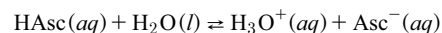


2. Answer the following questions about ascorbic acid (vitamin C).

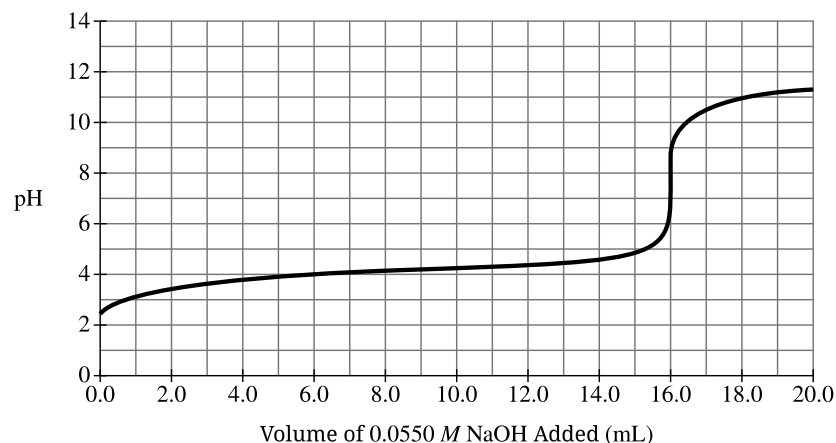
A. A student combusts a sample of ascorbic acid, $C_xH_yO_z$, to determine its chemical composition. The only products of the reaction are 0.2400 mol of CO_2 and 2.883 g of H_2O .

- Calculate the number of moles of H_2O produced.
- The mole ratio of carbon (C) to oxygen (O) is 1:1 in ascorbic acid. Based on this information and your answer to part A (i), determine the empirical formula of ascorbic acid.

B. Ascorbic acid, $HAsc(aq)$, acts as a weak acid, as shown in the equation.



The following titration curve was produced when a 10.0 mL sample of $HAsc(aq)$ was titrated using 0.0550 M $NaOH(aq)$.



- Calculate the molar concentration of the ascorbic acid solution.
- From the titration curve, determine the approximate pK_a of ascorbic acid.
- What is the value of the ratio $\frac{[Asc^-]}{[HAsc]}$ when the pH of the solution is 4.7?

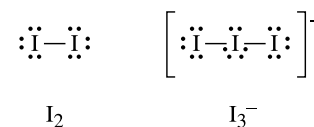
C. Dehydroascorbic acid (DHAsc) can be produced by reacting ascorbic acid with the triiodide ion, I_3^- , as represented by the following equation.



The student runs three trials of the reaction with different initial concentrations of $HAsc$ and I_3^- , producing the following data.

Trial	$[HAsc] (M)$	$[I_3^-] (M)$	Initial Rate of DHAsc Formation (M/s)
1	0.450	1.200	2.457×10^{-4}
2	0.450	0.600	1.229×10^{-4}
3	0.900	1.200	4.914×10^{-4}

- The rate law for the reaction is $rate = k[HAsc][I_3^-]$. Explain how the data in the table support the conclusion that the reaction is first order with respect to $[HAsc]$.
 - Calculate the value of the rate constant, k , for the reaction. Include units with your answer.
- D. The triiodide ion, I_3^- , is significantly more soluble in water than elemental iodine, I_2 , is. Identify an intermolecular force between I_3^- and water that is **not** present between I_2 and water, which could explain the difference in solubility. Lewis diagrams for I_2 and I_3^- are provided.



2. A chemical reaction between maleic acid ($\text{H}_2\text{C}_4\text{H}_2\text{O}_4$) and sodium bicarbonate (NaHCO_3) occurs in the presence of water to produce carbon dioxide and sodium maleate ($\text{Na}_2\text{C}_4\text{H}_2\text{O}_4$), as represented by the following equation.



- (a) A student combines equal masses of $\text{H}_2\text{C}_4\text{H}_2\text{O}_4(s)$ chunks and $\text{NaHCO}_3(s)$ chunks with sufficient water at 20.0°C . The student determines that 0.0114 mol of $\text{CO}_2(g)$ is produced after the reaction goes to completion.

(i) Calculate the number of grams of $\text{CO}_2(g)$ produced.

(ii) The $\text{CO}_2(g)$ produced from the reaction at 20.0°C was collected and found to have a pressure of 1.25 atm . Calculate the volume of $\text{CO}_2(g)$, in liters.

- (b) The student performs a second experiment that is identical to the first except that the student grinds the chunks of $\text{H}_2\text{C}_4\text{H}_2\text{O}_4(s)$ and $\text{NaHCO}_3(s)$ into powder before combining the powder with water.

(i) What happens to the surface area of the reactants when the student grinds the chunks into powder?

