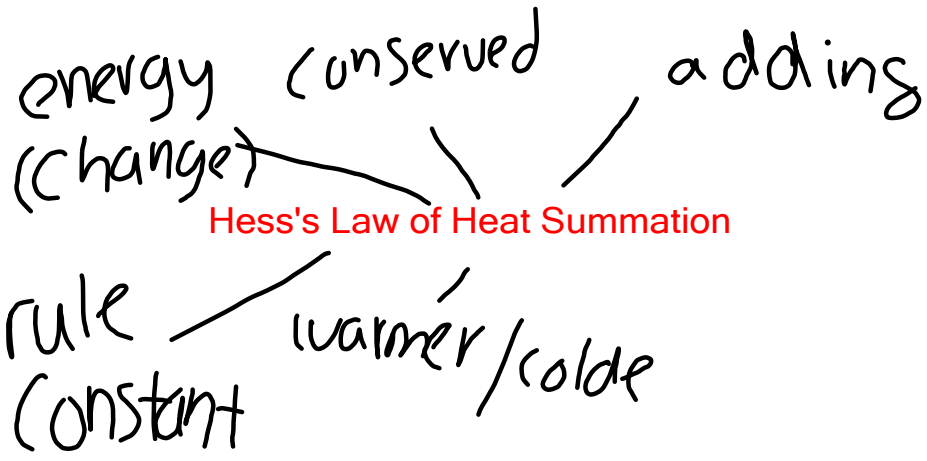
Calculating Heats of Reaction

- Warm-up Activity
- Video
- Hess's Law
- Standard Heats of Formation
- Activity
- Exit ticket

Tomorrow we will review section 17.3 & 17.4

Today: Extra help @ lunch, Independent Study help - sign up sheet

Feb 15-12:59 PM



Feb 15-1:01 PM

Questions for practice:

- Questions 32, 33 – page 531

Also, calculate the standard heat of reaction for the following reaction:

$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$

- Questions 34 – 37 – page 532

Mar 20-11:22 AM

p 531

#32

a) $Br_2(g) \longrightarrow Br_2(l)$

$\Delta H_f^\circ \ Br_{2\,(g)} = 30.91$ kJ/mol

$\Delta H_f^\circ \ Br_{2\,(l)} = 0$ kJ/mol

$\Delta H^\circ = \Delta H_f^\circ$ (products) $- \Delta H_f^\circ$ (reactants)

$= 0 - 30.91$ kJ

$= 3.091 \times 10^1$ kJ

Oct 2-8:36 AM

b) $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$

ΔH_f° $CaCO_3(s)$= -1207.0 kJ/mol

ΔH_f° $CaO(s)$ = -635.1 kJ/mol

ΔH_f° $CO_2(g)$= -393.5 kJ/mol

$\Delta H^\circ = \Delta H_f^\circ$ (products) – ΔH_f° (reactants)

$(-635.1\ kJ/mol + -393.5\ kJ/mol) - (-1207$ kJ

$= 178.4$ kJ

Oct 2-9:05 AM

c) $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$

$\Delta H^\circ = \Delta H_f^\circ$ (products) – ΔH_f° (reactants)

NO $\Delta H_f^\circ = 90.37$ kJ/mol

O_2 $\Delta H_f^\circ = 0$

NO_2 $\Delta H_f^\circ = 33.85$ kJ/mol

$(33.85\ kJ/mol \times 2) - (90.37 \times 2 + 0)$ kJ/mol

$(67.7\ kJ/mol) + (180.74)$

-113.0 kJ/mol

Oct 2-9:06 AM

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

ΔH_f° $SO_2(g)$= kJ/mol

ΔH_f° $O_2(g)$= 0 kJ/mol

ΔH_f° $SO_2(g)$= kJ/mol

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Answers

32. a. -3.091×10^1 kJ
b. 1.784×10^2 kJ
c. -1.130×10^2 kJ

33. CO is a compound and not an element in its standard state.

Practice Problems Plus L2

Calculate the standard heat of reaction for the following reaction:
$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ *(−197.8 kJ)*

Mar 20-11:23 AM

34. **Key Concept** What are two ways that the heat of reaction can be determined when it cannot be directly measured?

