Acids and Bases

Properties of Acids and Bases

Acids taste __________________. Lemon juice and ________________________________, for example, are both aqueous solutions of acids. Acids conduct electricity; they are __________________________. Some are strong electrolytes, while others are __________________ electrolytes. An acetic acid solution, which is a weak electrolyte, contains only a few ions and does not conduct as much current as a strong electrolyte. The bulb is only _______________________ lit. Acids cause certain colored dyes (___________________________) to change color. (Litmus paper turns ________________.) Acids cause the indicator phenolphthalein to turn _______________. Acids react with metals to form ____________________ gas. This property explains why acids corrode most metals.

Example: $2HBrO_3 + Zn \rightarrow Zn(BrO_3)_2 + H_2$ Acids react with hydroxides (bases) to form water and a ____________________. Example: $2HNO_3 + Ba(OH)_2 \rightarrow Ba(NO_3)_2 + 2H_2O$ Bases taste ___________________________ and feel ___________________________. Bases can be strong or weak electrolytes. Bases cause certain colored dyes (indicators) to change color. (Litmus paper turns ____________). Bases cause the indicator phenolphthalein to turn _______________.

Bases react with acids to form water and a salt. Bases do not commonly ______________ with metals.

Naming Acids

Acids are compounds that give off ___________________________ ions (H^+) when dissolved in water. Acids will always contain one or more hydrogen ions next to an ____________________________. The anion determines the name of the acid.

Naming Binary Acids

Binary acids contain hydrogen and an anion whose name ends in –ide. When naming the acid, put the prefix ________________________- and change -ide to -ic acid.

Example: HCl The acid contains the hydrogen ion and chloride ion. Begin with the prefix hydro-, name the nonmetallic ion and change -ide to -ic acid. __________________________________

Example: H_2S The acid contains the hydrogen ion and sulfide ion. Begin with the prefix hydro- and name the nonmetallic ion. The next step is change -ide to -ic acid, but for sulfur the “ur” is added before -ic. __________________________________

1) Name the following binary acids.

a) HF ____

b) H_3P ____

Writing the Formulas for Binary Acids

The prefix hydro- lets you know the acid is binary. Determine whether you need to criss-cross the oxidation numbers of hydrogen and the nonmetal.

Example: Hydrobromic acid The acid contains the hydrogen ion and the bromide ion. The two oxidation numbers add together to get zero. The prefix hydro- lets you know the acid is binary.

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Example: Hydrotelluric acid The acid contains the hydrogen ion and the telluride ion. The two oxidation numbers do NOT add together to get zero, so you must criss-cross. ____________________

2) Write the formulas for the following binary acids.

a) Hydrocyanic acid ____________________ b) Hydroselenic acid ____________________

Naming Ternary Acids

The acid is a ternary acid if the anion has oxygen in it. The anion ends in -ate or -ite. Change the suffix -ate to -________ acid Change the suffix -ite to -ous acid The hydro- prefix is NOT used!

Example: HNO_3 The acid contains the hydrogen ion and nitrate ion. Name the polyatomic ion and change -ate to -ic acid. ______________________________________

Example: HNO_2 The acid contains the hydrogen ion and nitrite ion. Name the polyatomic ion and change -ite to -ous acid. ____

Example: H_3PO_4 The acid contains the hydrogen ion and phosphate ion. Name the polyatomic ion and change -ate to -ic acid. ____

3) Name the following ternary acids.

a) H_2CO_3 ____

b) H_2SO_4 ____

c) H_2CrO_4 ____

d) $HClO_2$ ____

Writing the Formulas for Ternary Acids

The lack of the prefix hydro- from the name implies the acid is ternary, made of the hydrogen ion and a polyatomic ion. Determine whether you need to criss-cross the oxidation numbers of hydrogen and the polyatomic ion.

Example: Acetic acid The polyatomic ion must end in –ate since the acid ends in -ic. The acid is made of H^+ and the acetate ion. The two charges when added equal zero.

