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Exercise 5-6: ACIDS AND BASES; NEUTRALIZATION

1. Give the names and formulas of three common acids and bases.

Acids		Bases	
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....

2. According to the Arrhenius theory

(*a*) The element.....is present in all acids.

(*b*) In water solutions the acid molecule dissociates to form the characteristic.....ion, actually a free (*what type of electrical particle?*).....and a(n).....which varies from one acid to another.

(*c*) The hydrogen ion or proton does not exist free in solution, but unites with a .....molecule, forming the.....ion. The H_3O^+ ion is a hydrated.....and may be represented as $H^+ \cdot H_2O$.

3. (*a*) Four characteristics common to acids in water solution are.....,

.....,.....,

.....

(*b*) The properties common to all acid solutions result from the presence in solution of the .....ion.

4. (*a*) Complete the following equations, which represent the dissociation reaction of acids in water.

$HNO_3 + H_2O \rightarrow H_3O^+ +$ .....

HCl + ... → ..... + ...

(*b*) For most reactions, the hydration of the proton (formation of the hydronium ion, H_3O^+) may be disregarded and the dissociation reaction written according to the Arrhenius theory. Complete the following equations, disregarding the hydration of the proton:

H_2SO_4 → ..... + ... (sulfuric acid)

CH_3COOH → ..... + ... (acetic acid)

(*c*) Complete the following equations, which represent the replacement of hydrogen from an acid by an active metal and the neutralization of a base by an acid.

Zn + ...HCl → ..... + ...

.....NaOH + H_2SO_4 → ..... + ...

5. Acids are classified on the basis of the number of protons or hydrogen ions released when one molecule dissociates.

(*a*) A *monoprotic* acid releases.....proton when the molecule dissociates. An example of a monoprotic acid is.....

(*b*) An example of a *diprotic* acid, which releases.....protons upon dissociation of the molecule, is.....

(*c*) .....is an example of a *triprotic* acid.

6. A diprotic acid, such as sulfuric acid, ionizes in two steps, releasing one proton during the first ionization step and the second proton during the second ionization step.

(*a*) Complete the following equations, which represent the two steps of sulfuric acid ionization.

First step $H_2SO_4 \rightarrow$ ..... + HSO_4^- (hydrogen sulfate)

Second step $HSO_4^- \rightarrow$ ..... + SO_4^{--} (sulfate)

(*b*) In reaction with a base, such as sodium hydroxide, (*how many?*).....kinds of salts may be formed by a diprotic acid.

(*c*) Complete the following equations, which show the two kinds of salts that might be formed when sulfuric acid reacts with sodium hydroxide:

..... + $H_2SO_4 \rightarrow NaHSO_4$ + ...

.....NaOH + $H_2SO_4 \rightarrow Na_2SO_4$ + ...

(*d*) The names of the two sodium salts of sulfuric acid formed in the reactions in (*c*) are ..... and .....

.....

7. According to the Arrhenius theory

(*a*) The radical.....occurs in all bases.

(*b*) When a base is dissolved in water, ...ions are released.

(*c*) Four properties common to all soluble bases are

....., ...

....., ...

(*d*) The properties common to soluble bases result from the presence of..... ions in the solutions.

8. An acid-base theory proposed by Brönsted differs somewhat in its concept of acids and bases from that developed by Arrhenius in his theory of ionization.

(*a*) According to the Brönsted theory, an acid is any substance that (*accepts, releases*) .....a proton during chemical reaction.

(*b*) According to this theory a base is any substance which (*accepts, releases*)..... .....a proton during a reaction.

(*c*) The definition of a(n) (*acid, base*).....is almost identical in both theories.

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(*d*) According to the Brönsted theory, HCl, HNO_3, H_2SO_4, and H_3O^+, would be classified as (*acids, bases*).....and OH^-, H_2O, and NH_3, would be classified as (*acids, bases*) .....

9. The following equation illustrates a typical acid-base reaction involving conjugate acid-base pairs:

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

$$Acid_1 + Base_2 \rightleftharpoons \text{.....}_2 + \text{.....}_1$$

(*a*) When HCl donates a proton to....., the Cl^- ion becomes a proton (*acceptor, donor*).....and is known as the conjugate base of the acid .....

(*b*) When H_2O accepts a.....from HCl, it acts as a(n) (*acid, base*) .....; after accepting the proton the water becomes a(n)..... ion and can act as a proton (*acceptor, donor*).....; in this state it is known as the.....of the base, water (H_2O).

(*c*) In the blanks indicated by subscripts (1) and (2) under the equation above, write the appropriate term, *conjugate acid* or *conjugate base.*

(*d*) The two conjugate acid-base pairs in the reaction between HCl + H_2O are..... .....and.....; and..... and.....

(*e*) Opposite each of the following acids or bases write the formula for its conjugate acid or base:

Acid	Conjugate Base	Base	Conjugate Acid
HNO_3	.....	H_2O	.....
HSO_4^-	.....	$C_2H_3O_2^-$	.....
NH_4^+	.....	ClO_4^-	.....

10. (*a*) A more general acid-base theory than that of Brönsted was proposed in 1923 by .....

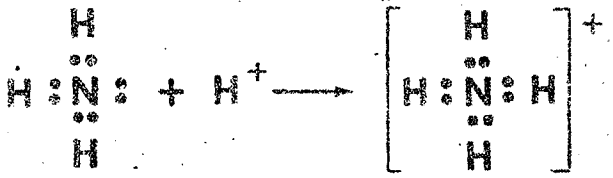
(*b*) According to this view, an acid is a substance (ion or molecule) that (*accepts, donates*).....a pair of electrons in a reaction.

(*c*) A base is a substance that (*accepts, donates*).....a pair of electrons.

(*d*) The bond formed between a Lewis acid and base is of the (*covalent, coordinate covalent*).....type.

11. (*a*) In the equation at the top of the next page, the ammonia is the Lewis (*acid, base*) .....because it is the electron pair (*donor, acceptor*).....;

the hydrogen ion is the Le is (*acid, base*).....because it is the electron pair (*donor, acceptor*).....



(*b*) In the reaction $CaO + SO_3 \rightarrow CaSO_4$, the oxide ion in the ionic compound calcium oxide acts as the Lewis (*acid, base*).....; the sulfur trioxide acts as the Lewis (*acid, base*).....

(*c*) In the space below, write an equation using electron-dot formulas for the reaction in *b*. Draw a circle around the "donated" electron pair.

12. When an acid reacts with a base, a(n).....and.....may be recovered from the solution. This reaction is called.....

13. A(n).....is used to determine just when the proper amount of acid has been added to neutralize a given amount of base. One example is.....

14. The reaction for neutralization of sodium hydroxide with hydrochloric acid may be written as follows:

$$Na^+ + OH^- + H^+ + Cl^- \rightarrow H_2O + Na^+ + Cl^-$$

(*a*) Ions of.....and.....are present among the reactants and the products (both sides of the arrow), and (*a change, no change*).....has occurred in the charge of these ions.

(*b*) The two ions.....and.....combined during this reaction to form.....

.....

(*c*) Actually, the only new product formed during the neutralization reaction was..... This total chemical change can be represented simply by the equation ..... + ... → ....., ignoring the Na^+ ions and Cl^- ions.

(*d*) What must be done to recover the Na^+ and Cl^- ions as a crystalline product?

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