حرارة التكوين القياسية

Standard Heat of formation (ΔH_f^o)

The heat change that results when 1 mol of the compound is formed from standard state of its elements

25 C°
1 atm

The standard enthalpy of formation of any element in its most stable form is zero.

ΔH^0 (C, diamond) = 1.90 kJ/mol

What is ΔH_f^o of O_2 (g), Hg(l), C(graphite)? ⟹ $\Delta H_f = 0$

oxygen   Mercury   جرافيت

قسم الكيمياء
Department of Chemistry

elements عناصر   Fe   Cu   Zn

Question 9

Calculate ΔH°_{rxn} for the combustion reaction of CH_4 shown below given the following:

$\Delta H^\circ f\ CH_4(g) = -74.8$ kJ/mol;

$\Delta H^\circ f\ CO_2(g) = -393.5$ kJ/mol;

$\Delta H^\circ f\ H_2O(l) = -285.5$ kJ/mol

$CH_4(g) + 2\,O_2(g) \longrightarrow CO_2(g) + 2\,H_2O(l)$

(1×-74.8) $(1 \times -393.5) + (2 \times -285.5)$ -964.5

A. -604.2 kJ
B. 889.7 kJ
C. -997.7 kJ
D. -889.7 kJ
E. None of the above

$\Delta H = H_p - H_R$

Question 10

Find the standard enthalpy of formation of ethylene, C2H4(g), given the following data:

$C2H4(g) + 3\ O2(g) \longrightarrow 2\ CO2(g) + 2\ H2O(l)$ $\Delta H^\circ_{rxn} = -1411$ kJ;

$C(s) + O2(g) \longrightarrow CO2(g)\ \Delta H^\circ_f = -393.5$ kJ;

$H2(g) + \frac{1}{2}O2(g) \longrightarrow H2O(l)\ \Delta H^\circ_f = -285.8$ kJ

A. 731 kJ
B. 2.77 x 103 kJ
C. 1.41 x 103 kJ
D. 87 kJ
E. 52 kJ

الأستاذ / محمد طاهر
مدرس كيمياء وفيزياء
٠٥٦٩٤٨٨٨٠

قسم الكيمياء
Department of Chemistry

Question 5

To which one of the following reactions, occurring at 25°C, does the symbol ΔH°_f [$H_2SO_4(l)$] refer?

- A. H2(g) + S(s) + 2 O2(g) ----> H2SO4(l)
- B. H2SO4(l) ----> H2(g) + S(s) + 2 O2(g)
- C. H2(g) + S(g) + 2 O2(g) ----> H2SO4(l)
- D. H2SO4(l) ----> 2 H(g) + S(s) + 4 O(g)
- E. 2 H(g) + S(g) + 4 O(g) ----> H2SO4(l)

Question 6

Given: SO2(g) + ½O2(g) ----> SO3(g) ΔH°_{rxn} = -99 kJ, what is the enthalpy change for the following reaction? 2 SO3(g) ----> O2(g) + 2 SO2(g)

- A. 99 kJ
- B. -99 kJ
- C. 49.5 kJ
- D. -198 kJ
- E. 198 kJ

Question 7

The specific heat of aluminum is 0.214 cal/g.°C. Determine the energy, in calories, necessary to raise the temperature of a 55.5 g piece of aluminum from 23.0 to 48.6°C.

- A. 109 cal
- B. 273 cal
- C. 577 cal
- D. 347 cal
- E. 304 cal

Question 8

Standard enthalpy of reactions can be calculated from standard enthalpies of formation of reactants.

- A. True
- B. False

Question 1

An exothermic reaction causes the surroundings to:

X A. become basic
B. decrease in temperature
C. condense
● increase in temperature
E. decrease in pressure

Question 2

How much heat is evolved when 320 g of SO_2 is burned according to the chemical equation shown below?

$2\ SO_2(g) + O_2(g) \longrightarrow 2\ SO_3(g)\ \ \Delta H^\circ_{rxn} = -198\ kJ$

A. 5.04 x 10-2 kJ
B. 9.9 x 102 kJ
C. 207 kJ
D. 5.0 x 102 kJ
E. None of the above

Question 3

$q = mc\Delta t$

The specific heat of aluminum is 0.214 cal/g.°C. Determine the energy, in calories, necessary to raise the temperature of a 55.5 g piece of aluminum from 23.0 to 48.6°C.

