x = \text{solubility of } \text{Ag}_2\text{SO}_4 = \boxed{4.1 \times 10^{-3} \text{ M}}$$