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[TP] “In my lecture I was told that change in enthalpy is **products minus reactants**, but my discussion leader told me that it is **reactants minus products**. I’ve also looked in another chemistry book and it says products minus reactants. Which is right?”

25% 1. products minus reactants
 25% 2. reactants minus products
 25% 3. both
 25% 4. neither

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Lecture 27 CH101 A1 (MWF 9 am)
 Friday, November 11, 2016

- Using $\Delta_f H^\circ$'s to compute any $\Delta_r H$

Next lecture: Bond enthalpies, $\Delta_b H$; Using $\Delta_b H$'s to **estimate** $\Delta_r H$; If some substances are not gases, using $\Delta_b H$'s works poorly; **Begin ch 8: Modeling atoms and their electrons** Review: What light is and how it interacts with matter; Natural frequencies of atoms; Light and matter exchange energy smoothly and slowly

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Using $\Delta_f H^\circ$'s to compute any $\Delta_r H$

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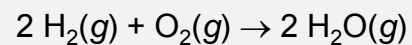
$$2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(g)$$

Sketch the enthalpy diagram for this reaction, labelling then enthalpy change as $\Delta_r H$.

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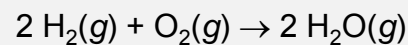
Add "2 H₂O(l)" to your diagram.



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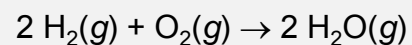
Add an arrow to your enthalpy diagram for $2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{l})$, and label the arrow $\Delta_2 H$.



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Add an arrow to your enthalpy diagram from 2 H₂O(l) to 2 H₂O(g), and label the arrow $\Delta_3 H$.

Since $\Delta_1 H = \Delta_2 H + \Delta_3 H$, ...

$$\Delta_3 H = \Delta_1 H - \Delta_2 H$$



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[TP] Based on your diagram, $\Delta_3 H$ is ...

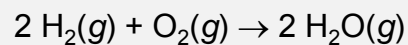
- 14% 1. $\Delta_f H(\text{H}_2\text{O}, \text{g})$
- 14% 2. $2 \Delta_f H(\text{H}_2\text{O}, \text{g})$
- 14% 3. $\Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 14% 4. $2 \Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 14% 5. $-\Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 14% 6. $-2 \Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 14% 7. Something else



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Use your diagram to write the expression for $\Delta_{\text{vap}}H(\text{H}_2\text{O})$ in terms of Δ_1H and Δ_2H .

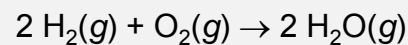
$$\Delta_{\text{vap}}H(\text{H}_2\text{O}) = \frac{1}{2} (\Delta_1H - \Delta_2H)$$



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Use your diagram to write the expression for $\Delta_{\text{vap}}H(\text{H}_2\text{O})$ in terms of the enthalpies of formation of liquid and gaseous water.

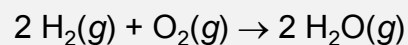
$$\Delta_{\text{vap}}H(\text{H}_2\text{O}) = \Delta_fH(\text{H}_2\text{O}, g) - \Delta_fH(\text{H}_2\text{O}, l)$$



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The enthalpy of formation of gaseous water is -241.8 kJ and that of liquid water is -285.8 kJ . Evaluate $\Delta_{\text{vap}}H(\text{H}_2\text{O})$.

$\Delta_{\text{vap}}H(\text{H}_2\text{O}) \dots$

$$= \Delta_fH(\text{H}_2\text{O}, g) - \Delta_fH(\text{H}_2\text{O}, l)$$

$$= -241.8 \text{ kJ} - (-285.8 \text{ kJ}) = 44.0 \text{ kJ}$$

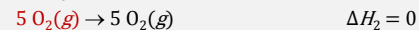
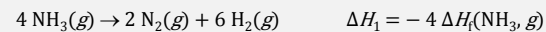
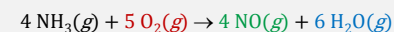


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Using Δ_fH° 's to compute Δ_rH



$$\begin{aligned} \text{Hess's law: } \Delta_rH &= \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 \\ &= +4 \Delta_fH_f(\text{NO}, g) + 6 \Delta_fH_f(\text{H}_2\text{O}, g) - 4 \Delta_fH_f(\text{NH}_3, g) \end{aligned}$$

Note: Elements in standard states are absent



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Using $\Delta_f H^\circ$'s to compute **any** $\Delta_r H^\circ$

The **key feature** of standard **enthalpies of formation** is that, the enthalpy change of **any reaction**, $\Delta_r H^\circ$, can be computed using them, as ...

$$\Delta_r H^\circ = \text{Sum}[\Delta_f H^\circ(\text{products})] - \text{Sum}[\Delta_f H^\circ(\text{reactants})]$$



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