10A-1 Arrhenius Acids and Bases (22 Questions)

- Arrhenius acid is a substance that produces hydrogen ions (H^+)in an aqueous solution.
  - The hydrogen ion is the only positive ion produced.
  - Example: HF ➔ $H^+ + F^-$ (Hydrofluoric Acid)
    - The hydrogen ion can react with the water to produce the hydronium ion (H_3O^+)
    - Hydrogen ion and hydronium ion are interchangeable.
  - The strength of the acid depends on the number of hydrogen ions produced.
- Each Arrhenius base produces a hydroxide ion (OH^-)in an aqueous solution.
  - As with acids, strength depends on the number of hydroxide ions produced in an aqueous solution.

1. An Arrhenius base yields which ion as the only negative ion in an aqueous solution?
   (1) hydride ion (3) hydronium ion
   (2) hydrogen ion (4) hydroxide ion

2. Which ion is the only negative ion produced by an Arrhenius base in water?
   (1) NO_3^- (3) OH^-
   (2) Cl^- (4) H^-

3. Which formula represents a hydronium ion?
   (1) H_3O^+ (3) OH^-
   (2) NH_4^+ (4) HCO_3^-

4. An Arrhenius acid has
   (1) only hydroxide ions in solution
   (2) only hydrogen ions in solution
   (3) hydrogen ions as the only positive ions in solution
   (4) hydrogen ions as the only negative ions in solution

5. The only positive ion found in an aqueous solution of sulfuric acid is the
   (1) hydroxide ion (3) sulfite ion
   (2) hydronium ion (4) sulfate ion

10A-2 Acid Examples (9 Questions)

- Acids produce the hydrogen (hydronium) ions (H^+ of H_3O^+) when in an aqueous solution.
  - The names of acids can be found in Table K
  - The strength of the acid depends on the number of hydrogen ions produced.
    - Hydrochloric acid (HCl) and Sulfuric Acid(H_2SO_4) - Strong acids as ionization in water approaches 100%
    - Organic acids (-COOH or $-\overset{\overset{O}{\|}}{C}-OH$) are weak acids and do not ionized nearly as much.
      - Examples include
        - acetic acid (vinegar) (CH_3COOH) and citric acid ($H_3C_6H_5O_7$)

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

7. Which compound is an Arrhenius acid?
   (1) H_2SO_4 (3) NaOH
   (2) KCl (4) NH_3

10A-3 Base Examples (8 Questions)

- Bases produce hydroxide ions (OH^-) when in an aqueous solution.
  - The names of acids can be found in Table L. Examples include:
    - Sodium Hydroxide (NaOH) (Lye) - Strong Base
    - Ammonia (NH_3) - weaker base ($NH_3 + H_20$ ➔ $NH_4^+ + OH^-$)
- Be careful alcohols look like bases, but they do not ionize and are not bases!
  - Examples include: Ethyl alcohol (CH_3CH_2OH) and methyl alcohol (CH_3OH)

8. Which compound is an Arrhenius base?
   (1) CH_3OH (3) LiOH
   (2) CO_2 (4) NO_2

9. Which substance yields hydroxide ion as the only negative ion in aqueous solution?
   (1) $Mg(OH)_2$ (3) $MgCl_2$
   (2) $C_2H_4(OH)_2$ (4) CH_3Cl

10. Which compound releases hydroxide ions in an aqueous solution?
    (1) CH_3COOH (3) HCl
    (2) CH_3OH (4) KOH

11. An aqueous solution of lithium hydroxide contains hydroxide ions as the only negative ion in the solution. Lithium hydroxide is classified as an
    (1) aldehyde (3) Arrhenius acid
    (2) alcohol (4) Arrhenius base

10B-1 Electrolytes (21 Questions)

- Electrolytes are substances whose water solutions conduct an electric current due to the presence of ions in solution. The greater the concentration of ions, the stronger the electrolyte and the better it can conduct electricity. Electrolytes include:
  - Acids and bases
    - Organic acids (-COOH) are weak electrolytes
    - Alcohols, such as Ethyl alcohol (CH_3CH_2OH) look like bases, but they do not ionize and are not electrolytes.
  - Salts

