Thermodynamics and **irreversibility complexes** for Life

Hess law and Prigogine attractors create order in chaos
U - Internal Energy; **H** – Enthalpy (Heat content);
S – Entropy, on changes (entity): *Greek language- en tropos*
G – Free Energy: Gibbs Energy

One mol Standard values of Enthalpy (Heat content) **ΔH°;** of Entropy **ΔS°;** of Gibbs Energy **ΔG°** for pure compound

Hess law for Heat, Entropy, Gibbs Energy change in Reaction

$$\Delta S_{dispersed} = -\Delta H_{Hess}/T$$

$$\Delta S_{total} = \Delta S_{Hess} + \Delta S_{dispersed}$$

bound energy $\Delta S_{total} \cdot T = -\Delta G_{Hess}$

$$\Delta H_{Hess} = \Sigma \Delta H^{\circ}_{product} - \Sigma \Delta H^{\circ}_{reactants};$$

$$\Delta S_{Hess} = \Sigma \Delta S^{\circ}_{product} - \Sigma \Delta S^{\circ}_{reactants};$$

$$\Delta G_{Hess} = \Delta H_{Hess} - T \cdot \Delta S_{Hess};$$

Negative **ΔG** the process (reaction) is **spontaneous, favored** (**ΔG<0**)
Positive **ΔG** process is forbidden, **non-spontaneous, unfavored** (**ΔG>0**)
Equilibrium Prigogine attractor is Gibbs free energy minimum $|\Delta G_{eq}|$

$$|\Delta G_{Hess}| > |\Delta G_{equilibrium}|; \ \Delta G_{equilibrium} = -R \bullet T \bullet \ln(K_{equilibrium}) .$$

$$\Delta G = \Delta G_{non\_equilibrium} = \Delta G_{equilibrium} + R \bullet T \bullet \ln(K_{homeostasis}) .$$

One mol compound A Chemical Potential μ_A calculates Δn_A as $\mu_A = \Delta G_A / \Delta n_A = \Delta G^{\circ}_A + R \bullet T \bullet \ln(X_A)$; ${}^{kJ}/_{mol}$ in mixture always is negative value of $\ln(X_A) < 0$ because $X_A < 1$ smaller as one.

Concentration Expression $X_A = n_A / n_{total}$ – Mole fraction

Equilibrium Constant $K_{equilibrium} = \left(\frac{X_C^c \bullet X_D^d}{X_A^a \bullet X_B^b} \right)$ value not depends but **Homeostasis constant** $K_{homeostasis}$ depends on mixture X_C, X_D, X_A, X_B $\Delta G_{Homeostasis} = \Delta G_{eq} + R \bullet T \bullet \ln(K_{Homeostasis})$.

Free Energy change in Equilibrium forms minimum as zero is $\Delta G = 0 = \Delta G_{eq} + R \bullet T \bullet \ln(K_{eq})$. So free energy change one calculates with negative natural logarithm $\Delta G_{eq} = -R \bullet T \bullet \ln(K_{eq})$ equilibrium constant K_{eq}. Its absolute value $|\Delta G_{eq}|$ at equilibrium is less the Hess law absolute value $|\Delta G_{Hess}|$ of pure reactants and products.

Free energy changes in **homeostasis** $\Delta G_{Homeostasis}$ irreversible processes are Prigogine attractors which drive dissipative structure containing with Brownian molecular engines as organisms life evolution and survival **homeostasis** instruments.

Chemical potential μ and **Process Spontaneous Direction** in Homeostasis

Professor Ilya Prigogine **chemical potential μ** of compound **A** shows, how much change of **free energy** ΔG_A brings into system of our interest when adding the **1 mol** amount of compound **A** in the mixture.
In a fact: how great amount of free energy belongs to one **1 mol** of compound in mixture.
Free energy $\Delta G°_A$ has the pure compound **A** itself per **1 mol** amount,
the **chemical potential** μ_A of compound **A** if amount with in mixture others for molar number is $\Delta n_A = 1$ **mol**

