Ca(oh)2 acid or base name

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For more information about the source of this book or why it is available for free, visit the project home page. There you can view or download additional books. To download the .zip that contains this book to use offline, simply click here. Did this book help you? Consider overheaing it: Creative Commons supports a free culture from music to education. Their licenses have helped you make this book available to you. DonorsChoose.org helps people like you help teachers fund their classroom projects, from art supplies to books to calculators. One of the most concentrated acids in the body is stomach acid, which can approximately approach as a solution of hydrochloric acid of 0.05 M. Special cells in the stomach wall drive this acid crazy, along with special enzymes, as part of the digestion process. In the lab, a solution of hydrochloric acid of 0.05 M would dissolve some metals. How does the stomach survive the presence of such reactive acid? In fact, the stomach has several mechanisms for withstanding this chemical attack. First, the stomach lining is coated with a thin layer of mucus containing some bicarbonate ions (HCO_3^-). They react with hydrochloric acid to produce water, carbon dioxide and harmless chloride ions. If any acid penetrates through the mucus, it can attack the surface layer of gastric cells, called the gastric epithelium. Cells in the gastric epithelium are constantly removed, so damaged cells are quickly removed and replaced with healthy cells. However, if the gastric epithelium is destroyed faster than it can be replaced, the acid can reach the wall of the stomach, resulting in ulcers. If the ulcer grows large enough, it can expose the blood vessels in the gastric sheath, causing bleeding. In extreme situations, blood loss through a severe ulcer can endanger a person's health. Ulcers may also be due to the presence of certain pylori – in the stomach. The mechanism for this ulcer formation is not the same as for ulcers caused by stomach acid and is not fully understood. However, there are two main treatments for ulcers: (1) antacids for chemical reaction with excess hydrochloric acid in the stomach and (2) antibiotics for the destruction of H. pylori bacteria in the stomach. Many of us are familiar with a group of chemicals called acids. But do you know what it takes for a compound to be acid? In fact, there are several different definitions of acid that chemistry uses, and each definition is appropriate in different circumstances. Lesser known – but equally important for chemistry and ultimately for us – is a group of chemicals known as bases. Both acids and bases are important enough to dedicate a whole chapter to them – their properties and their reactions. Figure 10.1 The prevalence of acids and bases illustrates how common acids and bases are in everyday life. Figure 10.1 Prevalence of acids and base Products shown in this photo, all acids or bases, give an idea of how widespread and important acids and bases are in everyday life. Learning goal Recognize the compound as an arrhenius acid or Arrhenius base. One way to define a class of compounds is to describe the different characteristics that its members have in common. In the case of compounds known as acids, common characteristics include an acidic taste, the ability to change the color of the litmus plant color to red, and the ability to dissolve certain metals and at the same time produce hydrogen gas. For compounds called bases, common characteristics are a slippery texture, a bitter taste and the ability to change the color of the litmus to blue. Acids and bases also react with each other to the formation of compounds generally known as salts. Although we include their flavors among the common characteristics of acids and bases, we never advocate tasting an unknown chemical! Chemists prefer, however, to have definitions for acids and bases in chemical terms. Swedish chemist Svante Arrhenius developed the first chemical definitions of acids and bases in the late 1800s. Arrhenius has defined a compound of acidA that increases the concentration of hydrogen ion (H^+) in aquatic solution. as a compound that increases the concentration of hydrogen ion (H^+) in aquatic solution. Many acids are simple compounds that release hydrogen dissipitation into the solution when dissolved. Similarly, Arrhenius defined a base compound that increases the concentration of hydroxide ion (OH^-) in the aquatic solution. as a compound that increases the concentration of hydroxide ion (OH^-) in the aquatic solution. Many bases are ion compounds that have hydroxide ion as an anion, which is released when the base is dissolved in water. Many bases and their aquatic solutions are called using common ion presented in Chapter 3 Ion binding and simple ion compounds, Section 3.4 of the Ion Nomenclature; that is, they are named as hydroxide compounds. For example, basic sodium hydroxide (NaOH) is both an ion compound and an aquas solution. However, the aquatic acid solution has its own naming rules. The names of binary acids (compounds with hydrogen and another element in their formula) are based on the root name of the second element preceded by the prefix hydrophyx, followed by the suffix -ic acid. Thus, the aquatic solution of HCl [designated as HCl(aq)] is called hydrochloric acid, H_2S(aq) is called hydrosulfuric acid and so on. Acids composed of more than two elements (usually hydrogen and oxygen and some other element) have names based on the name of another element, followed by the suffix -ic acid or -ous acid, depending on the number of oxygen atoms in the acid formula. Other prefixes, such as per- and hypo-, also appear in the names for some acids. Unfortunately, there is no strict rule for the number of oxygen atoms that are associated with the suffix -ic acid; the names of these acids are best remembered. Table 10.1 Formulas and names for some acids and bases lists some acids and bases and their names. Have a competition that the acids first wrote hydrogen, as if it were ion, while most bases have negative hydroxide ion, if it appears in the formula, written last. The name oxygen comes from the Latin meaning acid producer because