Acid-Base Review Packet! 1 page per Review Topic
5 Topics to Study for the Exam:
Theories of Acids/Bases
pH
Neutralization Reactions
Indicators
Titrations

Overall Practice Question:

A student used blue litmus paper and phenolphthalein paper as indicators to test the pH of distilled water and five aqueous household solutions. Then the student used a pH meter to measure the pH of the distilled water and each solution. The results of the student's work are recorded in the table below.

Testing Results

Liquid Tested	Color of Blue Litmus Paper	Color of Phenolphthalein Paper	Measured pH Value Using a pH Meter
2% milk	blue	colorless	6.4
distilled water	blue	colorless	7.0
household ammonia	blue	pink	11.5
lemon juice	red	colorless	2.3
tomato juice	red	colorless	4.3
vinegar	red	colorless	3.3

65 Identify the liquid tested that has the *lowest* hydronium ion concentration. [1]

66 Explain, in terms of the pH range for color change on Reference Table *M*, why litmus is *not* appropriate to differentiate the acidity levels of tomato juice and vinegar. [1]

67 Based on the measured pH values, identify the liquid tested that is 10 times more acidic than vinegar. [1]

Topic 1: THEORIES OF ACIDS AND BASES

Top 5 helpful hints:

1. Basic properties: Acids—taste sour, are corrosive (highly reactive with metals); Bases—are slippery, taste bitter
2. Arrhenius definition (first definition made by a man named Arrhenius in 1884): Acids—donate H^+ (hydrogen ion), also known as H_3O^+ (hydronium ion) in solution; Bases—donate OH^- (hydroxide ion) in solution.

Table K
Common Acids

Formula	Name
HCl(aq)	hydrochloric acid
HNO_3(aq)	nitric acid
H_2SO_4(aq)	sulfuric acid
H_3PO_4(aq)	phosphoric acid
H_2CO_3(aq) or CO_2(aq)	carbonic acid
CH_3COOH(aq) or $HC_2H_3O_2$(aq)	ethanoic acid (acetic acid)

Table L
Common Bases

Formula	Name
NaOH(aq)	sodium hydroxide
KOH(aq)	potassium hydroxide
$Ca(OH)_2$(aq)	calcium hydroxide
NH_3(aq)	aqueous ammonia

3. Acids have a pH <7; Bases have a pH> 7. Neutral solutions have a pH = 7.
4. Common acids are found on Table K. Acids also include lemons and vinegar. Common bases are found on Table L. They include detergent, bleach, antacids like Tums and Mylanta.
5. The Brønsted–Lowry alternate definition of acids and bases (named for two more scientists in 1923) is as follows. Acids have the ability to donate H^+ (protons); Bases have the ability to accept H^+ (protons)

1. In the reversible reaction, $2H_2O \leftrightharpoons H_3O^+ + OH^-$, showing the ionization of water, which of the following is true?
   (1) The forward reaction forming ions from water is favored.
   (2) The concentration of ions in pure water is high
   (3) The concentration of hydronium in pure water is higher than the concentration of hydroxide
   (4) The concentration of ions in pure water is low

2. The ion represented by the formula H_3O^+ is
   (1) hydroxide
   (2) hydroxyl
   (3) hydronium
   (4) hydrogen III oxide

3. The fact that the concentration of hydronium and hydroxide are equal in pure water accounts for the fact that water is
   (1) neutral
   (2) acid
   (3) base

4. Which substance is an Arrhenius acid?
   (1) LiF
   (2) HBr
   (3) $Mg(OH)_2$
   (4) CH_3CHO

5. Hydrogen chloride, HCl, is classified as an Arrhenius acid because it produces
   (1) H^+ ions in aqueous solution
   (2) Cl^- ions in aqueous solution
   (3) OH^- ions in aqueous solution
   (4) NH_4^+ ions in aqueous solution

