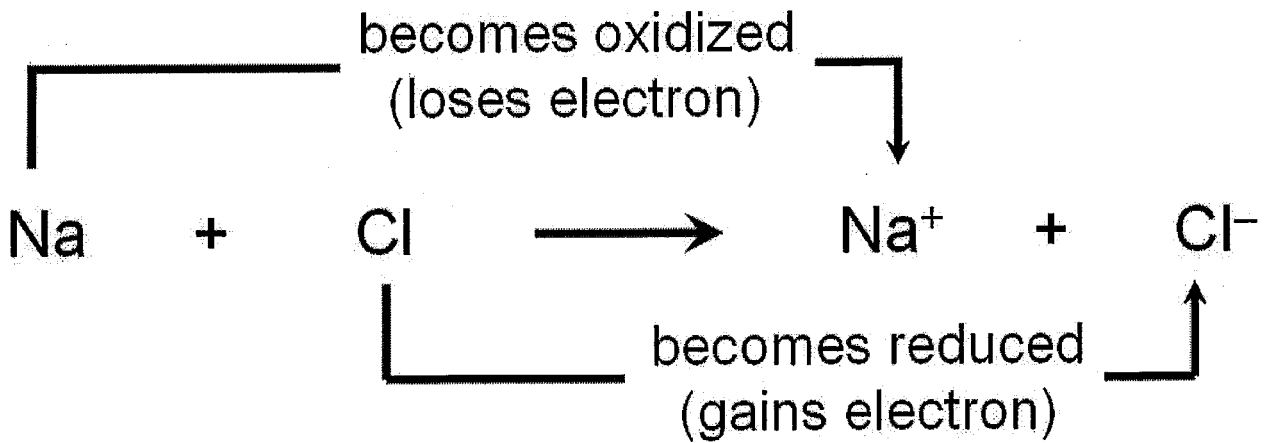
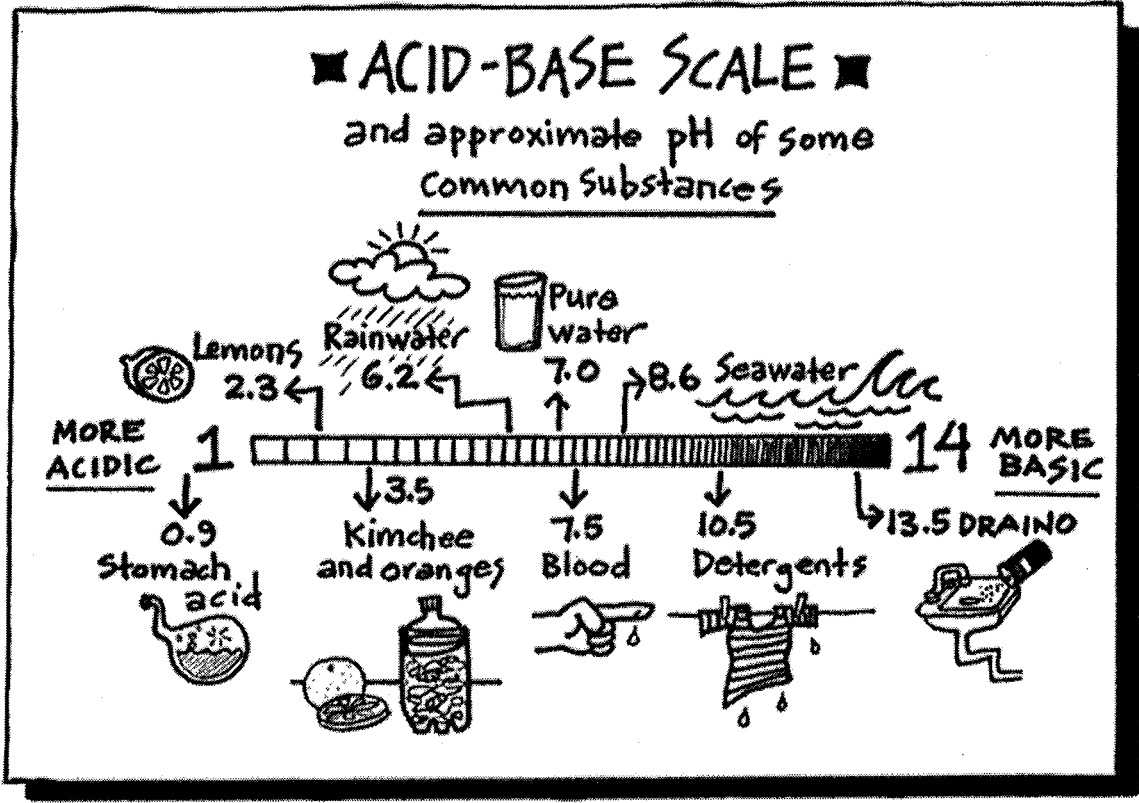


Unit #8 and 9: Acid-Base and REDOX



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Acid/Base/Salts Vocabulary

acidity a measure of the hydrogen (hydronium) ion concentration of a solution

alkalinity a measure of the hydroxide ion concentration of a solution

Arrhenius acid a substance that produces hydronium ions (H_3O^+) as the only positive ions when dissolved in water

Arrhenius base a substance that produces hydroxide ions (OH^-) as the only negative ions when dissolved in water

conductivity a measure of the ability of an electric current to flow through a substance

electrolyte a substance whose water solution conducts an electric current

hydrogen ion a hydrogen atom without its electron (consisting solely of a proton)

hydronium ion H_3O^+ , formed by the combination of water with a hydrogen ion

hydroxide ion the polyatomic anion produced by the ionization of a water molecule

indicator a substance that undergoes a color change that can be used to determine when a reaction is complete

neutralization the reaction between an acid and a base to produce water and a salt

pH scale a logarithmic scale that measures the acidity or alkalinity of a solution on a scale of 1 to 14

pH the negative logarithm of a solution's hydrogen ion concentration

salt the product (other than water) of a neutralization reaction; an ionic substance consisting of a metallic cation and anion other than the hydroxide ion

titration the process of determining the concentration of an unknown solution by a reaction with a solution of known concentration

Major Understandings

1. The behavior of many acids and bases can be explained by the Arrhenius theory.
 - a. These acids and bases are electrolytes.
2. An electrolyte is a substance which, when dissolved in water, forms a solution capable of conducting an electric current.
 - a. The ability to conduct an electric current depends on the concentration of the ions.
3. Arrhenius Acids yield H^+ (aq) as the only positive ion in a solution.
 - a. The hydrogen ion may also be written as H_3O^+ (aq) or hydronium.
4. Arrhenius bases yield OH^- (aq) as the only negative ion in a solution.
5. In neutralization, an Arrhenius acid and an Arrhenius base react to form salt and water.
6. Titration is a lab process in which a volume of solution of known concentration is used to determine the concentration of another solution.
7. Alternate acid-base theories exist
 - a. Ex Bronsted-Lowry where acids are H^+ donors and bases are H^+ acceptors.
8. The acidity or alkalinity of an aqueous solution can be measured by its pH value
 - a. The relative acidity or alkalinity of a solution can be shown by using indicators
9. On the pH scale, each decrease of one unit represents a tenfold increase in the hydronium ion concentration
 - a. Thus pH of 2 is 1000 times more acidic than pH of 5

1 **ACIDS/BASES/SALTS**

Table's K,L,M

Acid + Base \rightarrow Salt + Water

2 **The Arrhenius Theory: ACIDS-Table K**

○ An acid is a substance whose water solution has a hydrogen (H^+) ion as its positive ion

● Ex. $HF \rightarrow H^+ + F^-$

○ H^+ is also known as a proton (as a neutral Hydrogen atom will have 1 proton, 1 electron and no neutrons)

○ The H^+ ion is then attracted to non-bonding electrons, or lone pair, of a water molecule to form a hydronium ion, H_3O^+

3 **Hydronium**4 **Dissociation: The process of breaking up into ions**

○ Monoprotic acids: when only 1 H^+ is produced

● Ex. $HCl \rightarrow H^+ + Cl^-$

○ Diprotic acids: when 2 H^+ ions may be produced

● Ex. $H_2SO_4 \rightarrow H^+ + HSO_4^-$

• $HSO_4^- \rightarrow H^+ + SO_4^{2-}$

○ Triprotic acids: when 3 H^+ ions may be produced

● Ex. $H_3PO_4 \rightarrow H^+ + H_2PO_4^-$

• $H_2PO_4^- \rightarrow H^+ + HPO_4^{2-}$

• $HPO_4^{2-} \rightarrow H^+ + PO_4^{3-}$

5 **Organic Acids/Carboxylic Acids**

○

○ $R-COOH \rightarrow H^+ + R-COO^-$

6 **Properties of Acids**

○ Electrolytes in solution (conductivity)

○ Sour tasting: Citric acid in fruits, acetic acid in vinegar etc

○ Can change the color of an indicator (TABLE M)

○ Strong acids dissociate completely and have many ions in solution

○ Weak acids dissociate poorly and have few ions in solution

7 **Naming Acids**

○ Binary: H and one other atom

● Hydro____ic acid (modified ending)

• Ex. $HBr \rightarrow$ Hydrobromic acid

• Ex. $HI \rightarrow$ Hydroiodic acid

2

○ Ternary: H and two or more atoms (polyatomic ions etc)

- If polyatomic ends in ate → acid ends in 'ic'
- If polyatomic ends in ite → acid ends in 'ous'
- Term 'Hydro' is not used as a prefix
 - Ex. HNO_3 (nitrate ion) → Nitric acid
 - H_2SO_3 (sulfite ion) → Sulfurous acid

8 **The Arrhenius Theory: BASES (TABLE L)**

○ A base is a substance whose water solution has a hydroxide (OH^-) ion as its negative ion

○ Ex. $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$

-
-
-

○ Amines are bases (CH_3NH_2) etc. as they will react with water to produce OH^- ions

○ Do not confuse alcohols with bases as both have OH endings to them (C-OH is alcohol, not base)

9 **Properties of Bases**

○

- Electrolytes in solution (conductivity)
- Slippery feel
- Bitter taste
- Strong bases dissociate completely and have many (OH^-) ions in solution
- Weak bases dissociate poorly and have few (OH^-) ions in solution

10 **Neutralization**

○ Acid + Base → Salt + Water

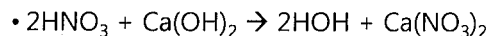
○ Arrhenius stated that the H^+ (or H_3O^+) will bond with the OH^- to form water

- Spectator ions will combine to form a salt

○ Most are double replacement reactions (be sure to balance your equations)

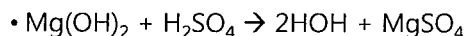
● Ex. $\text{HCl} + \text{NaOH} \rightarrow \text{HOH} + \text{NaCl}$

