Name _____ AP CHEM __/__/__

Chapter 11 Collected Essays - Answers

1971

Molarity and molality are two ways of expressing concentration.

(a) Clearly distinguish between them **molarity (M) - molar concentration; composition or concentration of a solution expressed as number of moles of solute per liter of solution. molality (*m*) - solution concentration expressed as number of moles of solute per kilogram of solvent. many possibilities, examples:**

(b) Indicate an experimental situation where expressing concentrations as molarity is particularly appropriate. **Acid - base titrations**

(c) Indicate an experimental situation where expressing concentration as molality is particularly appropriate. **Molecular weight determination by freezing point depression change.**

1975 D

Alcohol dissolves in water to give a solution that boils at a lower temperature than pure water. Salt dissolves in water to give a solution that boils at a higher temperature than pure water. Explain these facts from the standpoint of vapor pressure.

An alcohol-water solution has a higher than normal (pure water) vapor pressure because alcohol is a volatile solute and contributes substantially to the vapor of the solution. The higher the vapor pressure, the lower the boiling point. A salt-water solution has a lower than normal vapor because salt is a non-volatile solute and solute-solvent interaction decrease the vapor of the solution, the lower the vapor pressure, the higher the boiling point.

1976 B

(a) Calculate the molality of a 20.0 percent by weight aqueous solution of NH_4Cl. (Molecular weight: $NH_4Cl = 53.5$)

4.67 molal

(b) If this NH_4Cl solution is assumed to be ideal and is completely dissociated into ions, calculate the pressure of this solution at 29.0°C. **25.5 mmHg**

(c) Actually a solution of NH_4Cl of this concentration is not ideal. Calculate the apparent degree of dissociation of the NH_4Cl if the freezing point of this solution is -15.3°C? (Molal freezing point constant = 1.86°C) **76%**

1979 - #3

A solution of hydrochloric acid has a density of 1.15 grams per mL and is 30.% by weight HCl.

(a) What is the molarity of this solution of HCl? **9.45 M**

(b) What volume of this solution should be taken in order to prepare 5.0 liters of 0.20-molar hydrochloric acid by dilution with water? **0.106 L**

(c) In order to obtain a precise concentration, the 0.20-molar hydrochloric acid is standardized against pure HgO (molecular weight = 216.59) by titrating the OH^- produced according to the following quantitative reaction:

$HgO(s) + 4I^- + H_2O \rightarrow HgI_4^{2-} + 2OH^-$

In a typical experiment, 0.7147 gram of HgO required 31.67 milliliters of the hydrochloric acid solution for titration. Based on these data, what is the molarity of the HCl solution expressed to four significant figures? **0.2084 M**

1980 B

(a) A solution containing 3.23 grams of an unknown compound dissolved in 100.0 grams of water freezes at -0.97°C. The solution does not conduct electricity. Calculate the molecular weight of the compound. (The molal freezing point depression constant for water is 1.86°C kg $mole^{-1}$) **62 g/mol**

(b) Elemental analysis of this unknown compound yields the following percentages by weight H=9.74%; C=38.70%; O=51.56%. Determine the molecular formula for the compound. **$C_2H_6O_2$**

(c) Complete combustion of a 1.05 gram sample of the compound with the stoichiometric amount of oxygen gas produces a mixture of $H_2O(g)$ and $CO_2(g)$. What is the pressure of this gas mixture when it is contained in a 3.00 liter flask at 127°C? **0.926 atm**

1985 B

The formula and the molecular weight of an unknown hydrocarbon compound are to be determined by elemental analysis and the freezing-point depression method.