34. Use Hess's law of heat summation or use standard heats of formation.

Mar 20-11:25 AM

35. Calculate the enthalpy change (ΔH) in kJ for the following reaction.

$$2Al(s) + Fe_2O_3(s) \longrightarrow 2Fe(s) + Al_2O_3(s)$$

Use the enthalpy changes for the combustion of aluminum and iron:

$$2Al(s) + \tfrac{3}{2}O_2(g) \longrightarrow Al_2O_3(s) \quad \Delta H = -1669.8 \text{ kJ}$$

$$2Fe(s) + \tfrac{3}{2}O_2(g) \longrightarrow Fe_2O_3(s) \quad \Delta H = -824.2 \text{ kJ}$$

Oct 2-9:05 PM

36. What is the formula for calculating the standard heat of reaction?

$$\Delta H^\circ = \Delta H_f^\circ \text{ (products)} - \Delta H_f^\circ \text{ (reactants)}$$

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37. What is the standard heat of reaction (ΔH^0) for the decomposition of hydrogen peroxide?

$$2H_2O_2(l) \longrightarrow 2H_2O(l) + O_2(g)$$

ΔH_f° $H_2O_2(g)$= −187.8 kJ/mol

ΔH_f° $H_2O(l)$= −285.8 kJ/mol

ΔH_f° $O_2(g)$= 0 kJ/mol

$$\Delta H^\circ = \Delta H_f^\circ \text{ (products)} - \Delta H_f^\circ \text{ (reactants)}$$

$(2 \times -285.8\ kJ/mol) - (2 \times -187.8\ kJ/mol)$

$= -196.0\ kJ/mol$

Mar 20-11:26 AM

1. Calculate ΔH for the reaction $C_2H_4\ (g) + H_2\ (g) \rightarrow C_2H_6\ (g)$, from the following data.

$C_2H_4\ (g) + 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2\ H_2O\ (l)$ ΔH = -1411. kJ/mole

$C_2H_6\ (g) + 7/2\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 3\ H_2O\ (l)$ ΔH = -1560. kJ/mole

$H_2\ (g) + 1/2\ O_2\ (g) \rightarrow H_2O\ (l)$ ΔH = -285.8 kJ/mole

$C_2H_4(g) + 3\ O_2(g) \longrightarrow 2\ CO_2(g) + 2H_2O(l)$ H= -1411. kJ/mol

$2\ CO_{2(g)} + 3H_2O_{(l)} \rightarrow C_2H_{6(g)} + 3\ 1/2\ O_{2(g)}$ H = 1560 kJ/mol

$H_2\ (g) + 1/2\ O_2 \rightarrow H_2O$ H= 285.8 kJ/mol

-136.8 kJ

Oct 2-8:49 PM

2. Calculate ΔH for the reaction $4\ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (g)$, from the following data.

$N_2\ (g) + O_2\ (g) \rightarrow 2\ NO\ (g)$ ΔH = -180.5 kJ

$N_2\ (g) + 3\ H_2\ (g) \rightarrow 2\ NH_3\ (g)$ ΔH = -91.8 kJ

$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$ ΔH = -483.6 kJ

$N_2(g) + O_2(g) \longrightarrow 2NO(g)$ =-180.5kJ

$2\ NH_3(g) \longrightarrow N_2(g) + 3\ H_2(g)$ = 91.8 kJ (×2)

$2H_2(g) + O_2(g) \longrightarrow 2\ H_2O(g)$ = -483.6kJ (×3)

-1628.2 kJ/mol

-1.63×10^3 kJ/mol

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Mar 21-8:20 AM

Worksheet on Heat of Formation

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and

Hess's Law

SKMBT_50117100320201.pdf

Oct 4-8:37 AM

21. $CuO(s) \rightarrow Cu(s) + \frac{1}{2}O_2(g)$

$\Delta H = 155kJ$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$

$\Delta H = -242kJ$

$= -87kJ$

22) $Fe_2O_3(s) + 3C(gr,g) \rightarrow 2Fe + 3CO_2$

$-822.1 \quad -110.5 \quad 0 \quad -393.5$

$\Delta H_f^\circ = \Delta H_f^\circ \text{products} - \Delta H_f^\circ \text{reactants}$

$(0 + 3 \times 393.5) - (-822.1 + 3 \times -110.5)$

$= -26.9kJ$

Oct 5-8:45 AM

*Enthalpy Diagram

Feb 15-6:42 PM

* Video Clip

Feb 15-6:43 PM

Hess's Law

Hess's Law allows us to determine the heat of reaction indirectly so that we can measure enthalpy change for reactions that may take place

Hess's Law of heat summation states that if you add 2 or more thermochemical equations to give a final equation, then you can also add the heats of reaction to give the final heat of reaction.

