Teacher's Tools® Chemistry
Acids & Bases

1. How many moles of pure NaOH must be used to prepare 10.0 L of a solution that has a pH of 13.00?
(A) 1.0 mol (B) 0.10 mol (C) 0.011 mol (D) 0.0010 mol

2. Which of the following is a base-conjugate acid pair?
(A) $C_6H_5NH_2$, $C_6H_5NH_3^+$ (B) Cl-, NH_4^+
(C) NH_3, $HC_2H_3O_2$ (D) $HC_2H_3O_2$, H_2O

3. In the reaction: CO_3^{2-} + H_2O <=====> HCO_3^- + OH- the carbonate ion is acting as a(n)
(A) Arrhenius base (B) Arrhenius acid
(C) Bronsted-Lowry base (D) Bronsted-Lowry acid

4. Which of the following represents a Bronsted-Lowry conjugate acid-base pair?
(A) SO_3^{2-} and SO_2 (B) CO_3^{2-} and CO (C) H_3O+ and H_2 (D) NH_4+ and NH_3

5. If 5.00 mL of 15.4 M HNO_3 is diluted to 250 mL, what is the pH of the resulting solution?
(A) 0.52 (B) 0.76 (C) 1.45 (D) 2.89

6. A 0.20 M solution of the hypothetical weak acid HZ is found to have a pH of exactly 3.0. The ionization constant, K_a, of the acid HZ is
(A) 0.6 (B) 1.0×10^{-3} (C) 2.0×10^{-4} (D) 5.0×10^{-6}

7. If the pK_a of the acid HX is 8.0, the K_b for X- is
(A) 1×10^8 (B) 1×10^{-8} (C) 1×10^6 (D) 1×10^{-6} (E) None of these

8. What is the pH of a 1.0 M solution of aniline? ($K_b = 4 \times 10^{-10}$)
(A) 4.7 (B) 9.3 (C) 9.4 (D) None of these

9. A 0.30 M solution of a weak acid (HA) has an [H+] of 1.66×10^{-4} M. What is the K_a of this weak acid?
(A) 4.8×10^1 (B) 5.5×10^{-4} (C) 1.2×10^8 (D) 9.2×10^{-8}
(E) The Ka cannot be calculated without additional information.

10. The pH of a 0.10 M solution of a weak acid is 5.40. What is the K_a of the acid?
(A) 1.6×10^{-10} (B) 3.2×10^{-10} (C) 1.6×10^{-8} (D) 8.0×10^{-8}

11. 10.0 mL of a solution of HCl required 12.5 mL of 0.400 M $Ba(OH)_2$ for complete neutralization. How many moles of HCl were present in the sample?
(A) 5.00×10^{-3} (B) 1.00×10^{-2} (C) 1.00 (D) 2.00

12. A 50.0 mL solution of 1.50 M NaOH is being titrated with a 2.00 M HCl solution. What will the pH be after the addition of 35.0 ml of HCl?
(A) 1.23 (B) 11.7 (C) 12.8 (D) 2.3 (E) 10.5

13. A strong monoprotic acid is being titrated with a 0.500 M NaOH solution. Which statement is true for this titration?
(A) The pH at the equivalence point cannot be determined without knowing the identity of the acid.
(B) The pH at the equivalence point cannot be determined unless the concentration of the acid is known.
(C) The pH at the equivalence point depends on neither the identity nor the concentration of the acid.

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1. What will be the pH of a solution made by dissolving 5.50 g NaOH in enough water to make 500.0 mL of solution? [NaOH] = 0.275 pOH = 0.56 pH = 13.44

2. Find the pH of a solution made by dissolving 0.405 g of strontium hydroxide in enough water to make 800.0 mL of solution.
$[Sr(OH)_2] = 0.00416$ $[OH^-] = 0.00832$ pOH = 2.1 pH = 11.9

3. You have two similar beakers, one containing a colorless solution of a 0.1 M strong acid, and the other containing a colorless solution of a 0.1 M weak acid. How would you identify the strong acid?
Test pH → weak acid would have smaller [H+], higher pH

4. Determine the pH of a 0.10 M CH_3COOH (acetic acid) solution. ($K_a = 1.8 \times 10^{-5}$)
$1.8 \times 10^{-5} = \frac{x^2}{0.10}$ $x = [H^+] = 0.00134$ M pH = 1.87

5. Determine the pH of a 0.05 M NH_3. ($K_b = 1.8 \times 10^{-5}$)
$1.8 \times 10^{-5} = \frac{x^2}{0.05}$ $x = [OH^-] = 9.5 \times 10^{-4}$ M pH = 11.0

6. Determine the pH of 0.05 M $NaC_2H_3O_2$. ($K_a = 1.8 \times 10^{-5}$ for acetic acid) K_b for $C_2H_3O_2^- = 5.6 \times 10^{-10}$
$5.6 \times 10^{-10} = \frac{x^2}{.05}$ $x = [OH^-] = 5.3 \times 10^{-6}$ pH = 8.72

7. Determine the pH of 0.05 M NH_4NO_3. (K_b= 1.8 x 10-5 for ammonia) K_a for $NH_4^+ = 5.6 \times 10^{-10}$
$5.6 \times 10^{-10} = \frac{x^2}{0.05}$ $x = [H^+] = 5.3 \times 10^{-6}$ pH = 5.28

8. Determine the percent dissociation of a 1.0 M HClO solution if the pH = 3.7. (K_a for HClO = 2.8×10^{-8})
$[H^+] = 1.99 \times 10^{-4}$ M % ion = $\frac{1.99 \times 10^{-4}}{1.0} \times 100$ = 0.0199% Don't need K_a

