

[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 say products minus reactants. Which is right?"

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

Lecture 27 CH101 A1 (MWF 9:05 am)

Friday, November 10, 2017

For today ...

- Using $\Delta_f H°$ 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

Using $\Delta_f H°$ to compute any $\Delta_r H$

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

Sketch the enthalpy diagram for this reaction, labelling the enthalpy change as $\Delta_1 H$.

2 $H_2(g)$ + $O_2(g)$ → 2 $H_2O(g)$

Add "2 $H_2O(l)$" to your diagram.

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2 $H_2(g)$ + $O_2(g)$ → 2 $H_2O(g)$

Add an arrow to your enthalpy diagram for 2 $H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$, and label the arrow $\Delta_2 H$.

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2 $H_2(g)$ + $O_2(g)$ → 2 $H_2O(g)$

Add an arrow to your enthalpy diagram from 2 $H_2O(l)$ to 2 $H_2O(g)$, 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. $\Delta_f H(H_2O,\ g)$
14% 2. $2\ \Delta_f H(H_2O,\ g)$
14% 3. $\Delta_{vap} H(H_2O)$
14% 4. $2\ \Delta_{vap} H(H_2O)$
14% 5. $-\Delta_{vap} H(H_2O)$
14% 6. $-2\ \Delta_{vap} H(H_2O)$
14% 7. Something else

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2 $H_2(g)$ + $O_2(g)$ → 2 $H_2O(g)$

Use your diagram to write the expression for $\Delta_{vap}H(H_2O)$ in terms of $\Delta_1 H$ and $\Delta_2 H$.

$\Delta_{vap}H(H_2O) = ½ (\Delta_1 H - \Delta_2 H)$

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2 $H_2(g)$ + $O_2(g)$ → 2 $H_2O(g)$

Use your diagram to write the expression for $\Delta_{vap}H(H_2O)$ in terms of the enthalpies of formation of liquid and gaseous water.

$\Delta_{vap}H(H_2O) = \Delta_f H(H_2O, g) - \Delta_f H(H_2O, l)$

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2 $H_2(g)$ + $O_2(g)$ → 2 $H_2O(g)$

The enthalpy of formation of gaseous water is −241.8 kJ and that of liquid water is −285.8 kJ. Evaluate $\Delta_{vap}H(H_2O)$.

$\Delta_{vap}H(H_2O)$ ...

$= \Delta_f H(H_2O, g) - \Delta_f H(H_2O, l)$

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

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Using $\Delta_f H°$'s to compute $\Delta_r H$

$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$

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

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$$

$4\ NH_3(g) \rightarrow 2\ N_2(g) + 6\ H_2(g)$ $\quad \Delta H_1 = -\,4\ \Delta H_f(NH_3, g)$

$5\ O_2(g) \rightarrow 5\ O_2(g)$ $\quad \Delta H_2 = 0$

$2\ O_2(g) + 2\ N_2(g) \rightarrow 4\ NO(g)$ $\quad \Delta H_3 = +\ 4\ \Delta H_f(NO, g)$

$6\ H_2(g) + 3\ O_2(g) \rightarrow 6\ H_2O(g)$ $\quad \Delta H_4 = +\ 6\ \Delta H_f(H_2O, g)$

Hess's law: $\Delta_r H = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4$

$= +\ 4\ \Delta H_f(NO, g) + 6\ \Delta H_f(H_2O, g) - 4\ \Delta H_f(NH_3, g)$

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 $\Delta_b H$'s to *estimate* $\Delta_r H$

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$

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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