Chem 108

(Intermolecular Forces, Colligative Properties, Chemical Kinetics I)

Problem set # 1 **S. S. Massoud**

Please answer the following questions:

Part I: Multiple Choices. Please circle the **ONE** best answer:

1. Which of the following would have the lowest boiling point?

   a) CS_2 (linear) b) CCl_4 c) CI_4 d) CH_3OH

2. When water rises in a small-diameter glass tube, it is due to:

   a) vaporization b) viscosity b) cohesive forces d) capillary action

3. Which of the following would have the greatest melting point?

   a) MgO b) LiF c) NaCl d) CsI

4. Which of the following physical properties does not generally increase with increasing the strength of intermolecular forces?

   a) Boiling point b) P_{vap} c) surface tension d) ΔH_{vap}

5. When water boils, what primary forces are overcome?

   a) An H-O bond is broken.
   b) Only the dispersion forces are overcome.
   c) Hydrogen bonding forces are overcome.
   d) The dipole-dipole intermolecular forces are overcome.

6. Which notation is incorrect?
   a) Dispersion forces are present in all molecular substances
   b) The greater the dipole moment, the stronger the dipole-dipole forces.
   c) The polarizability of elongated molecules is greater than that of compact (more spherical molecules)
   d) Polar molecules always have higher boiling points than non-polar molecules.

7. The enthalpy of sublimation of Hg at 25° C is 61.3 kJ/mol. If the ΔH_{fusion} of Hg is 2.30 kJ/mol at its melting point of -38.9° C, estimate the ΔH_{vap} for hg at 25° C in kJ/mol.

   a) 63.60 b) 59.00 c) -63.60 d) -59.00

8. Concentrated sulfuric acid, H_2SO_4 has a density of 1.84 g/mL and is 95.0% by weight H_2SO_4. What is the molarity of this acid?

   a) 17.8 M b) 96.9 M c) 9.69 M d) 0.0180 M

9. Physiological saline, NaCl solution used in intravenous injections has a concentration of 0.90 % NaCl (mass/mass). How many grams of NaCl are needed to prepare 500. mL of this solution (assume the density of the saline solution is 1.0 g/mL)?

   a) 4.5 g b) 495.5 g c) 0.077 g d) 263 g

10. An aqueous solution of sucrose freezes at –3.6 ºC. What is its boiling temperature? (for water K_b = 0.512 °C/m and K_f = 1.86 °C/m)

a) 100.99 ºC b) 99.01 ºC c) 99 ºC d) 101.99 ºC

11. The exact volume of a solution is required for a concentration measured in:

a) molality b) mole fraction c) molarity d) mass percent

12. Which sets of materials will readily dissolve in water?
Set I: $CHCl_3$, CH_3OH, NH_3; **Set II**:$CaCl_2$, CH_3OH, NH_3; **Set III**: CBr_4, CH_3OH, NaBr

a) only Set I b) only Set II c) Sets I & III d) sets II & III

13. Which of the following aqueous solutions has the lowest freezing point?

a) 0. 2 m sugar b) 0.1 m NaCl c) 0.08 m $CaCl_2$ d) 0.04 m Na_2SO_4

14. The decomposition of ethane (C_2H_6) to methyl radicals is a first order reaction with a rate constant of 5.36 x 10^{-4} s^{-1} at 700 ºC. The initial concentration of ethane was 0.01 M. Calculate the half-life of the reaction.

a) 1.87 x 10^5 s b) 69.3 s c) 18.7 s d) 1.29 x 10^3 s

15. The density of a 16% by mass solution of KBr (molar mass = 119.0 g/mol) is 1.15 g/mL. How many grams of water are present in 1.000 L of this solution?

a) 984 g H_2O b) 966 g H_2O c) 840 g H_2O d) 814 g H_2O

16. A reaction follows the rate law, Rate = k$[A]^2$. To demonstrate the second order behavior of the reaction and determining the rate constant, the graphical plot of the quantity ----- on the Y-axis *vs.* time (t) produced a straight line. What was the quantity that plotted on the Y-axis?

a) ln [A] b) [A] c) 1/ln [A] d) 1/[A]

17. Which would have the lowest freezing point?

a) H_2 b) N_2 c) SO_2 d) H_2O

18. Initial data were obtained for the following reaction:

A (g) + 2 B (g) ⟶ C (g) + D (g)

Expt No.	Initial [A], mol/L	Initial [B], mol/L	Initial rate, mol/L.s
1	0.15	0.10	4.5 x 10^{-1}
2	0.30	0.10	1.8
3	0.15	0.20	9.0 x 10^{-1}

What is the rate law for the reaction?

a) Rate = k [A] b) Rate = k[A] [B]

c) Rate = k$[A]^2$ [B] d) Rate = k[A] $[B]^2$

19. Which plot would not yield the indicated data for the reaction: A ⟶ Product (s)

a) ln [A] *vs.* t: rate constant for a first order reaction.

b) 1/ [A] *vs.* t: rate constant for a second order reaction.

c) ln [A] *vs.* t: rate constant for a zero order reaction.

d) ln k *vs.* 1/T (K): activation energy

<u>Part II</u> <u>Show all work for full credit</u>. Please express all answers with proper units and correct number of significant figures.