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Example: Sulfurous acid Again the lack of the prefix hydro- implies the acid is ternary, made of the hydrogen ion and a polyatomic ion. The polyatomic ion must end in –ite since the acid ends in -ous. The acid is made of H^+ and the sulfite ion. The two charges when added do not equal zero, so you must crisscross the oxidation numbers. __________________________

4) Write the formulas for the following ternary acids.

a) perchloric acid ________________________ b) iodic acid _________________________

c) nitrous acid _________________________ d) bromic acid ________________________

Types of Acids and Bases

Arrhenius Definitions - The simplest definition is that an acid is a substance that produces _______________________________ ions when it dissolves in water. A hydronium ion, H_3O^+, consists of a hydrogen ion attached to a ___________________ molecule. A hydronium ion, H_3O^+, is equivalent to H^+. HCl and H_3PO_4 are acids according to Arrhenius. A base is a substance that produces __________________________ ions, OH^-, when it dissolves in water. $Ca(OH)_2$ and NaOH are Arrhenius bases. NH_3, ammonia, could not be an Arrhenius ____________________. Monoprotic acids have only _____________ ionizable hydrogen. Examples include $HC_2H_3O_2$ and HCl.

Ionization reaction: $HC_2H_3O_2 \leftrightarrow H^+ + C_2H_3O_2^-$ _________________________ acids have more than one ionizable hydrogen atom. Examples include H_2SO_4 and $H_3C_6H_5O_7$ (citric acid).

Ionization reaction: $H_3C_6H_5O_7 \leftrightarrow H^+ + H_2C_6H_5O_7^-$

Bronsted-Lowry Definitions - A Bronsted-Lowry acid is a _________________________ (H^+) donor. HBr and H_2SO_4 are Bronsted-Lowry acids. When a Bronsted-Lowry acid dissolves in water it gives its proton to water. HCl (g) + H_2O (l) ↔ H_3O^+ + Cl^- A Bronsted-Lowry base is a proton ___________________.

B + H_2O ↔ BH^+ + OH^- A Bronsted-Lowry base does not need to contain OH^-.

Consider $HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$ HCl donates a proton to water. Therefore, HCl is a(n) _____________. H_2O accepts a proton from HCl. Therefore, H_2O is a(n) ______________.

5) Identify the acid and base in the following reactions.

a) H_2SO_3 + H_2O ↔ HSO_3^- + H_3O^+

Acid ________________________________ base _________________________________

b) NH_3 + H_2SO_4 ↔ NH_4^+ + HSO_4^-

Acid ________________________________ base _________________________________

Molarity and Dilution

The concentration of a solution is the amount of solute present in a given quantity of solution.

___________________________ is the number of moles of solute in 1 liter of solution.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{Liters of solution}}$$

The procedure for preparing a less concentrated solution from a more concentrated one is called a

_____________________________.

$$M_1 V_1 = M_2 V_2$$

6) What is the molarity of an acetic acid ($HC_2H_3O_2$) solution with 4.0 moles dissolved in 250 mL of solution?

7) How many moles of hydrochloric acid (HCl) are needed to make 3.0 L of a 0.55 M HCl solution?

8) 0.600 moles of the base sodium hydroxide (NaOH) are dissolved in a small amount of water then diluted to 500. mL. What is the concentration?

9) 3.25 moles of the base potassium hydroxide (KOH) are dissolved in a small amount of water then diluted to 725 mL. What is the concentration?

10) How many moles are in 2.00 L of a 6.00 M solution of sulfuric acid (H_2SO_4)?

11) How many moles are in 1250 mL of a 3.60 M solution of nitric acid (HNO_3)?

12) 6.0 L of a 1.55 M LiOH solution are diluted to 8.8 L. What is the new molarity of the lithium hydroxide solution?

13) You have 250 mL of 6.0 M HCl. How many milliliters of 1.2 M HCl can you make?

14) 4.0 liters of a 0.75 M solution of sulfuric acid (H_2SO_4) are diluted to a 0.30 M solution. What is the final volume?

15) You need 350 mL of 0.25 M NaOH. All you have available is a 2.0 M stock solution of NaOH. How do you make the required solution?

Strength of Acids and Bases

The strength of a base is based on the degree of ________________________________. The strength of a base does NOT depend on the ___________________________. 1A and _______ hydroxides, excluding __________, are strong bases. Some bases, such as $Mg(OH)_2$, are not very soluble in water, and they don't produce a large number of OH^- ions. However, they are still considered to be strong bases because all the base that does dissolve completely dissociates. The strength of an acid is based on the degree of dissociation. The strength of an acid does NOT depend on the _________________________. K_a is referred to as the acid dissociation ____________________. The greater the K_a value, the _____________________ the acid. There are 6 strong acids: HCl, HBr, HI, $HClO_4$, HNO_3, and H_2SO_4. Strong acids and bases are strong ______________________________ because they dissociate completely. Electrolytes conduct ____________________________. Weak acids and bases don't completely ionize, so they are weak electrolytes. Although the terms *weak* and *strong* are used to compare the ___________________________ of acids and bases, *dilute* and *concentrated* are terms used to describe the ___________________________ of solutions.

