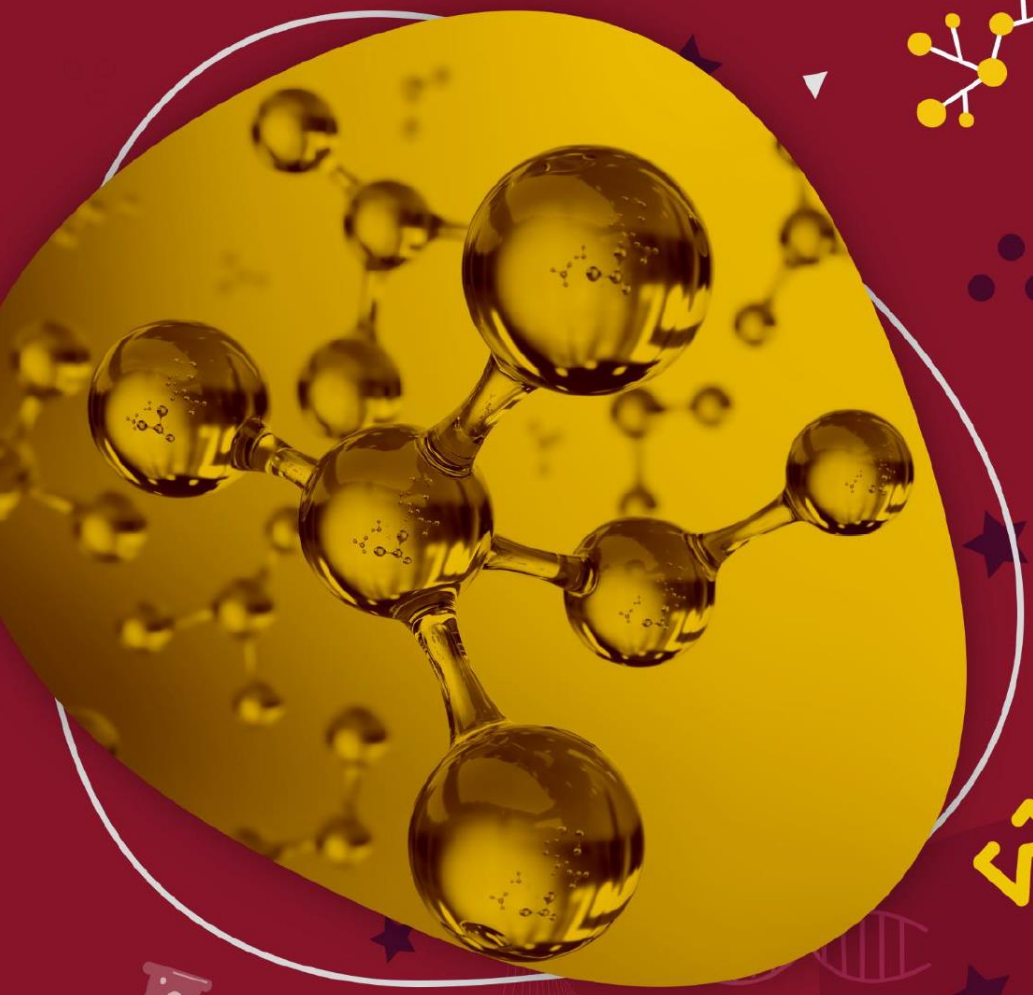
CHEMISTRY

12 Advanced

Mr. Hesham Eltoukhy

Acids and Bases



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My dear students

Mr. Hesham Eltoukhy Mr. Hesham Eltoukhy Mr. Hesham Eltoukhy

In your hands are papers in chemistry for grade 12 advanced. Here is a detailed explanation of the contents and method of study.

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These papers contain a complete explanation of everything in the book, in addition to all the book's questions and previous year's questions, knowing that they do not replace the textbook, and the papers consist of three parts.

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Part One (Explanation and Questions)

Detailed explanation with questions on each objective.

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Part Two (Questions with answers)

Additional questions on each section with answers at the end of each section.

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Part Three (Exams of last years)

Previous years exam questions with answers at the end of each exam.

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Part One (Explanation and Questions)

Detailed explanation with questions on each objective.

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Ions

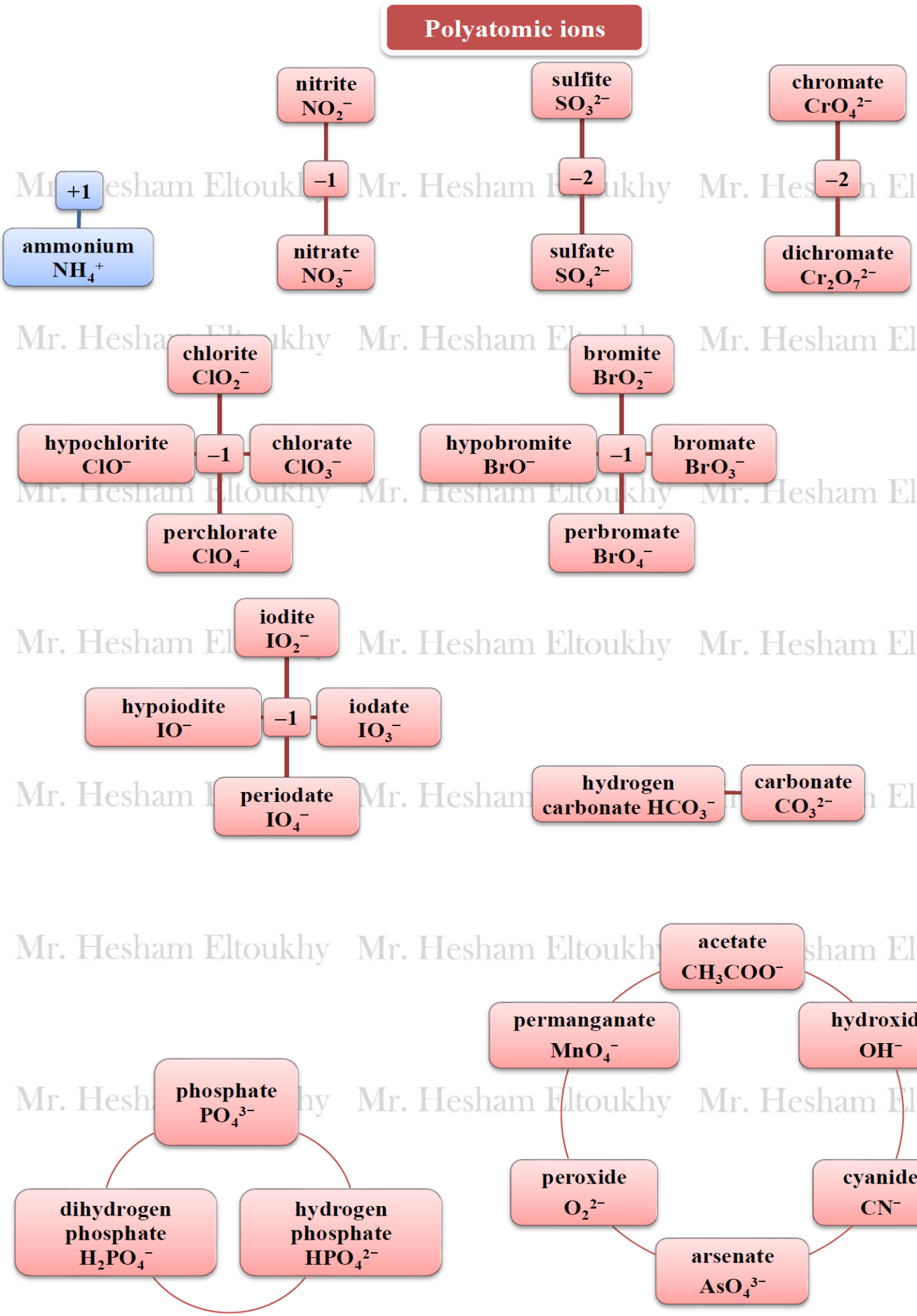
- Ion Charge
  - positive → cation
  - negative → anion

- Types of ions
  - monoatomic → one type of atoms
  - polyatomic → two or more types of atoms

Monoatomic ions

- +1
  - sodium Na^+
  - lithium Li^+
  - potassium K^+
  - hydrogen H^+
  - rubidium Rb^+
  - silver Ag^+
  - cesium Cs^+
- +2
  - calcium Ca^{2+}
  - magnesium Mg^{2+}
  - strontium Sr^{2+}
  - zinc Zn^{2+}
  - barium Ba^{2+}
  - cadmium Cd^{2+}
- +3
  - aluminum Al^{3+}
- −1
  - chloride Cl^-
  - bromide Br^-
  - fluoride F^-
  - iodide I^-
- −2
  - oxide O^{2-}
  - sulfide S^{2-}
- −3
  - nitride N^{3-}

Polyatomic ions



Sec. (1) Introduction to Acids and Bases

Acids properties

Methanoic (formic) acid	Ants release it when they sense a threat.
Acid rain	Caves formation in limestone rocks and damage to archaeological sites.
Carbonic and phosphoric acids	Added to soft drinks to give it a sour taste.
Citric and ascorbic acids	Responsible for the acidic taste in lemon and grapefruit.
Acetic acid	Makes vinegar taste acidic.
Stomach acid (muriatic) HCl	Digestion of food and industrially used to clean bricks and concrete.

- Its solutions have a pungent taste.
- Turns litmus paper into red.
- Its solutions conduct electricity.

Bases properties

Bases	Makes of soaps, household detergents, and antacid tablets.
Sodium hydroxide	Opening clogged sewer pipes.

- Its solutions have a bitter taste and a slippery feel.
- Turns litmus paper into blue.
- Its solutions conduct electricity.

Why is pure water non-conductive, but acidic and basic aqueous solutions are conductive? → **Because adding an acid or a base produces positive and negative ions that make the product conduct electricity.**

Some plants grow in rich, moist soils such as rosacea.

Some plants grow in less moist and basal soils such as the perennial plant and is known as hens and chicks.

Acids reactions

What results from the reaction of active metals with acid solutions? → **hydrogen gas $H_{2(g)}$**

Inactive metals

- copper Cu
- mercury Hg
- silver Ag
- platinum Pt
- gold Au

active metal + acid → salt + $H_{2(g)}$

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

What results from the reaction of metal carbonates or hydrogen metal carbonates with acid solutions? → **Carbon dioxide gas $CO_{2(g)}$**

carbonate (CO_3) + acid → salt + H_2O + $CO_{2(g)}$

When vinegar is added to baking soda, a reaction occurs between the ethanoic acid (acetic) dissolved in the vinegar and $NaHCO_3$ and produces CO_2 gas, which causes bubbles and produce water, and salt.

$$NaHCO_{3(s)} + HC_2H_3O_{2(aq)} \rightarrow NaC_2H_3O_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

Geologists use a solution of hydrochloric acid to identify limestone (consisting of $CaCO_3$). If a few drops of acid lead to the production of CO_2 gas bubbles, this indicates that the rock contains lime.

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(s)} + H_2O_{(l)} + CO_{2(g)}$$

1) **Which gas is produced by the reaction between aluminum and sulfuric acid?**

a. H_2 b. O_2 c. N_2 d. CO_2

2) **When a geologist adds a few drops of HCl to a rock, gas bubbles form. What can a geologist conclude about the nature of gas and rock?**

a. the gas is CO_2, and the rock is magnesium sulfate

b. the gas is H_2, and the rock is magnesium sulfate

c. the gas is CO_2, and the rock is calcium carbonate

d. the gas is H_2, and the rock is calcium carbonate

3) **What is the balanced chemical equation for the reaction of magnesium metal and hydrobromic acid?**

a. $Mg_{(s)} + 2HBr_{(aq)} \rightarrow MgH_{2(aq)} + Br_{2(l)}$

b. $Mg_{(s)} + 2HBr_{(aq)} \rightarrow MgBr_{2(aq)} + 2H^+_{(aq)}$

c. $Mg_{(s)} + 2HBr_{(aq)} \rightarrow MgBr_{2(aq)} + H_{2(g)}$

d. $Mg_{(s)} + 2HBr_{(aq)} \rightarrow MgH_{2(aq)} + 2Br^-_{(aq)}$

Hydronium ions and hydroxide ions

What results from the self-ionization of pure water? → **Equal numbers of H^+ and OH^- ions are produced.**

$$H_2O_{(l)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$$

What is produced when water molecules interact together? → **It produces the hydronium ion H_3O^+ and the hydroxide ion OH^-**

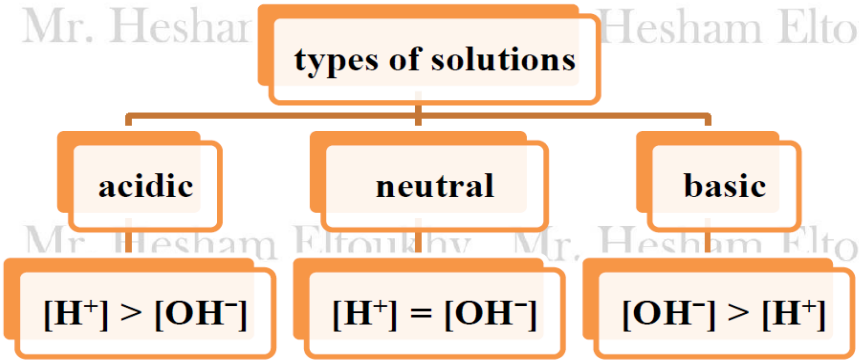
$$H_2O_{(l)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$$

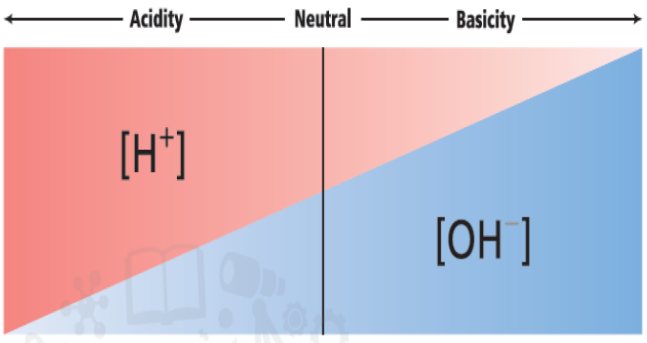
How is the hydronium ion produced? → **If a hydrogen ion bonded to a water molecule with a covalent bond.**

$$H^+_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)}$$

The symbols H^+ and H_3O^+ can be used interchangeably, i.e., placing one in the place of the other.

Aqueous solutions contain H^+ hydrogen ions and OH^- hydroxide ions.





4) What is the balanced equation that describes the self-ionization of water?

a. $H_2O_{(l)} + OH^-_{(aq)} \rightleftarrows H_3O^+_{(aq)} + H_2O_{(l)}$

b. $H_2O_{(l)} + H_3O^+_{(aq)} \rightleftarrows H_2O_{(l)} + OH^-_{(aq)}$

c. $H_3O^+_{(aq)} + OH^-_{(aq)} \rightleftarrows H_2O_{(l)} + H_2O_{(l)}$

d. $H_2O_{(l)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$

5) Why are H^+ and H_3O^+ used interchangeably in chemical equations?

a. because H_3O^+ is an H^+ ion bonded to a water molecule

b. because H_3O^+ is an H^+ ion bonded to KOH

c. because H_3O^+ is an OH^- ion bonded to a water molecule

d. because H_3O^+ is an OH^- ion bonded to KOH

6) What is the relationship between the concentrations of hydrogen ions and hydroxide ions in an acidic solution?

a. the concentration of OH^- ions is greater than the concentration of H^+ ions

b. the concentration of OH^- ions is equal to the concentration of H^+ ions

c. the concentration of H^+ ions is greater than that of OH^- ions

d. there is no relationship between the concentrations of H^+ ions and OH^- ions

Arrhenius model

Arrhenius acid: A substance containing hydrogen that ionizes in aqueous solutions to produce the hydrogen ion H^+

When hydrogen chloride (HCl) gas is dissolved in water, it ionizes to produce H^+ ions, which make the solution acidic: $HCl_{(g)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

Arrhenius base: A substance containing a hydroxide group that dissociates in aqueous solutions to produce the hydroxide ion, OH^-

When sodium hydroxide is dissolved, NaOH, in water, it dissociates to produce OH^- ions, which make the solution basic: $NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

7) Which of the following substances represents Arrhenius acid in aqueous solutions?

a. $Mg(OH)_2$ b. KOH

c. H_2S d. RbOH

8) Which of the following substances represents Arrhenius base in aqueous solutions?

a. HI b. H_2CO_3

c. H_3PO_4 d. LiOH

9) What is the balanced chemical equation for the dissociation of solid magnesium hydroxide in water?

a. $Mg(OH)_{2(s)} \rightarrow Mg^{2+}_{(aq)} + 2OH^-_{(aq)}$

b. $Mg(OH)_{2(s)} \rightarrow Mg^{2-}_{(s)} + 2OH^+_{(s)}$

c. $Mg(OH)_{2(s)} \rightarrow Mg_{(s)} + H_2O_{(l)}$

d. $Mg(OH)_{2(s)} \rightarrow Mg_{(s)} + H_2O_{2(l)}$

Sodium carbonate is responsible for making Lake Natron in Tanzania have an alkaline environment.

What are the shortcomings of Arrhenius model?

Ammonia NH_3 and Na_2CO_3 sodium carbonate do not contain a hydroxide group, but both produce hydroxide ions when dissolved in water, and they are both well-known bases.

Brønsted-Lowry model

Brønsted-Lowry acid: A hydrogen ion donor. — H^+ decrease

Brønsted-Lowry base: A hydrogen ion acceptor. — H^+ increase

$$HX_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + X^-_{(aq)}$$

acid base

Brønsted-Lowry

10) Which of the following statements is true for the reaction?

$$HCl_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + Cl^-_{(aq)}$$

a. HCl is Brønsted-Lowry acid

b. HCl is the Brønsted-Lowry base

c. H_2O is a proton donor

d. HCl is a proton acceptor

11) What equation is H_2O as a hydrogen ion donor?

a. $HI_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + I^-_{(aq)}$

b. $HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

c. $HPO_4^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + PO_4^{3-}{}_{(aq)}$

d. $C_6H_5NH_{2(aq)} + H_2O_{(l)} \rightleftarrows C_6H_5NH_3^+{}_{(aq)} + OH^-_{(aq)}$

12) Which of the following statements describes the following equation?

$$NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

a. H_2O is the Brønsted-Lowry base

b. NH_3 represents Arrhenius acid

c. NH_3 is a proton acceptor

d. NH_3 represents Brønsted-Lowry acid

Conjugate acid: the chemical compound produced when the base receives a hydrogen ion from an acid.

Conjugate base: The chemical compound that is produced when an acid donates a hydrogen ion.

Conjugate pair: two substances linked together by donating and receiving a pair hydrogen ion.

$$HX_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + X^-_{(aq)}$$

acid base conjugate acid conjugate base

Conjugate pairs :(HX, X^-), (H_2O, H_3O^+)

13) What are the conjugate pairs in the reaction? $HF_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + F^-_{(aq)}$

a. (HF, H_2O), (F^-, H_3O^+)

b. (HF, F^-), (H_2O, H_3O^+)

c. (H_3O^+, F^-), (H_2O, HF)

d. (H_2O, F^-), (HF, H_3O^+)

14) What are the conjugate pairs in the reaction? $NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-_{(aq)}$

a. (NH_4^+, H_2O), (OH^-, NH_3)

b. (OH^-, NH_4^+), (H_2O, NH_3)

c. (NH_3, NH_4^+), (H_2O, OH^-)

d. (H_2O, NH_4^+), (NH_3, OH^-)

15) What are the conjugate pairs in the reaction?

$$CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows HCO_3^-{}_{(aq)} + OH^-_{(aq)}$$

a. (OH^-, H_2O), (CO_3^{2-}, HCO_3^-) b. (OH^-, CO_3^{2-}), (HCO_3^-, H_2O)

c. (HCO_3^-, H_2O), (CO_3^{2-}, OH^-) d. (CO_3^{2-}, H_2O), (OH^-, HCO_3^-)

The difference in the conjugate pair between the acid and the base is H^+

To get the conjugate acid, add H^+ | **To get the conjugate base, subtract H^+**

16) Complete the following table by writing the conjugate acid or conjugate base.

acid	base
HNO_3	
	F^-
HSO_4^-	
	$H_2PO_4^-$
HCN	
	NH_3
$HC_2H_3O_2$	

17) Which of the following pairs is considered a conjugate pair according to the Brønsted-Lowry model?

a. HCl/ H_3O^+
b. $Na_2O/ NaOH$
c. NH_4^+/ NH_3
d. H_3O^+/ NH_3

18) If the products of an acid-base reaction are SO_4^{2-} and H_3O^+, what is the balanced equation for the reaction?

a. $SO_4^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows HSO_4^-{}_{(aq)} + H_3O^+{}_{(aq)}$

b. $H_2SO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows HSO_4^-{}_{(aq)} + H_3O^+{}_{(aq)}$

c. $H_2SO_{4(aq)} + H_2O_{(l)} \rightleftarrows SO_4^{2-}{}_{(aq)} + H_3O^+{}_{(aq)}$

d. $HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows SO_4^{2-}{}_{(aq)} + H_3O^+{}_{(aq)}$

All acids and bases that agree with the Arrhenius definition also agree with the Brønsted-Lowry definition.

However, some substances do not have a hydroxide group, which does not conform to the Arrhenius definition, but it is classified as a base according to the Brønsted-Lowry model.

Amphoteric substance: a substance that can behave like an acid and a base.

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$$HBr_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + Br^-_{(aq)}$$

acid base

Brønsted-Lowry

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$$NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

base acid

Brønsted-Lowry

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Examples: H_2O, NH_3, HS^-, OH^-, HCO_3^-, HSO_4^-, HPO_4^{2-} except: NH_2^-, H^-

Strong acids, weak acids, and strong bases are not amphoteric.

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19) Which of the following is an amphoteric substance?

a. SO_3^{2-} b. HSO_3^-

c. H_2SO_3 d. H_2SO_4

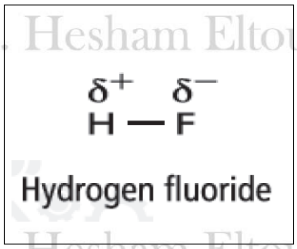
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20) Which of the following is not amphoteric?

a. H_2O b. OH^-

c. $H_2PO_4^-$ d. H_3O^+

What does ionization process mean?	The formation of the ions, and it depends on the polarity of the bond.
When does a hydrogen atom ionize in aqueous solution?	If it associated with a high electronegativity atom.
What atoms have more electronegativity than hydrogen?	Halogens (F, Cl ,Br ,I) and oxygen.
What results from the ionization of hydrogen in aqueous solution?	Hydronium ion H_3O^+ and negative ion.
What is the resulting solution of hydrogen ionization in aqueous solution?	acidic solution.

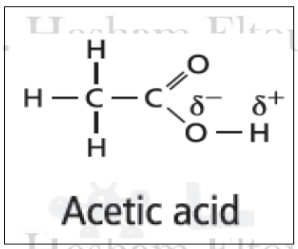


Hydrogen fluoride

hydrogen bonds with a highly electronegative atom.

hydrogen is ionizable.

represents acid.

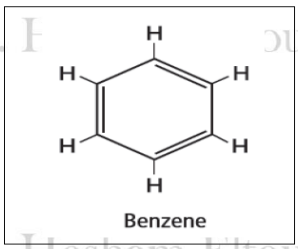


Acetic acid

hydrogen bonds with a highly electronegative atom.

hydrogen is ionizable.

represents acid.



Benzene

hydrogen does not bond with a highly electronegative

hydrogen is not ionizable.

does not represent acid.

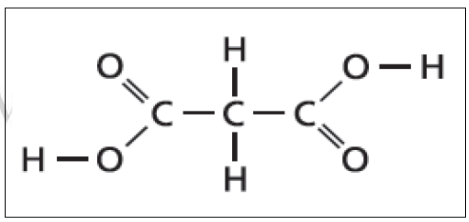
21) In the given structural formula below, how many hydrogen atoms are ionizable?

a. 1

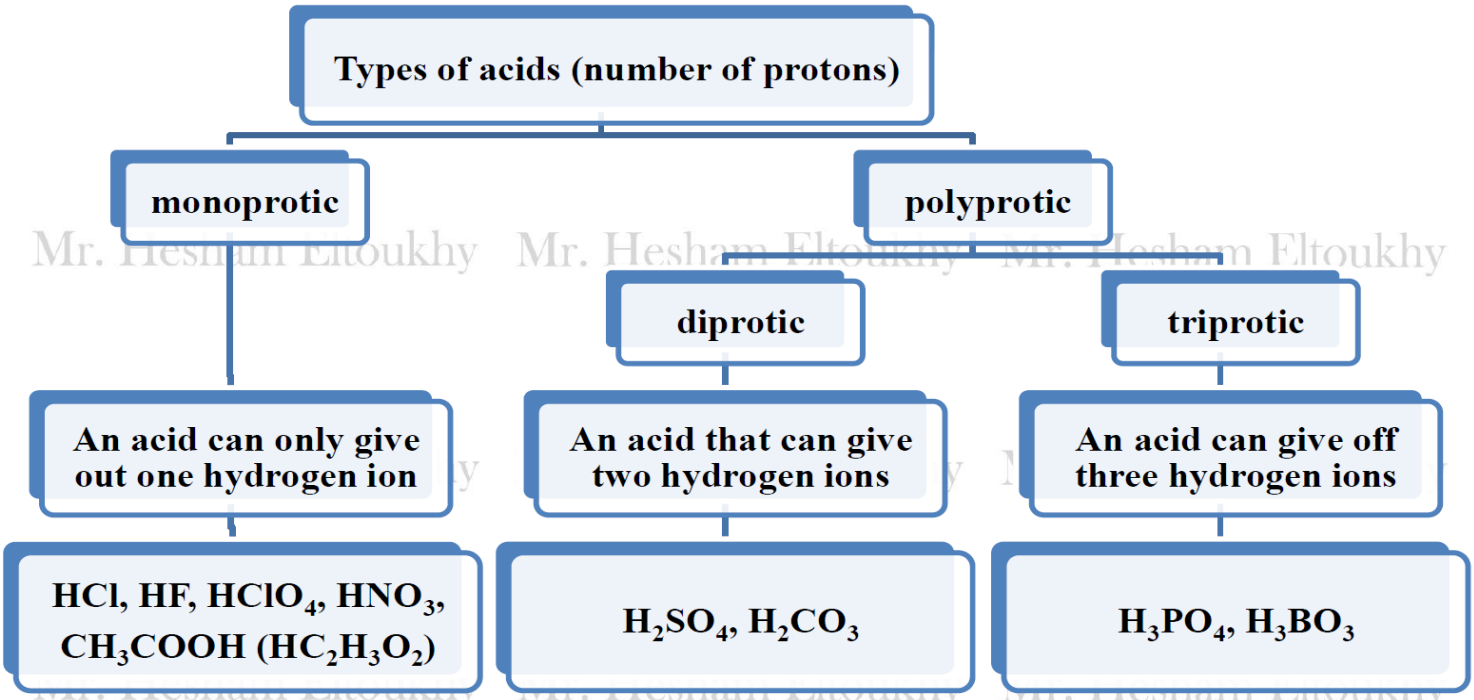
b. 2

c. 3

d. 4



Hydrogen fluoride is used to make various fluorine-containing compounds, by reacting with hydrocarbons to produce the non-stick coating in kitchen utensils.



acid type	monoprotic	diprotic	triprotic
number of hydrogen atoms that can be ionized	1	2	3
number of ionization phases	1	2	3
number of H_3O^+ ions produced by ionization	1	2	3
acid strength	strong or weak	strong or weak	weak

When a strong monoprotic acid ionizes, it produces H_3O^+ and the acid's negative ion.

$$HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

When a weak monoprotic acid is ionizes, it produces H_3O^+, the negative ion of the acid, and molecules of the weak acid.

$$HF_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + F^-_{(aq)}$$

When a strong diprotic acid ionizes, it produces H_3O^+ and the acid's negative ion

$$H_2SO_{4(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)}$$
$$HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + SO_4^{2-}{}_{(aq)}$$

When a weak diprotic acid is ionizes, it produces H_3O^+, the negative ion of the acid, and molecules of the weak acid

$$H_2CO_{3(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + HCO_3^-{}_{(aq)}$$
$$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + CO_3^{2-}{}_{(aq)}$$

When a weak triprotic acid is ionizes, it produces H_3O^+, the negative ion of the acid, and molecules of the weak acid

$$H_3PO_{4(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + H_2PO_4^-{}_{(aq)}$$
$$H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + HPO_4^{2-}{}_{(aq)}$$
$$HPO_4^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + PO_4^{3-}{}_{(aq)}$$

22) Which of the following acids is a triprotic acid?

a. CH_3COOH b. $Al(OH)_3$ c. H_3PO_4 d. HNO_3

23) What is the balanced chemical equation for the ionization of CH_3CH_2COOH propanoic acid in the water?

a. $CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftarrows CH_3CH_2COOH_{2\,(aq)} + OH^-{}_{(aq)}$

b. $CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftarrows CH_3CHCOOH_{(aq)} + H_3O^+_{(aq)}$

c. $CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftarrows CH_2CH_2COOH_{(aq)} + H_3O^+_{(aq)}$

d. $CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftarrows CH_3CH_2COO^-{}_{(aq)} + H_3O^+_{(aq)}$

24) What is the balanced chemical equation for the second ionization of H_2SO_4 in water?

a. $HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_2SO_{4(aq)} + H_3O^+_{(aq)}$

b. $HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows SO_4^{2-}{}_{(aq)} + 2OH^-{}_{(aq)}$

c. $HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows H_2SO_{4(aq)} + OH^-{}_{(aq)}$

d. $HSO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows SO_4^{2-}{}_{(aq)} + H_3O^+_{(aq)}$

Lewis model

Lewis acid: An electron pair acceptor.

