

شرح درس حساب التغير في المحتوى الحراري



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المزيد من مادة
كيمياء:

إعداد: Mouad

التواصل الاجتماعي بحسب الصف الحادي عشر المتقدم



صفحة المناهج
الإماراتية على
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الرياضيات

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التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف الحادي عشر المتقدم والمادة كيمياء في الفصل الأول

تلخيص المعادلات الكيميائية الحرارية equations thermochemical انسباير

1

تلخيص الدرس الأول الطاقة انسباير - Energy - 1 lesson 14 module inspire

2

أسئلة وزارية في الوحدة الأولى الطاقة والتغيرات الكيميائية

3

تلخيص الدرس الثاني الحرارة انسباير - 2 lesson 14 module heatinspire

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تجميع مراجعة صفحات الكتاب وفق الهيكل الوزاري نظام حديث ثلاثة مواد

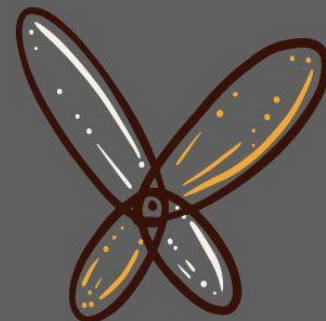
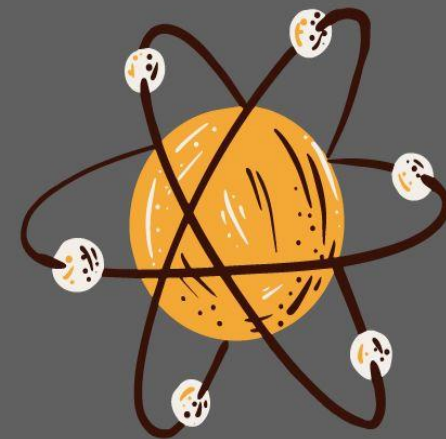
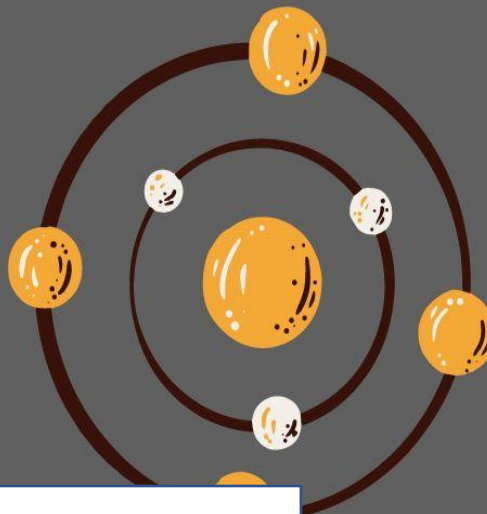
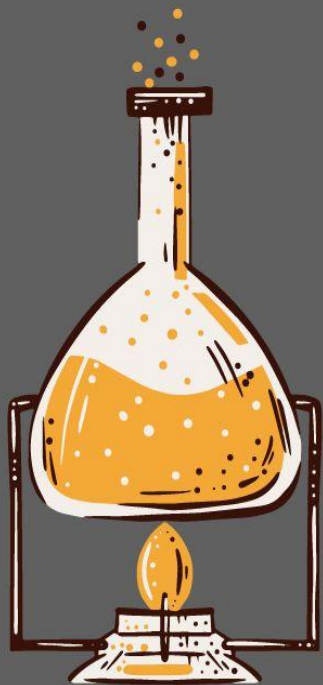
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CHEMISTRY



EasyChemistry4all by Mr. Mouad

مناهج دولة الإمارات

عام، متقدم ونخبة 9،10،11،12

00971557903129

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Inspire Chemistry

Module 14_Lesson 4: “Calculating Enthalpy Change”

LEARNING OBJECTIVES

- ▶ **Apply** Hess's law to calculate the enthalpy change for a reaction.
- ▶ **Explain** the basis for the table of standard enthalpies of formation.
- ▶ **Calculate** ΔH_{rxn} using thermochemical equations.
- ▶ **Determine** the enthalpy change for a reaction using standard enthalpies of formation data.

Part 1



- **Explain** why **Hess's Law** is used to calculate the enthalpy change for a reaction ΔH_{rxn} .
- **Apply** **Hess's law** to calculate the enthalpy change for a reaction ΔH_{rxn} .

Focus Question

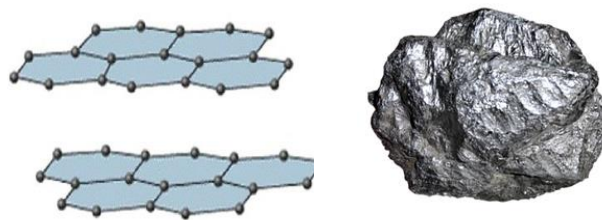
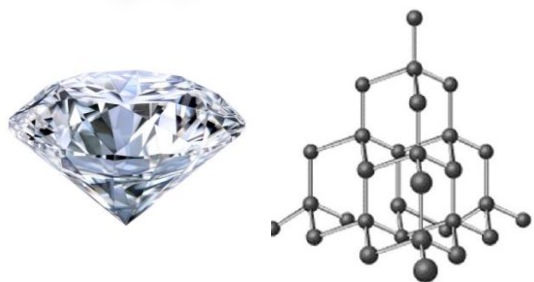
How much energy is released when rocket fuel reacts?

MAIN < **Idea** The enthalpy change for a reaction can be calculated using Hess's law.

