

Vers. A

8. Arsenous Acid, HAsO_2 , has an acid dissociation constant, $K_a = 8.0 \times 10^{-10}$. What is the approximate percent dissociation of a 0.03 M solution of HAsO_2 ?
(A) $4.9 \times 10^{-4} \%$ (B) $1.6 \times 10^{-2} \%$ (C) 9.9 (D) $1.6 \times 10^{-4} \%$
9. If added to 2 L of 0.50 M NaOH, which one of the following would form a buffer?
(A) 2. L of 0.40 M Nitric Acid (HNO_3)
(B) 2. L of 0.40 M Potassium Acetate (KAc)
(C) 2. L of 0.60 M Lactic Acid (HLac)
(D) 2. L of 0.40 M Acetic Acid (HAc)
10. The base equilibrium constant for aniline (Anil) is 4.3×10^{-10} . What is the approximate pH of a solution containing 0.30 M Aniline and 0.50 M Anilinium Bromide (AnilHBr)?
(A) 9.60 (B) 4.85 (C) 4.41 (D) 9.15
11. The acid dissociation constant of Propanoic Acid (HProp) is 1.5×10^{-5} . What is the approximate pH after 0.40 mol of NaOH is added to a solution initially containing 2.0 L of 0.50 M HProp ?
(A) 4.65 (B) 5.00 (C) 4.42 (D) 5.22

For #12 - #14: Consider the amino acid, Glutamic Acid (Glu). The most positive form of Glutamic Acid is Glu^{1+} and the most negative form is Glu^{2-} . The three pK_a 's of Glutamic Acid are: $\text{pK}_a' = 2.1$, $\text{pK}_a'' = 4.1$, and $\text{pK}_a''' = 9.5$.

12. What is the isoelectric point (pI) of Glutamic Acid?
(A) 3.1 (B) 6.8 (C) 2.1 (D) 4.1
13. At what pH does one have 50% Glu^0 (neutral) and 50% Glu^{1-} ?
(A) 3.1 (B) 9.5 (C) 6.8 (D) 4.1
14. What is the average charge on the Glutamic Acid molecule at pH = 6.8 ?
(A) -1.5 (B) -0.5 (C) -1.0 (D) -2.0

Ver s. A

15. 240 mL of 0.40 M NaOH(aq) is needed to completely neutralize 120 mL of an aqueous H_3PO_4 (aq) solution? What is the Molarity of the H_3PO_4 (aq) solution?

- (A) 0.27 M (B) 0.47 M (C) 0.80 M (D) 0.21 M

For #16 - #19: Arsenous acid, H_3AsO_3 , is a triprotic acid with acid dissociation constants, $K_{a1} = 5.6 \times 10^{-3}$, $K_{a2} = 1.7 \times 10^{-7}$, and $K_{a3} = 2.5 \times 10^{-12}$

16. Which one of the solutions below would be best to prepare a buffer with pH = 7.2?

- (A) $\text{K}_2\text{HAsO}_3/\text{Na}_3\text{AsO}_3$ (B) Na_2HAsO_3
(C) $\text{KH}_2\text{AsO}_3/\text{Na}_2\text{HAsO}_3$ (D) $\text{KH}_2\text{AsO}_3/\text{Na}_3\text{AsO}_3$

17. What is the approximate pH of a solution containing pure K_2HAsO_3 ?

- (A) 6.8 (B) 9.2 (C) 11.6
(D) The pH depends upon the K_2HAsO_3 concentration.

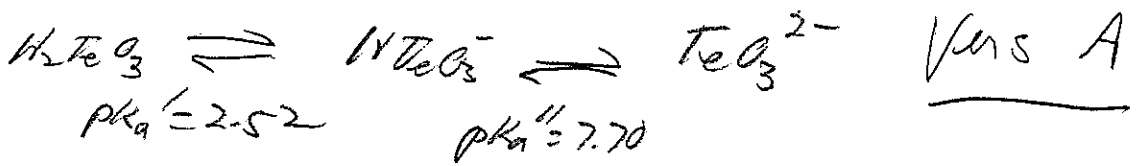
18. What is the approximate pH of a solution prepared by adding 0.30 mol of NaOH to 2.0 L of 0.40 M KH_2AsO_3 ?

