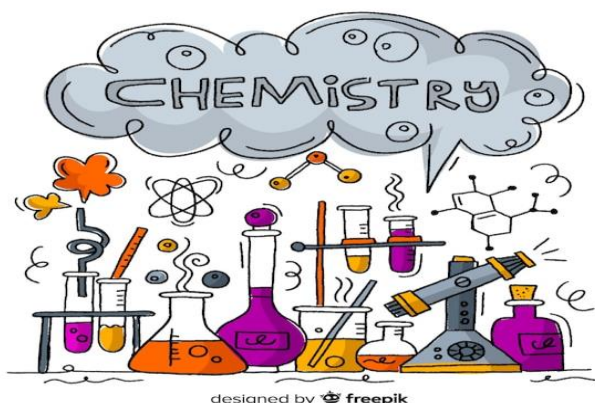




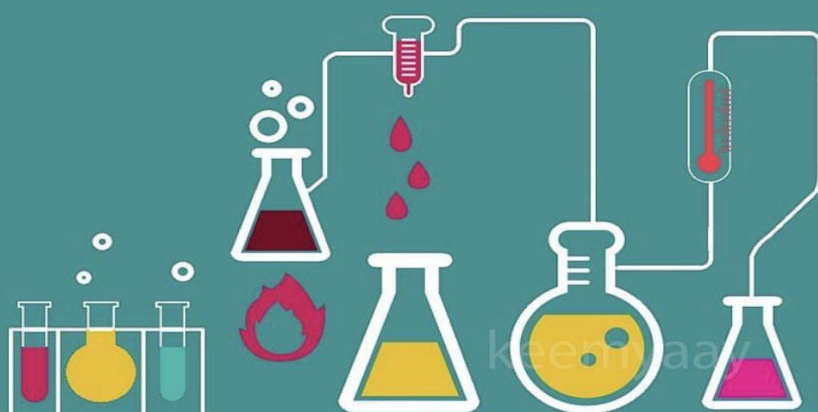
الكيمياء هي الحياة

مستر محمود بسيوني

ماجستير في الدراسات التربوية

باحث دكتوراه بجمهورية مصر العربية جامعة كفر الشيخ

الحياة كيمياء



الصف الثاني

عشر

المتقدم

خفف أحزانك، بخّر مخاوفك،
رشح أخطائك، اغلي غرورك،
لتحصل على بلّورات السعادة



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رواد التعليمية

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A

Energy and the chemical change

Section 1 : energy

Main idea: energy can change form and flow but always conserved.

CHEM 4you: when roller coaster zoom up and down each time a coaster climbs a steep grade or plunges down, the energy changes from one form to another.

Items	Definition
Energy	Is the ability to do work or produce heat .
Potential energy	Is energy due to the composition or position of an object .
Kinetic energy	Is energy of motion .
Law of conservation of energy (the first law of thermodynamics)	In any chemical reaction or physical process, energy can be converted from one to another, but its neither created nor destroyed .
Chemical potential energy	That energy stored in a substance because of its composition .
Heat (q)	Is energy that is in the process of flowing from a warmer object to a cooler object spontaneously .
calorie	The amount of energy required to raise the temperature of 1g of pure water by on degree Celsius .
Joule	The si unit of energy and of heat .
Specific heat of substance	Is the amount of heat required to raise the temperature of 1g of that substance by one degree Celsius (1C) .

the nature of energy :-

- Solar energy, nuclear energy efficient automobiles and other energy related topics are often discussed in the media.
- Energy used to: cook food, propels the vehicles, maintain a comfortable temperature in the home and school from burning fuels.
- Electric energy provides light and powers devices from computers and TV sets to cellular phones.
- In fact you can think of each cell in your body as a miniature factory that runs on energy derived from the food you eat.
- Energy exists in two basic forms, potential energy and kinetic energy.
- At the top of the course the skier has high P.E because of his position, the skier's P.E changes to K.E.
- Chemical systems contain both K.E and P.E.
- When temperature increase the motion of submicroscopic particles increase.
- K.E of substance is directly related to the constant random motion of its representative particles and is proportional to temperature.
- **The P.E depends on its composition:**
 - 1) The types of atoms.
 - 2) The number of chemical bonds.
 - 3) The number of chemical bonds joining the atoms.
 - 4) The particular way the atoms are arranged.

Law of conservation of energy :-

- Energy can change from one form to another but it always conserved the total amount energy remain constant.
- The potential energy stored in the bonds of propane molecules is converted to heat.

Example	Convert energy
Candle	Chemical potential energy → heat and light energy .
In hydroelectric plant: Water fall through in tank from its high position in the reservoir after that the rushing water spins the turbine .	Potential energy of water → kinetic → electric energy
Battery	Chemical potential energy → electric energy
Propane C ₃ H ₈ (fuel for cooking)	Chemical potential energy → heat and light energy .

	Heat (q)	Temperature
Definition	Is the energy that is ion process of flowing from a warmer object to a cooler object .	Is measurement of average kinetic energy of particles in a sample of substance .
Units	Cal , cal J , kJ	C° , K° , F°
The SI unit	Joule (J)	K°
Device used	Calorimeter	Thermometer

- The principal component of gasoline is octane (C₈H₁₈)
- When gasoline burns in an automobile's engine some of octane's chemical potential energy is converted to the work of moving the pistons which ultimately moves the wheels.
- Much of the chemical potential energy of octane is released as heat.
- When the warmer object loses energy its temperature decreases and the cooler absorbs energy its temperature rises.