its discoverer Antoine Lavoisier thought it was an essential element in acids. Lavoisier made a mistake, but now it's too late to change his name. Table 10.1 Formulas and names for some acids and bases Formula Name Acids HCl(aq) hydrochloric acid HBr(aq) hydrobromic acid HI(aq) hydroric acid H 2S(aq) hydrosulfuric acid $HC_2H_3O_2$(aq) acetic acid HNO_3(aq) nitric acid HNO_2(aq) nitric acid H_2SO_4(aq)) are the jampornic acid H_2SO_3(aq) sulphuric acid $HClO_3$(aq) chloric acid $HClO_4$(aq) perchloric acid $HClO_2$(aq) chlorine H_3PO_4(aq) phosphorus acid H_3PO_3(aq) phosphorus acid Base NaOH(aq) sodium hydroxide KOH(aq) potassium hydroxide Mg(OH) 2(aq) magnesium hydroxide $Ca(OH)_2$(aq) calcium hydroxide NH_3(aq) amonia Specify each substance. Solution This acid has only two elements in its formula, so the name includes a hydro-prefix. The stem of the name of the second element, fluorine, is fluoride, and we must include the ending of -ic acid. His name is hydro fluoride acid. This base is named as an ion compound between strotion ions and hydroxide: strontium hydroxide. Skill-Building Exercises The name of each substance. Notice that one base listed in Table 10.1 Formulas and names for some acids and bases — amonia — does not have hydroxide as part of its formula. How does this compound increase the amount of hydroxide in the aquatic solution? Instead of broken down into hydroxide ions, molecules react with water molecules by taking hydrogen ion from water molecules to produce ammonium iion and hydride: NH_3(aq) + H_2O(l) → NH_4^+(aq) + OH^-(aq) Because this ammonium reaction with water causes an increase in the concentration of ion hydroxide in the solution, ammonium meets the arrhenius definition of the base. Many other nitrogen-containing compounds are bases because they too react with water to produce hydroxide ions in an aqueous solution. As we noted earlier, acids and bases react chemically with each other to form salts. Salt is a general chemical term for any acid-based ion compound and base. In reactions where the acid is a hydrogen ion containing the compound, and the base is a hydroxide ion containing the compound, water is also a product. The general reaction is as follows: acid + base → water + salt Reaction of acid and base to make water and salt is called neutralization of acid and base to make water and salt.. Like any chemical equation, the chemical equation of neutralization must be properly balanced. For example, the neutralization reaction between sodium hydroxide and hydrochloric acid is as follows: NaOH(aq) + HCl(aq) → NaCl(aq) + H_2O(l) with odds implied as one. The neutralization reaction between sodium hydroxide and sulphuric acid is as follows: 2NaOH(aq) + H_2SO_4(aq) → Na_2SO_4(aq) + $2H_2O$(l) After the neutralization reaction is properly balanced, We can use it to perform stoichiometry calculations, such as those we practiced in Chapter 5 Introduction to Chemical Reactions and Chapter 6 Quantities in Chemical Reactions. Nitric acid [HNO_3(aq)] can be neutralised with calcium hydroxide [$Ca(OH)_2$(aq)]. Write a balanced chemical equation for the reaction between these two compounds and identify the salt it produces. For one reaction, 16.8g of HNO_3 is present initially. How many grams of $Ca(OH)_2$ does it take to neutralize so much HNO_3? In the second reaction, 805 mL of 0.672 M $Ca(OH)_2$ was initially present. What volume 0.432 M HNO_3 solution is needed to neutralize $Ca(OH)_2$ solution? Solution Since there are two OH^- ions in the $Ca(OH)_2$ formula, we need two HNO_3 moles to provide H^+ ions. The balanced chemical equation is as follows: $Ca(OH)_2$(aq) + $2HNO_3$(aq) → $Ca(NO_3)_2$(aq) + $2H_2O$(l) Salt formed is calcium nitrate. This calculation is similar to the calculations we made in Chapter 6 quantities in chemical reactions. First we convert the mass of HNO_3 into moles using its molar mass of 1.01 + 14.00 + 3(16.00) = 63.01 g/mol; then we use a balanced chemical equation to determine the associated number of $Ca(OH)_2$ moles needed to neutralize it; and then convert this number of moles $Ca(OH)_2$ into mass $Ca(OH)_2$ using its molar mass of 40.08 + 2(1.01) + 2(16.00) = 74.10 g/mol. 16.8 g HNO3 × 1 mol HNO 363.01 g/mol. Ca(OH) 22 mol HNO 3 × 74.10 g Ca(OH)21 mol Ca(OH) 2=9.88 g Ca(OH)2 required Concentration information allows us to use the skills we have developed in Chapter 9 Solutions. First, we use concentration and volume data to determine the number of moles present $Ca(OH)_2$. Recognizing that 805 mL = 0.805 L, 0.672 M Ca(OH)2=mol Ca(OH)20.805 L soln (0.672 M CaOH)2 × (0.805 L soln) = pier Ca(OH)2 = 0.541 mol Ca (OH)2 We combine this information with the correct ratio from a balanced chemical equation to determine the number of HNO_3 moles required: 0.541 mol Ca(OH)2×2 mol HNO31 mol Ca(OH) 2=1.08 mol HNO3 Now , using the definition of molars once again, we determine the volume of the required acid solution: 0.432 M HNO3=1.08 mol HNO3volume HNO3 volume HNO3=1.08 mol HNO30.. 432 M HNO3=2.50 L=2.50×103 HNO3 skills-building exercises Hydrocyanic acid [HCN(aq)] can be neutralised with potassium hydroxide [KOH(aq)]. Write a balanced chemical equation for the reaction between these two compounds and identify the salt it produces. For one reaction, 37.5 g of HCN was initially present. How many grams of KOH does it take to neutralize so much HCN? In the second reaction, 43.0 0 mL of 0.0663 M KOH was initially present. What volume of 0.107 M HCN solution is needed to neutralize KOH solution? Hydrocyanic acid (HCN) is one exception to the acid naming rules that determine the use of the prefix hydro- for binary acids (hydrogen-composed acids and just another element). Concept review exercises give arrhenius definitions of acid and base. Answers Arrhenius acid: a compound that increases the concentration of hydrogen ion (H^+) in aquatic solution; Arrhenius base: a compound that increases the concentration of hydroxide ion (OH^-) in the aquatic solution. the reaction of acid and the basic key takeaway arrhenius acid increases the concentration of H + ion in water, while the arrhenius base increases the concentration of OH^- ions in water. Exercises Give two examples of arrhenius acids. Give two examples of Arrhenius bases. List