

**I. Multiple Choice****20**

- |      |       |       |       |
|------|-------|-------|-------|
| 1. D | 6. C  | 11. C | 16. C |
| 2. C | 7. B  | 12. A | 17. C |
| 3. D | 8. A  | 13. B | 18. D |
| 4. B | 9. B  | 14. B | 19. D |
| 5. D | 10. C | 15. B | 20. C |

**II. Short Answer****50**

1. Determine  $[H^+]$  in a 0.02 M solution of perchloric acid,  $HClO_4$ . Perchloric acid is a very strong acid.

$$[H^+] = [HClO_4] = 0.02 \text{ M} \quad \mathbf{2}$$

2. Write the  $K_a$  expressions for each of these acids. Assume that only one hydrogen is ionized. **2**

a) hydrofluoric acid, HF

b) formic acid,  $HCHO_2$ 

$$K_a = \frac{[H^+][F^-]}{[HF]}$$

$$K_a = \frac{[H^+][CHO_2^-]}{[HCHO_2]}$$

3. Calculate the pH for the following solutions. Read the information provided carefully. Identify each as acidic, basic, or neutral. **8**

	<b>pH</b>	<b>acid, base, or neutral</b>
a) $[H^+] = 1.0 \times 10^{-10}$	10	B
b) $[OH^-] = 1.0 \times 10^{-10}$	4	A
c) $[OH^-] = 1.0 \times 10^{-1}$	13	B
d) $[H^+] = 1.0 \times 10^{-5}$	5	A

4. a) Calculate the hydrogen-ion concentration  $[H^+]$  for an aqueous solution in which  $[OH^-]$  is  $1.0 \times 10^{-11}$  M.

$$[H^+] = 1 \times 10^{-3} \text{ M}$$

- b) Is the solution acid, basic, or neutral? **3**

acidic

6. Calculate  $[H^+]$  in a 0.005 M solution of  $NaOH_{(aq)}$ . **3**

$$[H^+] = \frac{1 \times 10^{-14}}{0.005} = 2 \times 10^{-12} \text{ M}$$

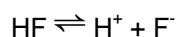
7. A student dissolves 250 g of hydrofluoric acid, HF, in enough water to make one litre of solution.

- a) Calculate the concentration of this solution in  $\text{mol} \cdot \text{L}^{-1}$ . **2**

$$[HF] = \frac{250 \text{ g}}{1} \times \frac{\text{mol}}{20.0 \text{ g}} \times \frac{1}{1 \text{ L}} = 12.5 \text{ M}$$

- b) Calculate  $[H^+]$  for this solution, given that  $K_a$  for hydrofluoric acid is  $6.7 \times 10^{-4}$ . **3**

Begin by writing a balanced equation.



$$K_A = \frac{[H^+][F^-]}{[HF]} \qquad 6.7 \times 10^{-4} = \frac{x^2}{12.5} \qquad x = [H^+] = 0.0915 \text{ M}$$

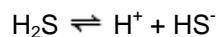
- c) Determine  $[OH^-]$  for this solution. **2**

$$[OH^-] = \frac{1 \times 10^{-14}}{0.915} = 1.09 \times 10^{-13} \text{ M}$$

- d) Determine the pH of this solution. **1**

$$\text{pH} = -\log(0.0915) = 1.04$$

7. Hydrosulfuric acid,  $H_2S$ , is a weak acid with  $K_a = 9.5 \times 10^{-8}$ . This acid ionizes as follows:



- Determine the pH of a 0.25 M solution of this acid. (Hint:  $[H_2S] = 0.25 \text{ M}$ . Find  $[H^+]$ ) **4**

$$K_A = \frac{[H^+][HS^-]}{[H_2S]} \qquad 9.5 \times 10^{-8} = \frac{x^2}{0.25} \qquad x = [H^+] = 1.54 \times 10^{-4} \text{ M}$$

$$\text{pH} = -\log(1.54 \times 10^{-4}) = 3.8$$

8.  $\text{Ca}(\text{OH})_2$  is a strong base. Determine the pH of a 0.11 M solution of  $\text{Ca}(\text{OH})_2$ . **4**

(Hints:  $[\text{Ca}(\text{OH})_2] = 0.11$ . Begin by finding  $[\text{OH}^-]$ )

$$[\text{OH}^-] = 2 \times 0.11 \text{ M} = 0.22 \text{ M}$$

$$[\text{H}^+] = \frac{1 \times 10^{-14}}{0.22} = 4.5 \times 10^{-14} \text{ M}$$

$$\text{pH} = -\log(4.5 \times 10^{-14}) = 13.3$$

9. Determine each of the following: **3**

- a) Find  $[\text{H}^+]$  of a solution whose pH is 8.3

$$[\text{H}^+] = \text{antilog}(-8.3) = 5.01 \times 10^{-9} \text{ M}$$

- b) Find  $[\text{H}^+]$  in a solution with a pOH of 3.75

$$\text{pH} = 14 - \text{pOH} = 10.25$$

$$[\text{H}^+] = \text{antilog}(-10.25) = 5.62 \times 10^{-11} \text{ M}$$

- c) Calculate  $[\text{OH}^-]$  in a solution with a pH of 9.2

$$\text{pOH} = 14 - \text{pH} = 4.8$$

$$[\text{OH}^-] = \text{antilog}(-4.8) = 1.6 \times 10^{-5} \text{ M}$$

10. Determine the concentration of a solution of KOH for which the pH is 11.89. KOH is a strong base. **3**

$$\text{pOH} = 14 - \text{pH} = 2.11$$

$$[\text{OH}^-] = 7.762 \times 10^{-3} \text{ M} = [\text{KOH}]$$

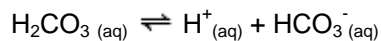
or

$$[\text{H}^+] = \text{antilog}(-11.89) = 1.29 \times 10^{-12} \text{ M}$$

$$[\text{OH}^-] = \frac{1 \times 10^{-14}}{1.29 \times 10^{-12}} = 7.762 \times 10^{-3} \text{ M} = [\text{KOH}]$$

11. A 0.24 M solution of the weak acid  $\text{H}_2\text{CO}_3$  has a pH of 3.49. Determine  $K_a$  for  $\text{H}_2\text{CO}_3$ .  
 $\text{H}_2\text{CO}_3$  dissociates according to:

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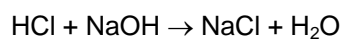


$$[\text{H}^+] = \text{antilog}(-3.49) = 3.24 \times 10^{-4} \text{ M} \quad \text{This is also } [\text{HCO}_3^-]$$

$$K_A = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} = \frac{(3.24 \times 10^{-4})(3.24 \times 10^{-4})}{0.24} = 4.36 \times 10^{-7}$$

12. A neutral solution is produced when 41.32 mL of a 0.1077 M HCl solution was used to titrate 50.00 mL of a NaOH solution. Calculate the concentration of the sodium hydroxide solution before titration.

3



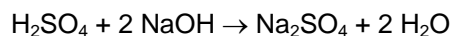
$$M_A V_A = M_B V_B$$

$$(0.1077)(41.32) = M_B (50.00)$$

$$M_B = 0.0890 \text{ M}$$

13. A 30.0 mL sample of sulfuric acid,  $\text{H}_2\text{SO}_4$ , is titrated to an end point with 90.0 mL of 0.40 M NaOH. What is the concentration of the sulfuric acid?

3



$$2M_A V_A = M_B V_B$$

$$2(M_A)(30) = (0.40)(90.0)$$

$$M_A = 0.600 \text{ M}$$