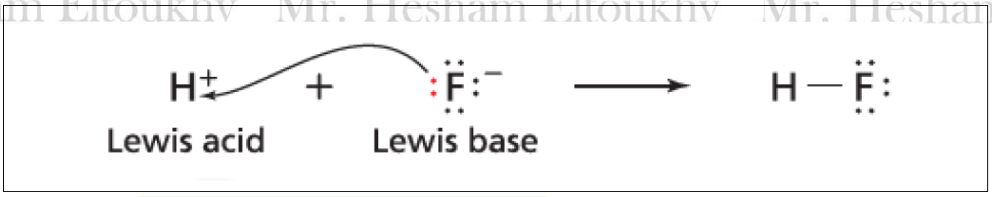
A Lewis acid has an empty atomic orbital that can accept (share) a pair of electrons.

Lewis base: An electron pair donor.

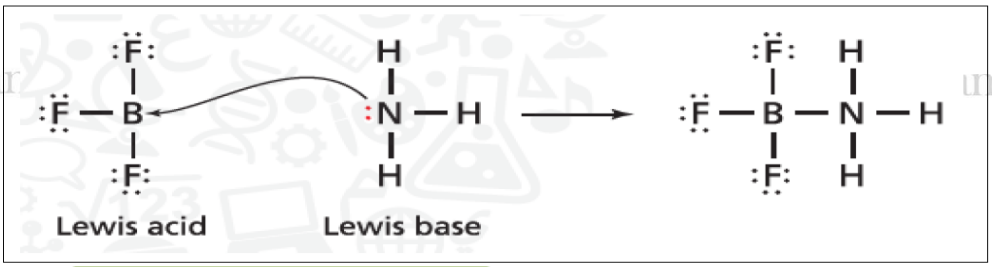
A Lewis base has an unshared pair of electrons that it can donate (share).

The Lewis model includes all substances classified as acids and bases according to the Brønsted-Lowry model and others.

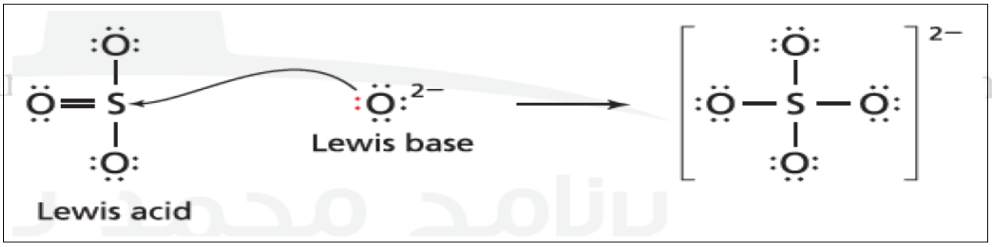
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acceptor donor
electron-pair



acceptor donor
electron-pair



acceptor donor
electron-pair

	Lewis acid	Lewis base
①	electron-pair acceptor	electron-pair donor
②	positive ion	negative ion
③	Al, B, S compounds	P, N compounds

25) Which of the following is a Lewis acid?

a. Cl^- b. NH_3 c. $AlCl_3$ d. F^-

26) Which of the following is a Lewis base?

a. NH_3 b. $AlCl_3$ c. BF_3 d. BCl_3

27) Identify acid and Lewis base in the reaction? $H^+ + OH^- \rightleftarrows H_2O$?

a. acid: H^+, base: OH^- b. acid: OH^-, base: H^+

c. acid: H^+, base: H_2O d. acid: H^+, base: H_2O

28) Identify acid and Lewis base in the reaction? $Cl^- + BCl_3 \rightleftarrows BCl_4^-$?

a. acid: Cl^-, base: BCl_3 b. acid: BCl_3, base: BCl_4^-

c. acid: BCl_4^-, base: Cl^- d. acid: BCl_3, base: Cl^-

29) Identify acid and Lewis base in the reaction? $SO_3 + H_2O \rightleftarrows H_2SO_4$?

a. acid: SO_3, base: H_2SO_4 b. acid: SO_3, base: H_2O

c. acid: H_2O, base: SO_3 d. acid: H_2SO_4, base: H_2O

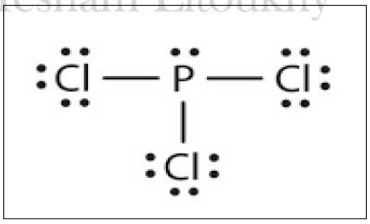
30) Depending on the presence of an unshared pair of electrons on the phosphorous atom in the Lewis structure of PCl_3. What is PCl_3 classified as?

a. Lewis acid

b. Lewis base

c. Arrhenius acid

d. Arrhenius base



The model	Acid	Base
Arrhenius	H^+ producer	OH^- producer
Brønsted-Lowry	H^+ donor	H^+ acceptor
Lewis	electron-pair acceptor	electron-pair donor

life applications

- The reaction of SO_3 with MgO is important because it produces the magnesium sulfate salt $MgSO_4.7H_2O$ known as Epsom salt which is used to relieve muscle pain and act as a plant nutrient.
- MgO is injected into the flue gases of coal-fired power plants, MgO reacts with SO_3 and removes it from the waste gases out into the atmosphere.
- When SO_3 is allowed into the atmosphere, it can combine with water in the atmosphere to form sulfuric acid, which falls to the ground as acid rain.

Connection to Earth Science

- **Acidic** solutions are produced when nonmetallic oxides are dissolved in water.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

nonmetal oxide + H_2O → acidic solution

- **Basic** solutions are produced when metallic oxides are dissolved in water.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

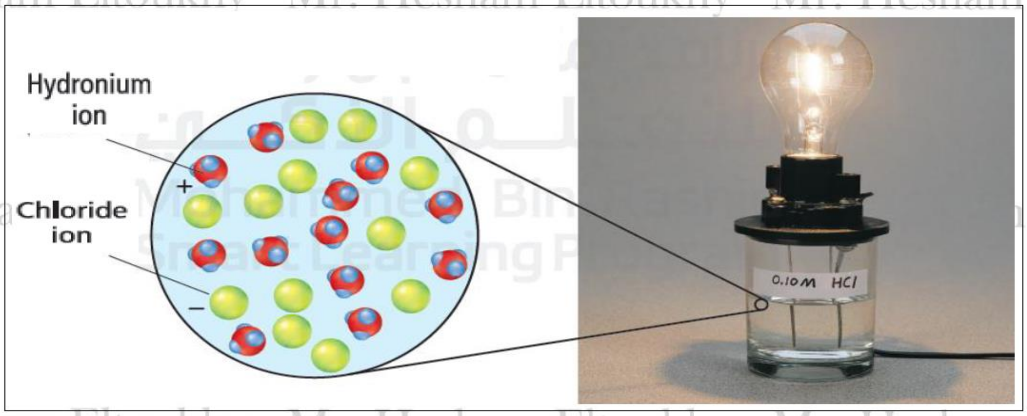
metal oxide + H_2O → basic solution

Connection to Earth Science

- CO_2 gas molecules combine with water molecules in the air to form carbonic acid, H_2CO_3, which falls with the rain. When it reaches the ground, it seeps into the soil to reach the limestone rocks, and slowly dissolves them, causing the formation of huge underground limestone caves. This lime is in the form of flakes. Icicles from the ceiling (stalactites) and blocks of calcium carbonate on the floor of caves (stalagmites).

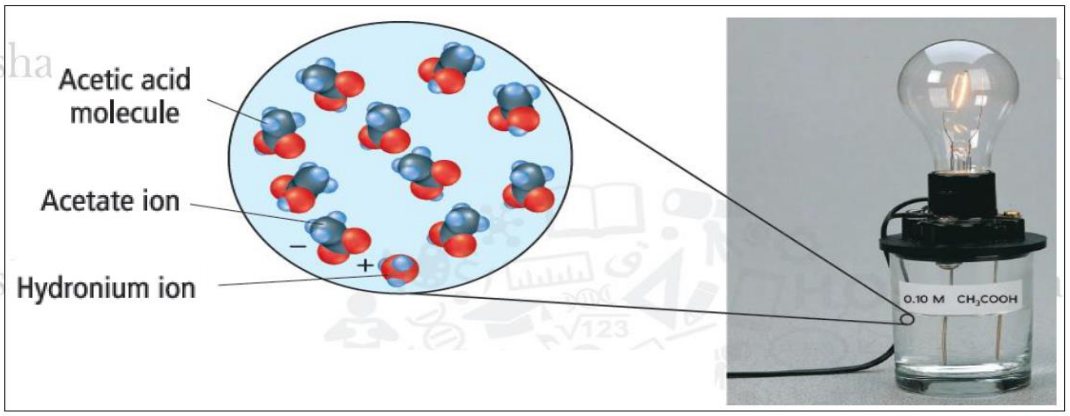
Sec. (2) Strength of Acids and Bases

Compare the electrical conductivity of two acid solutions of the same concentration.



0.1M aqueous solution of HCl → **more bulb brightness** → **better electrical conductivity** → **there are ions only** → **complete ionization strong) (acid**

$$HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$



0.1M aqueous solution of CH_3COOH → **less bulb brightness** → **weaker electrical conductivity** → **there are ions and molecules** → **incomplete ionization weak) (acid**

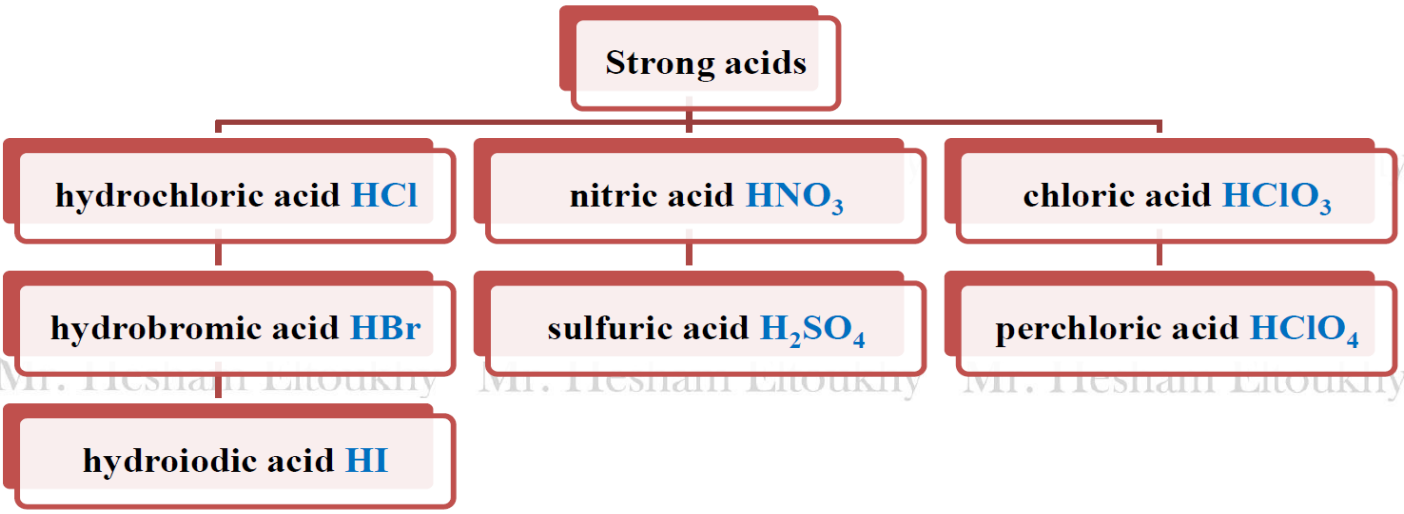
$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$$

Strong acids: Acids that ionize completely, produce the largest number of ions and are good conductors of electricity.

The HCl molecules in the solution all ionize, forming hydronium ions and chloride ions.

→ Indicates that the reaction is complete, and all molecules ionize to form ions.

Why are strong acids a good conductor of electricity? → Because it is completely ionized to produce ions in the solution, there are no molecules left.



31) What are the contents of a dilute aqueous solution of the strong acid HI?

a. H_3O^+ only

b. I^- only

c. H_3O^+, I^- only

d. HI, H_3O^+, I^-

32) Which reaction represents the ionization equation of a strong acid?

a. $HClO_{3(aq)} + H_2O_{(l)} \rightleftarrows H_2ClO_3^+{}_{(aq)} + OH^-_{(aq)}$

b. $HClO_{3(aq)} + H_2O_{(l)} \rightarrow H_2ClO_3^+{}_{(aq)} + OH^-_{(aq)}$

c. $HClO_{4(aq)} + H_2O_{(l)} \rightleftarrows ClO_4^-{}_{(aq)} + H_3O^+_{(aq)}$

d. $HClO_{4(aq)} + H_2O_{(l)} \rightarrow ClO_4^-{}_{(aq)} + H_3O^+_{(aq)}$

Weak acids: Acids that partially ionize in aqueous solution produce few ions and are poor conductors of electricity.

Not all the CH_3COOH molecules present in the solution are ionized.
After ionization, the ions and molecules are present together.

⇄ Indicates that the reaction is incomplete, the concentration of molecules is greater than the concentration of ions after ionization.

Why are weak acids not a good conductor of electricity? → Because it is incompletely ionized to produce molecules and ions in solution.

Weak acids

- hydrofluoric acid HF
- hydrocyanic acid HCN
- hydrosulfuric acid H_2S
- chlorous acid $HClO_2$
- hypochlorous acid HClO
- nitrous acid HNO_2
- sulfurous acid H_2SO_3
- carbonic acid H_2CO_3
- ethanoic (acetic) acid CH_3COOH
- methanoic (formic) acid HCOOH
- phosphoric acid H_3PO_4
- boric acid H_3BO_3

33) What are the contents of a dilute aqueous solution of the weak acid HCOOH?

a. H_3O^+ only

b. $HCOO^-$ only

c. H_3O^+, $HCOO^-$ only

d. HCOOH, H_3O^+, $HCOO^-$

34) Which reaction represents the ionization equation of a weak acid?

a. $HNO_{2(aq)} + H_2O_{(l)} \rightleftarrows NO_2^-{}_{(aq)} + H_3O^+{}_{(aq)}$

b. $HNO_{2(aq)} + H_2O_{(l)} \rightarrow NO_2^-{}_{(aq)} + H_3O^+{}_{(aq)}$

c. $HNO_{3(aq)} + H_2O_{(l)} \rightleftarrows NO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$

d. $HNO_{3(aq)} + H_2O_{(l)} \rightarrow NO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$

Acid strength and the Brønsted-Lowry model

A weak acid has a strong conjugate base. **A strong acid has a weak conjugate base.**

The acid-base reactions of Brønsted-Lowry favor the production of the weakest.

The strong acid HX ionizes as in the following equation:

$$HX_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + X^-_{(aq)}$$

strong acid — strong base — weak conjugate acid — weak conjugate base

- strong base: has more ability to attract H^+ ion.
- weak conjugate base: has less ability to attract H^+ ion.

H_2O is a stronger base (forward reaction) than the conjugate base X^- (reverse reaction).

The attraction of the H_2O base to the H^+ ion is greater than that of the conjugate base X^-

The ionization equilibrium is almost shifts to the right and HX ionizes at 100%

The weak acid HY ionizes as in the following equation:

$$HY_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + Y^-_{(aq)}$$

weak acid — weak base — strong conjugate acid — strong conjugate base

- weak base: has less ability to attract H^+ ion.
- strong conjugate base: has more ability to attract H^+ ion.

Y^- is a stronger base (reverse reaction) than the base H_2O (forward reaction).

The attraction of the conjugate base Y^- to the H^+ ion is greater than that of the base H_2O.

The ionization equilibrium is almost shifts to the left, and [HY] molecules is the largest.

35) Which of the following relationships is not correct for the relationship between the strength of a weak acid and the strength of its conjugate base?

a. The stronger the acid, the weaker its conjugate base

b. The weaker the acid, the stronger its conjugate base

c. a weak base has a strong conjugate acid

d. a strong acid has a weak conjugate acid

36) If the tendency of a substance to give off protons is large, how is its conjugate?

a. has a large tendency to give protons

b. has a weak tendency to give protons

c. has a large tendency to receive protons

d. has a weak tendency to receive protons

37) For the following balanced reaction, which of the following statements is true?

$$HC_2H_3O_{2(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$$

a. the base $C_2H_3O_2^-$ is stronger than the base H_2O

b. $HC_2H_3O_2$ is a strong acid

c. the base $C_2H_3O_2^-$ is weaker than the base H_2O

d. the ionization equilibrium is shifts to the right

38) For the following balanced reaction, why does the ionization shift to the left?

$$HF + H_2O \rightleftarrows H_3O^+ + F^-$$

a. the H_2O base has a more attraction to the H^+ ion than the conjugate base F^-

b. the K_a value of the acid is high, and it tends towards non-ionizing molecules

c. HF is a strong acid and its conjugate base F^- is weak

d. the conjugate base F^- is stronger than the base H_2O, so it attracts the H^+ ion more than the base H_2O

Acid ionization constants

The Brønsted-Lowry model helps explain the strength of acids, but it does not quantitatively compare the strengths of different acids.

The expression K_{eq} provides a quantitative measure of acid strength.

The ionization equation for HCN and the expression for the equilibrium constant:

$$HCN_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + CN^-_{(aq)} \qquad K_{eq} = \frac{[H_3O^+][CN^-]}{[HCN][H_2O]}$$

The concentration of $H_2O_{(l)}$ is constant, and a new equilibrium constant K_a is used.

$$K_{eq}\,[H_2O] = K_a = \frac{[H_3O^+][CN^-]}{[HCN]} = 6.2 \times 10^{-10}$$

Acid ionization constant Ka: The equilibrium constant for the ionization of a weak acid

What is produced if the value of K_a increases?	The concentrations of ions (products) in the numerator increase compared to the concentration of non-ionized molecules (reactants) in the denominator, as in strong acids.
What is produced if the value of K_a decreases?	The concentrations of non-ionizing molecules (reactants) increase in the denominator compared to the concentration of ions (products) in the numerator, as in weak acids.
Why do weak acids have the lowest Ka values?	Because their solutions have the lowest concentrations of ions and the highest concentrations of non-ionized acid molecules.

Most of the polyprotic acids are weakly ionized, and each ionization phase of the polyprotic acid has a different K_a value.

The value of K_a decreases for each subsequent ionization process.

Ionization Constants for Weak Acids	not required to memorize	
Acid	**Ionization Equation**	**K_a (298 K)**
Hydrosulfuric, first ionization	$H_2S \rightleftharpoons H^+ + HS^-$	8.9×10^{-8}
Hydrosulfuric, second ionization	$HS^- \rightleftharpoons H^+ + S^{2-}$	1×10^{-19}
Hydrofluoric	$HF \rightleftharpoons H^+ + F^-$	6.3×10^{-4}
Hydrocyanic	$HCN \rightleftharpoons H^+ + CN^-$	6.2×10^{-10}
Acetic	$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$	1.8×10^{-5}
Carbonic, first ionization	$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$	4.5×10^{-7}
Carbonic, second ionization	$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$	4.7×10^{-11}

39) What is the weakest acid among the acids in the table below?

acid	K_a (298 K)
HF	6.3×10^{-4}
H_2S	8.9×10^{-8}
HCN	6.2×10^{-10}
H_2CO_3	4.5×10^{-7}

a. H_2S

b. H_2CO_3

c. HF

d. HCN

40) Which of the following relationships represents the acid ionization constant (K_a) in the following equation? $HCOOH_{(aq)} + H_2O_{(l)} \rightleftarrows HCOO^-_{(aq)} + H_3O^+_{(aq)}$

a. $K_a = \frac{[HCOO^-][H_3O^+]}{[HCOOH]}$

b. $K_a = \frac{[HCOO^-][H_3O^+]}{[HCOOH][H_2O]}$

c. $K_a = \frac{[HCOOH][H_2O]}{[HCOO^-]}$

d. $K_a = \frac{[HCOOH][H_2O]}{[HCOO^-][H_3O^+]}$

41) Which of the following choices represents the chemical equation and K_a expression for the ionization of hypochlorous acid in water?

a. $HClO + H_2O \rightarrow H_3O^+ + ClO^-$, $K_a = \frac{[H_3O^+][ClO^-]}{[HClO][H_2O]}$

b. $HClO + H_2O \rightarrow H_3O^+ + ClO^-$, $K_a = \frac{[H_3O^+][ClO^-]}{[HClO]}$

c. $HClO + H_2O \rightleftarrows H_3O^+ + ClO^-$, $K_a = \frac{[H_3O^+][ClO^-]}{[HClO][H_2O]}$

d. $HClO + H_2O \rightleftarrows H_3O^+ + ClO^-$, $K_a = \frac{[H_3O^+][ClO^-]}{[HClO]}$

42) What is the correct order of the following weak acids in order of their conduction of electricity?

acid	CH_3COOH	HS^-	HCO_3^-	HF
K_a (298 K)	1.8×10^{-5}	1.0×10^{-19}	4.7×10^{-11}	6.3×10^{-4}

a. least: $HF \rightarrow HCO_3^- \rightarrow HS^- \rightarrow CH_3COOH$ most

b. least: $HF \rightarrow CH_3COOH \rightarrow HCO_3^- \rightarrow HS^-$ most

c. least: $CH_3COOH \rightarrow HS^- \rightarrow HCO_3^- \rightarrow HF$ most

d. least: $HS^- \rightarrow HCO_3^- \rightarrow CH_3COOH \rightarrow HF$ most

43) What is the second ionization equation for the acid H_2SeO_3 in water?

a. $H_2SeO_3 + H_2O \rightarrow H_3O^+ + HSeO_3^-$

b. $H_2SeO_3 + H_2O \rightleftarrows H_3O^+ + HSeO_3^-$

c. $HSeO_3^- + H_2O \rightarrow H_3O^+ + SeO_3^{2-}$

d. $HSeO_3^- + H_2O \rightleftarrows H_3O^+ + SeO_3^{2-}$

44) What is the expression for K_a for the ionization of nitrous acid in water?

a. $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2][H_2O]}$

b. $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]}$

c. $K_a = \frac{[HNO_2][H_2O]}{[H_3O^+][NO_2^-]}$

d. $K_a = \frac{[HNO_2]}{[H_3O^+][NO_2^-]}$

45) If the expression for the equilibrium constant for a reaction is: $K_a = \frac{[H_3O^+][AsO_4^{3-}]}{[HAsO_4^{2-}]}$

What is the balanced equation for the reaction?

a. $HAsO_4^{2-} + H_2O \rightleftarrows H_3O^+ + AsO_4^{3-}$

b. $HAsO_4^{2-} + H_2O \rightarrow H_3O^+ + AsO_4^{3-}$

c. $H_3O^+ + AsO_4^{3-} \rightleftarrows HAsO_4^{2-} + H_2O$

d. $H_3O^+ + AsO_4^{3-} \rightarrow HAsO_4^{2-} + H_2O$

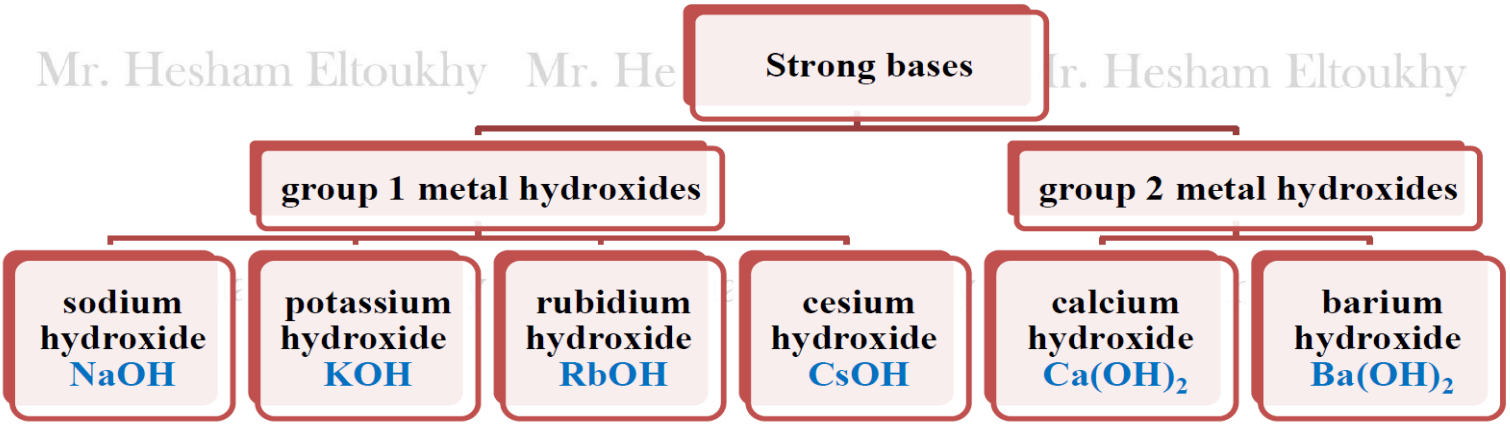
Strengths of bases

What applies to acids also applies to bases, except that OH^- ions are involved instead of H^+

The conductivity of the base depends on the degree to which the base produces OH^- ions in the aqueous solution.

