 **Demonstration of Hard-Soft Acid-Base Theory:**

**An Ion-Exchanger for Recovery of Rare Earth Metals**

*Literature Discussion Activity*

Layered A2Sn3S7·1.25H2O (A= Organic Cation) as Efficient Ion-Exchanger for Rare Earth Element Recovery

By

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1. Looking at **Figure 1**, how does *FJSM-SnS* maintain charge balance once it adsorbs cations like Ln3+?
2. a. Looking at **Table S2**, there is a comparison of the kinetics of removal of Eu3+ and Tb3+ by *FJSM-SnS* and a comparison to other adsorbants. How would you describe the rate of adsorption of *FJSM-SnS* compared to the other listed adsorbants: *about the same speed, moderately faster, or much faster than the other adsorbants that are listed*?
   1. *In your own words*, explain the authors’ rationale for your response in Question 2a.
3. Looking at the data in **Table S4** describe how the adsorption capacities for Eu3+and Tb3+ of *FJSM-SnS* (in mg/g) compare to the other listed adsorbants.
4. Referring to **Figure S4**, the pH dependence is described for the adsorption efficiency of a wide range of REE. At what pH is *FJSM-SnS* most efficient? Also, describe the overall pattern of efficiency of *FJSM-SnS* with respect to pH and why this is relevant for the application to real world waste streams.
5. What is the primary reason the authors hypothesize that *FJSM-SnS* has excellent selectivity for Eu3+ over ions like Al3+, Fe3+, or Na+?

1. Describe what the researchers learned from the scanning electron microscopy (SEM) images shown in Figure 3.
2. Use Figure S7 to compare the size of the unit cell of the Cs+-exchanged sulfide and of the Eu3+-exchanged sulfide. How do your results compare to the ionic radii of Cs+ and Eu3+?