

## WUCT: Chemistry of Cleaning Sample

1. Hard water is water that contains cations, especially  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ . When heated, these cations can form a solid precipitate, which can build up in household water pipes. An example of one of these precipitation reactions is that of  $\text{Ca}^{2+}$  with  $\text{HCO}_3^-$  to form solid calcium carbonate,  $\text{CaCO}_3$ .



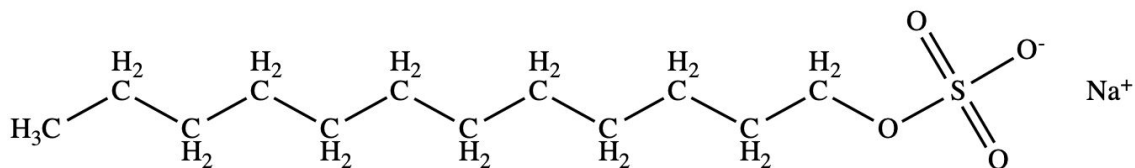
Selected Heats of Formation (kJ/mol)	
$\Delta H_f^\circ (\text{Ca}^{2+}, \text{aq})$	-542.8
$\Delta H_f^\circ (\text{CO}_3^{2-}, \text{aq})$	-673.3
$\Delta H_f^\circ (\text{CaCO}_3, \text{s})$	-1206.9
$\Delta H_f^\circ (\text{CO}_2, \text{g})$	-393.5
$\Delta H_f^\circ (\text{H}_2\text{O}, \text{g})$	-241.8
$\Delta H_{\text{vap}}^\circ (\text{H}_2\text{O})$	44.0

- a. Calculate  $\Delta H_{\text{rxn}}^\circ$  for this reaction at  $25^\circ\text{C}$ .
- b. Using your answer from part a, explain why hard water causes more mineral deposits to build up when hot.

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- c. Calculate the equilibrium constant,  $K$ , for this reaction at  $25^{\circ}\text{C}$  if  $\Delta S^{\circ} = 0.15$   $\text{kJ/mol}\cdot\text{K}$

2. Shown below is the structure of Sodium Lauryl Sulfate (SLS), a common detergent found in many shampoos.



- a. Circle and label any hydrophobic and hydrophilic regions on the structure above. Would you describe this molecule as hydrophilic, hydrophobic, or amphiphilic?
- b. Explain why detergents are used to clean hair. In other words, how do detergents interact with the water from a shower and the oil present on hair?

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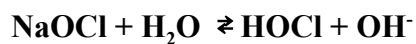
- c. A key step in the preparation of SLS is the sulfonation of lauryl alcohol with sulfuric acid.
- Write the balanced net ionic equation for the reaction of Lauryl Alcohol with Sulfuric Acid.
  - If excess pure sulfuric is added to 500 ml pure lauryl alcohol (density: 0.83 g/ml), how much SLS will be produced assuming the reaction continues to completion?
3. The main reactive ingredient of bleach, a common household cleaning agent, is sodium hypochlorite (NaOCl). Bleach is also used to clean swimming pools, and if you have ever been in a swimming pool, you have probably felt its effects on your eyes. Bleach was originally produced industrially using the reaction below:



- Which way would the equilibrium shift if any acid was added to the reaction?
- Is the backward reaction a redox reaction, ion exchange, or some other type?

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- c. The active ingredient in household bleach is NaOCl, as mentioned above. Why would adding something acidic, like vinegar (acetic acid) be a bad idea? Use the following reaction to explain your answer qualitatively:



- d. Organic compounds that produce unwanted colors can be found on many surfaces in our homes. The color of these compounds is correlated to the number of double bonds in the compound. A class of bleaches, known as reducing bleaches, is most often used to whiten these surfaces.
- i. To better understand how reducing bleaches work, draw the Lewis structure for ethene ( $\text{C}_2\text{H}_4$ ) and assign oxidation numbers to each carbon.
- ii. When reacted with bleach, the product is  $\text{C}_2\text{H}_5\text{OCl}$ . Draw the Lewis structure for this molecule and assign oxidation numbers to each carbon. Is the change in oxidation numbers expected?

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- iii. Using your answers to parts i, ii, and the information presented in part d, explain how reducing bleaches serve as whitening agents.