Strong base: A base that completely dissociates to produce metal ions and hydroxide ions OH^-

Dissociation equation for the strong base NaOH: $NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$



46) What are the contents of a dilute aqueous solution of most bases?

a. hydroxide ions and cations

b. hydroxide ions and anions

c. hydrogen ions and cations

d. hydrogen ions and anions

47) Which reaction represents the ionization equation of the strong base $Ba(OH)_2$?

a. $Ba(OH)_{2(s)} \rightarrow Ba^{2+}_{(aq)} + OH^-_{(aq)}$

b. $Ba(OH)_{2(s)} \rightleftarrows Ba^{2+}_{(aq)} + OH^-_{(aq)}$

c. $Ba(OH)_{2(s)} \rightarrow Ba^{2+}_{(aq)} + 2OH^-_{(aq)}$

d. $Ba(OH)_{2(s)} \rightleftarrows Ba^{2+}_{(aq)} + 2OH^-_{(aq)}$

Why is calcium hydroxide $Ca(OH)_2$ a poor source of OH^- ions? → **Because calcium hydroxide has poor solubility.**

Why calcium hydroxide has poor solubility? → **Because the K_{sp} value of calcium hydroxide is small.**

$$Ca(OH)_{2(s)} \rightleftarrows Ca^{2+}_{(aq)} + 2OH^-_{(aq)} \qquad K_{sp} = 6.5 \times 10^{-6}$$

Why are $Ca(OH)_2$ and other poorly soluble bases considered strong, even though they have a lower solubility in water? → **Because everything that dissolves from the compound dissociates completely.**

Weak Base: A base that partially ionizes in aqueous solutions.

Ionization equation for the weak base NH_3: $NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-_{(aq)}$

48) What is the reason for the low electrical conductivity of calcium hydroxide even though it is a strong base?

a. it has poor solubility in water

b. no OH^- ions are produced in water

c. partially ionizes in water

d. produces H^+ ions in water

Weak Bases

- ethylamine $C_2H_5NH_2$
- methylamine CH_3NH_2
- ammonia NH_3
- aniline $C_6H_5NH_2$

49) What group does aniline belong to?

a. strong base b. weak base

c. strong acid d. weak acid

The weak base CH_3NH_2 is ionized as in the following equation:

$$CH_3NH_{2\,(aq)} + H_2O_{(l)} \rightleftarrows CH_3NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$$

weak base — weak acid — strong conjugate acid — strong conjugate base

- CH_3NH_2: has less ability to attract H^+ ion.
- $CH_3NH_3^+$: has more ability to attract H^+ ion.

OH^- is a stronger base (reverse reaction) than the base CH_3NH_2 (forward reaction)

The attraction of the base OH^- to the H^+ ion is greater than that of the base CH_3NH_2

The ionization equilibrium is almost shifts to the left, and $[CH_3NH_2]$ is the largest.

Base ionization constants

The equilibrium constant is a measure of the degree of ionization of the base.

Base ionization constant K_b: Expression of the equilibrium constant for the ionization of a weak base.

Base ionization constant for CH_3NH_2: $K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]}$

What is produced if the value of K_b decreases? → The concentrations of non-ionizing molecules (reactants) increase in the denominator compared to the concentration of ions (products) in the numerator, as in weak bases.

Ionization Constants of Weak Bases

not required to memorize

Base	Ionization Equation	K_b (298 K)
Ethylamine	$C_2H_5NH_2(aq) + H_2O(l) \rightleftharpoons C_2H_5NH_3^+(aq) + OH^-(aq)$	5.0×10^{-4}
Methylamine	$CH_3NH_2(aq) + H_2O(l) \rightleftharpoons CH_3NH_3^+(aq) + OH^-(aq)$	4.3×10^{-4}
Ammonia	$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$	2.5×10^{-5}
Aniline	$C_6H_5NH_2(aq) + H_2O(l) \rightleftharpoons C_6H_5NH_3^+(aq) + OH^-(aq)$	4.3×10^{-10}

50) When the base can be considered as weak?

a. if its tendency to accept a proton is high

b. if its tendency to donate a proton is high

c. if its tendency to accept a proton is weak

d. if its tendency to donate a proton is weak

51) Which of the following options represents the chemical equation and the ionization expression K_b of ethylamine in water?

a. $C_2H_5NH_2 + H_2O \rightleftarrows C_2H_5NH_3^+ + OH^-$, $K_b = \frac{[C_2H_5NH_3^+][OH^-]}{[C_2H_5NH_2][H_2O]}$

b. $C_2H_5NH_2 + H_2O \rightarrow C_2H_5NH_3^+ + OH^-$, $K_b = \frac{[C_2H_5NH_3^+][OH^-]}{[C_2H_5NH_2][H_2O]}$

c. $C_2H_5NH_2 + H_2O \rightarrow C_2H_5NH_3^+ + OH^-$, $K_b = \frac{[C_2H_5NH_3^+][OH^-]}{[C_2H_5NH_2]}$

d. $C_2H_5NH_2 + H_2O \rightleftarrows C_2H_5NH_3^+ + OH^-$, $K_b = \frac{[C_2H_5NH_3^+][OH^-]}{[C_2H_5NH_2]}$

52) Which of the following options represents the chemical equation and the ionization expression K_b of the carbonate ion CO_3^{2-} in water?

a. $CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-$, $K_b = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]}$

b. $CO_3^{2-} + H_2O \rightleftarrows HCO_3^- + OH^-$, $K_b = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}]}$

c. $CO_3^{2-} + H_2O \rightarrow HCO_3^- + OH^-$, $K_b = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}][H_2O]}$

d. $CO_3^{2-} + H_2O \rightleftarrows HCO_3^- + OH^-$, $K_b = \frac{[HCO_3^-][OH^-]}{[CO_3^{2-}][H_2O]}$

53) Which of the following K_a values represents the acid with the strongest conjugate base?

a. 1.8×10^{-5} b. 1×10^{-6}

c. 1.4×10^{-4} d. 3.2×10^{-3}

54) Which of the following options represents the chemical equation and the ionization expression K_b of the hydrogen sulfite ion HSO_3^- in water?

a. $HSO_3^- + H_2O \rightleftarrows H_2SO_3 + OH^-$, $K_b = \frac{[H_2SO_3][OH^-]}{[HSO_3^-][H_2O]}$

b. $HSO_3^- + H_2O \rightarrow H_2SO_3 + OH^-$, $K_b = \frac{[H_2SO_3][OH^-]}{[HSO_3^-][H_2O]}$

c. $HSO_3^- + H_2O \rightleftarrows H_2SO_3 + OH^-$, $K_b = \frac{[H_2SO_3][OH^-]}{[HSO_3^-]}$

d. $HSO_3^- + H_2O \rightarrow H_2SO_3 + OH^-$, $K_b = \frac{[H_2SO_3][OH^-]}{[HSO_3^-]}$

55) What is an equation for the reversible equilibrium where the base in the forward reaction is PO_4^{3-} and the base in the reverse reaction is OH^-?

a. $HPO_4^{2-}{}_{(aq)} + OH^-{}_{(aq)} \rightarrow PO_4^{3-}{}_{(aq)} + H_2O_{(l)}$

b. $HPO_4^{2-}{}_{(aq)} + OH^-{}_{(aq)} \rightleftarrows PO_4^{3-}{}_{(aq)} + H_2O_{(l)}$

c. $PO_4^{3-}{}_{(aq)} + H_2O_{(l)} \rightarrow HPO_4^{2-}{}_{(aq)} + OH^-{}_{(aq)}$

d. $PO_4^{3-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows HPO_4^{2-}{}_{(aq)} + OH^-{}_{(aq)}$

56) What information does a small K_b value (4.3×10^{-10}) of aniline gives you?

a. aniline is strong base

b. aniline is incompletely ionized

c. aniline ionization in water produces only ions

d. its solution is a good conductor of electricity

57) What is the strongest base among the bases in the adjacent table, at 298 K?

a. methylamine

b. ethylamine

c. aniline

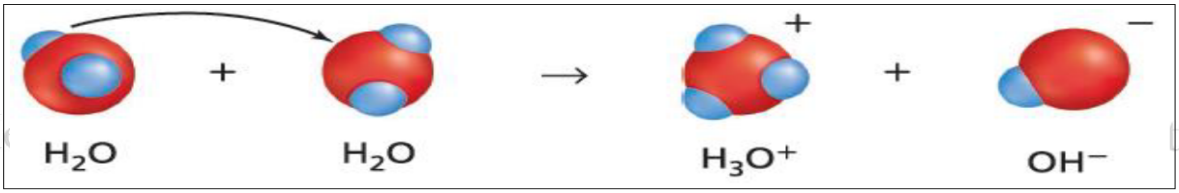
d. ammonia

base	K_b (298 K)
ethylamine	5.0×10^{-4}
methylamine	4.3×10^{-4}
ammonia	2.5×10^{-5}
aniline	4.3×10^{-10}

Sec. (3) Hydrogen ions and pH

Self-ionization of water: pure water contains equal concentrations of H^+ and OH^-

$$H_2O_{(l)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$$



In the self-ionization of water, one molecule of water acts as an acid, and the other molecule acts as a base.

Water ionization constant K_w: An expression for the equilibrium constant for the self-ionization of water.

or

The product of the hydrogen ion and hydroxide ion concentrations in dilute aqueous solutions.

$$K_w = [H^+][OH^-]$$

for the neutral solution

at room temperature (298 K)

$$[H^+] = [OH^-] = 1 \times 10^{-7} \text{ mol/L}$$

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

1 $\quad 1 \times 10^{-14} = [H^+][OH^-]$ $\quad$ 298 K

The K_w value is constant at a constant temperature.

Why does the value of K_w increase when the temperature increases? → Because ionization of water increases as the temperature increase.

K_w and Le Chatelier Principle

What produced when the concentration of H^+ ions increase? → acidic solution

H^+ reacts with OH^- and the reaction goes to the left to produce water H_2O

As a result, the concentration of H^+ increases and the concentration of OH^- decreases.

$[H^+] > [OH^-]$
acidic solution

H^+

$H_2O_{(l)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$

K_w
no change

What produced when the concentration of OH^- ions increases? → basic solution

OH^- reacts with H^+ and the reaction goes to the left to produce water H_2O

As a result, the concentration of OH^- increases and the concentration of H^+ decreases.

$[OH^-] > [H^+]$
basic solution

OH^-

$H_2O_{(l)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$

K_w
no change

Types of solutions

acidic	neutral	basic
$[H^+] > [OH^-]$	$[H^+] = [OH^-]$	$[OH^-] > [H^+]$
$[H^+] > 1\times10^{-7}$ mol/L	$[H^+] = [OH^-] = 1\times10^{-7}$ mol/L	$[OH^-] > 1\times10^{-7}$ mol/L

58) The concentration of the H^+ ion in a cup of coffee is 1×10^{-5} M at 298 K. What is the concentration of the OH^- ion in the coffee? Is coffee acidic, basic, or neutral?

a. $[OH^-] = 1 \times 10^{-9}$ M, basic

b. $[OH^-] = 1 \times 10^{-9}$ M, acidic

c. $[OH^-] = 1 \times 10^{-24}$ M, basic

d. $[OH^-] = 1 \times 10^{-24}$ M, acidic

59) What is the value of $[H^+]$ in a solution whose concentration of OH^- is 1×10^{-3} M?

a. 1×10^{-7} M

b. 1×10^{-17} M

c. 1×10^{-3} M

d. 1×10^{-11} M

60) What is the value of $[OH^-]$ in a solution whose concentration of H^+ is 4×10^{-5} M?

a. 2.5×10^{-10} M

b. 1×10^{-9} M

c. 2.5×10^{-9} M

d. 1×10^{-10} M

61) How many H^+ ions and how many OH^- ions are in 300 mL of pure water at 298 K?

$N_A = 6.022 \times 10^{23}$

a. $[H^+] = [OH^-] = 3 \times 10^{8}$ ions

b. $[H^+] = [OH^-] = 1.8 \times 10^{16}$ ions

c. $[H^+] = [OH^-] = 1.8 \times 10^{6}$ ions

d. $[H^+] = [OH^-] = 3 \times 10^{16}$ ions

62) Use Le Chatelier's principle to determine what happens to equilibrium when a few drops of HCl are added to pure water? $H_2O_{(l)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$

a. the equilibrium shifts to the left and K_w does not change

b. the equilibrium shifts to the left and K_w changes

c. the equilibrium shifts to the right and K_w does not change

d. the equilibrium shifts to the right and K_w changes

63) Use Le Chatelier's principle to determine what happens to $[H^+]$ when drops of NaOH are added to an acetic acid solution? $CH_3COOH_{(aq)} \rightleftarrows CH_3COO^-_{(aq)} + H^+_{(aq)}$

a. $[H^+]$ increases and equilibrium shifts to the right

b. $[H^+]$ decreases and equilibrium shifts to the right

c. $[H^+]$ increases and equilibrium shifts to the left

d. $[H^+]$ decreases and equilibrium shifts to the left

64) If the concentration of H^+ ions decrease in an aqueous solution, what must happen to the concentration of OH^- ions at a constant temperature? And what is the reason?

choice	$[OH^-]$	the reason
a.	decrease	K_w change
b.	decrease	K_w no change
c.	increase	K_w change
d.	increase	K_w no change

65) In the following equilibrium equation for pure water: $H_2O_{(l)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$

Why does the value of K_w not change when other hydrogen ions added to water?

a. shifting the equilibrium to the right and increasing the concentration of H^+ ions

b. increasing the rate of ionization of water molecules

c. increasing the concentration of OH^- ions in the solution

d. H^+ reacts with OH^- to form more H_2O molecules

pH and pOH

pH: the negative logarithm of hydrogen ion concentration.

2 $pH = -\log [H^+]$

pOH: the negative logarithm of hydroxide ion concentration.

3 $pOH = -\log [OH^-]$

What is the relationship between pH and pOH?

4 $pH + pOH = 14$ 298 K

pH, pOH have no units

66) What is the pH value of the solution that has: $[H^+] = 1.0 \times 10^{-2}$ M, at 298 K?

a. 2

b. 4

c. 12

d. 10

67) What is the pH value of the solution that has: $[H^+] = 0.000084$ M, at 298 K?

a. 10.924

b. 3.075

c. 9.924

d. 4.075

68) What is the pOH value of the solution that has: $[OH^-] = 1.0 \times 10^{-6}$ M, at 298 K?

a. 2

b. 8

c. 12

d. 6

69) What is the pOH value of the solution that has: $[OH^-] = 6.5 \times 10^{-4}$ M, at 298 K?

a. 10

b. 4

c. 10.81

d. 3.18

70) What is the pOH value of the solution that has: $[H^+] = 2.5 \times 10^{-2}$ M, at 298 K?

a. 12.4

b. 1.6

c. 12

d. 2

71) What is the pH value of the solution that has: $[OH^-] = 0.0055$ M, at 298 K?

a. 2.26

b. 11.74

c. 3

d. 11

72) What is the pH value of the neutral solution at 298 K?

a. 14

b. –7

c. 7

d. 0

Calculation of $[H^+]$ and $[OH^-]$ from pH and pOH

5	$[H^+] = 10^{-pH}$
6	$[OH^-] = 10^{-pOH}$

73) What is the value of $[H^+]$ for milk with pH = 6.5?

a. 1×10^{-8} M

b. 1×10^{-7} M

c. 3.16×10^{-8} M

d. 3.16×10^{-7} M

74) What is the value of $[H^+]$ for lemon juice with pOH = 11.6?

a. 2.51×10^{-12} M

b. 3.98×10^{-3} M

c. 2.51×10^{-3} M

d. 3.98×10^{-12} M

75) What is the value of $[OH^-]$ for a solution of magnesia with pOH = 3.5?

a. 3.16×10^{-3} M

b. 3.16×10^{-10} M

c. 3.16×10^{-4} M

d. 3.16×10^{-11} M

76) What is the value of $[OH^-]$ for household ammonia with pH = 11.9?

a. 7.94×10^{-3} M

b. 1.25×10^{-12} M

c. 7.94×10^{-12} M

d. 1.25×10^{-3} M

Molarity and pH of strong acids

A strong acid is 100% ionized, which means it has 100% ions (for monoprotic acids).

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$$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$$
1 mol/L 1 mol/L 1 mol/L

An acid with a concentration of 1 mol/L produces 1 mol H^+ per liter (for monoprotic acids).

7 $[H^+] = [acid] \times H$ number

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Molarity and pH for strong bases

The strong base disintegrates completely.

$$NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$$
1 mol/L 1 mol/L 1 mol/L

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A base with a concentration of 1 mol/L produces 1 mol OH^- per liter (for monohydroxide bases).

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$$Ca(OH)_{2(aq)} \rightarrow Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$$
1 mol/L 1 mol/L 2 mol/L

A base with a concentration of 1 mol/L produces 2 mol OH^- per liter (for dihydroxide bases).

8 $[OH^-] = [base] \times OH$ number

77) What is the pH value of the solution having concentration: 0.02 M HI?

a. 13.30

b. 0.69

c. 12.30

d. 1.69

78) What is the pH value of the solution having concentration: 2.4×10^{-5} M $Mg(OH)_2$?

a. 9.68

b. 4.31

c. 4.61

d. 9.38

79) What is the pOH value of the solution having concentration: 1×10^{-3} M KOH?

a. 2.69

b. 11.30

c. 3

d. 11

80) What is the pOH value of the solution having concentration: 0.05 M HNO_3?

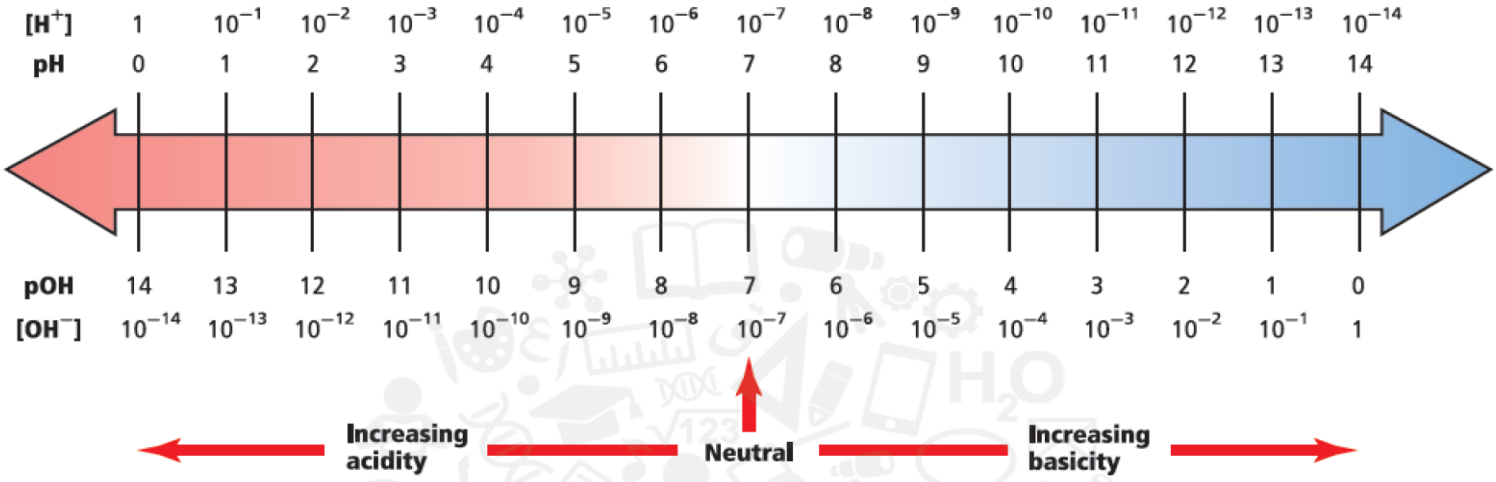
a. 1

b. 13

c. 1.30

d. 12.69

The relationship between pH, pOH, $[H^+]$, $[OH^-]$



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Types of solutions

acidic	neutral	basic
$[H^+] > [OH^-]$	$[H^+] = [OH^-]$	$[OH^-] > [H^+]$
$[H^+] > 1\times10^{-7}$ mol/L	$[H^+] = [OH^-] = 1\times10^{-7}$ mol/L	$[OH^-] > 1\times10^{-7}$ mol/L
pH < 7 ; pH < pOH	pH = pOH = 7	pH > 7 ; pH > pOH

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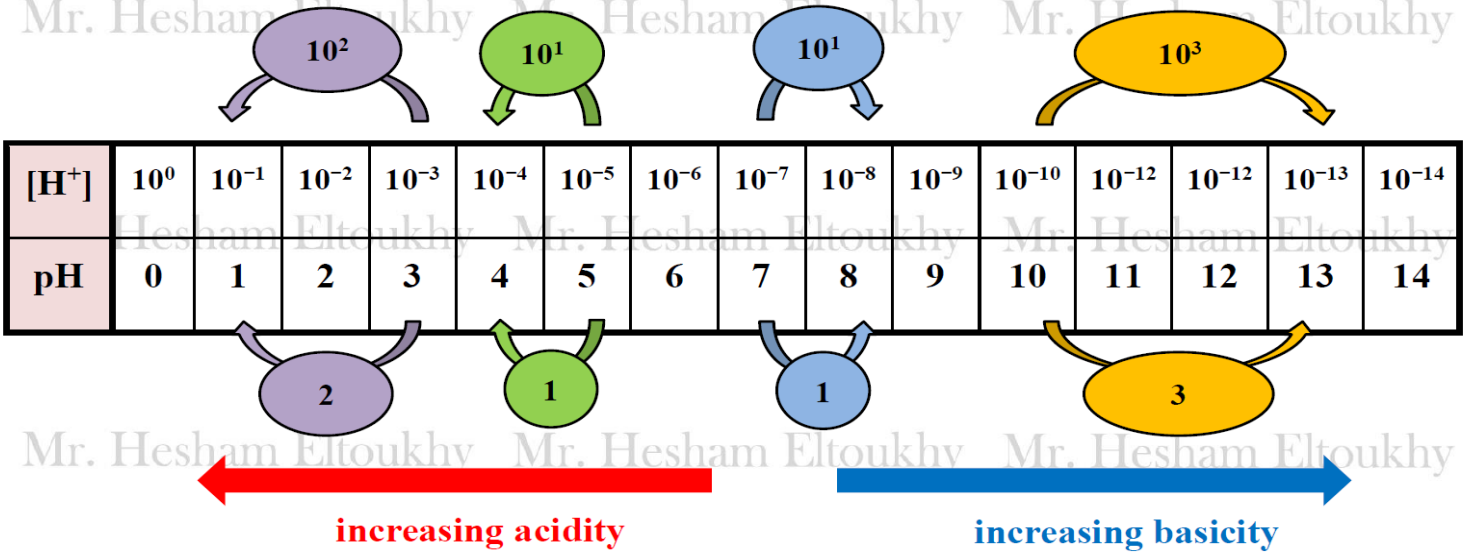
As the pH changes by 1, the concentration of the H^+ ion changes by 10

As pOH changes by 1, the concentration of the OH^- ion changes by 10

What is the hydrogen ion concentration when comparing a solution of pH = 3 with a solution of pH = 4?

→ A solution with a pH of 3 has 10 times more $[H^+]$ than a solution with a pH of 4

pH change	From 3 to 1 3 – 1 = 2	From 5 to 4 5 – 4 = 1	From 7 to 8 8 – 7 = 1	From 10 to 13 13 – 10 = 3
$[H^+]$ change	10^2	10^1	10^1	10^3



81) Based on the following data, which of the following statements is true?

a. the acidity of solution B is 3 times the acidity of solution A

b. the acidity of solution A is 3 times the acidity of solution B

c. the acidity of solution B is 10^3 times the acidity of solution A

d. the acidity of solution A is 10^3 times the acidity of solution B

substance	pH
A	2
B	5

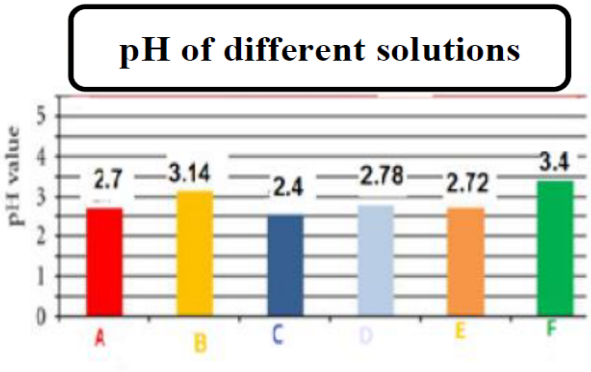
82) Using the adjacent graph, based on the two H^+ ion concentrations, how many times more acidic, is the most acidic solution than the least acidic solution?

a. 1000

b. 1

c. 10

d. 100



Calculate K_a from pH and Calculate K_b from pOH

Weak acids and bases ionize partially,
so, K_a and K_b values must be used to determine the $[H^+]$ and $[OH^-]$ ions

Why can't $[H^+]$ be obtained directly from the molarity of a weak acid?

Because a weak acid ionizes partially, one mole of acid does not produce a mole of H^+ ions

9 $$K_a = \frac{[H^+]^2}{[acid] - [H^+]}$$

10 $$K_b = \frac{[OH^-]^2}{[base] - [OH^-]}$$

83) What is the K_a value of a 0.04 M $HClO_2$ solution with pH = 1.8?

a. 0.01

b. 0.65

c. 0.39

d. 6.27×10^{-3}

84) What is the K_a value of HCOOH, if the pH is 2.38 for a 0.1 M HCOOH solution?

a. 0.0435

b. 1.81×10^{-4}

c. 0.0416

d. 1.73×10^{-4}

85) What is the K_a value of a C_6H_5COOH benzoic acid solution with a concentration of 0.0033 M and pOH = 10.7?

a. 0.179

b. 6.04×10^{-9}

c. 1.20×10^{-19}

d. 8.97×10^{-5}

86) What is the K_a value of a 0.22 M H_3AsO_4 acid solution and pH = 1.5?

a. 4.54×10^{-3}

b. 0.143

c. 0.167

d. 5.30×10^{-3}

87) What is the K_a value of a 0.1 M HCNO solution and pOH = 11.0?

a. 1.01×10^{-5}

b. 1.01×10^{-12}

c. 1.0×10^{-21}

d. 1.0×10^{-10}

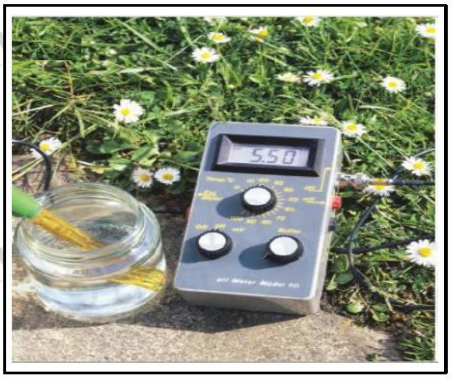
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pH measurement

litmus paper	pH paper	pH meter
determine the nature of a substance, an acid or a base	determine the pH value of the solution	gives a direct digital reading of pH





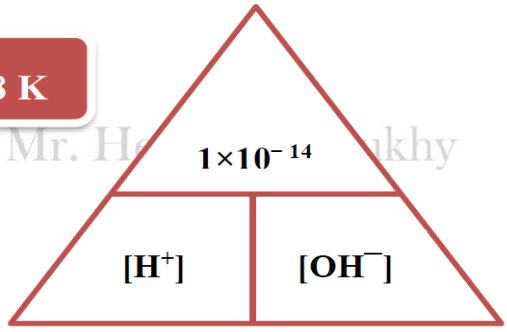


pH papers are treated with one or more substances called indicators.

