Name ____________________
Period ___ Date ___/___/___

# 14 • Solutions and Their Properties

**PRACTICE FRQ'S**

1996 B

Concentrated sulfuric acid (18.4-molar $H_2SO_4$) has a density of 1.84 grams per milliliter. After dilution with water to 5.20-molar, the solution has a density of 1.38 grams per milliliter and can be used as an electrolyte in lead storage batteries for automobiles.

(a) Calculate the volume of concentrated acid required to prepare 1.00 liter of 5.20-molar $H_2SO_4$.

$V \cdot M = V \cdot M$ $\quad (1.00 L)(5.20 M) = x\,(18.4 M)$

$x = .2826$ L

$= .283 L = 283$ mL

$H_2 = 2.02$
$S = 32.07$
$O_4 = 64.00$
98.09 g/mol

(b) Determine the mass percent of $H_2SO_4$ in the original concentrated solution.

$18.4 M\ H_2SO_4 \rightarrow 18.4 \text{ mol } H_2SO_4 \times \frac{98.09 g\ H_2SO_4}{1 \text{ mol } H_2SO_4} = 1804.856 g\ H_2SO_4$

1.00 L solution

$1.00 L \times \frac{1000 mL}{1 L} \times \frac{1.84 g}{1 mL} = 1840 g$ solution

$\frac{1805 g\ H_2SO_4}{1840 g \text{ soln}} \times 100$

$= 98.1\%$

(c) Calculate the volume of 5.20-molar $H_2SO_4$ that can be completely neutralized with 10.5 grams of sodium bicarbonate, $NaHCO_3$.

$H_2SO_4 + 2NaHCO_3 \rightarrow 2H_2O + 2CO_2 + Na_2SO_4$

$10.5 g\ NaHCO_3 \times \frac{1 \text{ mol } NaHCO_3}{84.02 g} \times \frac{1 \text{ mol } H_2SO_4}{2 \text{ mol } NaHCO_3} \times \frac{1 L \text{ soln}}{5.20 \text{ mol } H_2SO_4}$

$= 0.0120 L \approx 12.0$ mL

Na 23.00
H 1.01
C 12.01
$O_3$ 48.00
84.02 g/mol

(d) What is the molality of the 5.20-molar $H_2SO_4$?

$5.20 M\ H_2SO_4 \rightarrow 5.20 \text{ mol } H_2SO_4 \times \frac{98.09 g}{1 \text{ mol } H_2SO_4} = 510.068 g\ H_2SO_4$ solute

1.00 L

$1.00 L \text{ soln} \times \frac{1000 mL}{1.00 L} \times \frac{1.38 g \text{ soln}}{1.00 mL} = 1380 g$ solution

1380 g solution
− 510. g solute
870. g solvent
(actually 2 sig figs)

m

$\frac{5.20 \text{ moles } H_2SO_4}{.87 \text{ kg solvent}} = 5.977\ m$

$= 5.98\ m$

$= 6.0\ m$

1998 B

An unknown compound contains only the three elements C, H, and O. A pure sample of the compound is analyzed and found to be 65.60 percent C and 9.44 percent H by mass.

(a) Determine the empirical formula of the compound. Assume you have 100. g compound.

$65.60\ g\ C \times \frac{1\ mol}{12.01\ g} = 5.46\ mol\ C$ ÷ 1.56 → 3.5 : $9.44\ g\ H \times \frac{1\ mol\ H}{1.01\ g} = 9.35\ mol\ H$ ÷ 1.56 → 6 : $24.96\ g\ O \times \frac{1\ mol}{16.00\ g} = 1.56\ mol\ O$ ÷ 1.56 → 1

$C_7H_{12}O_2$

(b) A solution of 1.570 grams of the compound in 16.08 grams of camphor is observed to freeze at a temperature 15.2 Celsius degrees below the normal freezing point of pure camphor. Determine the molar mass and apparent molecular formula of the compound. (The molal freezing-point depression constant, $K_f$, for camphor is 40.0 kg·K·mol$^{-1}$.)