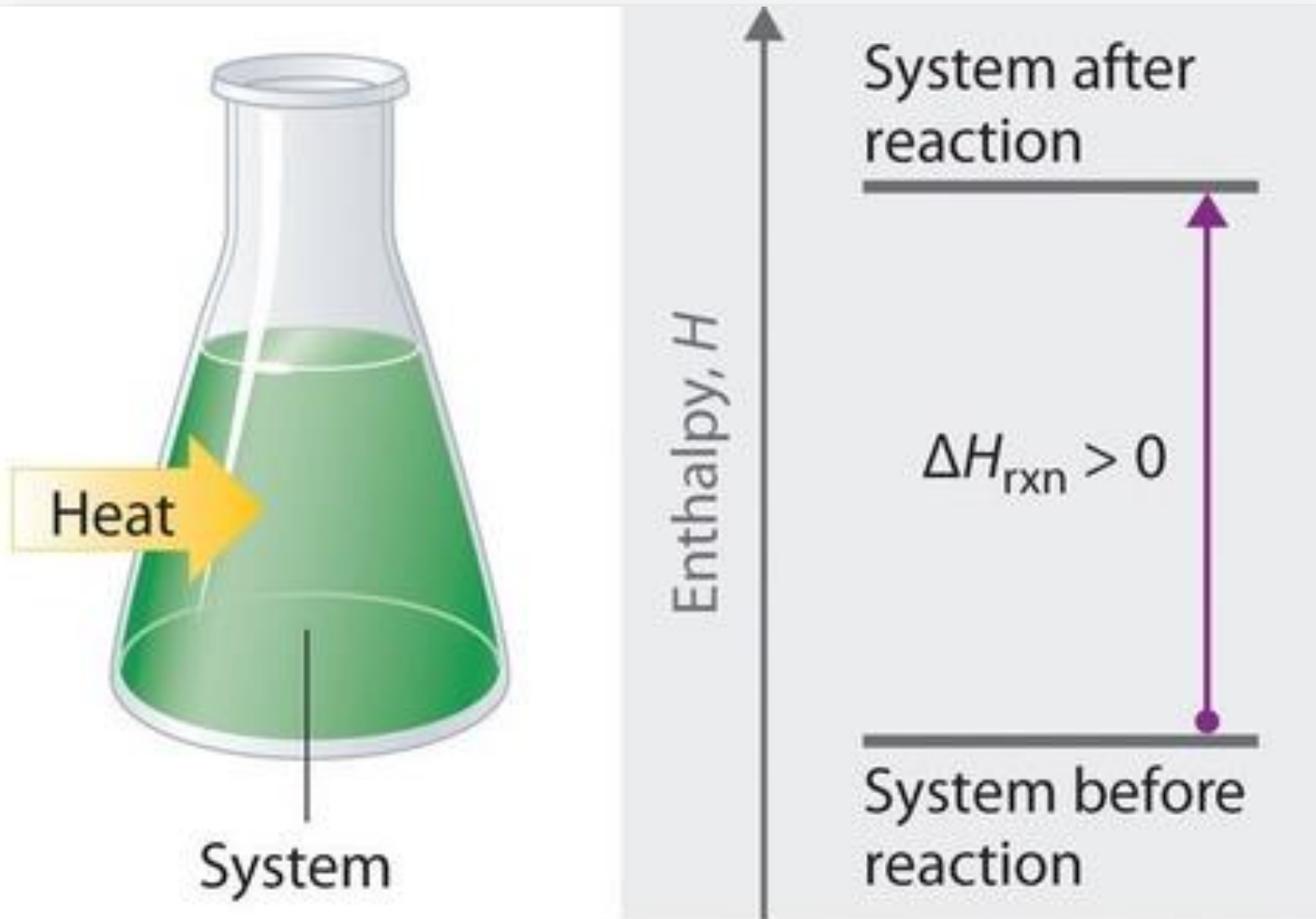
Activity

Which device is used to find the Enthalpy change of a reaction (q) or ΔH_{rxn} under a constant pressure? *The Calorimeter*

*Is it possible to use the calorimeter
for the below reaction?*



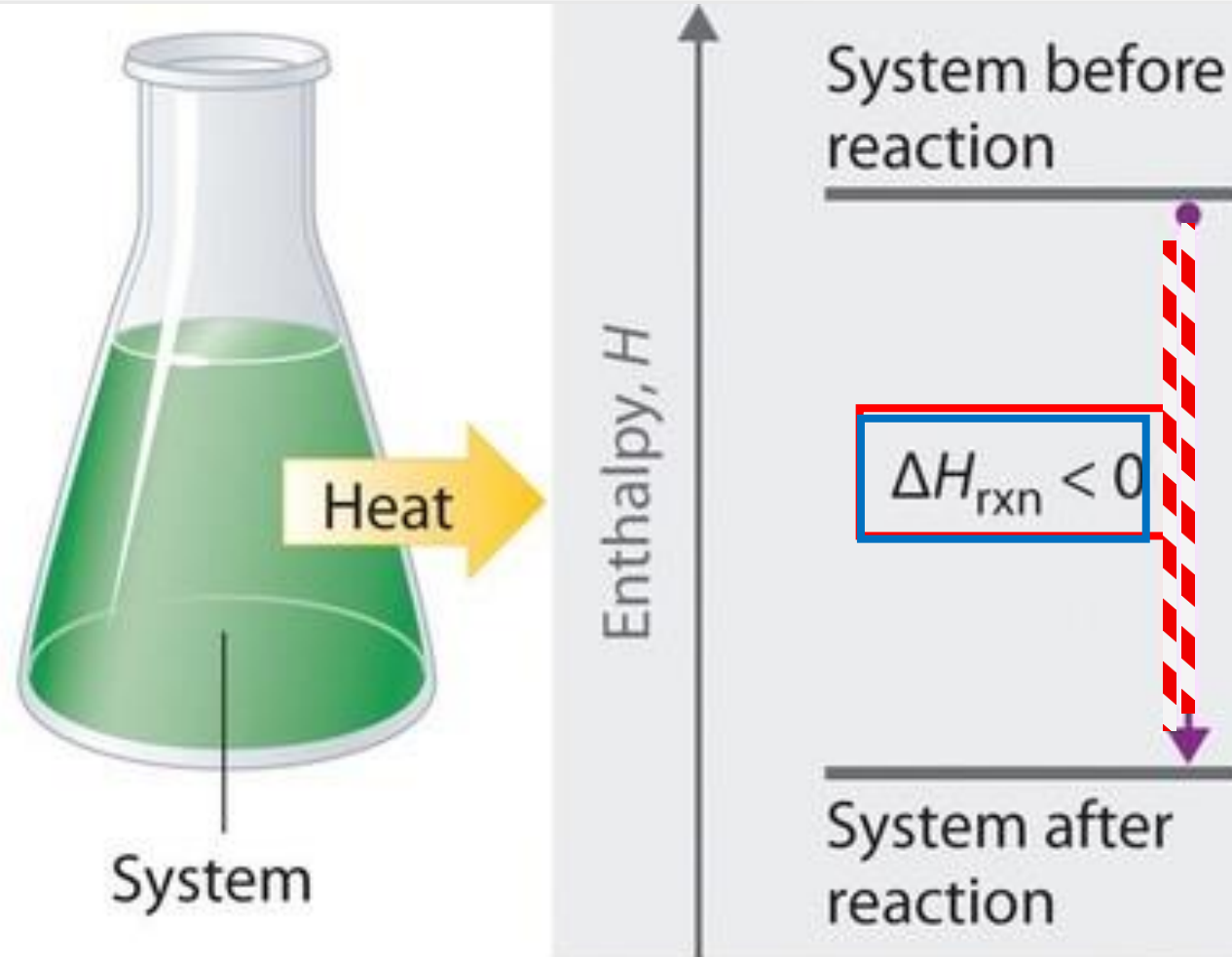
Activating
prior knowledge



(b) Endothermic reaction



**Activating
prior knowledge**



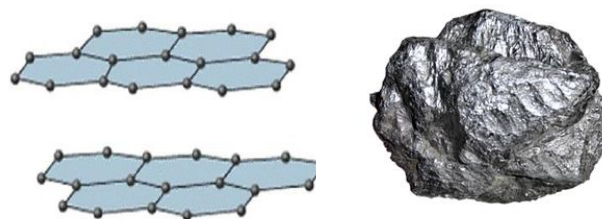
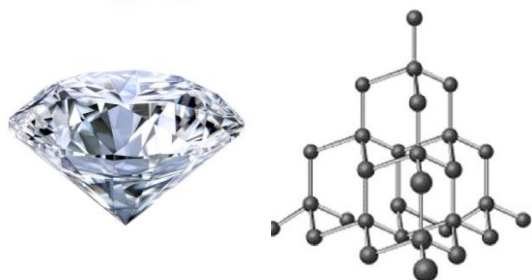
(a) Exothermic reaction



Introduction



$\Delta H =$



Sometimes it is impossible or impractical to measure the enthalpy change (ΔH) of a reaction by using a calorimeter.

Consider the reaction in the figure above, the conversion of carbon in its allotropic form, diamond, to carbon in its allotropic form, graphite. This reaction occurs so slowly that measuring the enthalpy change is impossible

Introduction, *cont.*:

Other reactions occur under conditions difficult to duplicate in a laboratory.

Still others produce products other than the desired ones. For example hydrogen react with carbon to give many different hydrocarbons



For these reactions, chemists use a theoretical way to determine ΔH



Hess's Law, *cont.* :

- Suppose you are studying the formation of sulfur trioxide in the atmosphere. You would need to determine ΔH for this reaction



Unfortunately, laboratory experiments to produce sulfur trioxide and determine its ΔH result in a mixture of products that is mostly sulfur dioxide (SO_2). In situations such as this, you can calculate ΔH by using **Hess's law of heat summation**

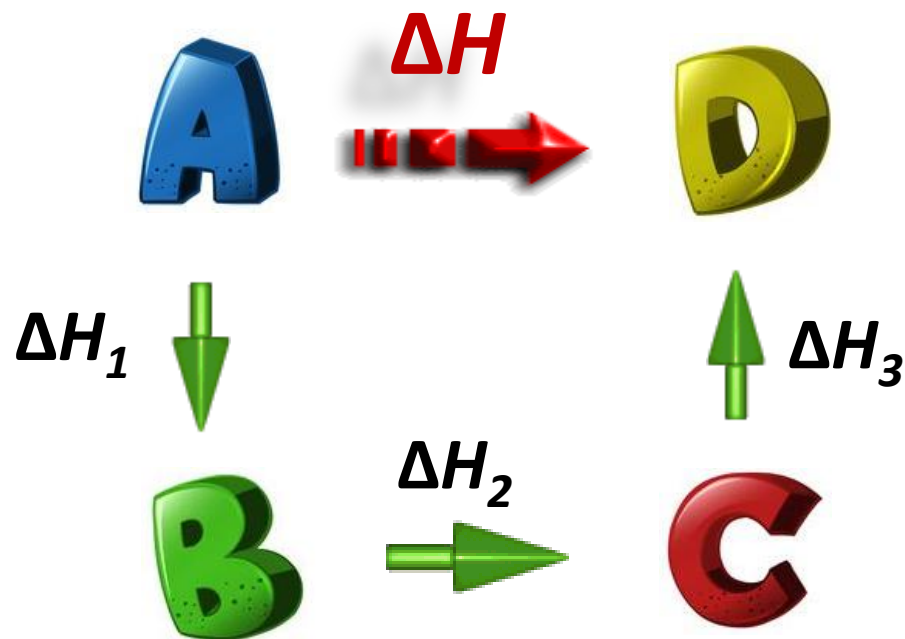
Quiz

1. Which answer best explains why it is sometimes impossible or impractical to measure the enthalpy change of a reaction in a calorimeter?