12. Which substance, when dissolved in water, forms a solution that conducts an electric current?
(1) C_2H_5OH (3) $C_{12}H_{22}O_{11}$
(2) $C_6H_{12}O_6(s)$ (4) CH_3COOH

13. A substance that conducts an electrical current when dissolved in water is called
(1) a catalyst (3) a nonelectrolyte
(2) a metalloid (4) an electrolyte

14. Which compound is an electrolyte?
(1) $C_6H_{12}O_6$ (3) $CaCl_2$
(2) CH_3OH (4) CCl_4

15. Which aqueous solution is the best conductor of an electrical current?
(1) 0.01 M CH_3OH (3) 0.1 M CH_3OH
(2) 0.01 M KOH (4) 0.1 M KOH

16. A substance is classified as an electrolyte because
(1) it has a high melting point
(2) it contains covalent bonds
(3) its aqueous solution conducts an electric current
(4) its aqueous solution has a pH value of 7

17. Which compound is an electrolyte?
(1) butene (3) dimethyl ether
(2) propane (4) methanoic acid

10C-1 Neutralization reactions (22 Questions)

- A Reaction between an acid and a base.
  - Water and a salt are always produced.
    - Example: $HCl(aq) + NaOH \rightarrow H_2O(\ell) + NaCl(aq)$
    - Salts are ionic substances having a metallic or polyatomic positive ion and a negative ion other than hydroxide (OH^-).
  - In all neutralization reactions there must be a 1:1 ratio of moles of Hydrogen and Hydroxide ions.
    - H^+ (Acid) + OH^- (Base) $\rightarrow$ $H_2O(\ell)$

18. Given the reaction:

$HCl(aq) + LiOH(aq) \rightarrow HOH(\ell) + LiCl(aq)$

The reaction is best described as
(1) neutralization (3) decomposition
(2) synthesis (4) oxidation-reduction

19. Which equation represents a neutralization reaction?
(1) $Na_2CO_3 + CaCl_2 \rightarrow 2\ NaCl + CaCO_3$
(2) $Ni(NO_3)_2 + H_2S \rightarrow NiS + 2\ HNO_3$
(3) $NaCl + AgNO_3 \rightarrow AgCl + NaNO_3$
(4) $H_2SO_4 + Mg(OH)_2 \rightarrow MgSO_4 + 2\ H_2O$

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

21. Which word equation represents a neutralization reaction?
(1) base + acid $\rightarrow$ salt + water
(2) base + salt $\rightarrow$ water + acid
(3) salt + acid $\rightarrow$ base + water
(4) salt + water $\rightarrow$ acid + base

22. Which substance is always a product when an Arrhenius acid in an aqueous solution reacts with an Arrhenius base in an aqueous solution?
(1) HBr (3) KBr
(2) H_2O (4) KOH

23. Which solution reacts with LiOH(aq) to produce a salt and water?
(1) KCl(aq) (3) NaOH(aq)
(2) CaO(aq) (4) $H_2SO_4(aq)$

10C-2 Reactions Between Metals and Acids (2 Questions)

- Any metal above hydrogen in Table J, (Activity Series), will react with an acid and produce hydrogen gas (H_2) and a salt.
  - Example: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

Base your answer to question 24 on the information below.

In a laboratory investigation, magnesium reacts with hydrochloric acid to produce hydrogen gas and magnesium chloride. This reaction is represented by the unbalanced equation below.

$Mg(s) + HCl(aq) \rightarrow H_2(g) + MgCl_2\ (aq)$

24. State, in terms of the relative activity of elements, why this reaction is spontaneous. [1]

Magnesium is more reactive than hydrogen so it displaces the hydrogen

25. Explain, in terms of activity, why HCl(aq) reacts with Zn(s), but HCl(aq) does not react with Cu(s). [1]

Zinc is more reactive than hydrogen while hydrogen is more reactive than copper.

