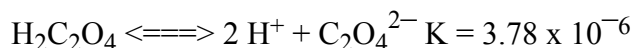


1997 Free Response Questions

- Question 1 was question 4 prior to 1996, question 2 was question 1 prior to 1996 and questions 3&4 were questions 2&3 prior to 1996.
- students are allowed 10 minutes to answer question 1, after which they must seal that portion of the test.

- 1) Give the formulas to show the reactants and products. You need not balance. (a) Excess potassium hydroxide solution is added to a solution of aluminum nitrate.
- (b) A solution of sodium bromide is added to an acidified solution of potassium bromate.
- (c) Sulfur dioxide gas is bubbled into distilled water.
- (d) Phosphine (phosphorus trihydride) gas is bubbled into liquid boron trichloride.
- (e) Hydrogen gas is passed over hot iron(II) oxide powder.
- (f) Solid potassium amide is added to distilled water.
- (g) A strip of magnesium metal is heated strongly in pure nitrogen gas.
- (h) A solution of nickel chloride is added to a solution of sodium sulfide.

- 2) The overall dissociation of oxalic acid, $\text{H}_2\text{C}_2\text{O}_4$ is represented below. The overall dissociation constant is also indicated.

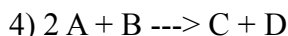


- a) What volume of 0.400-molar NaOH is required to neutralize completely a 5.00×10^{-3} -mole sample of pure oxalic acid?
- b) Give the equations representing the first and second dissociations of oxalic acid. Calculate the value of the first dissociation constant, K_1 , for oxalic acid if the value of the second dissociation constant, K_2 , is 6.40×10^{-5} .
- c) To a 0.015-molar solution of oxalic acid, a strong acid is added until the pH is 0.5. Calculate the $[\text{C}_2\text{O}_4^{2-}]$ in the resulting solution. (Assume the change in volume is negligible.)
- d) Calculate the value of the equilibrium constant, K_b , for the reaction that occurs when solid $\text{Na}_2\text{C}_2\text{O}_4$ is dissolved in water.

- 3) In an electrolytic cell, a current of 0.250 ampere is passed through a solution of a chloride of iron, producing Fe(s) and $\text{Cl}_2(\text{g})$.

- a) Write the equation for the reaction that occurs at the anode.
- b) When the cell operates for 2.00 hours, 0.521 gram of iron is deposited at one electrode. Determine the formula of the chloride of iron in the original solution.
- c) Write the balanced equation for the overall reaction that occurs in the cell.
- d) How many liters of $\text{Cl}_2(\text{g})$, measured at 25 °C and 750 mmHg, are produced when the cell operates as described in part (b)?
- e) Calculate the current that would produce chlorine gas at a rate of 3.00 grams per hour.

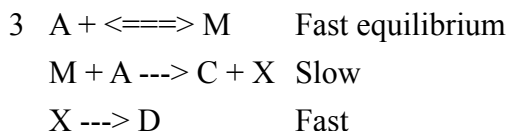
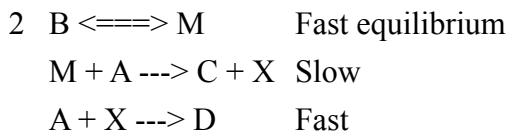
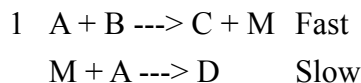
1997 Free Response Questions



The following results were obtained when the reaction represented above was studied at 25 °C

Experiment	Initial [A]	Initial [B]	Initial Rate of Formation of C ($\text{mol L}^{-1} \text{min}^{-1}$)
1	0.25	0.75	4.3×10^{-4}
2	0.75	0.75	1.3×10^{-3}
3	1.50	1.50	5.3×10^{-3}
4	1.75	??	8.0×10^{-3}

- Determine the order of the reaction with respect to A and B. Justify your answer.
- Write the rate law for the reaction. Calculate the value of the rate constant, specifying units.
- Determine the initial rate of change of [A] in Experiment 3.
- Determine the initial value of [B] in Experiment 4.
- Identify which of the reaction mechanisms represented below is consistent with the rate law developed in part (b). Justify your choice.