1. Nicotine, extracted from tobacco leaves, is a liquid completely miscible with water at temperature below 60 °C. If a solution made by dissolving 1.921 g of nicotine in 48.92 g H_2O starts to freeze at –0.450°C. What must be the molar mass of nicotine? (K_f = 1.86°C/m for water).

2. Glycerin, $C_3H_8O_3$ (92.1 g/mol), is a nonvolatile non-electrolyte with a density of 1.26 g/mL at 25 ºC.

   a) Calculate the vapor pressure at 25 ºC of a solution made by adding 50.0 mL of glycerin to 500.0 mL of water. The vapor pressure of pure water at 25 ºC is 23.8 torr.
   b) Calculate the freezing point of the resulting solution.

3. Camphor, a white solid with pleasant odor, is extracted from roots, branches, and trunk of the camphor tree. Assume you dissolve 45.0 g of camphor ($C_{10}H_{16}O$) in 425 mL of ethanol (C_2H_5OH, has a density of 0.785 g/mL). Calculate the molarity, molality, mole fraction and mass% of camphor in this solution.

4. A 50.00 mL sample of an aqueous solution contains 1.08 g of human serum albumin. A blood plasma protein. The solution has an osmotic pressure of 5.85 mmHg at 298 K. What is the molar mass of the albumin?

5. What is the freezing point of aqueous 0.0145 m $MgCl_2$? (K_f = 1.86°C/m for water).

6. Suppose that at some point in the reaction:

   $$A + 3\,B \longrightarrow 2\,C + 2\,D$$

   [B] = 0.9986 M, and that 13.20 min later [B] = 0.9746 M. What is the average rate of the reaction during this time period, expressed in M/s?

7. Consider the following kinetic data for the reaction:

   $$2\,HgCl_2\,(aq) + C_2O_4^{2-}\,(aq) \longrightarrow 2\,Cl^-\,(aq) + 2\,CO_2\,(g) + Hg_2Cl_2\,(s)$$

Experiment	$[HgCl_2]$, M	$[C_2O_4^{2-}]$, M	Initial rate, M/min
1	0.105	0.15	1.8×10^{-5}
2	0.105	0.30	7.1×10^{-5}
3	0.052	0.30	3.5×10^{-5}

a) What is the order of reaction with respect to $HgCl_2$ and $C_2O_4^{2-}$?

b) What is the overall order of the reaction?

c) What is the value of the rate constant?

8. The following rates of reaction were obtained in the three experiments with the reaction:

$2\ NO\ (g) + Cl_2\ (g) \longrightarrow 2\ NOCl\ (g)$

Expt. No.	Initial [NO] (mol/L)	Initial [Cl_2] (mol/L)	Initial Rate of Reaction (mol/L.s)
1	0.0125	0.0255	2.27×10^{-5}
2	0.0125	0.0510	4.55×10^{-5}
3	0.0250	0.0255	9.08×10^{-5}

a) What is the rate law of the reaction?
b) What is the value of the rate constant, k?

9. The vapor pressure of benzene, C_6H_6, is 40.1 mmHg at 7.6° C. What is its vapor pressure at 60.6° C? The molar heat of vaporization of benzene is 31.0 kJ/mol

ANSWERS:

Part I. MC:

1) a; 2) d; 3) a; 4) b; 5) c; 6) d; 7) b; 8) a; 9) a; 10) a; 11) c; 12) b; 13) c; 14) d; 15) b; 16) d; 17) a; 18) b; 19) c

15) Details of answer: 1000 mL solution x (1.15 g solution/1 mL) x (16 g KBr/100 g solution) = 184 g KBr, 1000 mL solution x (1.15g solution/1 mL) = 1150 g solution, mass H_2O = 1150 – 184 g = 966 g H_2O

Part II:

1) m = 0.242 mol nicotine/kg-H_2O, 0.0118 mol of nicotine & MM = 162 g/mol
2) a- 63 g glycerin, $\chi_2 = 0.0241$, $\Delta P^o = 0.574$ torr, $P_1 = 23.2$ torr; b- $\Delta T_f = 1.24^o$ C, $T_f = -1.24^o$ C
3) 0.296 mols of camphor, M = 0.696 mols/L, m = 0.886 mols/kg-ethanol, $\chi_2 = 0.0391$, 11.9%
4) MM = 8.86×10^4 g/mol
5) $\Delta T_f = -0.081°C$
6) Rate = 1.01×10^{-5} M/s
7) a- 1 & 2 respectively, b) 3, c) $7.6 \times 10^{-3}\ M^{-2}$/min
8) Rate = k $[NO_2]^2[Cl_2]$, k = 5.70 $M^{-2}s^{-1}$
9) ?