● Write the balanced equation for the following neutralization reaction between nitric acid and calcium hydroxide



11 **Neutralization continued**

● Write the balanced equation for the following neutralization reaction between magnesium hydroxide and sulfuric acid



○ **Salt formed is not always neutral on the pH scale

3

- Strong acid/weak base will result in an acidic salt
- Weak acid/strong base will result in a basic salt
- If Acid = Base, a neutral salt will result

12 **Titration**

- Adding a known volume and concentration of an acid or base with a burette to an unknown volume or concentration of another acid or base until neutralization is reached
- Unknown is determined with the following:
 - $M_A V_A = M_B V_B$
 - M_A = molarity of the acid ion (H^+)
 - V_A = volume of the acid
 - M_B = molarity of the base ion (OH^-)
 - V_B = volume of the base

13 **Titration continued**

- A 1:1 ratio between H^+/OH^- must be met in order for neutralization to be reached
- Molarity of concentration and molarity of ions may differ for acids and bases
 - Monoprotic acids \rightarrow 1:1 ratio
 - $HCl \rightarrow H^+ + Cl^-$
 - 1 mole \rightarrow 1 mole H^+ ions
 - Diprotic acids \rightarrow 1:2 ratio
 - $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$
 - 1 mole \rightarrow 2 moles H^+ ions
 - Triprotic acids \rightarrow 1:3 ratio
 - $H_3PO_4 \rightarrow 3H^+ + PO_4^{3-}$
 - 1 mole \rightarrow 3 moles H^+ ions

14 **Titration continued**

- If an unknown volume of 3.0M NaOH was added to 50.0mL of 4.0M HCl until neutralization was reached, what was the volume of base used?
 - $M_A V_A = M_B V_B$
 - $4.0M * 50.0mL = 3.0M * V_B$
 - $V_B = 67mL$
- What is the molarity of 200.mL of H_3PO_4 if 40.mL of 3.0M $Mg(OH)_2$ was added until neutralization?
 - $M_A V_A = M_B V_B$
 - $M_A * 200.mL = 6.0M (OH^-) * 40.mL$
 - $M_A = 1.2M (H^+) \dots \dots$ remember $3H^+$ per unit
 - $M_A \rightarrow 1.2M/3 = 0.4M H_3PO_4$

15 **The pH scale**

- Acidity(acids) and Alkalinity(bases)

(4)

- Dependent upon concentrations of H^+/OH^- ions
 - When $[H^+] > [OH^-]$ = Acidic
 - When $[H^+] < [OH^-]$ = Basic (alkaline)
 - Range of scale: 0-14
- 16 **The pH scale continued**
- (Weak Base) (Weak Acid)
 - $[H^+] > [OH^-]$ $[H^+] = [OH^-]$ $[H^+] < [OH^-]$
- 17 **The pH scale continued**
- A decrease in pH means that it is becoming more acidic/less basic
 - An increase means less acidic/more basic
 - Each $\downarrow\uparrow$ in number is equal to a tenfold change in strength
 - Ex. pH 2 \rightarrow 3 becomes 10 times less acidic, not 1 time less
 - pH 2 \rightarrow 4 is 100 times less acidic
 - pH 8 \rightarrow 3 is 100,000 more acidic
 - Strengths are dependent upon the level of dissociation (how well the acid or base breaks into ions)
- 18
- 19 **Bronsted-Lowry Acids and Bases**
- Another method to determine if a material is acidic or basic
 - Acids are proton (H^+ ion) donors
 - Bases are proton (H^+ ion) acceptors
 - Both rules allow for more substances being considered as acids and bases
- 20 **Indicators: (TABLE M)**
- A substance that changes colors when it gains or loses a proton (H^+ ion)
 - Ex. phenolphthalein is colorless when H^+ ions are present.
 - As base is added to the solution, the acid is neutralized (H^+ ions and OH^- ions are forming water and spectator ions are forming salt)
 - As more base is added and H^+ ions neutralized, the indicator will turn pink as it is now reacting with the excess base instead of the acid
 - The change in color is an 'indicator' that the titration/neutralization is complete
- 21 **Indicators**

Name _____

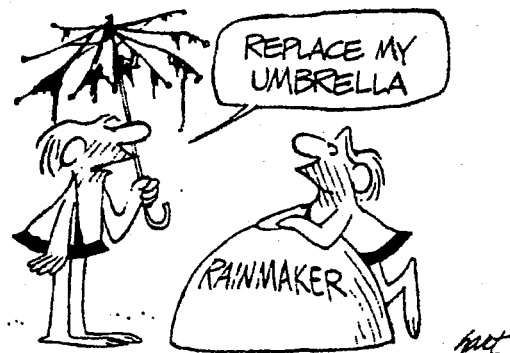
Unit 4C review: Acids/Bases

- 1) If I have 6 moles of sugar in 12L of solution, what is the molarity of the solution?
 - 2) I have a 1.5M solution that required 10.5 moles of HCl to make. What is the volume of my solution?
 - 3) I have 4L of a 5M H_2SO_4 solution. How many moles of H_2SO_4 were required to make this?
 - 4) How much less acidic is a normal fresh water lake with a pH of 6.5 compared to an acidic lake with a pH of 4.5?
-
- 5) An oven cleaner with a pH of ~ 12 is used to clean an oven. Most soap used for cleaning the body is actually pretty close to neutral (to not harm the skin and the user). How much more basic is the oven cleaner compared to the soap?
 - 6) What is the pH of a solution with a hydronium concentration of 0.00000000001?
 - 7) What is my pH if I have a solution with an H_3O^+ concentration of 1×10^{-4} ?
 - 8) What is the pH of my solution if the H_3O^+ and OH^- concentrations are equal?
-
- 9) List 5 acidic things:
 - a.
 - b.
 - c.
 - d.
 - e.
 - 10) List 5 basic things:
 - a.
 - b.
 - c.
 - d.
 - e.
- 6

B.C.

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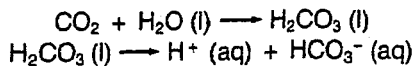
by johnny hart



What Is Acid Rain?

Acid rain is defined as precipitation that is more acidic than "normal" background precipitation, regardless of its cause—either natural or man-made. The acidity of precipitation can be determined accurately using well-designed analytical procedures, and it has been measured in a number of geographical locations in Scandinavia, Canada, and the U.S. The acidity of rain varies across the continental U.S., generally being higher in the East and lower in the West.

Unpolluted or "clean" rain is always slightly acidic, having a pH of 5.6. This is due to carbon dioxide, which dissolves in water in the atmosphere to produce carbonic acid. Carbonic acid is a weak acid also found in soda water and carbonated soft drinks:



Rain or snow is considered "acid" when its pH falls below 5.6. Acidic rain is generally formed by the following steps:

- 1) Emission into the air of oxides of sulfur and nitrogen, primarily SO_2 , NO , and NO_2 from natural and man-made sources.
- 2) Short- and long-range atmospheric transport of the oxides.
- 3) A series of chemical reactions between oxides, moisture, and other chemicals in the atmosphere to

form sulfuric acid, H_2SO_4 , and nitric acid, HNO_3 , and others (called the transformation step).

- 4) Rain or snow carrying the acids to the Earth's surface.

Although scientists agree with this general outline, the exact processes that take place from step one to step four are not clearly understood (see box of uncertainties).

Some people also use the term

"acid rain" to refer to the process called "dry deposition," even though rain is not carrying the acid. This occurs when the oxides of sulfur and nitrogen are deposited, or absorbed directly onto surfaces. It is believed that these oxides are then converted into acids after contacting water in the form of rain, dew, fog, or mist, or in the internal structure of plants, which have taken in these particles.

Extra Info! Some Acid Rain Uncertainties

The effects of acid rain were first acknowledged in the 1800s, but only in recent decades have these effects been examined in some detail. There are still many uncertainties associated with the issue. Major gaps in our understanding include the following:

- the pH of precipitation in the absence of human activity;
- evidence of a change in the acidity of precipitation over the past several decades;
- the controlling factors (reagents and processes) in the production of sulfur and nitrogen acids;
- the exact mechanism for oxidizing sulfur dioxide and nitrogen oxides; and
- the relationship between the location(s) of source(s) and the location(s) of the deposition(s).

Some Causes of Acid Rain

Acid rain probably occurred when the first rains fell on our newly formed planet. Volcanic eruptions, forest fires, and bacterial decomposition of organic matter produce sulfur or nitrogen oxides. Lightning bolts form nitrogen oxides from the nitrogen and oxygen gases in the atmosphere.

However, the Industrial Revolution, which began about two-and-a-half centuries ago, started a surge in the amount of man-made pollutants in the atmosphere. Suddenly, sulfur and nitrogen, which had been stored in fossil fuels for millions of years, were released as rapidly as coal could be burned. Today, the major sources of sulfur and nitrogen compound emissions are power-generating plants, ore smelting, petroleum refining, industrial furnaces, and vehicles of all kinds.

In 1980, more than 26 million tons of sulfur dioxide were released into the air in the U.S. In addition, nearly 22

RAIN

million tons of nitrogen oxides were produced. By way of comparison, the eruption of Mount St. Helens in the state of Washington on May 18, 1980, blew out some 400,000 tons of sulfur dioxide, which is just over 1.5% of the total from man-made sources in the U.S. for that same year.

Some Effects of Acid Rain

Lakes and Streams. Most scientists agree that acid conditions affect animals and plants that live in water—in streams, rivers, lakes, ponds, and marshes. The decline in fish population in some rivers and lakes has been linked to the toxic effect of aluminum, which is leached from soil by acid rain. Aluminum compounds collect in the gills of small fish. To combat the pollutant, the fish produce unusually large amounts of a mucus, which eventually strangles them.

A particularly bad time of the year for the aquatic community is spring when the snow melts and runs into

streams and ponds. Extensive fish kills in early spring have been attributed to the runoff of the large amount of acid that accumulates on the snow over the winter.

Forests and Crops. Acid rain can dissolve and wash away valuable minerals such as magnesium, calcium, and potassium from the soil. Severe acid rain also can dissolve the waxy covering that protects leaves from fungi and bacteria. It is a well-documented fact that a growing number of forests and crops suffer total or partial damage each year, and there is good reason to suspect that this damage is due, in part, to acid rain. More study is needed to determine the extent to which acid rain is responsible for this damage and to establish the precise cause-and-effect relationship.

