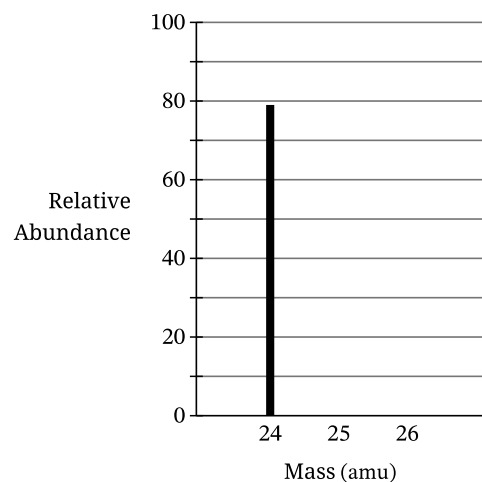


1. Answer the following questions about magnesium.

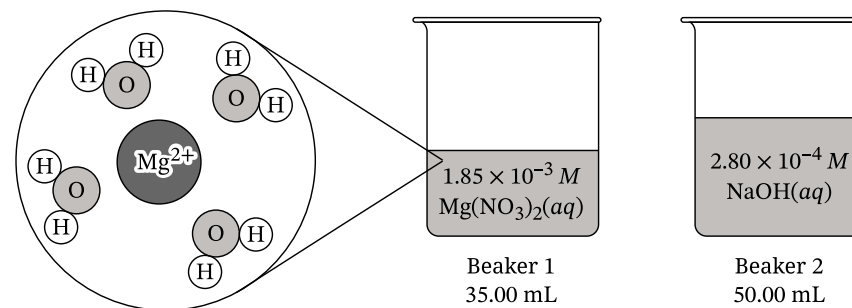
A. An incomplete mass spectrum for magnesium is shown in the diagram.



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.

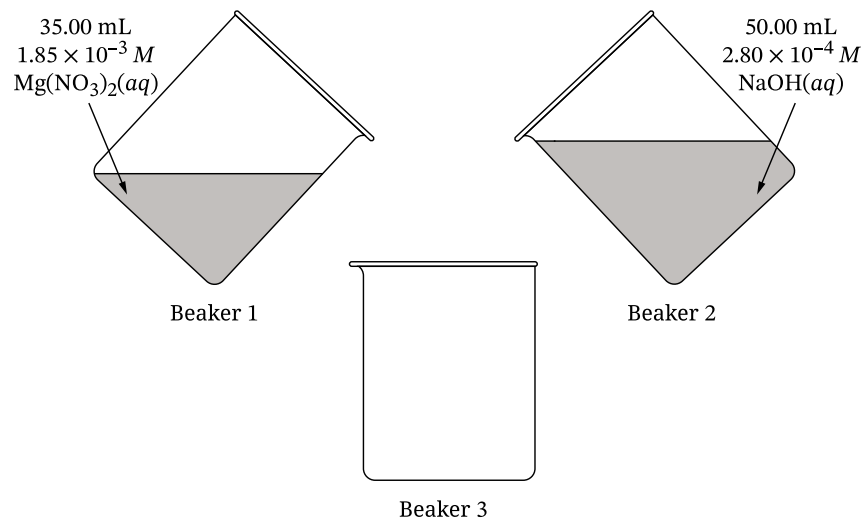


B. The particle diagram shown represents a magnesium ion, Mg^{2+} , in beaker 1. A sodium ion, Na^+ , in beaker 2 has a weaker attraction to water than the Mg^{2+} does. Explain this phenomenon using Coulomb's law and each of the following.

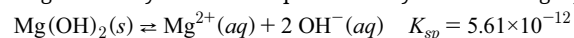
- The relative charge of the ions
- The relative radii of the ions

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.)

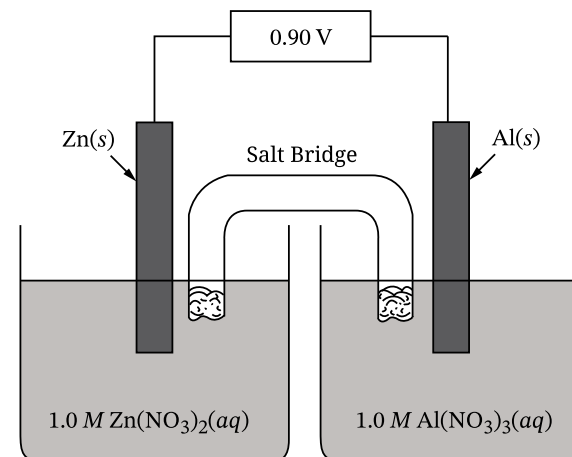


- E. The dissolution of magnesium hydroxide is represented by the following equation.



- 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.

6. A scientist constructs a galvanic cell as shown in the diagram. As the cell operates, the $\text{Zn}(s)$ electrode increases in mass and the $\text{Al}(s)$ electrode decreases in mass. A data table with the standard reduction potentials for the substances follows the diagram.



Half-Reaction	E° (V)
$\text{Zn}^{2+}(aq) + 2 e^- \rightarrow \text{Zn}(s)$	-0.76
$\text{Al}^{3+}(aq) + 3 e^- \rightarrow \text{Al}(s)$	-1.66

- Write the half-reaction for the oxidation that occurs at the anode.
- Write the balanced net ionic equation for the overall reaction that occurs in the galvanic cell.
- Initially, each electrode has a mass of 50.0 g. The cell is allowed to run for a period of time and is then stopped. Which electrode's mass changed the most? Justify your answer with a calculation.