- A** The reaction occurs too slowly.
- B** The reaction occurs under conditions that are hard to replicate in the laboratory.
- C** The reaction produces products other than those that are desired.
- D** All of the above.

Hess's Law, *cont.* :

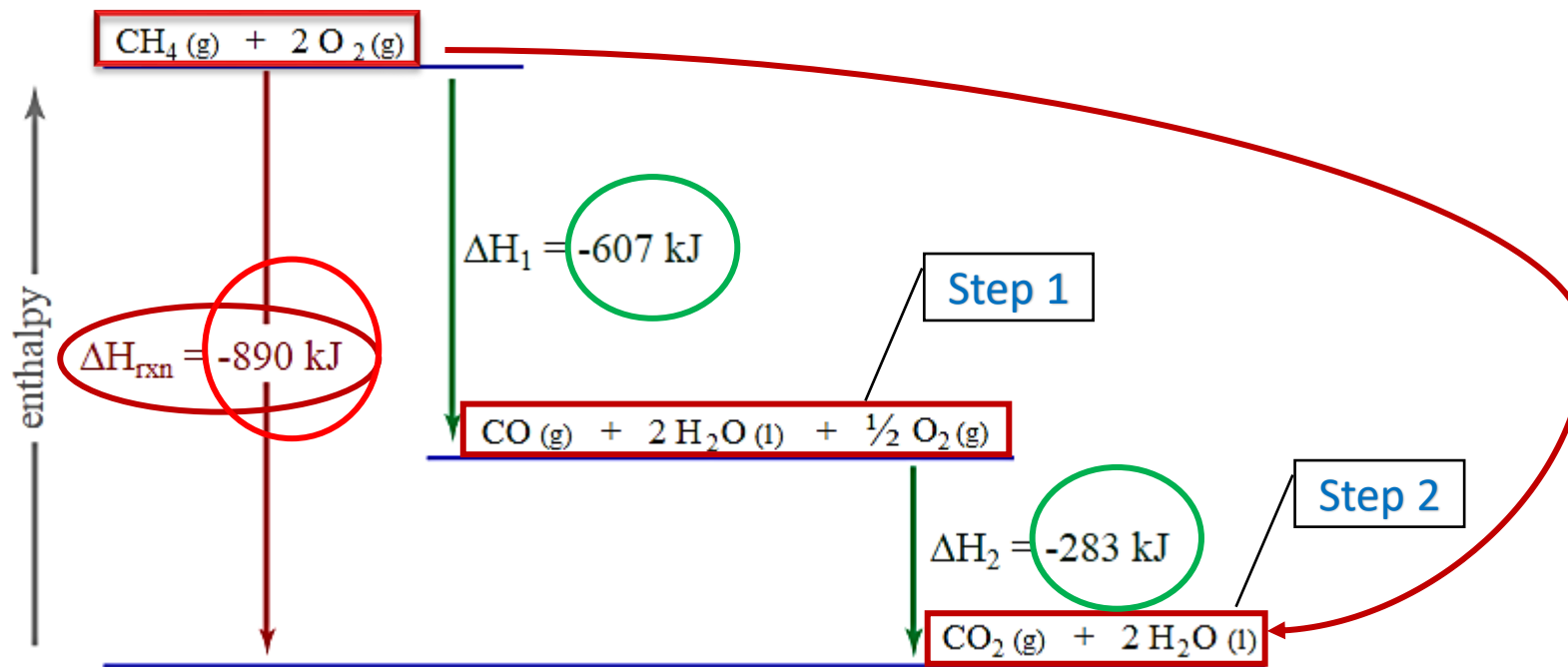
States that if you can add two or more thermochemical equations to produce a final equation for a reaction, then **the sum of the enthalpy changes for the individual reactions is the enthalpy change for the final reaction.**



$$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$$



Hess's Law, *cont.*:



$$\Delta H_{\text{rxn}} = \Delta H_1 + \Delta H_2 = -607 + (-283) = -890 \text{ kJ}$$



Quiz

2. What is the name of the law that states that if you can add two or more thermochemical equations to produce a final equation for a reaction, then the sum of the enthalpy changes for the individual reactions is the enthalpy change for the final reaction?

A Einstein's law

C Hess's law

B law of summation

D law of multiple proportions

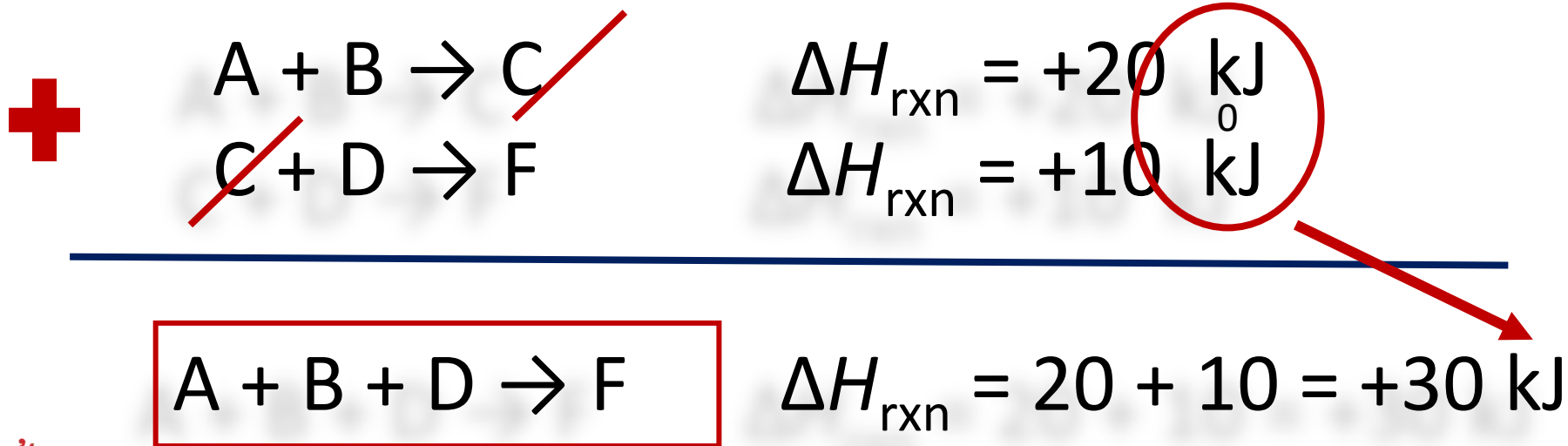
Rules for Hess's Law Calculations

A large, bold, red 3D graphic of the numbers '123'. The numbers are rendered with a thick, blocky font and have a slight shadow beneath them, giving them a three-dimensional appearance. They are positioned at the bottom of the slide, below the '123' text in the footer.