Measuring heat :-

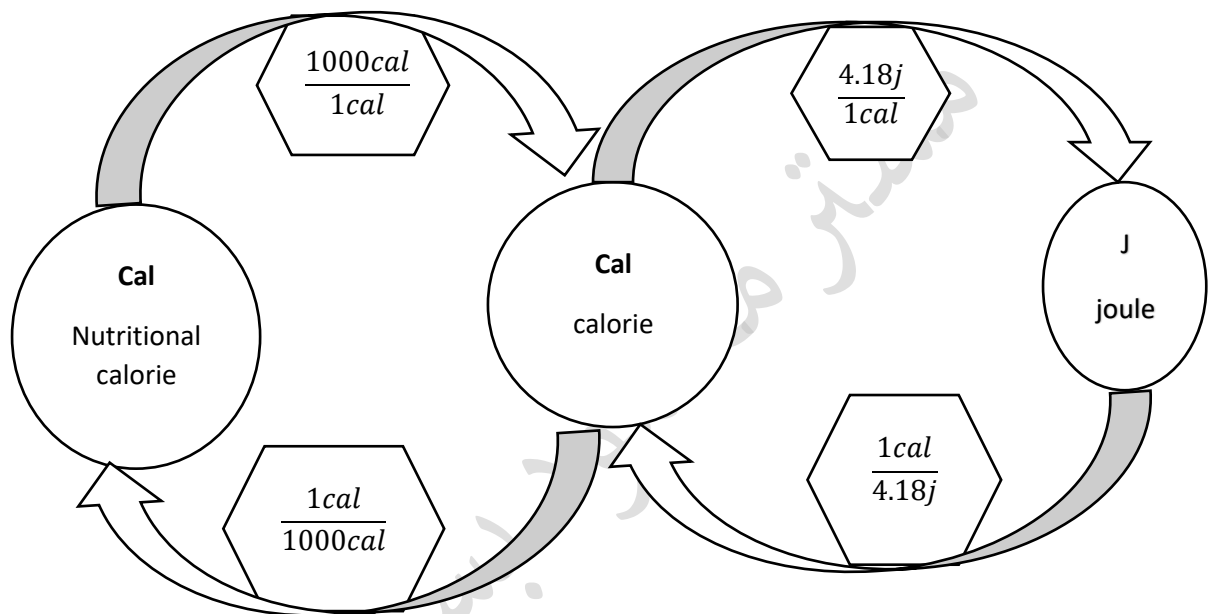
- The flow of energy and the resulting change in the temperature are clues to how heat is measured.
- What is the meaning one tablespoon of butter contains 100 calories? This means that if the butter was burned completely to produce CO₂ and H₂O 100 cal will be released.
- The relationships between calories, nutritional calories, joules and kilojoules.

Relationship Conversion
factors .

$$\begin{array}{r}
 1\text{J} = 0.2390\text{cal} \quad \frac{1\text{J}}{0.2390\text{cal}} \\
 \hline
 0.2390\text{ cal} \\
 \hline
 1\text{J}
 \end{array}$$

$$\begin{array}{r}
 1\text{cal} = 4.184\text{ J} \quad \frac{1\text{cal}}{4.184\text{J}} \\
 \hline
 4.184\text{J} \\
 \hline
 1\text{cal}
 \end{array}$$

1calorie=	$\frac{1J}{0.2390cal}$
1Kcal	$\frac{1000cal}{1\ calorie}$



Example 1:

- A break of cereal, orange juice and milk might contain 230 nutritional calories exoress this energy in joules?

Soloution:

$$230\ cal \times \frac{1000cal}{1cal} = 2.3 \times 10^5 cal$$

$$2.3 \times 10^5 cal \times \frac{4.184\ j}{1\ cal} = 9.6 \times 10^5 cal$$

Application :-

- 1- A fruit and oatmeal bar contain 142 nutritional calories convert this energy to calories.
- 2- An exothermic reaction releases 86.5kj how many kilocalories of energy are releases?

Specific heat :-

- **Each substance has its own specific heat (why?)**
Because different substance have different compositions.
- **What is meaning of specific heat of water is 4.184 j/g.k ?**
Mean: to raise the temperature of water by 1c, 4.148 j must be absorbed by every gram of water.
- **The specific heat of concrete is 0.48 j/(g.c) :** which means that the temperature of concrete increases roughly 5 times more than water's temperature when equal masses of concrete and water absorb the same amount of energy .
- **Relationship between Cp, ΔT inversely:** if substance has high specific heat it will appear small change in temperature.

Calculating heat absorbed and heat released :-

$$Q = m \times c \times \Delta T$$

- For the same mass and change temperature the water absorbed than 5 times the amount absorbed by the concrete (why?)

Because the specific heat of water is 4.184 j/g.c equal 5 times specific heat of concrete (0.84j/g.c) that mean the temperature of concrete increases roughly 5 times more than water's temperature when equal masses of concrete and water absorb the same amount of energy.

Notes: the cooler water of the fountain are welcome after walking on the hot concrete sidewalk. the water is cooler because the water must absorb 5 times the number of joules as concrete to each an equivalent temperature.

Determining specific heat :

Example: a piece of metal with a mass of 4.68 g a absorbs 256j of heat when it's temperature increases by 182 c° what is the specific heat of the metal? could the metal be one of the alkaline earth metals in the table.

