AP problem set #9

Name__________________

Period__________

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.

Be sure to write all your answers to the questions on the lined pages following each question in the booklet with the pink cover. Do NOT write your answers on the green insert.

Answer Question 1 below. The Section II score weighting for this question is 20 percent.

1. Answer the following questions relating to the solubilities of two silver compounds, Ag_2CrO_4 and Ag_3PO_4.

Silver chromate dissociates in water according to the equation shown below.

$$Ag_2CrO_4(s) \rightleftarrows 2\,Ag^+(aq) + CrO_4^{2-}(aq) \qquad K_{sp} = 2.6 \times 10^{-12} \text{ at } 25°C$$

(a) Write the equilibrium-constant expression for the dissolving of $Ag_2CrO_4(s)$.

(b) Calculate the concentration, in mol L^{-1}, of $Ag^+(aq)$ in a saturated solution of Ag_2CrO_4 at 25°C.

(c) Calculate the maximum mass, in grams, of Ag_2CrO_4 that can dissolve in 100. mL of water at 25°C.

(d) A 0.100 mol sample of solid $AgNO_3$ is added to a 1.00 L saturated solution of Ag_2CrO_4. Assuming no volume change, does $[CrO_4^{2-}]$ increase, decrease, or remain the same? Justify your answer.

In a saturated solution of Ag_3PO_4 at 25°C, the concentration of $Ag^+(aq)$ is 5.3×10^{-5} M. The equilibrium-constant expression for the dissolving of $Ag_3PO_4(s)$ in water is shown below.

$$K_{sp} = [Ag^+]^3[PO_4^{3-}]$$

(e) Write the balanced equation for the dissolving of Ag_3PO_4 in water.

(f) Calculate the value of K_{sp} for Ag_3PO_4 at 25°C.

(g) A 1.00 L sample of saturated Ag_3PO_4 solution is allowed to evaporate at 25°C to a final volume of 500. mL. What is $[Ag^+]$ in the solution? Justify your answer.

$$2\,Fe(s) + \frac{3}{2}\,O_2(g) \rightarrow Fe_2O_3(s) \qquad \Delta H_f^\circ = -824 \text{ kJ mol}^{-1}$$

Iron reacts with oxygen to produce iron(III) oxide, as represented by the equation above. A 75.0 g sample of $Fe(s)$ is mixed with 11.5 L of $O_2(g)$ at 2.66 atm and 298 K.

(a) Calculate the number of moles of each of the following before the reaction begins.

(i) $Fe(s)$

(ii) $O_2(g)$

(b) Identify the limiting reactant when the mixture is heated to produce $Fe_2O_3(s)$. Support your answer with calculations.

(c) Calculate the number of moles of $Fe_2O_3(s)$ produced when the reaction proceeds to completion.

(d) The standard free energy of formation, ΔG_f°, of $Fe_2O_3(s)$ is $-740.$ kJ mol^{-1} at 298 K.

(i) Calculate the standard entropy of formation, ΔS_f°, of $Fe_2O_3(s)$ at 298 K. Include units with your answer.

(ii) Which is more responsible for the spontaneity of the formation reaction at 298 K, the standard enthalpy of formation, ΔH_f°, or the standard entropy of formation, ΔS_f°? Justify your answer.

The reaction represented below also produces iron(III) oxide. The value of ΔH° for the reaction is $-280.$ kJ per mole of $Fe_2O_3(s)$ formed.

$$2\,FeO(s) + \frac{1}{2}\,O_2(g) \rightarrow Fe_2O_3(s)$$

(e) Calculate the standard enthalpy of formation, ΔH_f°, of $FeO(s)$.

The first-order decomposition of a colored chemical species, X, into colorless products is monitored with a spectrophotometer by measuring changes in absorbance over time. Species X has a molar absorptivity constant of 5.00×10^3 cm^{-1} M^{-1} and the path length of the cuvette containing the reaction mixture is 1.00 cm. The data from the experiment are given in the table below.

[X] (M)	Absorbance	Time (min)
?	0.600	0.0
4.00×10^{-5}	0.200	35.0
3.00×10^{-5}	0.150	44.2
1.50×10^{-5}	0.075	?

(a) Calculate the initial concentration of the colored species.

(b) Calculate the rate constant for the first-order reaction using the values given for concentration and time. Include units with your answer.

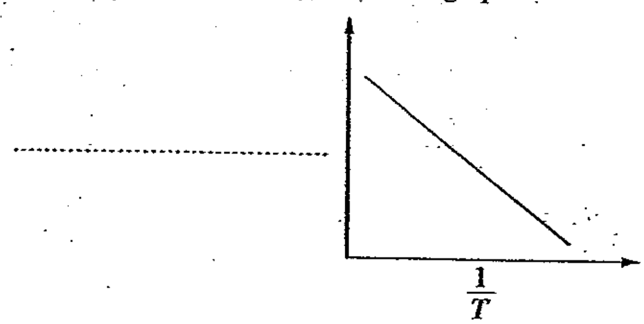
(c) Calculate the number of minutes it takes for the absorbance to drop from 0.600 to 0.075.

(d) Calculate the half-life of the reaction. Include units with your answer.

