Recitation Worksheet Six

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Textbook:

Chemistry & Chemical Reactivity
by John C. Kotz, Paul M. Treichel, John R. Townsend, David Treichel
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Instructions:

- This recitation worksheet covers Ch.13.4
- Please enter your first and last name as it appears on the eLC roster (do not use a nickname that is not reflected in eLC).
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    - Answers must be written in the corresponding answer boxes.
    - You must show your work when appropriate.
- This worksheet is due no later than **12:00 PM (noon) on the Saturday, October 4th.**
- A periodic table and formula sheet are attached to the end of this worksheet. Please keep these attached to your worksheet in the correct order when submitting to Gradescope.

1. What is the *total* vapor pressure of a solution obtained by mixing 35.8 g of benzene (C_6H_6, a **volatile solute**) in 56.7 g toluene ($C_6H_5CH_3$) solvent at 25 °C. The vapor pressure of pure benzene is 95.1 mmHg, and the vapor pressure of pure toluene is 28.4 mmHg at 25 °C.

   ☐ mmHg

2. Calculate the vapor pressure at 25 °C of a solution containing 165 g of glucose, $C_6H_{12}O_6$, **non-volatile solute** dissolved in 685 g of water. The vapor pressure of pure water is 23.8 mmHg at 25 °C.

   ☐ mmHg

3. Dissolving 1.10 g of an unknown compound in 75.22 g of benzene reduces its freezing point from 5.53 °C to 4.92 °C. What is the molar mass of the unknown compound? K_f benzene = −5.12 °C.

[ ] g/mol

4. If the freezing point depression of a 0.10 *m* **aqueous** solution of a solute can be expressed as $\Delta T_f = -i0.186$ °C. For the group of solutes given, which freezing points **correctly** matches the solutes dissolved in water? K_f for H_2O = −0.186 °C/*m*

[ ]

A. CH_3CH_2OH, $\Delta T_f = -0.930$ °C
B. $MgSO_4$, $\Delta T_f = -0.186$ °C
C. NH_4NO_3, $\Delta T_f = -0.774$ °C
D. $CaCl_2$, $\Delta T_f = -0.558$ °C
E. C_6H_6, $\Delta T_f = -0.297$ °C

5. Substance A has a **greater molar mass** than substance B. They are both nonvolatile and nonelectrolyte. If 10 g of substance A are completely dissolved in 250 g of water in one beaker (solution A), and 10 g of substance B are completely dissolved in 250 g of water in another beaker (solution B), then,

   A. the vapor pressure of solution A will be lower than the vapor pressure of solution B.
   B. the solution of A will freeze at a lower temperature than the solution of B.
   C. the two solutions will have the same vapor pressure.
   D. the boiling point of solution A will be lower than the boiling point of solution B.
   E. the solution of A will have a higher osmotic pressure than the solution of B.

6. We wish to lower the freezing point of the water in an automobile radiator to −40 °C. The total mass of water in radiator is 12.0 kg. For which one of the following compounds would we have to use the **greatest** mass of solute to achieve the same degree of freezing points depression? You may assume that K_f for water = −1.86 °C/*m* and that all ionizable solutes are completely ionized.

   A. AlF_3 (M.W. = 84 g/mol)
   B. C_2H_5OH. (M.W. = 46 g/mol)
   C. $CaCl_2$ (M.W. = 111 g/mol)
   D. $C_3H_6(OH)_2$ (M.W. = 76 g/mol)
   E. NaCl (M.W. = 58.5 g/mol)

7. What is the vapor pressure at 20 °C of a saturated solution of urea ($CO(NH_2)_2$), a non-volatile solute in methanol (CH_3OH) if the solubility of urea is 17.0 g urea/100 mL methanol? The density of methanol is 0.792 g/mL, and its vapor pressure at 20 °C is 95.7 mmHg.

[ ] mmHg

8. What mass of NaCl in grams should be added to a 2.50 L of water in an ice-cream maker to make a solution that freezes at −10.0 °C?

