Practice/Solutions-Solubility ***DO NOT SUBMIT***

1) Predict if the two substances below will be soluble in each other. If yes, then indicate which is solute and which is solvent.

a) 2.00 g KCl and 0.25 g CH_2Cl_2

no

b) 10.0 g $NaNO_3$ and 60.0 g H_2O

yes H_2O is solvent.

c) 8.00 g CH_4 and 5.00 g $CH_3CH_2CH_3$

yes CH_4 is solvent.

2) Answer as true or false.

a) (T) F Oxygen will dissolve more at 2 atm rather than at 1 atm.

b) (T) F It is expected that KNO_3 will dissolve more in water at higher temperature.

c) T (F) CO_2 and water will form a homogenous solution

d) T (F) As the temperature increases CO_2 will dissolve more in water.

3) How will you make a 2.30 kg of a solution that is 4.85 % $NaNO_3$ by mass?
(Ans: 112 g $NaNO_3$ + 2.19 kg water)

$2.30 kg \times \frac{1000 g\ soln}{1 kg\ soln} \times \frac{4.85\ NaNO_3}{100 g\ soln} = 112 g\ NaNO_3$

$2.3 \times 10^3 g - 112 g\ NaNO_3 = 2188 g \equiv 2.19 kg\ H_2O$

4) What is the mass percent of solute in each of the following solutions?
a) 175 mg NaCl/g solution (Ans: 17.5 %)

$175 \times 10^3 g \times 100\% soln = 17.5\%$

b) 0.275 L methanol (d=0.791 g/mL)/Kg water. (Ans:17.9 %)

$275 mL \times 0.791 g/mL = 218 g$ methanol.

$\frac{218}{(218 + 1000) g\ soln} \times 100\% = 17.9\%$

5) What is the mass percent of solute in each of the following solutions?
a) 4.12 g NaOH in 100.0 g water. (Ans: 3.96 %)

$\frac{4.12 g}{4.12 + 100 g} \times 100\% = 3.96\%$

b) 5.00 mL ethanol (d = 0.789 g/mL) in 50.0 g water. (Ans:7.31 %)

$5 mL \times 0.789 g/mL = 3.95 g$ ethanol

$\frac{3.95}{(3.95 + 50) g} \times 100\% = 7.31\%$.

6) What is the volume percent of the following solutions? Assume the volumes are additive.

a) 58.0 mL water in 625 mL of ethanol-water solution. (Ans: 9.28 %)

$\frac{58.0\ mL}{625\ mL} \times 100\% = \boxed{9.28\%}$

b) 10.00 g methanol (d = 0.791 g/mL) in 75.00 g ethanol (d = 0.789 g/mL). (Ans: 11.7 %)

$10\ g \times \frac{1\ mL}{0.791\ g} = 12.64\ mL\ meth.$

$75\ g \times \frac{1\ mL}{0.789\ g} = 95.06\ mL\ eth.$

$\frac{12.64}{12.64 + 95.06} \times 100\% = \boxed{11.7\%}$

7) Calculate the molality of a solution that has 1.02 kg sucrose ($C_{12}H_{22}O_{12}$ MW = 342.3 g/mol) in 554 g water. (Ans: 5.38 *m*)

$1.02 \times 10^3\ g\ suc \times 1\ mol / 342.3\ g = 2.9798\ mol\ suc.$

$\frac{2.9798\ mol}{0.554\ kg} = \boxed{5.38\ m}$

8) An aqueous solution is prepared by mixing 3.30 mL acetone (CH_3COCH_3; d = 0.789 g/mL, MW = 58.08 g/mol) with water to a final volume of 75.0 mL. The density of the final solution is 0.993 g/mL. What are the molarity and molality of the solution? (Ans: 0.598 M, 0.624 *m*)

$3.30\ mL \times 0.789\ g/mL \times 1\ mol / 58.0\ g = 0.04483\ mol$ acetone

Molarity $= 0.04483\ mol / 75 \times 10^{-3}\ L = \boxed{0.598\ M}$

$3.30\ mL \times 0.789\ g/mL = 2.60\ g$ acetone

$75\ mL \times 0.993\ g/mL = 74.5\ g$ soln.

$74.5 - 2.60 = 71.9\ g\ H_2O$

Molality $\frac{0.04483\ mol}{71.9 \times 10^{-3}\ kg} = \boxed{0.624\ m}$

9) What is the mol fraction of naphthalene ($C_{10}H_8$, MW 128.16g/mol) in a solution of:

a) 23.5 g naphthalene in 315 g benzene (C_6H_6, MW 78.11 g/mol)? (Ans: 0.0434)

23.5g naph x 1mol/128.16g = 0.183 mol naph.