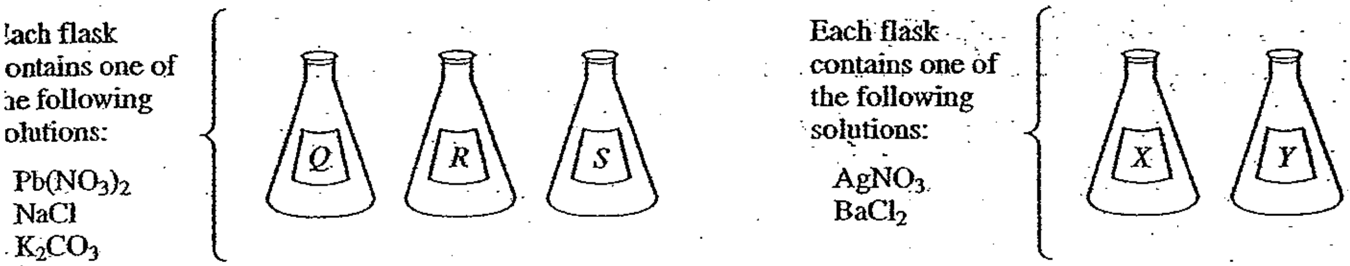
(e) Experiments were performed to determine the value of the rate constant for this reaction at various temperatures. Data from these experiments were used to produce the graph below, where T is temperature. This graph can be used to determine the activation energy, E_a, of the reaction.

(i) Label the vertical axis of the graph.

(ii) Explain how to calculate the activation energy from this graph.



In a laboratory class, a student is given three flasks that are labeled *Q*, *R*, and *S*. Each flask contains one of the following solutions: 1.0 *M* $Pb(NO_3)_2$, 1.0 *M* NaCl, or 1.0 *M* K_2CO_3. The student is also given two flasks that are labeled *X* and *Y*. One of these flasks contains 1.0 *M* $AgNO_3$, and the other contains 1.0 *M* $BaCl_2$. This information is summarized in the diagram below.



(a) When the student combined a sample of solution *Q* with a sample of solution *X*, a precipitate formed. A precipitate also formed when samples of solutions *Q* and *Y* were combined.

(i) Identify solution *Q*.

(ii) Write the chemical formulas for each of the two precipitates.

(b) When solution *Q* is mixed with solution *R*, a precipitate forms. However, no precipitate forms when solution *Q* is mixed with solution *S*.

(i) Identify solution *R* and solution *S*.

(ii) Write the chemical formula of the precipitate that forms when solution *Q* is mixed with solution *R*.

(c) The identity of solution *X* and solution *Y* are to be determined using only the following solutions: 1.0 *M* $Pb(NO_3)_2$, 1.0 *M* NaCl, and 1.0 *M* K_2CO_3.

(i) Describe a procedure to identify solution *X* and solution *Y*.

(ii) Describe the observations that would allow you to distinguish between solution *X* and solution *Y*.

(iii) Explain how the observations would enable you to distinguish between solution *X* and solution *Y*.

GO ON TO THE NEXT PAGE.

7. Use appropriate chemical principles to account for each of the following observations. In each part, your response <u>must</u> include specific information about <u>both</u> substances.

(a) At 25°C and 1 atm, F_2 is a gas, whereas I_2 is a solid.

(b) The melting point of NaF is 993°C, whereas the melting point of CsCl is 645°C.

(c) The shape of the ICl_4^- ion is square planar, whereas the shape of the BF_4^- ion is tetrahedral.

(d) Ammonia, NH_3, is very soluble in water, whereas phosphine, PH_3, is only moderately soluble in water.

GO ON TO THE NEXT PAGE.

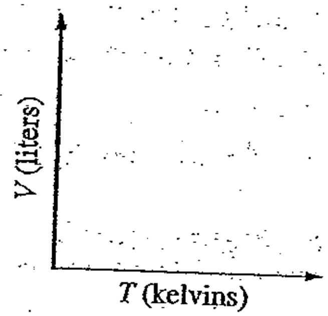
Answer the following questions about carbon monoxide, $CO(g)$, and carbon dioxide, $CO_2(g)$. Assume that both gases exhibit ideal behavior.

(a) Draw the complete Lewis structure (electron-dot diagram) for the CO molecule and for the CO_2 molecule.

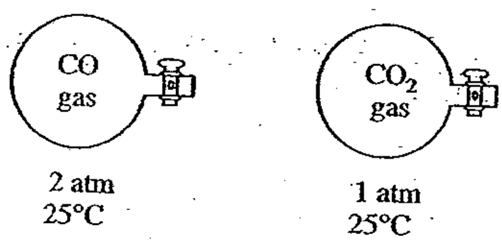
(b) Identify the shape of the CO_2 molecule.

(c) One of the two gases dissolves readily in water to form a solution with a pH below 7. Identify the gas and account for this observation by writing a chemical equation.

(d) A 1.0 mole sample of $CO(g)$ is heated at constant pressure. On the graph below, sketch the expected plot of volume versus temperature as the gas is heated.



(e) Samples of $CO(g)$ and $CO_2(g)$ are placed in 1 L containers at the conditions indicated in the diagram below.



(i) Indicate whether the average kinetic energy of the $CO_2(g)$ molecules is greater than, equal to, or less than the average kinetic energy of the $CO(g)$ molecules. Justify your answer.

(ii) Indicate whether the root-mean-square speed of the $CO_2(g)$ molecules is greater than, equal to, or less than the root-mean-square speed of the $CO(g)$ molecules. Justify your answer.

(iii) Indicate whether the number of $CO_2(g)$ molecules is greater than, equal to, or less than the number of $CO(g)$ molecules. Justify your answer.