[ ] g

9. An ideal liquid solution has two volatile components (a volatile solute dissolved in a volatile solvent). In the vapor in equilibrium with the solution, the **mole fractions** of the components are:

[ ]

A. Both equal to 0.5
B. Equal but not necessarily 0.5
C. Not very likely to be equal
D. 1.0 for the solvent and 0.0 for the solute

10. Some of us assume that adding salt to pasta water before boiling it helps with the cooking process by raising the boiling point of water. How many grams of table salt (NaCl, molar mass = 58.44 g/mol) would be added to 1L of water at 760 torr to raise the boiling point of water by 2.0 °C? K_b for H_2O = 0.512 °C/*m.*

[ ] g

11. An unknown compound is 42.9 % C, 2.4% H, 16.7% N, and 38.1% O by mass. Dissolving 6.45 g of this unknown compound in 50.0 mL of benzene (density of benzene = 0.879 g/mL), lowers the freezing point of benzene from 5.53 °C to 1.37 °C. What is the molecular formula of this compound? K_f for benzene = 5.12 °C/*m* *Formatting tip:* the elements in your answer should follow this order: **$C_wH_xN_yO_z$.**

[ ]

12. Which of the following will have the **lowest** boiling point?

A. 0.25 *m* aqueous sucrose
B. 0.50 *m* aqueous glucose
C. Pure water
D. 0.05 *m* aqueous FeI_3
E. 0.1 *m* aqueous $SrSO_4$

13. A 2.05 m aqueous solution of some unknown had a boiling point of 102.1 °C. Which one of the following could be the unknown compound? K_b for H_2O = 0.512 °C/*m.*

A. NaCl
B. CH_3OH
C. $C_6H_{12}O_6$
D. Na_2CO_3
E. $CaBr_2$

14. When 0.500 g of vitamin K is dissolved in 10.0 g of camphor (K_f = 40.0°C/m), the freezing point of the solution is 4.43°C lower than that of pure camphor. Assuming vitamin K is a nonelectrolyte in camphor, calculate its molar mass.

A. 0.451 g/mol
B. 55.4 g/mol
C. 451 g/mol
D. 3.54×10^4 g/mol

15. Two alcohols, isopropyl alcohol, and propyl alcohol, have the same molecular formula, C_3H_8O. A solution of the two is two-thirds by mass isopropyl alcohol has a vapor pressure of 0.110 atm at 313 K. A solution that is one-thirds by mass isopropyl alcohol has a vapor pressure of 0.089 atm at 313 K. What is the vapor pressure of pure isopropyl alcohol ($P°_{iso}$) and the vapor pressure of pure propyl alcohol ($P°_{pro}$) in atm?

A. $P°_{iso}$ ☐ atm

B. $P°_{pro}$ ☐ atm

Extra Practice Questions: these questions will not be graded

1. The freezing point of acetic acid is typically 16.6 °C. If a sample of 95% w/w acetic acid and 5% w/w water is cooled, at what temperature in degrees Celsius would it freeze? The density of acetic acid is 1.05 g/mL. (K_{fp} = -3.90 °C/m for acetic acid).

   [ ] °C

2. What is the *total* vapor pressure in mm Hg above a solution of 25% v/v methanol dissolved in ethanol? (Methanol: MW = 32.04 g/mol, density = 0.792 g/mL, VP at 25 °C = 97.7 mm Hg; Ethanol: MW = 46.07 g/mol, density = 0.789 g/mL, VP at 25 °C = 58.7 mm Hg).

   [ ] mm Hg

3. Which of the aqueous solutions below will have the **highest** vapor pressure?

   [ ]
   A. 0.10 m $MgSO_4$
   B. 0.030 m CH_3CH_2OH
   C. 0.0090 m $CaCl_2$
   D. 0.011 m KCl
   E. All the solutions have the same vapor pressure

4. A solution of hexane (volatile solute) and heptane contains a mole fraction of heptane, χ = 0.810 mol and the normal boiling point of the solution is 90.4 °C. The vapor pressure of pure hexane at this temperature is 1425 mm Hg. What is the vapor pressure in mmHg of pure heptane at 90.4 °C?

mmHg

5. Consider the four solutions, and choose which statement is **false** :

I) 1 L of pure Water
II) 1 L of water with 0.15 moles of CH_3OH added
III) 1 L of water with 0.15 moles of CH_3CH_2OH
IV) 1 L of water with 0.15 moles of NaCl added

A. The pure water solution will have the highest vapor pressure
B. The solution with 0.15 moles of CH_3OH will have the same vapor pressure as the
C. solution with 0.15 moles of CH_3CH_2OH
D. The solution with 0.15 moles of CH_3OH will have higher vapor pressure than the solution with 0.15 moles of NaCl
E. The solution with 0.15 moles of NaCl will have the highest vapor pressure

6. Which of the following effects would **not** result when $CaCl_2$ was added to water?

A. The melting point would decrease
B. The boiling point would decrease
C. The vapor pressure would decrease
D. The electrical conductivity of the solution would increase

7. Choose the **false** statement regarding a 1 L aqueous solution that contains 1.0 g of NaCl. If all statements are true, choose "none of these are false".

