

**AP® CHEMISTRY  
2013 SCORING GUIDELINES**

**Question 2**

Answer the following questions involving the stoichiometry and thermodynamics of reactions containing aluminum species.



An electrolytic cell produces 235 g of Al(l) according to the equation above.

(a) Calculate the number of moles of electrons that must be transferred in the cell to produce the 235 g of Al(l).

$235 \text{ g Al} \times \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} = 8.71 \text{ mol Al}$ $\text{Al}^{3+} + 3 e^- \rightarrow \text{Al}, \text{ therefore, 3 mol } e^- \text{ transferred per mol Al}$ $8.71 \text{ mol Al} \times \frac{3 \text{ mol } e^-}{1 \text{ mol Al}} = 26.1 \text{ mol } e^-$	1 point is earned for the number of moles of Al. 1 point is earned for correct stoichiometry and the number of moles of electrons.
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(b) A steady current of 152 amp was used during the process. Determine the amount of time, in seconds, that was needed to produce the Al(l).

charge = moles $e^-$ $\times$ Faraday's constant = $26.1 \text{ mol } e^- \times \frac{9.65 \times 10^4 \text{ C}}{1 \text{ mol } e^-} = 2.52 \times 10^6 \text{ C}$ $I = \frac{Q}{t}$ $t = \frac{Q}{I} = \frac{2.52 \times 10^6 \text{ C}}{152 \text{ C/s}} = 1.66 \times 10^4 \text{ s}$	1 point is earned for the correct amount of charge transferred. 1 point is earned for the correct time.
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(c) Calculate the volume of  $\text{CO}_2(g)$ , measured at 301 K and 0.952 atm, that is produced in the process.

$\text{mol CO}_2 = 8.71 \text{ mol Al} \times \frac{3 \text{ mol CO}_2}{4 \text{ mol Al}} = 6.53 \text{ mol CO}_2$ $PV = nRT$ $V = \frac{nRT}{P} = \frac{(6.53 \text{ mol}) \left( 0.0821 \frac{\text{L atm}}{\text{mol K}} \right) (301 \text{ K})}{0.952 \text{ atm}} = 1.70 \times 10^2 \text{ L CO}_2$	1 point is earned for the number of moles of $\text{CO}_2$ . 1 point is earned for the volume of $\text{CO}_2$ .
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