

Electrolytes and Net-ionic Equations

OBJECTIVES:

1. To practice writing Molecular-, total ionic- and net ionic- equations.
2. To predict if a solution of a mixture of ionic or covalent compounds would conduct electrical conductivity.
3. To classify substances as strong, weak or non-electrolytes.

DISCUSSION

1. Electrical conductivity of molten compounds

a. Ionic compounds, in the solid state, are composed of ions that are not free to move. The ions become mobile after the compound is heated to its melting temperature, becomes fluid, and the ions are freed from their positions in their crystalline lattice. The large number of mobile ions then causes the molten compounds to become good electrical conductors.

b. Covalent compounds do not conduct electricity even when molten because the resultant mobile particles are neutral molecules. Their movement cannot be used to carry an electric charge.

2. Electrical conductivity of metallic solids

Metals conduct electricity in the solid state because the valence electrons of the atoms generate a mobile "sea" of electrons.

3. Electrical conductivity of compounds in aqueous solutions

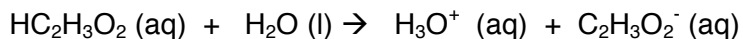
Water is a good solvent for many covalent and ionic compounds. Substances that dissolve in water to form electrically conducting solutions are **electrolytes**. Substances that dissolve to form nonconducting solutions are known as **nonelectrolytes**. All soluble ionic compounds are electrolytes. Water molecules are able to pull the positively and the negatively charged ions away from each other in the solid state, and carry them along to be distributed throughout the solution.



Most covalent compounds are nonelectrolytes. When dissolved, molecules of covalent compounds are separated from each other by water molecules. The separated molecules are not charged species and will not conduct electricity. However, some covalent compounds actually react with water to form ions. The process of forming ions in this manner is known as ionization.



If all dissolved molecules react to form ions, the solution becomes strongly conducting and the solutes are referred to as **strong electrolytes**. If only a fraction of the dissolved molecules ionizes the solution becomes weakly conducting and the compound is known as a **weak electrolyte**.



Below, you will find a diagram for a conductivity apparatus. The unit is made of an electric lamp connected to a cord that can be plugged onto an electric source. The electric lamp is also connected in series to open electrodes. When the electric cord is plugged to the electric source, electrons travel into the light bulb and the electrodes. To keep the electrons/electric charge circulating into the lamp, the electrodes must be immersed in a solution of ions. The movable ions in the solution carry the electric charge (electrons) from one electrode to the other and consequently the circuit is complete and the light bulb glows. The intensity of the light depends on the number of movable ions present in the solution. The more ions present in the solution, the more electricity will flow. Hence, the light bulb glows brighter.

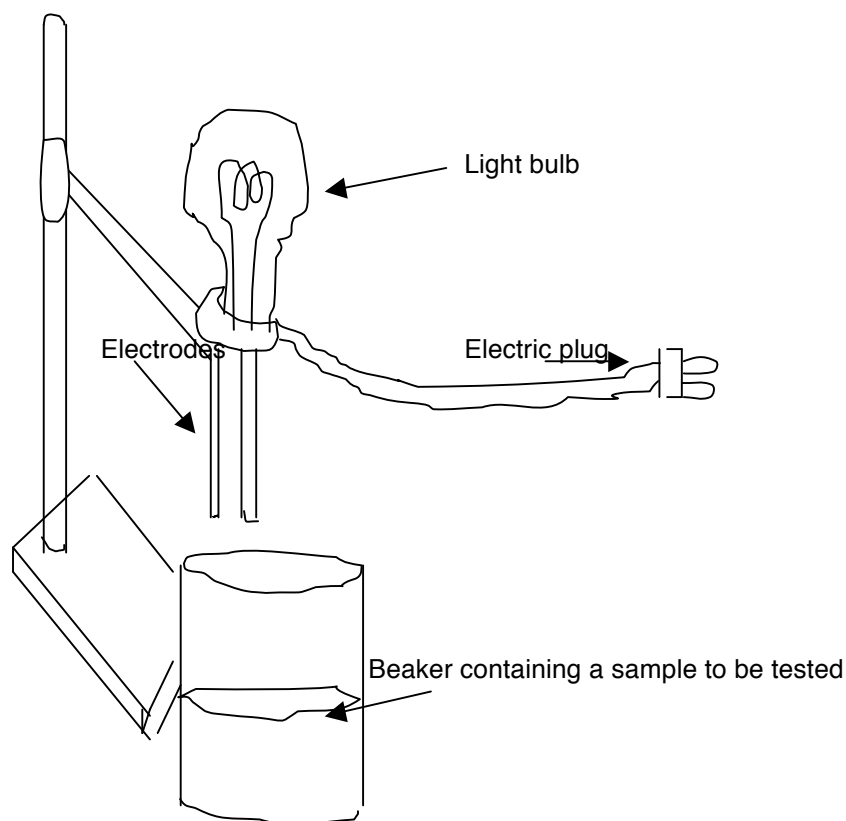


Figure 1: Light bulb conductivity apparatus

Caution: Today's lab is a dry lab. If you find the conductivity apparatus in the lab, DO NOT touch it. To prevent electric shock, do not plug the conductivity apparatus on, or use it.