The pH meter gives a more accurate measurement of pH

pH, pOH calculations

1 $1 \times 10^{-14} = [H^+][OH^-]$ — 298 K



2 $pH = -\log [H^+]$

3 $pOH = -\log [OH^-]$

4 $pH + pOH = 14$ — 298 K

5 $[H^+] = 10^{-pH}$

6 $[OH^-] = 10^{-pOH}$

calculate $[H^+]$, $[OH^-]$ from pH, pOH

7 $[H^+] = [acid] \times H$ number

8 $[OH^-] = [base] \times OH$ number

only strong acids and strong bases

Calculation of K_a for weak acids

9 $K_a = \frac{[H^+]^2}{[acid] - [H^+]}$

$K_a = \frac{(10^{-pH})^2}{[acid] - (10^{-pH})}$

Calculation of K_b for weak bases

10 $K_b = \frac{[OH^-]^2}{[base] - [OH^-]}$

$K_b = \frac{(10^{-pOH})^2}{[base] - (10^{-pOH})}$

88) What is the pOH value of a solution of $[H^+]$ = 0.000033 M at 298 K?

a. 9.51

b. 4.48

c. 10.51

d. 3.48

89) What is the pH value of a solution having $[OH^-]$ = 0.0095 M at 298 K?

a. 10.97

b. 3.02

c. 11.97

d. 2.02

90) What is the value of $[H^+]$ for the blood of a healthy person with a pH of 7.40?

a. 2.51×10^{-8} M

b. 3.98×10^{-7} M

c. 2.51×10^{-7} M

d. 3.98×10^{-8} M

91) What is the value of $[OH^-]$ in a seawater sample where pOH = 5.60?

a. 3.98×10^{-9} M

b. 2.51×10^{-6} M

c. 3.98×10^{-8} M

d. 2.51×10^{-7} M

92) What is the value of $[OH^-]$ for a tomato if the pH of a tomato is 4.50?

a. 3.16×10^{-5} M

b. 3.16×10^{-10} M

c. 3.98×10^{-6} M

d. 2.51×10^{-9} M

93) What is the pH of a solution containing 1.0×10^{-9} mol/L of OH^- ions in the solution?

a. 10

b. 9

c. 4

d. 5

94) What is the pOH value of an aqueous solution containing 1×10^{-3} mol of HCl dissolved in a 5 L solution at 298 K?

a. 3.7

b. 10.3

c. 3.0

d. 11.0

95) What is $[OH^-]$ in an aqueous solution at 298 K such that $[H^+] = 5.40 \times 10^{-3}$ M?

a. 5.40×10^{-3} M

b. 1.85×10^{-12} M

c. 3.42×10^{-10} M

d. 3.16×10^{-17} M

96) What is $[H^+]$ in an aqueous solution at 298 K such that $[OH^-] = 8.2 \times 10^{-6}$ M?

a. 2.51×10^{-9} M

b. 3.98×10^{-5} M

c. 1.21×10^{-9} M

d. 1.21×10^{-23} M

88	a	89	c	90	d	91	b	92	b
93	d	94	b	95	b	96	c		

Sec. (4) Neutralization

Neutralization reaction: A reaction between an acid and a base in an aqueous solution to produce a salt and water.

The neutralization reaction is a type of double replacement reaction.

acid + base → salt + water

$HX + YOH \rightarrow XY + H_2O$

Salt: An ionic compound composed of cation(positive ion) of base and an anion (negative ion) of an acid.

Antacids relieve indigestion symptoms by neutralizing the acidic solution in the stomach.

A neutralization reaction occurs when $Mg(OH)_2$ reacts with a solution of HCl acid.

$$2HCl_{(aq)} + Mg(OH)_{2(aq)} \rightarrow MgCl_{2(aq)} + 2H_2O_{(l)}$$

A neutralization reaction occurs when NaOH reacts with an acid solution of HCl

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

These compounds exist as ions in aqueous solution:

$$H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$$

Na^+ and Cl^- are spectator ions.

Net ionic equation:

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

or

$$H_3O^+_{(aq)} + OH^-_{(aq)} \rightarrow 2H_2O_{(l)}$$

97) What compound is always produced from a neutralization reaction?

a. $H_2O_{(l)}$

b. $Ca(OH)_{2(s)}$

c. $HNO_{3(aq)}$

d. $H_3PO_{4(aq)}$

98) What are the two substances produced when $HCl_{(aq)}$ is neutralized with $KOH_{(aq)}$?

a. $KH_{(aq)}$, $HClO_{(aq)}$

b. $KCl_{(aq)}$, $H_2O_{(l)}$

c. $Cl^-_{(aq)}$, $KH_2O^+_{(aq)}$

d. $KCl_{(aq)}$, $H_3O^+_{(aq)}$

99) What acid and base must react to produce an aqueous solution of sodium iodide?

a. HI, NaOH

b. H_2O, NaI

c. H_2I, NaOH

d. HI, $Na(OH)_2$

100) What are products of the neutralization reaction of $NaOH_{(aq)}$ and $HBr_{(aq)}$?

a. $NaH_{(aq)} + HBrO_{(aq)}$

b. $Br^-_{(aq)} + NaH_2O^+_{(aq)}$

c. $H_3O^+_{(aq)} + NaBr_{(aq)}$

d. $H_2O_{(l)} + NaBr_{(aq)}$

101) What is the net ionic equation for the reaction of HNO_3 with KOH solutions?

a. $H_3O^+_{(aq)} + OH^-_{(aq)} \rightarrow 2H_2O_{(l)}$

b. $K^+_{(aq)} + OH^-_{(aq)} \rightarrow KOH_{(s)}$

c. $H^+_{(aq)} + NO_3^-_{(aq)} \rightarrow HNO_{3(aq)}$

d. $K^+_{(aq)} + NO_3^-_{(aq)} \rightarrow KNO_{3(aq)}$

102) What are the spectator ions produced by neutralizing HCl with $Mg(OH)_2$ solutions?

a. H^+, OH^-

b. H^+, Cl^-

c. Mg^{2+}, OH^-

d. Mg^{2+}, Cl^-

Acid-base indicators

Chemists use chemical dyes instead of a pH scale to determine the equivalence point of a titration.

Acid-base indicators: chemical dyes whose colors are affected by acid and base solutions.

Each indicator has its pH range at which the color change occurs (indicator's range)

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indicator's range

less than range	in the range	more than range
acid color	endpoint color	base color

Example: phenolphthalein indicator has a range (8-10), and the colors are:

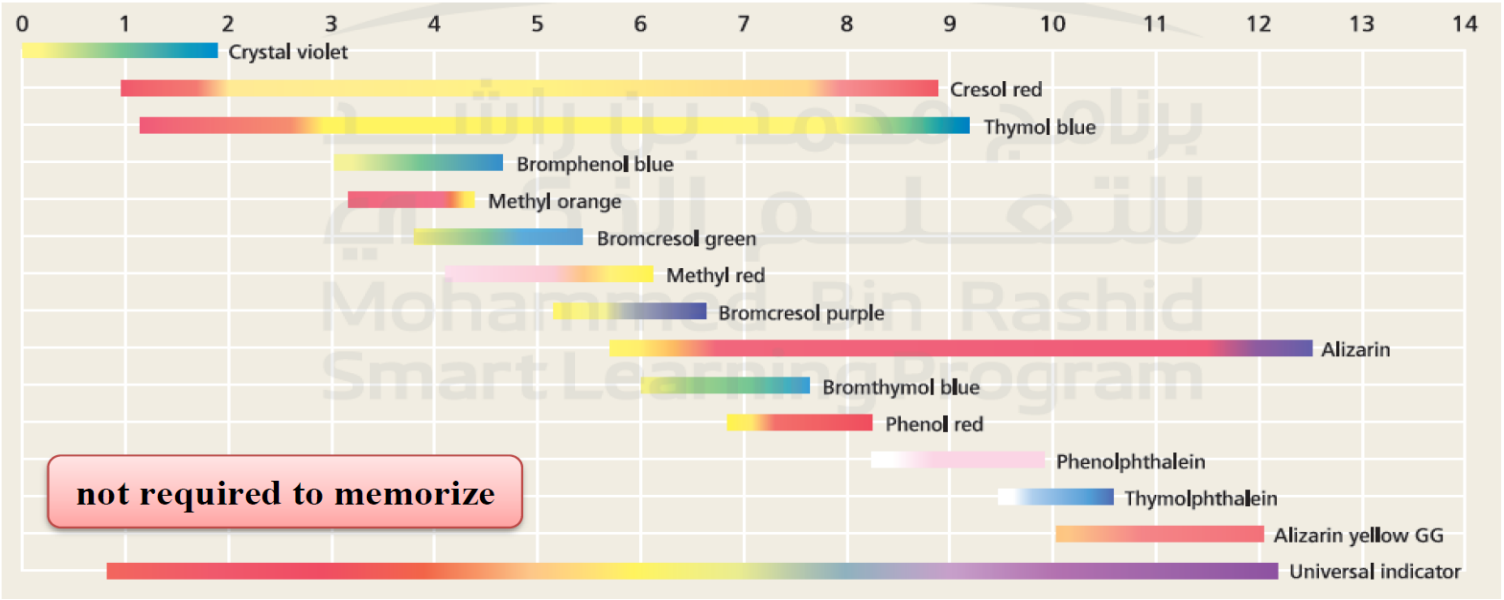
less than 8	8	8 – 10	10	more than 10
colorless		pink		purple

Endpoint: The point at which the indicator used in the titration changes color.

Why does tea color's changes when lemon juice is added to it?

Tea contains polyphenols with ionized hydrogen atoms, so they are weak acids. The addition of acid (lemon juice) slows down the ionization process and the color of the non-ionized polyphenols becomes more pronounced.





Titration: A method of concentrating a solution by reacting a known volume of that solution with a solution of known concentration.

titration solution and the equivalence point	strong acid	weak acid
strong base	neutral (pH = 7)	basic (pH > 7)
weak base	acidic (pH < 7)	no titration

Equivalence point: the point at which moles of the H^+ ion of the acid is equal to the moles of the OH^- ion of the base.

To find the concentration of an acid solution we titrate the acid solution with a base solution of known concentration.

To find the concentration of the base solution we titrate the base solution with an acid solution of known concentration.

Titration steps (acid of unknown concentration - base of known concentration)

1) A known volume of an acidic solution of unknown concentration is placed in a beaker, and the pH is measured using a pH meter.

2) The burette is filled with a base solution of known concentration, called the standard solution or titrant solution.

3) The base is added from the burette to the acid in the beaker slowly with stirring, the pH reading is recorded after each addition, this process continues until the reaction reaches the equivalence point.

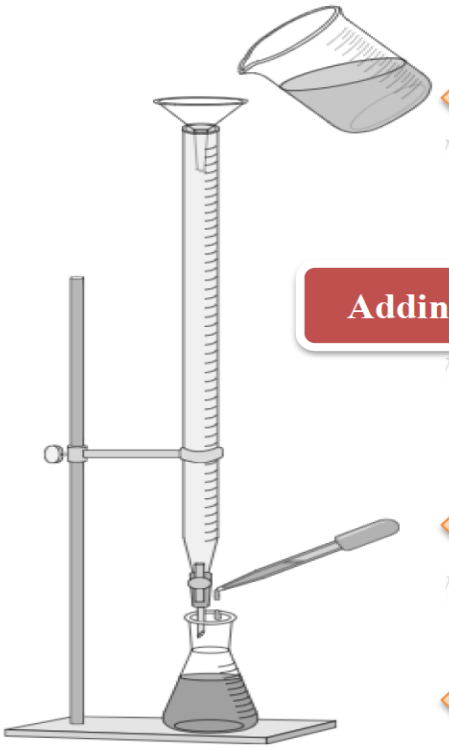
Titration of an acid of unknown concentration - a base of known concentration

4) open the burette and slowly add the base until you reach the endpoint color

5) close the burette and the volume of the base used to reach the equivalence point is measured

6) repeat the titration process three times to ensure the accuracy of the calculations

7) use the calculations to calculate the acid concentration used in the titration process



Adding the base to the acid

3) fill the burette with the base of the known concentration

2) put 3 drops of the appropriate indicator for titration

1) put a known volume of acid of unknown concentration

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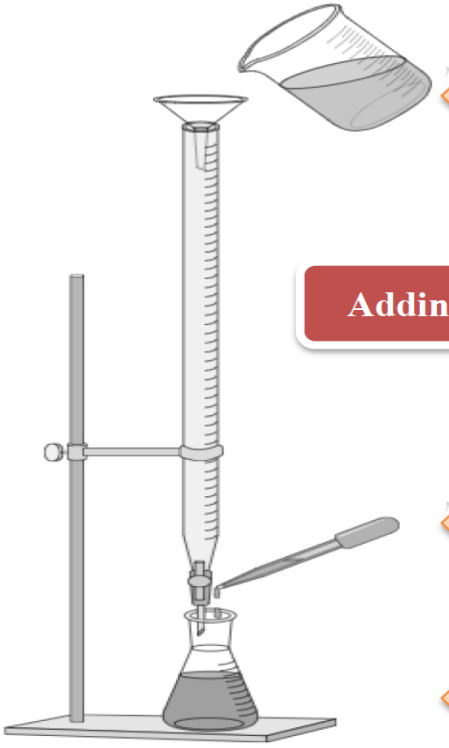
Titration of a base of unknown concentration - an acid of known concentration

4) open the burette and slowly add the acid until you reach the endpoint color

5) close the burette and the volume of the acid used to reach the equivalence point is measured

6) repeat the titration process three times to ensure the accuracy of the calculations

7) use the calculations to calculate the base concentration used in the titration process



Adding the acid to the base

3) fill the burette with the acid of the known concentration

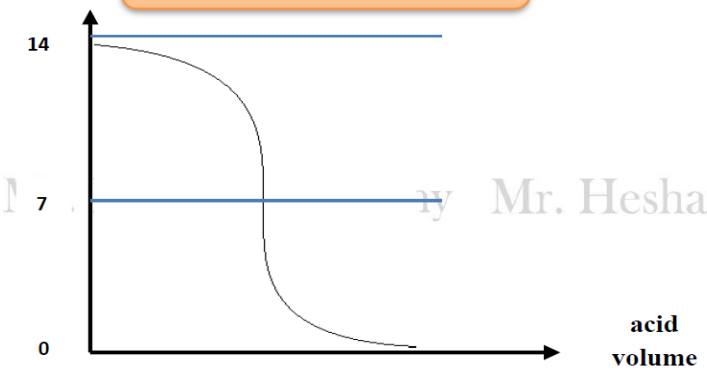
2) put 3 drops of the appropriate indicator for titration

1) put a known volume of base of unknown concentration

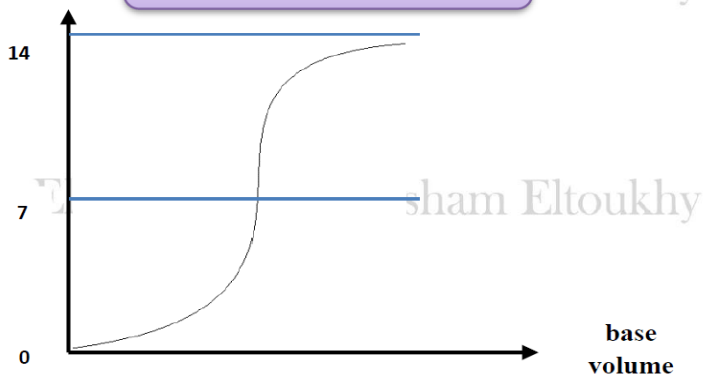
Types of titrations

Strong acid - strong base

add acid to base

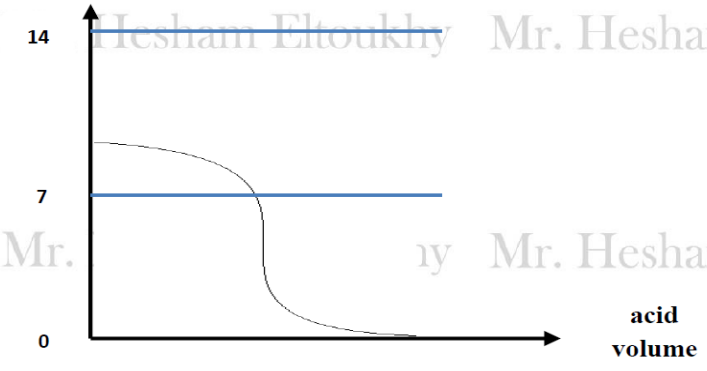


add base to acid

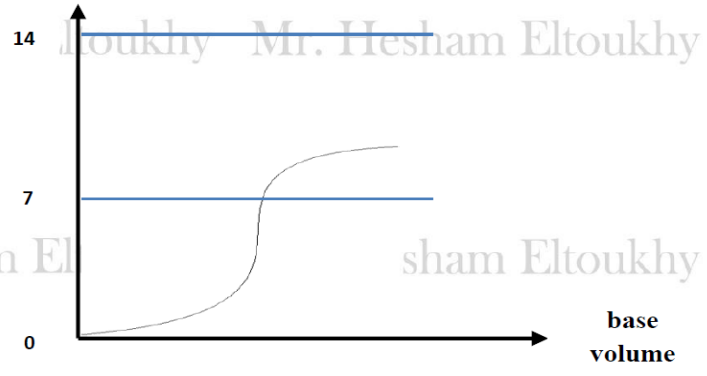


Strong acid - weak base

add acid to base

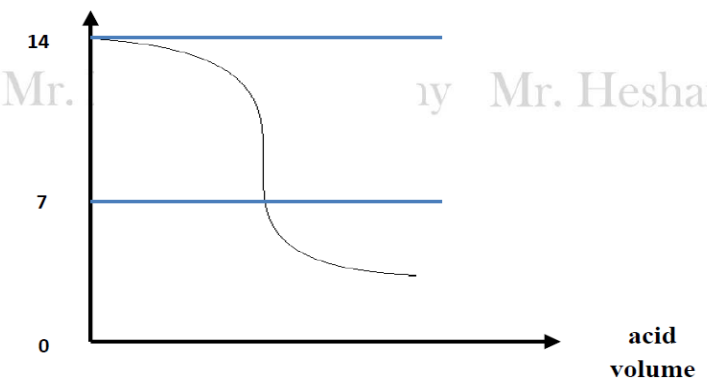


add base to acid

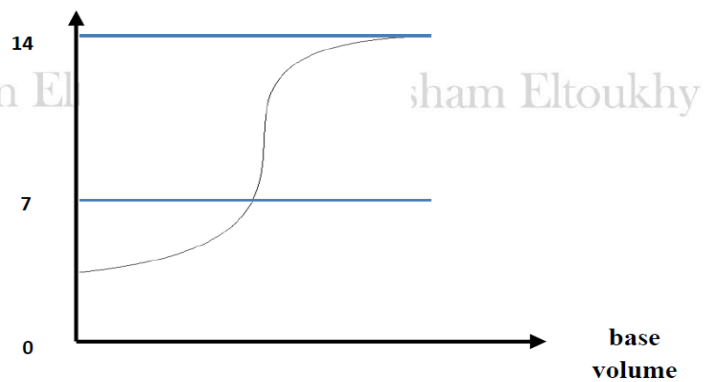


Weak acid - strong base

add acid to base

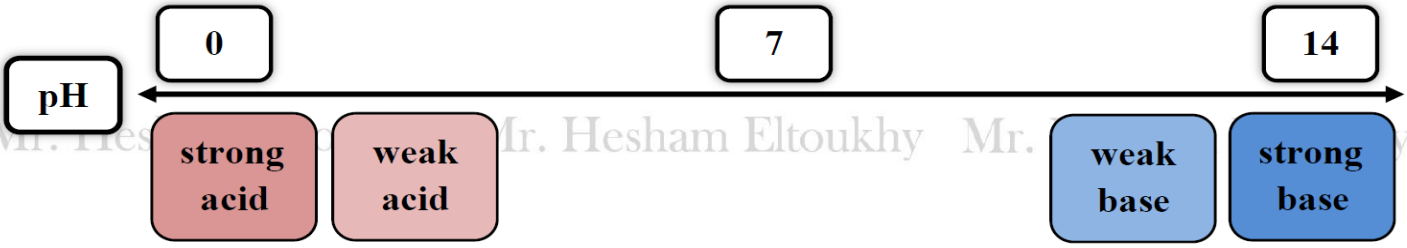


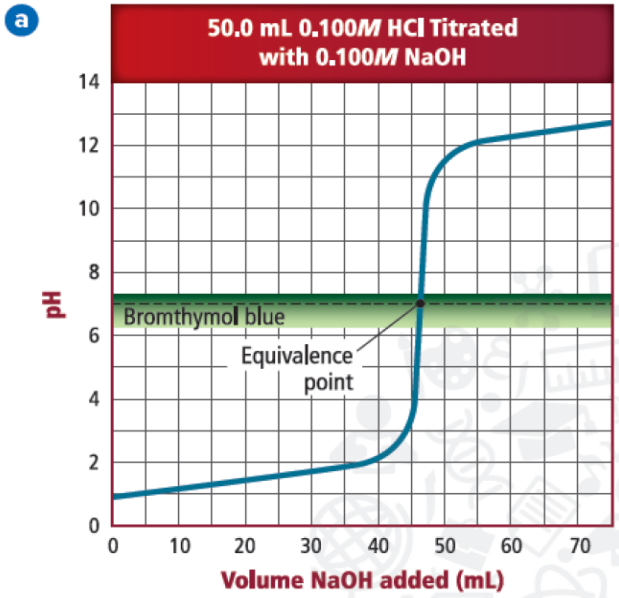
add base to acid

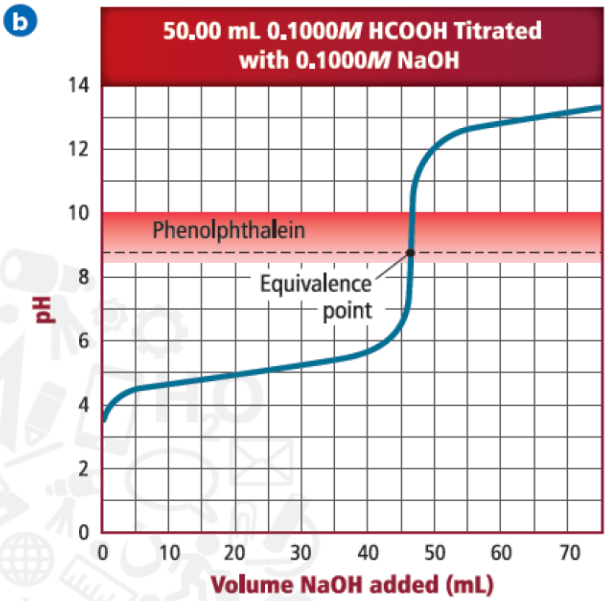


When the base is added to the acid in the titration process, the pH increases dramatically when the equivalence point is reached

When the acid is added to the base in the titration process, the pH decreases dramatically when the equivalence point is reached







103) What is the expected pH value at the equivalence point in a titration of a strong acid and a weak base?

a. 9

b. 7

c. 5

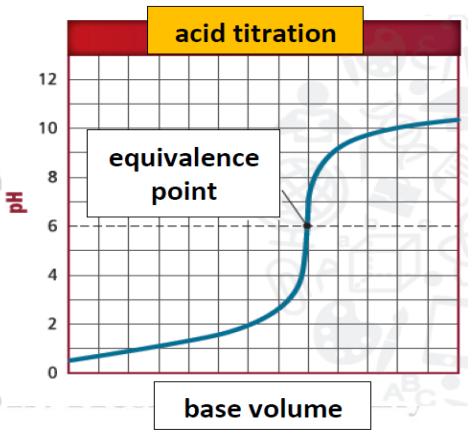
d. 1

104) When acid A reacts with base B, it produces compound C, which has a pH value of less than 7. What is the correct prediction for the strength of A and B?

choice	a.	b.	c.	d.
A	weak	strong	strong	weak
B	strong	weak	strong	weak

105) What acid-base indicator shown in the table will be suitable for a neutralization reaction whose titration curve is shown in figure?

Indicator	bromocresol purple	crystal violet	methyl orange	phenolphthalein
Range	5.2 – 6.8	0 – 1.9	3.1 – 4.4	8 – 10



a. methyl orange

b. phenolphthalein

c. bromocresol purple

d. crystal violet

Use the corresponding graph to answer the questions (106,107)

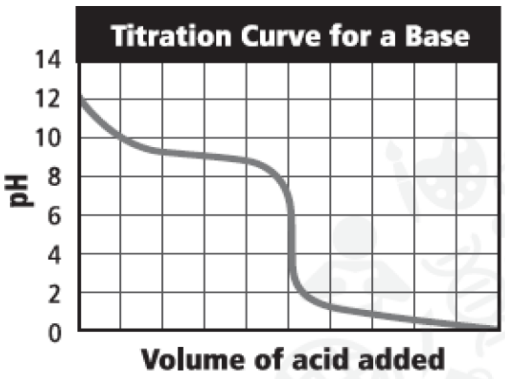
106) What is the pH value at the equivalence point of this titration?

a. 10

b. 9

c. 5

d. 1



107) What indicator would be effective for determining the endpoint of this titration?