A. 109 cal
B. 273 cal
C. 577 cal
D. 847 cal
E. 304 cal

Question 4

Energy is the ability to do work and can be:

● converted to one form to another
X B. can be created and destroyed
C. used within a system without consequences
D. none of the above

قسم الكيمياء
Department of Chemistry

8th lecture

التغير في المحتوى الحراري والحساب

2- Hess's Law

Calculate the enthalpy of the following reaction:

Fe_2O_3 (s) + 3CO (g) ⟶ 2Fe (s) + $3CO_2$ (g) ΔH = ??

1- CO (g) + ½O_2 (g) ⟶ CO_2 (g) ΔH^o = - 283.0 kJ

2- 2Fe (s) + 3/2O_2 (g) ⟶ Fe_2O_3 (s) ΔH^o = - 822.2 kJ

3CO (g) + 3/2O_2 (g) ⟶ $3CO_2$ (g) $\Delta H^o = 3\times - 283.0 = - 849$ kJ

Fe_2O_3 (s) ⟶ 2Fe (s) + 3/2O_2 (g) $\Delta H^o = + 822.2$ kJ

Fe_2O_3 (s) + 3CO (g) ⟶ 2Fe (s) + $3CO_2$ (g) $\Delta H^o = -26.7$ kJ

قسم الكيمياء
Department of Chemistry

Hess' Law: Details (cont.)

- If the coefficients of a reaction are multiplied by a constant, the value of ΔH is also multiplied by the same integer.

$$N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g) \qquad \Delta H = 68\ kJ$$

$$2N_2(g) + 4O_2(g) \longrightarrow 4NO_2(g) \qquad \Delta H = 136\ kJ$$

لو ضرب X رقم معامل ② ، تضرب ΔH X نفس الرقم معامل ②

قسم الكيمياء
Department of Chemistry

8th lecture

Hess' Law: Details

- Once can always reverse the direction of a reaction when making a combined reaction. When you do this, the sign of ΔH changes.

$$N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g) \qquad \Delta H = 68\ kJ$$

$$2NO_2(g) \longrightarrow N_2(g) + 2O_2(g) \qquad \Delta H = -68\ kJ$$

عند عكس معادلة تفاعل اعكس ΔH

قسم الكيمياء
Department of Chemistry

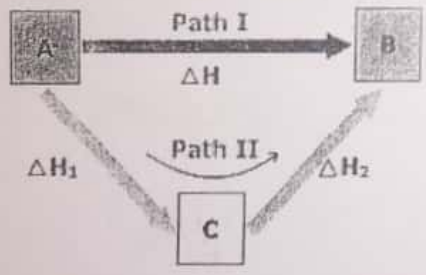
8th lecture

طرق غير مباشره

2- indirect method :(Hess's Law)

الأستاذ / محمد طاهر
مدرس كيمياء وفيزياء
٠٥٦٩٤٨٨٨٠٥

ΔH for a process involving the transformation of reactants into products is not dependent on pathway. Therefore, we can pick any pathway to calculate ΔH for a reaction.



When reactants are converted to products, the change in enthalpy is the same whether the reaction takes place in one step or in a series of steps.
ΔH is a state function

قسم الكيمياء
Department of Chemistry

أ.د سعاد / محمد طاهر
مدرس كيمياء وفيزياء
٠٥٦٩٤٨٨٨٠٥

Example

Calculate the enthalpy of the following reaction:

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

ΔH_f^o of Fe_2O_3, Al_2O_3 and $Fe(l)$ = - 822.2, - 1669.8 and 12.40 kJ/mol

[1] [2] [3] [1] [2] [3]

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

$\Delta H^o = [(\Delta H_f^o (Al_2O_3)) + (2\times \Delta H_f^o (Fe))] - [(2\times \Delta H_f^o (Al)) + (\Delta H_f^o (Fe_2O_3))]$

$\Delta H^o = [(-1669.8) + (2\times 12.40)] - [2\times(0) + (-822.2)] = -822.8$ kJ

8th lecture

كيفية حساب التغير في المحتوى الحراري للتفاعل .