- (A) 7.20 (B) 7.00 (C) 6.34 (D) 6.55

19. Approximately what ratio of $[\text{H}_3\text{AsO}_3]/[\text{H}_2\text{AsO}_3^-]$ will give a solution with pH = 2.9?

- (A) 0.2 (B) 0.6 (C) 5.6 (D) 4.5

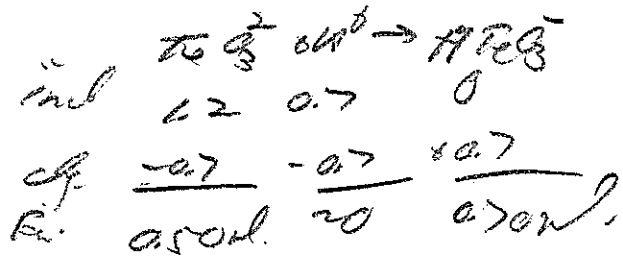
PART II. TWO (2) PROBLEMS BELOW: REMEMBER TO SHOW WORK FOR CREDIT



(16) 1. Tellurous acid, H_2TeO_3 , is a diprotic acid with acid dissociation constants, $K_a' = 3.0 \times 10^{-3}$ and $K_a'' = 2.0 \times 10^{-8}$

(6) (a) Calculate the pH of a solution prepared by mixing 2.0 L of 0.60 M K_2TeO_3 with 1.0 L of 0.70 M HCl.

0.7 L.



Can also be by V(3.0L) to get same, if wish

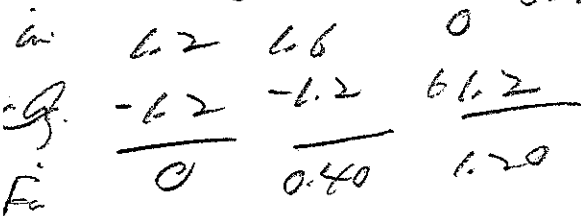
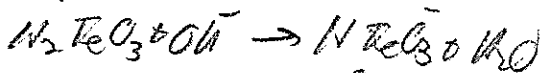
$$\begin{aligned} \text{pH} &= pK_a'' + \log \frac{[\text{TeO}_3^{2-}]}{[\text{HTeO}_3^-]} \\ &= 7.70 + \log \left(\frac{0.50}{0.70} \right) \\ &= \boxed{7.55} \end{aligned}$$

1.2 L.

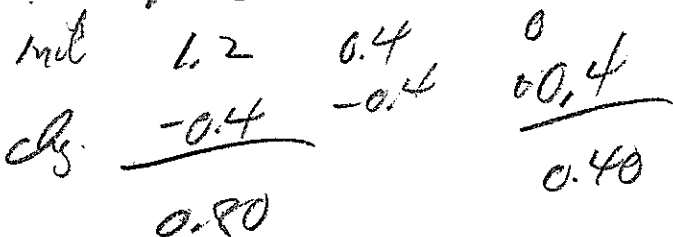
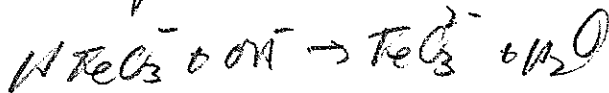
(6) (b) Calculate the pH of a solution prepared by mixing 2.0 L of 0.60 M H_2TeO_3 with 2.0 L of 0.80 M NaOH.

1.6 L.

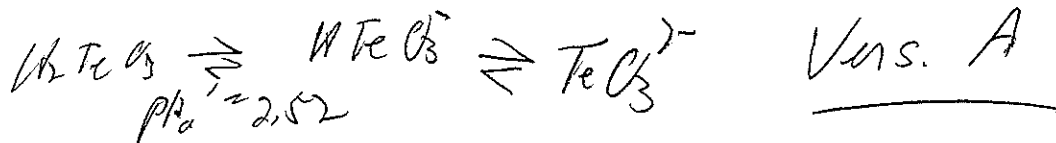
Step 1



Step 2



$$\begin{aligned} \text{pH} &= pK_a'' + \log \frac{[\text{TeO}_3^{2-}]}{[\text{HTeO}_3^-]} \\ &= 7.70 + \log \left(\frac{0.40}{0.80} \right) \\ &= \boxed{7.40} \end{aligned}$$



