

Producing Hydrogen Fuel for Fuel Cell Vehicles: Thermochemical Considerations

The article by Haryanto, *et al.* provides an overview of how hydrogen can be produced, as well as a more detailed discussion of the ethanol reforming process. Use sections 1-4 of the Haryanto paper and the case introduction provided in the pre-lecture homework to help answer the case study questions.

1) A. Haryanto, S. Fernando, N. Murali, S. Adhikari, *Energy and Fuels*, 2005, 19, pg. 2098-2106.

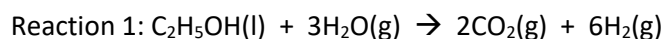
Case Study Questions

1. Despite the limitations of using hydrogen as a fuel source, it has advantages over fossil fuels. Use your assigned readings to determine what these advantages are.

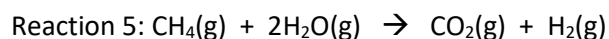
2. Most scientists agree that the most sustainable method for making hydrogen is to take water and decompose (“split”) it to create hydrogen gas. What is the enthalpy change for taking liquid water and using it to make hydrogen gas? Does your answer suggest it would be difficult to produce hydrogen from water? (note: use the table of thermochemical data provided in your textbook appendices to access the heats of formation for all reactants/products in the reaction).

3. What practical hurdle(s) exist for using water as the source of hydrogen gas?

4. What is an advantage of carrying out the steam reforming of ethanol (reaction 1, page 2100 in the Haryanto paper) versus the splitting of water? (hint: compare the enthalpies of reaction)



5. The current industrial production of hydrogen uses the steam reforming of methane (reaction 5, page 2100 in the Haryanto paper). Calculate the enthalpy of reaction for this reaction and compare it to the steam reforming of ethanol. Why are Haryanto and co-workers interested in investigating and optimizing the steam reforming of ethanol as opposed to the steam reforming of methane?



6. One disadvantage of the steam reforming of ethanol is the fact this process can lead to side reactions and unwanted by-products (see reactions 2 and 4 on page 2100 of the Haryanto paper). Carbon monoxide in particular is one by-product researchers would like to avoid. Methanation can be used to remove the carbon monoxide that is sometimes formed as a by-product in the synthesis of hydrogen gas during the ethanol reforming process (see reaction 13 on page 2101). Calculate the reaction enthalpy to determine if this reaction thermochemically spontaneous. $\text{CO(g)} + 3\text{H}_2\text{(g)} \rightarrow \text{CH}_4\text{(g)} + \text{H}_2\text{O(g)}$

7. Based on the information provided in the reading, do you think using the steam reforming of ethanol should be used instead of the water splitting reaction to produce hydrogen fuel?