pH Scale

Water ionizes; it falls apart into ________________. $H_2O \rightarrow H^+ + OH^-$ The preceding reaction is called the _____________________________________ of water. $[H^+] = [OH^-] = 1 \times 10^{-7}$ M When $[H^+] = [OH^-]$, the solution is ________________________. At 25°C, $K_w = [H^+][OH^-] = 1 \times 10^{-14}$ K_w is called the ion-product constant. If $[H^+] > [OH^-]$, the solution is ____________________. The solution is ________________________ when $[OH^-] > [H^+]$. In most applications, the observed range of possible hydronium or hydroxide ion concentrations spans 10^{-14} *M* to _____*M*. To make this range of possible concentrations easier to work with, the pH scale was developed. pH is a mathematical scale in which the concentration of hydronium ions (H_3O^+) in a solution is expressed as a number from ________ to

__________. pH meters are instruments that measure the exact pH of a solution. Indicators register different colors at different pH's. In neutral solution, pH = 7. In an acidic solution, pH < 7. In a basic solution, pH > 7. As the pH drops from 7, the solution becomes more acidic. As pH increases from 7, the solution becomes more basic.

The **pH** of a solution equals the negative logarithm of the **hydrogen** or **hydronium** ion concentration.

$$\mathbf{pH = -\log [H^+]}$$

pH "goes with" the terms hydrogen and __________________________.

The **pOH** of a solution equals the negative logarithm of the **hydroxide** ion concentration.

$$\mathbf{pOH = -\log [OH^-]}$$

pOH "goes with" the term _________________________.

On the graphing calculator, hit

- (−)
- log
- the number

On a scientific calculator hit

* the number
* log
* +/–

If either pH or pOH is known, the other may be determined by using the following relationship.

$$\mathbf{pH + pOH = 14.00}$$

16) Find the pH of the following solutions.

a) The hydronium ion concentration equals: 10^{-2} *M* = 1 x 10^{-2} *M*. pH = _________________

b) The hydrogen ion concentration equals: 10^{-11} *M*. pH = _________________

c) The hydronium ion concentration equals: 1 x 10^{-6} *M*. pH = _________________

d) The hydroxide ion concentration equals: 10^{-8} *M*. pH = _________________

e) The hydroxide ion concentration equals: 10^{-5} *M*. pH = _________________

f) The hydroxide ion concentration equals: 10^{-3} *M*. pH = _________________

17) If a certain carbonated soft drink has a hydrogen ion concentration of 1.0 x 10^{-4} *M*, what are the pH and pOH of the soft drink?

More pH and pOH

18) Find the pH if the hydrogen ion concentration equals: 3.25 x 10^{-3} M.

19) Find the pH if the hydroxide ion concentration equals: 7.36×10^{-5} M.

20) Find the pOH if the hydroxide ion concentration equals: 8.34×10^{-9} M.

21) Find the pOH if the hydronium ion concentration equals: 1.45×10^{-4} M.

Calculating Ion Concentrations From pH

If either pH or pOH is known, the hydrogen ion or hydroxide ion can be found.

$$[H^+] = 10^{-pH} \qquad [OH^-] = 10^{-pOH}$$

On the graphing calculator, hit

- 2nd
- log
- (-)
- and then the number.

On a scientific calculator hit

* the number
* +/-
* shift
* log

Always check to see if the terms match! If they do not, subtract the pH/pOH from 14 FIRST!

22) Find the $[H^+]$ of a solution that has a pH equal to 6.

23) Find the $[H^+]$ of a solution that has a pH equal to 12.

24) Find the $[H^+]$ of a solution that has a pH equal to 5.

25) Find the $[H^+]$ of a solution that has a pOH equal to 6.

26) Find the $[OH^-]$ of a solution that has a pOH equal to 6.

27) Find the $[H^+]$ of a solution that has a pOH equal to 2.

28) Find the $[H^+]$ of a solution that has a pOH equal to 4.

29) Find the $[OH^-]$ of a solution that has a pH equal to 10.

More Calculating Ion Concentrations From pH

30) Find the $[H^+]$ of a solution that has a pH equal to 4.23.

31) Find the $[H^+]$ of a solution that has a pOH equal to 6.34.

32) Find the $[OH^-]$ of a solution that has a pH equal to 10.5.

33) Find the $[OH^-]$ of a solution that has a pOH equal to 13.5.

