6.1B

Solutions for 6.1A Extra Practice Questions: Properties of Solutions

List some properties that could be used to construct diagnostic tests to identify the type of solute in each of the following solutions.

1. an aqueous solution of a molecular substance
   - **does not conduct electricity**
   - **has no effect on the color of litmus paper**

2. an aqueous solution of a neutral ionic compound
   - **conducts electricity**
   - **has no effect on the color of litmus paper**

3. an aqueous solution of an acid
   - **conducts electricity**
   - **turns blue litmus paper red**

4. an aqueous solution of a base
   - **conducts electricity**
   - **turns red litmus paper blue**

5. Identify, by name, the solute and solvent in each of the following solutions.

(a) $NaOH_{(aq)}$
solute: sodium hydroxide
solvent: water

(b) $CO_{2(aq)}$
solute: carbon dioxide
solvent: water

(c) $Br_{2(l)}$
solute: bromine
solvent: alcohol

(d) $Mg(HCO_3)_{2(aq)}$
solute: magnesium hydrogen carbonate
solvent: water

6. **Question**

Which of the solutions labelled A, B, C, and D contain HCl(aq), NaClO4(aq), $NH_2OH_{(aq)}$, $NaOH_{(aq)}$?

Experimental Design

(a) Write an experimental design to answer the question. Identify all variables and controls.

Each solution is tested with a conductivity apparatus and with litmus paper. The inpendent variable is the solution tested; the dependent variable is the diagnostic test; and the controlled variables are the concentration and temperature of the solution. Pure water is used as a control.

Materials

(b) List all materials required for this investigation.

lab apron
safety glasses
solutions A, B, C, D
distilled water bottle
well plate or small beaker
conductivity tester
red and blue litmus paper

Procedure

(c) Write a list steps necessary to answer the question. (There are no special disposal requirements.)

1. Place about 1 mL of pure water in a clean well.
2. Test and record the conductivity of the water.
3. Test with red and blue litmus, and record any color change.
4. Rinse and clean the conductivity leads.
5. Repeat steps 1-4 using the given solutions in place of water.
6. All solutions are disposed in the sink and litmus paper into the waste basket.

6.2B

Solutions for 6.2A Extra Practice Questions: Explaining Solutions

1. The following substances are common chemicals: butane, $C_4H_{10(g)}$, (lighters); ethanol, $C_2H_5OH_{(l)}$, (alcoholic drinks); dichloromethane, $CH_2Cl_{2(l)}$, (solvent in correction fluid)

   (a) Classify the type(s) of intermolecular forces present among molecules of each of these substances.
   butane, London dispersion forces; low
   ethanol, London dispersion, dipole-dipole, hydrogen-bonding forces; high
   dichloromethane, London dispersion and dipole-dipole; moderate

   (b) Predict the solubility (low, moderate, or high) of each substance in water. (**See above**)

2. Why do ionic compounds have a high solubility in water, compared to their solubility in any other solvent?
   Ionic compounds contain electrically-charged ions. The very polar water molecules are able to form many attractions to both the positive and negative ions.

3. List the three features of a water molecule that make water the best solvent.
   Water molecules have a small size, are highly polar, and have a considerable capacity for hydrogen bonding.

4. For each of the following substances, write the chemical formula including pure state of matter at SATP, predict the solubility (low/high) in water, and if appropriate write a balanced dissociation equation.

   (a) silver sulfide
   $Ag_2S_{(s)}$
   low

   (b) ammonium borate
   $(NH_4)_3BO_{3(s)}$
   high
   $(NH_4)_3BO_{3(s)} \rightarrow 3\ NH_4^+_{(aq)} + BO_3^{3-}_{(aq)}$

   (c) copper(II) nitrate trihydrate
   $Cu(NO_3)_2 \cdot 3H_2O_{(s)}$
   high
   $Cu(NO_3)_2 \cdot 3H_2O_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2\ NO_3^-_{(aq)} + 3\ H_2O_{(l)}$

   (d) glucose, $C_6H_{12}O_{6(s)}$
   high

6.3B

Solutions for 6.3A Extra Practice Questions: Concentration

Use concentration as a conversion factor to calculate the quantity requested in each question below. Communicate your problem-solving approach, including units and correct certainty.

1. Cow's milk contains 4.5 g of lactose per 100 mL of milk. What mass of lactose is present in 250 mL (one glass) of milk?

$$m_{\text{lactose}} = 250\ \text{mL} \times \frac{4.5\,\text{g}}{100\,\text{mL}} = 11\ \text{g}$$

2. A 10% W/V salt solution is used for making pickles. What mass of salt is present in 750 mL of this solution?

$$m_{\text{NaCl}} = 750\ \text{mL} \times \frac{10\,\text{g}}{100\,\text{mL}} = 75\ \text{g}$$

3. A 250 mL measuring cup of cleaning solution contains 1.2 mol of dissolved ammonia. What is the molar concentration of this solution?

$$C_{NH_3} = \frac{1.2\,\text{mol}}{0.250\,\text{L}} = 4.8\ \text{mol/L}$$

4. Fish require a concentration of about 4.5 ppm (4.5 mg/L) of dissolved oxygen in water. What volume of water would contain 100 mg of oxygen?

$$v_{H_2O} = 100\ \text{mg} \times \frac{1\,\text{L}}{4.5\,\text{mg}} = 22\ \text{L}$$

5. What volume of concentrated, 14.6 mol/L phosphoric acid would contain 2.00 mol of solute?

$$v_{H_3PO_4} = 2.00\ \text{mol} \times \frac{1\,\text{L}}{14.6\,\text{mol}} = 0.137\ \text{L}$$