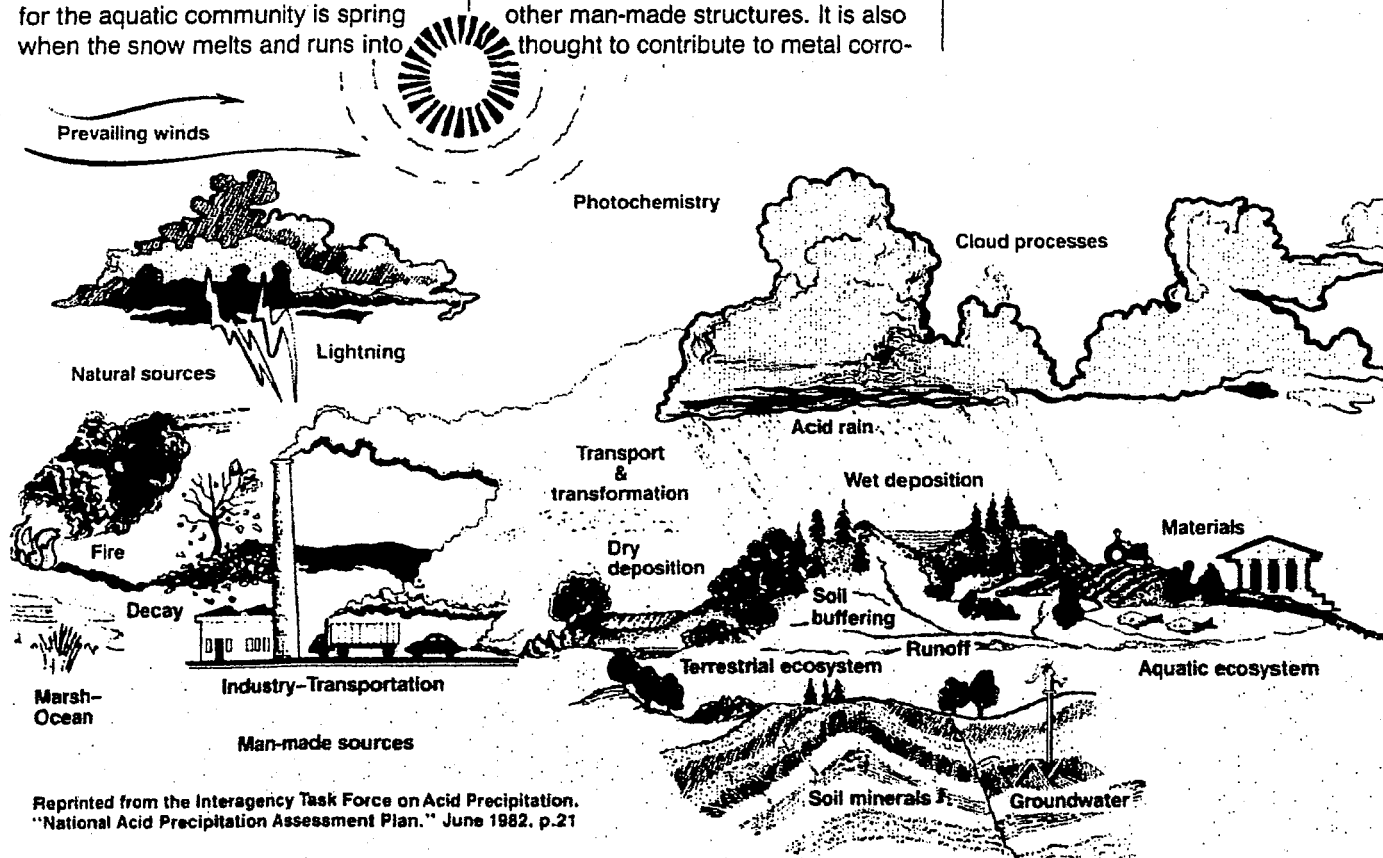
Materials. Acid rain is believed to be responsible for many forms of damage to buildings, monuments, and other man-made structures. It is also thought to contribute to metal corro-

WHAT ARE THE CAUSES OF ACID RAIN?

WHY IS ACID RAIN AN INTERSTATE AND INTERNATIONAL ISSUE?

IN WHAT WAY IS THE CONSUMER RESPONSIBLE FOR ACID RAIN?

TO WHAT EXTENT IS ACID RAIN PREVENTABLE?



Reprinted from the Interagency Task Force on Acid Precipitation. "National Acid Precipitation Assessment Plan." June 1982, p.21

Figure 1. Steps leading to acid rain formation

8

sion, to reduce exterior paint durability, and to deteriorate textiles, paper, and leather.

Human Health. Little is known about the effects of acid rain on health. There are, however, several reasons for concern. Sulfur dioxide and sulfates are known to be harmful if inhaled, especially by people who suffer from asthma or other respiratory problems. The food chain may also be adversely affected by acid rain. Toxic metals, dissolved by acid rain, may be deposited in waters and finally taken up by fish. In addition, an acidic drink-

ing water supply can dissolve such toxic metals as copper or lead. These metals are often present in the pipes or the pipe joints in plumbing.

No one is absolutely certain about all the effects of acid rain, how serious they are, or what controls are necessary to lessen these effects. Research is currently under way to answer these questions. In the meantime, many scientists are recommending across-the-board pollution emission reductions and are working to find methods of countering the effects of acid precipitation after it has fallen.

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A National Acid Rain Survey

Readers who wish to take part in an acid rain survey can do so by sending a self-addressed, stamped envelope to:

The American Chemical Society
 Office of High School Chemistry
 1155 16th St., N.W.
 Washington, D.C. 20036

By return mail, you will receive some pH indicator paper and instructions for its use. Narrow-range pH test strips have been donated by Whatman Paper Division, Whatman Laboratory Products Inc., producer of filter and indicator papers. These strips will be distributed on a first-come, first-served basis and hopefully will furnish your editors with a large number of pH readings of rainfall from a wide geographical area. We plan to share the results of this survey with you in a future issue of *Chem Matters*.

The Rain in Spain

*There was a young lady of Spain
 Who was angered by acid in rain,
 "We must pull up our SO_x
 And get rid of NO_x
 Or there won't be much left of the
 plain."*

—pHred

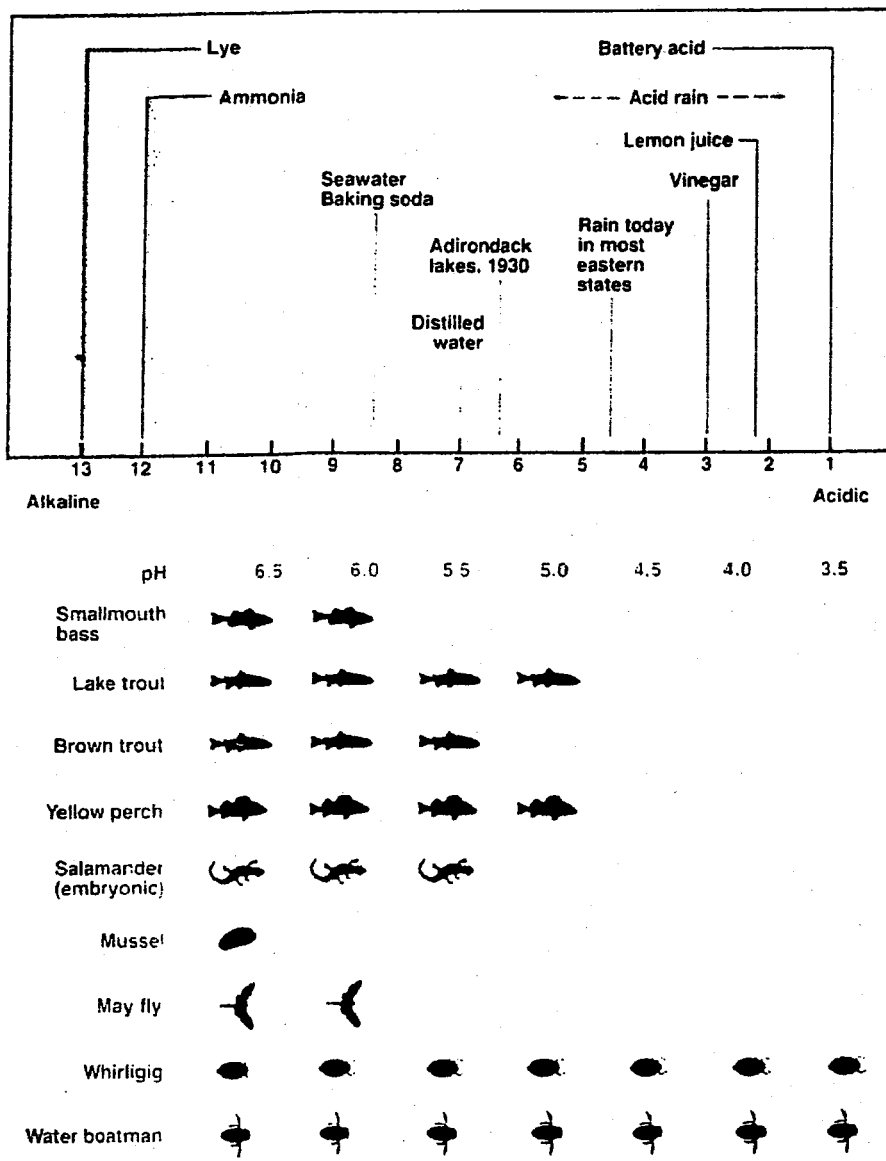


Figure 2. Graph shows acid tolerance of selected fish and invertebrates. Acid rain varies in pH over the approximate range indicated.

(from *The Science Teacher*, also in *National Geographic*—see references)

Name _____

Acid Rain Lab Questions

1. What are the causes of acid rain?
 - a. Natural

 - b. Man-made

2. In what way is the consumer responsible for acid rain?

3. Why is acid rain an interstate and international issue?

4. Explain why acid rain damages forests, crops and other materials.

5. How, and to what extent, can acid rain be prevented?

Table 1. Correlation of pH values and Hydronium ion concentrations

pH	Hydronium ion concentration (moles/L)
1	1×10^{-1}
2	1×10^{-2}
3	1×10^{-3}
4	1×10^{-4}
5	1×10^{-5}
6	1×10^{-6}
7	1×10^{-7}
8	1×10^{-8}
9	1×10^{-9}
10	1×10^{-10}
11	1×10^{-11}
12	1×10^{-12}
13	1×10^{-13}
14	1×10^{-14}

Name _____

Acid Base Quiz

- ① Arrhenius acids contain _____ ions in solution
- ② Arrhenius bases contain _____ ions in solution
- ③ Draw a hydronium Ion

④ List 2 properties of acids

A.

B.

⑤ List 2 properties of bases

A.

B.

⑥ Finish the equation: Acid + Base \rightarrow _____ + _____

⑦ Write the balanced equation for the Neutralization between phosphoric acid and Sodium hydroxide

⑧ What tables could you use to help with # 7: _____, _____, _____

⑨ What's the main difference between monoprotic, diprotic & triprotic acids?