RULE 1

Make sure to add the corresponding ΔH_{rxn} values when you add the two chemical equations together



Rule



If we reverse the direction of a chemical reaction, then the sign of ΔH_{rxn} should be reversed.



$$\Delta H_{\text{rxn}} = +20 \text{ kJ}$$

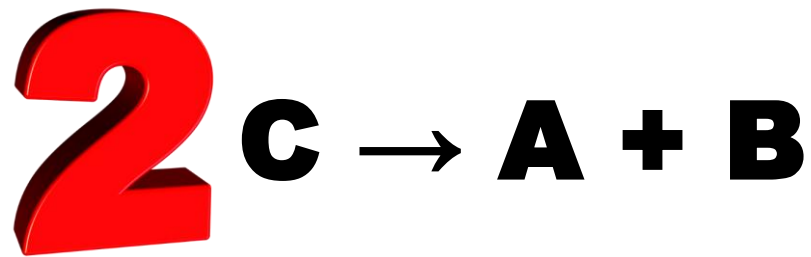


$$\Delta H_{\text{rxn}} = -20 \text{ kJ}$$



Rule 3

If you multiply a chemical reaction by a factor, then you need to multiply ΔH_{rxn} by the same factor



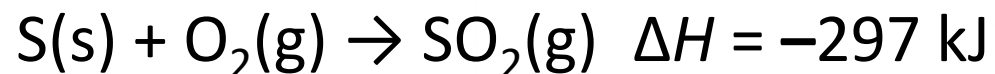
$$2 \Delta H_{\text{rxn}} = - 20 \text{ kJ}$$



$$\Delta H_{\text{rxn}} = - 40 \text{ kJ}$$

Quiz

3. A student reverses the thermochemical equation below.



What is the correct change in enthalpy for the reversed equation?

A -297 kJ

B 297 kJ

C -594 kJ

D 594 kJ

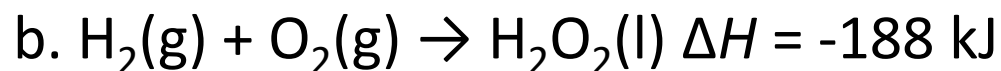
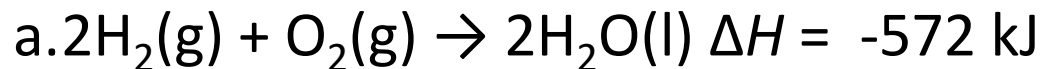
HESS'S LAW

IN-CLASS EXAMPLE

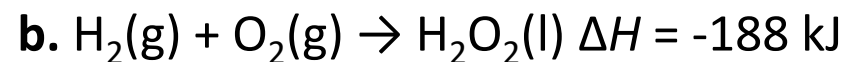
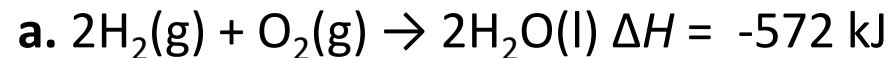
Use with Example Problem 5.

Problem (Page 26-27)

Use thermochemical Equations **a** and **b** below to determine ΔH for the decomposition of hydrogen peroxide (H_2O_2), a compound that has many uses ranging from bleaching hair to powering rocket engines.



KNOWN



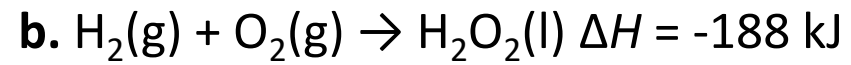
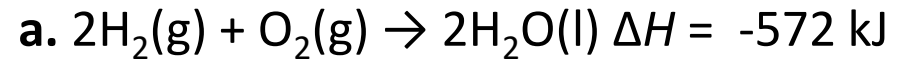
UNKNOWN

$$\Delta H = ? \text{ kJ}$$

HESS'S LAW

IN-CLASS EXAMPLE

KNOWN



UNKNOWN

$\Delta H = ? \text{ kJ}$

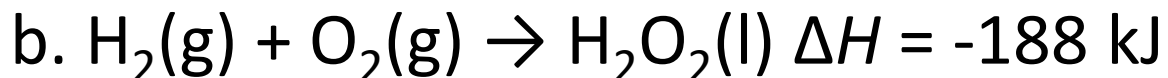
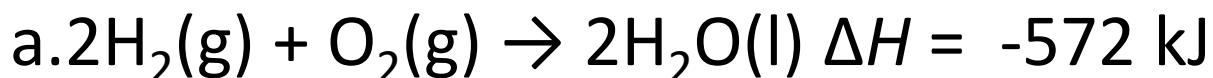
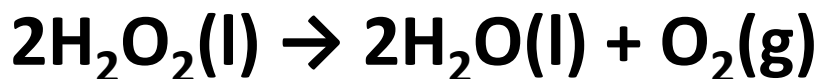
HESS'S LAW

IN-CLASS EXAMPLE

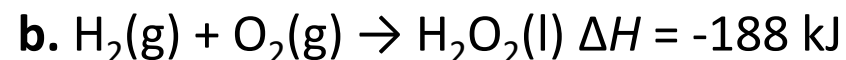
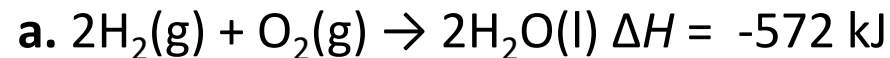
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Problem (Page 26-27)

Use thermochemical Equations **a** and **b** below to determine ΔH for the decomposition of hydrogen peroxide (H_2O_2), a compound that has many uses ranging from bleaching hair to powering rocket engines.



KNOWN



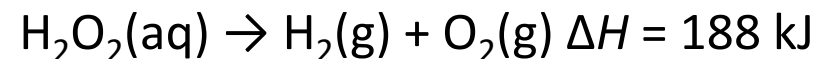
UNKNOWN

$$\Delta H = ? \text{ kJ}$$

SOLVE FOR THE UNKNOWN

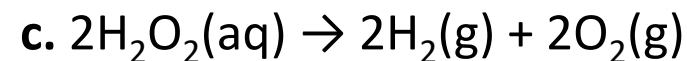
H_2O_2 is a reactant.

- Reverse Equation **b** and change the sign of ΔH .



Two moles of H_2O_2 are needed.

- Multiply the reversed Equation **b** by two to obtain Equation **c**.



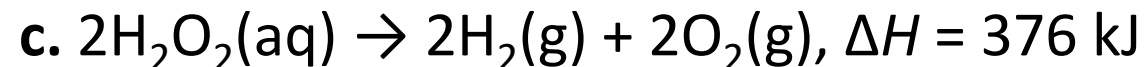
IN-CLASS EXAMPLE

SOLVE FOR THE UNKNOWN (continued)

- Multiply 188 kJ by two to obtain ΔH for Equation **c**.

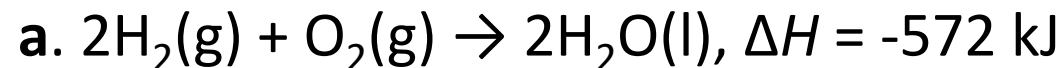
$$\Delta H \text{ for Equation c} = (188 \text{ kJ})(2) = 376 \text{ kJ}$$

- Write Equation **c** and ΔH .

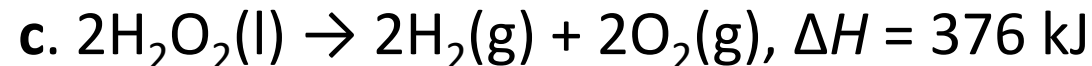


Add Equations **a** and **c**, canceling any terms common to both sides of the combined equation. Add the enthalpies of Equations **a** and **c**.

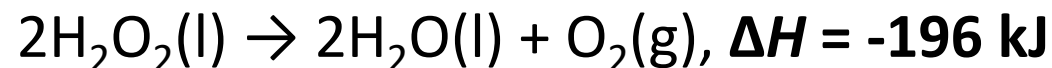
- Write Equation **a**.



- Write Equation **c**.