*We can measure the heat of reaction of diamond to graphite indirectly using known thermochemical equations and enthalpy data.

Feb 15-1:03 PM

Let's Look at figure 17.13 on page 528 of your text

what does it tell us?

We can use those known thermochemical equations and enthalpy data to determine the heat of reaction for:

$C_{(s,diamond)} \longrightarrow C_{(s,graphite)}$

flip a) $C_{(s,graphite)} + O_{2(g)} \longrightarrow O_{2(g)}$ $\Delta H = -393.5$ kJ

b) $C_{(s,diamond)} + O_{2(g)} \longrightarrow O_{2(g)}$ $\Delta H = -395.4$ kJ

c) $O_{2(g)} \longrightarrow C_{(s,graphite)} + O_2$ $\Delta H = 393.5$ kJ

$C_{(s,diamond)} \longrightarrow C_{(s,graphite)}$

$-395.4\text{kJ} + 393.5\text{kJ}$

$= -1.9\text{kJ}$

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Example:

Determine the Heat of reaction for $NO_{(g)} + O_{(g)} \longrightarrow NO_{2(g)}$ $\Delta H = ?$

Using:

flip a $O_{2(g)} \longrightarrow 2O_{(g)}$ $\Delta H = 495$ KJ

flip b $2O_{3(g)} \longrightarrow 3O_{2(g)}$ $\Delta H = -427$ KJ

2 c $NO_{(g)} + O_{3(g)} \longrightarrow NO_{2(g)} + O_{2(g)}$ $\Delta H = -199$ KJ

a) $2O_{(g)} \longrightarrow O_{2(g)}$ $\Delta H = -495$kJ

b) $3O_{2(g)} \longrightarrow 2O_{3(g)}$ $\Delta H = 427$kJ

c) $2NO_{(g)} + 2O_{3(g)} \longrightarrow 2NO_{2(g)} + 2O_{2(g)}$ $\Delta H = -398$ kJ

$2NO_{(g)} + 2O_{(g)} \longrightarrow 2NO_{2(g)}$

$NO_{(g)} + O_{(g)} \longrightarrow NO_{2(g)}$

$-495\text{kJ} + 427\text{kJ} + -398\text{K}$

$\Delta H = -199\text{kJ}$

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Example:

Determine the Heat of reaction for $NO_{(g)} + O_{(g)} \longrightarrow NO_{2(g)}$ $\Delta H = ?$

Using:

flip a $O_{2(g)} \longrightarrow 2O_{(g)}$ $\Delta H = 495$ KJ

flip b $2O_{3(g)} \longrightarrow 3O_{2(g)}$ $\Delta H = -427$ KJ

2 c $NO_{(g)} + O_{3(g)} \longrightarrow NO_{2(g)} + O_{2(g)}$ $\Delta H = -199$ KJ

a) $2O_{(g)} \rightarrow O_{2(g)}$ $\Delta H = -495$ KJ

b) $3O_{2(g)} \rightarrow 2O_{3(g)}$ $\Delta H = 427$ KJ

c) $2NO_{(g)} + 2O_{3(g)} \rightarrow 2NO_{2(g)} + 2O_{2(g)}$ $\Delta H = -398$ KJ

$2NO_{(g)} + 2O_{(g)} \rightarrow 2NO_{2(g)}$

$NO_{(g)} + O_{(g)} \rightarrow NO_{2(g)}$

$-495\text{KJ} + 427\text{KJ} + -398\text{K}$

$\Delta H = -199$ KJ

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Hess's Law is also useful when reactions yield products in addition to the product of interest

Example: Enthalpy change for the formation of CO from its elements.

$C_{(s,graphite)} + 1/2\ O_{2(g)} \longrightarrow CO_{(g)}$ $\Delta H = ?$

Using the following know thermochemical equations and enthalpy data we can determine the heat of reaction for the above reaction:

a $C_{(s,graphite)} + O_{2(g)} \longrightarrow CO_{2(g)}$ $\Delta H = -393.5$ KJ

b $CO_{(g)} + 1/2\ O_2 \longrightarrow CO_{2(g)}$ $\Delta H = -283.0$ KJ

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Standard Heats of Formation

The standard heat of formation of a compound is the change in enthalpy that accompanies the formation of one mole of a compound from its elements with all substances in their standard states.