the general properties of acids. Specify general base properties. They name every date. HBr(aq) $Ca(OH)_2$(aq) HNO_3(aq) $Fe(OH)_3$(aq) Name each compound. HI(aq) $Cu(OH)_2$(aq) H_3PO_4(aq) CsOH(aq) Suggest a water name (H_2O) using acid naming rules. Suggest a name for hydrogen peroxide (H_2O_2) using the rules for naming acids. Write a balanced chemical equation to neutralize $Ba(OH)_2$(aq) with HNO_3(aq). Write a balanced chemical equation to neutralize H_2SO_4(aq) with $Cr(OH)_3$(aq). How many sodium hydroxide moles (NaOH) is needed to neutralise 0.844 acetic acid moles ($HC_2H_3O_2$)? (Tip: Start by writing a balanced chemical equation for the process.) How much perchloric acid mole ($HClO_4$) is needed to neutralize 0.052 moles of calcium hydroxide [$Ca(OH)_2$]? (Tip: writing a balanced chemical equation for the process.) Hydrasoic acid (HN_3) can be neutralized by base. Write a balanced chemical equation for the reaction between hydrasasic acid and calcium hydroxide. How many milliliters of 0.0245 M $Ca(OH)_2$ is needed to neutralize 0.564 g of HN_3? Citric acid ($H_3C_6H_5O_7$) has three hydrogen atoms that can form hydrogen ions in the solution. Write a balanced chemical equation for the reaction between citric acid and sodium hydroxide. If the orange contains 0.0675 g $H_3C_6H_5O_7$, how many milliliters is 0.00332 M of NaOH solution needed to neutralize acid? Magnesium hydroxide [$Mg(OH)_2$] is an ingredient in some antacids. How many grams of $Mg(OH)_2$ is needed to neutralize acid in 158 2 2 of 0.106 M HCl(aq)? This could help write a balanced chemical equation in the first place. Aluminum hydroxide [$Al(OH)_3$] is an ingredient in some antacids. How many grams of Ala(OH)3 is needed to neutralize acid in 96.5 mL of 0.556 M H_2SO_4(aq)? This could help write a balanced chemical equation in the first place. Responses HCl and HNO_3 (responses will vary) sour taste, react with metals, react with bases, and convert litmus red hydrobromic acid calcium hydroxide nitric acid iron (III) hydroxide $2HNO_3$(aq) + $Ba(OH)_2$(aq) → $Ba(NO_3)_2$(aq) + 2H2 $2HN_3$(aq) + $Ca(OH)_2$ → $Ca(N_3)_2$ + $2H_2O$ 268 mL Learning goals Recognize the compound as Brønsted-Lowry acid or Brønsted-Lowry base. Illustrate the proton transfer process that defines the brønsted-Lowry acidic reaction. Ammonia (NH_3) increases the concentration of hydroxide in an aqueous solution by reacting with water instead of directly deflating hydrooxide ions. In fact, arrhenius definitions of acid and base focus on hydrogen ions and hydroxide ions. Are there fundamental definitions of acids and bases? Danish scientist Johannes Brønsted and English scientist Thomas Lowry independently proposed new definitions of acids and bases in 1923. Instead of considering hydrogen and hydroxide ions, they focused only on hydrogen iion. Brønsted-Lowry acidA compound that delivers hydrogen ion (H^+) in reaction; proton donor. is a compound that supplies hydrogen ion in reaction. Brønsted-Lowry baseA compound that accepts hydrogen ion (H^+) in reaction; proton acceptor., conversely, is a compound that accepts hydrogen ion in reaction. Thus, Brønsted-Lowry definitions of acid and base are focused on the movement of hydrogen ions in reaction, not on the production of hydrogen ions and hydroxide ions in aquatic solution. Let's use the amonia reaction in water to demonstrate brønsted-lowry definitions of acid and base. Ammonium and water molecules are reactant, while ammonium and hydroxide ion are products: NH_3(aq) + H_2O(l) → NH_4^+(aq) + OH^-(aq) What happened in this reaction is that the source water He donated hydrogen ion to the original amonia molecule, which in turn accepted hydrogen ions. We can illustrate this as follows: Since the water molecule donates hydrogen ion to the amonia, it is brønsted-Lowry acid, while the molecule is an amonia - which accepts hydrogen ion - the base of Brønsted-Lowry. Thus, the amonia acts as a base both in the arrhenius sense and in the Brønsted-Lowry sense. Is arrhenius acid like hydrochloric acid still acid in the Brønsted-Lowry sense? yes, but it requires us to figure out what really happens when HCl melts in water. Remember that a hydrogen atom is one proton surrounded by a single electron. To make hydrogen ion, we remove the electron, leaving a bare proton. Do we really have naked protons floating in the aquatic solution? No, we don't know. What really happens is that H^+ ion attaches to H_2O to make H_3O^+, which is called hydronium ion. For most purposes, H^+ and H_3O^+ represent the same type, but writing H_3O^+ instead of H^+ shows that we understand that there are no naked protons floating around in the solution. Instead, these protons are actually tied to solvent molecules. Proton in an aqueous solution can be surrounded by more than one water molecule, leading to formulas such as $H_5O_2^+$ or $H_9O_4^+$ instead of H_3O^+. However, it is easier to use H_3O^+. With this in mind, how do we define HCl as acid in the Brønsted-Lowry sense? Consider what happens when HCl dissolves in H_2O: HCl + H_2O(l) → H_3O^+ (aq) + Cl^-(aq) We can display this process using the Lewis Electron Dot Diagram: We now see hydrogen ion ion transmitted from the HCl molecule to the H_2O molecule to make chloride ion and hydronium ions. As a donor of hydrogen ions, HCl acts as brønsted-Lowry acid; As an ion hydrogen accepter, H_2O is the Brønsted-Lowry base. Thus, HCl is acid not only in the arrhenius sense, but also in Brønsted-Lowry terms. Moreover, according to the definitions of Brønsted-Lowry, H_2O is the base in the formation of aqueous HCl. Thus, Brønsted-Lowry definitions of acid and base classify the dissolution of HCl in water as a reaction between acid and base - although the definition of Arrhenius would not mark H_2O as a base in these circumstances. All arrhenius acids and bases are Brønsted-Lowry acids and bases as well. But not all Brønsted-Lowry acids and bases arrhenius acids and bases. Anilin ($C_6H_5NH_2$) is slightly soluble in water. It has a nitrogen atom that can accept hydrogen ion from a water molecule just like a nitrogen atom does in ammonia. Write a chemical equation for this reaction and identify Brønsted-Lowry acid and base. Solution $C_6H_5NH_2$ and H_2O are