(a) The hydrocarbon is found to contain 93.46 percent carbon and 6.54 percent hydrogen. Calculate the empirical formula of the unknown hydrocarbon. **C_6H_5**

(b) A solution is prepared by dissolving 2.53 grams of p-dichlorobenzene (molecular weight 147.0) in 25.86 grams of naphthalene (molecular weight 128.2). Calculate the molality of the p-dichlorobenzene solution. **0.666 molal**

(c) The freezing point of pure naphthalene is determined to be 80.2°C. The solution prepared in (b) is found to have an initial freezing point of 75.7°C. Calculate the molal freezing-point depression constant of naphthalene. **6.8°C**

(d) A solution of 2.42 grams of the unknown hydrocarbon dissolved in 26.7 grams of naphthalene is found to freeze initially at 76.2°C. Calculate the apparent molecular weight of the unknown hydrocarbon on the basis of the freezing-point depression experiment above. **154 g/mol**

(e) What is the molecular formula of the unknown hydrocarbon? **$C_{12}H_{10}$**

1993 - #2

Elemental analysis of an unknown pure substance indicates that the percent composition by mass is as follows:
Carbon - 49.02%
Hydrogen - 2.743%
Chlorine - 48.23%

A solution that is prepared by dissolving 3.150 grams of the substance in 25.00 grams of benzene, C_6H_6, has a freezing point of 1.12°C. (The normal freezing point of benzene is 5.50°C and the molal freezing point depression constant, K_f, for benzene is 5.12 C°/molal.)

(a) Determine the empirical formula of the unknown substance. **empirical formula = C_3H_2Cl**

(b) Using the data gathered from the freezing point depression method, calculate the molar mass of the unknown substance. **147 g / mol**

(c) Calculate the mole fraction of benzene in the solution described above. **0.94**

(d) The vapor pressure of pure benzene at 35°C is 150. millimeters of Hg. Calculate the vapor pressure of benzene over the solution described above at 35°C. **141 mm Hg**

1996 - #4

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. **282 mL**

(b) Determine the mass percent of H_2SO_4 in the original concentrated solution. **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 $NaHCO_3$. **12 mL**

(d) What is the molality of the 5.20-molar H_2SO_4? **5.98 m**

1998 - #2

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. **$C_7H_{12}O_2$**

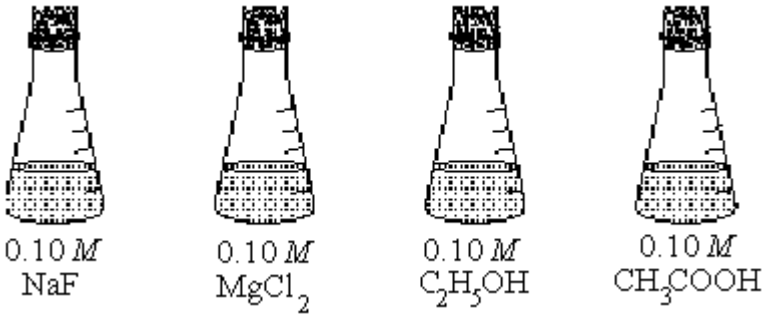
(b) A solution of 1.570 grams of the compound in 16.08 grams of camphor is observed to freeze at a temperature 15.2 Celsius degrees below the normal freezing point of pure camphor. Determine the molar mass and apparent molecular formula of the compound. (The molal freezing-point depression constant, K_f, for camphor is 40.0 kg-K-mol^{-1}.) **257 g / mol; $C_{14}H_{24}O_4$**

(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? **128 g/mol**

(d) Briefly describe what occurs in solution that accounts for the difference between the results obtained in parts (b) and (c). **The compound must form a dimer in solution, because the molar mass in solution is twice than it is in the gas phase.**

1999 - #7

Answer the following questions, which refer to the 100 mL samples of aqueous solutions at 25°C in the closed flasks shown below.



a. Which solution has the lowest electrical conductivity? Explain. **C_2H_5OH (Flask #3) Ethanol, a nonelectrolyte, does not break up or dissociate in solution.**

b. Which solution has the lowest freezing point? Explain. **$MgCl_2$ (Flask #2) The freezing-point depression is proportional to the concentration of solute particles. All solutes are at the same concentration, but the van't Hoff factor (*i*) is largest for $MgCl_2$.**

c. Above which solution is the pressure of water vapor greatest? Explain.**C_2H_5OH (Flask #3) The lowering of vapor pressure of water is directly proportional to the concentration of solute particles in solution. C_2H_5OH is the only nonelectrolyte, so it will have the fewest solute particles in solution.**

