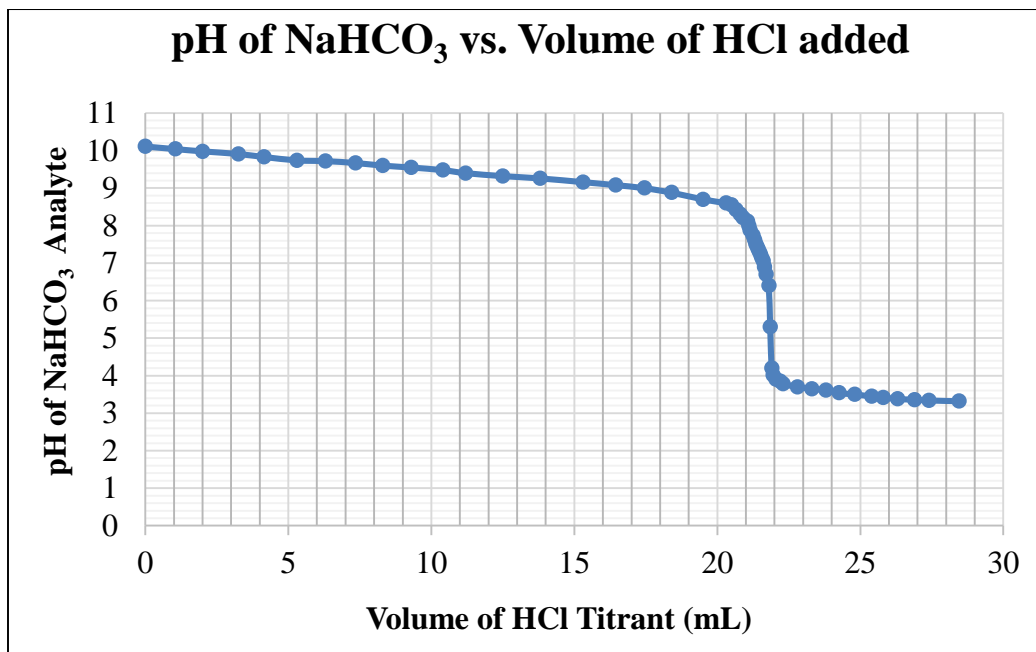


Team Round

- 1) The key ingredient in baking soda is sodium bicarbonate (NaHCO_3), which is used regularly in the kitchen. However, it is also used as a treatment for acid reflux; thus, sodium bicarbonate is referred to as an antacid. Jamie decided to titrate 1.32g NaHCO_3 using the titrant, 0.60M HCl , to determine the K_b of HCO_3^- . She recorded the pH at various points in the titration and plotted these as shown in the graph below (i.e. pH of analyte as a function of the volume of titrant added).



- Write the net ionic equation for the reaction occurring in this titration.
- At the start of the titration, Jamie notices that gas evolves upon the addition of titrant. Identify this gas.
- Based on the titration curve, how many milliliters of HCl were needed to bring the titration to its equivalence point? Write your answer to 3 decimal places.
- What is the experimental $\text{p}K_b$ of HCO_3^- ?
- What is the experimental molar mass of NaHCO_3 ?
- Jamie compared the experimental molar mass of sodium bicarbonate with the actual molar mass of the compound, and she realized that she made a mistake when reading the buret. It turns out that she misread the volume of the titrant to be lower than the actual volume of titrant. Does this help explain the disparity in molar mass?

- g) The table below lists various indicators and their corresponding pH ranges.

Indicator	pH range
Thymol Blue (1 st change)	1.2 – 2.8
Methyl Orange	3.2 – 4.4
Bromocresol Green	3.8 – 5.4
Methyl Red	4.8 – 6.0
Bromomethyl Blue	6.0 – 7.6
Phenol Red	6.8 – 8.4
Thymol Blue (2 nd change)	8.0 – 9.6
Phenolphthalein	8.2 – 10.0

Which indicator would have been best for Jamie to use in the titration of the antacid with hydrochloric acid?

- h) Jamie's best friend, Steven, did the same experiment. Unfortunately, Steven didn't listen to Jamie's advice; although Jamie recommended a certain indicator, Steven decided to go ahead and use Phenol Red as his indicator. How would have this selection changed his experimental molar mass of NaHCO_3 (lower, higher, or the same compared to the actual molar mass). Explain your reasoning.