6. What happens to the hydroxide ion concentration in water when an acid is added? Why?

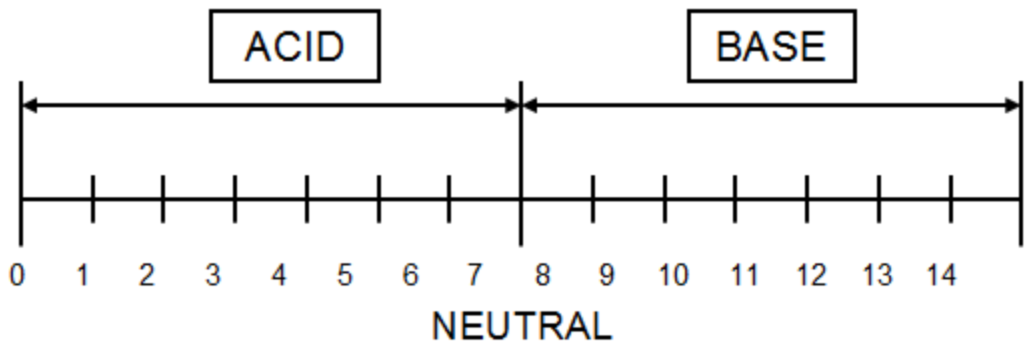
7. What happens to the hydronium ion concentration in water when an acid is added? Why?

8. Write the dissociation equation of potassium hydroxide in water.

$H_2O + KOH \rightarrow$

Topic 2 pH
Top 5 helpful hints:

1. This chart is most helpful.



2. The more H^+ ions there are (higher the concentration of H^+), the more **acidic** it will be → the **lower** the pH value.
3. The more OH^- there are (higher the concentration of OH^-), the more **basic** it will be → the **higher** the pH value.
4. Each change of a single pH unit signifies a tenfold change in the concentration of the hydrogen ion or the hydroxide ion.
   a. Example: a pH of 6 compared to a pH of 7 has 10 x more H^+ ions and 10 x fewer OH^- ions.
   b. Example: a pH of 10 compared to a pH of 7 has 1,000 x fewer H^+ and 1,000 x more OH^-

Strong acids have the ability to completely dissociate into their ions (H^+ and Anion), while weak acids do not completely dissociate. Strong bases also completely dissociate into their ions (Cation and OH^-)

1. For each of the questions below, circle the option that will have the ***higher pH***.

   a. Solution with H^+ concentrations of **0.43M** or **0.57M**

   b. Solution with OH^- concentrations of **4.3M** or **4.4M**

2. For each of the questions below, circle the option that will have the ***lower pH.***

   a. Solution with H^+ concentrations of **0.19M** or **0.23M**

   b. Solution with OH^- concentrations of **5.6M** or **5.25M**

Practice: (State which solution at the given pH value has the greatest amount of hydrogen or hydroxide ions and by how much)

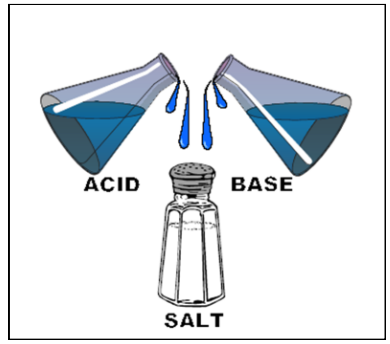
3. pH of 1 versus pH of 2

4. pH of 12 versus pH of 10

5. A truck carrying concentrated nitric acid overturns and spills its contents. The acid drains into a nearby pond. The pH of the pond water was 7.0 before the spill. After the spill, the pond water is 10,000 times more acidic. What is the new pH of the pond water after the spill?

Topic 3: NEUTRALIZATION REACTIONS

Top 5 helpful hints:

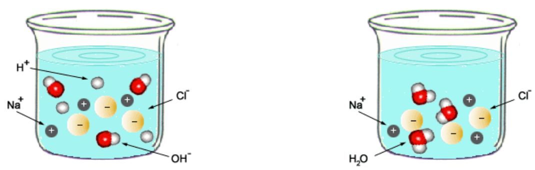


1. Neutralization reactions are chemical reactions involving acids and bases. They are called neutralization because the reaction makes each solution closer to neutral (the acid pH goes up; the base pH goes down)
2. Neutralization are double replacement reactions.
3. The products of neutralization are ALWAYS water and salt (an ionic compound that is not an acid or base)
4. Example:

$$HCl\ (aq) + NaOH\ (aq) \longrightarrow NaCl\ (aq) + H_2O\ (l)$$

This describes what the ions look like in words and pictures

$$H^+(aq) + Cl^-(aq) + Na^+(aq) + OH^-(aq) \longrightarrow Na^+(aq) + Cl^-(aq) + H_2O\ (l)$$