⑩ Acid, Base or neither: you choose for each

A) $\text{Ba}(\text{OH})_2$

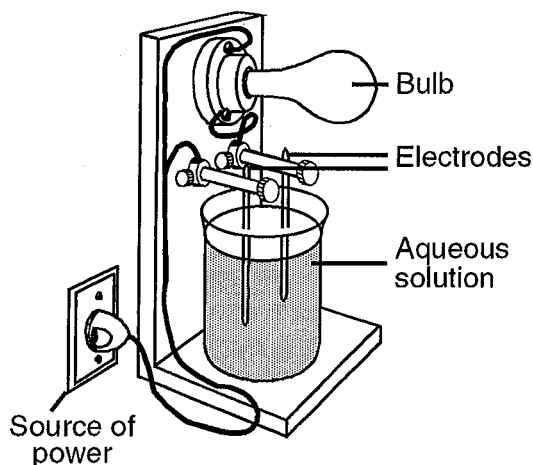
B) H_3COH

C) H_3COOH

⑫ _____

Name: _____

- 1) Which compound is a nonelectrolyte?
 A) HNO_3 C) CaCl_2
 B) KOH D) $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- 2) Red litmus will turn blue when placed in an aqueous solution of
 A) KCl C) CH_3OH
 B) KOH D) CH_3COOH
- 3) Which element at STP is a poor conductor of electricity and has a relatively high electronegativity?
 A) S C) Mg
 B) Cu D) Fe
- 4) Which compound will conduct an electric current when dissolved in water?
 A) $\text{C}_2\text{H}_5\text{OH}$ C) $\text{C}_6\text{H}_{12}\text{O}_6$
 B) NaOH D) $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- 5) If 50.0 milliliters of 3.0 M HNO_3 completely neutralized 150.0 milliliters of KOH , what was the molarity of the KOH solution?
 A) 3.0 M C) 6.0 M
 B) 1.0 M D) 4.5 M
- 6) The formula for the calcium salt of sulfuric acid is
 A) Ca_2S C) CaSO_4
 B) CaS D) Ca_2SO_4
- 7) The diagram below shows an apparatus used to test the conductivity of various materials.



Which aqueous solution will cause the bulb to light?

- A) $\text{CH}_3\text{OH}(\text{aq})$ C) $\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{aq})$
 B) $\text{LiOH}(\text{aq})$ D) $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq})$

- 8) Which type of reaction occurs when 50-milliliter quantities of $\text{Ba}(\text{OH})_2(\text{aq})$ and $\text{H}_2\text{SO}_4(\text{aq})$ are combined?
 A) neutralization C) ionization
 B) hydrogenation D) hydrolysis
- 9) Which substance is a conductor of electricity in the liquid phase but *not* in the solid phase?
 A) HBr C) Na
 B) Br_2 D) NaCl
- 10) Which statement *best* describes the solution produced when an Arrhenius acid is dissolved in water?
 A) The only positive ion in solution is H^+ .
 B) The only negative ion in solution is HCO_3^- .
 C) The only negative ion in solution is OH^- .
 D) The only positive ion in solution is NH_4^+ .
- 11) As 1 gram of sodium hydroxide dissolves in 100 grams of water, the conductivity of the solution
 A) increases
 B) remains the same
 C) decreases
- 12) Which compound is a salt?
 A) $\text{Ca}(\text{OH})_2$ C) Na_3PO_4
 B) CH_3COOH D) H_3PO_4
- 13) Which of the following 0.1 M solutions has the *lowest* pH?
 A) 0.1 M HCl C) 0.1 M NaCl
 B) 0.1 M NaOH D) 0.1 M CH_3OH
- 14) According to the Arrhenius theory of acids, citric acid in oranges and acetic acid in vinegar are classified as acids because their aqueous solutions contain
 A) hydroxide atoms C) hydrogen atoms
 B) hydroxide ions D) hydrogen ions
- 15) A 16-milliliter sample of 0.50 M KOH will completely neutralize 32 milliliters of
 A) 0.75 M HNO_3 C) 1.0 M HNO_3
 B) 0.50 M HNO_3 D) 0.25 M HNO_3
- 16) According to the Arrhenius theory, the only negative ions in an aqueous solution of a base are
 A) HCO_3^- ions C) H^- ions
 B) HS^- ions D) OH^- ions

- 17) If 20. milliliters of a 1.0 M solution of HCl is exactly neutralized by 40. milliliters of NaOH, the molarity of the NaOH solution is
- A) 4.0 M C) 1.0 M
B) 0.50 M D) 2.0 M
- 18) According to the Arrhenius theory, which list of compounds includes only bases?
- A) NaOH, Ca(OH)₂, and CH₃COOH
B) LiOH, Ca(OH)₂, and C₂H₄(OH)₂
C) KOH, NaOH, and LiOH
D) KOH, Ca(OH)₂, and CH₃OH
- 19) Which relationship is present in a solution that has a pH of 7?
- A) $[H^+] + [OH^-] = K_w$
B) $[H^+] = [OH^-]$
C) $[H^+] < [OH^-]$
D) $[H^+] > [OH^-]$
- 20) Red litmus will turn blue when placed in a 0.1 M solution of
- A) NaOH C) CH₃OH
B) HNO₃ D) HCl

Part II: Show all work in the following problems

- 1) Complete a neutralization reaction between Phosphoric acid and Potassium hydroxide. Show the balance reaction using molecular formulas for each material.
- 2) Will a reaction occur between HCL and Magnesium metal? If so, name the type of reaction occurring and complete a balanced equation.
- 3) Name the salt formed in a neutralization reaction between phosphoric acid and calcium hydroxide.
- 4) If the molarity of a phosphoric acid solution is 3.0M, what is the concentration of the $[H^+]$ ion (otherwise known as the normality)?
- 5) Indicators change color when they gain or lose which atomic particle?

Name: _____

- 1) Which substance yields hydroxide ion as the only negative ion in aqueous solution?
 A) $C_2H_4(OH)_2$ C) $Mg(OH)_2$
 B) $MgCl_2$ D) CH_3Cl
- 2) Which species can conduct an electric current?
 A) $HCl(aq)$ C) $NaOH(s)$
 B) $H_2O(s)$ D) $CH_3OH(aq)$
- 3) Which of these pH numbers indicates the *highest* level of acidity?
 A) 5 C) 8
 B) 12 D) 10
- 4) A compound whose water solution conducts electricity and turns phenolphthalein pink is
 A) HCl C) CH_3OH
 B) $HC_2H_3O_2$ D) $NaOH$
- 5) How many milliliters of 12.0 M $HCl(aq)$ must be diluted with water to make exactly 500. mL of 3.00 M hydrochloric acid?
 A) 100. mL C) 200. mL
 B) 250. mL D) 125. mL
- 6) Which substance is an Arrhenius acid?
 A) $LiF(aq)$ C) CH_3CHO
 B) $Mg(OH)_2(aq)$ D) $HBr(aq)$
- 7) Which compound could serve as a reactant in a neutralization reaction?
 A) CH_3OH C) $NaCl$
 B) CH_3CHO D) KOH
- 8) What is the molarity of an HCl solution if 20. milliliters of this acid is needed to neutralize 10. milliliters of a 0.50 M $NaOH$ solution?
 A) 0.50 M C) 0.25 M
 B) 0.75 M D) 1.0 M
- 9) Which ion is produced when an Arrhenius base is dissolved in water?
 A) H_3O^+ , as the only positive ion in solution
 B) H^- , as the only negative ion in solution
 C) OH^- , as the only negative ion in solution
 D) H^+ , as the only positive ion in solution
- 10) Which pH indicates a basic solution?
 A) 12 C) 5
 B) 7 D) 1
- 11) Given the following solutions:
 Solution A: pH of 10
 Solution B: pH of 7
 Solution C: pH of 5
- Which list has the solutions placed in order of increasing H^+ concentration?
 A) C, A, B C) B, A, C
 B) A, B, C D) C, B, A
- 12) Which of these 1 M solutions will have the *highest* pH?
 A) $NaCl$ C) $NaOH$
 B) HCl D) CH_3OH
- 13) A student neutralized 16.4 milliliters of HCl by adding 12.7 milliliters of 0.620 M KOH . What was the molarity of the HCl acid?
 A) 0.620 M C) 0.480 M
 B) 0.801 M D) 0.168 M
- 14) An Arrhenius acid has
 A) hydrogen ions as the only positive ions in solution
 B) only hydrogen ions in solution
 C) only hydroxide ions in solution
 D) hydrogen ions as the only negative ions in solution
- 15) Which of the following pH values indicates the *highest* concentration of hydronium ions in a solution?
 A) pH = 1 C) pH = 3
 B) pH = 2 D) pH = 4
- 16) If 5.0 milliliters of a 0.20 M HCl solution is required to neutralize exactly 10. milliliters of $NaOH$, what is the concentration of the base?
 A) 0.10 M C) 0.40 M
 B) 0.30 M D) 0.20 M
- 17) When the pH of a solution changes from a pH of 5 to a pH of 3, the hydronium ion concentration is
 A) 0.1 of the original content
 B) 100 times the original content
 C) 0.01 of the original content
 D) 10 times the original content
- 18) Given the reaction:

$$HCl(aq) + LiOH(aq) \rightarrow HOH(l) + LiCl(aq)$$
 The reaction is *best* described as
 A) decomposition
 B) neutralization
 C) synthesis
 D) oxidation-reduction

15

- 19) A substance that conducts an electrical current when dissolved in water is called
 A) a catalyst
 B) a metalloid
 C) an electrolyte
 D) a nonelectrolyte
- 20) Which equation represents a neutralization reaction?
 A) $\text{Ni}(\text{NO}_3)_2 + \text{H}_2\text{S} \rightarrow \text{NiS} + 2\text{HNO}_3$
 B) $\text{H}_2\text{SO}_4 + \text{Mg}(\text{OH})_2 \rightarrow \text{MgSO}_4 + 2\text{H}_2\text{O}$
 C) $\text{Na}_2\text{CO}_3 + \text{CaCl}_2 \rightarrow 2\text{NaCl} + \text{CaCO}_3$
 D) $\text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl} + \text{NaNO}_3$

Questions 21 and 22 refer to the following:

A truck carrying concentrated nitric acid overturns and spills its contents. The acid drains into a nearby pond. The pH of the pond water was 8.0 before the spill. After the spill, the pond water is 1,000 times more acidic.

- 21) (a) What is the new pH of the pond water after the spill?
 (b) What color would bromthymol blue be at this new pH?

- 22) Name an ion in the pond water that has increased in concentration due to this spill.

Questions 23 and 24 refer to the following:

Calcium hydroxide is commonly known as agricultural lime and is used to adjust the soil pH. Before the lime was added to a field, the soil pH was 5. After the lime was added, the soil underwent a 100-fold decrease in hydronium ion concentration.