- (16) 1. (Continued) Tellurous acid, H_2TeO_3 , is a diprotic acid with acid dissociation constants, $K_a' = 3.0 \times 10^{-3}$ and $K_a'' = 2.0 \times 10^{-8}$

- (4) (c) Calculate the ratio, $[\text{HTeO}_3^-]/[\text{H}_2\text{TeO}_3]$, needed to prepare a buffer solution with $\text{pH} = 3.20$

$$\text{pH} = \text{pK}_a' + \log \frac{[\text{HTeO}_3^-]}{[\text{H}_2\text{TeO}_3]}$$

$$3.2 = 2.52 + \log \frac{[\text{HTeO}_3^-]}{[\text{H}_2\text{TeO}_3]}$$

$$\log \frac{[\text{HTeO}_3^-]}{[\text{H}_2\text{TeO}_3]} = 3.2 - 2.52 = 0.68$$

$$\frac{[\text{HTeO}_3^-]}{[\text{H}_2\text{TeO}_3]} = 10^{0.68} = 4.79 \approx \boxed{4.8}$$

- (08) 2. Hypobromous Acid, HBrO , has an Acid Dissociation Constant, $K_a = 2.0 \times 10^{-9}$. Calculate the pH of a solution of Sodium Hypobromite, NaBrO ($M = 118.9 \text{ g/mol}$) that is 3.0% NaBrO by weight.

Note: Assume that the density of the solution is 1.0 g/mL

Calc of $[\text{NaBrO}] = [\text{BrO}^-]$

Assume $V = 1000 \text{ mL} = 1000 \text{ g}$

$$m_{\text{NaBrO}} = \frac{3.0}{100} \times 1000 = 30 \text{ g}$$

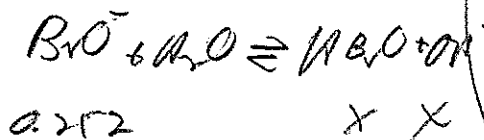
$$M_{\text{NaBrO}} = 30 \text{ g} \times \frac{1 \text{ mL}}{118.9 \text{ g}}$$

$$= 0.252 \text{ M}$$

$$[\text{NaBrO}] = [\text{BrO}^-] = 0.252 \text{ M}$$

(Since $V = 1.0 \text{ L}$)

Calc of pH



$$K_b(\text{BrO}^-) = \frac{10^{-14}}{K_a(\text{HBrO})}$$

$$= \frac{10^{-14}}{2 \times 10^{-9}}$$

$$= 5.0 \times 10^{-6}$$

$$K_b = \frac{[\text{HBrO}][\text{OH}^-]}{[\text{BrO}^-]} = \frac{x^2}{0.252} = 5 \times 10^{-6}$$

$$x^2 = 1.26 \times 10^{-6}$$

$$x = [\text{OH}^-] = 1.12 \times 10^{-3} \text{ M}$$

$$\text{pOH} = -\log(1.12 \times 10^{-3}) = 2.95$$

$$\text{pH} = 14 - 2.95 = 11.05$$

$$\approx \boxed{11.0 \text{ or } 11.1}$$

(76) PART I. MULTIPLE CHOICE (Circle the ONE correct answer)

1. Which of the following aqueous solutions is/are acidic?

- (i) Ammonium Bromide (NH_4Br)
- (ii) Potassium Bromide (KBr)
- (iii) Anilinium Chloride (AnilHCl)
- (iv) Sodium Lactate (NaLac)

- (A) iv only (B) i & ii & iii (C) i & ii & iv

(D) i & iii

For #2 - #3: Consider the weak base, Morphine (Morp). Its base equilibrium constant is 1.6×10^{-6} .

2. What is the approximate percent protonation in a 0.07 M solution of Morphine?

- (A) $3.3 \times 10^{-2} \%$ (B) 0.48% (C) $3.3 \times 10^{-4} \%$ (D) $4.8 \times 10^{-3} \%$

3. What is the approximate pH of a 0.04 M solution of Morphinium Chloride, (MorpHCl) ?

- (A) 3.6 (B) 4.8 (C) 5.3 (D) 9.2

4. What is the approximate pH of a solution containing 0.07 grams of the strong base, potassium hydroxide, KOH ($M = 56.1 \text{ g/mol}$), dissolved in 50 L of aqueous solution?