A. $\chi_{solvent} > \chi_{solute}$
B. T_f(aq. solution) > $T_f(H_2O)$
C. mol % solute < mol % solvent
D. T_b(aq. solution) > $T_b(H_2O)$
E. none of these are false

8. A mixture of benzene and toluene has a total vapor pressure at 25 °C of 45.06 mmHg. What is the partial pressure of benzene in this solution? The vapor pressure of pure benzene and pure toluene at 25 °C are 95.03 mmHg and 28.40 mmHg respectively.

A. 0.7500 mmHg
B. 23.76 mmHg
C. 0.3217 mmHg
D. 21.30 mmHg
E. 16.66 mmHg

9. Arrange the following three aqueous solutions (all 250 cm^3 in volume) according to decreasing osmotic pressure at 273 K: 5 g of C_2H_5OH, 5 g $C_6H_{12}O_6$,and 5 g $C_{12}H_{22}O_{11}$.

A. $C_2H_5OH > C_6H_{12}O_6 > C_{12}H_{22}O_{11}$
B. $C_2H_5OH > C_6H_{12}O_6 = C_{12}H_{22}O_{11}$
C. $C_6H_{12}O_6 > C_2H_5OH > C_{12}H_{22}O_{11}$
D. $C_{12}H_{22}O_{11} > C_6H_{12}O_6 > C_2H_5OH$
E. $C_{12}H_{22}O_{11} > C_2H_5OH > C_6H_{12}O_6$

10. Solutions are made that contain 0.10 moles of each of the following compounds in 100 g of H_2O. Choose the compound whose solution will have the highest freezing point.

A. K_2SO_4
B. NaI
C. $Mg(CH_3CO_2)_2$
D. $Sr(NO_3)_2$

Formula Sheet

Length
1 kilometer = 0.62137 mile
1 inch = 2.54 centimeters (exactly)
1 Ångstrom = 1×10^{-10} meter

Energy
1 joule = 1 kg·m^2/s^2
1 calorie = 4.184 joules
1 Calorie = 1 kilocalorie = 1000 calories
1 L·atm = 101.325 joules

Pressure
1 pascal = 1 N/m^3 = 1 kg/m·s^2
1 atmosphere = 101.325 kilopascals = 760 mm Hg = 760 torr = 14.70 lb/in^2
1 bar = 1×10^5 Pa (exactly)

Temperature
0 K = −273.15°C
K = °C + 273.15
°C = (5/9)(°F − 32)

Mass
1 kg = 2.205 lbs

Volume
1 mL = 1 cm^3 = 1 cc

Constants
c = 2.998×10^8 m/sec
h = 6.626×10^{-34} J·sec^{-1}
R = 0.08206 L·atm/mol·K = 8.314 J/mol·K
Specific heat of water = 4.184 J/g·K
Mass of an electron: 9.109 x 10^{-31} kg
Mass of a proton: 1.673 x 10^{-27} kg
RH = 2.18 x 10^{-18} J
Specific heat of water = 4.184 J/g·K
STP = 273.15 K and 1 atm
Avogadro's number: 6.022×10^{23}

Equations
d (density) = m/V
$P_1V_1=P_2V_2$
$V_1/T_1=V_2/T_2$
$P_1V_1/n_1T_1=P_2V_2/n_2T_2$
PV=nRT
$(P + a(n^2/V^2))\cdot(V - nb) = nRT$
molar mass (M) = mRT/PV
density (d) = MP/RT
$x_A = n_A/n_{tot} = P_A/P_{tot} = V_A/V_{tot}$
$P_{tot} = P_A + P_B + \ldots$
$n_{tot} = n_A + n_B + \ldots$

$$\mu_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\frac{Rate\ of\ effusion\ A}{Rate\ of\ effusion\ B} = \sqrt{\frac{MW_B}{MW_A}}$$