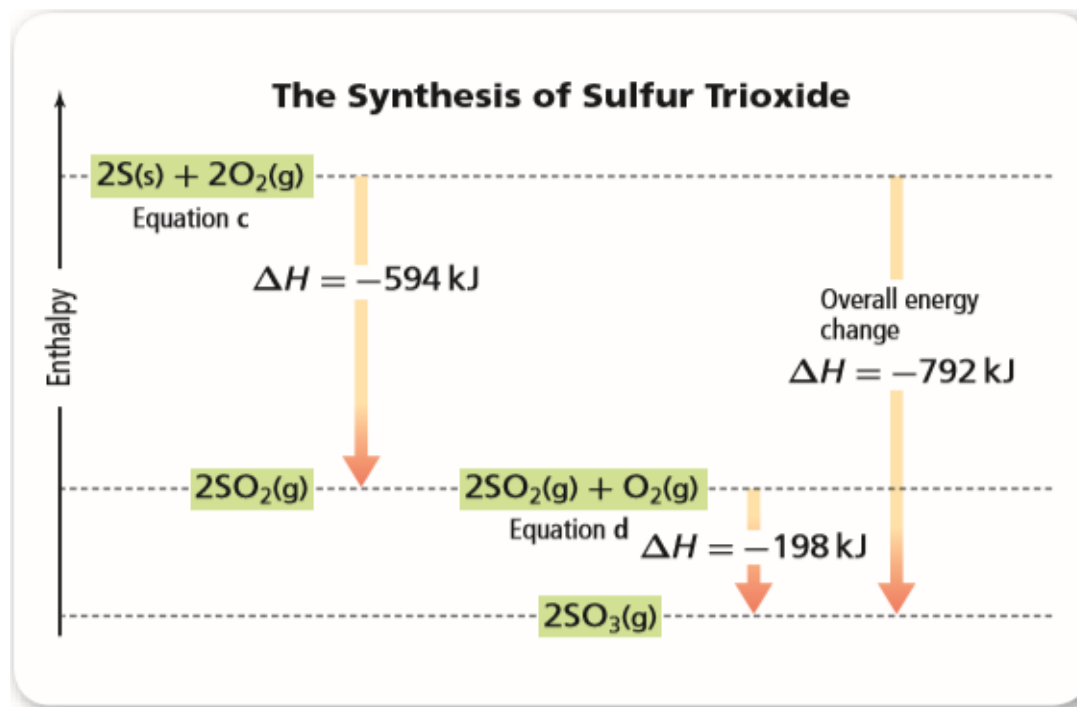


- Add Equations **a** and **c**. Add the enthalpies.



Applying Hess's Law

- Suppose you are studying the formation of sulfur trioxide in the atmosphere. You would need to determine ΔH for this reaction.



Hess's Law Example Calculation

Exercise

Suppose you are studying the formation of sulfur trioxide in the atmosphere. You would need to determine ΔH for this reaction.



Hess's Law Example Calculation

Worked Example 1

Suppose you are studying the formation of sulfur trioxide in the atmosphere. You would need to determine ΔH for this reaction.



STEP 1 >



$$\Delta H = -297 \text{ kJ}$$



$$\Delta H = 198 \text{ kJ}$$

STEP 2 >



$$\Delta H = 2(-297 \text{ kJ}) = -594 \text{ kJ}$$



+



$$\Delta H = -198 \text{ kJ}$$



STEP 3 >

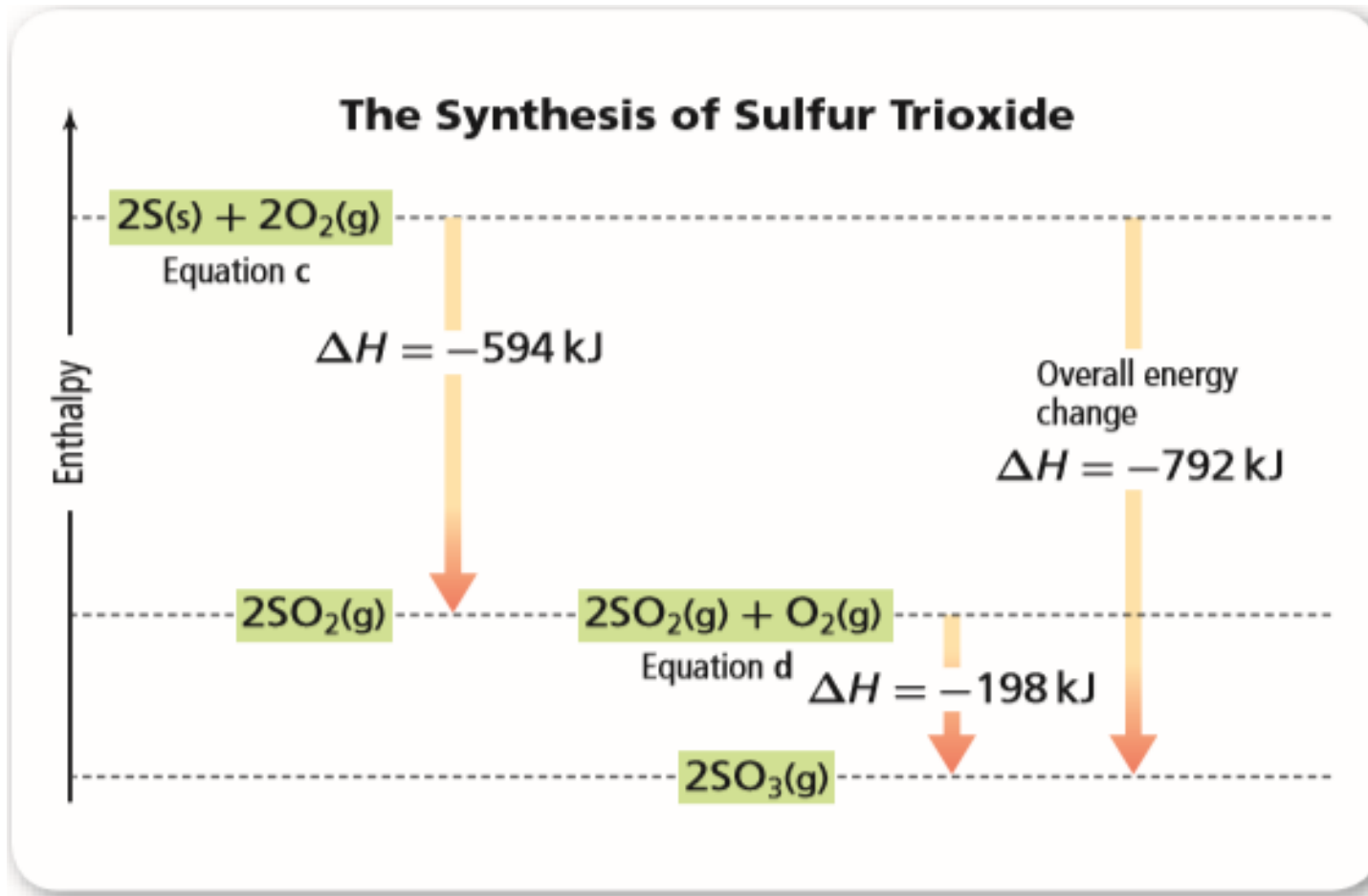


$$\Delta H = -792 \text{ kJ}$$

STEP 4 >



Applying Hess's law; *cont.*:

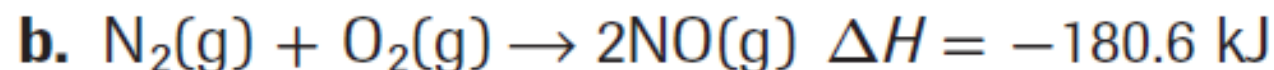
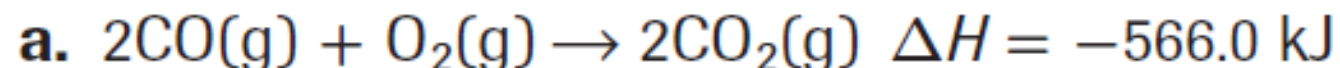
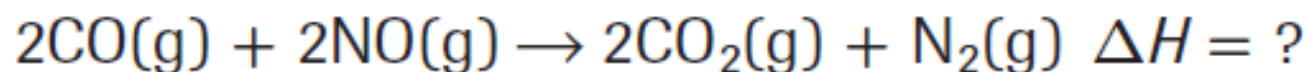


The arrow on the left indicates the release of 594 kJ as S and O₂ react to form SO₂ (Equation c). Then, SO₂ and O₂ react to form SO₃ (Equation d) with the release of 198 kJ (middle arrow). The overall energy change (the sum of the two processes) is shown by the arrow on the right.

Practice Problems

PRACTICE Problems

32. Use Equations **a** and **b** to determine ΔH for the following reaction.



Add the first equation to the second equation reversed.



