AP® CHEMISTRY
2015 SCORING GUIDELINES

Question 7

Aluminum metal can be recycled from scrap metal by melting the metal to evaporate impurities.

(a) Calculate the amount of heat needed to purify 1.00 mole of Al originally at 298 K by melting it. The melting point of Al is 933 K. The molar heat capacity of Al is 24 J/(mol·K), and the heat of fusion of Al is 10.7 kJ/mol.

To raise the temperature from 298 K to 933 K: $q = \frac{24\ \text{J}}{\text{mol K}} \times 1.00\ \text{mol} \times 635\ \text{K} = 15{,}000\ \text{J} = 15\ \text{kJ}$ It takes 10.7 kJ to melt the Al at 933 K. 15 kJ + 10.7 kJ = 26 kJ	1 point is earned for calculating the amount of heat needed to raise the temperature to 933 K. 1 point is earned for adding the heat of fusion to the previous result to get a final answer.

(b) The equation for the overall process of extracting Al from Al_2O_3 is shown below. Which requires less energy, recycling existing Al or extracting Al from Al_2O_3 ? Justify your answer with a calculation.

$$Al_2O_3(s) \rightarrow 2\ Al(s) + \frac{3}{2}O_2(g) \qquad \Delta H^\circ = 1675\ \text{kJ/mol}_{rxn}$$

For extracting Al from ore: $1675\ \text{kJ/mol}_{rxn} \times \frac{1\ \text{mol of reaction}}{2\ \text{mol Al}} = 837.5\ \text{kJ per mol of Al}$ Producing 1.00 mol of Al from Al_2O_3 requires 837.5 kJ. Because 26 kJ < 837.5 kJ, recycling requires less energy.	1 point is earned for a calculation to get equal numbers of moles for comparison. 1 point is earned for a correct comparison.