Solution: (metal = $\frac{q}{m \times \Delta T} = \frac{256J}{4.68g \times (182c^\circ)} = 0.301J / (g.c^\circ)$)

Using the sun's energy:

- Water is sometimes used to harness the energy of the sun
(why?)
Because of its high specific heat (4.184 j/g.c°)
- The hot water can be circulated in homes and business to provide heat.
- Radiation from the sun could supply all energy needs of the world and reduce or eliminate the use of CO₂ producing fuels.

Factors have delayed the development of solar technologies:

- 1- The sun shines for only a part of each day.
- 2- In some areas, clouds often reduce the amount of available radiation because of this variability effective methods for storing energy are critical.

Photovoltaic cells : A device convert solar radiation directly to electricity .

Uses of photovoltaic cell : These supply power for astronauts in space.

Disadvantages of photovoltaic cell: they are not used extensively for ordinary needs because of the cost of supplying electricity by means of photovoltaic cells is high compared the cost of burning coal or oil.

Applications :-

- 1- A 90.0g sample of an unknowing metal absorbed 25.6j heat as it's temperature increased 1.18°C , what is the specific heat of metal?
- 2- The temperature of a sample of water increases from 20.0°C TO 46.6°C as it absorbs 5650j of heat, what is the mass of the sample?
- 3- How much heat is absorbed by a $2.00 \times 10^3\text{g}$ granite boulder (c granite = $0.803\text{j} / (\text{g}\cdot^{\circ}\text{C})$) as it's temperature changes from 10.0°C TO 29.0°C ?
- 4- If the temperature of 34.4g of ethanol increases from 25.0°C to 78.8°C , how much heat has absorbed by the ethanol?
- 5- A 155g sample of an unknown substance was heated from 25.0°C to 40.0°C in the process, the substance absorbed 5696g of energy, what's the specific heat of the substance? identify the substance?
- 6- A 4.50g nugget of pure gold absorbed 276j of heat the initial temperature was 25.0°C what was the final temperature?
- 7- The temperature of a sample of iron with a mass of 10.0g changed from 50.4°C to 25.0°C with the release of 114j , what is the specific heat of iron ?

- 8- If 335g of water at 65.5C° loses 9750j of heat , what is the final temperature ?
- 9- Calculate the amount of heat absorbed by 5.00×10^3 g block of concrete side walk if temperature increases by 6.0C° (concrete = 0.84j / (g.c°) and compare the absorbed heat by water if water has the same mass?
- 10- Calculate the amount of heat absorbed when 5.5 g of aluminum is heated from 25.0C° to 95C° the specific heat of aluminum is 0.897j / (g.c°) .
- 11- Equal masses of Al, Au (gold), iron (Fe), Ag (silver) were left to site in the sun at the same time and for the length of time, arrange the four metals according to the increase in their temperature.

Section2 : heat

Main idea: the enthalpy change for reaction is the enthalpy of products, the enthalpy of reactants.

CHEM 4you: some chemical reaction absorb heat whereas others release heat. **Example:**

- 1- Think about standing under a hot water relaxing as your body absorbs heat from the water.
- 2- When you jump into a cold pool you might shiver as your body loses heat.

Items	Definition
A calorimeter	Is an insulated device used for the measuring the amount of heat absorbed or released during a chemical or physical processes .

Thermochemistry	Is the study of heat changes that accompany chemical reaction and phase change .
The system	Is the specific part of the universe that contains the reaction or process you wish to study .
The surroundings	Everything in the universe other than the system .
The universe	The system plus the surroundings .
Enthalpy (H)	Is the heat content of a system at constant pressure .
Enthalpy (heat) of reaction (ΔH_{rxn})	The change in enthalpy for reaction $\Delta H_{\text{rxn}} = H_{\text{products}} - H_{\text{reactants}}$

Calorimetry :-

- Food chemists obtain calorie information that appears on packaged food from combustion reaction carried out in calorimeters.

Uses of calorimeter:-

- 1- Measuring the amount of heat that absorbed or released during chemical or physical process.
- 2- Measurement of specific heat of an known metal.

A known mass of water is placed in an insulated chamber to absorb the energy released from the reacting system or to provide the energy absorbed by the system.

The data to be collected is the change of temperature of this mass of water.

Kind of calorimeter :-

- A bomb calorimeter (that is used by food chemist)
- Simple foam-cup calorimeter.

Structure of calorimeter:-

- 1- Steel inner chamber called bomb which a sample is positioned in it.
- 2- Bomb is filled with oxygen at high pressure.
- 3- Surrounding the bomb is a measured mass of water stirred by a low friction stirrer to ensure uniform temperature.
- 4- Thermometer used to measure temperature before experiment and after.
- 5- The reaction is initiated by a spark and the temperature is recorded until it reaches its maximum.

Example: calculate the specific heat of sample of unknown metal its 50.0 g heated to 115C° after that putting it in cup's calorimeter which has 125 g of water an initial temperature of water 25.0C° is recorded and the final temperature is 29.30C°.

