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1. Base your answer to the following question on information below and on your knowledge of chemistry.

A sample of nitric acid contains both  $\text{H}_3\text{O}^+$  ions and  $\text{NO}_3^-$  ions. This sample has a pH value of 1. Write a name of the positive ion present in this sample.

2. Identify *two* indicators from Reference Table M that are yellow in solutions with a pH of 5.5.
3. Base your answer to the following question on the information below

Sulfur dioxide,  $\text{SO}_2$ , is one gas produced when fossil fuels are burned. When this gas reacts with water in the atmosphere, an acid is produced forming acid rain. The pH of the water in a lake changes when acid rain collects in the lake.

Two samples of the same rainwater are tested using two indicators. Methyl orange is yellow in one sample of this rainwater. Litmus is red in the other sample of this rainwater.

Write the formula for *one* substance that can neutralize the lake water affected by acid rain.

4. Base your answer to the following question on the information below.

Some carbonated beverages are made by forcing carbon dioxide gas into a beverage solution. When a bottle of one kind of carbonated beverage is first opened, the beverage has a pH value of 3.

Using Table M, identify *one indicator that is yellow in a solution that has the same pH value as this beverage*.

5. Base your answer to the following question on the information below.

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                                |

Explain, using the reference table, in terms of the pH range for color change why litmus is *not* appropriate to differentiate the acidity levels of tomato juice and vinegar.

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Base your answers to questions 6 and 7 on the information below.

A student was studying the pH differences in samples from two Adirondack streams. The student measured a pH of 4 in stream A and a pH of 6 in stream B.

6. Compare the hydronium ion concentration in stream A to the hydronium ion concentration in stream B.
7. What is the color of bromthymol blue in the sample from stream A?

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8. Base your answer to the following question on the passage below.

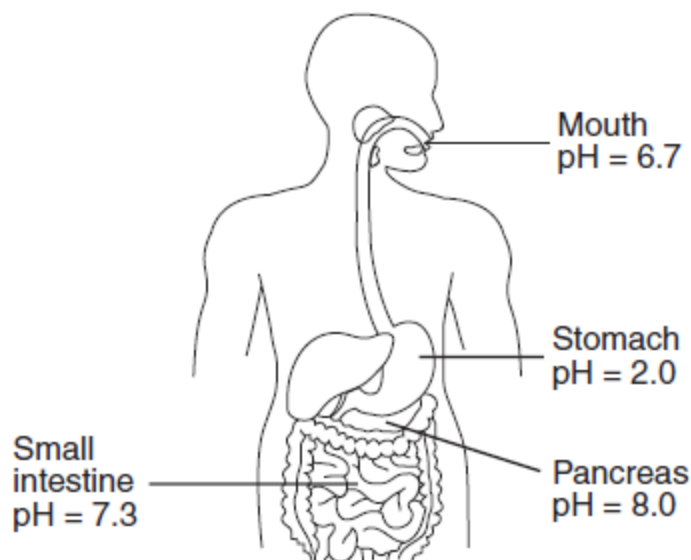
Acid rain lowers the pH in ponds and lakes and over time can cause the death of some aquatic life. Acid rain is caused in large part by the burning of fossil fuels in power plants and by gasoline-powered vehicles. The acids commonly associated with acid rain are sulfurous acid, sulfuric acid, and nitric acid.

In general, fish can tolerate a pH range between 5 and 9. However, even small changes in pH can significantly affect the solubility and toxicity of common pollutants. Increased concentrations of these pollutants can adversely affect the behavior and normal life processes of fish and cause deformity, lower egg production, and less egg hatching.

Using information in the passage, describe *one* effect of acid rain on future generations of fish species in ponds and lakes.

Base your answers to questions 9 and 10 on the information below.

The diagram below shows typical pH values found in four parts of the human digestive system. In the small intestine, the enzyme lipase acts as a catalyst, increasing the rate of fat digestion.