- 23) According to the *Solubility Guidelines* chemistry reference table, calcium hydroxide is soluble in water. Identify another hydroxide compound that contains a Group 2 element and is also soluble in water.
- 24) What is the new pH of the soil in the field described?

- 25) A student recorded the following buret readings during a titration of a base with an acid:

	Standard 0.100 M HCl	Unknown KOH
Initial reading	9.08 mL	0.55 mL
Final reading	19.09 mL	5.56 mL

Calculate the molarity of the KOH. [Show all work. Record your answer to the correct number of significant figures.]

16

REDOX: Reduction Oxidation Vocabulary and Key Ideas

VOCAB:

anode the site in an electrochemical cell where oxidation occurs

cathode the site in an electrochemical cell where reduction occurs

conductivity a measure of the ability of an electric current to flow through a substance

electrochemical cell a system in which there is an electric current flowing while a chemical reaction occurs

electrode the site at which oxidation or reduction occurs; an anode or a cathode

electrolysis a process in which an electric current forces a non-spontaneous redox reaction to occur

electrolyte a substance whose water solution conducts an electric current

electrolytic cell a cell that requires electricity to cause a non-spontaneous chemical reaction to occur

half-reaction a reaction that shows either the oxidation or reduction portion of a redox reaction

oxidation number (state) number assigned to keep track of electron gain or loss in redox reactions

oxidation the loss of electrons and an increase in oxidation state

oxidizing agent the substance reduced in a redox reaction

redox an oxidation-reduction reaction

reducing agent the substance oxidized in a redox reaction

reduction the gain of electrons and the loss of oxidation number

voltaic cell an electrochemical cell in which a spontaneous chemical reaction causes a flow of electrons

KEY IDEAS:

- An oxidation reduction (redox) reaction involves the transfer of electrons
- Reduction is the gain of electrons
- Oxidation is the loss of electrons
- A half reaction can be written to represent reduction OR oxidation
- In a redox reaction, the number of electrons lost is equal to the number of electrons gained.
- Oxidation numbers (states) can be assigned to atoms and ions. Changes in oxidation numbers indicate that oxidation and reduction have occurred.
- An electrochemical cell can either be voltaic or electrolytic. In an electrochemical cell, oxidation occurs at the anode and reduction at the cathode.
- A voltaic cell spontaneously converts chemical energy to electrical energy
- An electrolytic cell requires electrical energy to produce chemical change. This process is known as electrolysis.

1 **Reduction and Oxidation**

REDOX

2 **LEO GER vs. OIL RIG** LEO GER■ Loss of Electrons = Oxidation■ Gain of Electrons = Reduction OIL RIG■ Oxidation is Loss■ Reduction is Gain3 **LEO GER continued** Ex. Ionic bond between Magnesium and Oxygen4 **Oxidation Numbers** relate amount of electrons lost/gained by an atom or ion in a reaction Rules for Oxidation Number's: Uncombined/pure elements = Zero■ $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ ■ $\text{Mg} + \text{CuSO}_4 \rightarrow \text{MgSO}_4 + \text{Cu}$ Compounds/Molecules have oxidation sums of zero■ $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ (Ox. #'s are only in water)■ $\text{Mg} + \text{CuSO}_4 \rightarrow \text{MgSO}_4 + \text{Cu}$ 5 **Rules for Oxidation Number's continued** Monatomic ions have oxidation #'s equal to their ionic charge■ $\text{NaCl} \rightarrow \text{Na}^{+1} + \text{Cl}^{-1}$ Group 1 are all +1/Group 2 are all +2 Fluorine is always -1, while other halogens are usually -1, except when bonded to a more electronegative element Hydrogen usually +1, except when bonded to a metal, then it is -1■ HNO_3 = H is +1 NaH = H is -16 **Rules for Oxidation Number's continued** Oxygen usually -2, except when bonded with Fluorine, then it is +2 Polyatomic ions have oxidation #'s equal to their ionic charge ****Note for molecules/compounds/polyatomic ions:** subscripts need to be multiplied with charge for each atom to determine overall charge7 **Determining if REDOX has occurred**

- Did oxidation # change?
 - Assign oxidation #'s to all atoms in reactants and products to determine change
 - If change, REDOX occurred
- Is an atom in a compound on one side and uncombined on the other?
 - If true, REDOX occurred
 - Ex. $2\text{HCl} \rightarrow \text{H}_2 + \text{Cl}_2$
- Did a double replacement reaction occur?
 - These are typically NOT REDOX rxn's
 - Verify by checking all oxidation #'s

8 Determining if it is OXIDATION or REDUCTION

-
- If atoms have \uparrow in oxidation # = OXIDATION
 - They become more positive (loss of e-)
 - $-1 \rightarrow 0$, $+1 \rightarrow +3$, $0 \rightarrow +2$
- If atoms have \downarrow in oxidation # = REDUCTION
 - They become less positive (gain of e-)
 - $0 \rightarrow -2$, $+4 \rightarrow +2$

9 Solve the following

- determine which is oxidized and reduced by listing all changes in oxidation #
- $\text{MnO}_2 + 4\text{HCl} \rightarrow \text{MnCl}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$
- | <u>Reactants</u> | → | <u>Products</u> | <u>Result</u> |
|------------------|---|------------------|---------------|
| Mn^{+4} | → | Mn^{+2} | Reduction |
| O^{-2} | → | O^{-2} | = N/A |
| H^{+1} | → | H^{+1} | = N/A |
| Cl^{-1} | → | Cl^{-1} | = N/A |
| Cl^{-1} | → | Cl^0 | = Oxidation |

10 Reducing Agents

- Material Oxidized is known as the reducing agent
 - Reducing Agent: material that causes another element to be reduced by giving it electrons as it is oxidized
 - Ex. Chlorine is oxidized in above example as it loses/gives e- to manganese

11 Oxidizing Agents

- Material Reduced is known as the oxidizing agent
 - Oxidizing Agent: material that causes another element to be oxidized by taking electrons as it is reduced
 - Ex. Manganese is reduced in above example as it gains/takes e- from chlorine

12 Reducing and Oxidizing Agents

- Ex. $2\text{HCl} \rightarrow \text{H}_2 + \text{Cl}_2$
 - $\text{H}^{+1} \rightarrow \text{H}^0 = \text{GER} = \text{Reduction}$ and acts as oxidizing agent
 - $\text{Cl}^{-1} \rightarrow \text{Cl}^0 = \text{LEO} = \text{Oxidized}$ and acts as reducing agent
- What is the Reducing/Oxidizing agent for the following:
 - $4\text{HCl} + \text{MnO}_2 \rightarrow \text{MnCl}_2 + 2\text{H}_2\text{O} + \text{Cl}_2$
 - Reducing = Cl^{-1} Oxidizing = Mn^{+4}

13 **Half Reactions**

- Breaks REDOX into 2 equations to show loss/gain of e-
 - 2 half reactions can be put together to make complete reaction
- Follows conservation of matter, mass and charge
- Reduction: atoms/ions gain 1 or more e-
 - Oxidation #'s ↓
 - $\text{Fe}^{+3} + 3\text{e}^- \rightarrow \text{Fe}^0$ (shows gain on reactant side)
- Oxidation: atoms/ions lose 1 or more e-
 - Oxidation #'s ↑
 - $\text{Fe}^0 \rightarrow \text{Fe}^{+3} + 3\text{e}^-$ (shows loss on product side)

14 **Half reaction for REDOX**

-
- $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$
-
- HINT: Assign oxidation #'s and eliminate any that may not have changed
- 0 +1 -1 +2 -1 0
- $\text{Cu} + 2\text{Ag}(\text{NO}_3) \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$
- Eliminate the Nitrate ions (as they do not change)
- Do half reactions for Copper and Silver
- $\text{Cu}^0 \rightarrow \text{Cu}^{+2} + 2\text{e}^-$
- $2\text{Ag}^{+1} + 2\text{e}^- \rightarrow 2\text{Ag}^0$
- Shows conservation of matter, mass and charge

15 **Electrochemistry**

-
- Current caused by the flow of electrons in a REDOX reaction
- Occurs in Electrochemical Cells (2 types)
 - Voltaic: spontaneous reactions produce flow of electrons
 - $\text{Zn} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{Pb} + \text{Zn}(\text{NO}_3)_2$
 - Table J = Zn is higher than Pb and will replace it in a spontaneous reaction

16 **Electrochemical Cells (2 types)**
continued

- Electrolytic: electric current needed to force a non-spontaneous reaction to occur and for electrons to flow

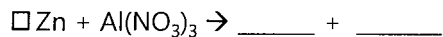


Table J=Zn is lower than Al and will not replace it spontaneously

- Energy source needed to force the reaction to occur

17 **Anode vs. Cathode**

Cells contain 2 surfaces (electrodes) that conduct electricity

- Anode → where Oxidation occurs (AnOx)

■

■

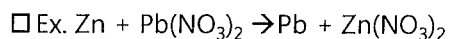
■

- Cathode → Where Reduction occurs (RedCat)

18 **Spontaneous Reactions associated with Voltaic Cells**

Table J → determine which is anode/cathode and which is oxidized/reduced

- Anode/Oxidation = AnOx = Higher element on table
- Cathode/Reduction = RedCat = Lower Element on table



Zn is higher = Anode/Oxidation

Pb is lower = Cathode/Reduction

19 **Salt Bridge-Spontaneous Rxn**

A salt bridge may also be used to connect separate solutions and allow for a complete circuit

- Ions would flow between beakers along a wire

20 **Salt Bridge continued**

21 **Voltaic vs. Electrolytic Cells**

22 **Voltaic vs. Electrolytic Cells**

- Both are REDOX reactions
- Current always flows from anode to cathode
- Anode is always Oxidation
- Cathode is always Reduction

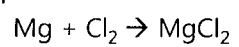
23 **Sample Problems:**

- 1. Balance the following redox reaction using the *smallest* whole-number coefficients.
-
- 2. What happens to the number of protons in a Zn atom when it changes to Zn^{2+} as in the previous redox reaction?