Solution: the heat gained by water

$$q_{\text{water}} = 4.184 \text{ j/(g.c)} \times 125\text{g} \times (29.30\text{C}^\circ - 25.60\text{C}^\circ)$$

$$= 4.184 \times 125 \times 3.7 = 1940\text{j}$$

$$q_{\text{water}} = q_{\text{metal}}$$

the heat lost by metal = the heat gained by water

$$q_{\text{metal}} = 1940\text{j}$$

$$m \times C_{\text{metal}} \times \Delta T = 1940\text{j}$$

$$C_{\text{metal}} = \frac{q}{m \Delta T} = \frac{-1940 J}{50 g \times (29.3^\circ C - 115^\circ C)} = 0.453 \text{ J/(g} \cdot ^\circ\text{C)}$$

applications:-

when a 58.8 g piece of hot alloy is placed in 125 g of cold water in a calorimeter, the temperature of the alloy decrease by 106.1°C, while the temperature of the water increases by 10.5°C what's the specific heat of the alloy?

chemical energy and the universe:-

- Virtually every chemical reaction and change of physical state release absorbs heat.
- The burning of fuel always produces heat.
- Soldiers in the field use a highly exothermic reaction to heat their meals.
- Using a heat pack to warm hands in cold days.
- The heat pack (the system) flow to your cold hands (part of the surroundings).



Universe = system + surroundings

Activity 1:

Steps: -

- Put barium hydroxide and ammonium thiocyanate crystals in a beaker.
- Put the beaker on a wet board.

Observation:

- The beaker freezes to the board.

Conclusion:

- Water is converted from liquid into ice (exothermic process).
- Heat flow from the water and board (the surroundings) into the beaker (the system).
- The reaction is endothermic because the reacting mixture draws enough energy from the water and board to lower temperature of the water and the board to freezing.

Enthalpy and enthalpy changes:

- it's impossible to know the total energy of a substance (why?)
- because the total amount of energy a substance contains depends on many factors, some of which are still not completely understood.
- for many reaction, the amount of energy lost or gained can be measured conveniently in a calorimeter at constant pressure.
- the foam cup is not sealed so the pressure is constant.
- q_p : the energy released or evolved from reaction carried out at constant pressure.
- many reactions take place at constant atmosphere pressure.

For example:

- those occur in living organisms on earth's surface, in lakes and oceans.
- Those that take place in open beakers and flasks in the laboratory.
- You cannot measure the actual energy or enthalpy of substance of substance but you can measure the change in enthalpy ΔH

$$\Delta H_{\text{rxn}} = H_{\text{products}} - H_{\text{reactants}}$$

	The heat – pack reaction	the cold – pack process
Type of system	Exothermic	Endothermic
$\Delta H_{\text{rxn}} (q_p)$	(-)	(+)
Thermochemical equation	$4\text{Fe}_{(s)} + 3\text{O}_{2(g)} \rightarrow 2\text{Fe}_2\text{O}_{3(s)}$ $\Delta H_{\text{cxn}} = -1625 \text{ kJ}$	$\text{NH}_4\text{NO}_3(s) \rightarrow \text{NH}_4^+(aq) + \text{NO}_3^-(aq)$ $\Delta H = 27 \text{ kJ}$
Enthalpy of products and reactions	$H_{\text{products}} < H_{\text{reactants}}$ The enthalpy of products is -1625 kJ less than the enthalpy of the reactant because the energy is released .	$H_{\text{products}} > H_{\text{reactants}}$ The enthalpy of products is 27kJ greater than the enthalpy of the reactant because the energy is absorbed .
Flow heat	Heat produced by the reaction flow from the heat – pack (the system) to your cold hands (part of the surroundings)	Heat flow from the surroundings to the system .

-: Section3: thermochemical equations :-

Main idea: thermochemical equation express the amount of heat released or absorbed by chemical reactions .

CHEM 4 you: when you make strenuous activity? You feel as your body has less energy than before the event. That tired feeling relates to combustion reactions that occur in the cells of your body.

item	Definition
A thermochemical equation	Is a balanced chemical equation that include the physical states of all reactants and products and the energy change (change in enthalpy ΔH)
The enthalpy (heat) of combustion (ΔH_{comb})	Is the enthalpy change for complete burning of one mole of substance .
Standard condition (STP)	Are 1 atm pressure and 298 k (25c°) and should not be confused with standard temperature and pressure .
cobusion	Is the reaction of a fuel with oxygen.

Writing thermochemical equation:-

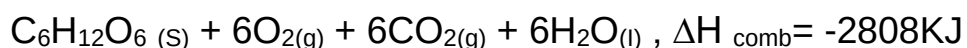
- The heat pack and cold pack equation are called thermochemical equation.



Table 3: standard enthalpies of vaporization and fusion :

substance	formula	$\Delta H^\circ_{\text{vap}}$ (kj/mol)	$\Delta H^\circ_{\text{fus}}$ (kj/mol)
Water	H ₂ O	40.7	6.01
Ethanol	C ₂ H ₅ OH	38.6	4.94
Methanol	CH ₃ OH	35.2	3.22
Acetic acid	CH ₃ COOH	23.4	11.7
Ammonia	NH ₃	23.3	5.66

- The change in energy is an important part of chemical reaction .
- The highly exothermic combustion of glucose ($C_6H_{12}O_6$) occur in the body as food is metabolized to produced energy.



- standard enthalpy changes have the symbol ΔH° (at standard condition STP : $p=1atm$, $T=298K$ ($25C^\circ$) .
- $\Delta H_{rxn} = H_{products} - H_{reactants}$.