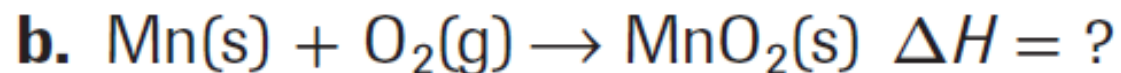
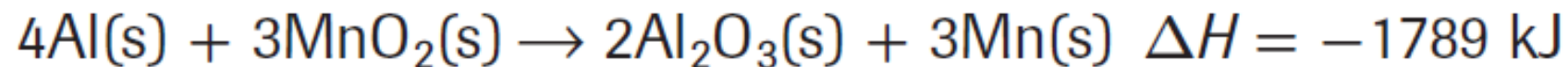
+



$$\Delta H = -385.4 \text{ kJ}$$

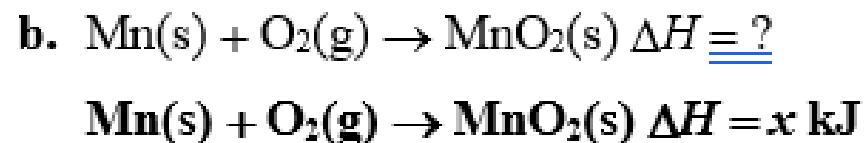
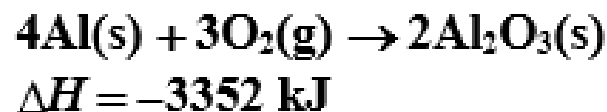
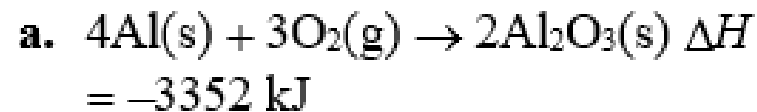
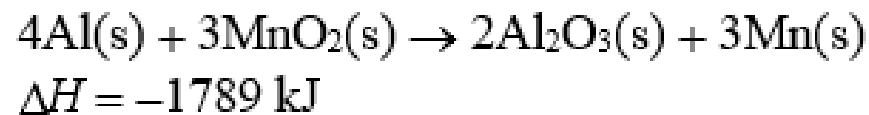
Practice Problems Page 27

33. Challenge ΔH for the following reaction is -1789 kJ. Use this and Equation **a** to determine ΔH for Equation **b**.



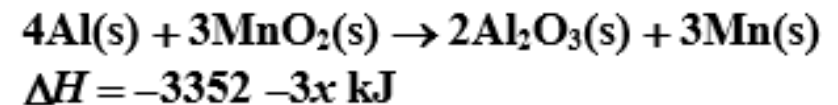
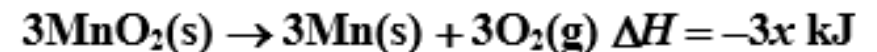
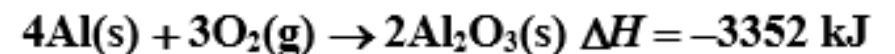
Practice Problems Page 27

33. **Challenge** ΔH for the following reaction is -1789 kJ . Use this and reaction **a** to determine ΔH for reaction **b**.



Let $x = \Delta H$ for equation **b**.

Add the Equation **a** to Equation **b** reversed and tripled.



$$-3352 - 3x \text{ kJ} = -1789 \text{ kJ}$$

Because the direction of Equation **b** was changed, ΔH for equation **b** = x =

$$\frac{-3352 + 1789}{3} = -521 \text{ kJ}$$

Determine the enthalpy change for a reaction using standard enthalpies of formation (ΔH_f°) data by applying the Summation equation.

Part 1 Applying Hess's Law

Review:

Calculate ΔH° for the following reaction



$\Delta H = ?$

Given



$\Delta H^\circ = -1170 \text{ kJ}$



$\Delta H^\circ = +1530 \text{ kJ}$

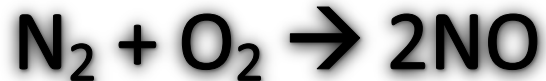
STEP 1 >



$\Delta H^\circ = +360 \text{ kJ}$

2

STEP 2 >

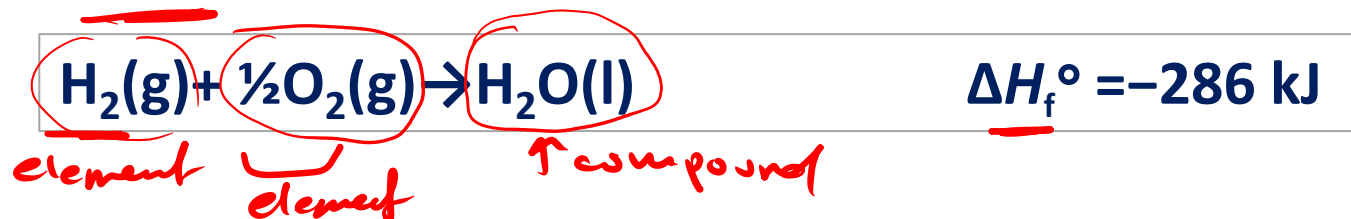


$\Delta H^\circ = +180 \text{ kJ}$ ✓

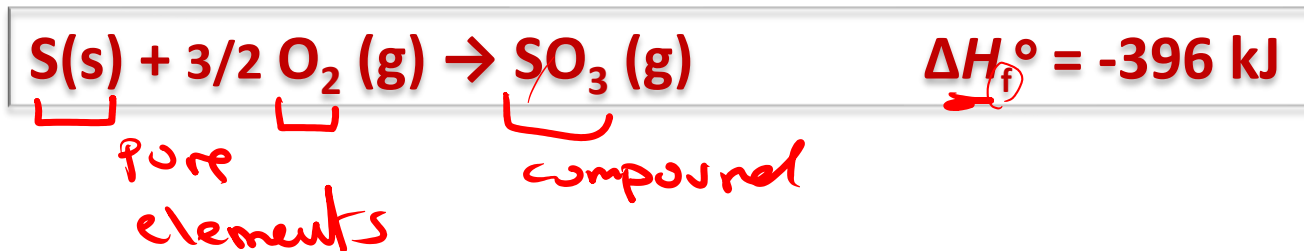
The standard enthalpy (heat) of formation (ΔH_f°) ^{of compounds}

The change in enthalpy when one mole of a substance in the standard state (1 atm of pressure and 298.15 K) ^{25°C} is formed from its pure elements under the same conditions. ^{عناصر}

Example: formation of water molecule from hydrogen and oxygen

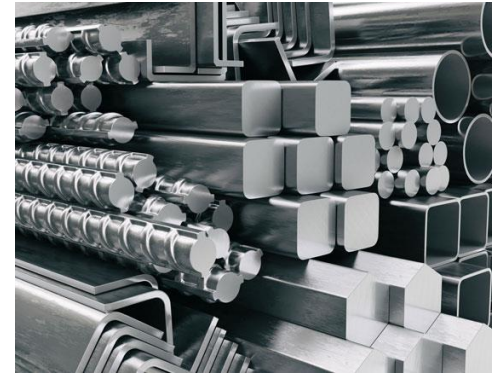


Example: formation of sulfur trioxide molecule from sulfur and oxygen



The standard enthalpy (heat) of formation (ΔH_f°)

The standard state of a substance:
it is the normal physical state of the
substance at 1 atm and 298 K
25°C



While
Mercury is
Liquid



Iron, Aluminum, Gold and
Copper in their standard
state they are solids

The standard enthalpy (heat) of formation (ΔH_f°)

Also, Graphite and diamond are two different allotropes of element **carbon**.