SOLUBILITY RULES FOR IONIC COMPOUNDS

<u>Ion contained in the Compound</u>	<u>Solubility</u>	<u>Exceptions</u>
Group IA	soluble	
NH_4^+	soluble	
$\text{C}_2\text{H}_3\text{O}_2^-$	soluble	
NO_3^-	soluble	
Cl^- , Br^- , and I^-	soluble	Ag^+ , Pb^{2+} , Hg_2^{2+}
SO_4^{2-}	soluble	Ca^{2+} , Sr^{2+} , Ba^{2+} , Pb^{2+}
CO_3^{2-} , PO_4^{3-} , CrO_4^{2-}	insoluble	group IA and NH_4^+
S^{2-}	insoluble	group IA, IIA, and NH_4^+
OH^-	insoluble	group IA, Ca^{2+} , Ba^{2+} , Sr^{2+}

STRONG BASES

LiOH	CsOH
KOH	$\text{Sr}(\text{OH})_2$
RbOH	$\text{Ba}(\text{OH})_2$
NaOH	$\text{Ca}(\text{OH})_2$

STRONG ACIDS

HNO_3	HCl
HClO_4	HBr
H_2SO_4	HI

Exercise

Part I

1) **A)** Name three **classes** of compounds that are strong electrolytes.

i) _____ ii) _____ iii) _____

2) Which of the following must be written as ions when writing the total ionic equation?

Strong electrolytes, weak electrolytes, or non-electrolytes? Answer _____

3) What is the fundamental difference between the mechanism of electrical conductivity in a solution of electrolyte and electrical conductivity through a metal?

4) **A)** What are spectator ions in a chemical reaction?

B) Define: i) Nonelectrolyte:

ii) Electrolyte:

Make sure to memorize the solubility rules and the list of strong acids and strong bases given on page 3 to be able to do part II given below.

Part II

a) Write the molecular, total-ionic, and net-ionic equations

b) Predict the expected electrical conductivity after stoichiometric amounts of the reagents are mixed together.

c) Justify your answer by listing the ions causing the electrical conductivity, if any.

1) Potassium carbonate and ferrous bromide.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

2) ammonium chloride and sodium sulfate.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

3) sodium carbonate and nitric acid.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

4) calcium hydroxide and phosphoric acid

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

5) hydrochloric acid and calcium carbonate

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

6) Ammonium phosphate is mixed with strontium hydroxide

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

7) hydrochloric acid is mixed with lead (II)acetate

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

8) sulfuric acid is mixed with calcium sulfide

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

9) ammonium carbonate is mixed with calcium hydroxide

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

10) hydrochloric acid is mixed with lead (II)phosphate

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

11) sodium fluoride is mixed with hydrochloric acid

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

12) hydrobromic acid is mixed with silver acetate

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

13) hydrosulfuric acid is mixed with lead (II)acetate

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

14) Lithium hydroxide and lead (II) nitrate.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

15) copper(II)bromide and potassium phosphate.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

16) magnesium sulfide and nickel(II) chloride.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

17) calcium hydroxide and sulfuric acid.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

18) barium hydroxide and sodium iodide.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

19) silver nitrate and calcium bromide.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

20) Lithium phosphate and ammonium sulfide.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

21) barium hydroxide and chromic acid

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

22) potassium hydroxide and ammonium iodide

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

23) potassium chromate is mixed with strontium hydroxide.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

24) nickel (II) chloride and ammonium phosphate.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

25) sodium bromide is mixed with ammonium nitrate.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

26) Potassium phosphate is mixed with strontium hydroxide.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

27) Ferric chloride and ammonium sulfate.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

28) Lead (II)nitrate is mixed with sodium sulfide.

Molecular equation:

Total-ionic:

Net-ionic:

Conductivity: Strong, weak, or none? Ans: _____. Why? List the ions causing the conductivity, if any.

Make sure to memorize the solubility rules and the list of strong acids and strong bases given on page 3.