2) The following question tests concepts related to physical equilibria.

- a) An egg boils at 100°C at sea level. However, if you boil the same egg at Mt. Everest's basecamp (elevation of 17388 feet), you will see that the egg boils at 82°C . Explain why this phenomenon is observed.
- b) In Marshland, individuals are immune to toxic liquids. Dr. Lee, the founder of Marshland, wants to make spinach lasagna for his chemistry students' graduation, but he's running out of time! He needs to boil liquid at as high a temperature as possible to cook his lasagna. He has a variety of liquids that he can use:

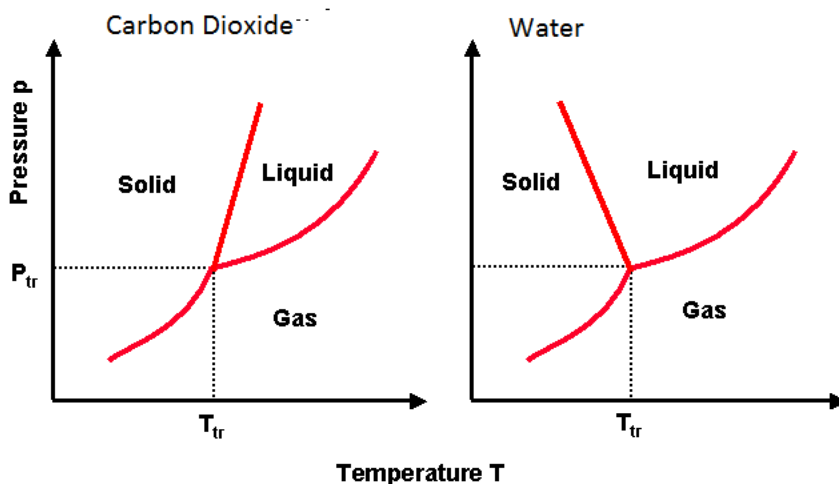
Octane: $\text{CH}_3(\text{CH}_2)_6\text{CH}_3$

Pentane: $\text{CH}_3(\text{CH}_2)_3\text{CH}_3$

Neopentane: $\text{C}(\text{CH}_3)_4$

Which liquid should he boil his lasagna in? Briefly rationalize your choice.

- c) Below are two phase diagrams, illustrations that describe the different temperatures and pressures corresponding to solid, liquid, and gas forms of water and carbon dioxide.

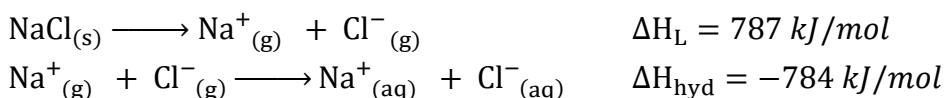


Explain why the solid – liquid boundary has a positive slope in most solids (such as CO_2), while the solid – liquid boundary has a negative slope in water.

- d) The enthalpy of solution is given by ΔH_{sol} which is the sum of the lattice enthalpy (ΔH_{L}) and the hydration enthalpy (ΔH_{hyd}).

In equation form: $\Delta H_{\text{sol}} = \Delta H_{\text{L}} + \Delta H_{\text{hyd}}$

Lattice enthalpy is the amount of energy that it takes for the conversion of an ionic solid to its gaseous ions. Enthalpy of hydration is the amount of energy it takes to convert the gaseous ions into their aqueous form.



We see an overall $\Delta H_{\text{sol}} = +3 \text{ kJ/mol}$, which is endothermic. Yet, we see NaCl spontaneously dissolve in water. Explain why this process is spontaneous.

- e) Detergents are molecules that have both nonpolar tails and polar head groups. For example, sodium dodecyl sulfate (SDS) (shown below) is a detergent. It is a molecule that has a long nonpolar hydrocarbon tail and an anionic head group.



Oils are molecules that are made of multiple hydrocarbon tails bonded to a three carbon glycerol molecule. The hydrocarbon tails are long enough to cause the entire molecule to be extremely hydrophobic.

Based on the above information, rationalize why the chemical properties of SDS make it an effective detergent for removing oils from clothing.