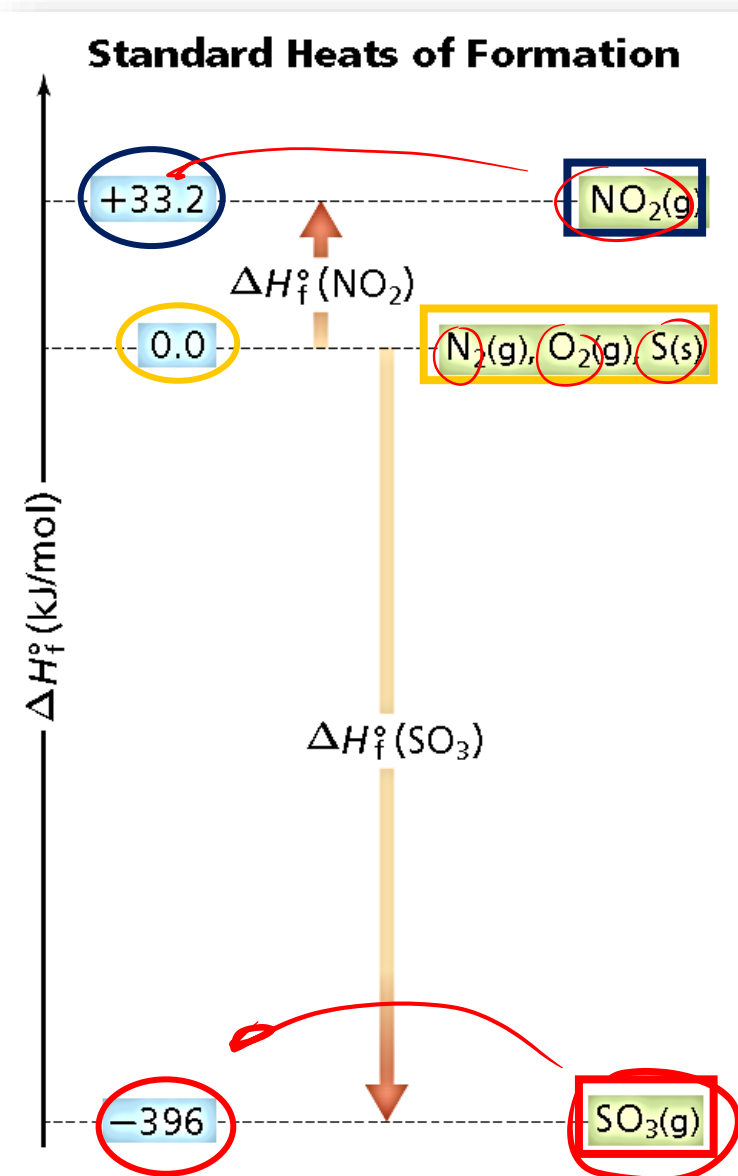
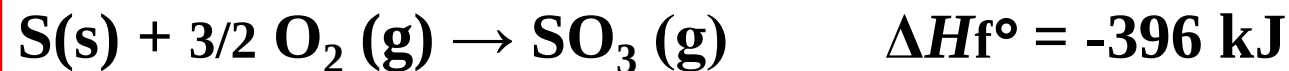
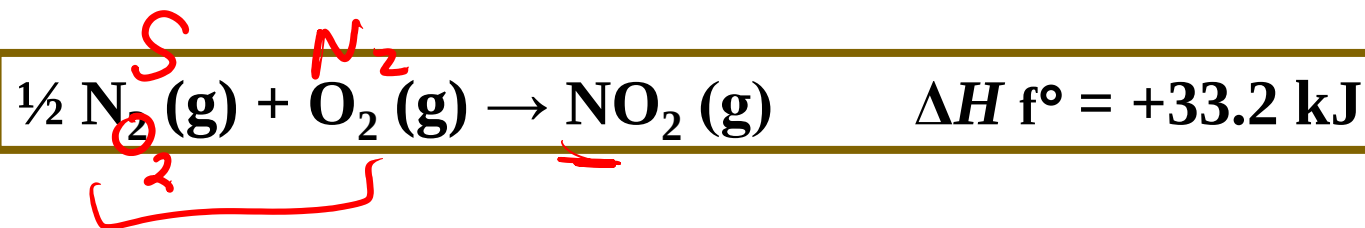
But because graphite is more stable at 1 atm pressure and 25°C, so the standard state of carbon is graphite.



The standard enthalpy (heat) of formation (ΔH_f°)



The standard enthalpy of formation of any **element** in its standard state **is zero** by definition.



Quiz

ΔH_f° 4. What is true of the standard enthalpy of formation of **elements** in their standard states?

- A It is always positive.
- B It is always negative.
- C It is always 0.0 kJ. ✓
- D It depends on the element.

Standard Enthalpy (Heat) of Formation

Table 5 lists standard enthalpies of formation for some common compounds.

Table 5 Standard Enthalpies of Formation		
Compound	Formation Equation	ΔH_f° (kJ/mol)
H ₂ S(g)	$\text{H}_2(\text{g}) + \text{S}(\text{s}) \rightarrow \text{H}_2\text{S}(\text{g})$	-21
HF(g)	$\frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{F}_2(\text{g}) \rightarrow \text{HF}(\text{g})$	-273
SO ₃ (g)	$\text{S}(\text{s}) + \frac{3}{2}\text{O}_2(\text{g}) \rightarrow \text{SO}_3(\text{g})$	-396
SF ₆ (g)	$\text{S}(\text{s}) + 3\text{F}_2(\text{g}) \rightarrow \text{SF}_6(\text{g})$	-1220

Standard Enthalpy (Heat) of Formation

Table R-11 Heat of Formation Values

ΔH_f° (kJ/mol) (concentration of aqueous solutions is 1 M)

Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°	Substance	ΔH_f°
Ag(s)	0	CsCl(s)	-443.0	H ₃ PO ₄ (aq)	-1271.7	NaBr(s)	-361.1
AgCl(s)	-127.0	Cs ₂ SO ₄ (s)	-1443.0	H ₂ S(g)	-20.6	NaCl(s)	-411.2
AgCN(s)	146.0	CuI(s)	-67.8	H ₂ SO ₃ (aq)	-608.8	NaHCO ₃ (s)	-950.8
Al ₂ O ₃	-1675.7	CuS(s)	-53.1	H ₂ SO ₄ (aq)	-814.0	NaNO ₃ (s)	-467.9
BaCl ₂ (aq)	-855.0	Cu ₂ S(s)	-79.5	HgCl ₂ (s)	-224.3	NaOH(s)	-425.8
BaSO ₄	-1473.2	CuSO ₄ (s)	-771.4	Hg ₂ Cl ₂ (s)	-265.4	Na ₂ CO ₃ (s)	-1130.7
BeO(s)	-609.4	F ₂ (g)	0	Hg ₂ SO ₄ (s)	-743.1	Na ₂ S(s)	-364.8
BiCl ₃ (s)	-379.1	FeCl ₃ (s)	-399.49	I ₂ (s)	0	Na ₂ SO ₄ (s)	-1387.1
Bi ₂ S ₃ (s)	-143.1	FeO(s)	-272.0	K(s)	0	NH ₄ Cl(s)	-314.4
Br ₂	0	FeS(s)	-100.0	KBr(s)	-393.8	O ₂ (g)	0
CCl ₄ (l)	-128.2	Fe ₂ O ₃ (s)	-824.2	KMnO ₄ (s)	-837.2	P ₄ O ₆ (s)	-1640.1
CH ₄ (g)	-74.6	Fe ₃ O ₄ (s)	-1118.4	KOH	-424.6	P ₄ O ₁₀ (s)	-2984.0
C ₂ H ₂ (g)	227.4	H(g)	218.0	LiBr(s)	-351.2	PbBr ₂ (s)	-278.7
C ₂ H ₄ (g)	52.4	H ₂ (g)	0	LiOH(s)	-487.5	PbCl ₂ (s)	-359.4
C ₂ H ₆ (g)	-84.0	HBr(g)	-36.3	Mn(s)	0	SF ₆ (g)	-1220.5
CO(g)	-110.5	HCl(g)	-92.3	MnCl ₂ (aq)	-555.0	SO ₂ (g)	-296.8
CO ₂ (g)	-393.5	HCl(aq)	-167.159	Mn(NO ₃) ₂ (aq)	-635.5	SO ₃ (g)	-395.7
CS ₂ (l)	89.0	HCN(aq)	108.9	MnO ₂ (s)	-520.0	SrO(s)	-592.0
Ca(s)	0	HCHO	-108.6	MnS(s)	-214.2	TiO ₂ (s)	-944.0
CaCO ₃ (s)	-1206.9	HCOOH	-425.0	N ₂ (g)	0	TlI(s)	-123.8
CaO(s)	-634.9	HF(g)	-273.3	NH ₃ (g)	-45.9	UCl ₄ (s)	-1019.2
Ca(OH) ₂ (s)	-985.2	HI(g)	26.5	NH ₄ Br(s)	-270.8	UCl ₆ (s)	-1092.0
Cl ₂ (g)	0	H ₂ O(l)	-285.8	NO(g)	91.3	Zn(s)	0
Co ₃ O ₄ (s)	-891.0	H ₂ O(g)	-241.8	NO ₂ (g)	33.2	ZnCl ₂ (aq)	-415.1
CoO(s)	-237.9	H ₂ O ₂ (l)	-187.8	N ₂ O(g)	81.6	ZnO(s)	-350.5
Cr ₂ O ₃ (s)	-1139.7	H ₃ PO ₂ (l)	-595.4	Na(s)	0	ZnSO ₄ (s)	-982.8

