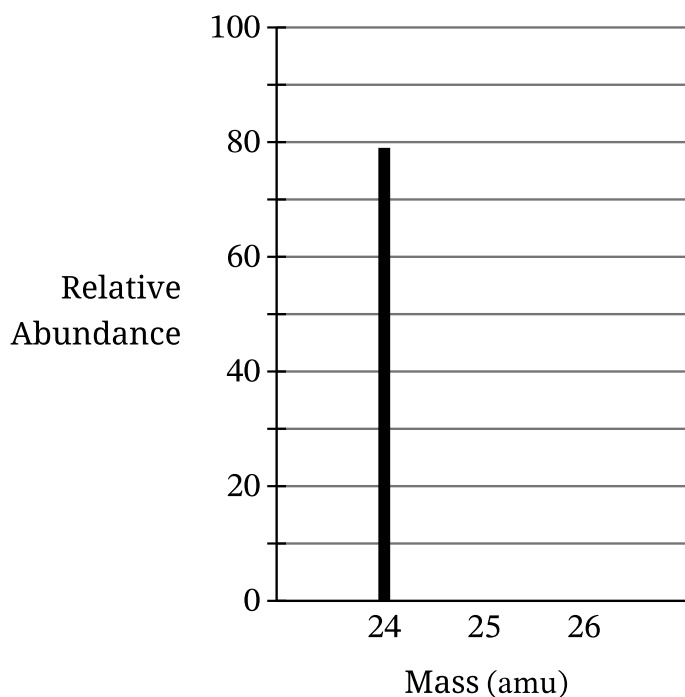


1. Answer the following questions about magnesium.

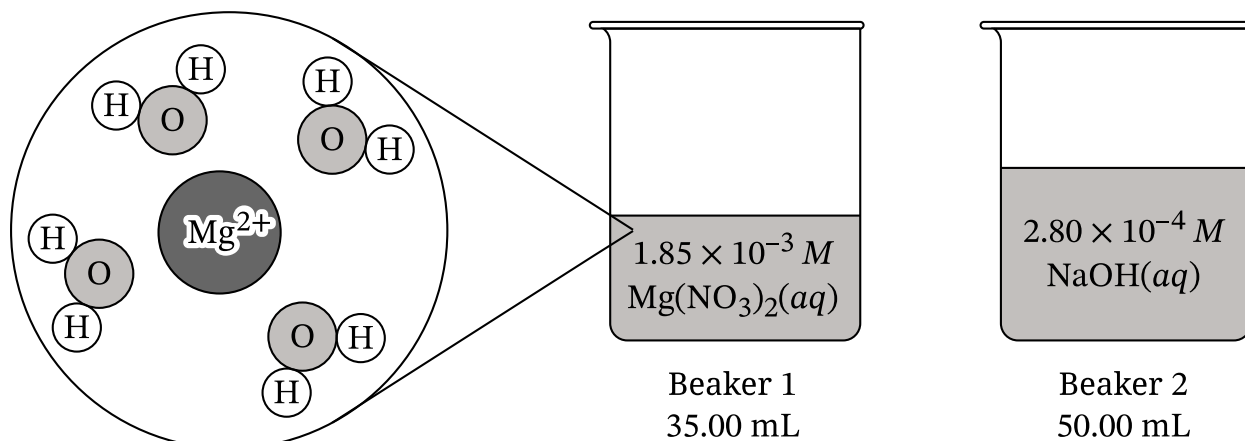
A. An incomplete mass spectrum for magnesium is shown in the diagram.



The percent abundance of magnesium-24 is 79%. The percent abundances of the other two natural isotopes of magnesium, magnesium-25 and magnesium-26, are approximately equal.

- Complete the mass spectrum in part A by drawing thick lines in the appropriate locations to represent the percent abundance of magnesium-25 and magnesium-26.
- Describe the difference in atomic structure that accounts for the difference in mass between magnesium-25 and magnesium-26.

A student prepares a $1.85 \times 10^{-3} M$ solution of $\text{Mg}(\text{NO}_3)_2(aq)$ in beaker 1 and a $2.80 \times 10^{-4} M$ solution of $\text{NaOH}(aq)$ in beaker 2, as shown.