reactant. When $C_6H_5NH_2$ accepts a proton from H_2O, it receives an additional H and a positive charge and leaves oh− ion behind. The reaction is as follows: $C_6H_5NH_2$(aq) + H_2O(l) → $C_6H_5NH_3^+$(aq) OH^-(aq) Since $C_6H_5NH_2$ accepts proton, it is brønsted-lowry base. The molecule H_2O, because it donates proton, is Brønsted-Lowry acid. Skill-building exercise caffeine ($C_8H_{10}N_4O_2$) is a stimulant in coffees and teas. When dissolved in water, it can accept a proton from a water molecule. Write a chemical equation for this process and identify Brønsted-Lowry acid and base. Brønsted-Lowry definitions of acid and base can be applied to chemical reactions that occur in solvents other than water. The following example illustrates. Sodium in the middle ($NaNH_2$) dissolves in methanol (CH_3OH) and is separated into sodium ions and ions (NH_2^-). Amid ions react with methanol to make ammonia and methoxide ion (CH_3O^-). Write a balanced chemical equation for this process and identify Brønsted-Lowry acid and base. Solution The equation for reaction is between NH_2^- and CH_3OH to make NH_3 and CH_3O^- the following: NH_2^-(solv) + CH_3OH(l) → NH_3(solv) + CH_3O^-(solv) The mark (solv) indicates that the species dissolves in a solvent, as opposed to (aq), which determines the aquatic (H_2O) solution. In this reaction we see that NH_2^- ion accepts proton from the CH_3OH molecule to make the molecule NH_3. So, as a proton acquirer, NH_2^- is the Brønsted-Lowry base. As a proton donor, CH_3OH is Brønsted-Lowry acid. The piridinium chloride (C_5H_5NHCl) skill-building exercise dissolves in ethanol (C_2H_5OH) and is separated into pyridine ions ($C_5H_5NH^+$) and chloride ions. Pyridinium ion can transfer hydrogen ion to a solvent molecule. Write a balanced chemical equation for this process and identify Brønsted-Lowry acid and base. There are many interesting applications of Brønsted-Lowry acid-base reactions in the pharmaceutical industry. For example, drugs often need to be soluve in water for maximum efficiency. However, many complex organic compounds are not soluve or are only slightly soluve in water. Fortunately, those drugs containing nitrogen atoms that accept protons (and there are many) can be reacted with diluted hydrochloric acid [HCl(aq)]. Nitrogen atoms - acting as Brønsted-Lowry bases - accept hydrogen ions from acid to make ion, which is usually much more soluous in water. Modified molecules of the drug can then be isolated as chloride salts: RN(sl aq) + H+(aq) → RNH+(aq) →Cl−(aq) RNHCl(s) where RN represents an organic compound containing nitrogen. The mark (sl aq) means slightly aqueous, indicating that the RN compound is only slightly soluble. Drugs that are modified in this way are called hydrochloride salts. Examples include a powerful pain codeine, commonly used as codeine hydrochloride. Acids other than hydrochloric acid are also used. Hydrobromic acid, for example, gives hydrobromide salts. an ingredient in many cough medicines, is issued as dextromethorfan hydrobromide. The accompanying figure shows another drug like hydrochloride salt. Concept review exercises give definitions of Brønsted-Lowry acid and Brønsted-Lowry base. The Brønsted-Lowry acid response is proton donor, while Baza Brønsted-Lowry is a proton accepter. Key Takeaways A Brønsted-Lowry acid is a proton donor and Baza Brønsted-Lowry is a proton acceptor. Brønsted-Lowry acid-base reactions are basically proton transfer reactions. Exercises Mark each reactive as Brønsted-Lowry acid or Brønsted-Lowry base. HCl(aq) + NH3(aq) → NH4+(aq) + Cl−(aq) Mark each reactive as brønsted-lowry acid or brønsted-lowry base. H2O(l) + N2H4(aq) → N2H5+(aq) + OH−(aq) Explain why brønsted-lowry acid can be called a proton donor. Explain why the Brønsted-Lowry base can be called a proton acceptor. Write the chemical equation of the amonia reaction in water and mark brønsted-lowry acid and base. Write the chemical equation methylamine reaction (CH3NH2) in water and mark brønsted-lowry acid and base. Show that melting HNO3 in water is actually a brønsted-Lowry acid-base reaction describing it with a chemical equation and marking Brønsted-Lowry acid and base. Identify brønsted-Lowry acid and base in the following chemical equation: C3H7NH2 (aq) + H3O + (aq) → C3H7NH3 +(aq) + H2O(l) Write a chemical equation for the reaction that occurs when cocaine hydrochloride (C17H22ClNO4) dissolves in water and donates proton to the water molecule. (When hydrochlorides dissolve in water, they are separated into chloride ions and appropriate cations.) If codeine hydrobromide has the formula C18H22BrNO3, what is the codeine formula of the parent compound? Answers HCl: Brønsted-Lowry acid; NH3: Brønsted-Lowry base Brønsted-Lowry acid gives H + ion – nominally, proton – in the reaction of the acidic base. NH3 + H2O → NH4+ + OH−; NH3: Brønsted-Lowry Base; H2O: Brønsted-Lowry acid HNO3 + H2O → H3O+ + NO3−; HNO3: Brønsted-Lowry acid; H2O: Brønsted-Lowry Base C17H22NO4 + H2O → H3O + C17H21NO4 Learning goal Write chemical equations for water that acts as an acid and as a base. Water (H2O) is an interesting compound in many respects. Here we will consider its ability to behave like acid or base. In some circumstances, the water molecule will accept the proton and thus act as a Brønsted-Lowry base. We saw an example in the dissolution of HCl in H2O: HCl + H2O(l) → H3O+(aq) + Cl−(aq) In other circumstances, a water molecule can donate a proton and thus act as Brønsted-Lowry acid. For example, in the presence of ions in the middle (see Example 4 in section 10.2 Brønsted-Lowry Definition of acids and bases), the water molecule donates proton, making ammonia as a product: H2O(l) NH2−(aq) → OH−(aq) + NH3(aq) In this case, NH2− is a Brønsted-Lowry base (proton acquirer). Thus, depending on the circumstances, H2O can act either as a Brønsted-Lowry acid or Brønsted-Lowry base. Water is not the only substance that in some cases can react as acid or base in others, but it is certainly the most common example – and the most important. A substance that can donate or accept a proton, depending on the circumstances, is called an amphiprotic substance that can donate or accept a proton, depending on the circumstances. Date. The water molecule