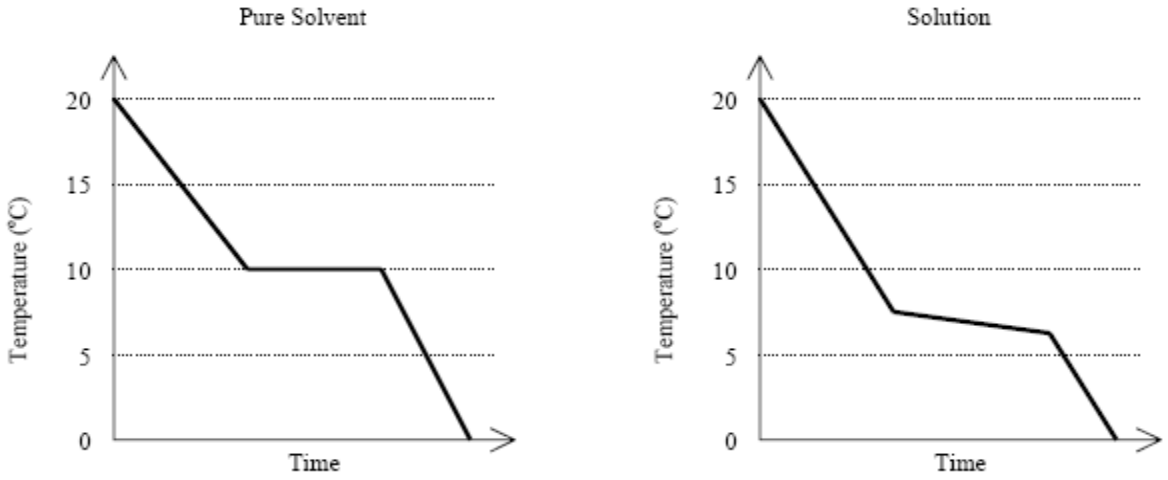
d. Which solution has the highest pH? Explain. **NaF (Flask #1) The F^- ion, generated upon dissolution of NaF, is a weak base. It is the only solution with pH > 7.**

2000 - #5

The molar mass of an unknown solid, which is nonvolatile and a nonelectrolyte, is to be determined by the freezing-point depression method. The pure solvent used in the experiment freezes at 10°C and has a known molal freezing-point depression constant, K_f. Assume that the following materials are also available.

test tubes	stirrer	pipet	thermometer	balance
beaker	stopwatch	graph paper	hot-water bath	ice

(a) Using the two sets of axes provided below, sketch cooling curves for (i) the pure solvent and for (ii) the solution as each is cooled from 20°C to 0.0°C.



(b) Information from these graphs may be used to determine the molar mass of the unknown solid.

(i) Describe the measurements that must be made to determine the molar mass of the unknown solid by this method. **Measure mass of solute, mass of solvent, mass of solution. Measure the freezing points.**

(ii) Show the setup(s) for the calculation(s) that must be performed to determine the molar mass of the unknown solid from the experimental data. **molar mass = (*i*)(*Kf*)(g solute)/(Δ*T*)(kg solvent)**

(iii) Explain how the difference(s) between the two graphs in part (a) can be used to obtain information needed to calculate the molar mass of the unknown solid. **the difference in the vertical position of the horizontal portions of the graphs is equal to Δ*Tfp* , the change in freezing point due to the addition of the solute.**

(c) Suppose that during the experiment a significant but unknown amount of solvent evaporates from the test tube. What effect would this have on the calculated value of the molar mass of the solid (i.e., too large, too small, or no effect)? Justify your answer. **The molar mass is too small. If some of the solvent evaporates, then the (kg solvent) term used in the equation in (b) (ii) is larger than the actual value. If the (kg solvent) term used is too large, then the value calculated for the molar mass will be too small.**

(d) Show the setup for the calculation of the percentage error in a student's result if the student obtains a value of 126 g mol^{-1} for the molar mass of the solid when the actual value is 120. g mol^{-1}. **% error = 6/120 x 100**

2003 - #6b

For each of the following, use appropriate chemical principles to explain the observation. Include chemical equations as appropriate.

