

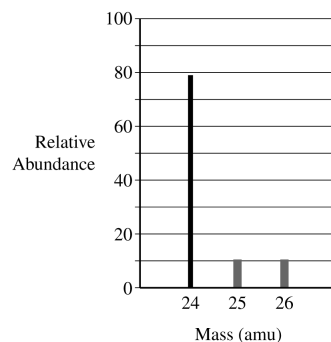
Question 1: Long Answer

10 points

A (i) For the correct plotted lines:

Point 01

The abundance for the two lines should be between 10 and 11.



(ii) For the correct answer:

Point 02

Magnesium-26 has one more neutron than magnesium-25 does.

B (i) For a correct explanation:

Point 03

The charge on the sodium ion is less than the charge on the magnesium ion. A smaller charge results in a weaker Coulombic attraction between Na^+ and water.

(ii) For a correct explanation:

Point 04

The Na^+ ion is larger than the Mg^{2+} ion, so the distance between the Na^+ and the oxygen on the water molecule will be greater. As distance increases, Coulombic attraction decreases.

C For the correct calculated value:

Point 05

$$\text{pOH} = -\log(2.80 \times 10^{-4}) = 3.553$$

$$\text{pH} = 14 - \text{pOH} = 14 - 3.553 = 10.447$$

D For the correct calculated value:

Point 06

$$M_1V_1 = M_2V_2$$

$$M_2 = \frac{(1.85 \times 10^{-3} M)(0.03500 \text{ L})}{(0.03500 \text{ L} + 0.05000 \text{ L})} = 7.62 \times 10^{-4} M$$

E (i) For the correct expression:

Point 07

$$K_{sp} = [\text{Mg}^{2+}][\text{OH}^-]^2$$

(ii) For the correct calculated value, consistent with part D and part E (i):

Point 08

$$Q = [\text{Mg}^{2+}][\text{OH}^-]^2 = (7.62 \times 10^{-4})(1.65 \times 10^{-4})^2 = 2.07 \times 10^{-11}$$

(iii) For the correct prediction and justification, consistent with part E (ii).

Point 09

Examples of acceptable responses may include the following:

- $Q > K_{sp}$, so a precipitate will form.
- The concentration of the ions in solution (represented by Q) is greater than that of a saturated solution, so a precipitate will form.

F For the correct answer and justification:

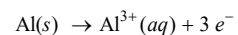
Point 10

Decrease. The H^+ from $\text{HNO}_3(aq)$ will react with OH^- , decreasing $[\text{OH}^-]$ and causing $Q < K_{sp}$. As a result, more $\text{Mg}(\text{OH})_2(s)$ will dissolve until equilibrium is reestablished, resulting in less $\text{Mg}(\text{OH})_2(s)$.

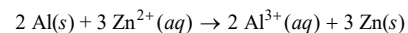
4 points

Question 6: Short Answer

A For the correct equation (state symbols not required): **Point 01**



B For the correct balanced net ionic equation (state symbols not required): **Point 02**



C For the correct answer and a valid justification that correctly compares the masses of Al and Zn based on their molar masses and the stoichiometry of the balanced equation. **Point 03**

Examples of acceptable responses may include the following:

- Zn experiences a greater change in mass. Assuming the entire Al anode reacts:

$$50.0 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} \times \frac{3 \text{ mol Zn}}{2 \text{ mol Al}} \times \frac{65.38 \text{ g Zn}}{1 \text{ mol Zn}} = 182 \text{ g Zn}$$

- Zn experiences a greater change in mass.

$$1 \text{ mol}_{\text{rxn}} \times \frac{3 \text{ mol Zn}}{1 \text{ mol}_{\text{rxn}}} \times \frac{65.38 \text{ g Zn}}{1 \text{ mol Zn}} = 196.1 \text{ g Zn}$$

$$1 \text{ mol}_{\text{rxn}} \times \frac{2 \text{ mol Al}}{1 \text{ mol}_{\text{rxn}}} \times \frac{26.98 \text{ g Al}}{1 \text{ mol Al}} = 53.96 \text{ g Al}$$

Thus, for however many moles of reaction that proceed, the mass of Zn produced will be greater than the mass of Al consumed.