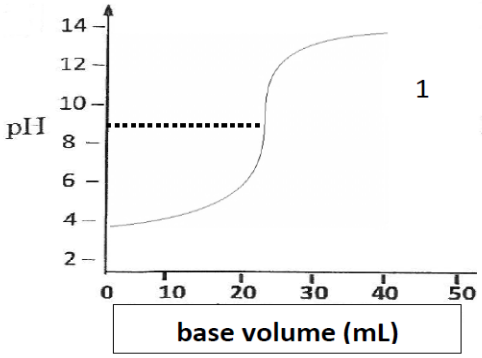
a. methyl orange (range 3.2 - 4.4)

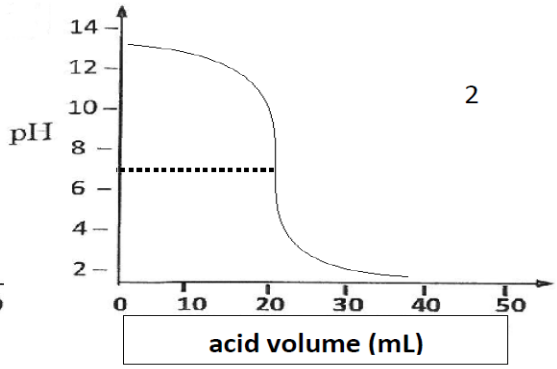
b. bromocresol (range 3.8 - 5.4)

c. phenolphthalein (range 8.2-10)

d. thymol blue (range 8.0 - 9.6)

Using titration curves and indicators table, answer the following questions. (108-111)





Indicator	Range
A	3.1 – 4.4
B	6.2 – 7.6
C	8 – 10

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108) What type of acid and base are used in titration (1)?

choice	a.	b.	c.	d.
acid	weak	strong	strong	weak
base	strong	weak	strong	weak

109) What is the pH value of the equivalence point of titration (2)?

a. 3 b. 10

c. 13 d. 7

110) What is the appropriate indicator symbol for the titration (1)?

a. C b. A

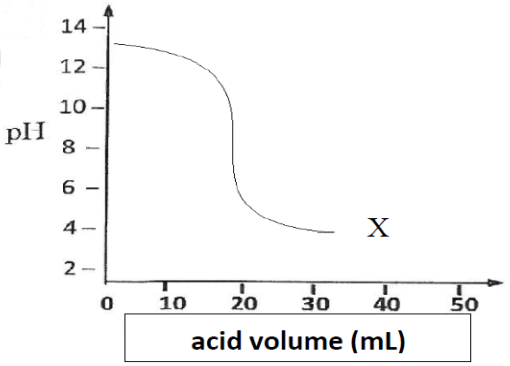
c. B d. all is not suitable

111) What substance is added from the burette in titration (2)?

a. strong base b. weak base

c. strong acid d. weak acid

Study the titration curve and answer the questions. (112-114)



112) What is the nature of the excess matter at point X?

a. strong base b. weak base

c. strong acid d. weak acid

113) What is the nature of the material that is gradually added from the burette to the beaker for the titration process?

a. strong base b. weak base

c. strong acid d. weak acid

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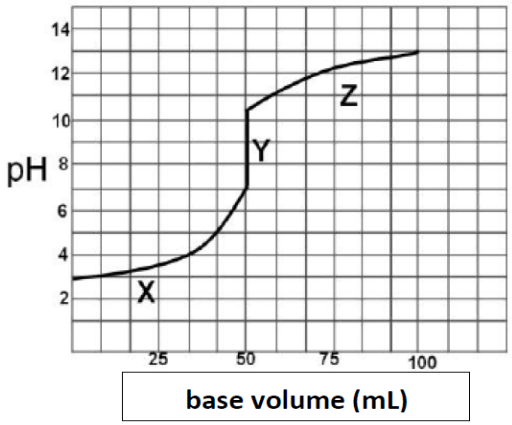
114) What is the pH value of the equivalence point in this titration?

a. 9 b. 3

c. 7 d. 14

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Study the adjacent figure and answer the following questions. (115-119)



115) Which of the following symbols represents the equivalence point?

a. X b. Z c. Y

116) Which of the following symbols is the acid in excess?

a. Y b. X c. Z

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117) How much volume (mL) does the base need to add to completely neutralize the acid

a. 25 b. 75 c. 50

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118) What is the acid and base strength of this titration?

choice	a.	b.	c.	d.
acid	weak	strong	strong	weak
base	strong	weak	strong	weak

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119) Which of the following indicators is suitable for this titration?

a. bromothymol blue

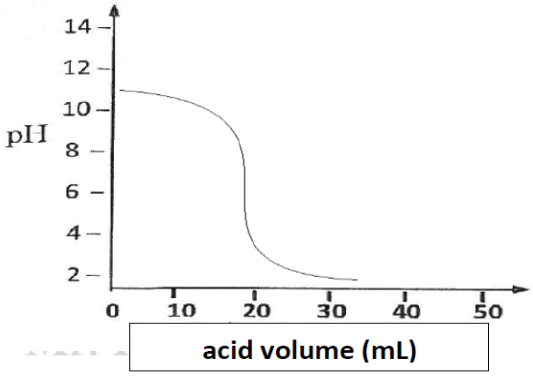
b. phenolphthalein

c. methyl orange

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Indicator	
methyl orange	3.1 – 4.4
bromothymol blue	6.2 – 7.6
phenolphthalein	8 – 10

The adjacent figure represents an acid-base titration curve. Note the relationship between the volume of acid added and the pH values, then answer the questions. (120-122)



120) What is the pH value of the equivalence point in this titration?

a. 9.5 b. 1

c. 11 d. 5.5

121) How can the relationship between the neutralization point and the equivalence point be described in this titration?

a. equivalence point = neutralization point

b. equivalence point > neutralization point

c. equivalence point < neutralization point

122) Which of the following indicators is suitable for this titration?

a. phenol red

b. phenolphthalein

c. methyl red

Indicator	Range
methyl red	4.2 – 6.2
phenol red	6.4 – 8.0
phenolphthalein	8 – 10

Consider the following table and answer the following questions. (123, 124)

indicator	range	color		
		before range	in range	after range
phenolphthalein	8 – 10	colorless	pink	purple
phenol red	6.4 – 8	yellow	light yellow	pink
bromophenol blue	3 – 4.6	yellow	pink	purple

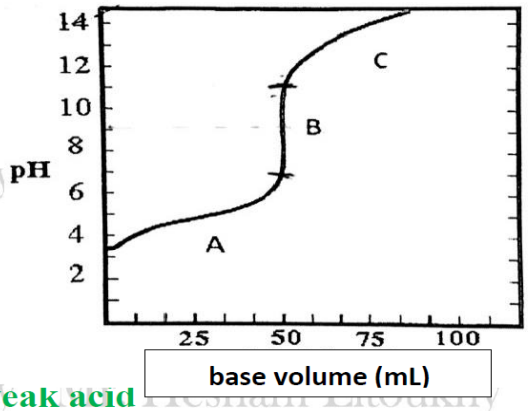
123) What is the appropriate indicator to titrate CH_3COOH with the base NaOH?

a. phenol red b. phenolphthalein c. bromophenol blue

124) What is the pH value of a solution that gives a purple color with bromophenol blue indicator and a yellow color with phenol red indicator?

a. 4.6 b. 6.4 c. 5.5 d. 7.5

Study the titration curve and answer the following questions. (125-129)



125) What does the symbol (B) on the curve represent?

a. neutralization point

b. end-point

c. equivalence point

126) What is the nature of substance at (C)?

a. strong base b. weak base d. weak acid

127) What is the expected pH value of a salt solution at its equivalence point?

a. 14 b. 7 c. 3 d. 9

128) Which of these pairs of solutions does the titration curve apply to?

a. CH_3COOH, NH_4OH b. HCl, NaOH

c. HCl, NH_4OH d. CH_3COOH, NaOH

129) Which of the following indicators is suitable for this titration?

a. bromothymol blue

b. phenolphthalein

c. methyl orange

Indicator	Range
methyl orange	3.1 – 4.4
bromothymol blue	6.2 – 7.6
phenolphthalein	8 – 10

Consider the following table and answer the following questions. (130, 131)

indicator	range	acid color	range color	base color
phenolphthalein	8 – 10	colorless	light pink	pink
bromophenol blue	3 – 4.6	yellow	light pink	purple
bromothymol blue	6.2 – 7.6	yellow	light green	purple

130) What is the appropriate indicator to titrate HBr with KOH?

a. bromothymol blue b. phenolphthalein c. bromophenol blue

131) What is the pH value of a solution that gives a purple color with bromophenol blue indicator and is colorless with phenolphthalein indicator?

a. 6.3 b. 2.5 c. 8.7 d. 9.6

Titration Caculations

First, you must write a balanced chemical equation between the acid and the base to determine the molar ratio.

1) Calculate the number of moles of the substance of known concentration (for the given).

$$n = M \times V$$

2) Calculate the number of moles of the unknown (for the unknown).

$$\text{given mol} \times \frac{\text{unknown mol}}{\text{given mol}}$$

3) Calculate molarity or volume (for the unknown).

$$M = \frac{n}{V} \qquad V = \frac{n}{M}$$

Or use formula

$$\frac{M \times V}{n}\ (\text{acid}) = \frac{M \times V}{n}\ (\text{base})$$

quantity		unit
symbol	meaning	
M	molarity	M or (mol/L)
V	volume	L
n	mol number	mol

Acid-base ratios in titration

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

1 mol 1 mol

$$2HCl_{(aq)} + Mg(OH)_{2\ (aq)} \rightarrow MgCl_{2\ (aq)} + 2H_2O_{(l)}$$

2 mol 1 mol

132) If 44 mL of a 0.1 M KOH solution is needed for an equation of 20 mL of nitric acid HNO_3, what is the molarity of the acid solution?

a. 0.11 M

b. 0.22 M

c. 0.02 M

d. 1.14 M

HNO_3	KOH
M =	M =
V =	V =
n =	n =

133) In an acid-base titration 46 mL of a sulfuric acid solution is titrated to the endpoint of 74 mL of a 0.4 M NaOH solution, what is the molarity of the H_2SO_4 solution?

a. 0.08 M

b. 0.64 M

c. 0.16 M

d. 0.32 M

H_2SO_4	NaOH
M =	M =
V =	V =
n =	n =

134) How many milliliters (volume) of 0.5 M NaOH equal 25 mL of 0.1 M H_3PO_4?

a. 15 mL

b. 45 mL

c. 5 mL

d. 30 mL

H_3PO_4	NaOH
M =	M =
V =	V =
n =	n =

135) How many milliliters of 0.225 M HCl are needed to titrate 6.0 g in 1 L of KOH?

(KOH = 56 g/mol)

a. 952 mL

b. 238 mL

c. 476 mL

d. 1904 mL

HCl	KOH
M =	M =
V =	V =
n =	n =

136) In a titration it was found that 25 mL of $Ba(OH)_2$ solution equilibrated with 10 mL of 0.066 M HCl solution to reach the equivalence point. What is the base concentration in g/L. ($Ba(OH)_2$ = 171 g/mol)

a. 4.51 g/L

b. 1.54×10^{-4} g/L

c. 2.26 g/L

d. 7.72×10^{-5} g/L

HCl	$Ba(OH)_2$
M =	M =
V =	V =
n =	n =

137) If 50 mL of 0.6 M HCl is needed to neutralize 25 mL of NH_4OH ammonia solution used for household cleaning. What is the concentration of ammonia solution?

a. 2.4 M

b. 1.2 M

c. 3.6 M

d. 0.6 M

HCl	NH_4OH
M =	M =
V =	V =
n =	n =

138) A volume of 18.5 mL of a standard solution of 0.1 M NaOH is required to equalize 25 mL of the HCOOH acid solution. What is the molarity of methanoic acid?

a. 0.296 M

b. 0.025 M

c. 0.222 M

d. 0.074 M

HCOOH	NaOH
M =	M =
V =	V =
n =	n =

139) For a titration of 118 mL of a H_3PO_4 acid solution, a volume of 114 mL of a 0.8 M NaOH solution is needed, what is the concentration of the acid?

a. 0.26 M

b. 0.77 M

c. 0.086 M

d. 1.04 M

H_3PO_4	NaOH
M =	M =
V =	V =
n =	n =

140) If 30 mL of 0.1 M NaOH is required to titrate 25 mL of HBr what is the molarity of the acid when the equivalence point is reached?

a. 1.2 M

b. 0.12 M

c. 2.4 M

d. 0.6 M

HBr	NaOH
M =	M =
V =	V =
n =	n =

141) In a titration experiment, a sample of 0.2 M NaOH solution needed 20 mL of 0.15 M acetic acid CH_3COOH solution, what was the volume of the NaOH sample?

a. 45 mL

b. 60 mL

c. 15 mL

d. 30 mL

CH_3COOH	NaOH
M =	M =
V =	V =
n =	n =

142) In a titration, 25 mL of 0.02 M H_2SO_4 solution was added to 100 mL of NaOH solution of unknown concentration to reach the equivalence point. What is the molarity of a basic solution?

a. 1.0 M

b. 2.0 M

c. 0.02 M

d. 0.01 M

H_2SO_4	NaOH
M =	M =
V =	V =
n =	n =

143) Calculate the molarity of a solution of HCl, if you know that 15 mL of HCl is equivalent to 20 mL of a 1.5×10^{-2} M solution of $Ca(OH)_2$?

a. 0.04 M

b. 0.08 M

c. 0.02 M

d. 0.01 M

HCl	$Ca(OH)_2$
M =	M =
V =	V =
n =	n =

140	b	141	c	142	d	143	a		

Salt Hydrolysis

Hydrolysis

dissociated salt cations donate hydrogen ions H^+ to water

$$XH^+_{(aq)} + H_2O_{(l)} \rightleftarrows X_{(aq)} + H_3O^+_{(aq)}$$

hydrolysis of the cation (produces an acidic solution)

dissociated salt anions accept hydrogen ions H^+ from water

$$Y^-_{(aq)} + H_2O_{(l)} \rightleftarrows HY_{(aq)} + OH^-_{(aq)}$$

hydrolysis of the anion (produces basic solution)

Why does hydrolysis happen to weak acids and weak bases?

→ **Because the ionization is incomplete, and the reaction is reversible.**

To find out the acid and base that make up the salt

cation (+) is added to → **OH^-** → **We get the base**

anion (–) is added to → **H^+** → **We get the acid**

Salts that produce basic solutions

Potassium fluoride KF dissociates into K^+, F^- ions in water.

$$KF_{(s)} \rightarrow K^+_{(aq)} + F^-_{(aq)}$$

K^+ does not react with water ← **result from strong base KOH**

result from weak acid HF → **F^- reacts with water**

$$F^-_{(aq)} + H_2O_{(l)} \rightleftarrows HF_{(aq)} + OH^-_{(aq)}$$

It produces OH^- ions, making the solution basic.

Salts that produce acidic solutions

Ammonium chloride NH_4Cl dissociates into NH_4^+, Cl^- ions in water

$$NH_4Cl_{(s)} \rightarrow NH_4^+{}_{(aq)} + Cl^-{}_{(aq)}$$

- NH_4^+ reacts with water ← result from weak base NH_4OH
- result from strong acid HCl → Cl^- does not react with water

$$NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O^+{}_{(aq)}$$

H_3O^+ ions are produced, making the solution acidic.

Salts that produce neutral solutions

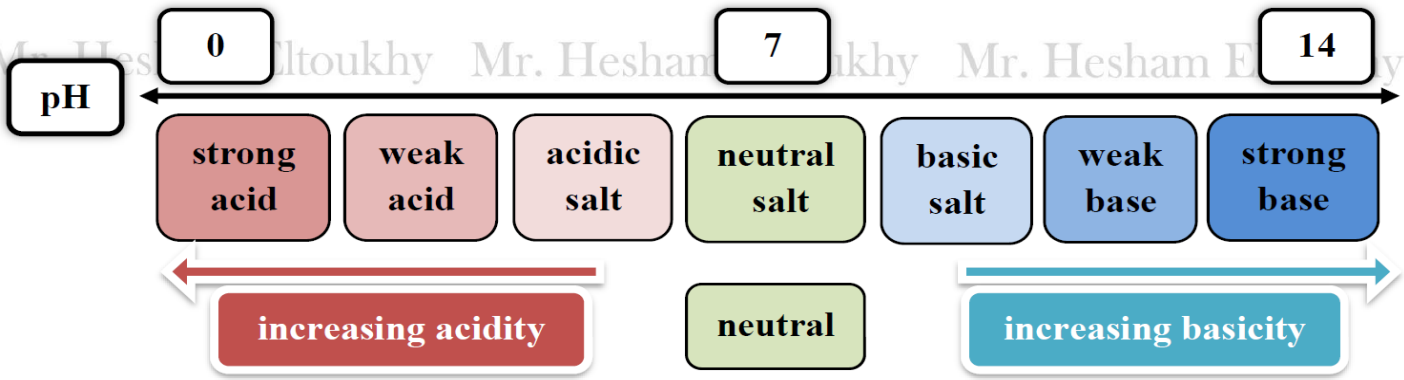
Sodium nitrate $NaNO_3$ decomposes into Na^+, NO_3^- ions in water

$$NaNO_{3(s)} \rightarrow Na^+{}_{(aq)} + NO_3^-{}_{(aq)}$$

- Na^+ does not react with water ← result from strong base NaOH
- result from strong acid HNO_3 → NO_3^- does not react with water

Little or no hydrolysis of this salt occurs.

The resulting salt solution is neutral.



144) Complete the table by writing the type of acid and base in terms of strength or weakness when the salt dissolves in water.

What is the type of salt (acidic, basic, or neutral).

Salt	Ions	Acid (H^+)		Base (OH^-)		Salt type
		formula	strengh	formula	strengh	
NaCl	Na^+, Cl^-	$H^+ + Cl^-$ → HCl		$Na^+ + OH^-$ → NaOH		
CaS	Ca^{2+}, S^{2-}	$H^+ + S^{2-}$ → H_2S		$Ca^{2+} + OH^-$ → $Ca(OH)_2$		
NH_4NO_3	NH_4^+, NO_3^-	$H^+ + NO_3^-$ → HNO_3		$NH_4^+ + OH^-$ → NH_4OH		
$KHCO_3$	K^+, HCO_3^-	$H^+ + HCO_3^-$ → H_2CO_3		$K^+ + OH^-$ → KOH		
NH_4Br	NH_4^+, Br^-	$H^+ + Br^-$ → HBr		$NH_4^+ + OH^-$ → NH_4OH		
K_2SO_4	K^+, SO_4^{2-}	$H^+ + SO_4^{2-}$ → H_2SO_4		$K^+ + OH^-$ → KOH		

145) Which of the following ions undergoes hydrolysis in aqueous solution?

a. PO_4^{3-}

b. NO_3^-

c. SO_4^{2-}

d. K^+

146) What kind of reaction takes place in an aqueous solution when a salt of a weak acid and a strong base is dissolved?

a. hydrolysis of water

b. hydrolysis of cation

c. hydrolysis of anion

d. hydrolysis of cation and anion

147) Which of the following salts undergoes hydrolysis for the cation only?

a. CH_3COONH_4

b. CH_3COOK

c. $(NH_4)_2SO_4$

d. Na_2SO_4

148) Which of the following solutions of salts does not hydrate any of the ions?

a. KF

b. Na_2S

c. NH_4Br

d. Na_2SO_4

149) Which of the following solutions of salts has a basic effect?

a. NaCl

b. Na_2CO_3

c. KNO_3

d. K_2SO_4

150) Which of the following solutions of salts does not have a pH value of 7?

a. $LiNO_3$

b. $KClO_4$

c. NaCl

d. NH_4Cl

151) Which of the following equations describes the hydrolysis of NH_4NO_3 in water?

a. $NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O^+{}_{(aq)}$

b. $NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftarrows NH_5^{2+}{}_{(aq)} + OH^-{}_{(aq)}$

c. $NO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows HNO_{3(aq)} + H_3O^+{}_{(aq)}$

d. $NO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows HNO_{3(aq)} + OH^-{}_{(aq)}$

152) Which of the following equations describes the hydrolysis of $CaCO_3$ in water?

a. $Ca^{2+}{}_{(aq)} + H_2O_{(l)} \rightleftarrows Ca(OH)_{2(aq)} + H_3O^+{}_{(aq)}$

b. $Ca^{2+}{}_{(aq)} + H_2O_{(l)} \rightleftarrows Ca(OH)_{2(aq)} + OH^-{}_{(aq)}$

c. $CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows HCO_3^-{}_{(aq)} + H_3O^+{}_{(aq)}$

d. $CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows HCO_3^-{}_{(aq)} + OH^-{}_{(aq)}$

153) Which of the following salt solutions does not hydrate in water?

a. $(NH_4)_2SO_4$

b. K_2SO_4

c. K_2CO_3

d. Na_2CO_3

154) What is the pH value and type of solution produced by titrating NH_4OH with HBr?

a. pH > 7, the salt solution is acidic

b. pH > 7, the salt solution is basic

c. pH < 7, the salt solution is acidic

d. pH < 7, the salt solution is basic

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Part Two (Questions with answers)

Additional questions on each section with answers at the end of each section.

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Section (1) Practices

Glossary	
Self-ionization of water	The reaction between water molecules to produce a hydronium ion H_3O^+ and hydroxide ion OH^-
Hydronium ion	A hydrogen ion bound to a water molecule by a covalent bond.
Arrhenius acid	A substance containing hydrogen that ionizes in aqueous solutions to produce the hydrogen ion H^+.
Arrhenius base	A substance that contains a hydroxide group and dissociates in aqueous solutions to produce a hydroxide ion.
Bronsted-Lowry acid	A hydrogen ion donor.
Bronsted-Lowry base	A hydrogen ion acceptor.
Conjugate acid	The chemical compound that is produced when a base accepts a hydrogen ion from an acid.
Conjugate base	The chemical compound that is produced when an acid donates a hydrogen ion.
Conjugate pair	Two substances linked together by donating and accepting a single hydrogen ion.
Amphoteric substance	A substance that can behave like an acid and a base.
Monoprotic acid	An acid containing one hydrogen atom that can be ionized.
Polyprotic acid	An acid that contains more than one hydrogen atom that can be ionized.
Diprotic acid	An acid containing two hydrogen atoms that can be ionized.
Triprotic acid	An acid containing three hydrogen atoms that can be ionized.
Lewis acid	An electron pair acceptor.
Lewis base	An electron pair donor.
Acidic solutions	Solutions produced when nonmetallic oxides dissolve in water.
Basic solutions	Solutions produced when metal oxides dissolve in water.

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Essay Questions		
1	Why are many Lewis acids and bases not classified as Arrhenius or Bronsted-Lowry acids and bases?	Lewis acid: acceptor of a pair of electrons. Lewis base: donor of a pair of electrons. Lewis acid does not contain a hydrogen ion or a hydroxide ion (so it is not an Arrhenius acid or base). A Lewis acid does not contain a hydrogen ion to give it away (so it is not Brønsted-Lowry acid), but all Lewis bases are Brønsted-Lowry bases because they are able to accept a hydrogen ion.
2	Compare the physical and chemical properties of acids and bases.	Physical properties: Acids have an acidic taste and conduct electricity, while bases have a bitter taste and are slippery to the touch and conduct electricity. Chemical properties: Acids react with metals to produce hydrogen gas, turning the color of litmus red, and bases turning the color of litmus to blue.
3	Interpret the meaning of the relative sizes of the two shaded areas to the right of the dark vertical line in the acid-base figure.	The larger area at the bottom means that in basic solutions the concentration of hydroxide ions is greater than the concentration of hydrogen ions in the smaller area at the top.
4	How does the definition of a Lewis acid differ from the definition of a Brønsted-Lowry acid?	Lewis acid: a substance that accepts a pair of electrons, Brønsted-Lowry acid: a hydrogen ion donor.
5	Is it possible for an Arrhenius acid to not be a Bronsted-Lowry acid? Is it possible for an acid according to the Bronsted-Lowry model not to be an Arrhenius acid? Is it possible for a Lewis acid to be classified neither as an Arrhenius acid nor as a Brønsted-Lowry acid? Explain and give examples.	All Arrhenius acids are also Brønsted-Lowry acids, and most Brønsted-Lowry acids are Arrhenius acids when they are in aqueous solution. Examples include: HCl, H_2SO_4, H_3PO_4. Lewis acids are acceptors of electron pairs. Since the hydrogen ion accepts a pair of electrons, all Arrhenius and Bronsted-Lowry acids are also Lewis acids, and some Lewis acids are not Arrhenius acids and are not Brønsted-Lowry acids, such as BF_3.
6	Discuss the statement (A substance whose chemical formula contains hydroxide should be considered a base).	Incorrect. If the substance disintegrates or reacts with water to produce hydroxide ions in the solution, it is considered a base. However, there are substances such as organic acids that contain hydroxyl groups attached so that they give off hydrogen ions in the water, producing acidic solutions.
7	What factors determine whether a molecule is polar or nonpolar?	The existence of a covalent bond between two nonmetallic atoms with a difference in electronegativity.

