Accounting for Ions in a Model Water Softener

Base your answers on the information provided and your knowledge of chemistry. Use the 2025 Chemistry Reference Tables as needed.

A class models an ion exchange cartridge. The cartridge contains fixed negative sites that initially hold Na^+ ions. As Ca^{2+} ions pass through the cartridge, one Ca^{2+} can replace enough Na^+ to keep the fixed sites electrically balanced. Assume these are the only ions the cartridge exchanges.

1 How many Na^+ ions must leave the cartridge for each Ca^{2+} ion it holds? Use the charges to explain. [1]

Answer and work

The class passes three equal portions through the same cartridge in sequence. It measures the amount of Ca^{2+} entering and leaving in each portion. The inlet amount is 0.50 mmol Ca^{2+} each time.

Portion	**Ca^{2+} leaving (mmol)**
1	0.10
2	0.25
3	0.50

2 Calculate the amount of Na^+ released from the cartridge into portion 2. Show how you used the calcium measurement and the exchange ratio. [1]

Answer and work

3 Which interpretation best fits the three calcium readings?

(1) The cartridge removes more calcium from each successive portion.

(2) The cartridge removes the same amount of calcium each time.

(3) The cartridge removes less calcium from each successive portion.

(4) The cartridge adds calcium to portion 3.

4 A student argues that removing calcium must lower the total amount of dissolved ions in the first portion. Consider only the Ca^{2+} and Na^+ ions changed by the exchange. Use the ratio to evaluate the claim. [1]

Answer and work