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.

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

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

a $\quad 1\ \cancel{mol} \cdot \frac{24\ J}{mol\ \cancel{K}} \cdot 635\ \cancel{K} = 15240\ J = 15.240\ kJ$

$+10.7$

$25.9\ kJ$

$26\ kJ$

b recycling existing aluminum

as we just calculated the purification of 1 mole Al would require around 26 kJ but extracting 1 mole Al from Al_2O_3 would take 837.5 kJ of energy

$$1\ mol\ Al \cdot \frac{1\ mol\ rxn}{2\ mol\ Al} \cdot \frac{1675\ kJ}{1\ mol\ rxn} = 837.5\ kJ$$

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7. Aluminum metal can be recycled from scrap metal by melting the metal to evaporate impurities. 7B 1 of 1

(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.

(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.

$$Al_2O_3(s) \rightarrow 2\,Al(s) + \frac{3}{2}O_2(g) \qquad \Delta H° = 1675\ kJ/mol_{rxn}$$

A) 933K − 298K = 635K

635 × 24 = 15240J

It would require 15,200J to melt the aluminum entirely.

B) $1675\ kJ/mol \cdot \frac{1KJ}{2mol} = 837.5KJ$ 837,500J > 15,200J

It would require 837,500J to create one mole of aluminum which is a significantly higher amount of energy then the 15,200J needed to recycle existing aluminum.

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   2 sig figs

   (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.

include
$\Delta T = 933-298$

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

a) $Q = mc\Delta T$

$Q = (24\frac{J}{mol \cdot K})(635\ K)(1\ mol)$

$Q = 15240\ J$ $\boxed{Q = 15000\ J}$

b) Recycling existing A b/c you need 15240J of heat energy to make Aluminum metal while it takes 1675 KJ of energy if you wish to extract it from Al_2O_3.

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Question 7

Overview

Students were required to use calorimetry to compare two methods of producing aluminum, either through recycling it from scrap metal or by extracting it from aluminum oxide. Part (a) asked for the amount of heat needed to bring aluminum from its solid state at 298 K to its liquid state at 933 K. Part (b) required students to determine whether the amount of energy required to recycle aluminum is more or less than that required to extract the metal from aluminum oxide. The reaction for obtaining aluminum from the oxide, together with its standard enthalpy of reaction, is given in the question. Part (a) required students to use the molar heat capacity, together with the temperature change, to determine the heat required for aluminum to reach the melting point. Afterwards, the heat of fusion must be added to the result to obtain the overall heat required to convert the aluminum to a liquid. Part (b) required students to convert the enthalpy of reaction (in kJ/mol_{rxn}) to the enthalpy change per mole of aluminum. Then, the result must be compared to the student's answer from part (a) to conclude that less energy is used in recycling the aluminum.

Sample: 7A
Score: 4

Two points were earned in part (a): 1 point for the correct calculation of the amount of energy required to raise the temperature of the Al to 933 K and 1 point for then adding the heat of fusion to the result to give the heat required to melt the Al metal. Two points were earned in part (b): 1 point for correctly determining the amount of energy required to extract 1 mol of Al from Al_2O_3, and 1 point for then correctly compares this value to the amount of energy calculated in part (a) to conclude that recycling Al metal would take less energy.

Sample: 7B
Score: 3

One point was earned in part (a) for correctly calculating the amount of energy required to raise the temperature of the Al to 933 K. However, the heat of fusion required is omitted from the calculation, so the second point was not earned. The response earned 2 points in part (b): 1 point for correctly determining the amount of energy required to extract 1 mol of Al from Al_2O_3 and 1 point for then comparing this result to the amount of energy calculated in part (a) to conclude that recycling Al metal would take less energy.

Sample: 7C
Score: 2

One point was earned in part (a) for correctly calculating the amount of energy required to raise the temperature of the Al to 933 K. However, the heat of fusion required is omitted from the calculation, so the second point was not earned. In part (b) the response does not correctly use the $\Delta H°$ of the reaction to determine the amount of energy required to extract 1 mol of Al from Al_2O_3. However, a reasonable comparison between $\Delta H°$ and the amount of energy calculated in part (a) is made and the response concludes that recycling Al metal would take less energy, so 1 point was earned.