$$M = \frac{K_f \cdot w \cdot 1000}{\Delta T \cdot W} = \frac{(40.0\ kg \cdot K \cdot mol^{-1})(1.570\ g)(1000\ g/kg)}{(15.2\ K)(16.08\ g)} = 256.9\ \frac{g}{mol}$$

$C_7$ 7(12.01) = 84.07
$H_{12}$ 12(1.01) = 12.12
$O_2$ 2(16.00) = 32.00
128.19

Molecular Formula = $C_{14}H_{24}O_4$

(c) When 1.570 grams of the compound is vaporized at 300°C and 1.00 atmosphere, the gas occupies a volume of 577 milliliters. What is the molar mass of the compound based on this result?

$PV = nRT$

$$n = \frac{PV}{RT} = \frac{(1.00\ atm)(.577\ L)}{(0.0821\ \frac{L\ atm}{mol \cdot K})(573\ K)} = .012265\ mol$$

$$MM = \frac{1.570\ g}{.012265\ mol} = 128.0\ g/mol$$

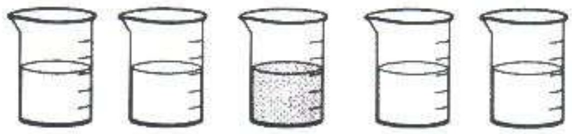
(d) Briefly describe what occurs in solution that accounts for the difference between the results obtained in parts (b) and (c).

THE molecule forms a "dimer" in solution so the 128 g/mole particle has a molar mass of 256 g/mole.

As a gas, it remains as individual monomers.

2001 D Required *NOTE (b) is from Chapter 17 (d) is from Ch2

Solution 1 Solution 2 Solution 3 Solution 4 Solution 5



| Solution 1 | Solution 2 | Solution 3 | Solution 4 | Solution 5 |
|---|---|---|---|---|
| 0.10 *M* $Pb(NO_3)_2$ | 0.10 *M* NaCl | 0.10 *M* $KMnO_4$ | 0.10 *M* $C_2H_5OH$ | 0.10 *M* $KC_2H_3O_2$ |

Answer the questions below that relate to the five aqueous solutions at 25°C shown above.

(a) Which solution has the highest boiling point? Explain. THE SOLUTE WITH THE GREATEST VAN'T HOFF FACTOR, i, IS $Pb(NO_3)_2$

SINCE ALL SOLUTIONS HAVE THE SAME CONCENTRATION, THE 3 ions per mole FOR $Pb(NO_3)_2$ will have the highest BP.

*(b) Which solution has the highest pH? Explain.

Highest pH ≈ most basic.
$C_2H_3O_2^-$ is the conjugate base of the weak acid, $HC_2H_3O_2$.
$C_2H_3O_2^- + H_2O \rightleftharpoons HC_2H_3O_2 + OH^-$ The $OH^-$ ions make the solution BASIC.

(c) Identify a pair of the solutions that would produce a precipitate when mixed together. Write the formula of the precipitate. FROM THE SOLUBILITY RULES, WE KNOW THAT

$$Pb(NO_3)_2 + 2NaCl \rightarrow PbCl_{2(s)} + 2KNO_{3(aq)}$$

(d) Which solution could be used to oxidize the $Cl^-_{(aq)}$ ion? Identify the product of the oxidation.

* FROM OUR "STUFF I SHOULD KNOW..." LIST, $KMnO_4$ is an OXIDIZER

$MnO_4^- + H^+ + 2Cl^- \rightarrow Cl_2 + Mn^{2+} + H_2O$ (not balanced)

Note $ClO^-$, $ClO_2^-$, $ClO_3^-$, and $ClO_4^-$ would also work as product,

(e) Which solution would be the least effective conductor of electricity? Explain.

$C_2H_5OH$ is a non-electrolyte (won't conduct) because it is a molecular compound and forms no ions.