How to calculate ΔH^{o}_{rxn}

الأستاذ / محمد طاهر
مدرس كيمياء وفيزياء
٠٥٦٩٤٨٨٠٥

1- Direct method طريقة مباشرة 2- indirect method غير مباشرة

1- Direct method: by standard heat of formation

$$\Delta H^{o} = \sum n\, \Delta H_f^{o}\ (\text{products}) - \sum n\, \Delta H_f^{o}\ (\text{reactants})$$

نواتج المتفاعلات

n = no. of moles in the balanced thermochemical equation

$$\Delta H = H_P - H_R$$

قسم الكيمياء
Department of Chemistry

8th lecture

Thermochemical Equations

$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$ $\Delta H = -890.4$ kJ/mol

- It shows the physical states of all products and reactants
- Balanced
- It shows Heat of reaction kJ

$H_2O(s) \longrightarrow H_2O(l)$ $\Delta H = 6.01$ kJ/mol

If you reverse a reaction, the sign of ΔH changes

$H_2O(l) \longrightarrow H_2O(s)$ $\Delta H = -6.01$ kJ/mol

- If you multiply both sides of the equation by a factor *n*, then ΔH must change by the same factor *n*.

$2H_2O(s) \longrightarrow 2H_2O(l)$ $\Delta H = 2 \times 6.01 = 12.0$ kJ

قسم الكيمياء

8th lecture

التغير في المحتوى الحراري القياسي للتفاعل

Standard Enthalpy (Heat) of reaction (ΔH^o_{rxn})

للتفاعل

الشروط " الظروف "

Enthalpy change at standard conditions (25 °C, 1 atm)

Temperature. Pressure

elements عناصر

$N_2\,(g) + 3H_2\,(g) \longrightarrow 2NH_3\,(g)\ \Delta H^o = \ominus 92.38\ kJ$

exo

$H_{product} < H_{reactant}$

Thermochemical reaction

قسم الكيمياء
Department of Chemistry

8th lecture

أنواع العمليات

Kinds of Processes
تغيرات فيزيائية تفاعلات كيميائية
(chemical reactions or physical changes)

Endothermic processes ماص

H_2O (s)

Supplied to
إمتصاص حرارة من المحيط إلى النظام

امتص
Heat absorbed from system to surroundings

$q = +$

H_2O (l)

Exothermic processes طارد

CH_4 (g) + $2O_2$ (g)

give off
يطلق حرارة من النظام للمحيط

يطلق
Heat released from system to surroundings

$q = -$

CO_2 (g) + $2H_2O$ (l)

UQU
قسم الكيمياء

8th lecture

Changes in Enthalpy (ΔH)

الأستاذ / محمد ماهر
مدرس كيمياء وفيزياء
٠٥٦٩٤٨٨٨٠٥

- Consider the following expression for a chemical process:

$$\Delta H = H_{products} - H_{reactants}$$

$\Delta H = +$ If $\Delta H > 0$ then $q_p > 0$. (+) The reaction is endothermic

$\Delta H = -$ If $\Delta H < 0$ then $q_p < 0$. (-) The reaction is exothermic

$$\Delta H = q_p$$

q_p : heat at constant pressure

Calorimetry: the measurement of heat change

8th lecture

Enthalpy of Chemical Reactions

المحتوى الحراري للتفاعلات الكيميائية

H

الأستاذ / محمد طاهر
مدرس كيمياء وفيزياء
٠٥٦٩٢٨٨٨٠٥

Definition of Enthalpy

تعريف المحتوى الحراري

- Thermodynamic Definition of Enthalpy (H):

$$H = E + PV$$

E = energy of the system — طاقة النظام

P = pressure of the system — ضغط النظام

V = volume of the system — حجم النظام

energy + heat + work

$$E = q + W$$

$$W = F \times d$$

force × distance

صيغة القانون الأول للديناميكا الحرارية

قسم الكيمياء
Department of Chemistry

universe = System + Surroundings

8th lecture

Thermochemistry

الكيمياء الحرارية

دراسة تغير الحرارة في التفاعل الكيميائي

Thermochemistry is the study of **heat change** in chemical reactions.