$\mu_A = \frac{\Delta G_A}{\Delta n_A}$; $\mu_A = \Delta G°_A + R \bullet T \bullet \ln(X_A)$, where X_A is concentration of **A** unit less **mol fraction** X_A

$= \frac{n_A}{n_{total}}$ (5)

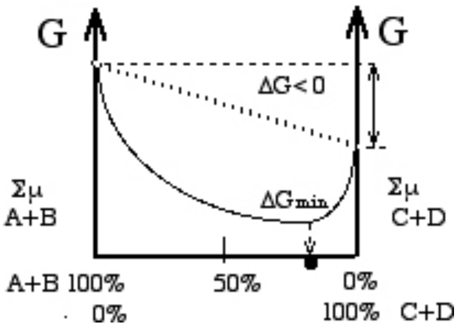
For pure compound **A** when $n_A = n_{total}$ **mol fraction** is $X_A = 1$ so $\ln(1) = 0$ and
$\mu = \Delta G°_A$ that present **standard free energy** of formation the **1 mol** pure compound **A** from elements.
Conflict in consideration pure compound $\Delta G°_A$ greater as mixture amount for one mole $|\mu_A| < |\Delta G°_A|$.
Minimisation in mixture I. Prigogine, R. Defey. "Chemical Thermodynamics".1954, Longmans Green & co ©.

Chemical equilibrium and **Thermodynamics** of energy minimum

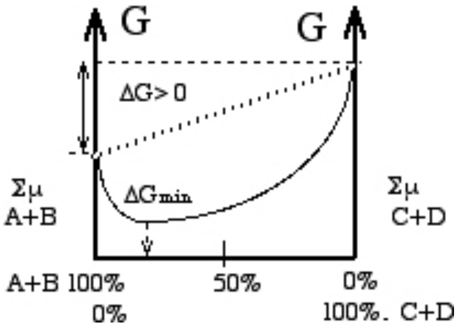
Free energy change-difference of pure products and reactants $\Delta G°_{Hess}$ is criteria of process direction spontaneous for pure products 100% (negative $\Delta G°_{Hess} < 0$) or thermodynamic forbidden, as products are absent 0%, but reactants are pure 100% (positive $\Delta G°_{Hess} > 0$).

In state of equilibrium sum of chemical potentials for initial compounds is equal to sum of chemical potentials for products – according chemical reaction equation reactants aA + bB and products cC + dD:

$aA + bB \underset{revers}{\overset{direct}{\rightleftarrows}} cC + dD$; **chemical potential** sum at equilibrium are equal $a\mu_A + b\mu_B = c\mu_C + d\mu_D$,



Strong electrolytes



weak acids and electrolytes

The concentrations **X** of **reactants** and **products** at **equilibrium** mixture define the **equilibrium constant**, K_{eq}. **Chemical potential** sum for **reactants** $\Sigma\mu_{reactant}$ and **products** $\Sigma\mu_{product}$ at equilibrium are equal:

$\Sigma\mu_{reactant} = \Sigma\mu_{product}$;

and free energy change for reaction is zero: $0 = \Delta G = \Sigma\mu_{product} - \Sigma\mu_{reactant}$ as minimum energy in mixture. Than energy minimum $\Delta G°_{eq}$ is calculated of mixture **chemical potential** sum equivalence $a\mu_A + b\mu_B = c\mu_C + d\mu_D$;

$$-\Delta G°_{eq} = R \bullet T \bullet \ln\left(\frac{X_C^c \bullet X_D^d}{X_A^a \bullet X_B^b}\right) = R \bullet T \bullet \ln(K_{eq}) ;\ K_{eq} = \frac{X_C^c \bullet X_D^d}{X_A^a \bullet X_B^b} \qquad (1\text{-}3)$$

Reaching equilibrium becomes zero: $\Delta G_{Homeostasis} = \Delta G_{eq} + R \bullet T \bullet \ln\left(\frac{X_C^c \bullet X_D^d}{X_A^a \bullet X_B^b}\right) = 0$ and calculates ΔG_{eq}

$$\Delta G_{eq} = -R \bullet T \bullet \ln\left(\frac{X_C^c \bullet X_D^d}{X_A^a \bullet X_B^b}\right) = -R \bullet T \bullet \ln(K_{eq}) ;\ K_{eq} = \frac{X_C^c \bullet X_D^d}{X_A^a \bullet X_B^b} \qquad (1\text{-}3)$$

