

Objective 2. Classify substances as elements, compounds, mixtures. Relate substance type to properties. Use properties to identify substances and separate mixtures.

Quiz Practice problems

Key ideas: elements are classified as metals and non-metals. Compounds are classified as ionic and molecular. Acids and bases are important and common substances. Each substance type has different properties. Properties are used to identify substances and separate mixtures.

It is hard to get solids to react with each other. So the solid is dissolved in a solvent to make a solution (solution is a homogeneous mixture) and the solutions are mixed together to get a reaction to occur. For solutions, use concentration in Molarity = moles/volume.

Skills: Use the periodic table to identify metal, non-metal, ionic compound, molecular compound.

Identify properties, e.g., state of matter, hard, soft, high/low b.p., pH, litmus, conductivity test.

Use properties to identify a substance.

Use a difference in a property to separate a mixture.

Prepare a solution from solid.

1. a. Metal properties: soft, conductors, shiny, lose electrons to form cations. See the Periodic Table.

(i) Give two examples of elements that are metals.

(ii) What is the charge of each metal when your example metal is contained in a compound?

b. Non-metal properties: hard, dull, insulators, gain electrons to form anions. See the Periodic Table.

(i) Give two examples of elements that are non-metals.

(ii) What is the charge of each non-metal when your example non-metal is contained in a compound?

c. The Periodic Table of the Elements is based on patterns and relationships.

(i) One way to classify elements is by metals, non-metal, and semi-metals. Some elements are more metallic than others. Some elements are more non-metallic than others. Going from left to right across a row in the Periodic Table, do elements show more metallic character or less metallic character? In other words, do elements behave more like metals or less like metals going from left to right across a row? Explain your reasoning.

(ii) Going down a column in the Periodic Table, do elements become more like metals or less like metals? Explain your reasoning.

d. Ionic compound properties: hard, brittle, high melting point. What type of elements form an ionic compound? Give one example of an ionic compound.

e. Molecular compound properties: soft, low melting point. What type of elements form a molecular compound? Give one example of a molecular compound.

2. Of all the known substances, most are organic compounds. Organic compounds contain C, H, O, and N.

a. Classify each element as a metal or non-metal.

b. Are organic compounds ionic compounds or molecular compounds?

c. When an organic compound forms an anion and combines with sodium, what type of compound forms? Give reasons.

3. The Top 10 chemicals produced in the U.S. are:

| 2000 RANK (by mass) | CHEMICAL | 2000 PRODUCTION (in 10 ⁹ kg) | FORMULA | Element or Compound? | Element Type (metal or non-metal) Or Compound Type (ionic or molecular) |
|---------------------|-------------------|---|---|----------------------|---|
| 1 | Sulfuric acid | 39.62 | H ₂ SO ₄ | | |
| 2 | Ethylene | 25.15 | C ₂ H ₄ | | |
| 3 | Lime | 20.12 | CaO | | |
| 4 | Phosphoric acid | 16.16 | H ₃ PO ₄ | | |
| 5 | Ammonia | 15.03 | NH ₃ | | |
| 6 | Propylene | 14.45 | C ₃ H ₆ | | |
| 7 | Chlorine | 12.01 | Cl ₂ | | |
| 8 | Sodium hydroxide | 10.99 | NaOH | | |
| 9 | Sodium carbonate | 10.21 | Na ₂ CO ₃ | | |
| 10 | Ethylene chloride | 9.92 | C ₂ H ₄ Cl ₂ | | |

Reference: Chemical and Engineering News, 6/25/01 and <http://scifun.chem.wisc.edu/CHEMWEEK/sulf&top/sulf&top.html>

a. Classify each substance as an element or compound.

(i) If the substance is an element, classify the element as a metal or non-metal.

(ii) If the substance is a compound, classify the compound as ionic or molecular.

(iii) Which of the Top 10 chemicals is/are acids? Which of the Top 10 chemicals is/are bases?

b. Which compound has the highest melting point? Give reasons.