Calculating Ion Concentration From Ion Concentration

If either $[H^+]$ or $[OH^-]$ is known, the hydrogen ion or hydroxide ion can be found.

$$[H^+][OH^-] = 1 \times 10^{-14}$$

34) Find the hydrogen ion concentration if the hydroxide ion concentration equals: 1×10^{-8} *M*.

35) Find the hydrogen ion concentration if the hydroxide ion concentration equals: 1×10^{-2} *M*.

36) Find the hydroxide ion concentration if the hydrogen ion concentration equals: 1×10^{-4} *M*.

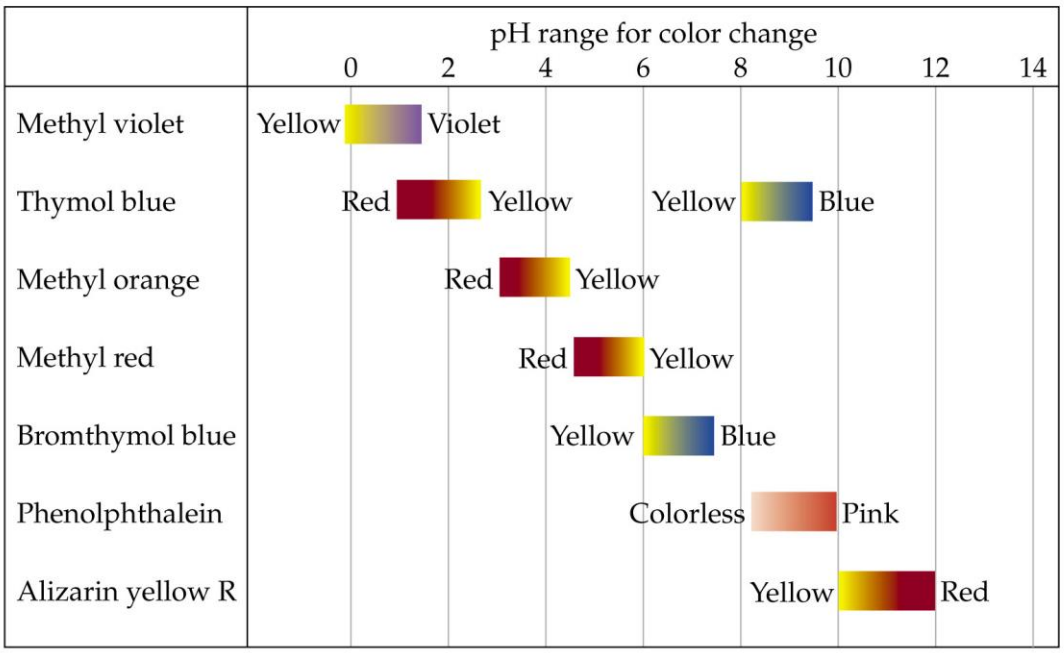
37) Find the hydroxide ion concentration if the hydrogen ion concentration equals: 1×10^{-9} *M*.

38) Find the hydrogen ion concentration if the hydroxide ion concentration equals: 3.25×10^{-3} *M*.

39) Find the hydroxide ion concentration if the hydrogen ion concentration equals: 6.44×10^{-6} *M*.

Indicators

Chemical _____________________ whose colors are affected by acidic and basic solutions are called indicators. Many indicators do not have a sharp color change as a function of ____________. Most indicators tend to be __________________ in more acidic solutions.



40) Which indicator is best to show an equivalence point pH of 4?

41) Which indicator is best to show an equivalence point pH of 11?

42) Which indicator is best to show an equivalence point pH of 2?

Neutralization Reactions

The reaction of an acid and a base is called a neutralization reaction. Acid + base → salt + water A salt is an ___________________ compound.

43) Predict the products of and balance the following neutralization reactions. (Remember to check the oxidation numbers of the ions in the salt produced.)

a) HNO_3 + KOH →

The salt is composed of the ________________ ion of the base and the _________________ ion of the acid.

b) HCl + $Mg(OH)_2$ →

c) H_2SO_4 + NaOH →

Neutralization

44) How many moles of HNO_3 are needed to neutralize 0.86 moles of KOH?

$$KOH + HNO_3 \rightarrow KNO_3 + H_2O$$

45) How many moles of HCl are needed to neutralize 3.5 moles of $Mg(OH)_2$?

$$2HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2H_2O$$

46) How many moles of H_3PO_4 are needed to neutralize 3.5 moles of $Mg(OH)_2$?