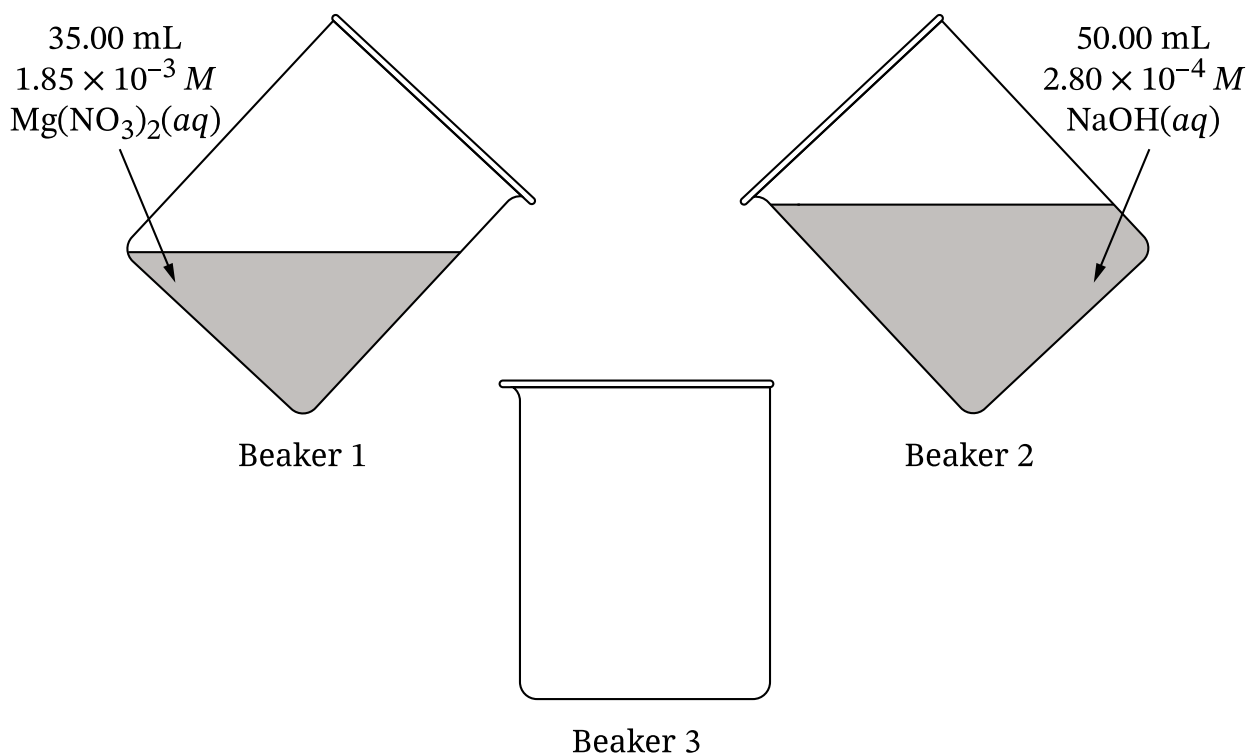


B. The particle diagram shown represents a magnesium ion, Mg^{2+} , in beaker 1. A sodium ion, Na^+ , in beaker 2 has a weaker attraction to water than the Mg^{2+} does. Explain this phenomenon using Coulomb's law and each of the following.

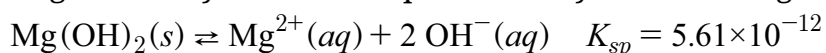
- The relative charge of the ions
- The relative radii of the ions

C. Calculate the pH of the solution in beaker 2.

- D. A student combines 35.00 mL of $1.85 \times 10^{-3} M \text{Mg}(\text{NO}_3)_2(aq)$ with 50.00 mL of $2.80 \times 10^{-4} M \text{NaOH}(aq)$, as shown in the diagram. Calculate $[\text{Mg}^{2+}]$ after the two solutions are combined but before any reaction takes place. (Assume that volumes are additive.)



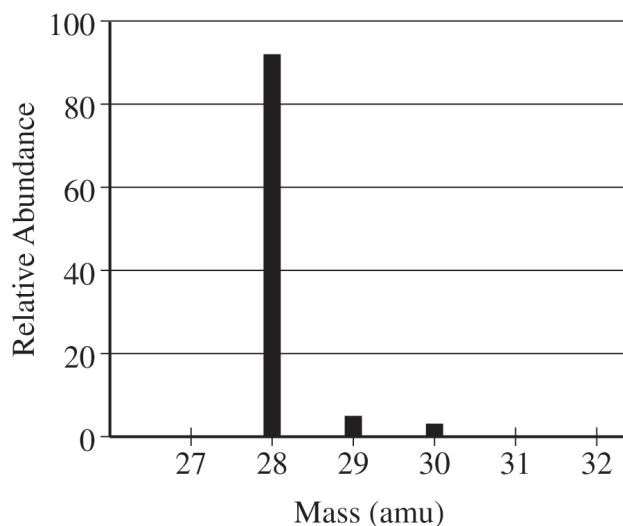
- E. The dissolution of magnesium hydroxide is represented by the following equation.