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Reduction Half-Reaction	E° (V)
$\text{Au}^{3+}(aq) + 3 e^- \rightarrow \text{Au}(s)$	+1.50
$\text{Zn}^{2+}(aq) + 2 e^- \rightarrow \text{Zn}(s)$	-0.76
$\text{Mn}^{2+}(aq) + 2 e^- \rightarrow \text{Mn}(s)$	-1.19
$\text{Al}^{3+}(aq) + 3 e^- \rightarrow \text{Al}(s)$	-1.66
$\text{Be}^{2+}(aq) + 2 e^- \rightarrow \text{Be}(s)$	-1.85

- D. The standard Zn/Al cell has a value of E°_{cell} equal to 0.90 V. The scientist needs a galvanic cell that produces a greater voltage. The scientist has access to the chemical systems in the table. If the scientist uses the Zn half-cell and one of the other options from the table, what is the MAXIMUM voltage that could be generated at standard conditions?

3. Answer the following questions relating to the element aluminum, Al.

- (a) Write the complete ground-state electron configuration of an Al atom.
- (b) Based on principles of atomic structure, explain why the radius of the Al atom is larger than the radius of the Al^{3+} ion.

A student plans to combine solid aluminum with an aqueous solution of silver ions. The student determines the mass of solid AgNO_3 needed to prepare the solution with a specific concentration.

- (c) In the following table, briefly list the steps necessary to prepare 200.0 mL of an aqueous solution of AgNO_3 using only equipment selected from the choices given. Assume that all appropriate safety measures are already in place. Not all equipment or lines in the table may be needed.

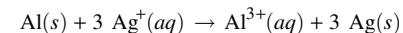
- | | | |
|-------------------------|------------------------------|------------------|
| · Solid AgNO_3 | · Weighing paper and scoop | · 250 mL beakers |
| · Distilled water | · 200.00 mL volumetric flask | · Pipet |
| · Balance | · 50.0 mL graduated cylinder | |

Step	Step Description
1.	Use weighing paper to measure the determined mass of solid AgNO_3 on a balance.
2.	

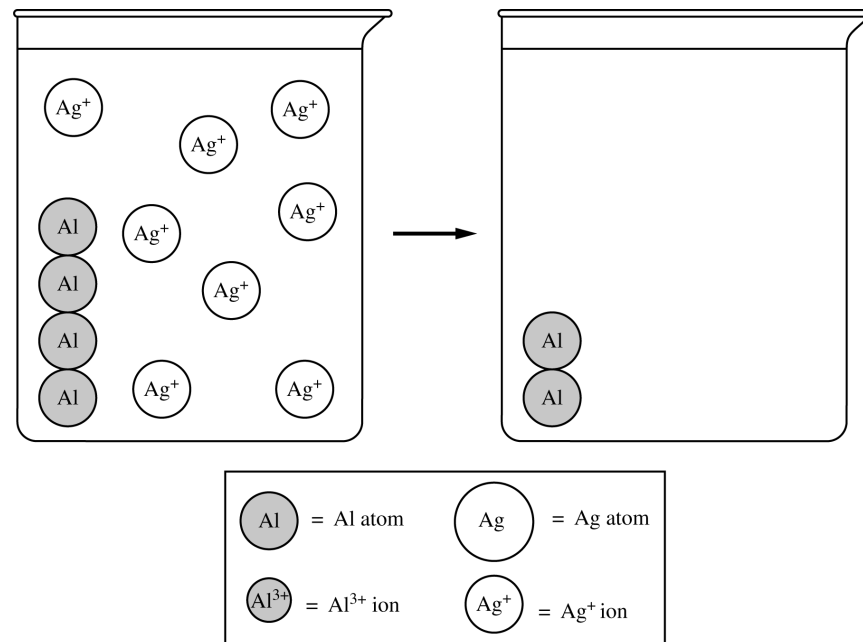
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Continue your response to QUESTION 3 on this page.

After preparing the solution, the student places some of the solution into a beaker and adds a sample of aluminum. The reaction represented by the following equation occurs.



- (d) The following diagram gives an incomplete particulate representation of the reaction. The beaker on the left represents the system before the mixture reacts. Complete the drawing on the right to represent the system after the reaction has occurred. Be sure to include 1) the correct type and number of particles based on the number shown on the left and 2) the relative spacing to depict the appropriate phases.



The student finds the standard reduction potentials given in the table, which are related to the reaction that occurs.

Half-Reaction	E°
$\text{Ag}^+(aq) + e^- \rightarrow \text{Ag}(s)$	0.80 V
$\text{Al}^{3+}(aq) + 3 e^- \rightarrow \text{Al}(s)$	-1.66 V

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 3** on this page.

(e) Using the standard reduction potentials, calculate the value of E° for the reaction.

(f) Based on the value of E° , would the standard free energy change of the reaction under standard conditions, ΔG° , be positive, negative, or zero? Justify your answer.

(g) Once the reaction appears to stop progressing, would the change in free energy, ΔG , be positive, negative, or zero? Justify your answer.

GO ON TO THE NEXT PAGE.