Table 4: standard enthalpies of combustion

substance	formula	$\Delta H^\circ_{comb}(kJ/mol)$
Sucrose (table sugar)	$C_{12}H_{22}O_{11}(s)$	-5644
Octane (a component of gasoline)	$C_8H_{18}(l)$	-5471
Glucose (a simple sugar found in fruit)	$C_6H_{12}O_6(s)$	-2808
Propane (a gaseous fuel)	$C_3H_8(g)$	-2219
Methane (a gaseous fuel)	$CH_4(g)$	-891

Change of state :-

- Many processes other than chemical reactions absorb or release heat.
- When you step out of a hot shower, you shiver as water evaporates from your skin. that is because your skin provide the heat needed to vaporize the water.
- As a heat is taken from your skin to vaporize the water, you cool down.
- If you want a glass of cold water you might drop an ice cube into it, the water cools as it provides the heat to melt the ice.

	Molar enthalpy (heat) of fusion	Molar enthalpy (heat) of vaporization
Definition	The heat required to melt 1 mole of a solid substance .	The heat required to vaporize 1 mole of a liquid substance .
Symbol	ΔH_{fus}	ΔH_{vap}
Unit	KJ/mole	KJ/mole
Type of process	Endothermic process	Endothermic process
Example	$\text{H}_2\text{O}_{(\text{s})} \rightarrow \text{H}_2\text{O}_{(\text{l})}$, $\Delta H_{\text{fus}} = +6.01$ KJ/mole	$\text{H}_2\text{O}_{(\text{l})} \rightarrow \text{H}_2\text{O}_{(\text{g})}$, $\Delta H_{\text{vap}} = +40.7$ kJ/mole

Is meaning molar enthalpy (heat) of vaporization for water equal 40.7kJ/mole?

- That mean energy required to vaporate 1 mole of water to 1 mole of water vapour equal 40.7 kJ (energy is absorbed).
- $\text{H}_2\text{O} \rightarrow \text{H}_2\text{O}_{(\text{g})}$, $\Delta H_{\text{vap}} = +40.7\text{kJ}$

Is meaning molar enthalpy (heat) of fusion for ice equal 6.01 kJ/mole?

- That mean energy required to melt 1 mole of ice to 1 mole of liquid water equal 6.01 kJ (energy is absorbed)
- $\Delta H_{\text{vap}} = -\Delta H_{\text{cond}}$
- $\Delta H_{\text{fus}} = +\Delta H_{\text{solid}}$
- $\text{H}_2\text{O}_{(\text{g})} \rightarrow \text{H}_2\text{O}_{(\text{l})}$, $\Delta H_{\text{cond}} = - 40.7\text{kJ}$
- $\text{H}_2\text{O}_{(\text{l})} \rightarrow \text{H}_2\text{O}_{(\text{s})}$, $\Delta H_{\text{solid}} = - 6.01\text{kJ}$

	Molar enthalpy (heat) of solidification	Molar enthalpy (heat) of condensation
Definition	The heat released when freezing 1 mole of a liquid into solid	The heat released when condensed 1 mole of gas into liquid .
Symbol	ΔH_{solid}	ΔH_{cond}
Unit	Kj/mole	Kj/mole
Type of process	Exothermic process	Exothermic process
Example	$\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}, \Delta H_{\text{solid}} = - 6.01$ kj/mole	$\text{H}_2\text{O}_{(g)} \rightarrow \text{H}_2\text{O}_{(l)}, \Delta H_{\text{cond}} = - 40.7$ kj/mole

Notes:

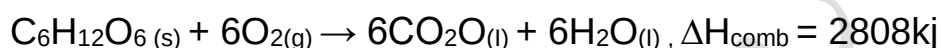
- 1- Some farmers make use of the heat of fusion of water to protect fruit and vegetables from freezing if the temperature is predicted to drop to freezing they flood their orchards or fields with water (why?)
 - When the water freezes, energy (ΔH_{fus}) is released and warms the surrounding air enough to prevent frost damage.
- 2- When the mole of glucose is burned in a bomb calorimeter, 2808kj of energy is released the same amount of energy is produced in your body when an equal mass of glucose is metabolized in the process of cellular respiration the process takes place in every cell of your body in a series of complex steps in which glucose is broken down and CO_2 and H_2O are released these are the same products produced by the combustion of glucose in a calorimeter.

3- The energy released is stored as chemical potential energy in the bonds of molecules of adenosine triphosphate (ATP) when energy is needed by any part of the body, molecules of ATP released their energy .

$$\Delta H_{\text{(reaction)}} = \sum \Delta H_{\text{f(products)}} - \sum \Delta H_{\text{f(reactants)}}$$

Example:

