FlinnPREP™ for Practice Exam 2
Untimed Free Response

1. The K_{sp} of $Fe(OH)_3$ is 4×10^{-38}.

   a. Calculate the molar solubility of $Fe(OH)_3$ in 0.2 M $Fe(NO_3)_3$. (1)

   b. Generally, heating a solution increases the amount of dissolved solid. Use thermodynamic terms to explain why this is the case. (2)

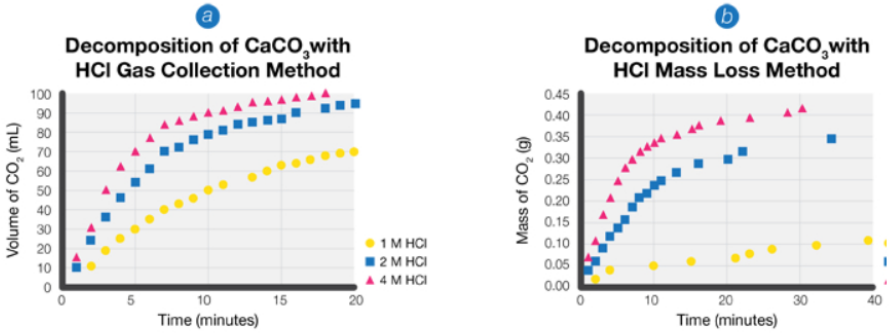
   c. Predict whether the enthalpy of dissociation in an aqueous solution of $Fe(OH)_3$ is larger or smaller than the enthalpy of dissociation of NaCl. Justify your answer. (1)

2. A student investigates the kinetics of the reaction between finely ground calcium carbonate and aqueous hydrochloric acid by two methods. In one method, the student collects evolved carbon dioxide in a syringe by combining the reactants in a flask and then quickly capping with the syringe. In the other method, the student performs the reaction in a flask that sits atop a balance and measures mass lost over time.

   a. Write a balanced, net ionic equation for the reaction. (1)

   b. In a typical experiment, the amount of CO_2 increases rapidly at first and in a linear fashion but then begins to level off after some time. Explain this observation in terms of the collisions between reactant particles. (1)

   c. Data for both methods is provided below.

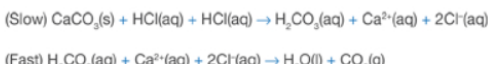


Concentration of HCl	Initial Rate	
	Gas Collection Method	Mass Loss Method
1 M	6 mL CO_2/min	0.01 g CO_2/min
2 M	12 mL CO_2/min	0.03 g CO_2/min
4 M	20 mL CO_2/min	0.06 g CO_2/min

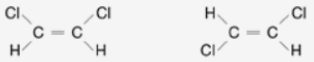
   i. Write an approximate rate law for the reaction, i.e. express orders of reaction using whole numbers only. (2)
   ii. Graph "b" indicates that significant mass loss occurs in the first minute of the reaction between $CaCO_3$ and 4 M HCl. What does this imply about the experimental error associated with the gas-collection method—is it likely to become more significant or less significant as the acid concentration increases? Explain. (2)
   iii. Explain, in terms of graph "b", why the student should use a balance that can measure to the nearest 0.001 g, as opposed to the nearest 0.01 g, to measure the mass lost for reactions that use low concentrations of acid. (2)

   d. A student in another lab uses a comparable amount of coarse (large-particle size) $CaCO_3$ to determine the rate law. Will the substitution of coarse for fine $CaCO_3$ result in slower or faster reactions with equimolar HCl? Justify your answer. (1)

   e. An internet source claims the reaction of $CaCO_3$ with HCl takes place via the following elementary steps. Is the experimentally-determined rate law consistent with this mechanism? Justify your answer. (1)



3.



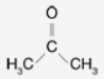
Cis

Trans

The two isomers of 1,2-dichloroethylene are shown above.

a. One of the isomers boils at 60.2 °C, and the other boils at 48.5 °C. Match the isomers with the correct boiling points, and justify your answer. (2)

b. A student analyzes a mixture of the two isomers using thin-layer chromatography. If acetone is used as the eluent and silica gel-coated paper as the absorbent, which of the isomers gives the larger R_f value? Explain. (2)



acetone

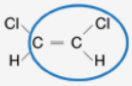
c. The cis isomer of 1,2-dichloroethylene can be prepared by controlled chlorination of acetylene.