315g benz x 1mol/78.11g = 4.03 mol benz.

$\chi_{naph} = \frac{0.183}{0.183 + 4.03} =$ **0.0434**

b) A 0.250 *m* solution of naphthalene in benzene. (Ans: 0.0192)

1000g benz x 1mol/78.11g = 12.80mol benz.

$\frac{0.25\,mol}{0.25 + 12.80} =$ **0.0192 χ_{naph}.**

10) Calculate the molarity and mass percent of a 0.550 *m* NaOH aqueous solution. The density of the solution is 1.012 g/mL. (Ans: 0.545 M, 2.15%)

NaOH = 23
+ 16
+ 1
40 g/mol.

0.550mol x 40g/mol = 22g NaOH.

1kg $H_2O \equiv$ 1000g H_2O

g soln = 1000 + 22 = 1022g soln.

$1022g \times \frac{1mL}{1.012g} = 1009.88\,mL \equiv 1.00988L$

Molarity $= \frac{0.550mol}{1.00988L} =$ **0.545M**

Mass % $= \frac{22g\ NaOH}{1022g\ soln} \times 100\% =$ **2.15%**

11) For a 250. mL of a solution that is 7.5 % by mass CH_3OH in CH_3CH_2OH solution (density = 1.12 g/mL), calculate a) the grams of CH_3OH in that volume of solution; b) the molality of the solution; c) molarity of the solution; and d) mol fraction of CH_3OH.. (Ans: 18.8 g, 1.71 m, 1.78 M, 0.0728) ?

$$250\text{mL soln} \times \frac{1.12\text{g}}{\text{mL}} = 280\text{g soln.}$$

(a) $$280\text{g soln} \times \frac{7.5\text{ meth.}}{100\text{ g soln}} = \boxed{21\text{ g meth}}$$

(b) $C + 4H + O$
$12 + 4 + 16 = 32\text{g/mol}$

$$21\text{g meth} / 32\text{g/mol} = 0.65625 \text{ mol. meth.}$$

$$280\text{g soln} - 21\text{g meth} = 259\text{g eth} = 0.259\text{kg.}$$

$$\frac{0.65625\text{mol}}{0.259\text{ kg}} = \boxed{2.53\text{ m}}$$

(c) $$\frac{0.65625\text{ mol meth.}}{0.25\text{L soln.}} = \boxed{2.63\text{ M}}$$

(d) $2C + 6H + O$
$24 + 6 + 16 = 46\text{g/mol}$

$$259\text{g eth} / 46\text{g/mol} = 5.63$$

$$\frac{0.65625}{0.65625 + 5.63} = \boxed{0.104\ \chi_{\text{methanol}}}$$

$0.65625 + 5.63 = 6.2867$

Practice/Solutions-Colligative Properties ***DO NOT SUBMIT***

K_f water = -1.88 °C/*m* K_f benzene = -5.12 °C/*m*
K_b water = 0.512 °C/*m* K_b benzene = 2.53 °C/*m*

12)What is the vapor pressure of water above a 0.200 *m* glucose ($C_6H_{12}O_6$) solution at 20 °C? (VP H_2O at 20 °C = 17.5 mmHg) (Ans:17.4 mmHg)

0.20 m glu / 1 kg H_2O 1000g H_2O x 1mol / 18g = 55.49 mol.

$\chi_{H_2O} = \frac{55.4}{55.4+0.2} = 0.9964$ || VP = 0.9964 x 17.55 = 17.44 mm Hg.

13)What is the vapor pressure of a solution with 25.0 g CH_2Cl_2 (MW: 84.93 g/mol;VP at 25 °C = 435 mmHg) and 25.0 g $CHCl_3$ (MW: 119.4 g/mol; VP at 25 °C VP = 197 mmHg). (Ans: 336 mmHg)

CH_2Cl_2 25g / 84.93 g/mol = 0.294
$CHCl_3$ 25g / 119.4 g/mol = 0.209

$\chi_{CH_2Cl_2} = \frac{0.294}{0.294+0.209} = 0.5841$ VP. x 435 mmHg = 254.08

$\chi_{CHCl_3} = \frac{0.209}{0.294+0.209} = 0.4152$ x 197 mmHg = 81.79 + 254.08 = 335.8 = 336 mmHg

14)Determine the freezing point of a

a) 0.25 *m* urea in water. (Ans: -0.47 °C)

$\Delta T = -k_f m = -(1.86°C/m \times 0.25m) = -0.465°C$.