Multiple choice questions

1) **Where is acetic acid found in large quantities?**

a. lemon b. vinegar c. apples d. spoiled milk

2) **What is the texture feeling of the bases?**

a. rough b. dry c. wet d. slippery

3) **Which of the following is a property of aqueous solutions of bases?**

a. conducts electricity b. produces CO_2 gas when it reacts with carbonates

c. has a sour taste d. turns litmus paper to the red color

4) **Which of the following produces H_2 gas when it reacts with acids?**

a. Nonmetals b. Metalloids

c. Active metals d. Inactive metals

5) **What element reacts with HCl to produce H_2 gas?**

a. copper b. silver

c. gold d. zinc

6) **Which of these properties are suitable for distinguishing between solutions of acids and bases in the scientific laboratory in a safe way?**

a. Taking bases as antacids

b. Taste: acid has a sour taste and base has a bitter taste

c. To the touch, the base has a slippery feel

d. Changing litmus paper color

7) **What explains the occurrence of bubbles when an acetic acid solution is added to sodium hydrogen carbonate?**

a. $O_{2(g)}$ production b. $N_{2(g)}$ production

c. $CO_{2(g)}$ production d. $H_{2(g)}$ production

8) Which of the following does not result from the reaction of an acid with carbonate?

a. salt
b. water
c. carbon dioxide
d. oxygen

9) Why are many compounds containing one or more hydrogen atoms not classified as Arrhenius acids?

a. Arrhenius acids are hydrogen ion donors
b. Arrhenius acids are hydrogen ion acceptors
c. Arrhenius acids are a substance that accepts a pair of electrons
d. Arrhenius acids are substances that have one or more hydrogen atoms can be ionized

10) Which of the following statements is incorrect regarding Arrhenius acids?

a. Increases the concentration of OH^- in the aqueous solution
b. Molecular compounds containing hydrogen atoms that can be ionized
c. Aqueous solutions conduct electricity
d. Increases the concentration of H+ in aqueous solutions

11) Which of the following statements is incorrect regarding Arrhenius bases?

a. Some of them are ionic hydroxides
b. Increases the concentration of H^+ in the aqueous solution
c. Its solutions conduct electric current
d. Dissociate in solution to give hydroxide ions

12) Which definition of acids and bases focuses on the role of protons?

a. Brønsted-Lowry
b. Lewis
c. Arrhenius
d. Faraday

13) Which of the following describes a Brønsted-Lowry acid?

a. electron pair acceptor
b. proton acceptor
c. electron pair donor
d. proton donor

14) What does H_2O represent in the equation: $H_2O_{(l)} + NH_{3(aq)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$?

a. Brønsted-Lowry acid
b. Arrhenius acid
c. Brønsted-Lowry base
d. Lewis base

15) Which substance in the equation is a Bronsted-Lowry acid?

$$HCl_{(g)} + H_2O_{(l)} \rightleftarrows H_3O^+{}_{(aq)} + Cl^-{}_{(aq)}$$

a. H_2O
b. HCl
c. Cl^-
d. There is no acid in the above

16) Which acid-base theory is concerned with conjugate acids and bases?

a. Arrhenius
b. Lewis
c. Brønsted-Lowry
d. None of the choices

17) How many conjugate (acid-base) pairs participate in a Brønsted-Lowry acid-base reaction?

a. 0
b. 1
c. 2
d. 4

18) Which of the following describes the acid in the acid-base conjugate pair?

a. An acid has one more proton than a base
b. An acid has one less proton than a base
c. An acid has two fewer protons than a base
d. The number of protons in the acid is equal to the number of protons in the base

19) What is the conjugate acid-base pairs in the following equation?

$$HCOOH_{(aq)} + H_2O_{(l)} \rightleftarrows HCOO^-_{(aq)} + H_3O^+_{(aq)}$$

a. (HCOOH, HCOOH), (H_2O, H_2O)
b. (HCOOH, H_2O), ($HCOO^-$, H_3O^+)
c. (HCOOH, $HCOO^-$), (H_2O, H_3O^+)
d. (H_2O, $HCOO^-$), (HCOOH, H_3O^+)

20) What is the conjugate acid-base pairs in the following equation?

$$NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

a. (NH_3, OH^-), (H_2O, NH_4^+)
b. (NH_3, NH_4^+), (H_2O, OH^-)
c. (OH^-, OH^-), (NH_3, NH_4^+)
d. (NH_3, H_2O), (NH_4^+, OH^-)

21) What is the conjugate acid-base pairs in the following equation?

$$H_3PO_{4(aq)} + H_2O_{(l)} \rightleftarrows H_2PO_4^-{}_{(aq)} + H_3O^+_{(aq)}$$

a. (H_3PO_4, H_3PO_4), ($H_2PO_4^-$, $H_2PO_4^-$)
b. (H_3PO_4, H_2O), ($H_2PO_4^-$, H_3O^+)
c. (H_3PO_4, H_3O^+), (H_2O, $H_2PO_4^-$)
d. ($H_2PO_4^-$, H_3PO_4), (H_2O, H_3O^+)

22) What is the conjugate acid-base pairs in the following equation?

$$HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftarrows CO_3^{2-}{}_{(aq)} + H_3O^+_{(aq)}$$

a. (HCO_3^-, CO_3^{2-}), (H_2O, H_3O^+)
b. (HNO_2, H_3O^+), (CO_3^{2-}, H_2O)
c. (H_3O^+, CO_3^{2-}), (H_2O, HCO_3^-)
d. (HCO_3^-, HCO_3^-), (CO_3^{2-}, H_2O)

23) What is the conjugate acid-base pairs in the following equation?

$$HNO_{2(aq)} + H_2O_{(l)} \rightleftarrows NO_2^-{}_{(aq)} + H_3O^+_{(aq)}$$

a. (HNO_2, NO_2^-), (H_2O, H_3O^+)
b. (HNO_2, H_2O), (NO_2^-, H_3O^+)
c. (HNO_2, HNO_2), (NO_2^-, NO_2^-)
d. (HNO_2, H_3O^+), (H_2O, NO_2^-)

24) How do conjugate acid-base pairs differ from each other?

a. water molecule
b. proton
c. hydroxide ion
d. hydronium ion

25) Which of the following pairs is considered a conjugate pair?

a. OH^-/ H^+
b. H_2SO_4/ SO_4^{2-}
c. NH_4^+/ NH_2^-
d. HCl/ Cl^-

26) What is the conjugate acid-base pairs in the following equation?

$$HF_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + F^-_{(aq)}$$

a. HF/ F^-
b. HF/ H_2O
c. H_3O^+/ HF
d. H_2O/ F^-

27) Which of the following statements is correct for the reaction?

$$HF_{(aq)} + HPO_4^{2-}{}_{(aq)} \rightarrow F^-_{(aq)} + H_2PO_4^-{}_{(aq)}$$

a. HF is the base
b. HPO_4^{2-} is an acid
c. F^- is the conjugate base
d. $H_2PO_4^{2-}$ is the conjugate base

28) Which of the following substances is a diprotic acid?

a. KOH
b. H_2SO_4
c. HCOOH
d. $Ca(OH)_2$

29) Which of the following substances is a triprotic acid?

a. H_2S
b. CH_3COOH
c. H_3PO_4
d. H_2CO_3

30) Which of the following formulas represents an acid containing one ionizable hydrogen atom?

a. CH_3COOH
b. H_2SO_4
c. KOH
d. H_3PO_4

31) Which of the following substances is a polyprotic acid

a. HNO_3

b. H_2SeO_3

c. CH_3COOH

d. $HClO_4$

32) How many steps are there in the ionization of sulfuric acid H_2SO_4?

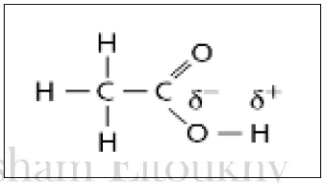
a. 4

b. 1

c. 2

d. 3

33) How many ionizable hydrogen atoms are in the following compound?



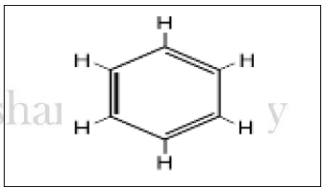
a. 3

b. 2

c. 4

d. 1

34) How many ionizable hydrogen atoms are in the following compound?



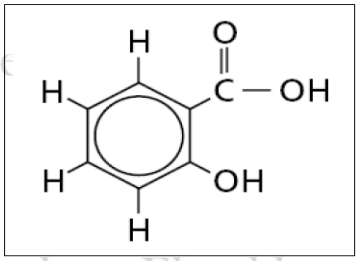
a. 1

b. 3

c. 0

d. 6

35) Based on your knowledge of the ionizable hydrogen in the acetic acid molecule CH_3COOH, predict how many ionizable hydrogen atoms in salicylic acid are likely to be?



a. 1

b. 6

c. 2

d. 4

36) Which of the following is an amphoteric substance?

a. H_2SO_4

b. SO_4^{2-}

c. H^+

d. HSO_4^-

37) Which of the following is an amphoteric substance?

a. H_3PO_4

b. H^+

c. HPO_4^{2-}

d. PO_4^{3-}

38) Which of the following is an amphoteric substance

a. H_2O b. H_3O^+

c. H^+ d. O^{2-}

39) Which of the following is not amphoteric substance?

a. HCO_3^- b. H_3O^+

c. OH^- d. H_2O

40) Which of the following substances is a Lewis acid?

a. BF_3 b. F^-

c. Br^- d. NH_3

41) Which of the following substances is a Lewis base?

a. H^+ b. BF_3

c. SO_3 d. NH_3

42) What does ammonia do when it donates a pair of electrons?

a. Brønsted-Lowry base b. Lewis acid

c. Lewis base d. Arrhenius acid

43) What does Ag^+ represent in the reaction: $Ag^+_{(aq)} + 2NH_{3(aq)} \rightarrow [Ag(NH_3)_2]^+_{(aq)}$?

a. Lewis acid b. Brønsted-Lowry base

c. Lewis base d. Brønsted-Lowry acid

44) What does H_2O represent in the reaction: $Ni^{2+}_{(aq)} + nH_2O_{(l)} \rightarrow [Ni(H_2O)_n]^{2+}_{(aq)}$?

a. Brønsted-Lowry acid b. Lewis base

c. Brønsted-Lowry base d. Lewis acid

45) Which of the following statements agrees with the concept of the Brønsted-Lowry base?

a. electron pair acceptor b. proton donor

c. electron pair donor d. proton acceptor

46) What does CH_3NH_2 represent in the reaction?

$$CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftarrows CH_3NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$$

a. Brønsted-Lowry acid
b. Brønsted-Lowry base
c. Arrhenius acid
d. Lewis acid

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47) What does H^+ represent in the reaction: $H^+_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)}$?

a. electron pair acceptor
b. electron pair donor
c. hydroxide ion producer
d. proton acceptor

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48) What does O^{2-} represent in the reaction: $SO_{3(g)} + O^{2-}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)}$?

a. Arrhenius base
b. Arrhenius acid
c. Lewis base
d. Lewis acid

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49) Which of the following is not a definition of a base in acid-base models?

a. electron pair donor
b. proton acceptor
c. OH^- ion producer
d. proton acceptor

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50) Which of the following statements is true regarding the reaction?

$$NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

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a. NH_3 is an Arrhenius base
b. NH_3 receives an electron pair from H_2O
c. H_2O is a Brønsted-Lowry acid
d. H_2O receives an H^+ ion in the forward reaction

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51) What gas is produced during the reaction of sodium hydrogen carbonate with an aqueous solution of acetic acid?

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a. N_2
b. CO_2
c. H_2
d. O_2

Answer Key

1	b	2	d	3	a	4	c	5	d
6	d	7	c	8	d	9	d	10	a
11	b	12	a	13	d	14	a	15	b
16	c	17	c	18	a	19	c	20	b
21	d	22	a	23	a	24	b	25	d
26	a	27	c	28	b	29	c	30	a
31	b	32	c	33	d	34	c	35	a
36	d	37	c	38	a	39	b	40	a
41	d	42	c	43	a	44	b	45	d
46	b	47	a	48	c	49	d	50	c
51	b								

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Section (2) Practices

Glossary	
Strong acids	Acids that ionize completely, produce the largest number of ions, and are good conductors of electricity.
Weak acids	Acids partially ionize, produce few ions, and are poor conductors of electricity.
Acid ionization constant	Equilibrium constant expression for ionization of a weak acid.
Strong bases	The base that completely dissociates to produce metal ions and hydroxide ions (OH).
Weak Bases	A base that partially ionizes in aqueous solutions.
Base ionization constant	Equilibrium constant expression for weak base ionization.

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Essay Questions		
1	How do you compare the strengths of two weak acids experimentally? How do you do this using a table or guidebook?	By experiment: Comparing the conductivity ability of equal concentration solutions of the two acids, using a table: Comparing the ionization constant for each
2	Which of the two beakers contains the 0.1M hypochlorous acid solution? Explain your answer.  	The cup is on the left, because hypochlorous acid is weak and partially ionizes in water, and its electrical conductivity is low.
3	The weak base ZaH_2 reacts with water to give a solution with a concentration of OH^- ions in it equal to 2.68×10^{-4} M and the chemical equation for the reaction is: $ZaH_{2(aq)} + H_2O_{(l)} \rightleftarrows ZaH_3{}^+{}_{(aq)} + OH^-{}_{(aq)}$ if $[ZaH_2]$ At equilibrium 0.0997 mol/L, what is the value of Kb for ZaH_2?	$K_b = \frac{[ZaH_3^+][OH^-]}{[ZaH_2]}$ $= \frac{(2.68\times10^{-4})^2}{(0.0997 - 2.68\times10^{-4})}$ $= 7.22 \times 10^{-7}$

4	Choose a strong acid and explain how you would prepare a dilute solution of the acid. Choose a weak acid and explain how you would prepare a concentrated solution of the acid.	A diluted solution of a strong acid is prepared by dissolving a small amount of a strong acid in a large amount of water. A concentrated solution of a weak acid is prepared by dissolving a large amount of a weak acid in a small amount of water.
5	Strontium hydroxide is used in refining beet sugar. An amount of 4.1 g of strontium hydroxide can dissolve in 1L of water at 273 K, considering that the solubility is very low. Explain why strontium hydroxide is a strong base?	All the $Sr(OH)_2$ dissolved in water dissociates to form Sr^{2+} and OH^- ions.

Multiple choice questions

1) Why are two opposite arrows used in ionization equations for some acids?

a. the acid solution is weak

b. acid solution exists in the form of ions only

c. acid solution is a good conductor of electricity

d. acid solution is completely ionized

2) What substance completely ionizes in aqueous solutions and produces H_3O^+?

a. strong base **b. weak base**

c. strong acid **d. weak acid**

3) What is in a dilute aqueous solution of a weak acid?

①	②	③
Hydronium ions	**Acid anions**	**Acid molecules**

a. ① and ② only **b. ① and ③ only**

c. ② and ③ only **d. ① and ② and ③**

4) **Which of the following is a strong base?**

a. ammonia

b. aniline

c. sodium hydroxide

d. acetic acid

5) **Which of the following describes group 1 metal hydroxides?**

a. They are all weak bases

b. They are all strong bases

c. They are all acids

d. They may be strong or weak bases

6) **Which of the following solutions of acids or bases is a good conductor of electricity?**

a. HF

b. KOH

c. HCN

d. NH_4OH

7) **Which of the following solutions of acids or bases is a weak conductor of electricity?**

a. NH_4OH

b. HCl

c. $Ca(OH)_2$

d. H_2SO_4

8) **Which of the following substances completely ionizes in the following solutions and produces hydronium ions, H_3O^+?**

①	HCl
②	$HC_2H_3O_2$
③	H_2SO_4
④	HClO

a. ① and ② only

b. ② and ③ only

c. ① and ③ only

d. ① and ② and ④ only

9) **What is the expression for the acid ionization constant for the equation below?**

$$HNO_{2(aQ)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + NO_2^-{}_{(aq)}$$

a. $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]}$

b. $K_a = \frac{[HNO_2]}{[H_3O^+][NO_2^-]}$

c. $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2][H_2O]}$

d. $K_a = \frac{[HNO_2][H_2O]}{[H_3O^+][NO_2^-]}$

10) What is the relationship between K_{eq} and K_a?

a. $K_{eq} = K_a$

b. $K_{eq} = K_a[H_3O^+]$

c. $K_a = K_{eq}[H_2O]$

d. $K_a = \frac{[H_3O^+]}{K_{eq}}$

11) What is the expression for the base ionization constant for the equation below?

$$C_3H_7NH_{2(aq)} + H_2O_{(l)} \rightleftarrows C_3H_7NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$$

a. $K_b = \frac{[C_3H_7NH_3^+][OH^-]}{[C_3H_7NH_2][H_2O]}$

b. $K_b = \frac{[C_3H_7NH_3^+][OH^-]}{[C_3H_7NH_2]}$

c. $K_b = \frac{[C_3H_7NH_2][H_2O]}{[C_3H_7NH_3^+][OH^-]}$

d. $K_b = \frac{[C_3H_7NH_2]}{[C_3H_7NH_3^+][OH^-]}$

12) Which of the following represents the chemical equation and K_b expression for the ionization of hexylamine in water?

choice	The chemical equation	K_b
a.	$C_6H_{13}NH_{2(aq)} + H_2O_{(l)} \rightleftarrows C_6H_{13}NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$	$K_b = \frac{[C_6H_{13}NH_3^+][OH^-]}{[C_6H_{13}NH_2][H_2O]}$
b.	$C_6H_{13}NH_{2(aq)} + H_2O_{(l)} \rightarrow C_6H_{13}NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$	$K_b = \frac{[C_6H_{13}NH_3^+][OH^-]}{[C_6H_{13}NH_2][H_2O]}$
c.	$C_6H_{13}NH_{2(aq)} + H_2O_{(l)} \rightarrow C_6H_{13}NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$	$K_b = \frac{[C_6H_{13}NH_3^+][OH^-]}{[C_6H_{13}NH_2]}$
d.	$C_6H_{13}NH_{2(aq)} + H_2O_{(l)} \rightleftarrows C_6H_{13}NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$	$K_b = \frac{[C_6H_{13}NH_3^+][OH^-]}{[C_6H_{13}NH_2]}$

13) Which of the following statements is correct regarding the reaction below?

$$CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftarrows CH_3NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$$

a. The base CH_3NH_2 is weak and the conjugate base OH^- is strong

b. The base CH_3NH_2 is strong and the conjugate base OH^- is weak

c. The OH^- ion has a lower attraction to the H^+ ion than does the CH_3NH_2 molecule

d. The equilibrium shifts far to the right

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Answer Key

1	a	2	c	3	d	4	c	5	b
6	b	7	a	8	c	9	a	10	c
11	b	12	d	13	a				

Section (3) Practices

Glossary	
Self-ionization of water	Pure water contains equal concentrations of H^+ and OH^- ions.
Water ionization constant	Expression of the equilibrium constant for self-ionization of water or the product of the concentrations of hydrogen ions and hydroxide ions in dilute aqueous solutions.
pH	Negative logarithm of hydrogen ion concentration.
pOH	Negative logarithm of the hydroxide ion concentration.

Essay Questions		
1	Why is the pH of an acidic solution always a smaller number than the pOH of the same solution?	Because the sum of pH and pOH is 14, if the solution is acidic, the pH is <7, and therefore pOH is >7
2	What information is required to calculate K_a for a weak acid?	pH or [H+] and the initial concentration of the acid.
3	Use the water ionization constant at 298 K to explain why any solution with a pH of 3.0 must have a pOH of 11.0	pOH = 11, pH + pOH = 14, pH = 3

Multiple choice questions

1) What is the sum of pH and pOH of a solution at 25°C?

a. 7 b. 10^{-7}

c. 14 d. 10^{-14}

2) What is the product of $[H^+]$ and $[OH^-]$ of pure water at 25°C?

a. 10^{-7} b. 10^{7}

c. 10^{14} d. 10^{-14}

3) **Which of the following equations represents the Self-ionization equation of water?**

a. $2H_2O_{(l)} \rightleftarrows 2H_{2(g)} + O_{2(g)}$

b. $H_2O_{(l)} \rightleftarrows H^+_{(aq)} + OH^-_{(aq)}$

c. $H_2O_{(l)} \rightleftarrows H^-_{(aq)} + OH^+_{(aq)}$

d. $H_2O_{(l)} \rightleftarrows H^-_{(aq)} + OH^+_{(aq)}$

4) **What factor affects the value of the water ionization constant K_w?**

a. Pressure

b. OH^- concentration

c. H^+ concentration

d. Temperature

5) **What is the relationship between pOH and $[OH^-]$ in the solution?**

a. $pOH = \log [OH^-]$

b. $pOH = -\log [OH^-]$

c. $pOH = \log [H^+]$

d. $pOH = -\log [H^+]$

6) **What is the pH of a solution if the hydrogen ion concentration is 8.26×10^{-5} M?**

a. 2.16

b. 4.08

c. 3.91

d. 8.02

7) **What is the hydrogen ion concentration (M) in a solution with a pH of 7.3?**

a. 1.4×10^{-11}

b. 3.8×10^{-8}

c. 5.0×10^{-8}

d. 7.1×10^{-6}

8) **What is the concentration of hydrogen ions (M) in a solution with pOH of 12.4?**

a. 2.5×10^{-2}

b. 4.4×10^{-2}

c. 8.9×10^{-2}

d. 1.0×10^{-1}

9) **What is the pH of a 10^{-8} M HCl solution?**

a. 4

b. 6

c. 8

d. 10

10) What is the pH of a 10^{-3} M KOH solution?

a. 3

b. 5

c. 9

d. 11

11) What is the value of the ionization constant of water at 25 °C?

a. 55.4

b. 0

c. 10^{-7}

d. 10^{-14}

12) What is the value of the ionization constant of water at a temperature of 50 °C?

a. 1×10^{-14}

b. 5.3×10^{-14}

c. 1.2×10^{-15}

d. 3×10^{-15}

13) What happens when the water temperature increases?

a. pH value remains constant

b. pOH value remains constant

c. $[H^+]$ ions decrease

d. The value of Kw increases

14) If the K_w value of pure water is 2.92×10^{-15} at 10 °C, what are the $[H^+]$ and pH values of pure water at 10 °C?

choice	$[H^+]$	pH
a.	5.4×10^{-8} M	7.26
b.	1.7×10^{-7} M	7.26
c.	5.4×10^{-8} M	6.76
d.	1.7×10^{-7} M	6.76

15) If the K_w value of pure water is 2.92×10^{-14} at 40 °C, what are the $[H^+]$ and pH values of pure water at 40 °C?

choice	$[H^+]$	pH
a.	1.7×10^{-7} M	7.26
b.	5.4×10^{-8} M	6.76
c.	1.7×10^{-7} M	6.76
d.	5.4×10^{-8} M	7.26

16) How does the pH value of pure water change when the temperature increases?

a. decreases b. increases

c. does not change d. cannot be determined

17) Arrange the solutions of acids in the corresponding table according to the increase in the concentration of H^+ ions?

a. least: $CH_3COOH \rightarrow HF \rightarrow HNO_3 \rightarrow HCl$ greatest

b. least: $HNO_3 \rightarrow HCl \rightarrow CH_3COOH \rightarrow HF$ greatest

c. least: $HF \rightarrow CH_3COOH \rightarrow HCl \rightarrow HNO_3$ greatest

d. least: $HCl \rightarrow HNO_3 \rightarrow HF \rightarrow CH_3COOH$ greatest

Solution	pH
HCl	1
HF	2.1
CH_3COOH	2.4
HNO_3	1.3

18) Which of the following values represents an acidic solution?

a. pH = 10

b. pOH = 10

c. $[H^+] = 10^{-8}$ M

d. $[OH^-] = 10^{-5}$ M

19) Which of the following relationships indicates an aqueous solution with a pH > 7?

a. $[H^+] = [OH^-]$

b. $[H^+] > [OH^-]$

c. $[H^+] < [OH^-]$

d. pOH = 11

20) What solution has a pOH of 12?

a. $[H^+] = 10^{-12}$ M

b. $[OH^-] = 12$ M

c. $[OH^-] = 10^{-2}$ M

d. $[H^+] = 10^{-2}$ M

21) What is the pOH value of 0.0375 M hydrogen bromide (HBr) at 25°C?

a. 12.57

b. 12.27

c. 1.73

d. 1.43

22) Which of the following solutions represents an acidic solution at 25 °C?

a. pH = 6

b. pOH = 5

c. $[H^+] = 10^{-8}$

d. $[OH^-] = 10^{-4}$

23) Which of the following solutions represents a basic solution at 25 °C?

a. pH = 3

b. pOH = 12

c. pOH = 5

d. pH = 4

24) Which of the following solutions represents a basic solution at 25 °C?

a. $[H^+] = 10^{-4}$ M

b. $[H^+] = 10^{-2}$ M

c. $[OH^-] = 10^{-4}$ M

d. $[OH^-] = 10^{-8}$ M

25) Which of the following solutions has the greatest pH value at 25 °C?

a. 0.1 M HCl

b. 0.1 M NaOH

c. 0.5 M HNO_3

d. 0.005 M $Ca(OH)_2$

26) Which of the following solutions has the least pH value at 25 °C?

a. pH = 5

b. pOH =10

c. $[H^+] = 1\times10^{-2}$ M

d. $[OH^-] = 1\times10^{-8}$ M

27) Which of the following solutions has the greatest H^+ concentration at 25 °C?

a. pH = 4

b. pOH = 8

c. $[OH^-] = 1\times10^{-5}$ M

d. $[H^+] = 1\times10^{-3}$ M

28) Which of the following solutions has the least H^+ concentration at 25 °C?

a. pH = 8

b. pH = 10

c. pOH = 10

d. pOH = 5

29) Which of the following solutions has the greatest pOH value at 25 °C?

a. KOH (0.1 M)

b. NH_4OH, $[H^+] = 10^{-10}$ M

c. $Ba(OH)_2$ (0.005 M)

d. CH_3COOH, $[H^+] = 10^{-3}$ M

30) Which of the following solutions has the least pOH value at 25 °C?

a. $[H^+] = 1\times10^{-4}$ M

b. $[OH^-] = 1\times10^{-12}$ M

c. $[H^+] = 1\times10^{-8}$ M

d. $[OH^-] = 1\times10^{-3}$ M

31) Which solution of the following acids has the least $[H^+]$ at ionization at 25 °C?

a. $K_a = 1.8 \times 10^{-5}$ CH_3COOH

b. $K_a = 6.2 \times 10^{-10}$ HCN

c. $K_a = 4.5 \times 10^{-4}$ HCOOH

d. $K_a = 7.2 \times 10^{-4}$ HF

32) Which of the following solutions has the greatest pOH value at 25°C?

a. $[OH^-] = 10^{-9}$ M

b. pOH = 10.5

c. $[H^+] = 10^{-12}$ M

d. pH = 7

33) Which of the following solutions has the greatest pH value at 25°C?

a. $[OH^-] = 10^{-9}$ M

b. pOH = 10.5

c. $[H^+] = 10^{-12}$ M

d. pH = 7

34) Which of the following relationships describe a neutral solution at 25 °C?

a. $[H^+] < [OH^-]$

b. $[OH^-] < [H^+]$

c. $[H^+] = 7$

d. $[OH^-] = [H^+]$

35) Which of the following relationships describe a basic solution at 25 °C?

a. $[H^+] < [OH^-]$

b. $[OH^-] < [H^+]$

c. $[OH^-] = 0$ M

d. $[OH^-][H^+] = 14$

36) What is the relationship between the concentrations of both OH^- and H^+ ions in an aqueous solution with pH = 1.5?

a. $[H^+] = [OH^-]$

b. $[H^+] > [OH^-]$

c. $[H^+] < [OH^-]$

d. $[H^+][OH^-] = 7$

37) What is the nature of the solution in which $[OH^-] > [H^+]$?

a. acidic

b. neutral

c. amphoteric

d. basic

38) What is the nature of the solution in which $[OH^-]$ is greater than $[H^+]$?

a. acidic

b. basic

c. neutral

d. amphoteric

39) What is the type of a solution that pH < pOH?

a. acidic

b. basic

c. neutral

d. amphoteric

40) A student measured the pH of four juices and recorded this in the corresponding table. Which juice type has the greatest OH^- concentration value?

a. orange

b. lemon

c. apple

d. banana

juice type	pH
lemon	2
apple	3
orange	4
banana	5

41) The hydrogen ion concentration in pure water is ten times its value in seawater if pH = 7 for pure water. What is the pH of seawater at 25°C?

a. 0.0

b. 6.0

c. 7.0

d. 8.0

42) If 5.0 mL of 6.0 M HCl is added to 95.0 mL of pure water, the final volume of the solution will be 100.0 mL. What is the pH value of the solution?

$M \times V$ (before) = $M \times V$ (after)

a. 1.52

b. 0.3

c. 7.9

d. 0.52

43) Chromic acid H_2CrO_4 is used as an industrial metal cleaner. What is the K_a value for the second ionization of chromic acid if the pH of a 0.04 M sodium hydrogen chromate solution is 3.946?

a. 3.2×10^{-7}

b. 2.8×10^{-3}

c. 3.2×10^{-3}

d. 2.8×10^{-7}

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44) The electrode of the pH meter is immersed in a solution of 0.2 M monoprotic acid HA at 303 K. What is the K_a value of the acid at 303 K if the pH = 3.1?

a. 4.0×10^{-3}

b. 3.2×10^{-3}

c. 4.0×10^{-6}

d. 3.2×10^{-6}

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45) Calculate the K_a of a solution of butanoic acid, C_3H_7COOH, with a concentration of 0.15 M and pOH = 11.18?

a. 2.9×10^{-22}

b. 1.5×10^{-5}

c. 4.4×10^{-11}

d. 1.0×10^{-2}

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46) Calculate the K_a of a solution of 0.0091 M hydrofluoric acid (HF) and pH = 2.68?

$$HF_{(aq)} \rightleftarrows H^+_{(aq)} + F^-_{(aq)}$$

a. 7.6×10^{-5}

b. 9.9×10^{-5}

c. 6.3×10^{-4}

d. 4.8×10^{-4}

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47) Calculate Ka for a 0.0091 M solution of an unknown acid HX whose pOH is 11.32

a. 2.9×10^{-1}

b. 5.2×10^{-10}

c. 6.2×10^{-4}

d. 2.5×10^{-21}

48) In the following equation: $CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftarrows CH_3NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$, if $[OH^-] = 3.31 \times 10^{-6}$ M and the concentration of the base solution CH_3NH_2 is 0.1 M, what is the value of the base ionization constant K_b?

a. 1.09×10^{-10}

b. 3.31×10^{-5}

c. 3.31×10^{-10}

d. 1.09×10^{-5}

49) What is the pH value of a solution of 0.2 M hypobromous acid HBrO?