- (A) 9.4 (B) 4.6 (C) 9.7 (D) 4.3

5. What is the Base Equilibrium Constant of the weak base, Hydroxylamine, if a 0.05 M hydroxylamine solution has a $\text{pH} = 9.4$?

- (A) 5.0×10^{-4} (B) 3.2×10^{-18} (C) 1.3×10^{-8} (D) 4.8×10^{-6}

6. Sulfurous Acid, H_2SO_3 , is a diprotic acid with acid dissociation constants, $K_a' = 1.2 \times 10^{-2}$, and $K_a'' = 6.6 \times 10^{-8}$. What is the approximate pH of a 0.10 M solution of sodium sulfite, Na_2SO_3 ?

- (A) 3.9 (B) 10.1 (C) 9.9 (D) 4.1

7. Benzoic Acid (HBenz) is a weak acid with an acid dissociation constant of 6.3×10^{-5} . What is the approximate pH of a 0.20 M solution of Sodium Benzoate (NaBenz)?

- (A) 2.4 (B) 5.2 (C) 11.6

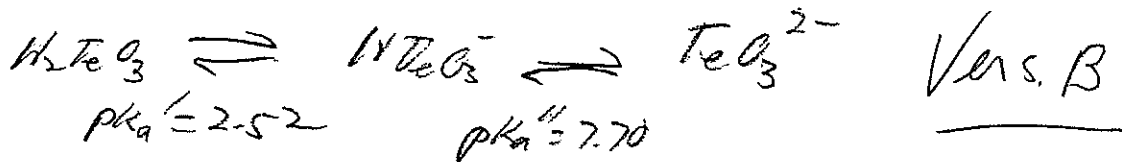
(D) 8.8

Ans B

For #15 - #18: Arsenous acid, H_3AsO_3 , is a triprotic acid with acid dissociation constants, $K_a' = 5.6 \times 10^{-3}$, $K_a'' = 1.7 \times 10^{-7}$, and $K_a''' = 2.5 \times 10^{-12}$

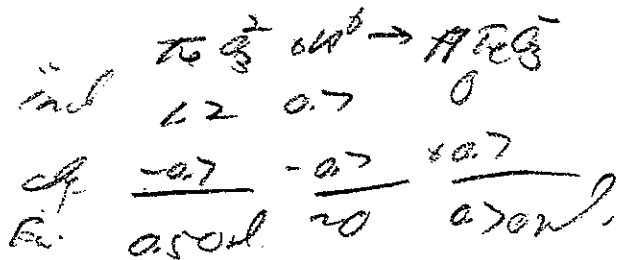
15. What is the approximate pH of a solution containing pure K_2HAsO_3 ?
(A) 9.2 (B) 11.6 (C) 6.8
(D) The pH depends upon the K_2HAsO_3 concentration.
16. Which one of the solutions below would be best to prepare a buffer with $\text{pH} = 7.2$?
(A) $\text{K}_2\text{HAsO}_3/\text{Na}_3\text{AsO}_3$ (B) Na_2HAsO_3
(C) $\text{KH}_2\text{AsO}_3/\text{Na}_3\text{AsO}_3$ (D) $\text{KH}_2\text{AsO}_3/\text{Na}_2\text{HAsO}_3$
17. What is the approximate pH of a solution prepared by adding 0.30 mol of NaOH to 2.0 L of 0.40 M KH_2AsO_3 ?
(A) 6.55 (B) 7.00 (C) 6.34 (D) 7.20
18. Approximately what ratio of $[\text{H}_3\text{AsO}_3]/[\text{H}_2\text{AsO}_3^-]$ will give a solution with $\text{pH} = 2.9$?
(A) 2.5 (B) 0.6 (C) 5.6 (D) 0.2
19. 240 mL of 0.40 M NaOH(aq) is needed to completely neutralize 120 mL of an aqueous H_3PO_4 (aq) solution? What is the Molarity of the H_3PO_4 (aq) solution?
(A) 0.47 M (B) 0.80 M (C) 0.27 M (D) 0.21 M

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(6) (a) Calculate the pH of a solution prepared by mixing 2.0 L of 0.60 M K_2TeO_3 with 1.0 L of 0.70 M HCl.
0.7 L.



con. div by V (3.0 L) to get concs, if used

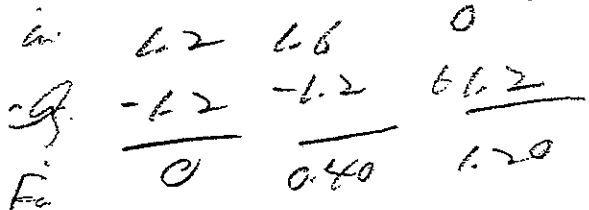
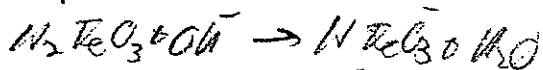
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1.2 vol.