can act as an acid or base even in a sample of pure water. About 6 in every 100 million (6 to 108) water molecules undergo the following reaction: H2O(l) + H2O(l) → H3O+(aq) + OH−(aq) This process is called water autoionization The process by which water ionizes into hydronic ions and hydroxide ions because it acts as acid and base. (Figure 10.2 Autoionization) and occurs in each water sample, whether clean or part of the solution. Autoionization occurs to some extent in any amphiprotic fluid. (By comparison, liquid amonia also undergoes autoionization, but only about 1 molecule per million billion (1 in 1015) reacts with another molecule of amonia.) Figure 10.2 Autoionization A small part of water molecules – approximately 6 in 100 million – spontaneously ionizes into hydronic ions and hydrooxide ions. This image necessarily over-represents the amount of autoionization that really occurs in clean water. Identify water as Brønsted-Lowry acid or Brønsted-Lowry base. H2O(l) + NO2−(aq) → HNO2(aq) + OH−(aq) HC2H3O2(aq) + H2O(l) → H3O+(aq) + C2H3O2−(aq) Solution In this reaction, the water molecule bestords the proton NO2− ion, making OH−(aq). As a proton donor, H2O acts as Brønsted-Lowry acid. In this reaction, the water molecule accepts the proton from HC2H3O2, becoming H3O +(aq). As a proton acquirer, H2O is a Brønsted-Lowry base. Skill building exercise Identify water as brønsted-lowry acid or brønsted-lowry base. HCOOH(aq) + H2O(l) → H3O+(aq) + HCOO−(aq) H2O(l) + PO43−(aq) → OH−(aq) + HPO42−(aq) Concept review exercises Explain how water can act as acid. Explain how water can act as a base. Answers Under the right conditions, H2O can donate proton, making it Brønsted-Lowry acid. Under the right conditions, H2O can accept proton, making it a Brønsted-Lowry base. Key takeaway water molecules can act as both acid and base, depending on the conditions. Exercise Does H2O(l) act as an acid or base? H2O(l) + NH4+(aq) → H3O+(aq) + NH3(aq) Does H2O(l) act as an acid or base? CH3−(aq) + H2O(l) → CH4(aq) + OH−(aq) In aqueous solutions of some salts, one of the salt ions may react with water molecules. In some cases, solutions, the following reaction may occur: C2H3O2−(aq) + H2O(l) → HC2H3O2(aq) + OH−(aq) Does H2O act as an acid or base in this reaction? In aqueous solutions of some salts, one of the ions from salt can react with water molecules. In some NH4+ solutions, the following reaction may occur: NH4+(aq) + H2O → NH3(aq) + H3O+(aq) Does H2O act as an acid or base in this reaction? Aluminum hydroxide [Al(OH)3] is amphoteric; reacts to both acids and bases. Suggest chemical equations for Ala(OH)3 reactions with H+ and OH−. Based on the information in this section, autoonia (NH3) autoionizes more or less than water? Write a chemical equation for autoionizing ammoniania. Answer Al(OH)3 + H+ → HAl(OH)3+; Al(OH)3 + OH− → Al(OH)4− Learning goals Describe the difference between strong and weak acids and bases. Describe how the chemical reaction reaches the chemical balance. Define the pH scale and use it to describe acids and bases. Acids and bases do not all show the same degree of chemical activity in the solution. Different acids and bases have different advantages. Let's first consider the benefits of acids. A small number of acids are completely ionized in an aquaose solution. For example, when HCl is dissolved in water, each HCl molecule is separated into hydronic ion and chloride: HCl + H2O(l) → ~ 100% H3O + (aq) + Cl−(aq) HCl(aq) is one example of strong acidic acid that is 100% ionized in aqueous solution., which is a compound that is intest 100% ionized in an aquatic solution. There are very few strong acids. The important ones are listed in Table 10.2 of the Strong Acid and Base (All in Aquatic Solution). Table 10.2 Strong Acids and Bases (All in Aquatic Solution) HCl LiOH Base Acid HBR NaOH HI KOH HNO3 Mg(OH)2 H2SO4 Ca(OH)2 HClO4 Analogy, a powerful baseA base that is 100% ionized in aquatic solution. is a compound that is basically 100% ionized in an aquatic solution. As with acids, there are only a few strong bases, which are also listed in table 10.2 strong acids and bases (All in aqueous solution). If the acid is not specified in Table 10.2 of the Strong Acid and Base (All in aquatic solution), it is likely a weak acidic acid that is less than 100% ionized in the aquatic solution., a compound that is not 100% ionized in the aquaose solution. Similarly, a weak baseA base that is less than 100% ionized in a watercolor solution. is a compound that is not 100% ionized in a watery solution. For example, acetic acid (HC2H3O2) is weak acid. The reaction of ionization for acetic acid is as follows: HC2H3O2(aq) + H2O(l) → H3O+(aq) + C2H3O2−(aq) Depending on the concentration of HC2H3O2, the ionization reaction can only occur for 1%-5% of acetic acid molecules. Many household products are acids or bases. For example, a pool owner may use muriatic acid to Swimming pool. Muriatic acid is another name for hydrochloric acids [HCl(aq)]. Vinegar has already been mentioned as a diluted solution of acetic acid [HC2H3O2(aq)]. A bottle of vitamin C tablets can be found in the medical chest; the chemical name of vitamin C is ascorbic acid (HC6H7O6). One of the more well-known grounds for household is amonia (NH3), which is found in a number of cleaning agents. As we have already mentioned, ammonia is a base because it increases the concentration of hydroxide ions by reacting with water: NH3(aq) + H2O(l) → NH4+(aq) + OH−(aq) Many soaps are also a little basic because they contain compounds that act as Brønsted-Lowry bases, accepting protons from water and forming excess hydroxide ions. This is one of the reasons that soap solutions are slippery. Perhaps the most dangerous chemical in the household is a liana-based drain cleaner. Lye is a common name for sodium hydroxide, although it is also used as a synonym for potassium hydroxide. Alkaline is an extremely causal chemical that can react with fat, hair, food particles and other substances that can build up and form clogging in pipes. Unfortunately, lychees can also attack tissues and other substances in our body. So, when using alkaline-based drain cleaners, we must be very careful not to touch any of the solid drains or spill the