In each sum a, b, c, and d are the number of molecules of A, B, C, and D participating in active mass law, the **equilibrium constant** is expressed by (1-3) where X_A, X_B, X_C, and X_D are the **molar fraction** concentrations of the reaction components (reactants and products) at the minimum point of **equilibrium** mixture.
When the **equilibrium** is shifted out then start to work Le Chatelier's principal toward reaching **equilibrium** as Prigogine attractor the **free**-energy change minimum point ΔG_{min}. Under **standard conditions 298.15 K**, **25 °C**, when reactants and products are present in **molar fraction** concentrations, at partial pressures for total pressure as sum $p_{total} = 101.3$ **kilo-Pascals (kPa)**, the force driving the system toward equilibrium is defined as Prigogine attractor **free**-energy change minimum point ΔG_{eq}. By this definition the **standard state** for reactions maintains equilibrium constant value in ratio $\frac{X_C^c \bullet X_D^d}{X_A^a \bullet X_B^b} = K_{eq}$.

$\Delta \mathbf{G}_{eq}$ is a constant: it has a characteristic, unchanging value for a given reaction. But the actual **free**-energy change, $\Delta \mathbf{G}$, is a function of **reactant** and **product** concentrations **X** and of the temperature $\mathbf{T = 310.15\ K}$ prevailing during the reaction in human body, which will not necessarily match the **standard conditions**. Moreover, the $\Delta \mathbf{G}$ of any reaction proceeding → spontaneously toward its **equilibrium** state is always negative $\mathbf{\Delta G<0}$, becomes less negative reaching equilibrium point and $\mathbf{\Delta G=0}$ is zero with $(\mathbf{XD}^d \bullet \mathbf{XC}^c)/(\mathbf{XA}^a \bullet \mathbf{XB}^b) = \mathbf{K}_{eq}$, indicating constant value that no more work $\mathbf{W = -\Delta G = 0}$ can be done by the reaction: $a\mathbf{A} + b\mathbf{B} = c\mathbf{C} + d\mathbf{D}$ according expression (1-3) $\mathbf{\Delta G = \Delta G_{eq} + R \bullet T \bullet \ln(K_{eq}) = 0}$.

Studies in „Medical chemistry”, „Biochemistry”. Studies of Gibs free energy change $\mathbf{\Delta G_{reac} = \Delta H_{reac} - T \cdot \Delta S_{reac}}$

