Chemistry 212 Test 1 Name: _____
Fall 2022 (Please print)

Multiple Choice (5 points each, Put answers in CAPS in the left margin.)
R = 8.314 J/mol•K = 0.0821 L•atm/mol•K

1. The additional energy added to a solid to cause it to liquefy is called its

   A) Heat of formation
   B) Lattice energy
   C) Heat of fusion
   D) Heat of vaporization
   E) Heat of liquefication

2. Which of the following has the strongest solute-to-solvent interaction? (Problem 13.4)

   A) NH_3 in H_2O
   B) CH_4 in C_6H_6
   C) KCl in H_2O
   D) CH_2Cl_2 in C_6H_6
   E) CH_2Cl_2 in CH_3OH

3. For the compounds CH_4, CH_3Cl, and CH_3OH, what is the correct trend with respect to their boiling points? (Homework 10.10)

   A) $CH_4 < CH_3Cl < CH_3OH$
   B) $CH_4 < CH_3OH < CH_3Cl$
   C) $CH_3Cl < CH_4 < CH_3OH$
   D) $CH_3Cl < CH_3OH < CH_4$
   E) $CH_3OH < CH_4 < CH_3Cl$
   F) $CH_3OH < CH_3Cl < CH_4$

4. Which of the following pairs is unlikely to be miscible?

   A) CH_3OH and H_2O
   B) CH_3OH and CH_3Br
   C) CH_3Br and H_2O
   D) CH_3OH and CH_3CH_2OH
   E) H_2O and $CH_3(CH_2)_4CH_3$

5. Which of the following would have the highest boiling point? (Homework 11.24)

   A) 0.12 *m* KI
   B) 0.35 *m* C_2H_5OH
   C) 0.30 *m* NH_3
   D) 0.19 *m* CaF_2
   E) pure H_2O

6. Which of the following is false about colloids?

   A) They are generally opaque or translucent.
   B) Brownian motion accounts for the existence and appearance of colloids.
   C) They are usually composed of very small solid particles suspended in a liquid.
   D) Filtration is an easy way to separate a colloid.
   E) Milk, mayonnaise, and shaving cream are common colloids.

7. What is the reaction order for the following elementary reaction: $A + B \rightarrow C + D$

   A) 1 B) 2 C) 3 D) 4 E) cannot determine from given information

8. The reaction $2\ NO_{2\ (g)} \longrightarrow 2\ NO_{(g)} + O_{2\ (g)}$ is suspected to be second order in NO_2. Which of the following kinetic plots would be the best to do to prove the reaction is second order?

A) $[NO_2]$ vs t
B) $\ln[NO_2]$ vs t
C) $[NO_2]^2$ vs t
D) $[NO_2]^{-1}$ vs t
E) $\ln[NO_2]^{-1}$ vs t

Discussion Questions (You must show your work to receive credit):

1. At 1 atm, how much energy is required to heat 57.0 g $H_2O_{(s)}$ at −20.0 ºC to $H_2O_{(\ell)}$ at 59.0 ºC? Specific heat $H_2O_{(s)}$ = 2.087 J/(g·°C) and specific heat $H_2O_{(\ell)}$ = 4.184 J/(g·°C), ΔH_{fus}^{o} = 6.010 kJ/mol (8 points)

   There are 3 steps in this calculation: i) heat ice to melting, ii) melt ice, iii) warm water to 59 ºC.

   $\Delta H_1 = (57.0\ g)\left(2.087\ \frac{J}{g \cdot ^oC}\right)(0\ ^oC - (-20^o\ C)) = 2379\ J$

   $\Delta H_2 = (57.0\ g)\left(\frac{1\ mol}{18.02\ g}\right)\left(6.010\ \frac{kJ}{mol}\right)\left(\frac{1000\ J}{kJ}\right) = 1.901 \times 10^4\ J$

   $\Delta H_3 = (57.0\ g)\left(4.184\ \frac{J}{g \cdot ^oC}\right)(59\ ^oC - 0\ ^o) = 1.407 \times 10^4\ J$

   $\Delta H_{overall} = (2379\ J) + (1.901 \times 10^4\ J) + (1.407 \times 10^4\ J) = 3.55 \times 10^4\ J$ (or 35.5 kJ)

2. Define viscosity and explain how it changes with changing intermolecular forces. (8 points)

   Viscosity is the resistance to flow by a liquid. As intermolecular forces increase, molecules are more attracted to each other. When this happens, molecules slide past one another (flow) more slowly and the viscosity increases.