24 **Sample Problems:**

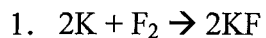
- 3. What is the oxidation number of chromium in $\text{K}_2\text{Cr}_2\text{O}_7$
-

□ 4. Complete balanced half reactions for the following:



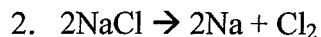
Name _____

Half Reaction Practice: Complete the following half reactions for both oxidation and reduction:



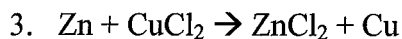
a. Oxidation Half Reaction _____

b. Reduction Half Reaction _____



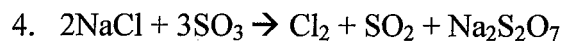
a. Oxidation Half Reaction _____

b. Reduction Half Reaction _____



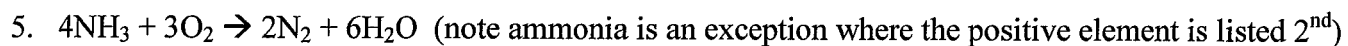
a. Oxidation Half Reaction _____

b. Reduction Half Reaction _____



a. Oxidation Half Reaction _____

b. Reduction Half Reaction _____



a. Oxidation Half Reaction _____

b. Reduction Half Reaction _____

Name _____

Oxidation Numbers Practice: Determine oxidation numbers for each element in the molecules/compounds listed below: Put final Oxidation # in spaces provided for each element

1. Na_2CrO_4
a. Na _____
b. Cr _____
c. O _____

2. $\text{Na}_2\text{Cr}_2\text{O}_7$
a. Na _____
b. Cr _____
c. O _____

3. H_2CO_3
a. H _____
b. C _____
c. O _____

4. H_2SO_4
a. H _____
b. S _____
c. O _____

5. NO
a. N _____
b. O _____

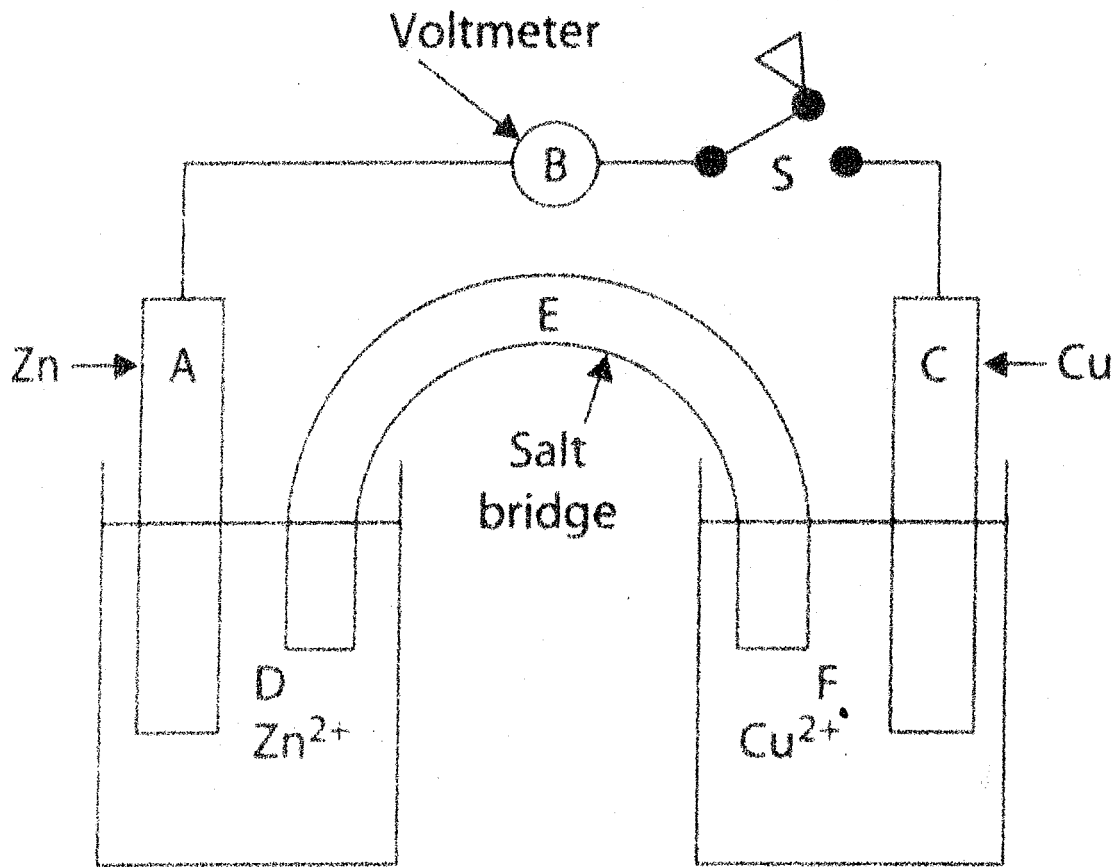
6. NO_2
a. N _____
b. O _____

7. N_2O
a. N _____
b. O _____

8. KMnO_4
a. K _____
b. Mn _____
c. O _____

Voltaic Cell

The diagram below shows an electrochemical cell.



Name _____

REDOX QUIZ

1. LEO GER and OIL RIG...what does it all mean
 - a. Reduction is the _____ of electrons
 - b. Oxidation is the _____ of electrons

2. What is the oxidation number for Chlorine in each of the following materials?
 - a. NaClO_4

 - b. NaClO

3. Oxygen has a +2 oxidation number when bonded to Fluorine; Give one reason why this occurs.

4. Determine whether a REDOX reaction has occurred or not. A simple yes or no answer will do.
 - a. $2\text{KI} + \text{Pb}(\text{NO}_3)_2 \rightarrow \text{PbI}_2 + 2\text{KNO}_3$ _____
 - b. $\text{H}_2 + \text{Br}_2 \rightarrow 2\text{HBr}$ _____
 - c. $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$ _____

5. If the oxidation number changes from -1 to +1, which process has occurred?

6. Which material is being oxidized in the following reaction?
 $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$

Bonus: Answer the following based on Regents Review Live from Lab class:

1. What stuffed animal represented a type of bonding?
2. What big city did many of the calls come from?
3. What was the name of the overhead projector like device he used? (Hint...Red, fuzzy and easily tickled)

26

REDOX

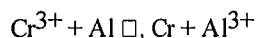
Name: _____

- ___ 1) In which compound does chlorine have the *highest* oxidation number?
 A) NaClO₂ C) NaClO₄
 B) NaClO₃ D) NaClO

- ___ 2) What is the oxidation state of nitrogen in NaNO₂?
 A) +1 C) +3
 B) +2 D) +4

- ___ 3) The transfer of which particle is required for a redox reaction to occur?
 A) proton C) ion
 B) neutron D) electron

- ___ 4) Given the redox reaction:

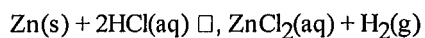


As the reaction takes place, there is a transfer of

- A) protons from Cr³⁺ to Al
 B) protons from Al to Cr³⁺
 C) electrons from Cr³⁺ to Al
 D) electrons from Al to Cr³⁺
- ___ 5) Which reaction is an example of an oxidation-reduction reaction?
 A) AgNO₃ + KI \square , AgI + KNO₃
 B) Cu + 2AgNO₃ \square , Cu(NO₃)₂ + 2Ag
 C) Ba(OH)₂ + 2HCl \square , BaCl₂ + 2H₂O
 D) 2KOH + H₂SO₄ \square , K₂SO₄ + 2H₂O

- ___ 6) As a Ca atom undergoes oxidation to Ca²⁺, the number of neutrons in its nucleus
 A) increases
 B) decreases
 C) remains the same

- ___ 7) Given the reaction:



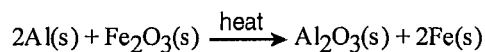
Which statement correctly describes what occurs when this reaction takes place in a closed system?

- A) There is a net gain of mass.
 B) Atoms of Zn(s) lose electrons and are oxidized.
 C) There is a net loss of mass.
 D) Atoms of Zn(s) gain electrons and are reduced.
- ___ 8) Which type of reaction occurs when nonmetal atoms become negative nonmetal ions?
 A) condensation
 B) substitution
 C) oxidation
 D) reduction

- ___ 9) In an oxidation-reduction reaction, reduction is defined as the
 A) loss of electrons
 B) gain of electrons
 C) gain of protons
 D) loss of protons

- ___ 10) In any redox reaction, the substance that undergoes reduction will
 A) gain electrons and have an increase in oxidation number
 B) lose electrons and have an increase in oxidation number
 C) gain electrons and have a decrease in oxidation number
 D) lose electrons and have a decrease in oxidation number

- ___ 11) Given the reaction:

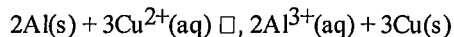


Which species undergoes reduction?

- A) Fe C) Fe³⁺
 B) Al³⁺ D) Al
- ___ 12) When a neutral atom undergoes oxidation, the atom's oxidation state
 A) increases as it gains electrons
 B) increases as it loses electrons
 C) decreases as it loses electrons
 D) decreases as it gains electrons
- ___ 13) Which change in oxidation number indicates oxidation?
 A) +3 to +2 C) +2 to -3
 B) -1 to -2 D) -1 to +2
- ___ 14) According to the *Activity Series* chemistry reference table, which of these metals will react most readily with 1.0 M HCl to produce H₂(g)?
 A) K C) Ca
 B) Zn D) Mg
- ___ 15) Which metal reacts spontaneously with a solution containing zinc ions?
 A) copper C) silver
 B) magnesium D) nickel

- ___ 16) In a redox reaction, how does the total number of electrons lost by the oxidized substance compare to the total number of electrons gained by the reduced substance?
- The number lost is always greater than the number gained.
 - The number lost is sometimes less than the number gained.
 - The number lost is always equal to the number gained.
 - The number lost is sometimes equal to the number gained.

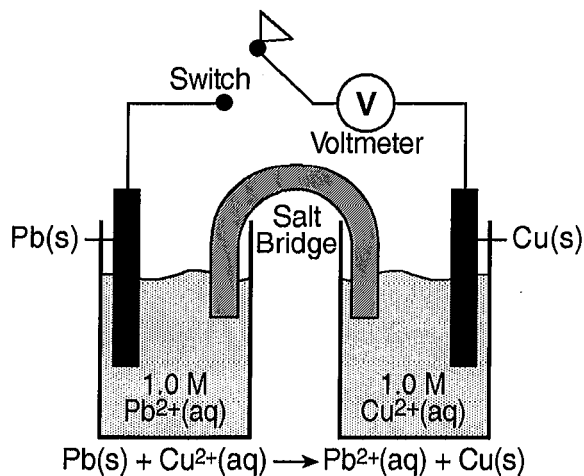
- ___ 17) Given the balanced ionic equation:



Compared to the total charge of the reactants, the total charge of the products is

- greater
 - less
 - the same
- ___ 18) What is conserved during a chemical reaction?
- neither mass nor charge
 - charge, only
 - mass, only
 - both mass and charge

- ___ 22) A diagram of a chemical cell and an equation are shown below.