6. What mass of table salt is needed to prepare 1.20 L of 5.20 mol/L solution?

$$n_{\text{NaCl}} = 1.20\ \text{L} \times \frac{5.20\,\text{mol}}{1\,\text{L}} = 6.24\ \text{L}$$

$$m_{\text{NaCl}} = 6.24\ \text{L} \times \frac{58.44\,\text{g}}{1\,\text{mol}} = 365\ \text{g}$$

7. What is the molar concentration of zinc nitrate if 94.2 g of solute is dissolved to make 2.00 L of solution?

$$n_{Zn(NO_3)_2} = 94.2\,\text{g} \times \frac{1\,\text{mol}}{189.40\,\text{g}} = 0.497\ \text{mol}$$

$$C_{Zn(NO_3)_2} = \frac{0.497\,\text{mol}}{2.00\,\text{L}} = 0.249\ \text{mol/L}$$

6.5D

Solutions for 6.5C Extra Practice Questions: Dilution

In the following questions, "concentrated" refers to the concentration of the most common commercial reagent as listed in the table of Concentrated Reagents inside the back cover of the textbook.

1. An ammonia solution is made by diluting 150 mL of the concentrated commercial reagent until the final volume reaches 1000 mL. What is the final molar concentration?

$$v_i C_i = v_f C_f$$
$$150\ \text{mL} \times 14.8\ \text{mol/L} = 1000\ \text{mL} \times C_f$$
$$C_f = 2.22\ \text{mol/L}$$

2. What volume of a 500 ppm reagent solution is required to prepare a 2.5 L solution with a 100 ppm concentration?

$$v_i c_i = v_f c_f$$
$$v_i \times 500\ \text{ppm} = 2.5\ \text{L} \times 100\ \text{ppm}$$
$$v_i = 0.50\ \text{L}$$

3. A 500 mL bottle of concentrated acetic acid is diluted to make a 5.0% solution.
Find the volume of diluted solution that is prepared.

$$v_i c_i = v_f c_f$$
$$500\ \text{mL} \times 99.5\% = v_f \times 5.0\%$$
$$v_f = 10\ \text{L}$$

4. In a chemical analysis, a 25.0 mL sample was diluted to 500.0 mL and analyzed.
If the diluted solution had a molar concentration of 0.108 mol/L, what was the molar concentration of the original sample?

$$v_i C_i = v_f C_f$$
$$25.0\ \text{mL} \times C_i = 500.0\ \text{mL} \times 0.108\ \text{mol/L}$$
$$C_i = 2.16\ \text{mol/L}$$

5. If a 355 mL can of soda pop is diluted to a final volume of 1.00 L, what can be said quantitatively about the concentration of the diluted solution as compared with the original solution?

$$v_i c_i = v_f c_f$$
$$0.355\ \text{L} \times c_i = 1.00\ \text{L} \times c_f$$
$$c_f = 0.355\ c_i$$

The diluted solution has a concentration 0.355 times or 35.5% of the original solution.

6.5F

Solutions for 6.5E Extra Practice Questions: Solution Preparation

Communicate your problem-solving approach when answering the questions below.

1. Calculate the molar concentration of a solution made by dissolving 20.0 g of sodium hydroxide to make 300 mL of solution.

$$n_{NaOH} = 20.0\text{ g} \times \frac{1\text{ mol}}{40.00\text{ g}} = 0.500\text{ mol}$$

$$C_{NaOH} = \frac{0.500\text{ mol}}{0.300\text{ L}} = 1.67\text{ mol/L}$$

2. Pure sodium thiosulfate-5-water, $Na_2S_2O_3 \cdot 5H_2O_{(s)}$, is used to make 250 mL of 20.0 mmol/L solution. Find the mass of solute required.

$$n_{Na_2S_2O_3 \cdot 5H_2O} = 0.250\text{ L} \times \frac{20.0\text{ mmol}}{1\text{ L}} = 5.00\text{ mmol}$$

$$m_{Na_2S_2O_3 \cdot 5H_2O} = 5.00\text{ mmol} \times \frac{248.20\text{ g}}{1\text{ mol}} = 1.24\text{ g}$$

3. What mass of copper(II) nitrate will be required to prepare 10.0 L of 0.100 mol/L solution?

$$n_{Cu(NO_3)_2} = 10.0\text{ L} \times \frac{0.100\text{ mol}}{1\text{ L}} = 1.00\text{ mol}$$

$$m_{Cu(NO_3)_2} = 1.00\text{ mol} \times \frac{187.57\text{ g}}{1\text{ mol}} = 188\text{ g}$$

4. What volume of 75 mmol/L solution can be prepared from 10 g of sodium carbonate?

$$n_{Na_2CO_3} = 10\text{ g} \times \frac{1\text{ mol}}{105.99\text{ g}} = 94\text{ mmol}$$

$$v_{Na_2CO_3} = 94\text{ mmol} \times \frac{1\text{ L}}{75\text{ mmol}} = 1.3\text{ L}$$

5. Determine the volume of concentrated hydrochloric acid required to prepare 10.0 L of a 0.200 mol/L solution.

$$v_i C_i = v_f C_f$$

$$v_i \times \frac{11.6\text{ mol}}{1\text{ L}} = 10.0\text{ L} \times \frac{0.200\text{ mol}}{1\text{ L}}$$

$$v_i = 0.172\text{ L}$$

6. What volume of concentrated ammonia is required to prepare 2.0 L of a 1.0 mol/L solution?

$$v_i C_i = v_f C_f$$

$$v_i \times \frac{14.8\text{ mol}}{1\text{ L}} = 2.0\text{ L} \times \frac{1.0\text{ mol}}{1\text{ L}}$$

$$v_i = 0.14\text{ L}$$