- Zn experiences a greater change in mass. As the reaction proceeds, three moles of Zn are used for every two moles of Al. Thus, for every 196 g of Zn that are produced, 54 g of Al are consumed.

D For the correct calculated value. **Point 04**

Examples of acceptable responses may include the following:

- $E_{\text{cell}} = 1.50 \text{ V} + 0.76 \text{ V} = 2.26 \text{ V}$
- $$\begin{array}{lcl} \text{Au}^{3+}(aq) + 3 e^{-} \rightarrow \text{Au}(s) & +1.50 \text{ V} \\ \text{Zn}(s) \rightarrow \text{Zn}^{2+}(aq) + 2 e^{-} & +0.76 \text{ V} \\ \hline E_{\text{cell}} = 2.26 \text{ V} \end{array}$$

10 points

Question 3: Long Answer

(a) For a correct electron configuration: **1 point**

Accept one of the following:

- $1s^2 2s^2 2p^6 3s^2 3p^1$
- $[\text{Ne}] 3s^2 3p^1$

(b) For a correct explanation: **1 point**

The highest occupied electron shell ($n=3$) of Al is at a greater average distance from the nucleus than the highest occupied electron shell ($n=2$) of Al^{3+} .

(c) For the correct steps to dissolve the solute in water (steps may be consolidated): **1 point**

- Partially fill the volumetric flask with some distilled water
- Add the weighed $\text{AgNO}_3(s)$ to the volumetric flask
- Swirl to dissolve the solid

For the correct step to ensure quantitative dilution: **1 point**

- After the solid is dissolved, fill the flask to the calibration (200.00 mL) mark and mix.

Total for part (c) 2 points

(d) For a drawing that shows product formation and indicates the conservation of matter: **1 point**

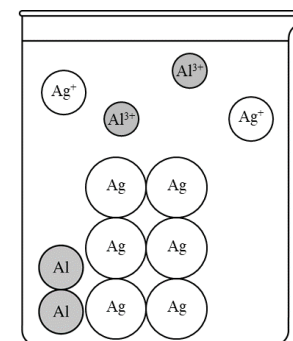
4 Al and 8 Ag particles in the beaker on right (see sample drawing below)

For a drawing that shows product formation and conservation of charge: **1 point**

2 Ag^{+} ions and 2 Al^{3+} ions in the beaker on the right (see sample drawing below)

For a drawing that shows product formation and correct phases of matter for all species: **1 point**

6 Ag atoms that are solid and 2 Al^{3+} ions that are aqueous in the beaker on the right



Total for part (d) 3 points

(e)	For the correct calculated value: Accept one of the following: $E^\circ = 0.80 \text{ V} + 1.66 \text{ V} = 2.46 \text{ V}$ $E^\circ_{\text{cell}} = E^\circ_{\text{red}} - E^\circ_{\text{ox}} = 0.80 \text{ V} - (-1.66 \text{ V}) = 2.46 \text{ V}$	1 point
(f)	For the correct answer and a valid justification: <i>Negative. The reaction has a positive value of E°, indicating that it is thermodynamically favorable and would therefore have a negative value of ΔG°. ($\Delta G^\circ = -nFE^\circ$)</i>	1 point
(g)	For the correct answer and a valid justification: Accept one of the following: <i>Zero. The observation that the reaction stops progressing implies that $E_{\text{cell}} = 0$, indicating that there is no longer a driving force for the reaction.</i> <i>Zero. The observation that reaction stops progressing implies that equilibrium is established, and $\Delta G = 0$ at equilibrium.</i>	1 point
Total for question 3		10 points