$$2H_3PO_4 + 3Mg(OH)_2 \rightarrow Mg_3(PO_4)_2 + 6H_2O$$

47) How many moles of $HC_2H_3O_2$ are needed to neutralize 3.5 moles of $Cr(OH)_3$?

$$3HC_2H_3O_2 + Cr(OH)_3 \rightarrow Cr(C_2H_3O_2)_3 + 6H_2O$$

48) If it takes 87 mL of an HCl solution to neutralize 0.67 moles of $Mg(OH)_2$ what is the concentration of the HCl solution? $2HCl + Mg(OH)_2 \rightarrow MgCl_2 + 2H_2O$

49) If it takes 58 mL of an H_2SO_4 solution to neutralize 0.34 moles of NaOH what is the concentration of the H_2SO_4 solution? $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

50) If it takes 85 mL of an HNO_3 solution to neutralize 0.54 moles of $Mg(OH)_2$ what is the concentration of the HNO_3 solution? $2HNO_3 + Mg(OH)_2 \rightarrow Mg(NO_3)_2 + 2H_2O$

51) If it takes 150. mL of an $Ca(OH)_2$ solution to neutralize 0.800 moles of HCl what is the concentration of the $Ca(OH)_2$ solution? $Ca(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

Titration

The general process of determining the molarity of an acid or a base through the use of an acid-base reaction is called an acid-base ______________________. The known reactant molarity is used to find the unknown _________________________ of the other solution. Solutions of known molarity that are used in this fashion are called ________________________ solutions. In a titration, the molarity of one of the reactants, acid or base, is known, but the other is unknown.

52) A 15.0-mL sample of a solution of H_2SO_4 with an unknown molarity is titrated with 32.4 mL of 0.145*M* NaOH to the bromothymol blue endpoint. Based upon this titration, what is the molarity of the sulfuric acid solution? $H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

53) If it takes 45 mL of a 1.0 M NaOH solution to neutralize 57 mL of HCl, what is the concentration of the HCl ? $NaOH + HCl \rightarrow NaCl + H_2O$

54) If it takes 67.0 mL of 0.500 M H_2SO_4 to neutralize 15.0 mL of $Al(OH)_3$ what was the concentration of the $Al(OH)_3$? $3H_2SO_4 + 2Al(OH)_3 \rightarrow Al_2(SO_4)_3 + 6H_2O$

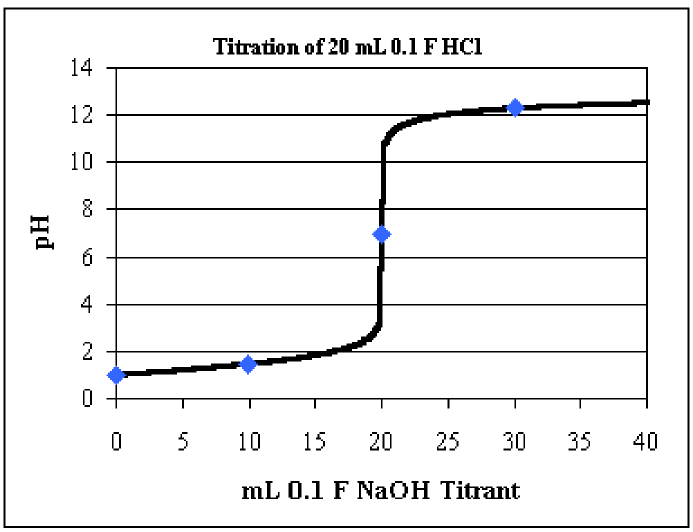
55) How many moles of 0.275 M HCl will be needed to neutralize 25.0 mL of 0.154 M NaOH?

$$HCl + NaOH \rightarrow NaCl + H_2O$$

Titration Curves

A plot of ___________ versus volume of acid (or base) added is called a titration curve.

Strong Base-Strong Acid Titration Curve



Consider adding a strong base (e.g. NaOH) to a solution of a strong acid (e.g. HCl). Before any base is added, the pH is given by the strong _________________ solution. Therefore, pH ____ 7. When base is added, before the equivalence point, the pH is given by the amount of strong acid in _________________________. Therefore, pH < 7. At the _______________________ point, the amount of base added is stoichiometrically equivalent to the amount of acid originally present.

Therefore, pH =_________. To detect the equivalence point, we use an indicator that changes ____________________somewhere near 7.00. Past the equivalence point *all acid has been consumed.* Thus one needs only to account for excess __________________. Therefore, pH ______ 7.