Exothermic process is any process that gives off heat – transfers thermal energy from the system to the surroundings.

released

$2H_2\,(g) + O_2\,(g) \longrightarrow 2H_2O\,(l) + \text{energy}$ $\quad \Delta H = -$

$H_2O\,(g) \longrightarrow H_2O\,(l) + \text{energy}$

less than

Endothermic process is any process in which heat has to be supplied to the system from the surroundings.

greater than

$\text{energy} + 2HgO\,(s) \longrightarrow 2Hg\,(l) + O_2\,(g)$ $\quad \Delta H = +$

absorbed

$\text{energy} + H_2O\,(s) \longrightarrow H_2O\,(l)$

الأستاذ / محمد طاهر
مدرس كيمياء فيزيائية
٠٥٦٩١٨٨٨٠٤

قسم الكيمياء
Department of Chemistry

8th lecture

Thermodynamic State Functions

أنواع الدوال — دوال الديناميكا الحرارية

• Thermodynamic State Functions: Thermodynamic properties that are dependent on the state of the system only regardless of the pathway. Examples: (Energy, pressure, volume, temperature)

تعتمد على — حالة النظام — فقط

(1)

$\Delta E = E_{final} - E_{initial}$ (التغير = النهائي − البدائي)

$\Delta P = P_{final} - P_{initial}$

$\Delta V = V_{final} - V_{initial}$

$\Delta T = T_{final} - T_{initial}$

ΔE, ΔP, ΔV, ΔT

energy — طاقة | Pressure — ضغط | Volume — حجم | Temp — درجة الحرارة

(2)

أنواع أخرى — تعتمد على المسار — (الطريق)

• Other variables will be dependent on pathway (Examples: q and w). These are Path Functions. The pathway from one state to the other must be defined.

المحتوى الحراري enthalpy — H | heat — q | work — w

قسم الكيمياء
Department of Chemistry

8th lecture

القانون الأول في الديناميكا الحرارية

First Law of Thermodynamics

الطاقة ثابتة في الكون

تعريف First Law: Energy of the Universe is Constant

$$E = q + w$$

E = energy, q = heat, w = work

q = heat. Transferred between two bodies

الحرارة تنتقل من جسم لآخر

شرط Different Temperature

w = work. Force acting over a distance (F x d)

الشغل

$$w = F \times d$$

F = قوة, d = مسافة

القوة المؤثرة خلال مسافة على الجسم

الأستاذ / محمد طاهر
مدرس كيمياء وفيزياء
٠٥٦٩٢٨٨٨٠٥

قسم الكيمياء
Department of Chemistry

8th lecture

تنتقل الحرارة دائماً من جسم ساخن الى جسم بارد object.

Heat (q)

حرارة يتساوى الجسمان
في درجة الحرارة يعني (مفقود في الحرارة يصفر)

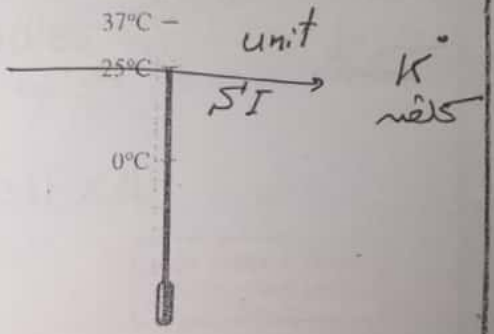
الطاقة الحرارية نقل

Heat is the transfer of thermal energy between two bodies that are at different temperatures.

تنتقل من جسم بسبب الحرارة

Temperature is a measure of the thermal energy

درجة الحرارة وقياس الطاقة الحرارية



Temperature ≠ Thermal Energy

درجة الحرارة ليست مقياس الطاقة الحرارية

قسم الكيمياء
Department of Chemistry

8th lecture

الديناميكا الحرارية
Thermodynamics

تعريف

دراسة علمية

Thermodynamics is the scientific study of the interconversion of heat and other kinds of energy

تحول داخلي

الحرارة

وأنواع الطاقات

الأستاذ / محمد طاهر
مدرس كيمياء وفيزياء
٠٥٦٩٤٨٨٨٠٥

قسم الكيمياء
Department of Chemistry