Lecture Notes D: Demo on Combustion Processes

In this demo, we will consider the combustion of the following gases: hydrogen (H₂), methane (CH₄), and propane (C₃H₈). The amount of heat released by the combustion can be calculated as follows.

Concept
Assume the balloons all have the same size (volume). Which contains the most molecules:
(a) hydrogen (H₂)       (b) methane (CH₄)      (c) propane (C₃H₈)    (d) they contain the same # molecules

Which weighs more, a liter of dry air or a liter of wet air?
(a) wet air       (b) dry air       (c) they weigh the same

<table>
<thead>
<tr>
<th></th>
<th>MW (amu)</th>
<th>ΔH^o_f (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrogen (H₂)</td>
<td>2.016</td>
<td>0</td>
</tr>
<tr>
<td>methane (CH₄)</td>
<td>16.043</td>
<td>-74.81</td>
</tr>
<tr>
<td>propane (C₃H₈)</td>
<td>44.096</td>
<td>-103.85</td>
</tr>
<tr>
<td>H₂O(g)</td>
<td>18.01</td>
<td>-241.82</td>
</tr>
<tr>
<td>CO₂(g)</td>
<td>44.01</td>
<td>-393.51</td>
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</table>

Consider ΔH for the combustion reactions,

\[
\text{H}_2 (g) + \frac{1}{2} \text{O}_2 (g) \rightarrow \text{H}_2\text{O}(g) \quad \Delta H = \Delta H^o_f(\text{H}_2\text{O}(g)) = -241.82 \text{kJ/mol}
\]

\[
\text{CH}_4 (g) + 2 \text{O}_2 (g) \rightarrow \text{CO}_2 (g) + 2 \text{H}_2\text{O}(g) \quad \Delta H = 2 \Delta H^o_f(\text{H}_2\text{O}(g)) + \Delta H^o_f(\text{CO}_2 (g)) - \Delta H^o_f(\text{CH}_4 (g))
\]

\[
= 2(-241.82) + (-393.51) - (-74.81) = -802.34 \text{kJ/mol}
\]

\[
\text{C}_3\text{H}_8 (g) + 5 \text{O}_2 (g) \rightarrow 3 \text{CO}_2 (g) + 4 \text{H}_2\text{O}(g) \quad \Delta H = 4 \Delta H^o_f(\text{H}_2\text{O}(g)) + 3 \Delta H^o_f(\text{CO}_2 (g)) - \Delta H^o_f(\text{C}_3\text{H}_8 (g))
\]

\[
= 4(-241.82) + 3(-393.51) - (-103.85) = -2044 \text{kJ/mol}
\]

Concept
Which balloon will give off the most heat when exploded
(a) hydrogen (H₂)       (b) methane (CH₄)      (c) propane (C₃H₈)