($K_a = 2.8 \times 10^{-9}$)

a. pH = 4.748

b. pH = 9.251

c. pH = 9.375

d. pH = 4.625

50) You have 20 mL of a weak acid solution HX, whose K_a is 2.14×10^{-6} Showing that the pH of the solution is 3.8, how much distilled water should you add to the solution to increase the pH to 4.0?

a. 50 mL

b. 20 mL

c. 40 mL

d. 30 mL

51) Which of the following describes what happens to a neutral solution when it becomes more acidic?

choice	$[H^+]$	pH	pOH
a.	decrease	increase	increase
b.	increase	decrease	increase
c.	increase	decrease	decrease
d.	decrease	increase	decrease

52) Which of the following describes what happens to a neutral solution when it becomes more basic?

choice	$[H^+]$	pH	pOH
a.	increase	decrease	decrease
b.	decrease	increase	decrease
c.	increase	decrease	increase
d.	decrease	increase	increase

53) Hydrogen bromide (HBr) is a strong acid that is highly corrosive. What is the pOH value of a 0.0375 M HBr solution?

a. 1.42

b. 2.42

c. 11.57

d. 12.57

54) What is the correct ascending order according to pOH value for solutions Z, Y, and X with the following properties?

solution	property
X	pH = 10.5
Y	$[H^+] = 10^{-12}$ M
Z	$[OH^-] = 10^{-9}$ M

a. least: Y → X → Z greatest

b. least: X → Y → Z greatest

c. least: Z → X → Y greatest

d. least: X → Z → Y greatest

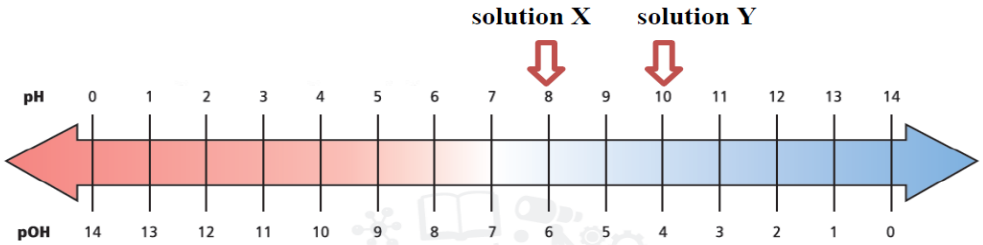
55) How many times is the hydrogen ion concentration [H^+] in solution X greater than in solution Y according to the figure below?

a. 2 times

b. 10 times

c. 100 times

d. 1000 times



56) Based on the data in the following table, which of the following statements is correct?

substance	household ammonia	antacid	blood	soft drinks
pH	11.3	9.4	7.4	3.0

a. the most basic substance is blood

b. soft drinks have a concentration of $H^+ = 4.0 \times 10^{-10}$ M

c. pOH value of household ammonia is 11.0

d. the basicity of an antacid is 10^2 times the basicity of blood

57) Use the following table of constants to determine which of the following statements is correct?

Ionization Constants and pH Data for Several Weak Organic Acids

Acid	pH of 1.000*M* Solution	K_a
Formic	1.87	1.78×10^{-4}
Cyanoacetic	?	3.55×10^{-3}
Propanoic	2.43	?
Lutidinic	1.09	7.08×10^{-3}
Barbituric	2.01	9.77×10^{-5}

a. Formic acid represents the strongest acid among the acids in the table

b. pH value of a 0.4 M solution of cyanoacetic acid = 1.44

c. all acids listed in the table are completely ionized in the water

d. the hydrogen ion concentration of propanoic acid is 7.3×10^4 M

Answer Key

1	c	2	d	3	b	4	d	5	b
6	b	7	c	8	a	9	c	10	d
11	d	12	b	13	d	14	a	15	c
16	a	17	a	18	b	19	c	20	d
21	a	22	a	23	c	24	c	25	b
26	c	27	d	28	b	29	d	30	d
31	b	32	b	33	c	34	d	35	a
36	b	37	d	38	a	39	a	40	d
41	d	42	d	43	a	44	d	45	b
46	c	47	c	48	a	49	d	50	d
51	b	52	c	53	d	54	a	55	c
56	d	57	b						

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Section (4) Practices

Glossary	
Neutralization reaction	A reaction that occurs between an acid and a base in an aqueous solution to produce a salt and water.
The salt	An ionic compound composed of a base cation and an acid anion.
Titration	A method for determining the concentration of a solution by reacting a known volume of that solution with a solution of known concentration.
Titration solution	A solution of known exact concentration that is used in the titration process.
Equivalence point	The point at which moles of H+ ions from an acid equal mole of OH^- ions from a base.
Acid-base indicators	Chemical dyes whose colors are affected by acidic and basic solutions.
End point	The point at which the color of the indicator used in the titration changes.
Hydrolysis	The anions of the dissociated salt accept hydrogen ions from the water, or the cations of the dissociated salt donate hydrogen ions to the water.

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Essay Questions		
1	Why is the pure ionic equation for the neutralization reaction of any strong acid with any strong base always the same and unchanged?	Each neutralization reaction is the reaction of 1 mol of hydrogen ion with 1 mol of hydroxide to form 1 mol of water.
2	What is the difference between equivalence point and end point?	The equivalence point is the pH at which moles of H^+ ions from the acid are equal to moles of OH^- ions from the base. The end point is the point at which the color of the indicator used in the titration changes.
3	Describe how you would design and perform a titration using 0.25 M HNO_3 to determine the molarity of a cesium hydroxide solution.	Place a known volume of CsOH solution in a beaker and add indicator, fill a burette with 0.25 M HNO_3 solution and record the initial burette reading. Then slowly add the HNO_3 solution to the CsOH solution until the end point and record the final reading of the burette and calculate the volume of HNO_3 added. Use the volume and molarity of HNO_3 and the volume of CsOH to calculate the molarity of the CsOH solution.

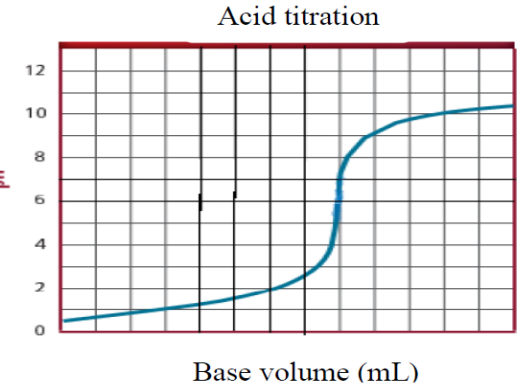
4	When is a pH meter likely to be better than an indicator in determining the endpoint of an acid-base titration?	The pH meter is used if there is no indicator that changes its color at or near the equivalence point, or when no indicator is available.
5	When methyl red is added to an aqueous solution, a pink color is produced. When methyl orange is added to the same solution, a yellow color is produced. What is the approximate pH range of the solution? Use the indicator color chart.	pH approximately between 4.2 and 5.6

Multiple choice questions

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1) Which of the following statements is correct according to the titration curve and indicator table shown below?

Indicator	Range
Phenolphthalein	8.2 – 10.0
Methyl red	4.2 – 6.2
Thymophthalein	9.5 – 10.7



a. The acid is weak and the appropriate indicator to use in this titration is phenolphthalein

b. The acid is strong and the appropriate indicator to use in this titration is methyl red

c. The acid is strong and the appropriate indicator to use in this titration is phenolphthalein

d. The acid is weak and the appropriate indicator to use in this titration is thymophthalein

2) When HCl reacts with NaOH at a concentration of 0.1 M, what is the expected pH symbol for the resulting compound?

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	W				Z		Y			X				

a. W **b. Z**

c. X **d. Y**

3) **One of the learners chose an indicator from Table (B) to use in a titration process between an acid and a base. He used a pH meter to track the change in the pH value and recorded the results as in Table (A). Which of the following statements is correct?**

Table A										
pH	1	1.95	2.69	3	3.7	7	10.3	11	11.96	12.36

Table B	
Indicator	range
Methyl yellow	2.9 – 4.0
Bromothymol blue	6.0 – 7.6
Methyl orange	3.2 – 4.4

a. The acid is weak and the appropriate indicator to use in this titration is methyl orange

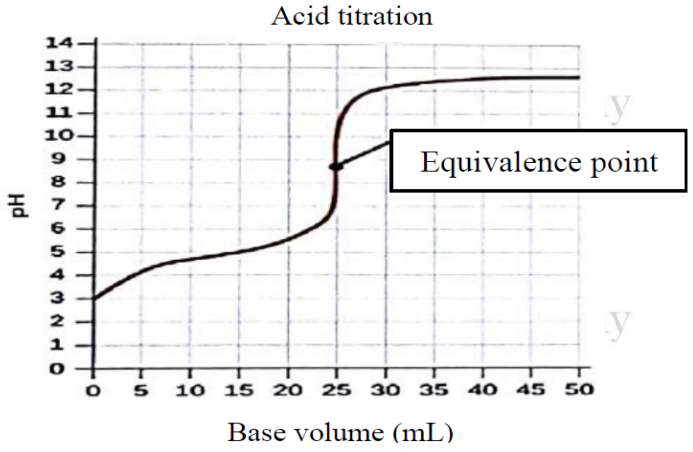
b. The acid is strong and the appropriate indicator to use in this titration is methyl yellow

c. The acid is strong and the appropriate indicator to use in this titration is bromothymol blue

d. The acid is weak and the appropriate indicator to use in this titration is methyl yellow

4) **Which of the following statements is correct according to the titration curve and indicator table shown below?**

Indicator	Range
Phenolphthalein	8.2 – 10.0
Methyl red	4.2 – 6.2
Thymophthalein	9.5 – 10.7



a. The acid is weak and the appropriate indicator to use in this titration is methyl red

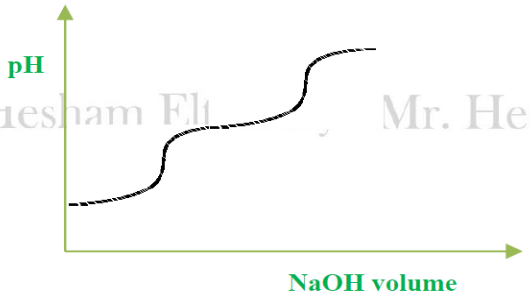
b. The acid is strong and the appropriate indicator to use in this titration is thymophthalein

c. The acid is strong and the appropriate indicator to use in this titration is phenolphthalein

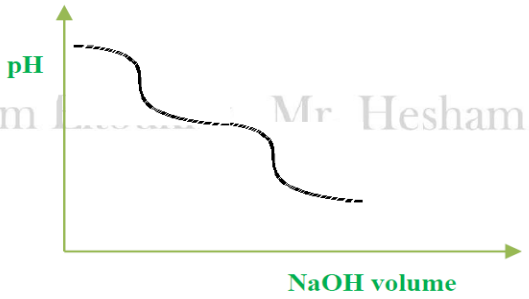
d. The acid is weak and the appropriate indicator to use in this titration is phenolphthalein

5) Which of the following curves represents an approximate volume versus pH curve that would result from titrating diprotic acid with a 0.1 M NaOH solution?

a.



b.



c.

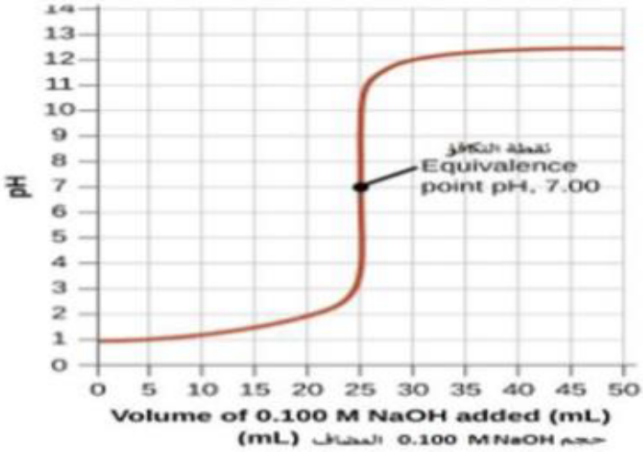


d.



6) Which of the following statements is correct according to the titration curve and indicator table shown below?

مدى الكاشف Indicator range	الكاشف Indicator
8.2-10	فينولفثالين Phenolphthalein
6.0-7.6	ازرق البروموثيمول Bromthymol blue



a. The acid is weak and the appropriate indicator to use in this titration is phenolphthalein

b. The acid is strong and the appropriate indicator to use in this titration is bromothymol blue

c. The acid is strong and the appropriate indicator to use in this titration is phenolphthalein

d. The acid is weak and the appropriate indicator to use in this titration is bromothymol blue

7) **What is the molarity of NaOH if 40 mL of a 0.2 M HNO_3 standard solution is needed to neutralize 32 mL of NaOH?**

a. 6.25 M

b. 4 M

c. 1.56 M

d. 0.25 M

HNO_3	NaOH
M =	M =
V =	V =
n =	n =

8) **What is the concentration of the ammonia solution NH_4OH used in household cleaning if 50 mL of a 0.6 M HCl solution is needed to neutralize 25 mL of the solution?**

a. 0.83 M

b. 0.3 M

c. 1.2 M

d. 0.024 M

HCl	NH_4OH
M =	M =
V =	V =
n =	n =

9) **In a titration process, 30 mL of $Ba(OH)_2$ solution was added to 16 mL of 2.3 M HNO_3 solution to reach the equivalence point. What is the molarity of $Ba(OH)_2$ solution?**

a. 0.61 M

b. 1.22 M

c. 0.3 M

d. 2.42 M

HNO_3	$Ba(OH)_2$
M =	M =
V =	V =
n =	n =

10) **If 27.4 mL of a 0.017 M LiOH solution is equivalent to 17.6 mL of H_2SO_4, what is the molar concentration of the acid?**

a. 1.2 M

b. 0.013 M

c. 1.54 M

d. 0.0084 M

H_2SO_4	LiOH
M =	M =
V =	V =
n =	n =

11) If 72.1 mL of 0.534 M H_2SO_4 are needed to neutralize 34 mL of KOH solution, what is the molarity of KOH?

a. 2.26 M

b. 1.3 M

c. 0.4 M

d. 4.07 M

H_2SO_4	KOH
M =	M =
V =	V =
n =	n =

12) A 25.0 mL sample of lithium hydroxide is titrated with a 0.34 M hydrochloric acid solution, and it is found that 15.22 mL of acid is required to reach the end point of the titration. What is the molarity of LiOH solution?

a. 0.2 M

b. 1.7 M

c. 3.2 M

d. 0.005 M

HCl	LiOH
M =	M =
V =	V =
n =	n =

13) A 0.5 M HCl acid solution is titrated with a NaOH solution. If 8 mL of acid is required to neutralize 10 mL of base, what is the molarity of the base solution?

a. 0.2 M

b. 0.8 M

c. 0.4 M

d. 0.1 M

HCl	NaOH
M =	M =
V =	V =
n =	n =

14) What is the molarity of a solution of $Ba(OH)_2$ if 1900 mL of it is equivalent to a titration with 260 mL of a 0.5 M HNO_3 solution?

a. 0.017 M

b. 0.034 M

c. 0.068 M

d. 0.0085 M

HNO_3	$Ba(OH)_2$
M =	M =
V =	V =
n =	n =

15) What volume of 0.3 M NaOH solution is needed to neutralize 50 mL of 0.25 M H_2SO_4 solution?

a. 10.41 mL

b. 20.83 mL

c. 41.66 mL

d. 83.33 mL

H_2SO_4	NaOH
M =	M =
V =	V =
n =	n =

16) 18.3 mL of 0.1 M NaOH solution is required to titrate 25 mL of acetic acid solution. What is the molarity of the acid solution?

a. 0.12 M

b. 0.073 M

c. 0.73 M

d. 0.012 M

CH_3COOH	NaOH
M =	M =
V =	V =
n =	n =

17) In a titration experiment, it was found that a 12.5 mL sample of 1.75×10^{-2} M $Ba(OH)_2$ is sufficient to neutralize 14.5 mL of HNO_3 solution. What is the molarity of the HNO_3 solution?

a. 0.01 M

b. 0.02 M

c. 0.03 M

d. 0.04 M

HNO_3	$Ba(OH)_2$
M =	M =
V =	V =
n =	n =

18) What is the molarity of a solution of sulfuric acid H_2SO_4 if 68.4 mL of a 0.333 M NaOH solution is needed to neutralize 49 mL of the acid solution?

a. 0.232 M

b. 0.464 M

c. 0.928 M

d. 0.116 M

H_2SO_4	NaOH
M =	M =
V =	V =
n =	n =

19) Which of the following equations represents the hydrolysis of Na_2CO_3 in water?

a. $Na^+_{(aq)} + H_2O_{(l)} \rightleftarrows NaOH_{(aq)} + H_3O^+_{(aq)}$

b. $Na^+_{(aq)} + H_2O_{(l)} \rightleftarrows NaOH_{(aq)} + OH^-_{(aq)}$

c. $CO_3^{2-}_{(aq)} + H_2O_{(l)} \rightleftarrows HCO_3^-_{(aq)} + H_3O^+_{(aq)}$

d. $CO_3^{2-}_{(aq)} + H_2O_{(l)} \rightleftarrows HCO_3^-_{(aq)} + OH^-_{(aq)}$

20) Which of the following equations represents the hydrolysis of NH_4Br in water?

a. $NH_4^+_{(aq)} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O^+_{(aq)}$

b. $NH_4^+_{(aq)} + H_2O_{(l)} \rightleftarrows NH_5^{2+}_{(aq)} + OH^-_{(aq)}$

c. $Br^-_{(aq)} + H_2O_{(l)} \rightleftarrows HBr_{(aq)} + H_3O^+_{(aq)}$

d. $Br^-_{(aq)} + H_2O_{(l)} \rightleftarrows HBr_{(aq)} + OH^-_{(aq)}$

21) Which of the following equations represents the hydrolysis of $RbCH_3COO$ in water?

a. $Rb^{2+}_{(aq)} + H_2O_{(l)} \rightleftarrows Rb(OH)_{2(aq)} + OH^-_{(aq)}$

b. $Rb^{2+}_{(aq)} + H_2O_{(l)} \rightleftarrows Rb(OH)_{2(aq)} + H_3O^+_{(aq)}$

c. $CH_3COO^-_{(aq)} + H_2O_{(l)} \rightleftarrows CH_3COOH_{(aq)} + OH^-_{(aq)}$

d. $CH_3COO^-_{(aq)} + H_2O_{(l)} \rightleftarrows CH_3COOH_{(aq)} + H_3O^+_{(aq)}$

22) Which of the following reactions indicates anion hydrolysis?

a. $CO_3^{2-}_{(aq)} + H_3O^+_{(aq)} \rightleftarrows HCO_3^-_{(aq)} + H_2O_{(l)}$

b. $HPO_4^{2-}_{(aq)} + H_2O_{(l)} \rightleftarrows OH^-_{(aq)} + H_2PO_4^-_{(aq)}$

c. $NH_4^+_{(aq)} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O^+_{(aq)}$

d. $NH_4^+_{(aq)} + OH^-_{(aq)} \rightleftarrows NH_{3(aq)} + H_2O_{(l)}$

23) Which of the following salt solutions undergoes cation hydrolysis?

a. Na_2CO_3 b. KF c. $Ca(CN)_2$ d. NH_4NO_3

24) What is the nature of the aqueous solution of ammonium chloride NH_4Cl?

a. acidic b. basic

c. neutral d. amphoteric

25) Which of the following salts, when dissolved in water, produces a neutral solution?

a. Rubidium acetate $RbCH_3COO$ b. Calcium carbonate $CaCO_3$

c. Potassium sulfate K_2SO_4 d. Ammonium nitrate NH_4NO_3

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Answer Key

1	b	2	d	3	c	4	d	5	a
6	b	7	d	8	c	9	a	10	b
11	a	12	a	13	c	14	b	15	d
16	b	17	c	18	a	19	d	20	a
21	c	22	b	23	d	24	a	25	c

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Part Three (Exams of last years)

Previous years exam questions with answers at the end of each exam.

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Exam 2020-2021 (12 Advanced)

1) **What gas is produced during the reaction of sodium hydrogen carbonate with an aqueous solution of acetic acid?**

a. N_2 b. CO_2

c. H_2 d. O_2

2) **Which of the following statements is correct regarding the reaction below?**

$$NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

a. NH_3 considered as Arrhenius base

b. H_2O considered as Brønsted-Lowry acid

c. NH_3 accepts an electron pair from H_2O

d. H_2O accepts H^+ ion in the forward reaction

3) **Which of the following substances completely ionizes in aqueous solutions and produces hydronium ions, H_3O^+?**

a. I and II

b. II and III

c. I and III

d. I, II and IV

I	HCl
II	$HC_2H_3O_2$
III	H_2SO_4
IV	HClO

4) **What is the expression for the acid ionization constant for the equation below?**

$$HNO_{2(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+{}_{(aq)} + NO_2^-{}_{(aq)}$$

a. $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2]}$

b. $K_a = \frac{[HNO_2]}{[H_3O^+][NO_2^-]}$

c. $K_a = \frac{[H_3O^+][NO_2^-]}{[HNO_2][H_2O]}$

d. $K_a = \frac{[HNO_2][H_2O]}{[H_3O^+][NO_2^-]}$

5) **Which of the following statements is correct regarding the reaction below?**

$$CH_3NH_{2(aq)} + H_2O_{(l)} \rightleftarrows CH_3NH_3^+{}_{(aq)} + OH^-{}_{(aq)}$$

a. The base CH_3NH_2 is weak and the conjugate base OH^- is strong

b. The base CH_3NH_2 is strong and the conjugate base OH^- is weak

c. The OH^- ion has a lower attraction to the H^+ ion than does the CH_3NH_2 molecule

d. The equilibrium shifts far to the right

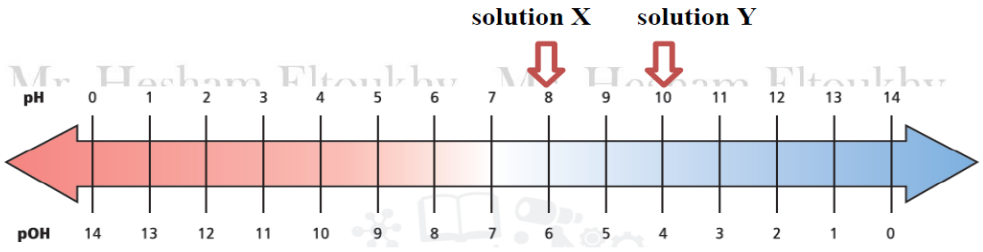
6) **How many times is the hydrogen ion concentration $[H^+]$ in solution X greater than in solution Y according to the figure below?**

a. 2 times

b. 10 times

c. 100 times

d. 1000 times



7) **What is the K_a value of a solution of 0.0091 M hydrofluoric acid (HF) and pH = 2.68?**

$$HF_{(aq)} \rightleftarrows H^+{}_{(aq)} + F^-{}_{(aq)}$$

a. 7.6×10^{-5}

b. 9.9×10^{-5}

c. 6.3×10^{-4}

d. 4.8×10^{-4}

8) **What is the correct ascending order according to pOH value for solutions Z, Y, and X with the following properties?**

a. least: Y → X → Z greatest

b. least: X → Y → Z greatest

c. least: Z → X → Y greatest

d. least: X → Z → Y greatest

solution	property
X	pH = 10.5
Y	$[H^+] = 10^{-12}$ M
Z	$[OH^-] = 10^{-9}$ M

9) **What is the molarity of a solution of sulfuric acid H_2SO_4 if 68.4 mL of a 0.333 M NaOH solution is needed to neutralize 49 mL of the acid solution?**

a. 0.232 M

b. 0.464 M

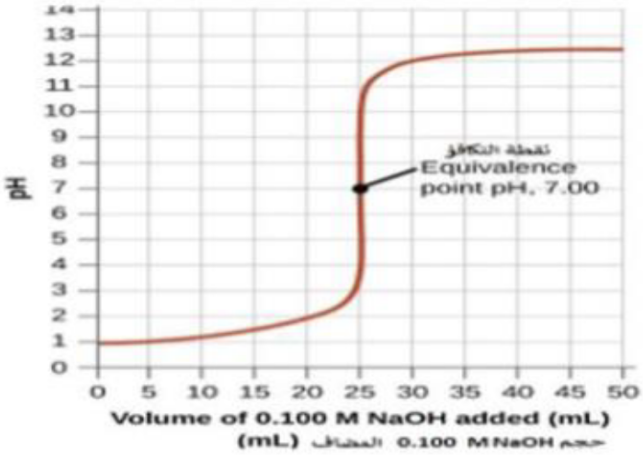
c. 0.928 M

d. 0.116 M

H_2SO_4	NaOH
M =	M =
V =	V =
n =	n =

10) **Which of the following statements is correct according to the titration curve and indicator table shown below?**

مدى الكاشف Indicator range	الكاشف Indicator
8.2-10	فينولفثالين Phenolphthalein
6.0-7.6	ازرق البروموثيمول Bromthymol blue



a. The acid is weak and the appropriate indicator to use in this titration is phenolphthalein

b. The acid is strong and the appropriate indicator to use in this titration is bromothymol blue

c. The acid is strong and the appropriate indicator to use in this titration is phenolphthalein

d. The acid is weak and the appropriate indicator to use in this titration is bromothymol blue

Answer Key

1	b	2	b	3	c	4	a	5	a
6	c	7	c	8	a	9	a	10	b

Exam 2021-2022 (12 Advanced)

1) **Which of the following are properties of acids?**

   a. feels slippery

   b. it tastes bitter

   c. turn red litmus paper blue

   d. reacts with zinc to produce hydrogen gas

2) **Which of the following is correct?**

   a. in acidic solution $[H^+] > [OH^-]$

   b. in acidic solution $[H^+] < [OH^-]$

   c. in neutral solution $[H^+] > [OH^-]$

   d. in basic solution $[H^+] > [OH^-]$

3) **In the reaction equation below, which of the following is correct?**

$$HX_{(aq)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + X^-_{(aq)}$$

   a. HX accepts a hydrogen ion from water H_2O

   b. HX donates a hydrogen ion to water H_2O

   c. HX is a Brønsted-Lowry base

   d. H_2O is a Brønsted-Lowry acid

4) **What substance contains hydrogen and ionizes to produce hydrogen ions in aqueous solution?**

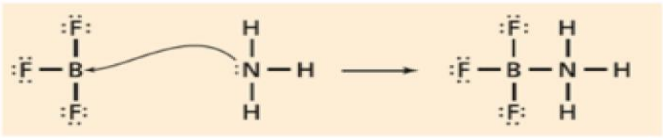
   a. Arrhenius acid

   b. Lewis base

   c. Arrhenius base

   d. Lewis acid

5) Which of the following is correct?