water into which it was poured. Safer drain cleaners that do not use peroxide compounds to react to materials in the clog and clean the drain. The behavior of weak acids and bases illustrates a key concept in chemistry. Does a chemical reaction describing the ionization of weak acid or base only stop when acid or base is done ionizingly? Actually, no. Instead, the reverse process - the reformation of the molecular form of acid or base - occurs, ultimately at the same rate as the ionization process. For example, the ionization of weak acid HC2H3O2 (aq) is as follows: HC2H3O2(aq) + H2O(l) → H3O +(aq) + C2H3 H3 The reverse procedure begins: H3O+(aq) + C2H3O2−(aq) → HC2H3O2(aq) + H2O(l) Finally, there is a balance between the two competing procedures, and there are no additional changes. The chemical reaction is better represented at the moment with a double arrow: HC2H3O2(aq) + H2O(l) ⇆ H3O + (aq) + C2H3O2−(aq) ⇆ implies that both forward and vice versa reactions occur, and their effects cancel each other out. The process at this time is considered a chemical balance (or balance)A condition in which the extent of the chemical reaction does not change further.. It is worth noting that the processes do not stop. They are balancing each other so that there is no further net change; that is, chemical balance is a dynamic balance. Write a chemical balance equation for partial ionization of each weak acid or base. Solution HNO2(aq) + H2O(l) ⇆ NO2−(aq) + H3O+(aq) C5H5N(aq) + ⇆ C5H5NH+(aq) + OH−(aq) Skills Building Exercise Write a chemical balance equation for partial ionization of each weak acid or base. Hydro fluoride acid [HF(aq)] is one chemical that reacts directly with glass. (Very few chemicals react with glass.) Fluoride acid is used in cutting glass. Finally, you may realize that water autoionization is actually a process of balance, so it is more regularly written with a double arrow: H2O(l) + H2O(l) ⇆ H3O+(aq) + OH−(aq) One qualitative measure of acid strength or basic solution is the pH scaleA logarithmic scale related to hydrogen ion ion concentration in the solution. , which is based on the concentration of hydronic (or hydrogen) ions in the aquatic solution. A neutral (neither acidic nor basic) solution, one that has the same concentration of hydrogen and hydroxide ions, has a pH of 7. PH below 7 means that the solution is acidic, with lower pH values corresponding to increasingly acidic solutions. PH greater than 7 indicates the basic solution, with higher pH values that correspond to all basic solutions. So, given the pH of several solutions, you can find which are sour, which are basic, and which are more acidic or more basic than others. Table 10.3 PH of some common solutions lists the pH of several common solutions. Notice that some biological fluids are nowhere near neutral. Table 10.3 PH Values of some common solutions Solution pH battery acid 0.3 stomach acid 1–2 lemons or lime juice 2.1 vinegar 2.8–3.0 Coca-Cola 3 wine 2.8–3.8 beer 4-5 coffee 5 milks 6 urine 6 pure H2O 7 (human) blood 7.3–7.5 seawater 8 antacid (magnesium milk) 10.5 NH3 (1 M) 11.6 bleach 12.6 NaOH (1 M) 14.0 Weak acids and bases are relatively common. You may notice from table 10.3 PH the values of some common solutions that many food products are slightly acidic. They are acidic because they contain solutions of weak acids. If the acidic components of this food are strong acids, the food would probably be non-eerie. Concept review exercises explain the difference between strong acid or base and weak acid or base. Explain what happens when a chemical reaction reaches balance. Responses Strong acid or base is 100% ionized in a waterous solution; the weak acid or base is less than 100% ionized. The overall reaction progress stops because the reverse process flattens the process forward. pH is a measure of hydrogen ion concentration. Key Takeaways acids and bases can be strong or weak depending on the extent of ionization in the solution. Most chemical reactions reach balance at which point there is no net change. Ph scale is used to summarize the acidity or basis of the solution. Exercises Specify strong acid and weak acid. Name a strong base and a weak base. Is each compound strong acid or Acid? Let's assume everyone's in an unquestionable solution. Is each compound strong acid or weak acid? Let's assume everyone's in an unquestionable solution. Is each compound a strong base or a weak base? Let's assume everyone's in an unquestionable solution. Is each compound a strong base or a weak base? Let's assume everyone's in an unquestionable solution. Write a chemical equation for the balance process for each weak acid in exercise 3. Write a chemical equation for the balance process for each weak acid in exercise 4. Write a chemical equation for the balance process for each weak base in Exercise 5. Write a chemical equation for the balance process for each weak base in exercise 6. What is stronger acid – HCl(aq) or HF(aq)? What is the stronger base – KOH(aq) or Ni(OH)2(aq)? Consider the two acids in exercise 11. For solutions that have the same concentration, from which would you expect to have a lower pH? Consider the two bases in exercise 12. For solutions that have the same concentration, which one would you expect to have a higher pH? Answers strong acid: HCl; weak acid: HC2H3O2 (responses will vary) 3a: HF(aq) ⇆ H+(aq) + F−(aq); 3b: HC2H3O2(aq) ⇆ H+(aq) + C2H3O2−(aq) 5a: NH3(aq) + H2O ⇆ NH4+(aq) + OH−(aq); 5d: Cu(OH)2(aq) ⇆ Cu2+(aq) + 2OH−(aq) Learning goal Define the clipboard and describe how it responds with acid or base. As stated in section 10.4 The benefits of acids and bases, weak acids are relatively common, even in the foods we eat. But occasionally we come across a strong acid or base, such as stomach acid, which has a very acidic pH of 1-2. By definition, strong acids and bases can produce a relatively large amount of hydrogen or hydroxide ions and, as a consequence, have significant chemical activity. In addition, very small amounts of strong acids and bases can very quickly change the pH solution. If 12 stomach acids are added to the bloodstream [which we will approximate to 0.05 M HCl(aq)] and if there is no correction mechanism, the blood pH would go from about 7.4 to about 