(b) When table salt (NaCl) and sugar ($C_{12}H_{22}O_{11}$) are dissolved in water, it is observed that

(i) both solutions have higher boiling points than pure water, and

The higher boiling point is due to the change in vapor pressure above the solution compared to the vapor pressure above pure water. The presence of a nonvolatile solute lowers the vapor pressure above the solution and results in a higher boiling point.

(ii) the boiling point of 0.10 *M* NaCl(*aq*) is higher than that of 0.10 *M* $C_{12}H_{22}O_{11}$(*aq*).

NaCl has a higher boiling point because the change in boiling point, ΔT_{bp}, is directly dependent on the number of solute particles in solution. NaCl is an ionic compound which dissociates into two particles, whereas $C_{12}H_{22}O_{11}$ is a covalent compound and does not dissociate.

2008B – #5

The identity of an unknown solid is to be determined. The compound is one of the seven salts in the following table.

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	$CaCO_3$	$CuSO_4 \cdot 5H_2O$
NaCl	$BaSO_4$	$Ni(NO_3)_2 \cdot 6H_2O$	

Use the results of the following observations or laboratory tests to explain how each compound in the table may be eliminated or confirmed. The tests are done in sequence from (a) through (e).

(a) The unknown compound is white. In the table below, cross out the two compounds that can be eliminated using this observation. Be sure to cross out these same two compounds in the tables in parts (b), (c), and (d).

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	$CaCO_3$	~~$CuSO_4 \cdot 5H_2O$~~
NaCl	$BaSO_4$	~~$Ni(NO_3)_2 \cdot 6H_2O$~~	

(b) When the unknown compound is added to water, it dissolves readily. In the table below, cross out the two compounds that can be eliminated using this test. Be sure to cross out these same two compounds in the tables in parts (c) and (d).

$Al(NO_3)_3 \cdot 9H_2O$	$BaCl_2 \cdot 2H_2O$	~~$CaCO_3$~~	~~$CuSO_4 \cdot 5H_2O$~~
NaCl	~~$BaSO_4$~~	~~$Ni(NO_3)_2 \cdot 6H_2O$~~	

(c) When $AgNO_3(aq)$ is added to an aqueous solution of the unknown compound, a white precipitate forms. In the table below, cross out each compound that can be eliminated using this test. Be sure to cross out the same compound(s) in the table in part (d).

~~$Al(NO_3)_3 \cdot 9H_2O$~~	$BaCl_2 \cdot 2H_2O$	~~$CaCO_3$~~	~~$CuSO_4 \cdot 5H_2O$~~
NaCl	~~$BaSO_4$~~	~~$Ni(NO_3)_2 \cdot 6H_2O$~~	

(d) When the unknown compound is carefully heated, it loses mass. In the table below, cross out each compound that can be eliminated using this test.

~~$Al(NO_3)_3 \cdot 9H_2O$~~	$BaCl_2 \cdot 2H_2O$	~~$CaCO_3$~~	~~$CuSO_4 \cdot 5H_2O$~~
~~NaCl~~	~~$BaSO_4$~~	~~$Ni(NO_3)_2 \cdot 6H_2O$~~	

(e) Describe a test that can be used to confirm the identity of the unknown compound identified in part (d). Limit your confirmation test to a reaction between an aqueous solution of the unknown compound and an aqueous solution of one of the other soluble salts listed in the tables. Describe the expected results of the test; include the formula(s) of any product(s). **Mix an aqueous solution of $BaCl_2*2H_2O$ with an aqueous solution of $CuSO_4*5H_2O$. The $BaSO_4$ will precipitate.**