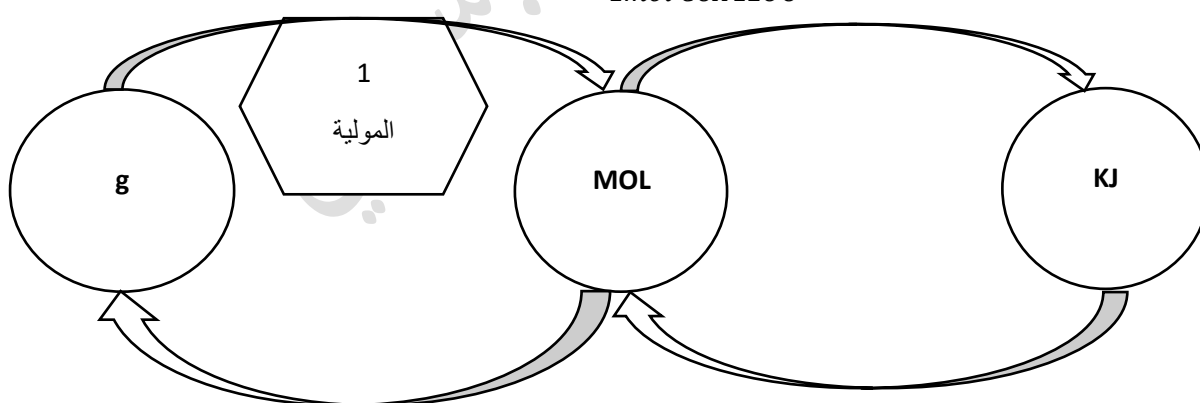
A bomb calorimeter is useful for measuring the energy released in combustion reactions the reaction is carried out a constant volume bomb with a high pressure oxygen, how much heat is evolved when 54.0g glucose (C₆H₁₂O₆) is burned according to this equation?



Atomic mass = (c=12 , o=16 , h=1)

Solution : $54.0 \text{ g C}_6\text{H}_{12}\text{O}_6 \times \frac{1\text{mol C}_6\text{H}_{12}\text{O}_6}{180\text{g C}_6\text{H}_{12}\text{O}_6} = 0.300\text{mol C}_6\text{H}_{12}\text{O}_6$

$$0.300\text{mol C}_6\text{H}_{12}\text{O}_6 \times \frac{2808\text{KJ}}{1\text{mol C}_6\text{H}_{12}\text{O}_6} = 842 \text{ KJ}$$



Applications:-

- 1- Calculating the heat required to melt 25.7g of solid methanol CH₃OH at its melting point? ($\Delta H_{\text{fus}} = +3.22 \text{ kJ/mole}$)
- 2- How much heat evolve when 275g of ammonia gas (NH₃) condenses to liquid at its boiling point? ($\Delta H_{\text{cond}} = - 23.3\text{kJ/mole}$)

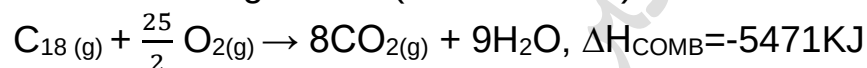
- 3- Challenge : what mass of methane (CH₄) must be burned in order to liberate 12880kj of heat?
- 4- How much heat is released by combustion of 206g of hydrogen gas? ($\Delta H_{\text{com}} = - 286 \text{ kJ/mole}$)
- 5- The molar heat of vaporization of ammonia is 23.3kJ/mol , what is the molar heat of condensation of ammonia?

Combustion reaction:-

- Is the reaction of a fuel with oxygen.
- In abiological system food is the fuel.

Combustion reaction very important for :

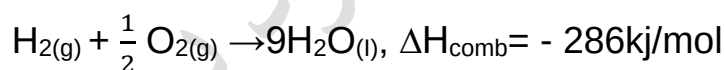
- 1- To keep your body warm (combustion of glucose)
- 2- To transport you in vehicles cars, airplanes, boats and trucks run on the combustion of gasoline (octane C₈H₁₈)



- 3- One way you might heat your home or cook your food is by burning methane gas (CH₄).



- 4- The combustion of H₂ provides the energy to lift the shuttle into space.



Section4: calculating enthalpy change

Main idea : the enthalpy change for a reaction can be calculated using hess's law .

CHEM 4 you : hess's law make chemical equation like algebra equation.

Item	Definition
Hess's law	State that if you can added two or more thermochemical equation for a reaction then the sum of the enthalpy changes for the individuals reactions is the enthalpy change for the final reaction.
The standard enthalpy (heat) of formation (ΔH_f°)	The change in enthalpy that accompanies the formation of one mole of the compound in its standard state from its elements in their standard states .

**The
standard
state of a
substance**

That mean the normal physical state of the substance at 1 atm and 298 k (25C°)

Hess's law:

-by hess's law we can measure the ΔH of the reaction which it is impossible or impractical to measure it by calorimeter.

Example:

- The conversion of carbon in its allotropic form (diamond) to carbon in its allotropic form (grapite).
- This reaction occurs so slowly that measuring the enthalpy change is impossible.
- The durability of diamonds tells you the conversion of diamond to graphite is so slow that it would be impossible to measure its enthalpy change.
- Other reaction occurs under the conditions difficult to duplicate in a laboratory.
- Still other produce products other than the desired ones.
- For these reaction chemists use a theoretical way to determine ΔH .

Suppose you are studing the formation of SO₃ in the atmosphere:

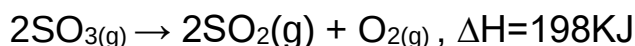
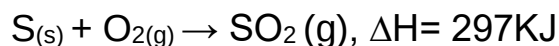
- You would need to determine ΔH for this reaction :
$$2S_{(s)} + 3O_{2(g)} \rightarrow 2SO_3(g), \Delta H = ? \text{ KJ}$$
- Unfortunately, laboratory experiments to produce SO₃ and determine its ΔH result in a mixture of a products that is mostly SO₂.
- You can calculate ΔH by using hess's law of heat summation .

Applying hess's law :-

Example : calculate the enthalpy change ΔH for this reaction?