5) Consider the molecules PF_3 and PF_5 .

- Draw the Lewis electron-dot structures for PF_3 and PF_5 and predict the molecular geometry of each.
- Is the PF_3 molecular polar, or is it nonpolar? Explain.
- On the basis of bonding principles, predict whether each of the following compounds exists. In each case, explain your prediction.



6) Explain each of the following observations using principles of atomic structure and/or bonding.

- Potassium has a lower first-ionization energy than lithium.
- The ionic radius of N^{3-} is larger than that of O^{2-} .
- A calcium atom is larger than a zinc atom.
- Boron has a lower first-ionization energy than beryllium.

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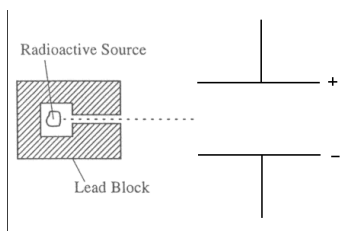
7) For the gaseous equilibrium represented below, it is observed that greater amounts of PCl_3 and Cl_2 are produced as the temperature is increased.

$$\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$$

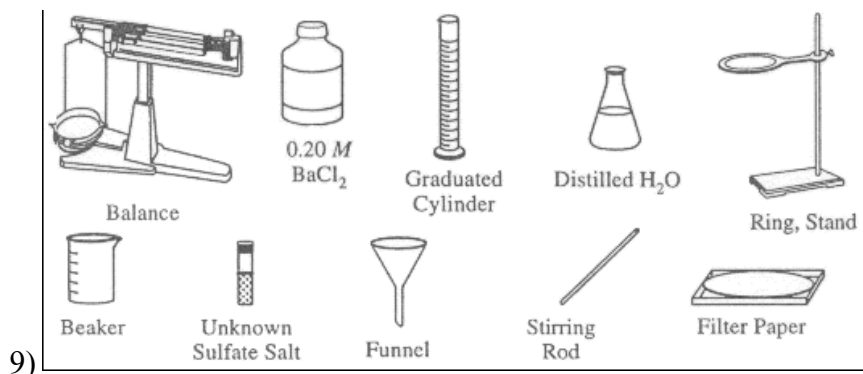
- What is the sign of ΔS° for the reaction? Explain.
- What change, if any, will occur in ΔG° for the reaction as the temperature is increased. Explain your reasoning in terms of thermodynamic principles.
- If He gas is added to the original reaction mixture at constant volume and temperature, what will happen to the partial pressure of Cl_2 ? Explain.
- If the volume of the original reaction is decreased at constant temperature to half the original volume, what will happen to the number of moles of Cl_2 in the reaction vessel? Explain.

8) Answer each of the following questions regarding radioactivity.

- Write the nuclear equation for decay of ${}_{94}^{234}\text{Pu}$ by alpha emission.
- Account for the fact that the total mass of the products of the reaction in part (a) is slightly less than that of the original ${}_{94}^{234}\text{Pu}$.
- Describe how α , β , and γ rays each behave when they pass through an electric field. Use the diagram below to illustrate your answer.



d) Why is it not possible to eliminate the hazard of nuclear waste by the process of incineration?



9)

An experiment is to be performed to determine the mass percent of sulfate in an unknown soluble sulfate salt. The equipment shown above is available for the experiment. A drying oven is also available.

- Briefly list the steps needed to carry out this experiment.
- What experimental data need to be collected to calculate the mass percent of sulfate in the unknown?
- List the calculations necessary to determine the mass percent of sulfate in the unknown.
- Would 0.20-molar MgCl_2 be an acceptable substitute for the BaCl_2 solution provided for this experiment? Explain.