9. What is the color of thymol blue at the pH of the small intestine?
  10. State how the catalyst lipase increases the rate of the fat digestion.
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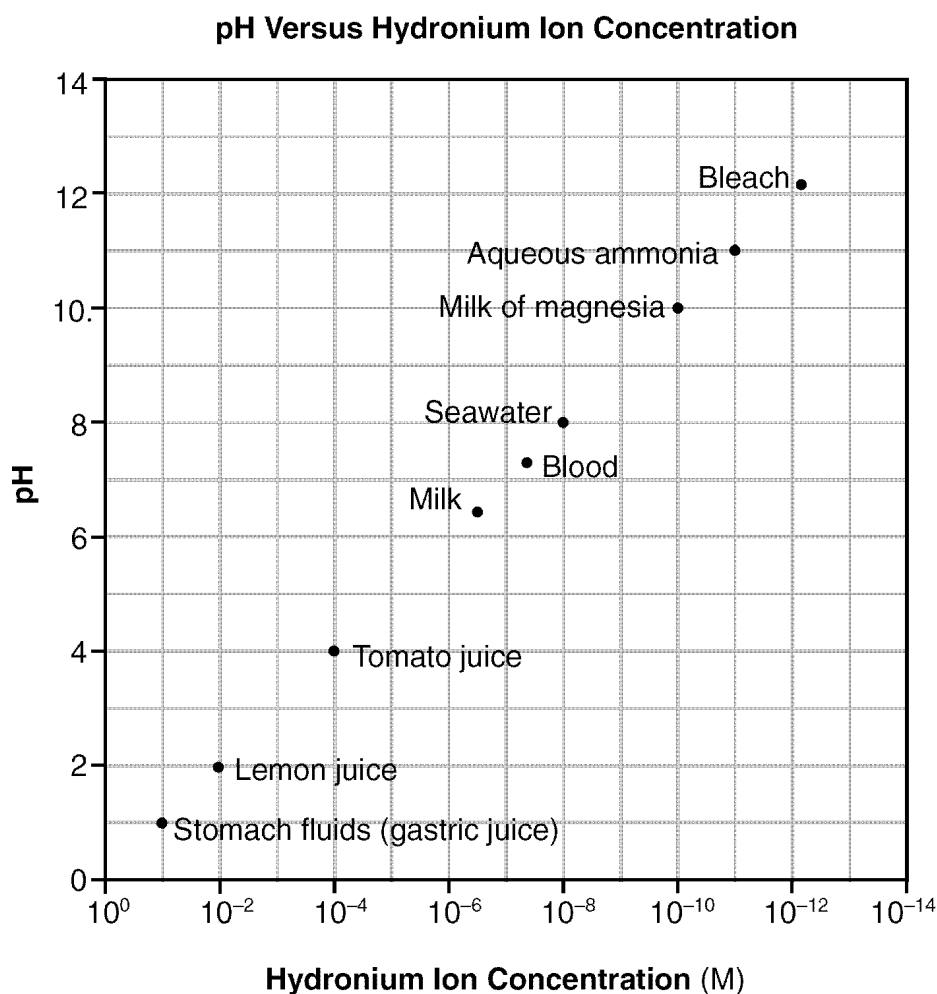
11. Base your answer to the following question on the information below.

In liquid water, an equilibrium exists between  $\text{H}_2\text{O}(\ell)$  molecules,  $\text{H}^+(\text{aq})$  ions, and  $\text{OH}^-(\text{aq})$  ions. A person experiencing acid indigestion after drinking tomato juice can ingest milk of magnesia to reduce the acidity of the stomach contents. Tomato juice has a pH value of 4. Milk of magnesia, a mixture of magnesium hydroxide and water, has a pH value of 10.

Identify the negative ion found in milk of magnesia.

Base your answers to questions 12 and 13 on the graph below.

The graph shows the relationship between pH value and hydronium ion concentration for common aqueous solutions and mixtures.



12. What is the hydronium ion concentration of tomato juice?

13. What color is thymol blue when added to milk of magnesia?

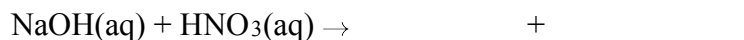
Base your answers to questions 14 and 15 on the information below.

In a laboratory activity, 0.500 mole of  $\text{NaOH}(\text{s})$  is completely dissolved in distilled water to form 400. milliliters of  $\text{NaOH}(\text{aq})$ . This solution is then used to titrate a solution of  $\text{HNO}_3(\text{aq})$ .

14. Identify the negative ion produced when the  $\text{NaOH}(\text{s})$  is dissolved in distilled water.

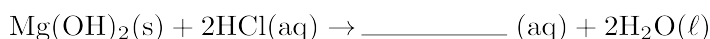
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15. Complete the equation representing the titration reaction by writing the formulas of the products.



16. Base your answer to the following question on the information below and on your knowledge of chemistry.

The gastric juice of the human stomach has a pH value of approximately 1.5. Hydrochloric acid in the gastric juice is necessary for the digestion process. However, excess hydrochloric acid may harm the stomach lining. One type of antacid uses  $\text{Mg(OH)}_2\text{(s)}$  to neutralize excess hydrochloric acid in the stomach. This neutralization is represented by the incomplete equation below.



Complete the equation by writing the formula of the missing product.

17. Base your answer to the following question on the information below.

The health of fish depends on the amount of oxygen dissolved in the water. A dissolved oxygen (DO) concentration between 6 parts per million and 8 parts per million is best for fish health. A DO concentration greater than 1 part per million is necessary for fish survival.

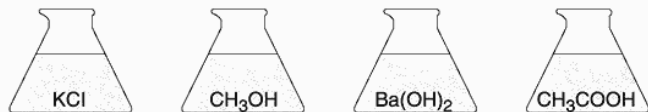
Fish health is also affected by water temperature and concentrations of dissolved ammonia, hydrogen sulfide, chloride compounds, and nitrate compounds. Most freshwater fish thrive in water with a pH between 6.5 and 8.5.

