

Problem	Points	Score
Part 1	36	
Part 2 no.1	6	
2	15	
3	5	
4	6	
5	10	
6	12	
7	10	
Total	100	

Part 1 (36 points) Multiple choice.

- _____ 1. Which one of the following liquids would be the best solvent for I₂?
 a. HCl b. NH₃ c. CCl₄ d. CH₃OH e. H₂O
- _____ 2. Which one of the following pairs of solute/solvent would you predict would not form a homogeneous solution?
 a. C₈H₁₈ / C₆H₆ b. NaCl / CCl₄ c. HF / H₂O d. KNO₃ / H₂O
- _____ 3. Which of the following is the correct order for the solubility of O₂, LiCl, Cl₂, and CH₃OH in water?
 a. Cl₂ < O₂ < CH₃OH < LiCl b. LiCl < O₂ < Cl₂ < CH₃OH
 c. O₂ < Cl₂ < LiCl < CH₃OH d. LiCl < CH₃OH < O₂ < Cl₂
- _____ 4. The solubility of CO₂ gas in water is greatest at
 a. high pressure and high temperature b. low pressure and low temperature
 c. high pressure and low temperature d. low pressure and high temperature
- _____ 5. Consider a solution made by mixing equal amounts of ethanol (VP = 44 mmHg at 20°C) and methanol (VP = 94 mmHg at 20°C). Which of the following statements is not true?
 a. The vapor pressure of the solution is due to only methanol molecules in the gas phase.
 b. The vapor pressure of the solution will increase with increasing temperature.
 c. The vapor above this solution will contain both methanol and ethanol molecules in the gas phase.
 d. The vapor above the solution will be enriched in methanol relative to the composition of the solution.
- _____ 6. Which of the following aqueous solutions has the lowest freezing point? (K_f = 1.86°C/m)
 a. 0.20 m Na₂SO₄ b. 0.30 m HNO₃ c. 0.40 m KCl d. 0.50 m CH₃COOH
- _____ 7. Which of the following does not play a part in determining the rate of a reaction?

- a. the temperature
- b. the concentrations of the reactants
- c. the presence of a catalyst
- d. the relative energies of the reactants and products

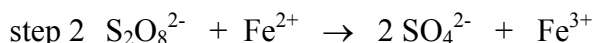
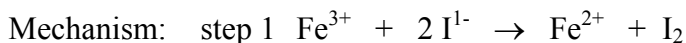
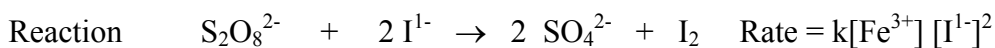
_____ 8. For the following reaction, $-\Delta[\text{C}_6\text{H}_{14}]/\Delta t$ was found to be $6.2 \times 10^{-3} \text{ M/s}$. Determine $\Delta[\text{H}_2]/\Delta t$ for the reaction at the same time. $\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_6 + 4 \text{H}_2$

- a. $6.2 \times 10^{-3} \text{ M/s}$
- b. $1.6 \times 10^{-3} \text{ M/s}$
- c. $2.5 \times 10^{-2} \text{ M/s}$
- d. $-1.6 \times 10^{-3} \text{ M/s}$
- e. $-2.5 \times 10^{-2} \text{ M/s}$

_____ 9. When the concentrations of reactant molecules are increased, the rate of reaction increases. The best explanation is: As the reactant concentration increases;

- a. the average kinetic energy of molecules increases.
- b. the frequency of molecular collisions increases.
- c. the rate constant increases.
- d. the activation energy increases.
- e. the order of the reaction increases.

Use the following rate law and mechanism to answer questions 10-12.



_____ 10. What is the slow step in the reaction mechanism?

- a. step 1
- b. step 2
- c. can not tell

_____ 11. What is the catalyst in this reaction?

- a. Fe^{3+}
- b. I^-
- c. $\text{S}_2\text{O}_8^{2-}$
- d. Fe^{2+}
- e. SO_4^{2-}

_____ 12. What is the reaction intermediate in this reaction?

- a. Fe^{3+}
- b. I^-
- c. $\text{S}_2\text{O}_8^{2-}$
- d. Fe^{2+}
- e. SO_4^{2-}

Part 2. Problems. Show all your work for full credit. (Remember significant figures and units.)

1. (6 points) The dissolution of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, in water is exothermic. Describe the solution process in terms of enthalpy and entropy. Describe all enthalpy changes. Indicate which terms are favorable and why the solution process proceeds.

2. (15 points) Antifreeze is made by dissolving equal volumes of ethylene glycol and water. One sample of this solution could contain 110.0 g ethylene glycol ($\text{HOCH}_2\text{CH}_2\text{OH}$, MM = 62.08 g/mol), a nonvolatile nonelectrolyte dissolved in 100.0 g of water (MM = 18.02 g/mol).

- a. Calculate the mass percent, mole fraction and molality of the ethylene glycol in this solution.
- b. Calculate the vapor pressure of the solution at 30°C. The vapor pressure of water at 30°C is 31.82 mmHg.
- c. Calculate the boiling point of this same solution. Water boils at 100.00°C and its K_b value is 0.52°C/m.

3. (5 points) Calculate the molality of 6.00 M H_2SO_4 aqueous solution. The density of the solution is 1.34 g/mL and the molar mass of sulfuric acid is 98.08 g/mol.

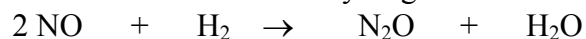
4. (6 points) Calculate the van't Hoff (i) factor of Na_3PO_4 in a 0.40 m solution whose freezing point is -2.6°C. Water freezes at 0.00°C and its K_f value is 1.86°C/m. Compare your answer to the expected value of i for Na_3PO_4 .

5. (10 points) Sketch a potential energy versus reaction progress plot of the following reaction. Label the reactants, products, energy of activation, enthalpy of reaction and the position of the activated species.



What is the significance of the energy of activation?

6. (12 points) Nitric oxide reacts with hydrogen to form nitrous oxide and water.



The following set of rate data were obtained from a series of reactions.

[NO] (M)	[H ₂] (M)	Initial Rate (M/s)
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Exp. 1	0.021	0.065	0.0243
Exp. 2	0.021	0.26	0.0243
Exp. 3	0.042	0.065	0.0973
Exp. 4	0.50	0.50	?

a. Determine the rate law for this reaction.

b. Determine the value of the rate constant.

c. Calculate the rate of reaction for Exp. 4.

7. (10 points) The thermal decomposition of phosphine (PH_3) into phosphorus and hydrogen is a first-order reaction. The rate constant for the reaction is 0.0198 s^{-1} . $4 \text{ PH}_3(\text{g}) \rightarrow \text{P}_4(\text{s}) + 6 \text{ H}_2(\text{g})$

For a first order reaction: $\ln[A]_t = -kt + \ln[A]_o$ $\ln([A]_o/[A]_t) = kt$ $t_{1/2} = 0.693/k$

a. Calculate the half-life for this reaction?

b. Calculate the time required for 33 percent of the phosphine to decompose.

c. Calculate the amount of phosphine left after 10.0 g decomposes for 180 seconds.