1. Complete and balance each of the acid base neutralizations below and circle the spectator ions.

   a. ___ H_2SO_4 + ___ $Mg(OH)_2$ → ______________________________

   b. ___ HNO_3 + ___ $Al(OH)_3$ → ______________________________

   c. ___ H_3PO_4 + ___ $Ca(OH)_2$ → ______________________________

   d. ___ HI + ___ KOH → ______________________________

2. Which equation represents a neutralization reaction?

   (1) $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

   (2) $2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$

   (3) $HNO_3(aq) + KOH(aq) \rightarrow KNO_3(aq) + H_2O(\ell)$

   (4) $AgNO_3(aq) + KCl(aq) \rightarrow KNO_3(aq) + AgCl(s)$

3. What substances form during an acid-base neutralization>

   (1) hydronium and hydroxide
   (2) salt and water
   (3) acid and base
   (4) metal and nonmetal

Topic 4: INDICATORS

Top 5 helpful hints:

1. An acid-base indicator is a colored dye that is useful in determining changes in pH.
2. There are many ways to determine the exact pH of a solution, such as with pH paper. However, indicators have a different role—they are more useful in determining if the pH increases or decreases slightly.
3. There are several different indicators listed on Table M. Each has a pH range where the color of their dye changes.
4. Indicator dyes have two alternate colors. They are different on each side of the specific pH range listed on Table M.
5. It is important for scientists to pick an acid-base indicator most relevant for the situation they are examining. It is important to choose an indicator close to the solution that they are monitoring to easily detect if the pH changes.

Table M
Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.2–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8.2–10	colorless to pink
litmus	5.5–8.2	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

1. Identify two indicators from Reference Table M that are yellow in solutions with a pH of 5.5.

2. Which indicator in Reference Table M can be used to distinguish between the solutions in each of the following pairs?
   (a) Solution A: pH = 2.0; solution B: pH = 5.0

   (b) Solution C: pH = 5.0; solution D: pH = 9.0

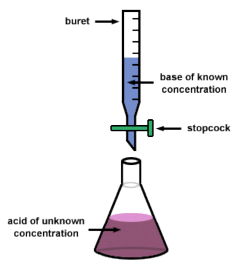
   (c) Solution E: pH =7.0; solution F: pH 10.0

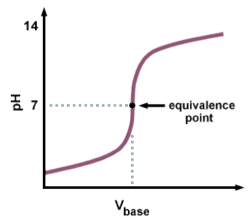
3. According to Reference Table M, what is the color of the indicator methyl orange in a solution that has a pH of 2?

Topic 5: TITRATIONS

Top 5 helpful hints:

1. Titrations are a way to determine an acid or base unknown concentration, in Molarity.
2. To do a titration, chemists set up a controlled neutralization reaction. A solution of known concentration is slowly dripped by a biuret to neutralize the solution of unknown concentration. The volumes of both solutions are measured. An indicator is used to determine when the solution is completely neutralized. The point of complete neutralization is known as the equivalence point.
3. To determine the unknown concentration of a base, a known concentration of acid must be used. To determine the unknown concentration of an acid, a known concentration of base must be used. In both cases, the volumes must be accurately measured for both acid and base.
4. $M_A \times V_A = M_B \times V_B$ found on Table T, can be used in titration experiments:
   M_A = molarity of H^+ (acid) M_B = molarity of OH^- (base)
   V_A = volume of acid in mL V_B = volume of base in mL
5. The setup with the biuret is shown below. Also shown is the pH change in pictures.





1. What is the concentration of a sulfuric acid solution if 50.0mL of a 0.25M KOH are needed to neutralize 20.0mL of the H_2SO_4 solution of unknown concentration?

2. Consider the following reaction.
   $KOH + HCl \rightarrow H_2O + HOH$
   How many milliliters of 2.0M KOH are necessary to neutralize 50.0mL of 1.0M HCl?

3. A 2.0mL sample of NaOH solution is exactly neutralized by 4.0mL of 3.0M HCl solution. What is the concentration of the NaOH solution?

4. A 10mL sample of hydrochloric acid neutralizes 15mL of a 0.40M solution of NaOH. What is the molarity of the hydrochloric acid?