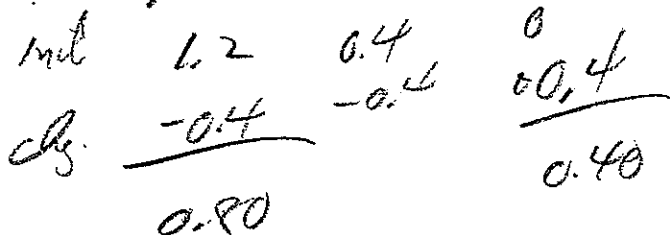
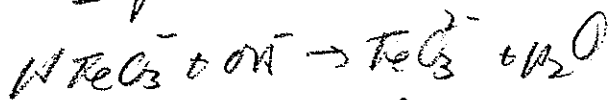
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1.6 L.

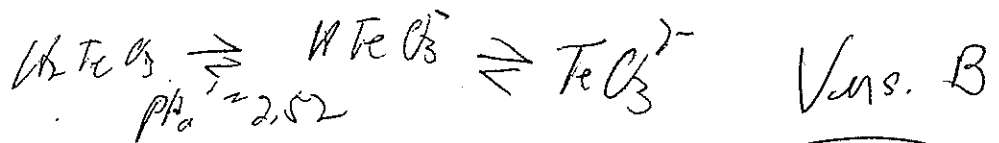
Step 1



Step 2



$$\begin{aligned} \text{pH} &= pK_a'' + \log \frac{[\text{TeO}_3^{2-}]}{[\text{HTeO}_3^-]} \\ &= 7.70 + \log \left(\frac{0.40}{0.80} \right) \\ &= \boxed{7.40} \end{aligned}$$



(16) 1. (Continued) Tellurous acid, H_2TeO_3 , is a diprotic acid with acid dissociation constants, $K_a' = 3.0 \times 10^{-3}$ and $K_a'' = 2.0 \times 10^{-8}$

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Note: Assume that the density of the solution is 1.0 g/mL

Calc of $[\text{NaBrO}] = [\text{BrO}^-]$

Assume $V = 1000 \text{ mL} = 1000 \text{ g}$

$$M_{\text{NaBrO}} = \frac{3.0}{100} \times 1000 = 30 \text{ g}$$

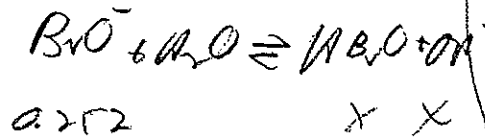
$$n_{\text{NaBrO}} = 30 \text{ g} \times \frac{1 \text{ mol}}{118.9 \text{ g}}$$

$$= 0.252 \text{ mol}$$

$$[\text{NaBrO}] = [\text{BrO}^-] = 0.252 \text{ M}$$

(Since $V = 1.0 \text{ L}$)

Calc of pH



$$K_b(\text{BrO}^-) = \frac{10^{-14}}{K_a(\text{HBrO})}$$

$$= \frac{10^{-14}}{2 \times 10^{-9}}$$

$$= 5.0 \times 10^{-6}$$

$$K_b = \frac{[\text{HBrO}][\text{OH}^-]}{[\text{BrO}^-]} = \frac{x^2}{0.252} = 5.0 \times 10^{-6}$$

$$x^2 = 1.26 \times 10^{-6}$$

$$x = [\text{OH}^-] = 1.12 \times 10^{-3} \text{ M}$$

$$\text{pOH} = -\log(1.12 \times 10^{-3}) = 2.95$$

$$\text{pH} = 14 - 2.95 = 11.05$$

$$\approx \boxed{11.0 \text{ or } 11.1}$$