4.9 – a pH that does not favor the continuation of life. Fortunately, the body has a mechanism to minimize such dramatic pH changes. The mechanism includes a bufferA solution that resists dramatic changes in pH., a solution that resists dramatic changes in pH. Buffers do this by consisting of certain pairs of soluts: either weak acid plus salt derived from this weak acid or weak base plus salt and weak base. For example, the buffer may consist of dissolved acetic acid (HC2H3O2, weak acid) and sodium acetate (NaC2H3O2, salt derived from this acid). Another example of buffer is a solution containing ammonium (NH3, weak base) and ammonium chloride (NH4Cl, salt obtained from this base). Let's use a buffer of acetic acid and sodium acetate to demonstrate how buffers work. If a strong base - the source of OH−(aq) ions - is added to the Solution, these hydroxide ions will react with acetic acid in acid-base reaction: HC2H3O2(aq) + OH−(aq) → H2O(l) + C2H3O2−(aq) Instead of dramatically changing the pH making the solution basic, added hydroxide ion reacts to make water, and the pH does not change much. Many people are aware of the concept of buffers from tampon aspirin, which is aspirin that also has magnesium carbonate, calcium carbonate, magnesium oxide or some other salt. Salt acts as a base, while aspirin itself is weak acid. If strong acid is added to the buffer solution – the source of H+ ions, H+ ions will react with anion from salt. Since HC2H3O2 is weak acid, it is not much ionized. This means that if a lot of hydrogen ions and acetate (from sodium acetate) are present in the same solution, they will gather to make acetic acid: H+(aq) + C2H3O2−(aq) → HC2H3O2(aq) Instead of dramatically changing the pH and making the solution acidic, added hydrogen ions react to make the molecules weak acidic. Figure 10.3 Buffer action illustrates both buffer actions. Figure 10.3 The action of buffers can react with both strong acids (top) and strong bases (bottom) to reduce major changes in pH. Buffers made of weak bases and salt weak bases act similarly. For example, on a clipboard that contains NH3 and NH4Cl, Ammonia molecules can react with any excess hydrogen ions introduced by strong acids: NH3(aq) + H+(aq) → NH4+(aq) while ammonium ions [NH4+(aq))] can react with any hydroxide ions introduced by strong bases: NH4+(aq) + OH−(aq) → NH3(aq) + H2O(l) What combinations of solut can make a buffer solution? Let's assume they're all unquestionable solutions. HCHO2 and NaCHO2 HCl and NaCl CH3NH2 and CH3NH3Cl NH3 and NaOH Solution Formic acid (HCHO2) are weak acid, while NaCHO2 salt is made of weak acid anion – ion format (CHO2−). The combination of these two souths would be a buffer solution. Hydrochloric acid (HCl) is a strong acid, not a weak acid, so a combination of these two soruths would not make a buffer solution. Methyliamine (CH3NH2) is like an amonia with one of the hydrogen atoms replaced by the CH3 (methyl) group. Since it's not on our list of strong bases, we can assume it's a weak base. The compound CH3NH3Cl is salt made from that weak base, so a combination of these two soluts would make a buffer solution. Amonia (NH3) is a weak base, but naOH is a strong base. The combination of these two greetings would not be a buffer solution. Skill building exercises What combinations can make a buffer solution? Let's assume they're all unquestionable solutions. Buffers work well only for limited amounts of added strong acid or base. Once responsive or solute, the solution is no longer a buffer, and rapid changes in pH may occur. We say the tampon has capacity The amount of strong acid or base buffer can suppress.. Buffers that have more dissolved in them have higher capacities to begin with, as might be expected. Human blood has a buffer system to reduce extreme changes in pH. One buffer in the blood is based on the presence of HCO3− and H2CO3 [H2CO3 is another way of writing CO2(aq)]. With this buffer present, even if some stomach acid found its way directly into the bloodstream, the change in the pH of the blood would be minimal. Inside many body cells there is a buffer system based on phosphate ions. At this point in this text, you should have the idea that blood chemistry is quite complex. Because of this, people who work with blood must be specially trained to work with it correctly. A blood bank technology expert is trained in routine and special tests of blood samples from blood banks or transfusion centers. This specialist measures the pH of blood, types (according to blood ABO + / − type, Rh factors and other typing schemes), tests it for the presence or absence of various diseases and uses blood to determine if the patient has any of several medical problems, such as anemia. A blood bank technology expert can also interview and prepare donors to give blood and can actually collect blood donations. Blood bank technology experts are well trained. Typically, they require a college degree with at least a year of special training in blood biology and chemistry. In the U.S., training must comply with standards established by the American Blood Banks Association. Concept review exercise Explain how the Clipboard prevents major changes in pH. Answer Buffer has components that react with strong acids and strong bases to resist sudden changes in pH. Key Takeaway A buffer is a solution that resists sudden changes in pH. Exercises Describe the tampon. What are the two associated chemical components needed to make the buffer? Can buffer be made by combining strong acid with a strong base? Why or why not? What combinations can make a tampon? Let's assume they're all unquestionable solutions. HCl and NaCl HNO2 and NaNO2 NH4NO3 and HNO3 NH4NO3 and NH3 What greeting combinations can I make a tampon? Let's assume they're all unquestionable solutions. H3PO4 and Na3PO4 NaHCO3 and Na2CO3 NaNO3 and Ca(NO3)2 HN3 and NH3 For each combination in exercise 3 which is a buffer, write chemical equations for reactions of buffer components when strong acid and a strong base are added. For each combination in exercise 4 which is a buffer, write chemical equations for the reaction of buffer components when strong acid and a strong base are added. The complete system of phosphate buffers is based on four