If you know the following equation :

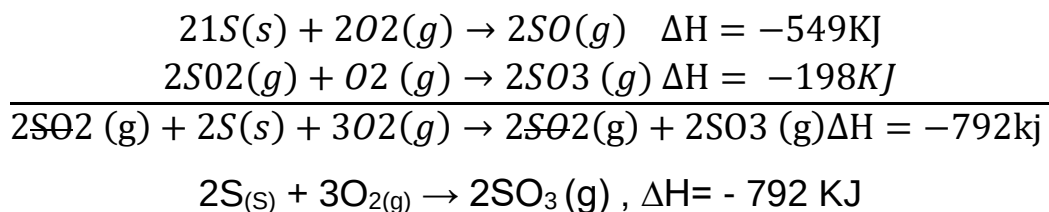


Solution :-

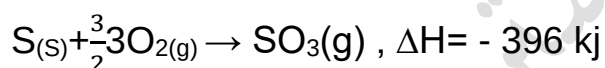
Step1: multiplying the coefficients of equation (1) by 2 double the enthalpy change.

Step 2: revers an equation (2) you must change the sign of its ΔH .

Step 3: added two equation to obtained the desired reaction.

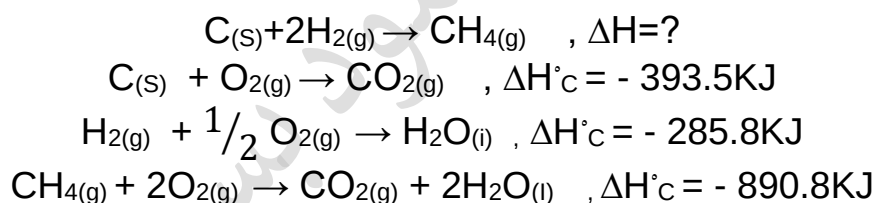


Note: the thermochemical equation for the reacting between sulfur and oxygen to form 1 mole of sulfur trioxide is the following:

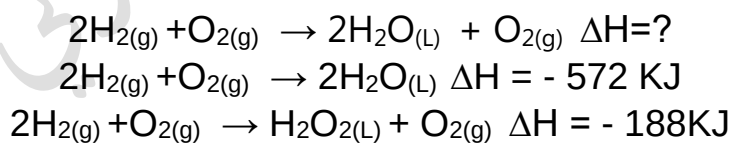


Application :-

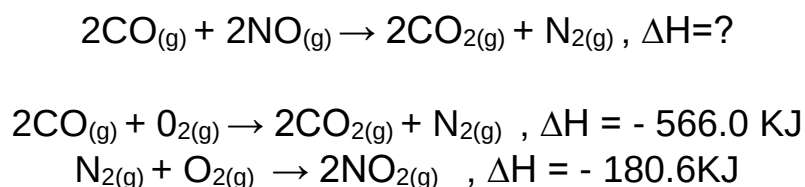
1- By uses hess's law calculate the enthalpy change for the following reactions?



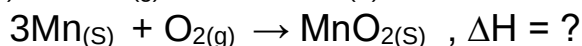
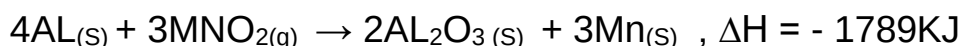
2- By using hess's law calculate the enthalpy change of the following reactions?



3- Use two equations to determine ΔH for the following reaction?



4- Challenge : ΔH for the following reactions is – 1789 kJ use this and equation (a) to determine ΔH for equation (b) :



Standard enthalpy (heat) of formation (ΔH_f°):-

- Hess's law allow you to calculate unknown ΔH values unknown reaction.
- Their reactions experimentally determine ΔH values.
- Scientists record and use enthalpy changes for only one type of reaction, a reaction in which a compound is formed from elements in their standard states.

Example: a typical standard heat formation reaction is the formation of 1 mole of SO_3 from its elements



Note: SO_3 is a suffocating gas that produces acid rain when mixed with moisture in the atmosphere to form sulfuric acid H_2SO_4 which reaches earth as acid precipitation which slowly destroy trees and property.

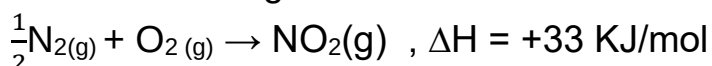
Where do standard heats of formation come from?

- Elements on their standard state have a ΔH_f° of a 0.0 kJ .
- Think of zero of enthalpy scale as being similar to the arbitrary assignments of 0.0°C to the freezing point of water.

Enthalpies of formation from experiments:

- standard enthalpies of information of many compounds have been measured experimentally.

Example: formation of nitrogen dioxide.



- on the scale of standard enthalpies of formation of NO_2 is placed 33.2 KJ above the elements from which it was formed.
- Sulfur trioxide (SO_3) is placed 396 kJ below zero on the scale because the formation of SO_3 is exothermic reaction.

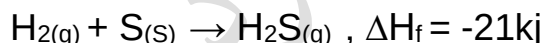
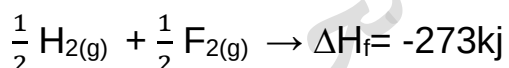
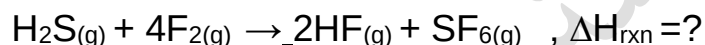
Table 5: standard enthalpies of formation :-

Compound	Formation equation	ΔH_f° (kJ/mol)
H ₂ S(s)	H ₂ (g) + S(s) → H ₂ S(g)	-21
HF(g)	$\frac{1}{2}$ H ₂ (g) + $\frac{1}{2}$ F ₂ (g) → HF(g)	-273
SO ₃ (g)	S(s) + $\frac{3}{2}$ O ₂ (g) → SO ₃ (g)	-396
SF ₆ (g)	S(s) + 3F ₂ (g) → SF ₆ (g)	-1220

using standards enthalpies of formation :-

- Standard enthalpies of formation can be used to calculate the enthalpies of many reactions.