In order to compare enthalpy changes scientists specify a common set of conditions to use as a reference point. The common set of conditions is what we call **standard state**- meaning the substance is at 25 degrees Celsius and 101.3 kPa

Table 17.4 on page 530 lists the standard heat of formation (represented by H_f^o) at 25 degrees Celsius and 101.3kPa.

H_f^o of a free element in its standard state is 0 (as well as for the graphite form of carbon ($C_{s,graphite}$)

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Standard Heat of Formation is an alternative to Hess's Law

For a reaction that occurs at standard conditions, you can calculate the heat of reaction by using **standard heats of formation** (ΔH_f^o)

The enthalpy change is called the **standard heat of reaction** symbolized by ΔH^o

The Standard Heat of Reaction is the difference between standard heats of formation of all the reactants & products

$$\Delta H^o = \Delta H_{f\ (products)}^o - \Delta H_{f\ (reactants)}^o$$

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Example: Calculating the Standard Heat of Reaction

What is the standard heat of reaction (ΔH^o) for the reaction of $CO_{(g)}$ with $O_{2(g)}$ to form $CO_{2(g)}$

Remember:

$$\Delta H^o = \Delta H_f^o{}_{(products)} - \Delta H_f^o{}_{(reactants)}$$

$2\,CO_{(g)} + O_{2(g)} \longrightarrow 2\,(O_{2(g)})$

Reactants	ΔH_f^o	Products	ΔH_f^o
$2\,CO_{(g)}$	$-110.5\,kJ/2$	$2\,(O_{2(g)})$	$(2)-393.5$
$O_{2(g)}$	$-221\,kJ$		$-787.0\,kJ$
	$0.0\,kJ$		

$\Delta H^o = \Delta H_f^o(products) - \Delta H_f^o(reactants)$

$-787.0\,kJ - (-221\,kJ)$

$\Delta H^o = -566.0\,kJ$

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What is the standard heat of reaction (ΔH^0) for the decomposition of hydrogen peroxide?

$2H_2O_{2(l)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$

Feb 15-7:16 PM

ACTIVITY

- Your slip of paper tells you which group you are in (the # on the slip) and your role.

- As a group you will be given a reaction in which you have to determine the ΔH (heat of reaction or enthalpy change) using the known thermochemical equations that will be given to you.

-You will determine the ΔH and you will write each step on your chart paper, explaining in words what you are doing at each step.

-At the end of the activity your group will present their chart paper, explaining how they determined the ΔH to the rest of the class.

-You will have approximately 10 minutes to complete this activity.

-*When I say Go*, the person with the slip of paper that says "materials" on it will come up and get a piece of chart paper, their problem and markers etc.

-2 groups can work out into the hallway (stay between the benches and Ms.Sherrards room)

*C4U

Feb 15-4:21 PM

ROLES

Task Manager: Keeps the group on task and focused on the activity.

Materials: Gets the chart paper, problem, and markers.

Time Keeper: Keeps group aware of how much time is left.

Recorder: Records the solution/steps on the chart paper.

Presenter: Presents to the class their solution.

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Expectations

Work quietly
Allow everyone to participate
Ask for you help if you need it

Your chart paper should:

Have group members names
Have the original reaction
The known thermochemical equations and their enthalpies
Explanations in words at each step

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EXIT Ticket

1. Determine the ΔH for:

$2H_2O_{(g)} + CH_{4(g)} \longrightarrow CO_{2(g)} + 4H_{2(g)}$

Using both Hess's Law & Standard Heats of Formation

Given the following: $\longrightarrow$

$H_2O_{(g)} + CH4(g) \longrightarrow CO_{(g)} + 3H_{2(g)}$ $\Delta H = 206$ KJ

$CO_{2(g)} + H_{2(g)} \quad H2O_{(g)} + CO_{(g)}$ $\Delta H = 41$ KJ

2. Write down one thing you learned today :)

Feb 15-4:37 PM

EXIT Ticket

1. Determine the ΔH for:

$2H_2O_{(g)} + CH_{4(g)} \longrightarrow CO_{2(g)} + 4H_{2(g)}$

Using both Hess's Law & Standard Heats of Formation

Given the following: $\longrightarrow$

$H_2O_{(g)} + CH4(g) \longrightarrow CO_{(g)} + 3H_{2(g)}$ $\Delta H = 206$ KJ

$CO_{2(g)} + H_{2(g)} \quad H2O_{(g)} + CO_{(g)}$ $\Delta H = 41$ KJ

2. Write down one thing you learned today :)

Feb 15-4:37 PM

Feb 15-4:42 PM

Attachments

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