substances: H3PO4, H2PO4−, HPO42−, and PO43−. What different protective solutions can be made of these substances? Explain why NaBr can't be acidic or basic buffer. Two solutions were made containing the same concentrations of solut. One solution consists of phosphorus acid and sodium phosphate, while the other consists of hydrocyanic acid and sodium cyanide. What solution should have a higher capacity as a buffer? Two solutions were made containing the same concentrations of solut. One solution consists of ammonium ammonium nitrate, while the other consists of sulfuric acid and sodium sulfate. What solution should have a higher capacity as a buffer? Answers Buffer resists sudden changes in pH. It has weak acid or base and salt and weak acids or bases. not a clipboard buffer, not buffer 3b: strong acid: H+ + NO2− → HNO2; strong base: OH− + HNO2 → H2O + NO2−; 3d: strong acid: H + NH3 → NH4+; Strong base: OH− + NH4+ → H2O + NH3 Buffers can be made by combining H3PO4 and H2PO4−, H2PO4− and HPO42−, and HPO42− and PO43−. Phosphoric acid – phosphate buffer To make sure you understand the material in this chapter, you should review the meanings of bold terms in the following summary and ask yourself how they relate to the topics in the chapter. The earliest chemical definition of acid, the definition of Arrhenius, says that acid is a compound that increases the amount of hydrogen ion (H+) in an aqueous solution. The Arrhenius base is a compound that increases the amount of hydroxide ion (OH−) in the aquatic solution. While most bases are named as ion hydroxide compounds, aqueous acids have a naming system unique to acids. Acids and bases react together in a characteristic chemical reaction called neutralization, in which water and salt are produced. The principles of stoicchiometry, together with a balanced chemical equation for the reaction between acid and base, can be used to determine how much one compound will react with a certain amount of the other. Brønsted-Lowry acid is any substance that donates proton to another substance. The Brønsted-Lowry base is any substance that accepts proton from another substance. Reaction of amonia with water to make amonia ion and hydroxide ion can be used to illustrate Brønsted-Lowry acid and base behavior. Some compounds may donate or accept protons, depending on the circumstances. Such compounds are called amphiprotic. Water is one example of an amphiprotic compound. One result of amphiprotic water is that a water molecule can donate a proton to another water molecule to make hydronium ion and hydroxide ion. This process is called water autoionization and occurs in any water sample. Not all acids and bases are equal to chemical power. Strong acid is an acid whose molecules are all dissociated into ions in an aquaose solution. Hydrochloric acid is an example of strong acid. Similarly, a strong base is the base of molecules are disposed of on ions in an aquaose solution. Sodium hydroxide is an example of a strong base. Any acid or base whose molecules are not all dissociated into ions in an aquaoj solution is weak acid or a weak base. Solutions of weak acids and weak bases reach a chemical balance between the non-ionized form of the compound and dissociated ions. It's a dynamic balance because acid molecules and bases are constantly disassociate into ions and reassociate into neutral molecules. The PH scale is a scale used to express the concentration of hydrogen ions in a solution. Neutral solution, neither acidic nor basic, has a pH of 7. Acidic solutions have a pH lower than 7, while basic solutions have a pH higher than 7. Buffers are solutions that resist dramatic changes in pH when acid or base is added to them. They contain weak acid and salt and weak acids, or weak base and salt and weak bases. When a buffer is present, each strong acid reacts with salt anion, forms weak acid and minimizes the presence of hydrogen ions in the solution. Each strong base reacts with weak acid, minimizing the amount of additional hydroxide ions in the solution. However, buffers have only limited capacity; there is a limit to the amount of strong acid or strong base with which any amount of buffer will react. Additional exercises Compare the properties of 1.0 M HCl solution and HC2H3O2 solution of 1.0 M. Measurements show that the hydrochloric acid solution has a higher osmotic pressure than the acetic acid solution. Explain why. Of the 0.50 M HNO3 solution and the 0.50 M HC2H3O2 solution, which should have a higher boiling point? Explain why. The reaction of sulphuric acid [H2SO4(aq)] sodium hydroxide [NaOH(aq)] can be represented by two separate steps, he said only one hydrogen ion that reacts in each step. Write a chemical equation for each step. The reaction of aluminum hydroxide [Al(OH)3(aq)] with hydrochloric acid [HCl(aq)] can be represented by three separate steps, with only one hydroxide ion reacting in each step. Write a chemical equation for each step. A friend brings you a small sample of an unknown chemical. Assuming the chemical is soluble in water, to determine if the chemical is acid or base? The neutral solution has a hydrogen ion concentration of × 10−7 M. What is the concentration of hydroxide in a neutral solution? Lewis' definitions of acid and base are based on pairs of electrons, not protons. Lewis' acid is an electronic couple's acceptor, while Lewis' base is a donor to an electronic couple. Use Lewis diagrams to show that H+(aq) + OH−(aq) → H2O(l) is a sour-base reaction in Lewis's senses, as well as in the Arrhenius and Brønsted-Lowry senses. With regard to the chemical reaction NH3(g) + BF3(g) → NH3 - BF3(s) show that the reaction is illustrated by this equation reaction if we use Lewis' definitions of acid and base (see Exercise 7). The product contains a connection between N and B atoms. The HCl responses are strong acid and yield more ions in the solution. H2SO4 + NaOH → NaHSO4 + H2O; NaHSO4 + NaOH → Na2SO4 + H2O One way is to add it to NaHCO3; If it bubbles, it's acid. Alternatively, add a pattern to the litmus and look for a characteristic discoloration (red for acid, blue for base). About the atom donates the electronic pair H + ion, making the base a donor of electronic vapor, and acid electronic steam. acceptors.