

Lecture 27 CH101 A1 (MWF 9:05 am) Fall 2017 Copyright © 2017 Dan Dill dan@bu.edu

[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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Friday, November 10, 2017

For today ...

- Using  $\Delta_f H^\circ$  to compute *any*  $\Delta_r H$
- Bond enthalpies,  $\Delta_b H$
- Using  $\Delta_b H$  to *estimate*  $\Delta_r H$

Next lecture: Complete: Using  $\Delta_b H$  to *estimate*  $\Delta_r H$ ; If some substances are not gases, using  $\Delta_b H$  works poorly; Begin ch 8: Modeling atoms and their electrons

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

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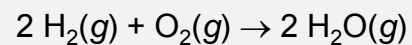
$2 \text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{g})$

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

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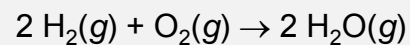
Add "2 H<sub>2</sub>O(l)" to your diagram.



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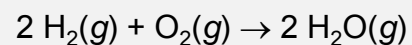
Add an arrow to your enthalpy diagram for  $2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(l)$ , and label the arrow  $\Delta_2 H$ .



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Add an arrow to your enthalpy diagram from 2 H<sub>2</sub>O(l) to 2 H<sub>2</sub>O(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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**[Quiz]** Based on your diagram,  $\Delta_3 H$  is ...

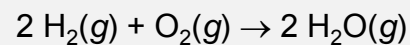
- 14% 1.  $\Delta_f H(\text{H}_2\text{O}, g)$
- 14% 2.  $2 \Delta_f H(\text{H}_2\text{O}, g)$
- 14% 3.  $\Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 14% 4.  $2 \Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 14% 5.  $-\Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 14% 6.  $-2 \Delta_{\text{vap}} H(\text{H}_2\text{O})$
- 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  $\Delta_1H$  and  $\Delta_2H$ .

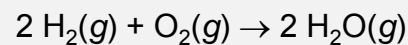
$$\Delta_{\text{vap}}H(\text{H}_2\text{O}) = \frac{1}{2} (\Delta_1H - \Delta_2H)$$



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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.

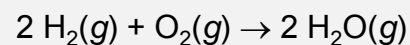
$$\Delta_{\text{vap}}H(\text{H}_2\text{O}) = \Delta_fH(\text{H}_2\text{O}, g) - \Delta_fH(\text{H}_2\text{O}, l)$$



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

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

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

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

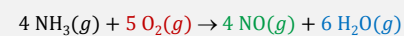


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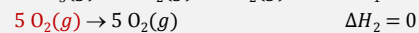
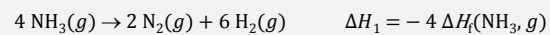
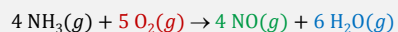
Using  $\Delta_fH^\circ$ 's to compute  $\Delta_rH$



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

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

Note: Elements in **standard states** are **absent**



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

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

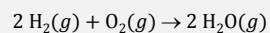
$$\Delta_r H = \text{Sum}[\Delta_f H(\text{products})] - \text{Sum}[\Delta_f H(\text{reactants})]$$



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Using  $\Delta_b H^\circ$ 's to **estimate**  $\Delta_r H$ 

How much enthalpy change to break reactants apart into atoms?

How much enthalpy change to combine reactant atoms into products?

What is the total enthalpy change?



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