When the switch is closed, electrons will flow from

- the $\text{Cu}^{2+}(\text{aq})$ to the $\text{Cu}(s)$
- the $\text{Pb}^{2+}(\text{aq})$ to the $\text{Pb}(s)$
- the $\text{Pb}(s)$ to the $\text{Cu}(s)$
- the $\text{Cu}(s)$ to the $\text{Pb}(s)$

- ___ 23) Which process requires an external power source?
- electrolysis
 - synthesis
 - neutralization
 - fermentation

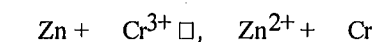
- ___ 19) In a voltaic cell, chemical energy is converted to
- nuclear energy, nonspontaneously
 - electrical energy, spontaneously
 - nuclear energy, spontaneously
 - electrical energy, nonspontaneously
- ___ 20) Which statement is true for any electrochemical cell?
- Oxidation occurs at the anode, only.
 - Reduction occurs at both the anode and the cathode.
 - Reduction occurs at the anode, only.
 - Oxidation occurs at both the anode and the cathode.
- ___ 21) What is the purpose of the salt bridge in a voltaic cell?
- It blocks the flow of electrons.
 - It is a path for the flow of electrons.
 - It is a path for the flow of positive and negative ions.
 - It blocks the flow of positive and negative ions.

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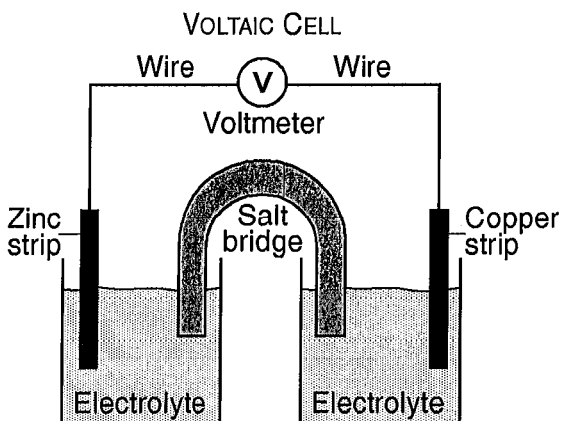
- ___ 24) Where does oxidation occur in an electrochemical cell?
- A) at the anode in an electrolytic cell and at the cathode in a voltaic cell
- B) at the anode in both an electrolytic cell and a voltaic cell
- C) at the cathode in an electrolytic cell and at the anode in a voltaic cell
- D) at the cathode in both an electrolytic cell and a voltaic cell
- ___ 25) The redox reaction below occurs spontaneously in an electrochemical cell.



Balance the equation below using the *smallest* whole-number coefficients.



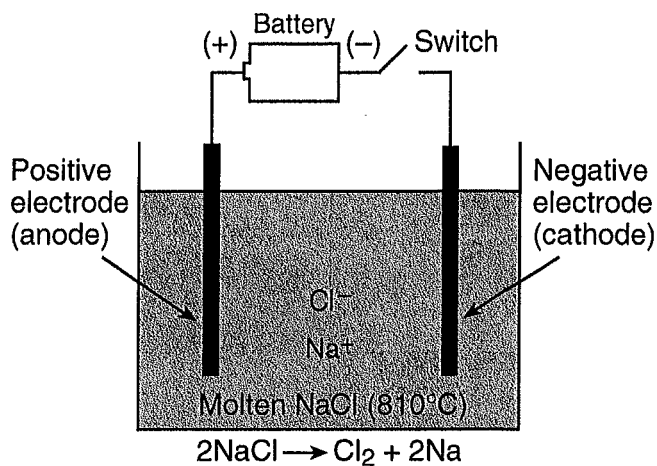
___ 26)



On the given diagram, indicate with one or more arrows the direction of electron flow through the wire.

Questions 26 and 27 refer to the following:

The diagram and balanced equation below represents the electrolysis of molten NaCl.



- ___ 27) When the switch in the diagram is closed, which electrode will attract the sodium ions?
- ___ 28) What is the purpose of the battery in the electrolytic cell shown?

Questions 28 and 29 refer to the following:

Aluminum is one of the most abundant metals in Earth's crust. The aluminum compound found in bauxite ore is Al_2O_3 . Over one hundred years ago, it was difficult and expensive to isolate aluminum from bauxite ore. In 1886, a brother and sister team, Charles and Julia Hall, found that molten (melted) cryolite, Na_3AlF_6 , would dissolve bauxite ore. Electrolysis of the resulting mixture caused the aluminum ions in the Al_2O_3 to be reduced to molten aluminum metal. This less expensive process is known as the Hall process.

- ___ 29) Write the balanced half-reaction equation for the reduction of Al^{3+} to Al.
- ___ 30) Explain, in terms of ions, why the molten cryolite discussed in the reading passage conducts electricity.

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REDOX

- _____ 1. If an atom is reduced in a redox reaction, what must happen to another atom in the system?
a. It must be oxidized. b. It must be reduced. c. It must be neutralized. d. Nothing needs to happen to another atom in the system.
- _____ 2. What is another name for an oxidation-reduction reaction?
a. O-reaction b. R-reaction c. redox reaction d. oxred reaction
- _____ 3. Oxidation is _____.
a. a loss of oxygen b. a gain of electrons c. a loss of electrons d. a gain of hydrogen
- _____ 4. $\text{Cu} \rightarrow \text{Cu}^{2+} + 2 \text{e}^-$
The equation above represents the type of reaction called _____.
a. redox b. hydrolysis c. reduction d. oxidation
- _____ 5. What is the reducing agent in the following reaction?
 $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2$
a. Na b. H_2O c. NaOH d. H_2
- _____ 6. What is the oxidizing agent in the following reaction?
 $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
a. CH_4 b. O_2 c. CO_2 d. H_2O
- _____ 7. The oxidation number of bromine in bromine gas is _____.
a. -2 b. -1 c. 0 d. +1
- _____ 8. The oxidation number of sulfur in each of the following is +6 EXCEPT for _____.
a. SO_3 b. Na_2SO_4 c. SO_4^{2-} d. $\text{S}_2\text{O}_4^{2-}$
- _____ 9. In the following unbalanced reaction, which atom is reduced?
 $\text{H}_2\text{O} + \text{Cl}_2 + \text{SO}_2 \rightarrow \text{HCl} + \text{H}_2\text{SO}_4$
a. hydrogen b. oxygen c. chlorine d. sulfur
- _____ 10. In the following unbalanced reaction, which atom is oxidized?
 $\text{HNO}_3 + \text{HBr} \rightarrow \text{NO} + \text{Br}_2 + \text{H}_2\text{O}$
a. hydrogen b. nitrogen c. oxygen d. bromine
- _____ 11. Which element decreases its oxidation number in the following reaction?
 $\text{BiCl}_2 + \text{Na}_2\text{SO}_4 \rightarrow 2\text{NaCl} + \text{BiSO}_4$
a. bismuth b. chlorine c. oxygen d. No element decreases its oxidation number.
- _____ 12. Which of the following reactions is a redox reaction?
a. acid-base b. double-replacement c. combustion d. all of the above
- _____ 13. What is shown by a half-reaction?
a. oxidation or reduction of an element b. neutralization of an ion or molecule c. decomposition of an ion or molecule d. none of the above
- _____ 14. Which metal is the most easily oxidized?
a. highly active metal b. moderately active metal c. slightly active metal d. an inactive metal

Name: _____

ID: A

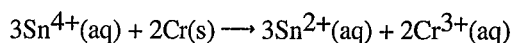
- _____ 15. What happens in a voltaic cell?
a. Chemical energy is changed to electrical energy. b. Electrical energy is changed to chemical energy.
c. Electrical energy is changed to magnetic energy. d. Magnetic energy is changed to electrical energy.
- _____ 16. At which electrode does oxidation occur in a voltaic cell?
a. anode only b. cathode only c. both anode and cathode d. either anode or cathode, depending on the metal
- _____ 17. Which electrode is labeled as positive in a voltaic cell?
a. anode only b. cathode only c. both anode and cathode d. neither anode nor cathode
- _____ 18. Which of the following is the name of a process in which electrical energy causes a chemical reaction?
a. hydrolysis b. electrolysis c. oxidation d. electronation
- _____ 19. What is the direction of electron flow in an electrolytic cell?
a. from cathode to anode b. from anode to cathode c. in either direction d. There is no flow.
- _____ 20. Which of the following is true about an electrolytic cell?
a. It changes electrical energy into chemical energy. b. It is the type of cell used in electroplating. c. It uses an electric current to make a nonspontaneous reaction go. d. all of the above
- _____ 21. What occurs in electroplating?
a. deposition of a salt layer on a metal b. deposition of a metal layer on a material c. decomposition of a metal layer d. decomposition of a salt layer

Short Answer

22. Round off the measurement 0.003 095 5 m to three significant figures.
23. What is the temperature 128 K expressed in degrees Celsius?
24. What is the sum of the oxidation numbers in calcium carbonate?
25. In the following unbalanced reaction, what is the total decrease in oxidation number for the reduced element?
 $\text{HNO}_3 + \text{HI} \rightarrow \text{NO} + \text{I}_2 + \text{H}_2\text{O}$

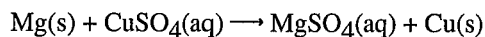
Name: _____

- 1) A redox reaction *always* demonstrates the conservation of
 A) both mass and charge
 B) neither mass nor charge
 C) mass, only
 D) charge, only
- 2) Based on *Standard Electrode Potentials* chemistry reference table, which metal will *not* react with 1 M HCl?
 A) Sn(s) B) Ni(s) C) Zn(s) D) Au(s)
- 3) Which equation represents a redox reaction?
 A) $2O_3 \rightarrow 3O_2$
 B) $FeS + 2HCl \rightarrow FeCl_2 + H_2S$
 C) $MgO + H_2O \rightarrow Mg(OH)_2$
 D) $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$
- 4) Given the reaction:



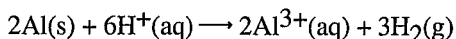
Which half-reaction correctly represents the reduction that occurs?

- A) $Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$
 B) $Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$
 C) $Sn^{2+}(aq) \rightarrow Sn^{4+}(aq) + 2e^-$
 D) $Cr(s) \rightarrow Cr^{3+}(aq) + 3e^-$
- 5) Given the redox reaction:



Which species acts as the oxidizing agent?

- A) Cu(s) B) $Cu^{2+}(aq)$ C) $Mg^{2+}(aq)$ D) Mg(s)
- 6) The reaction $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$ is forced to occur by use of an externally applied electric current. This procedure is called
 A) electrolysis B) esterification C) neutralization D) hydrolysis
- 7) Which reaction is a nonspontaneous redox reaction under standard conditions?
 A) $Ba(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + H_2(g)$
 B) $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
 C) $Cu(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2(g)$
 D) $Sn(s) + 2HCl(aq) \rightarrow SnCl_2(aq) + H_2(g)$
- 8) In a redox reaction, the reducing agent will
 A) gain electrons and be oxidized
 B) gain electrons and be reduced
 C) lose electrons and be reduced
 D) lose electrons and be oxidized
- 9) Given the balanced reaction:

What is the total number of moles of electrons gained by $H^+(aq)$ when 2 moles of Al(s) is completely reacted?