3. At 298 K, the Henry's law constant for oxygen is 0.00130 M/atm. Air is 21.0% oxygen. At 298 K, what is the solubility of oxygen in water exposed to pure oxygen? To air at 1.00 atm? (10 points) (Homework 11.9)

   $[pure_{O2}] = (1\ atm)\left(\frac{0.00130\ M}{atm}\right) = 0.00130\ M$

   $[air_{O2}] = (1\ atm)\left(\frac{0.00130\ M}{atm}\right)(0.21) = 0.000273\ M$

4. A solution of $H_2SO_{4\ (aq)}$ with a molal concentration of 2.24 m has a density of 1.135 g/mL. What is the molar concentration of this solution? (5 points) (Homework 11.12)

   Start by assuming 1 kg of water, then there would be 2.24 mol of H_2SO_4 in the solution.

   $mass_{H2SO4} = (2.24\ mol)\left(\frac{98.01\ g}{mol}\right) = 219.5\ g_{H2SO4}$

   $mass_{soln} = 1000\ g_{H2O} + 219.5\ g_{H2SO4} = 1220\ g$

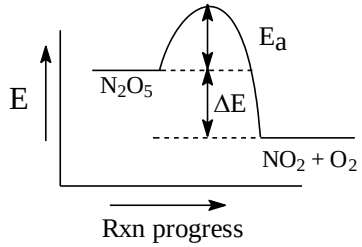
   $V_{soln} = (1220\ g)\left(\frac{mL}{1.135\ g}\right)\left(\frac{1\ L}{1000\ mL}\right) = 1.075\ L$

   $[H_2SO_4] = \left(\frac{2.24\ mol_{H2SO4}}{1.075\ L}\right) = 2.08\ M$

5. One mole of KCl is added to a liter of pure water and one mole of MgF_2 is added to a different liter of pure water. Which has the higher boiling point? Explain your answer (5 points)

   MgF_2. MgF_2 has 50% more particles than KCl (3 moles vs. 2 moles). The extra ions block more surface sites and this reduces the number of locations where water molecules can leave the liquid phase. It thus requires a higher temperature to increase the rate at which particles enter the gas phase.

6. For the reaction $2\ N_2O_{5(g)} \longrightarrow 4\ NO_{2(g)} + O_{2(g)}$, the activation energy and overall ΔE are 100 kJ/mol and -23 kJ/mol respectively. (a) Sketch the energy profile for this reaction. (b) What is the activation energy for the reverse reaction? (9 points)



$E_a(\text{reverse}) = E_a(\text{forward}) + DE$
$= 100\ \text{kJ/mol} + 23\ \text{kJ/mol}$
$= 123\ \text{kJ/mol}$

7. For the reaction $C_5H_{10} + O_3 \longrightarrow C_5H_{10}O_3$ the following data were collected:

$[C_5H_{10}]$ (M)	$[O_3]$ (M)	rate (Ms^{-1})
0.010	0.0028	2.2
0.0050	0.0028	1.1
0.010	0.010	4.4

   a) What is the rate law for this reaction?
   b) What is the value of the rate constant for this reaction? (15 points)
   c) Could this be an elementary reaction? Explain.

   a) General rate law: $\text{rate} = k[C_5H_{10}]^x[O_3]^y$

$$\frac{\text{rate}_1}{\text{rate}_2} = \frac{\cancel{k}(0.010\ M)^x\cancel{(0.0028\ M)^y}}{\cancel{k}(0.0050\ M)^x\cancel{(0.0028\ M)^y}} = \frac{2.2\ Ms^{-1}}{1.1\ Ms^{-1}}$$

$$2.0 = \left(\frac{0.010\ M}{0.0050\ M}\right)^x = (2.0)^x \quad \Rightarrow x = 1$$

$$\frac{\text{rate}_1}{\text{rate}_3} = \frac{\cancel{k(0.010\ M)^x}(0.0028\ M)^y}{\cancel{k(0.010\ M)^x}(0.010\ M)^y} = \frac{0.0028\ Ms^{-1}}{0.010\ Ms^{-1}}$$

$$0.50 = \left(\frac{0.0028\ M}{0.010\ M}\right)^y = (0.28)^y \quad \Rightarrow y = 1/2$$

   Thus the rate law is: $\text{rate} = k[C_5H_{10}][O_3]^{1/2}$

   b) $4.4\ Ms^{-1} = k(0.010\ M)(0.010\ M)$
   $k = 4.4 \times 10^{-3}\ M^{-1/2}s^{-1}$

   c) No. An elementary reaction has a rate law following the step stoichiometry. Since this rate law has a 1/2 power that is impossible.