$T_f = -0.465°C$

b) 5.00 %, by mass of para dichlorobenzene, $C_6H_4Cl_2$ (MW = 146.8 g/mol) in benzene (C_6H_6). (Ans: 3.70 °C)

$\frac{5.0\ C_6H_4Cl_2}{95 \times 10^{-3}\ kg\ benzene} \times \frac{1\ mol}{147\ C_6H_4Cl_2} = 0.358m$

$\Delta T = -5.12°C/m \times 0.358m = -1.83°C$

$\Delta T = -1.83°C = T_f - T_i = T_f - 5.53°C$ | $T_f = 3.70°C$

15) Determine the boiling points of

a) 0.440 *m* naphthalene in benzene. (Ans: 81.2 °C)

$\Delta T = 2.53\,^{\circ}C/m \times 0.44\,m = 1.11\,^{\circ}C$

$\Delta T = 1.11\,^{\circ}C = T_f - T_i = T_f - 80.1\,^{\circ}C$

$\boxed{T_f = 81.2\,^{\circ}C}$

b) 1.800 M sucrose ($C_{12}H_{22}O_{11}$) in water. (d = 1.23 g/mL) (Ans: 101.5 °C)

→ 1.8 mol/L 1000 mL × 1.23 g/mL = 1230 g soln.

→ 1.8 mol × 342.3 g/mol = 616 g sucrose

1230 − 616 g = 610 g H_2O

$1.8\ mol / 0.610\ kg = 2.9\,m$ || $\Delta T = 0.512 \times 2.9 = 1.5\,^{\circ}C$

$1.5\,^{\circ}C = T_f - 100$ ∴ $\boxed{T_f = 101.5\,^{\circ}C}$

16) How many grams of naphthalene, $C_{10}H_8$, would you add to 50.0 g benzene (C_6H_6, Fpt. = 5.53 °C), to produce a solution that has the same freezing point as pure water? (Ans: 6.92 g)

$T_f = 0.00\,^{\circ}C$ $T_i = 5.53\,^{\circ}C$ $\Delta T = T_f - T_i = 0 - 5.53 = -5.53\,^{\circ}C$

$-5.53\,^{\circ}C = -k_f m = -5.12\,^{\circ}C/m \times m$

$m = \frac{-5.53}{-5.12} = \frac{1.08\ mol\ naph}{1\ kg\ benz.}$

$\frac{1.08\ mol\ naph}{1000\ g\ benz.} \times 50\ g\ benz. \times \frac{128.2\ g\ naph.}{1\ mol\ naph} = \boxed{6.92\ g\ naph}$

17) A 1.45 g sample of an unknown compound is dissolved in 25.00 mL benzene (C_6H_6, d = 0.879 g/mL). The solution freezes at 4.25 °C. What is the molar mass of the unknown? (Ans: 264 g/mol)

$\Delta T = 4.25 - 5.53 = -1.28\,^{\circ}C$

$\Delta T_f = -k_f m$; $m = \frac{\Delta T}{-k_f} = \frac{-1.28\,^{\circ}C}{-5.12\,^{\circ}C/m} = 0.250\,m$

$0.250\,m = \frac{mol}{0.022\ kg\ benz}$; $mol = 0.25 \times 0.022 = 0.00550\ mol$.

$\frac{1.45\ g}{0.00550\ mol} = \boxed{264\ g/mol}$

18) The osmotic pressure exerted by 0.325 g of a polystyrene sample in 50.00 mL of benzene at 25 °C is 0.34 mmHg. What is the molar mass of the polystyrene? (Ans: ~~468 g/~~mol)

(1) $\Pi = MRT$

$25 + 273 = 298$

$0.34\ mmHg / 760 = 4.47 \times 10^{-4}$

(2) $M = \frac{\Pi}{RT} = \frac{4.47 \times 10^{-4}}{0.0821 \times 298}$

$= 1.829 \times 10^{-5}\ mol/L$

(3) $mol = 1.829 \times 10^{-5}\ mol/L \times 50 \times 10^{-3}\ L = 9.135 \times 10^{-7}\ mol.$

(4) $\frac{0.325\ g}{9.135 \times 10^{-7}\ mol} = \boxed{3.56 \times 10^{5}\ g/mol}$

19) Arrange the following in causing the biggest change in freezing point using Van't Hoff factor principle: 0.10 *m* glucose ($C_6H_{12}O_6$), 0.10 *m* $CaCl_2$, 0.10 *m* CH_3COOH and 0.10 *m* KI.

$CaCl_2 > KI > CH_3COOH >$ glucose