9. A 0.10 molar solution of $HC_2H_3O_2$ is 1.3% ionized. What is the pH of this solution?
$0.013 = \frac{[H^+]}{.1}$ $[H^+] = 0.0013$ M pH = 2.89

10. Calculate the pH of a solution prepared by dissolving 10.5 g of NaF in 500.0 mL of water. $[F^-] = 0.5$ M
(K_a of HF = 7.0×10^{-4}) K_b of $F^- = 1.4 \times 10^{-11}$
$1.4 \times 10^{-11} = \frac{x^2}{.5}$ $x = [OH^-] = 2.65 \times 10^{-6}$ pH = 8.42

11 Determine the percent dissociation of a 2.25 M weak base solution with a pH = 11.8. pOH = 2.2
$[OH^-] = 0.0063$ M % = $\frac{0.0063}{2.25} \times 100$ = 0.28%

12. Chloroacetic acid $ClCH_2COOH$, has a K_a of 1.4×10^{-4}.
(A) Calculate [H+], pH and % ionization for 1.00 liter of a 0.100 M solution of this acid. $[H^+] = 0.0037$ M
(B) What would the pH be if you added 4.00 grams of NaOH? (assume no volume change) pH = 2.43
4 grams NaOH = 0.10 mole OH^- added (see last page for work) % = 3.7%

13. A sample of 20.0 mL of a 0.100-molar HCN solution is titrated with a 0.150-molar NaOH solution. (K_a HCN = 6.2×10^{-10})
(A) What volume of NaOH is used in the titration in order to reach the equivalence point?
(B) What is the molar concentration of CN- at the equivalence point?
(C) What is the pH of the solution at the equivalence point?
(see last page of packet)

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Classify each of the following compounds as a **weak acid, weak base, strong acid, strong base, acidic salt, basic salt**, or **neutral salt** when placed in water. Write a behavior equation to explain your choice. Refer to K_a and K_b information as needed.

COMPOUND	CLASSIFICATION	BEHAVIOR EQUATION
(A) $NaNO_2$	basic salt	$NO_2^- + H_2O \rightleftharpoons OH^- + HNO_2$
(B) H_3PO_4	weak acid	$H_3PO_4 + H_2O \rightleftharpoons H_3O^+ + H_2PO_4^-$
(C) CH_3NH_2	weak base	$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$
(D) NH_4Br	acidic salt	$NH_4^+ + H_2O \rightleftharpoons H_3O^+ + NH_3$
(E) SrF_2	basic salt	$F^- + H_2O \rightleftharpoons OH^- + HF$
(F) $Ca(OH)_2$	strong base	$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$ dissolves 100%
(G) HNO_2	weak acid	$HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$
(H) NH_4Cl	acidic salt	see (D)
(I) Na_2SO_4	basic salt	$SO_4^{2-} + H_2O \rightleftharpoons HSO_4^- + OH^-$
(J) NH_3	weak base	$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
(K) Na_2SO_3	basic salt	$SO_3^{2-} + H_2O \rightleftharpoons HSO_3^- + OH^-$
(L) $MgCO_3$ ↙ acidic ↳ basic	depends on K_a K_b can't find K_a for $Mg(H_2O)_4^{2+}$	
(M) HBr	strong acid	$HBr + H_2O$ $H_3O^+ + Br^-$ 100%
(N) $ZnCl_2$	acidic salt	$Zn(H_2O)_4^{2+} \rightleftharpoons H^+ + [Zn(OH)(H_2O)_3]^{1+}$
(O) LiOH	strong base	$LiOH \rightarrow Li + OH^-$ 100%
(P) AlF_3 ✱ Al $K_a = 1.2 \times 10^{-5}$ F⁻ $K_b = 1.4 \times 10^{-11}$	acidic salt	$Al(H_2O)_6^{3+} \rightleftharpoons H^+ + [Al(OH)(H_2O)_5]^{2+}$

#12 (B) NaOH reacts w/ $ClCH_2COOH$ (similar to titration)

$$OH^- + ClCH_2COOH \longrightarrow H_2O + ClCH_2COO^-$$

OH^-	$ClCH_2COOH$	H_2O	$ClCH_2COO^-$
0.10 mol	0.10 mole	—	0
−0.10 mol	−0.10 mol		+0.10 mol
0	0		0.10 mol of $ClCH_2COO^-$

Solution becomes a <u>weak base</u> solution

w/ $[ClCH_2COO^-] = \frac{0.10\ mol}{1\ L} = 0.1\ M$

Find K_b for $ClCH_2COO^-$ using K_a

$K_b = 7.1 \times 10^{-11}$ So $7.1 \times 10^{-11} = \frac{x^2}{0.10}$ $x = [OH^-] = 2.67 \times 10^{-5}\ M$

pH = 9.42

#13 $HCN + OH^- \longrightarrow CN^- + H_2O$

(A) $(0.020\ L)(0.100) = 0.0020$ mole HCN $\times \frac{1\ OH^-}{1\ HCN} = 0.0020$ moles OH^-/NaOH

$0.150\ M = \frac{0.0020\ \text{mole NaOH}}{\text{volume}} \Rightarrow$ volume = **13.3 mL of NaOH**

(B) At end point 0.0020 moles HCN has becomes 0.0020 mole CN^-

$[CN^-] = \frac{0.0020\ \text{moles}}{0.0333\ L} = 0.0600\ M$

↖ 20.0 + 13.3

(C) Use K_b for CN^- ($K_b = 1.6 \times 10^{-5}$)

$1.6 \times 10^{-5} = \frac{x^2}{0.0600}$ $x = [OH^-] = 9.8 \times 10^{-4}\ M$ (pH ≈ 11)