(ii) The rate-determining step for the overall reaction is the dissolving of the solids. Would the time required for the dissolving of the solids in the second experiment be longer than, shorter than, or the same as the time required in the first experiment? Justify your answer based on the collisions between particles.

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 2** on this page.

- (iii) When the reaction is complete, will the volume of $\text{CO}_2(g)$ at the end of the second experiment be greater than, less than, or equal to the volume at the end of the first experiment? Justify your answer.

The student conducts additional trials of the experiment and produces the following data table.

Trial	Mass of $\text{H}_2\text{C}_4\text{H}_2\text{O}_4$ (grams)	Mass of NaHCO_3 (grams)	Moles of CO_2 Produced (mol)
3	1.543	1.251	0.01489
4	1.543	1.686	0.02007

- (c) Based on the student's data, identify the limiting reactant in trial 3. Justify your answer.

- (d) The reaction has a value of ΔS° greater than zero. Using particle-level reasoning, explain why the entropy increases as the reaction progresses.

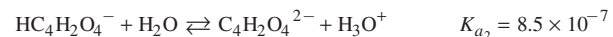
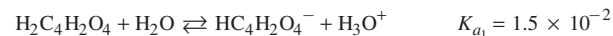
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Continue your response to **QUESTION 2** on this page.

The student notices that the temperature of the reaction mixture decreases as the reaction takes place and correctly determines that the reaction is endothermic.

- (e) The student claims that the reaction is thermodynamically favorable at all temperatures because $\Delta S_{rxn}^{\circ} > 0$ and the reaction is endothermic. Do you agree or disagree with the student's claim? Justify your answer.

Next, the student investigates the acid-base behavior of maleic acid. The student notes that maleic acid is a diprotic acid. The two acid dissociation processes that occur are represented by the following equations.



- (f) Calculate the $\text{p}K_{a2}$ value for the $\text{HC}_4\text{H}_2\text{O}_4^-$ ion.

- (g) A buffer solution with a pH of 7.00 is prepared using $\text{C}_4\text{H}_2\text{O}_4^{2-}$ and $\text{HC}_4\text{H}_2\text{O}_4^-$. Calculate the ratio

$$\frac{[\text{C}_4\text{H}_2\text{O}_4^{2-}]}{[\text{HC}_4\text{H}_2\text{O}_4^-]} \text{ in this solution.}$$

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CHEMISTRY**Section II****7 Questions****Time—90 minutes**

YOU MAY USE YOUR CALCULATOR FOR THIS SECTION.

Directions: Questions 1–3 are long free-response questions that require about 20 minutes each to answer and are worth 10 points each. Questions 4–7 are short free-response questions that require about 7 minutes each to answer and are worth 4 points each.

Write your response in the space provided following each question. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

Mass of KI tablet	0.425 g
Mass of thoroughly dried filter paper	1.462 g
Mass of filter paper + precipitate after first drying	1.775 g
Mass of filter paper + precipitate after second drying	1.699 g
Mass of filter paper + precipitate after third drying	1.698 g

1. A student is given the task of determining the I^- content of tablets that contain KI and an inert, water-soluble sugar as a filler. A tablet is dissolved in 50.0 mL of distilled water, and an excess of 0.20 M $\text{Pb}(\text{NO}_3)_2(aq)$ is added to the solution. A yellow precipitate forms, which is then filtered, washed, and dried. The data from the experiment are shown in the table above.
 - (a) For the chemical reaction that occurs when the precipitate forms,
 - (i) write a balanced, net-ionic equation for the reaction, and
 - (ii) explain why the reaction is best represented by a net-ionic equation.
 - (b) Explain the purpose of drying and weighing the filter paper with the precipitate three times.
 - (c) In the filtrate solution, is $[\text{K}^+]$ greater than, less than, or equal to $[\text{NO}_3^-]$? Justify your answer.
 - (d) Calculate the number of moles of precipitate that is produced in the experiment.
 - (e) Calculate the mass percent of I^- in the tablet.
 - (f) In another trial, the student dissolves a tablet in 55.0 mL of water instead of 50.0 mL of water. Predict whether the experimentally determined mass percent of I^- will be greater than, less than, or equal to the amount calculated in part (e). Justify your answer.

(g) A student in another lab also wants to determine the I^- content of a KI tablet but does not have access to $\text{Pb}(\text{NO}_3)_2$. However, the student does have access to 0.20 M AgNO_3 , which reacts with $\text{I}^-(aq)$ to produce $\text{AgI}(s)$. The value of K_{sp} for AgI is 8.5×10^{-17} .

- (i) Will the substitution of AgNO_3 for $\text{Pb}(\text{NO}_3)_2$ result in the precipitation of the I^- ion from solution? Justify your answer.
- (ii) The student only has access to one KI tablet and a balance that can measure to the nearest 0.01 g. Will the student be able to determine the mass of AgI produced to three significant figures? Justify your answer.