$Q = C \times \Delta T = c_{specific} \times m \times \Delta T$
$Q = n \times \Delta H\ (kJ/mol) = m \times \Delta H\ (kJ/g)$
$w = -P\Delta V$
$\Delta E = q + w$
$\Delta H° = \Sigma n\Delta Hf°(products) - \Sigma n\Delta Hf°(reactants)$
$\Delta H° = \Sigma n\Delta H°(bonds\ broken) - \Sigma n\Delta H°(bonds\ formed)$
$E=h\nu$
$c=\lambda\nu$
$\lambda = h/m\nu$

$$\Delta E = -2.18 \times 10^{-18} J(\frac{1}{n_f^2} - \frac{1}{n_i^2})$$

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$C_g = kP_g$
$P_{solution}=P_{solvent}\ X_{solvent}$
$P_{solution}=\sum P_j=\sum P_j X_j$
$\Delta T_b = K_b m i$
$\Delta T_f = K_f m i$
$\pi = MRTi$

Thermodynamic and Electrochemistry

$S = k_b \times \ln(W)$
$k_b = 1.381 \times 10^{-23}\ J/K$
$\Delta S = q_{rev}/T$
$\Delta S_{surr} = q_{surr}/T = -q_{rev}/T$
$\Delta S_{univ} = \Delta S_{sys} + \Delta S_{surr}$
$\Delta S°_{rxn} = \Sigma \nu S°_{products} - \Sigma \nu S°_{reactants}$
$\Delta H°_{rxn} = \Sigma \nu H°_{products} - \Sigma \nu H°_{reactants}$
$\Delta G°_{rxn} = \Sigma \nu G°_{products} - \Sigma \nu G°_{reactants}$
$\Delta G = \Delta H - T\Delta S$
$\Delta G = \Delta G° + RT \cdot \ln Q$
$R=8.314\ J/mol.K$
$\Delta G° = -RT \cdot \ln K$
$\Delta G= -nFE_{cell}$
$F = 96485\ J/(V \cdot mol\ e^-)$
$E°_{cell} = RT/nF\ \ln K$
$E°_{cell} = (0.0257/n)\ \ln K = (0.0592/n)\ \log K$
$E_{cell} = E°_{cell} - (RT/nF)\ \ln Q$
$E_{cell} =E°_{cell} - (0.0257/n)\ \ln Q$
Electrolysis: $Q\ (total\ charge) = I \times t = n \times F$

Integrated Rate Laws & half-life

$$\ln\frac{[A]}{[A]_0} = -kt$$

$$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$$

$$[A] = -kt + [A]_0$$

$$t_{1/2} = \frac{[A]_0}{2k}$$

$$t_{1/2} = \frac{\ln 2}{k} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

$$ln\frac{k_2}{k_1} = -\frac{\mathrm{E_a}}{\mathrm{R}}(\frac{1}{\mathrm{T_2}} - \frac{1}{\mathrm{T_1}})$$

Equilibrium and Acid / Base

$K_P = K_c \times (RT)^{\Delta n}$

$pH = -\log[H_3O^+]$

$K_w = 1.0 \times 10^{-14}$ at 25 °C

$K_w = [H_3O^+] \times [OH^-]$

$K_w = K_a \times K_b$

$pK_a = -\log[K_a]$

Buffer: $pH = pK_a + \log\frac{[A^-]}{[HA]}$

$$ln\frac{K_2}{K_1} = \frac{\Delta H^\circ_{rxn}}{R}(\frac{1}{T_1} - \frac{1}{T_2})$$

Periodic Table of the Elements

1												13	14	15	16	17	18
1 H 1.01	2																2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.63	33 As 74.92	34 Se 78.97	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.95	43 Tc [97]	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
37 Cs 132.91	56 Ba 137.33		72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po [209]	85 At [210]	86 Rn [222]
87 Fr [223]	88 Ra [226]		104 Rf [267]	105 Db [268]	106 Sg [269]	107 Bh [270]	108 Hs [269]	109 Mt [277]	110 Ds [281]	111 Rg [282]	112 Cn [285]	113 Nh [286]	114 Fl [290]	115 Mc [290]	116 Lv [293]	117 Ts [294]	118 Og [294]

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm [145]	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.05	71 Lu 174.97
89 Ac [227]	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np [237]	94 Pu [244]	95 Am [243]	96 Cm [247]	97 Bk [247]	98 Cf [251]	99 Es [252]	100 Fm [257]	101 Md [258]	102 No [259]	103 Lr [262]