- c. Sulfuric acid is used as the electrolyte in car batteries. What property of sulfuric acid makes it a good battery acid? Hint: the electrolyte is the ionic current that carries ions from one electrode to another in a battery.
- d. Phosphoric acid gives soda its tart taste and is also used as a rust remover. What property of phosphoric acid makes it taste tart?
- e. Ammonia is a cleaner that removes grease. Ammonia is a base, which means grease must be a _____.
- f. Sodium carbonate, which is a base, is used in laundry detergent. Is the sodium ion or carbonate ion the basic part? Give reasons.
- g. Farmers use lime to raise the pH of soil. Lime is a _____.

4. You find two liquids in your basement. One liquid is in a blue bottle and the other liquid is in a green bottle. You want to identify each liquid and know that one liquid is HCl and the other liquid is ammonia. Each liquid is colorless. You test the liquid in the green bottle and observe the following: the liquid turns blue litmus paper red but when phenolphthalein is added, nothing happens. The pH of this liquid is 4.2. You decide not to test the liquid in the blue bottle. What is the identity of the liquid in each bottle? Give reasons.

5. Before you leave for spring break, you decide to check out your car to make sure it won't break down. When you look under the car, you see a few drops of liquid. The liquid could either be oil (a large hydrocarbon, $C_{20}H_{42}$), battery acid (sulfuric acid), or antifreeze (ethylene glycol, $C_2H_6O_2$). You perform the following tests on this liquid:

| <u>Test/Observation</u> | <u>Conclusion</u> |
|-------------------------|-------------------|
|-------------------------|-------------------|

- (i) blue litmus stays blue
- (ii) red litmus stays red
- (iii) conductivity = 90 μ S

- a. Draw a conclusion for each observation in the space above.
- b. What is the identity of this liquid? If you can't definitively identify the liquid, what other observation or test would you need to do to identify the liquid under your car?

Solution preparation – see lab skills: how many g of solid to make ___ ml of solution?

Give mass of solid and volume of solution to make. Calculate concentration of solution.

Give volume and concentration of solution to be made. Calculate mass of solid to use.

6. Many pure substances are made into mixtures.

a. You pour 1 tablespoon of sugar ($C_{12}H_{22}O_{11}$) in enough water to make $\frac{1}{2}$ cup (120 ml) of solution.

1 tablespoon of sugar = 3 teaspoons of sugar

1 teaspoon of sugar = 4 g of sugar

Molar concentration (symbol = M) is the moles of solute in 1 liter of solution.

Example: 1 M means 1 Molar concentration solution = 1 mole of solute in 1 liter of solution.

So 1 M sugar solution = 1 mole of sugar in 1 liter of solution.

- (i) Calculate the mass of sugar in 1 tablespoon. (What is the conversion factor?)
- (ii) Calculate the moles of sugar in 1 tablespoon. (What is the conversion factor?)
- (iii) Calculate the Molar concentration of sugar. (Answer: between 0.25 and 0.33 M)

b. You want to make 250 ml of a 1 M sugar ($C_{12}H_{22}O_{11}$) solution.

- (i) How many moles of sugar are in 250 ml of 1 M sugar solution? (What is the conversion factor?)
- (ii) Calculate the mass of sugar to make this solution. (Answer: between 85 and 95 g)

c. You want to make $\frac{1}{2}$ cup (120 ml) of a 1.5 M baking soda ($NaHCO_3$) solution. Calculate the mass of baking soda to make this solution. (Answer: between 13 and 17 g)

d. You need to use 0.25 moles of baking soda for a chemical reaction. You have $\frac{1}{2}$ cup of 1.5 M baking soda solution. Calculate the volume of 1.5 M baking soda solution that contains 0.25 moles of baking soda.

Do you have enough 1.5 M baking soda solution to get the 0.25 moles of baking soda that you need? (Answer: no)
How much more 1.5 M baking soda solution do you need?

7. Most substances are mixtures. Scientists spend a lot of time and energy trying to separate a mixture into its component pure substances.

You are at the beach with your lab partner. Your lab partner is about to put sugar in a glass of unsweetened lemonade when you (accidentally) knock the sugar out of your lab partner's hand with a beach ball. The sugar spills to the sand. Since your lab partner does not have any more sugar and can't stand drinking too tart lemonade, you two figure you can use your combined knowledge of chemistry and separate the sugar from the sand. All of a sudden, your lab partner

dumps the sand/sugar mixture into the glass of lemonade and claims this will sweeten the lemonade and give 100% recovery of sand. Explain how this method will work and give a 100% recovery of sand.