Average Bond Enthalpies (kJ/mol)	
C — H	413
C — C	348
C — Cl	328
Cl — Cl	242
C = C	614
C ≡ C	839
H — Cl	431

$$C_2H_2(g) + Cl_2(g) \rightarrow C_2H_2Cl_2(g)$$

i. Given the table of bond energies above, determine whether the chlorination of acetylene is an exothermic or endothermic process. Justify your answer. (1)

ii. Is the reaction favorable from an entropy perspective? Explain.(1)



d. Part of the cis isomer is circled above.

i. What is the molecular geometry of the area indicated? (1)

ii. What is the hybridization of the central C atom in the circled region? (1)

e. Trichloroethylene is structurally similar to both isomers of 1,2-dichloroethylene, with the difference being an additional Cl atom that takes the place of one of the H atoms. Predict how the boiling point of trichloroethylene compares to the boiling points of the two isomers of 1,2-dichloroethylene. Justify your prediction. (2)

4.

$$Cd^{2+}(aq) + Sn(s) \rightarrow Sn^{2+}(aq) + Cd(s) \qquad \Delta G > 0$$

$$Cu^{2+}(aq) + Zn(s) \rightarrow Zn^{2+}(aq) + Cu(s) \qquad \Delta G < 0$$

A student is tasked with designing a Galvanic cell under standard conditions using two of the metals represented in the reactions above.

a. Identify two metals that can be used to form the cell, and indicate which functions as the anode and which functions as the cathode. Justify your answer. (2)

b. In a separate experiment, the student constructs a nonstandard cell using 0.75 M solutions in volumes equal to the solutions used in the standard cell. What effect does this have on the cell potential? Justify your answer. (1)

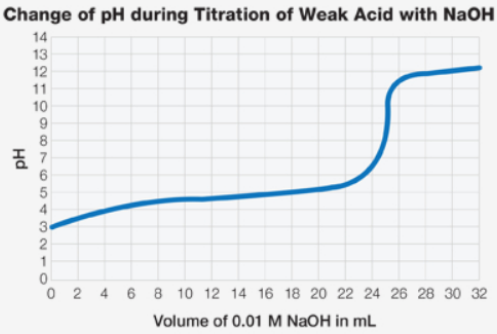
c. In a separate experiment, the student constructs a nonstandard cell using 0.25 M solutions equal in volume to the solutions in the standard cell. The student attaches the standard and nonstandard cells to different lightbulbs. Which lightbulb remains lit for the longer period of time? Explain. (1)

5. Salts of benzoic acid, $HC_7H_5O_2$, are commonly used as food preservatives. A student was tasked with preparing a stock solution of benzoic acid. The value of K_a for benzoic acid is 6.3×10^{-5}

.

a. The solubility of benzoic acid at 25°C is 3.44 g/L. What is the pH of a saturated solution of aqueous benzoic acid at 25°C? (2)

b. The student titrated 25.00 mL of an unsaturated, stock solution of benzoic acid with 0.01 M NaOH. The titration curve is shown below.



i. Calculate the concentration of $HC_7H_5O_2$ in the stock solution. (1)
ii. Which of the following indicators did the student use to observe the endpoint? Justify your answer. (1)

		Color Transition Range (pH)
	pK_a	1 2 3 4 5 6 7 8 9 10 11 12 13
Methyl orange	3.40	Red / Yellow
Methyl red	4.95	Red / Yellow
Phenolphthalein	9.4	Colorless / Red
Bromthymol blue	7.1	Yellow / Blue

c. For each of the following statements, determine whether the statement is true or false. In each case, explain your reasoning.
i. The student used methyl orange as an indicator. As a result, the calculated pH of the benzoic acid solution was higher than the actual pH. (2)
ii. The student neglected to rinse several drops of NaOH that adhered to the inside of the flask that held the benzoic acid solution. As a result, the calculated pH of the benzoic acid solution was higher than the actual pH. (2)

d. In a separate experiment, the student titrated an equal volume of equimolar HCl with 0.01 M NaOH. Describe two ways in which the resulting titration curve differs from the benzoic acid titration curve. (1)

e. In another experiment, the student was tasked with preparing 100 mL of a buffer solution, using 50 mL of 0.01 M $HC_7H_5O_2$ and an undetermined amount of $NaC_7H_5O_2$ dissolved in 50 mL water. How much solid $NaC_7H_5O_2$ would be needed to maximize the buffering capacity of the buffer solution? (1)