X
R
Y
Z

The Summation Equation

Sum مجموع

$$\Delta H^{\circ}_{\text{reaction}} = \sum \Delta H_f^{\circ} (\text{products}) - \sum \Delta H_f^{\circ} (\text{Reactants})$$

Example:



$$\Delta H_f^{\circ} (\text{X}) = 410 \text{ KJ}$$

$$\Delta H_f^{\circ} (\text{Y}) = -140 \text{ KJ}$$

$$\Delta H_f^{\circ} (\text{Z}) = 570 \text{ KJ}$$

$$\Delta H_f^{\circ} (\text{R}) = 220 \text{ KJ}$$

$$\Delta H^{\circ}_{\text{reaction}} = [\Delta H_f^{\circ} (\text{Z}) + \Delta H_f^{\circ} (\text{R})] - [\Delta H_f^{\circ} (\text{X}) + \Delta H_f^{\circ} (\text{Y})]$$

$$\Delta H^{\circ}_{\text{reaction}} = [(570 \text{ kJ}) + (220 \text{ kJ})] - [(410 \text{ kJ}) + (-140 \text{ kJ})] = 520 \text{ kJ}$$



$$\Delta H_{rxn} = (\Delta H_f^\circ R) - (2 \times \Delta H_f^\circ X + \Delta H_f^\circ Y)$$

$\Delta H_f^\circ X = 100 \text{ kJ}$

$\Delta H_f^\circ Y = 50 \text{ kJ}$

$\Delta H_f^\circ R = 200 \text{ kJ}$

$200 - (2 \times 100 + 50)$

$200 - 250 = -50 \text{ kJ}$

5. Which of the following equations summarizes how standard enthalpies of formation combine to produce a desired equation and its ΔH_{rxn}° ?

☒ A $\Delta H_{rxn}^\circ = \Sigma \Delta H_f^\circ(\text{products}) - \Sigma \Delta H_f^\circ(\text{reactants})$

☐ B $\Delta H_{rxn}^\circ = \Sigma \Delta H_f^\circ(\text{reactants}) - \Sigma \Delta H_f^\circ(\text{products})$

☐ C $\Delta H_{rxn}^\circ = \Delta H_f^\circ(\text{products}) - \Delta H_f^\circ(\text{reactants})$

☐ D None of the above.

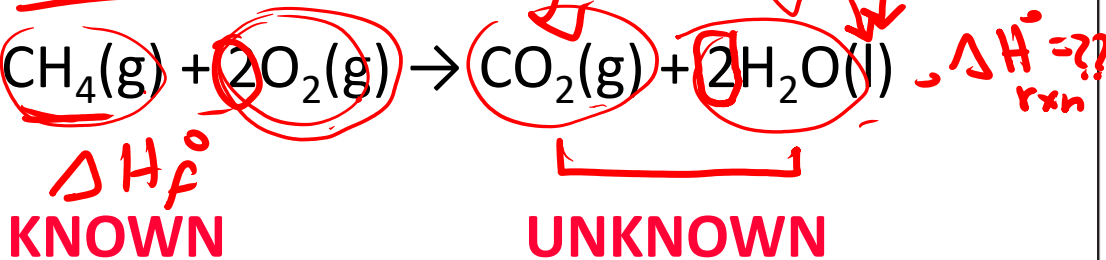
ENTHALPY CHANGE FROM STANDARD ENTHALPIES OF FORMATION

IN-CLASS EXAMPLE

Use with Example Problem 6.

Problem

Use standard enthalpies of formation to calculate $\Delta H^\circ_{\text{rxn}}$ for the combustion of methane.



- $(\text{CO}_2) = -394 \text{ kJ}$
- $(\text{H}_2\text{O}) = -286 \text{ kJ}$
- $(\text{CH}_4) = -75 \text{ kJ}$
- $(\text{O}_2) = 0.0 \text{ kJ}$

$\Delta H_{\text{rxn}}^\circ = ? \text{ kJ}$

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

$$= [\Delta H_f^\circ \text{CO}_2 + 2 \times \Delta H_f^\circ \text{H}_2\text{O}] - [\Delta H_f^\circ \text{CH}_4 + 2 \times \Delta H_f^\circ \text{O}_2]$$

$$= [-394 + (2 \times -286)] - [-75 + (2 \times 0)] = -891 \text{ kJ}$$

Table R-11 Heat of Formation Values

ΔH_f° (kJ/mol) (concentration of aqueous solutions is 1 M)							
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Bi ₂ S ₃ (s)	-143.1	FeO(s)	-272.0	K(s)	0	NH ₄ Cl(s)	-314.4
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CCl ₄ (l)	-128.2	Fe ₂ O ₃ (s)	-824.2	KMnO ₄ (s)	-837.2	P ₄ O ₆ (s)	-1640.1
CH ₄ (g)	-74.6	Fe ₃ O ₄ (s)	-1118.4	KOH	-424.6	P ₄ O ₁₀ (s)	-2984.0
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CO(g)	-110.5	HCl(g)	-92.3	MnCl ₂ (aq)	-555.0	SO ₂ (g)	-296.8
CO ₂ (g)	-393.5	HCl(aq)	-167.159	Mn(NO ₃) ₂ (aq)	-635.5	SO ₃ (g)	-395.7
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CaCO ₃ (s)	-1206.9	HCOOH	-425.0	N ₂ (g)	0	TiI ₃ (s)	-123.8
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Ca(OH) ₂ (s)	-985.2	HI(g)	26.5	NH ₄ Br(s)	-270.8	UCl ₆ (s)	-1092.0
Cl ₂ (g)	0	H ₂ O(l)	-285.8	NO(g)	91.3	Zn(s)	0
Co ₃ O ₄ (s)	-891.0	H ₂ O(g)	-241.8	NO ₂ (g)	33.2	ZnCl ₂ (aq)	-415.1
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Cr ₂ O ₃ (s)	-1139.7	H ₃ PO ₂ (l)	-595.4	Na(s)	0	ZnSO ₄ (s)	-982.8

ENTHALPY CHANGE FROM STANDARD ENTHALPIES OF FORMATION

IN-CLASS EXAMPLE

Table 3 Standard Enthalpies of Combustion		
Substance	Formula	$\Delta H^\circ_{\text{comb}}$ (kJ/mol)
Sucrose (table sugar)	$\text{C}_{12}\text{H}_{22}\text{O}_{11}(\text{s})$	−5644
Octane (a component of gasoline)	$\text{C}_8\text{H}_{18}(\text{l})$	−5471
Glucose (a simple sugar found in fruit)	$\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$	−2808
Propane (a gaseous fuel)	$\text{C}_3\text{H}_8(\text{g})$	−2219
Methane (a gaseous fuel)	$\text{CH}_4(\text{g})$	−891

Acid Rain: integration to environmental science



Sulfur trioxide combines with water in the atmosphere to form sulfuric acid (H_2SO_4), a strong acid, which reaches Earth as acid precipitation. Acid precipitation slowly destroys trees and property

Activity: write down the four steps of formation of acid rain

Acid Rain: integration to environmental science

Answer

- 1. burning fossil fuel produce sulfur (impurities in fossil fuel)
- 2. Sulfur from fossil fuel combines with oxygen in air to form SO_2 and SO_3
- 3. In the atmosphere (clouds) it reacts with water to give sulfurous acid H_2SO_3
- 4. Further it reacts with oxygen and produce H_2SO_4 (strong acid)

Thus all sulfur oxides are harmful and dangerous to the environment