	$NH_3(aq) + H_2O(l) \leftrightharpoons NH_4^+(aq) + OH^-(aq)$
1	2

a. the ammonia NH_3 in reaction 2 is a Brønsted-Lowry acid

b. the ammonia NH_3 in reaction 2 is an electron pair acceptor

c. the ammonia NH_3 in reaction 1 is a Lewis base

d. the ammonia NH_3 in reaction 1 is a Lewis acid

6) Regarding the figure below, which of the following is correct?

	
1	2

a. the light glows brightly in 2 because HCl is a strong acid

b. the light is dim in 1 because CH_3COOH is a strong acid

c. the lamp glows brightly in 2 because HCl ionizes only partially

d. the light is dim in 1 because CH_3COOH ionizes completely

7) Which of the following is considered a conjugate acid-base pair?

a. H_2SO_4, SO_4^{2-}

b. H_2O, O^{2-}

c. H_3PO_4, HPO_4^{2-}

d. HNO_3, NO_3^-

8) **What is the correct descending order of the acids in the table below according to the concentrations of ions in each solution?**

acid	ionization constants
H_2S	8.9×10^{-8}
HF	6.3×10^{-4}
CH_3COOH	1.8×10^{-5}
H_2CO_3	4.5×10^{-7}

a. $CH_3COOH \rightarrow HF \rightarrow H_2CO_3 \rightarrow H_2S$

b. $H_2S \rightarrow H_2CO_3 \rightarrow HF \rightarrow CH_3COOH$

c. $HF \rightarrow CH_3COOH \rightarrow H_2CO_3 \rightarrow H_2S$

d. $H_2S \rightarrow H_2CO_3 \rightarrow CH_3COOH \rightarrow HF$

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9) **If $[OH^-] = 2.5 \times 10^{-7}$ M in a solution, what is the pH of the solution?**

a. 7.4

b. 4.7

c. 6.6

d. 3.3

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10) **The pH of a 0.2 M solution of HF hydrofluoric acid is 2.15, what is the K_a value of HF acid?**

a. 3.2×10^{-9}

b. 2.6×10^{-4}

c. 4.7×10^{-11}

d. 1.8×10^{-5}

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11) **What is the pH of a 6.5×10^{-2} M solution of calcium hydroxide $Ca(OH)_2$?**

a. 7.5

b. 9.8

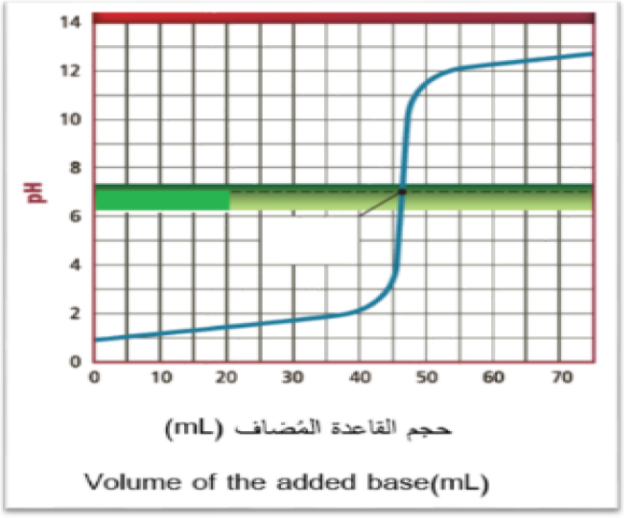
c. 13.1

d. 4.3

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12) Which of the following statements is correct according to the titration curve and indicator table shown below?

indicator	pH values at which the indicator's color changes
Bromophenol blue	3.1–4.7
Methyl orange	3.2–4.6
Methyl red	4.2–6.2
Bromothymol blue	6.0–7.6



a. the acid is weak, and the base is strong and the suitable indicator is Methyl orange

b. the acid is strong, and the base is weak and the suitable indicator is Methyl red

c. the acid is strong, and the base is strong and the suitable indicator is Bromothymol blue

d. the acid is weak, and the base is weak and the suitable indicator is Bromophenol blue

13) In an acid-base titration, 25.8 mL of a solution of sulfuric acid H_2SO_4 is titrated to the end point with 54.7 mL of 0.65 M potassium hydroxide KOH solution. What is the molarity of the H_2SO_4 solution? $H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$

a. 1.2 M

b. 0.6 M

c. 0.7 M

d. 1.4 M

H_2SO_4	KOH
M =	M =
V =	V =
n =	n =

14) Which of the following salts produces an acidic solution when dissolves in water?

a. rubidium acetate $RbC_2H_3O_2$

b. calcium carbonate $CaCO_3$

c. ammonium nitrate NH_4NO_3

d. potassium fluoride KF

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Answer Key

1	d	2	a	3	b	4	a	5	c
6	a	7	d	8	c	9	a	10	b
11	c	12	c	13	c	14	c		

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Exam 2022-2023 (12 Advanced)

1) Which of the following chemical equations represents a reaction between an aqueous solution of an acid and a metal hydrogen carbonate?

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a. $NaHCO_{3(s)} + HC_2H_3O_{2(aq)} \rightarrow NaC_2H_3O_{2(aq)}\ H_2O_{(l)} + CO_{2(g)}$

b. $Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)}\ H_{2(g)}$

c. $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

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d. $Cu_{(s)} + 4HNO_{3(aq)} \rightarrow Cu(NO_3)_{2(aq)} + 2H_2O_{(l)} + 2NO_{2(g)}$

2) Which of the following is not a conjugate acid-base pair?

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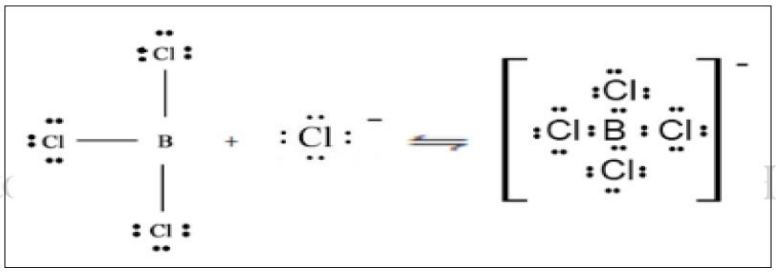
a. H_2O/ OH^-

b. $HClO_4$/ ClO_4^-

c. HSO_3^-/ SO_3^{2-}

d. H_3O^+/ OH^-

3) Why does BCl_3 represent a Lewis acid in the following reaction?



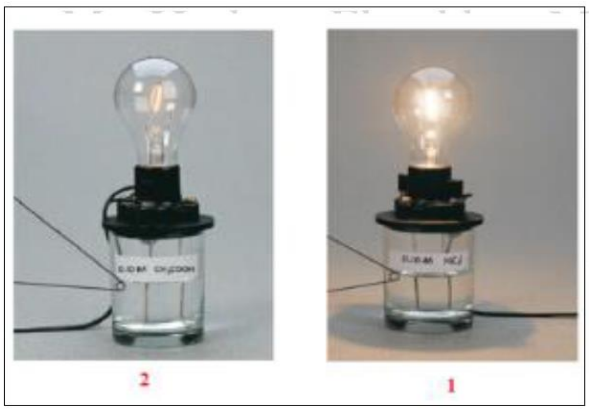
a. Because it is a proton donor to the base Cl^-

b. Because it is a proton acceptor from the base Cl^-

c. Because it is an electron pair donor to the base Cl^-

d. Because it is an electron pair acceptor from the base Cl^-

4) The bulb is connected to a solution of 0.1 M HCl in figure 1, while the bulb is connected to a solution of 0.1 M $HC_2H_3O_2$ in figure 2. What is the reason for the difference in brightness of the bulb in the two figures below?



a. HCl is a weak acid and only partially ionizes in aqueous solution

b. $HC_2H_3O_2$ is a strong acid and completely ionizes in aqueous solution

c. The number of ions in HCl solution is less than the number of ions in $HC_2H_3O_2$ solution

d. The number of ions in HCl solution is more than the number of ions in $HC_2H_3O_2$ solution

5) **Which of the following statements is correct regarding the following ionization equation?** $NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$

a. The equilibrium lies far to the right because the base NH_3 is weak, and the conjugate base OH^- is strong

b. The equilibrium lies far to the right because the base NH_3 is strong, and the conjugate base OH^- is weak

c. The equilibrium lies far to the left because the base NH_3 is weak, and the conjugate base OH^- is strong

d. The equilibrium lies far to the left because the base NH_3 is strong, and the conjugate base OH^- is weak

6) **Which of the following statements is correct regarding the following ionization equation?**

K_a (298 K)	معادلة التأين Ionization equation	الحمض Acid
8.9×10^{-8}	$H_2S \rightleftharpoons H^+ + HS^-$	الهيدروكبريتيك، التأين الأول Hydrosulfuric, first ionization
1×10^{-19}	$HS^- \rightleftharpoons H^+ + S^{2-}$	الهيدروكبريتيك، التأين الثاني Hydrosulfuric, second ionization

a. The acid in the second ionization is weaker than the acid in the first ionization

b. Hydrosulfuric acid is a strong acid because it is a polyprotic

c. The acid in the first ionization is weaker than the acid in the second ionization

d. The concentrations of ions produced by the second ionization are greater than the concentrations of ions produced by the first ionization

7) **Which of the following aqueous solutions is acidic? (Concentrations at 298 K)**

المحلول A Solution A	المحلول B Solution B	المحلول C Solution C	المحلول D Solution D
$[H^+] = 1.0 \times 10^{-13}$	$[OH^-] = 1.0 \times 10^{-3}$	$[OH^-] = 1.0 \times 10^{-7}$	$[H^+] = 4.0 \times 10^{-4}$

a. Solution A **b. Solution B**

c. Solution C **d. Solution D**

8) What is the correct ascending order according to the pH value for each of the following solutions?

الأمونيا المنزلية Household ammonia	عصير الليمون Lemon juice	حليب المغنيسيا Milk of magnesia	الحليب Milk
pOH= 2.10	pH= 2.37	$[OH^-]= 3.2\times 10^{-4}$	$[H^+]= 3.2\times 10^{-7}$

a. Milk → household ammonia → lemon juice → milk of magnesia

b. Lemon juice → milk → milk of magnesia → household ammonia

c. Household ammonia → lemon juice → milk → milk of magnesia

d. Milk of magnesia → milk → lemon juice → household ammonia

9) What is the value of K_a for 0.0400 M solution of acid $HClO_2$ with pH = 1.80?

a. 1.0×10^{-2}

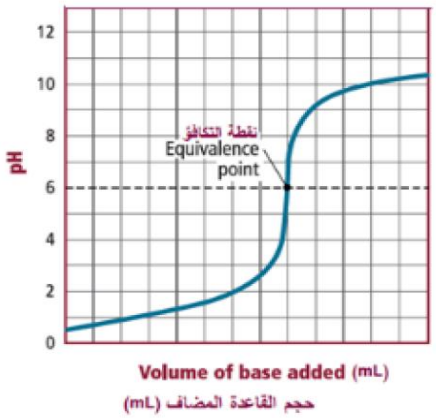
b. 5.8×10^{-3}

c. 2.6×10^{-4}

d. 4.9×10^{-9}

10) Which of the following statements is correct according to the titration curve and indicator table shown below?

مدى الكاشف Indicator range	الكاشف Indicator
5.2-6.8	بنفسجي برومو كريزول Bromocresol purple
8.2-10.0	الفينولفثالين Phenolphthalein



a. The base is KOH, and bromocresol purple is the suitable indicator

b. The base is NH_4OH, and phenolphthalein is the suitable indicator

c. The base is NH_4OH, and bromocresol purple is the suitable indicator

d. The base is KOH, and phenolphthalein is the suitable indicator

11) What is the molarity of H_2SO_4 solution if 74.30 mL of 0.4388 M NaOH solution is needed to neutralize 45.78 mL of the acid solution?

a. 0.3561 M

b. 0.2320 M

c. 0.4211 M

d. 0.1569 M

H_2SO_4	NaOH
M =	M =
V =	V =
n =	n =

12) Potassium fluoride salt KF dissociates in solution as in equation below, which of the following is correct in relation to salt solution? $KF_{(s)} \rightarrow K^+_{(aq)} + F^-_{(aq)}$

	pH	Reason
A	Less than 7	Because the K^+ ions react with water, but the F^- ion is a strong Brønsted-Lowry base do not react with water.
B	More than 7	Because the K^+ ions do not react with water, but the F^- ion is a weak Brønsted-Lowry base react with water.
C	Equals 7	Because the K^+ ions do not react with water, the F^- ion is a strong Brønsted-Lowry base do not react with water.
D	Equals 0	Because the K^+ ions react with water, the F^- ion is a weak Brønsted-Lowry base react with water.

a. A

b. B

c. C

d. D

Answer Key

1	a	2	d	3	d	4	d	5	c
6	a	7	d	8	b	9	a	10	c
11	a	12	b	13		14			

Exam 2021-2022 (12 General)

1) **What property does the experiment describe in the picture below?**



a. Taste sour

b. Feel slippery

c. Change in the color of litmus paper

d. The ability to conduct electricity

2) **At what concentration of H^+ in the solution in the picture the color of litmus paper turns blue?**



a. Equals zero

b. Less than OH^- concentration

c. More than OH^- concentration

d. Equals OH^- concentration

3) **Which of the following is not an Arrhenius base?**

a. KOH

b. NaOH

c. NH_3

d. $Ca(OH)_2$

4) **Which of the following is the conjugate acid of the weak base NH_3?**

a. NH_2^+

b. NH_4

c. NH_4^+

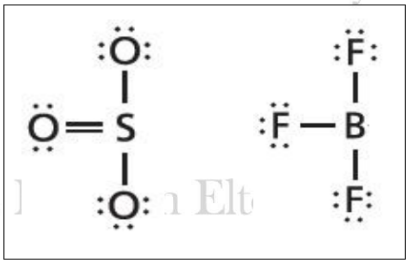
d. NH_3^+

5) **Which of the following is a polyprotic acid?**

a. H_3PO_4 b. HCl

c. $HC_2H_3O_2$ d. HNO_3

6) **What is the similarity between the following two formulas?**



a. Both are Arrhenius bases

b. Both are Lewis bases

c. Both are Arrhenius acids

d. Both are Lewis acids

7) **Which of the following tables is correct about the solutions contained in beakers 1 and 2 below?**



كأس 1
Beaker 1



كأس 2
Beaker 2

a.

Beaker 1	Beaker 2
strong acid	weak acid
completely ionized	partially ionized

b.

Beaker 1	Beaker 2
weak acid	strong acid
partially ionized	completely ionized

c.

Beaker 1	Beaker 2
Strong acid	Weak acid
partially ionized	completely ionized

d.

Beaker 1	Beaker 2
weak acid	strong acid
completely ionized	partially ionized

8) **Which of the following is correct according to the following reaction?**

$$HC_2H_3O_{2(aq)} + H_2O_{(l)} \rightleftarrows C_2H_3O_2^-{}_{(aq)} + H_3O^+{}_{(aq)}$$

a. The ionization equilibrium lies far to the left

b. Conjugate base $C_2H_3O_2^-$ is weaker than H_2O base

c. H_2O base has a greater attraction for the H^+ ion than does the base $C_2H_3O_2^-$

d. The ionization equilibrium lies far to the right

9) What is the correct order of the following bases in order of strength, from weakest to strongest?

K_b (298 K)	Base القاعدة
5.0×10^{-4}	Ethylamine إيثيل أمين
4.3×10^{-4}	Methylamine ميثيل أمين
2.5×10^{-5}	Ammonia أمونيا
4.3×10^{-10}	Aniline أنيلين

a. Methylamine → Ethylamine → Aniline → Ammonia

b. Aniline → Ammonia → Ethylamine → Methylamine

c. Ethylamine → Methylamine → Ammonia → Aniline

d. Aniline → Ammonia → Methylamine → Ethylamine

10) What is the value of $[OH^-]$ in orange juice at 298 K that have $[H^+] = 1.0 \times 10^{-3}$ M?

a. 1.0×10^{-3} M

b. 1.0×10^{-11} M

c. 1.0×10^{-4} M

d. 1.0×10^{-14} M

11) What is the pH of an aqueous solution that have $[H^+]=2.5 \times 10^{-2}$ M at 298 K?

a. 2.00 b. 10.81

c. 12.40 d. 1.60

12) How many times more acidic is solution A than solution B?

pH	Solution المحلول
2	A
5	B

a. 10

b. 1000

c. 3

d. 100

13) What are the products of the neutralization reaction?

a. A base and water b. Acid and water

c. Acid and base d. A salt and water

14) What are the chemical dyes whose colors are affected by acidic and basic solutions called?

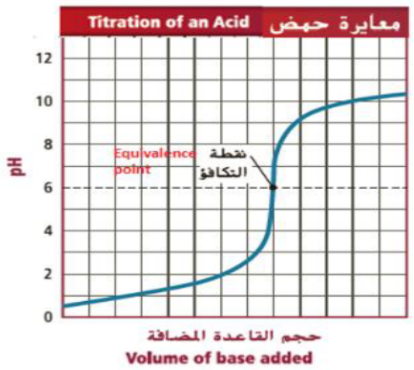
a. Amphoteric substances

b. Anhydrides

c. Indicators

d. Standard solutions

15) What is the titration in the curve shown in the figure below?



a. A strong acid with a strong base

b. A weak acid with a strong base

c. A strong acid with a weak base

d. A weak acid with a weak base

16) 40.0 mL of a hydrochloric acid solution HCl is titrated to the end point with 20.0 mL of 0.2 M sodium hydroxide solution NaOH. What is the molarity of HCl solution?

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

a. 0.1 M

b. 0.05 M

c. 0.025 M

d. 0.2 M

HCl	NaOH
M =	M =
V =	V =
n =	n =

Answer Key

1	d	2	b	3	c	4	c	5	a
6	d	7	a	8	a	9	d	10	b
11	d	12	b	13	d	14	c	15	c
16	a								

Exam 2022-2023 (12 General)

1) **Which of the following are properties of basic solutions?**

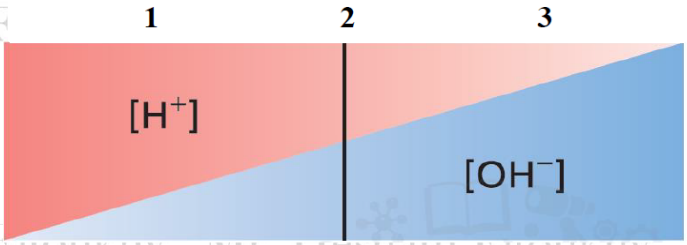
   a. Taste bitter and feel slippery

   b. Taste sour

   c. Cause blue litmus paper to turn red

   d. Reacts with zinc to produce hydrogen gas

2) **The figure below describes the change in the concentration of hydrogen ions and hydroxide ions with a change in the type of solution. Which of the following is correct?**



   a. 1 is an acidic solution

   b. 2 is a basic solution

   c. 3 is an acidic solution

   d. 1 is a basic solution

3) **In the reaction below. Which of the following is not correct?**

$$CO_3^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftarrows HCO_3^-{}_{(aq)} + OH^-{}_{(aq)}$$

   a. H_2O acts as Arrhenius acid

   b. H_2O acts as Bronsted-Lowry acid

   c. CO_3^{2-} ion accepts a H^+ ion from water

   d. Water H_2O gives up H^+ ion to CO_3^{2-} ion

4) **Which of the following is not considered as amphoteric substance?**

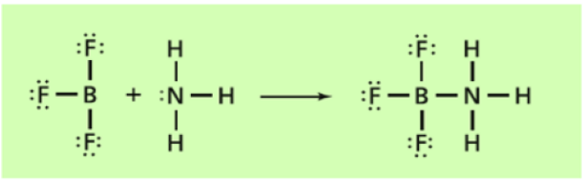
   a. OH^-

   b. $C_2H_3O_2^-$

   c. H_2O

   d. $H_2PO_4^-$

5) **In the following reaction. Why BF_3 is considered as Lewis's acid?**



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a. **Because it ionizes to produce hydrogen ions in aqueous solution**

b. **Because it dissociates to produce hydroxide ions in aqueous solution**

c. **Because it donates an electron pair to NH_3 molecule**

d. **Because it accepts an electron pair from NH_3 molecule**

6) **In the following figures, experiment of electrical conductivity of aqueous solutions its concentration is 0.1 M of hydrochloric acid and acetic acid. What can be concluded from the experiment?**



a. **Strong acids are good conductors of electricity**

b. **Weak acids are good conductors of electricity**

c. **Strong acids produces fewer ions**

d. **Weak acids produce the maximum number of ions**

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7) **What is the correct order of the following acids according to its strength from weakest to strongest?**

K_a (298 K)	Acid الحمض
6.3×10^{-4}	Hydrofluoric الهيدروفلوريك
6.2×10^{-10}	Hydrocyanic الهيدروسيانيك
1.8×10^{-5}	Acetic الأسيتيك
1.8×10^{-4}	Formic الفورميك

a. **Hydrofluoric → Hydrocyanic → Acetic → Formic**

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b. **Hydrocyanic → Acetic → Formic → hydrofluoric**

c. **Acetic → Formic → Hydrofluoric → Hydrocyanic**

d. **Formic → Hydrocyanic → Hydrofluoric → Acetic**

8) **Which of the following is correct according to the following reaction?**

$$NH_{3(aq)} + H_2O_{(l)} \rightleftarrows NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

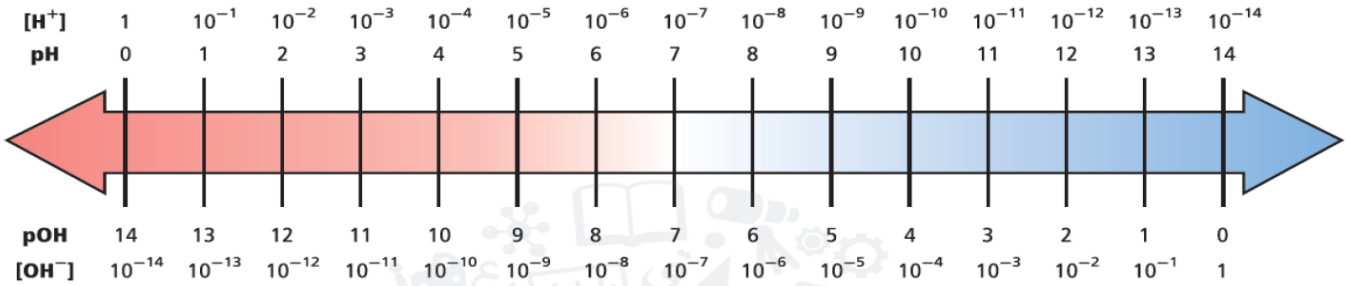
a. NH_3 is a strong base completely ionizes in dilute aqueous solution

b. The equilibrium lies far to the left because the base NH_3 is weak while the conjugate base OH^- is strong

c. NH_3 molecule has a greater attraction for H^+ ion more than OH^- ion

d. The equilibrium lies far to the right because the base NH_3 is strong while the conjugate base OH^- is weak

9) **Which of the following is false according to the pH scale?**



a. $pH + pOH = 14$

b. $[H^+][OH^-]\ 1.0 \times 10^{-14}$

c. $pH = -\log[H^+]$

d. $pH = -\log[OH^-]$

10) **Which of the following substances has the highest pH value?**

Seawater ماء البحر	Milk الحليب	Blood الدم	Ammonia الأمونيا
pOH = 5.60	pH = 6.50	$[H^+] = 4.0 \times 10^{-8}$ M	$[OH^-] = 4.0 \times 10^{-3}$ M

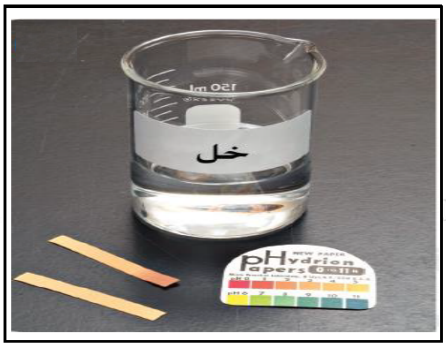
a. Ammonia

b. Blood

c. Milk

d. Seawater

11) Which of the following statements is not correct according to the figures a and b?



a



b

a. Both figures, the pH of the solution is measured

b. Figure b provides more accurate measure of pH

c. Figure a provides more accurate measure of pH

d. Figure b gives a direct analog or digital readout of pH

12) Which of the following is not true about salt?

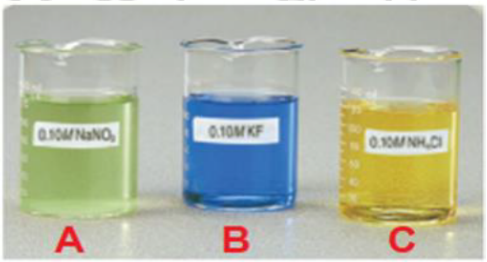
a. An ionic compound made up of a cation from a base and an anion from an acid

b. An ionic compound made up of a cation from an acid and an anion from a base

c. An ionic compound produced by a neutralization reaction

d. An ionic compound produced by a double replacement reaction

13) When bromothymol blue indicator is added to three of ionic salts solutions 0.1 M: ammonium chloride NH_4Cl, sodium nitrate $NaNO_3$, and potassium fluoride KF. The solutions turn the indicator to the colors shown in the figure below. Which solution is neutral?



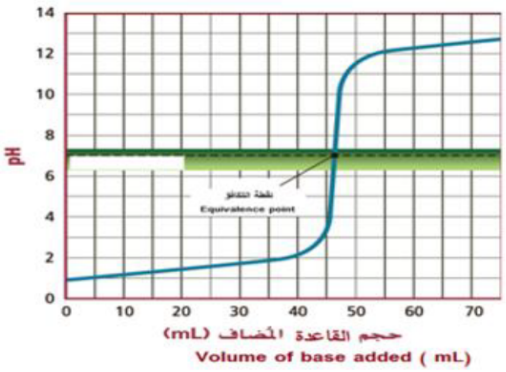


a. A only **b. B only**

c. A, B **d. B, C**

14) Which of the following statements is correct according to the titration curve and indicator table shown below?

Indicator	Range
Bromothymol blue	6.0 – 7.6
Methyl red	4.2 – 6.2
Methyl orange	3.2 – 4.6



a. The acid and the base are strong, and bromothymol blue is the suitable indicator

b. The acid is strong, and the base is weak, and methyl red is the suitable indicator

c. The acid and the base are weak, bromothymol blue is the suitable indicator

d. The acid is weak, and the base is strong, methyl orange is the suitable indicator

15) What is the molarity of a nitric acid solution if 43.33 mL of a 0.1000 M KOH is needed to neutralize 20.00 mL of the acid solution?

$$HNO_{3(aq)} + KOH_{(aq)} \rightarrow KNO_{3(aq)} + H_2O_{(l)}$$

a. 0.830 M

b. 0.462 M

c. 0.560 M

d. 0.217 M

HNO_3	KOH
M =	M =
V =	V =
n =	n =

Answer Key

1	a	2	a	3	a	4	b	5	d
6	a	7	b	8	b	9	d	10	a
11	c	12	b	13	a	14	a	15	d