2025

AP® Chemistry

Sample Student Responses and Scoring Commentary

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Free-Response Question 6

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Question 6: Short Answer — 4 points

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

$$Al(s) \rightarrow Al^{3+}(aq) + 3\ e^-$$

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

$$2\ Al(s) + 3\ Zn^{2+}(aq) \rightarrow 2\ Al^{3+}(aq) + 3\ Zn(s)$$

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.*

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

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

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:

- $E^\circ_{cell} = 1.50\ \text{V} + 0.76\ \text{V} = 2.26\ \text{V}$
- $Au^{3+}(aq) + 3\ e^- \rightarrow Au(s) \quad +1.50\ \text{V}$

  $Zn(s) \rightarrow Zn^{2+}(aq) + 2\ e^- \quad +0.76\ \text{V}$

  $E^\circ_{cell} = 2.26\ \text{V}$

Sample 6A

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 6

Part A

$Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-$

Part B

$3Zn^{2+} + 2Al \rightarrow 3Zn + 2Al^{3+}$

Part C

If $6\ e^-$ transferred:

mass Zn gained: $\left(\frac{6\ mol\ e^-}{1}\right)\left(\frac{3\ mol\ Zn}{6\ mol\ e^-}\right)\left(\frac{65.38\ g}{1\ mol\ Zn}\right) = 196.14\ g\ Zn$

mass Al lost: $\left(\frac{6\ mole^-}{1}\right)\left(\frac{2\ mol\ Al}{6\ mol\ e^-}\right)\left(\frac{26.98\ g}{1\ mol\ Al}\right) = 53.96\ g\ Al$

The [Zn electrode's] mass changed more, since it gained 196.14 g in mass compared to the Al electrode's 53.96 g lost, if $6\ e^-$ were transferred between them, and this relationship is true regardless of how many e-'s are transferred.

Part D

Largest difference = Au and Zn:

$\mathcal{E}°_{cell} = \mathcal{E}°_{cathode} - \mathcal{E}°_{anode}$

$\mathcal{E}°_{cell} = (1.50\ V) - (-0.76\ V) = \boxed{+2.26\ V}$

(1.50 V: ↑ Au; −0.76 V: ↑ Zn)

Continue to Question 7.

Sample 6B

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 6

Part A

$Al(s) \rightarrow Al^{3+} + 3e^-$

Part B

$3Zn^{2+}_{(aq)} + 2Al_{(s)} \rightarrow 3Zn_{(s)} + 2Al^{3+}_{(aq)}$

Part C

For every 2 mol of Al dissolved, 3 mol of Zn attach to the electrode.

$2\ mol\ Al \cdot \frac{26.98\ g}{1\ mol} = 53.96\ g$ $3\ mol\ Zn \cdot \frac{65.38\ g}{1} = 196.14$

For every 53.96 g of Al dissolved, 196.14 g of Zn appears, making Zn the electrode with the most change in mass.

Part D

The maximum voltage comes from Be(s),

$1.85 + (-0.76) = 1.09\ E^\circ$

Continue to Question 7.

Use a pencil or a pen with black or dark blue ink. Do NOT write your name. Do NOT write outside the box.

Question 6

Part A

$Al(s) \rightarrow Al^{3+}(aq) + 3e^-$

Part B

$Zn^{2+} + 2e^- \rightarrow Zn$

$Al \rightarrow 3e^- + Al^{3+}$

Answer

$3Zn^{2+}(aq) + 2Al(s) \rightarrow 3Zn(s) + 2Al^{3+}(aq)$

Part C

The electrodes mass that changed the most was the Zn because for every 2 mol of Al used, 1 3 moles of Zn were produced, therefor having a greater change

Part D

$-.76 + 1.85 = \underline{1.09}$

Continue to Question 7.

Question 6

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

NEW for 2025: The question overviews can be found in the *Chief Reader Report on Student Responses* on AP Central.

Sample: 6A
Score: 4

Point 01: 1
Part A: The point was earned for correctly writing the half-reaction corresponding to the oxidation (loss of electrons) for Al metal.

Point 02: 1
Part B: The point was earned for writing the correct balanced net ionic equation, showing the combination of the oxidation of Al and the reduction of Zn^{2+}.

Point 03: 1
Part C: The point was earned for assuming 6 moles of electrons are transferred from anode to cathode, and then correctly calculating the mass of Zn gained and the mass of Al lost from the stoichiometry of the reaction. Although the response mentions "$6\ e^-$" as part of the justification (as opposed to 6 moles), the calculations show 6 moles of electrons transferred, and the conclusion that the mass of Zn would change by a greater amount is true in either case.

Point 04: 1
Part D: The point was earned for correctly showing the calculation of the Zn / Au cell, with Zn being oxidized and Au being reduced.

Sample: 6B
Score: 3

Point 01: 1
Part A: The point was earned for correctly writing the half-reaction corresponding to the oxidation (loss of electrons) for Al metal.

Point 02: 1
Part B: The point was earned for writing a correct balanced net ionic equation that shows the oxidation of Al with the reduction of Zn^{2+}.

Point 03: 1
Part C: The point was earned for correctly calculating the relative masses of Al and Zn using the correct molar masses and stoichiometry as the reaction proceeds. The response then correctly states, "for every $53.96\ \mathrm{g}$ of Al dissolved, $196.14\ \mathrm{g}$ of Zn appears" and concludes the Zn mass changes the most.

Question 6 (continued)

Point 04: 0

Part D: The point was not earned because the response correctly calculates the numerical value of E°_{cell} for a galvanic cell that utilizes Zn as the cathode and Be as the anode, but this combination is not the one that will generate the greatest voltage from the options provided in the table.

Sample: 6C
Score: 2

Point 01: 1

Part A: The point was earned for writing the half-reaction corresponding to the oxidation (loss of electrons) for Al.

Point 02: 1

Part B: The point was earned for writing a correct balanced net ionic equation that shows the oxidation of Al and the reduction of Zn^{2+}.

Point 03: 0

Part C: The point was not earned. Although the response correctly states that for "every 2 mol of Al used, 3 moles of Zn were produced," a greater change in moles does not necessarily mean a greater change in mass. The molar masses of both species need to be utilized to make a mass-to-mass comparison, so the justification given is not sufficient to support the claim that the mass of Zn changes more.

Point 04: 0

Part D: The point was not earned. The response utilizes an electrochemical cell with Be as the anode and Zn as the cathode, as can be deduced from the half-reaction voltages used. Although the voltage for the Be / Zn cell is calculated correctly, it is not the cell utilizing the Zn / Zn^{2+} half-cell that would generate the maximum voltage from the choices given.