26. According to Reference Table J, which of these metals will react most readily with 1.0 M HCl to produce $H_2(g)$?

(1) Ca (3) Mg
(2) K (4) Zn

10D-1 Titration defined (5 Questions)

- Titration is a process in which a known concentration of an acid or base is used in a neutralization reaction to determine the concentration of an unknown base or acid.

27. Which process uses a volume of solution of known concentration to determine the concentration of another solution?

(1) distillation (3) transmutation
(2) substitution (4) titration

28. In which laboratory process could a student use 0.10 M NaOH(aq) to determine the concentration of an aqueous solution of HBr?

(1) chromatography
(2) decomposition of the solute
(3) evaporation of the solvent
(4) titration

10D-2 Titation Problems (49 Questions)

- The titration formula is $M_A \times V_A = M_B \times V_B$ where:
  - M_A = Molarity of H^+ and V_A = Volume of acid in milliliters
    M_B = Molarity of OH^- and V_B = Volume of base in milliliters
  - Molarity = $\frac{\text{moles of solute}}{\text{liters of solution}}$
  - Very important! The molarity must be expressed in terms of the Hydrogen ion (H^+) or Hydroxide ion (OH^-). Examples include:
    - 1.0 M HF = 1.0 M H^+
    - 1.0 M H_2SO_4 = 2.0 M H^+
    - 1.0 M H_3PO_4 = 3.0 M H^+
    - 1.0 M KOH = 1.0 M OH^-
    - 1.0 M $Mg(OH)_2$ = 2.0 M OH^-

Base your answer to question 29 on the information below.

A student titrates 60.0 mL of $HNO_3(aq)$ with 0.30 M NaOH(aq). Phenolphthalein is used as the indicator. After adding 42.2 mL of NaOH(aq), a color change remains for 25 seconds, and the student stops the titration.

29. In the space below, show a correct numerical setup for calculating the molarity of the $HNO_3(aq)$. [1]

$$Ma = \frac{(0.30m)(42.2mL)}{60.0mL}$$

30. If 5.0 milliliters of a 0.20 M HCl solution is required to neutralize exactly 10. milliliters of NaOH, what is the concentration of the base?

(1) 0.10 M (3) 0.30 M
(2) 0.20 M (4) 0.40 M

31. A student neutralized 16.4 milliliters of HCl by adding 12.7 milliliters of 0.620 M KOH. What was the molarity of the HCl acid?

(1) 0.168 M (3) 0.620 M
(2) 0.480 M (4) 0.801 M

32. When 50. milliliters of an HNO_3 solution is exactly neutralized by 150 milliliters of a 0.50 M solution of KOH, what is the concentration of HNO_3?

(1) 1.0 M (3) 3.0 M
(2) 1.5 M (4) 0.5 M

Base your answers to questions 33 on the information below.

In a titration experiment, a student uses a 1.4 M HBr(aq) solution and the indicator phenolphthalein to determine the concentration of a KOH(aq) solution. The data for trial 1 is recorded in the table below.

Trial 1

Buret Readings	**HBr**(aq)	**KOH**(aq)
Initial volume (mL)	7.50	11.00
Final volume (mL)	22.90	33.10
Volume used (mL)	15.40	22.10

33. In the space provided below, show a correct numerical setup for calculating the molarity of the KOH(aq) solution for trial 1. [1]

$$Mb = \frac{(1.4m)(15.40mL)}{22.10mL}$$

34. What volume of 0.120 M HNO_3(aq) is needed to completely neutralize 150.0 milliliters of 0.100 M NaOH(aq)?

(1) 62.5 mL
(2) 125 mL
(3) 180. mL
(4) 360. mL

35. A 25.0-milliliter sample of HNO_3(aq) is neutralized by 32.1 milliliters of 0.150 M KOH(aq). What is the molarity of the HNO_3(aq)?

(1) 0.117 M
(2) 0.150 M
(3) 0.193 M
(4) 0.300 M

36. How many milliliters of 0.100 M NaOH(aq) would be needed to completely neutralize 50.0 milliliters of 0.300 M HCl(aq)?