- Write the expression for the solubility product constant, K_{sp} .
 - After the two solutions are combined in beaker 3 as described in part D, but before any reaction takes place, $[\text{OH}^{-}] = 1.65 \times 10^{-4} M$. Using your answer to part D, calculate the value of the reaction quotient, Q .
 - Using the reaction quotient, Q , predict whether a precipitate should form as the mixture in beaker 3 approaches equilibrium. Justify your answer.
- F. In a separate experiment, the student adds $\text{HNO}_3(aq)$ to decrease the pH of a saturated solution containing undissolved $\text{Mg}(\text{OH})_2(s)$. Does the amount of undissolved $\text{Mg}(\text{OH})_2(s)$ increase, decrease, or remain the same as the $\text{HNO}_3(aq)$ is added? Justify your answer.

2. Answer the following questions about the element Si and some of its compounds.

(a) The mass spectrum of a pure sample of Si is shown below.



(i) How many protons and how many neutrons are in the nucleus of an atom of the most abundant isotope of Si ?

(ii) Write the ground-state electron configuration of Si.

Two compounds that contain Si are SiO_2 and SiH_4 .

(b) At 161 K, SiH_4 boils but SiO_2 remains as a solid. Using principles of interparticle forces, explain the difference in boiling points.

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At high temperatures, SiH_4 decomposes to form solid silicon and hydrogen gas.

(c) Write a balanced equation for the reaction.

A table of absolute entropies of some substances is given below.

Substance	S° (J/(mol · K))
$\text{H}_2(g)$	131
$\text{Si}(s)$	18
$\text{SiH}_4(g)$	205

(d) Explain why the absolute molar entropy of $\text{Si}(s)$ is less than that of $\text{H}_2(g)$.

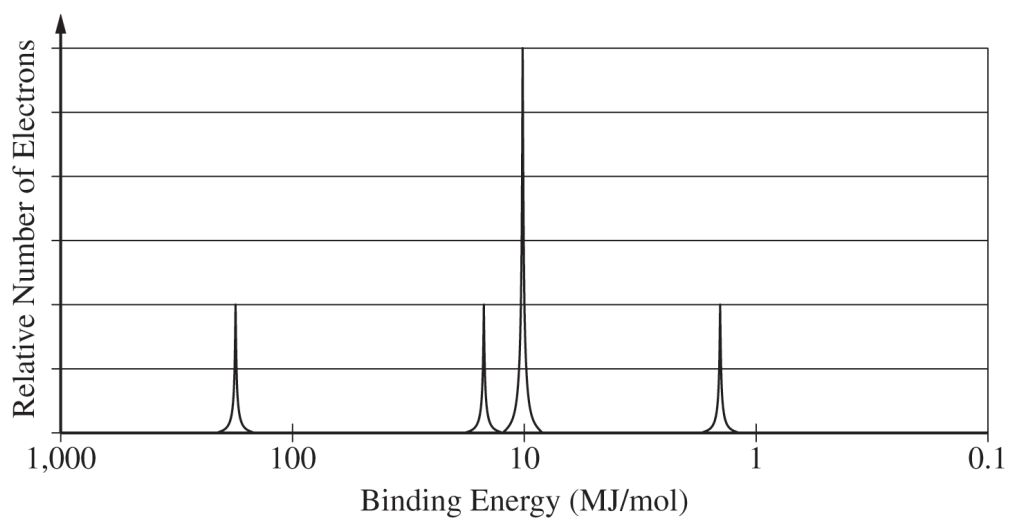
(e) Calculate the value, in J/(mol · K), of ΔS° for the reaction.

(f) The reaction is thermodynamically favorable at all temperatures. Explain why the reaction occurs only at high temperatures.

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(g) A partial photoelectron spectrum of pure Si is shown below. On the spectrum, draw the missing peak that corresponds to the electrons in the $3p$ sublevel.



(h) Using principles of atomic structure, explain why the first ionization energy of Ge is lower than that of Si.

(i) A single photon with a wavelength of $4.00 \times 10^{-7} \text{ m}$ is absorbed by the Si sample. Calculate the energy of the photon in joules.

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