Example: calculate $\Delta H_{\text{rxn}}^\circ$ for this reaction :

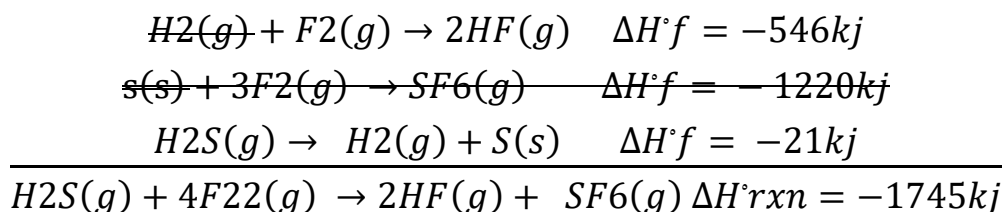


Solution:

Step 1: multiplying the coefficients of equations (1) by 2 double the enthalpy change.

Step 2: reverse an equations (3) you must change the sign of its ΔH .

Step 3: added three equations to obtained the desired reaction.

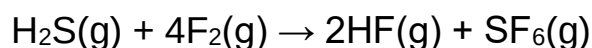


Note: sulfur hexafluoride SF₆ is used to etch minute and sometimes intricate patterns on silicon wafers in the production semiconductor devices, semiconductor are important components of modern electronic equipment, include computers, cell phones, and MP3 players.

The summation equation :

- The stepwise procedure you have just read about shows how standard heats of formation equations combine to produce the desired equation and its ΔH_{rxn} .
- The procedure can be summed up in the following formula.
$$\Delta H^{\circ}_{\text{rxn}} = \sum \Delta H^{\circ}_{\text{f}}(\text{products}) - \sum \Delta H^{\circ}_{\text{f}}(\text{reactants})$$
- ΔH_{rxn} is obtained by subtracting the sum of heats of formation of the reactants from the heats of formation of products.

Another solution for example 2:

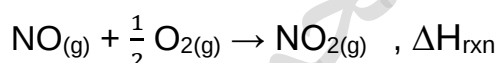


$$\Delta H^{\circ}_{\text{rxn}} = [(2) \Delta H^{\circ}_{\text{f}}(\text{HF}) + \Delta H^{\circ}_{\text{f}}(\text{SF}_6)] - [\Delta H^{\circ}_{\text{f}}(\text{H}_2\text{S}) + (4) \Delta H^{\circ}_{\text{f}}(\text{F}_2)]$$

$$\Delta H_{\text{rxn}} = [(-273\text{KJ}) + (-1220\text{KJ})] - [-21\text{KJ} + 4(0.0\text{KJ})]$$

$$\Delta H^{\circ}_{\text{rxn}} = -1745 \text{ KJ}$$

Example : calculate the ΔH_{rxn} for the following reaction :



$\Delta H^{\circ}_{\text{f}}(\text{NO}_2) = +33.2 \text{ kJ/mol}$, $\Delta H^{\circ}_{\text{f}}(\text{NO}) = +90.29 \text{ KJ/mol}$ M $\Delta H^{\circ}_{\text{f}}(\text{O}_2) = 0 \text{ KJ/mol}$

Solution :

$$\Delta H^{\circ}_{\text{rxn}} = \sum \Delta H^{\circ}_{\text{f}}(\text{products}) - \sum \Delta H^{\circ}_{\text{f}}(\text{reactants})$$

$$\Delta H^{\circ} = \Delta H^{\circ}_{\text{f}}(\text{NO}_2) - [\Delta H^{\circ}_{\text{f}}(\text{NO}) + \Delta H^{\circ}_{\text{f}}(\text{O}_2)]$$

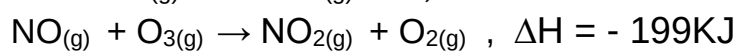
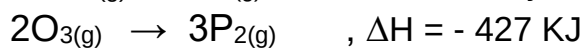
$$= +33.2 \text{ KJ/mol} - (+90.29 \text{ kJ/mol} + 0 \text{ kJ/mol})$$

$$= 33.2 \text{ kJ/mol} - 90.29 \text{ kJ/mol}$$

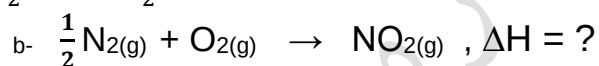
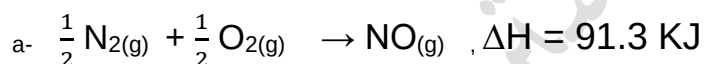
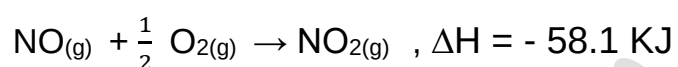
$$= -57.1 \text{ kJ}$$

Application:-

1- By using hess's law to calculate the ΔH_{rxn} for the following reaction?



2- Challenge : two enthalpy of formation equation a and b , combine to form the equation for the reaction of nitrogen oxide and oxygen . the product of the reaction is nitrogen dioxide :



What is the ΔH_f for equation b?

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