A student's fish tank contains fish, green plants, and 3800 grams of fish-tank water with  $2.7 \times 10^{-2}$  gram of dissolved oxygen. Phenolphthalein tests colorless and bromthymol blue tests blue in samples of the fish-tank water.

Based on the test results for the indicators phenolphthalein and bromthymol blue, what is the pH range of the fish-tank water?

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18. Four flasks each contain 100 milliliters of aqueous solutions of equal concentrations at 25°C and 1 atm.



- a Which solutions contain electrolytes?
- b Which solution has the *lowest* pH?
- c What causes some aqueous solutions to have a low pH?
- d Which solution is most likely to react with an Arrhenius acid to form a salt and water?
- e Which solution has the *lowest* freezing point?  
Explain your answer.
19. Base your answer to the following question on the information below and on your knowledge of chemistry.

During a titration, 10.00 mL of acetic acid, HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>(aq), is completely neutralized by adding 12.50 mL of 0.64 M sodium hydroxide, NaOH(aq).

Identify the only positive ion in the HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>(aq).

20. Base your answer to the following question on the information below.

Indigestion may be caused by excess stomach acid (hydrochloric acid). Some products used to treat indigestion contain magnesium hydroxide. The magnesium hydroxide neutralizes some of the stomach acid. The amount of acid that can be neutralized by three different brands of antacids is shown in the data table below.

| Antacid Brand | Mass of Antacid Tablet(g) | Volume of HCl(aq) Neutralized (mL) |
|---------------|---------------------------|------------------------------------|
| X             | 2.00                      | 25.20                              |
| Y             | 1.20                      | 18.65                              |
| Z             | 1.75                      | 22.50                              |

Which antacid brand neutralizes the most acid per gram of antacid tablet?

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21. Base your answer to the following question on the information below.

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 8.0 before the spill. After the spill, the pond water is 1,000 times more acidic.

What color would bromthymol blue be at this new pH?

22. Base your answer to the following question on the information below and on your knowledge of chemistry.

The pH of various aqueous solutions are shown in the table below.

### pH of Various Aqueous Solutions

| Aqueous Solution                                   | pH |
|--|----|
| HCl(aq)  | 2  |
| HC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> (aq) | 3  |
| NaCl(aq)   | 7  |
| NaOH(aq)   | 12 |

State how many times greater the hydronium ion concentration in the HCl(aq) is than the hydronium ion concentration in the HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>(aq).

Base your answers to questions **23** through **25** on the information below and on your knowledge of chemistry.

Vinegar is a commercial form of acetic acid, HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>(aq). One sample vinegar has a pH value of 2.4.

23. State the color of bromthymol blue indicator in a sample of the commercial vinegar.
24. Explain, in terms of particles, why HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub>(aq) can conduct an electric current.
25. State the pH value of a sample that has ten times fewer hydronium ions than an equal volume of a vinegar sample with a pH value of 2.4.
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Base your answers to questions 26 through 28 on the information below and on your knowledge of chemistry.

A company produces a colorless vinegar that is 5.0% HC<sub>2</sub>H<sub>3</sub>O<sub>2</sub> in water. Using thymol blue as an indicator, a student titrates a 15.0-milliliter sample of the vinegar with 43.1 milliliters of a 0.30 M NaOH (aq) solution until the acid is neutralized.

26. Based on Table *M*, what is the color of the indicator in the vinegar solution before any base is added?
27. The concentration of the base used in this titration is expressed to what number of significant figures?
28. Identify the negative ion in the NaOH(aq) used in this titration.

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29. Base your answer to the following question on the information below and on your knowledge of chemistry.

The incomplete data table below shows the pH value of solutions *A* and *B* and the hydrogen ion concentration of solution *A*.

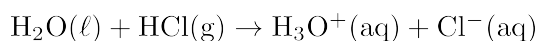
**Hydrogen Ion and pH Data for HCl(aq) Solutions**

| HCl(aq) Solution | Hydrogen Ion Concentration (M) | pH  |
|------------------|--------------------------------|-----|
| A                | $1.0 \times 10^{-2}$           | 2.0 |
| B                | ?                              | 5.0 |

State the color of methyl orange in a sample of solution *A*.

30. Base your answer to the following question on the information below and on your knowledge of chemistry.

A scientist bubbled HCl(g) through a sample of H<sub>2</sub>O(ℓ). This process is represented by the balanced equation below.



The scientist measured the pH of the liquid in the flask before and after the gas was bubbled through the water. The initial pH value of the water was 7.0 and the final pH value of the solution was 3.0.

Explain, in terms of ions, why the gaseous reactant in the equation is classified as an Arrhenius acid.

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