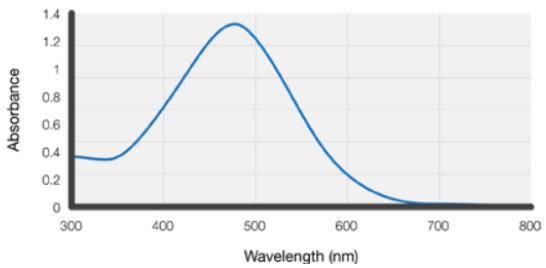
6. A student was tasked with calculating the equilibrium constant, K_{eq} for the reaction of iron(III) ions with thiocyanate ions. A series of reference solutions and test solutions were prepared. The reference solutions were prepared by mixing a large excess of Fe^{3+} ions with known amounts of SCN^- ions and the test solutions were prepared by mixing a constant amount of Fe^{3+} ions with different amounts of SCN^- ions. The absorbance values of both the reference solutions and the test solutions were measured using a spectrophotometer.

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons FeSCN^{2+}(aq) \qquad K_{eq} = 150$$

pale yellow colorless blood-red

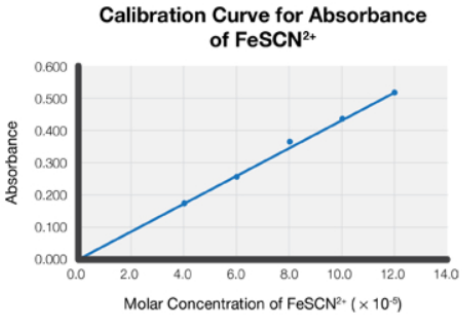
a. It is assumed that all of the SCN^- ions present in the reference solutions will be converted to product. Justify this assumption. (1)

b. See the absorption spectrum for $FeSCN^{2+}(aq)$. Select the optimum wavelength region for absorption readings of the reference reaction solutions. (1)



c. See the data below.

Reference Solutions	0.200 M $Fe(NO_3)_3$, mL	0.00020 M KSCN, mL	$[FeSCN^{2+}]$, M
1	8.0	2.0	4.0×10^{-5}
2	7.0	3.0	6.0×10^{-5}
3	6.0	4.0	8.0×10^{-5}
4	5.0	5.0	1.0×10^{-4}
5	4.0	6.0	1.2×10^{-4}



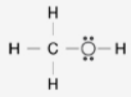
i. Determine the concentrations and absorbance values of reference solutions #4 and #5. Justify your findings. (2)

7. A student was tasked with designing a portable ice pack based on the controlled dissolution of 10.0 g of a soluble ionic compound in 100.0 g of water. The two components are segregated and only mix when the ice pack is squeezed to break the barrier that separates them.

Solid	ΔH_{soln}(kJ/mole)
NaCl	3.8
$CaCl_2$	−70.2
$NaCH_3CO_2$	−17
Na_2CO_3	−29
LiCl	−36.8
NH_4Cl	18

a. The enthalpies of solution for a number of ionic compounds are given in the table above. Which of the compounds is best suited for the application described? Justify your answer. (2)

In a separate experiment, the student decided to test whether a mixture of equal parts of methyl alcohol and water as the solvent would lead to a greater temperature change. The student mixed 50 mL of methyl alcohol (shown below) with 50 mL of water and noted that a homogeneous solution formed. The student then began to add solid NaCl to the mixture and observed that the addition of a sufficient amount of NaCl caused the formation of two immiscible layers.



Methyl alcohol

b. Justify this observation in terms of intermolecular forces. (2)

Finished

FLINNPREP™
P.O. Box 219
Batavia, IL 60510
800-452-1261
866-452-1436
flinn@flinnsci.com

Visit Flinn Canada