(1) 16.7 mL
(2) 50.0 mL
(3) 150. mL
(4) 300. ML

37. A student completes a titration by adding 12.0 milliliters of NaOH(aq) of unknown concentration to 16.0 milliliters of 0.15 M HCl(aq). What is the molar concentration of the NaOH(aq)?

(1) 0.11 M
(2) 0.20 M
(3) 1.1 M
(4) 5.0 M

Base your answer to question 38 on the information and equation below.

Antacids can be used to neutralize excess stomach acid. Brand A antacid contains the acid neutralizing agent magnesium hydroxide, $Mg(OH)_2$. It reacts with HCl(aq) in the stomach, according to the following balanced equation:

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

38. If a person produces 0.050 mole of excess HCl in the stomach, how many moles of $Mg(OH)_2$ are needed to neutralize this excess hydrochloric acid? [1]

.025 mol

Base your answers to questions 39 and 40 on the information below.

In a titration, 15.65 milliliters of a KOH(aq) solution exactly neutralized 10.00 milliliters of a 1.22 M HCl(aq) solution.

39. Complete the equation below for the titration reaction by writing the formula of each product. [1]

$HCl(aq) + KOH(aq) \rightarrow$ KCl + H_2O

40. In the space below, show a correct numerical setup for calculating the molarity of the KOH(aq) solution. [1]

$$Mb = \frac{(1.22m)(10.00mL)}{15.65mL}$$

41. Identify one additional safety precaution the student should have taken before performing the titration. [1]

Put on safety glasses

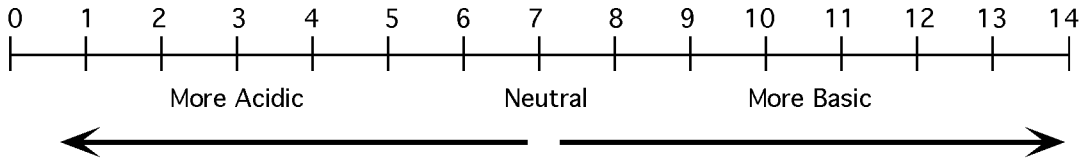
42. Write a chemical name for the acid used in the titration. [1]

Answer: Hydrochloric acid

10E-1 pH (36 Questions)

- A scale called the pH scale is used to express the acidity or alkalinity of an acid or base. The scale is a logarithmic scale and each unit indicates a tenfold change in the presence of the hydrogen (hydronium) ion.
  - Acid values are from 0 to 7 while base values are from 7 to 14. (7 is neutral)
    - A substance with a pH of 1.0 contains 10 times more hydrogen ions that a substance with a pH of 2.0 and 100 times more hydrogen ions with a pH of 3.0.
    - Note: The presence of Hydroxide ions in solution are inversely proportioned to the hydrogen ions. As the hydrogen ions decrease, the presence of hydroxide ions increases. A substance with a pH of 10.0 contains ten times more hydroxide ions than a substance with a pH of 9.0. However, it is important to realize that the pH scale indicates the hydrogen ion concentration.

  - The pH Scale



43. Which of the following pH values indicates the highest concentration of hydronium ions in a solution?
(1) pH = 1 (3) pH = 3
(2) pH = 2 (4) pH = 4

44. Which of these 1 M solutions will have the highest pH?
(1) NaOH (3) HCl
(2) CH_3OH (4) NaCl

45. Given the following solutions:
Solution A: pH of 10
Solution B: pH of 7
Solution C: pH of 5

Which list has the solutions placed in order increasing H^+ concentration?
(1) A, B, C (3) C, A, B
(2) B, A, C (4) C, B, A

46. The pH of an aqueous solution changes from 4 to 3 when the hydrogen ion concentration in the solution is
(1) decreased by a factor of $\frac{3}{4}$
(2) decreased by a factor of 10
(3) increased by a factor of $\frac{4}{3}$
(4) increased by a factor of 10

