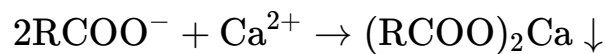


Chemistry Analysis of Water Hardness

<https://gemini.google.com/app/ba4fc0bf8b6f7dc7>

Response: Analysis of each statement based on chemistry principles:

- **(a) Incorrect:** The cleaning efficiency of soap is **lower** in hard water because the polyvalent cations (Ca^{2+} , Mg^{2+} , etc.) react with soap anions (RCOO^-) to form insoluble precipitates (scum), which reduces the amount of free soap available for cleansing.
- **(b) Incorrect:** The precipitates (scum) formed by reacting polyvalent cations with soap anions contain long hydrocarbon chains, making them insoluble sticky solids that typically **float on water** (less dense than water/forms a surface scum or floats in suspension) rather than sinking as dense precipitates.
- **(c) Correct:** Soap anions (RCOO^-) contain a negatively charged carboxylate group that is attracted to polyvalent cations (such as Ca^{2+} or Mg^{2+}) via ionic interaction, forming insoluble salts:



- **(d) Correct:** Water hardness is caused by dissolved polyvalent metal cations, primarily Ca^{2+} and Mg^{2+} , along with other polyvalent ions like Fe^{2+} or Fe^{3+} .

Correct statements: (c) and (d)
