BRIDGIOUS SERIES PRACTICAL CHEMISTRY SAMPLE ITEM 0752676417

ACTIVITY OF INTEGRATION

TOPIC: THERMOCHEMISTRY

TIME: 2HR

ITEM 1

Aqua Spark Propulsion Ltd. is currently developing a prototype marine drone powered by metal-oxygen reactions as a clean energy source. The team is investigating the combustion of a diatomic metal element **Y** with oxygen to produce heat energy for propulsion. To evaluate the system's potential, they need to determine the amount of heat released when **1 mole** of metal Y combusts in oxygen to form its corresponding metal oxide:

$Y_{(s)} + O_{2(g)} \longrightarrow YO_{(s)}$ $\Delta H^{\ominus}$combustion=??

Since direct laboratory combustion isn't practical, engineers are tasked with using **Hess's Law and calorimetry** to calculate the enthalpy change indirectly. This involves measuring the enthalpies of the following two reactions involving **metal Y** and its **oxide YO** with hydrochloric acid:

$Y_{(s)} + 2HCl_{(aq)} \longrightarrow YCl_{2(aq)} + H_{2(g)}$

$YO_{(S)} + 2HCl_{(aq)} \longrightarrow YCl_{2(aq)} + H_2O_{(l)}$

Additionally, the standard enthalpy of combustion for hydrogen is provided:

$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$
$\Delta H°\_combustion = -285.5\ kJ \cdot mol^{-1}$

You are provided with: 0.15 g of metal Y, 0.25 g of metal oxide YO and 50 mL of hydrochloric acid.

Assumption.

Specific heat capacity of the reaction mixture is 4.2KJ/g/K

Task

a) Design a scientific investigation that can be used in the determining of the Enthalpy of Combustion of Metal Y Using Hess's Law and Calorimetry.

Aim:

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Hypothesis:

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Variables:

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Apparatus and materials:

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Procedure:

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Risks and mitigations:

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b) Carry out the experiment and record your results.

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c) Analyze and interpret your results.

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d) Conclusion and recommendation

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ITEM 2.

Carbon dioxide (CO_2) is a major greenhouse gas that contributes significantly to global warming. To help reduce its concentration in the atmosphere, carbon capture technologies have been developed, particularly for removing CO_2 from industrial emissions. However, current methods—such as amine-based scrubbing—are often energy-intensive, corrosive, and costly to maintain, limiting their long-term practicality and widespread use.

As a more sustainable option, sodium carbonate (Na_2CO_3) can be used to capture CO_2 by forming sodium hydrogen carbonate ($NaHCO_3$). For the process to be efficient and reusable, $NaHCO_3$ must thermally decompose back into Na_2CO_3 and release CO_2. To be considered viable, this decomposition must require no more than **100 kJ/mol of energy**, as recommended for cost-effective carbon capture systems. You have been assigned the task of calculating the enthalpy change (ΔH) for this decomposition using the reactions of both sodium carbonate and sodium hydrogen carbonate with hydrochloric acid, applying Hess's Law to determine whether the energy requirement can be met.

$$\mathbf{2NaHCO_{3(s)} \longrightarrow Na_2CO_3(s) + CO_{2(g)} + H_2O_{(g)}}$$

$$\mathbf{NaHCO_{3(s)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}}$$

$$\mathbf{Na_2CO_{3(s)} + 2HCl \longrightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}}$$

You are provided with, 10 g of the solid samples of the carbonate and hydrogen carbonate and 50 cm³ of the hydrochloric acid solution.

Assumption:

Specific heat capacity of the reaction mixture is 4.18 J/K/g

Task:

a) Design a scientific investigation that can be used in the determining of the Enthalpy of decomposition of sodium hydrogen carbonate Using Hess's Law and Calorimetry.

Aim:

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Hypothesis:

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Variables:

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Apparatus and materials:

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Procedure:

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Risks and mitigations:

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b) Carry out the experiment and record your results.

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c) Analyze and interpret your results.

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d) Conclusion and recommendation

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