47. Which change in pH represents a hundredfold increase in the concentration of hydronium ions in a solution?
(1) pH 1 to pH 2 (3) pH 2 to pH 1
(2) pH 1 to pH 3 (4) pH 3 to pH 1

48. When the pH value of a solution is changed from 2 to 1, the concentration of hydronium ions
(1) decreases by a factor of 2
(2) increases by a factor of 2
(3) decreases by a factor of 10
(4) increases by a factor of 10

10E-2 Acid Base Indicators (39 Questions)

- An indicator is a substance that will change color when there is a change in the pH.
- Each indicator has a range of pH in which the color will change.
  - This is the indicator working range.
  - See table M

Base your answer to question 49 on the information below.

A student titrates 60.0 mL of $HNO_3(aq)$ with 0.30 M NaOH(aq). Phenolphthalein is used as the indicator. After adding 42.2 mL of NaOH(aq), a color change remains for 25 seconds, and the student stops the titration.

49. What color change does phenolphthalein undergo during this titration? [1]

Colorless to Pink

50. Which statement correctly describes a solution with a pH of 9?
(1) It has a higher concentration of H_30^+ than OH^- and causes litmus to turn blue.
(2) It has a higher concentration of OH^- than H_30^+ and causes litmus to turn blue.
(3) It has a higher concentration of H_30^+ than OH^- and causes methyl orange to turn yellow.
(4) It has a higher concentration of OH^- than H_30^+ and causes methyl orange to turn red.

51. Which solution when mixed with a drop of bromthymol blue will cause the indicator to change from blue to yellow?
(1) 0.1 M HCl (3) 0.1 M CH_3OH
(2) 0.1 M NH_3 (4) 0.1 M NaOH

52. Which indicator is yellow in a solution with a pH of 9.8?
(1) methyl orange
(2) bromthymol blue
(3) bromcresol green
(4) thymol blue

53. In which 0.01 M solution is phenolphthalein pink?
(1) $CH_3OH(aq)$
(2) $Ca(OH)_2(aq)$
(3) $CH_3COOH(aq)$
(4) $HNO_3(aq)$

54. Based on the results of testing colorless solutions with indicators, which solution is most acidic?
(1) a solution in which bromthymol blue is blue
(2) a solution in which bromcresol green is blue
(3) a solution in which phenolphthalein is pink
(4) a solution in which methyl orange is red

10F-1 Brønsted-Lowry Acids and Bases (8 Questions)

- An acid is any substance that donates a hydrogen atom (H^+) including those not in an aqueous solution.
  - All Arrhenius acids are Brønsted-Lowry acids, but not all Brønsted-Lowry acids are arrhenius acids
- A base is any substance that accepts a hydrogen ion (proton).
  - All Arrhenius bases are Brønsted-Lowry bases, but not all Brønsted-Lowry bases are arrhenius bases.
- Brønsted-Lowry Acids and bases exist as conjugate Acid-Base pairs.
  - HF ➔ H^+ + F^- (H^+ acts as the acid while F^- acts as the base).
- Note: most of these questions include the words "One acid-base theory."

55. One acid-base theory states that an acid is
(1) an electron donor
(2) a neutron donor
(3) an H^+ donor
(4) an OH^- donor

56. One acid-base theory defines a base as an
(1) H+ donor
(2) H+ acceptor
(3) H donor
(4) H acceptor

57. According to one acid-base theory, a water molecule acts as an acid when the water molecule
(1) accepts an H^+
(2) accepts an OH^-
(3) donates an H^+
(4) donates an OH^-

58. One alternate acid-base theory states that an acid is an
(1) H^+ donor
(2) H^+ acceptor
(3) OH^- donor
(4) OH^- acceptor

59. Given the balanced equation representing a reaction:

$HSO_4^-(aq)$ $H_2O(\ell)$ ➞ $H_3O^+(aq)$ $SO_4^{2-}(aq)$

According to one acid-base theory, the $H_2O(\ell)$ molecules act as
(1) a base because they accept H ions
(2) a base because they donate H ions
(3) an acid because they accept H ions
(4) an acid because they donate H ions