- A) 6 B) 12 C) 3 D) 2
- 10) If fused silver chloride is electrolyzed, the Ag^+ ions are
 A) oxidized at the negative electrode
 B) oxidized at the positive electrode
 C) reduced at the positive electrode
 D) reduced at the negative electrode
- 11) In the reaction $2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$, the oxidation number of sulfur changes from
 A) -2 to +6 B) +2 to +4 C) -2 to +4 D) 0 to -2

- 12) In the reaction $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$, the magnesium
- A) gains electrons and is oxidized
 B) gains electrons and is reduced
 C) loses electrons and is reduced
 D) loses electrons and is oxidized
- 13) Which reducing agent can be used to free chromium from its compound Cr_2O_3 ?
- A) Pb
 B) Al
 C) Sn
 D) Cu
- 14) Given the reaction:
- $$\text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$$
- Which substance is oxidized?
- A) $\text{H}^+\text{(aq)}$
 B) HCl(aq)
 C) Zn(s)
 D) $\text{Cl}^-\text{(aq)}$
- 15) The oxidation number of nitrogen in N_2 is
- A) +1
 B) +3
 C) 0
 D) -3
- 16) What is the oxidation number of sulfur in H_2SO_4 ?
- A) 0
 B) +6
 C) +4
 D) -2
- 17) In the reaction $2\text{Na} + \text{Cl}_2 \rightarrow 2\text{Na}^+ + 2\text{Cl}^-$, the reducing agent is
- A) Cl_2
 B) Cl^-
 C) Na
 D) Na^+
- 18) In a chemical reaction, as a species is oxidized, its oxidation number
- A) remains the same
 B) increases
 C) decreases
- 19) Which redox reaction is balanced?
- A) $\text{Fe}^{3+} + \text{Ni} \rightarrow \text{Fe}^{2+} + \text{Ni}^{2+}$
 B) $3\text{Fe}^{3+} + 2\text{Ni} \rightarrow 3\text{Fe}^{2+} + 2\text{Ni}^{2+}$
 C) $2\text{Fe}^{3+} + \text{Ni} \rightarrow 2\text{Fe}^{2+} + \text{Ni}^{2+}$
 D) $\text{Fe}^{3+} + 2\text{Ni} \rightarrow \text{Fe}^{2+} + 2\text{Ni}^{2+}$
- 20) Which type of chemical reaction occurs when an iron nail rusts?
- A) ionization-dissociation
 B) oxidation-reduction
 C) neutralization
 D) condensation

Part II: Answer in complete sentences and show all work

1. In the spaces provided, balance the following redox reaction using the *smallest* whole-number coefficients.



2. State what happens to the number of protons in a Zn atom when it changes to Zn^{2+} as the following redox reaction occurs
- $$\text{Zn} + \text{Cr}^{3+} \rightarrow \text{Zn}^{2+} + \text{Cr}$$

3. Two chemistry students each combine a different metal with hydrochloric acid. Student A uses zinc, and hydrogen gas is readily produced. Student B uses copper, and no hydrogen gas is produced. Explain the reasoning behind the difference in the student's results.

4. State one difference between voltaic cells and electrolytic cells. Include information about *both* types of cells in your answer.

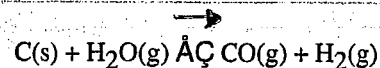
5. What is the oxidation number of chromium in $\text{K}_2\text{Cr}_2\text{O}_7$

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Name: _____

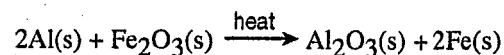
- 1) In which compound does chlorine have the *highest* oxidation number?
- A) NaClO_2 C) NaClO_4
 B) NaClO_3 D) NaClO
- 2) What is the oxidation number of chromium in $\text{K}_2\text{Cr}_2\text{O}_7$?
- A) +6 C) +7
 B) +12 D) +2
- 3) The transfer of which particle is required for a redox reaction to occur?
- A) proton C) electron
 B) neutron D) ion
- 4) As a Ca atom undergoes oxidation to Ca^{2+} , the number of neutrons in its nucleus
- A) remains the same
 B) increases
 C) decreases
- 5) Given the reaction:
- $$\text{Mg} + \text{CuSO}_4 \rightleftharpoons \text{MgSO}_4 + \text{Cu}$$
- Which equation represents the oxidation that takes place?
- A) $\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$
 B) $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$
 C) $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$
 D) $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
- 6) Given the reaction:
- $$\text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$$
- Which statement correctly describes what occurs when this reaction takes place in a closed system?
- A) There is a net gain of mass.
 B) There is a net loss of mass.
 C) Atoms of Zn(s) lose electrons and are oxidized.
 D) Atoms of Zn(s) gain electrons and are reduced.
- 7) In any redox reaction, the substance that undergoes reduction will
- A) lose electrons and have a decrease in oxidation number
 B) gain electrons and have an increase in oxidation number
 C) gain electrons and have a decrease in oxidation number
 D) lose electrons and have an increase in oxidation number

- 8) Given the equation:



Which species undergoes reduction?

- A) H^+ C) C^{2+}
 B) $\text{H}_2\text{(g)}$ D) C(s)
- 9) Given the reaction:



Which species undergoes reduction?

- A) Fe^{3+} C) Al
 B) Fe D) Al^{3+}
- 10) What is conserved during a chemical reaction?

- A) both mass and charge
 B) neither mass nor charge
 C) charge, only
 D) mass, only

- 11) Which statement is true for any electrochemical cell?

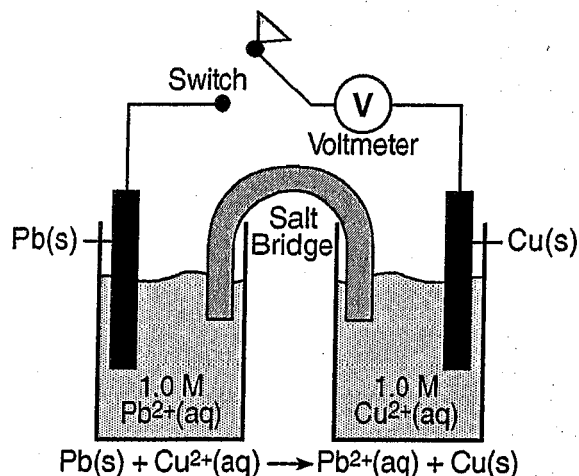
- A) Oxidation occurs at both the anode and the cathode.
 B) Reduction occurs at both the anode and the cathode.
 C) Reduction occurs at the anode, only.
 D) Oxidation occurs at the anode, only.

- 12) What is the purpose of the salt bridge in a voltaic cell?

- A) It is a path for the flow of electrons.
 B) It blocks the flow of electrons.
 C) It is a path for the flow of positive and negative ions.
 D) It blocks the flow of positive and negative ions.

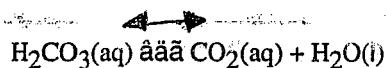
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- 13) A diagram of a chemical cell and an equation are shown below.



When the switch is closed, electrons will flow from

- A) the Cu(s) to the Pb(s)
 - B) the Cu²⁺(aq) to the Cu(s)
 - C) the Pb(s) to the Cu(s)
 - D) the Pb²⁺(aq) to the Pb(s)
- 14) According to the *Activity Series* chemistry reference table, which of these metals will react most readily with 1.0 M HCl to produce H₂(g)?
- A) Zn
 - B) Ca
 - C) K
 - D) Mg
- 15) Which process requires an external power source?
- A) synthesis
 - B) fermentation
 - C) neutralization
 - D) electrolysis
- 16) Human blood contains dissolved carbonic acid, H₂CO₃, in equilibrium with carbon dioxide and water. The equilibrium system is shown below.



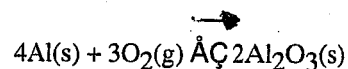
In the given equilibrium system, what is the oxidation number of carbon in H₂CO₃(aq)?

- 17) Given the reaction:



Write a correctly balanced reduction half-reaction for the equation above.

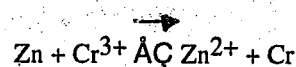
- 18) Given the reaction:



- (a) Write the balanced oxidation half-reaction for this oxidation-reduction reaction.
- (b) What is the oxidation number of oxygen in Al₂O₃?

Questions 19 and 20 refer to the following:

The redox reaction below occurs spontaneously in an electrochemical cell.

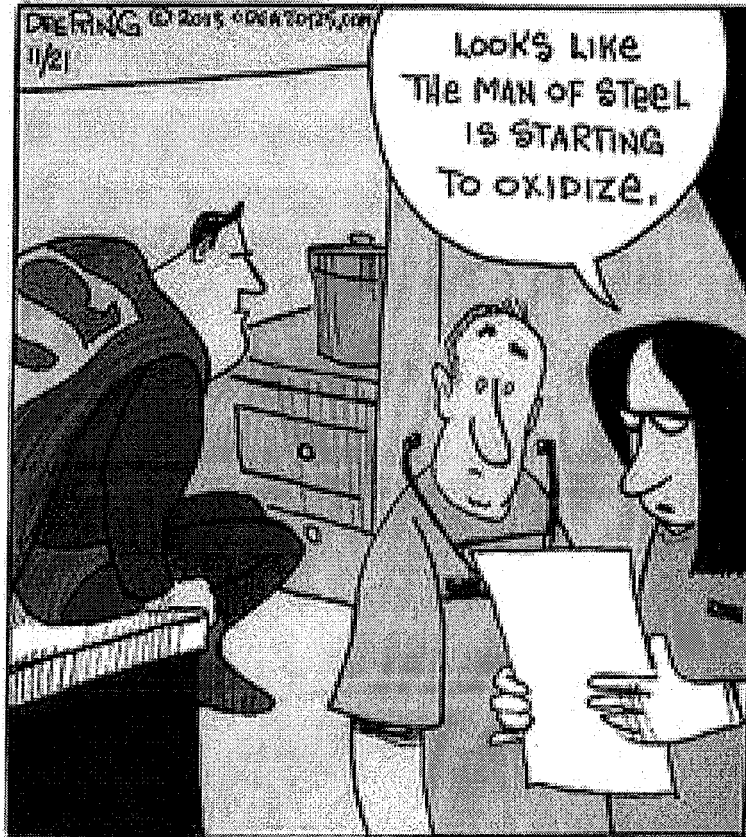


- 19) In the equation below, balance the equation using the *smallest* whole-number coefficients.



- 20) State what happens to the number of protons in a Zn atom when it changes to Zn²⁺ as the redox reaction occurs.

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NOTE: The final exam will not pass itself...You need to put an honest effort into your preparation for this exam if you are to be successful on it in June, which is now very close.

Remember...You get out of it what you put into it!

Acids-Bases

REDOX

Mr. Gardner