$\mathbf{\Delta H}_{Hess}$ **Enthalpy**	$\mathbf{\Delta S}_{total}$ **Entropy**	**T Temperature**	$\mathbf{\Delta G}_{Hess}$ **Free energy**	**Spontaneous ability of reaction**
Dispersed energy bound in surrounding and is lost as used free energy $\mathbf{\Delta G_{Hess}<0}$	$T \cdot \Delta S_{total}>0$ is $\Delta S_{total}>0$ **Positive** entropy increases entropy change is positive	**decomposition** reaction	Biochemical **AB → A + B**	catabolism organisms consume the free energy in **spontaneous** reactions maintain organisms living in **Homeostasis**.
1. **Endothermic Positive** $\Delta H_{Hess}>0$		low **T** ↓ $\Delta H_{Hess}>\lvert -T \cdot \Delta S_{Hess} \rvert$	**Positive** $\mathbf{\Delta G_{Hess}>0}$ $\Delta H_{Hess} - T \cdot \Delta S_{Hess}>0$	**unfavorable** reaction at low temperature
	Dispersed energy is forming greater measure of chaos $\Delta S_{total}>0$ **Positive. Spontaneous** catabolic reactions consume free energy change $\mathbf{\Delta G_{Hess}<0}$ for life maintenances of organisms 37° C in human as well as to supply the heat for organisms.	high **T** ↑ $\Delta H^{\circ}_{Hess}<\lvert -T \cdot \Delta S_{Hess} \rvert$	**Negative** $\mathbf{\Delta G_{Hess}<0}$ $\Delta H_{Hess} - T \cdot \Delta S_{Hess}<0$	**spontaneous** reaction at high temperature
2. **Exothermic Negative** $\Delta H_{Hess}<0$		any **T**	**Negative** $\mathbf{\Delta G_{Hess}<0}$ $\Delta H_{Hess} - T \cdot \Delta S_{Hess}<0$	**thermodynamically spontaneous** reaction at any temperature
Living cell proliferations and existing conditions for Life	$\Delta S_{total}<0$ **Negative** entropy decreases entropy change is negative	**synthesis** reaction	Biochemical anabo and organize in **A + B → AB**	lism energy accumulates compounds as synthesized the higher order decreases measure of chaos $\Delta S_{Hess}<0_{\mathbf{negative}}$
3. **Endothermic Positive** $\Delta H_{Hess}>0$	Synthesized as well as produced free energy $\mathbf{\Delta G_{Hess}>0}$ **Positive** accumulates in **photosynthesis**, in **ATP synthesis**, in **polypeptides** as well as in **proteins**, in **synthesized molecules**, living cells live and proliferates	any **T**	**Positive** $\mathbf{\Delta G_{Hess}>0}$ $\Delta H_{Hess} - T \cdot \Delta S_{Hess}>0$	**unfavorable** reaction **thermodynamically** forbidden at any temperature
4. **Exothermic Negative** $\Delta H_{reac}<0$		high **T** ↑ $\lvert \Delta H_{Hess} \rvert<\lvert -T \cdot \Delta S_{Hess} \rvert$	**Positive** $\mathbf{\Delta G_{Hess}>0}$ $\Delta H_{Hess} - T \cdot \Delta S_{Hess}>0$	**unfavorable** reaction at high temperature
		low **T** ↓ $\lvert \Delta H_{Hess} \rvert>\lvert -T \cdot \Delta S_{Hess} \rvert$	**Negative** $\mathbf{\Delta G_{Hess}<0}$ $\Delta H_{Hess} - T \cdot \Delta S_{Hess}<0$	**spontaneous** reaction at low temperature

In life important are negative change $\Delta S_{Hess}<0$ of **entropy** and positive increase $\Delta G_{reac}>0$ of **free energy**!
Negative change $\Delta S_{Hess}<0$ dispersed energy $T\Delta S\downarrow$ decreases and into reaction accumulates supplied +**Q** energy into compound macroergic bonds as increase the free energy $\uparrow\Delta G_{Hess}>0$.

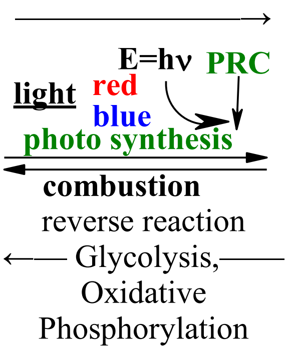
$$\Delta H_{Hess}=\uparrow\Delta G_{Hess}+T\cdot\Delta S_{Hess}\downarrow.$$

Opposite to spontaneous reaction $\downarrow\Delta G_{Hess}>0$ negative change of free energy is lost energy.

4th page http://aris.gusc.lv/BioThermodynamics/BioThermodynamics.pdf

Three Reaction examples studies of Homeostasis for students Medical Chemistry :

1. Glucose and oxygen **Green** plants **Photosynthesis**
← **Homeostasis**
red and **blue** light photons energy **E=hν** absorption heat and free energy accumulates in glucose and **oxygen** n substance
positive $\Delta H_{Hess}>0$ = **-Q Endothermic** ΔH_{Hess}= **+2812,6** $^{kJ}/_{mol}$
$6HCO_3^-+6H_3O^+ + Q + \Delta G_{Hess}$
photosynthetic process is **Endoergic** ΔG_{Hess}=**+3336,5** kJ/mol
free energy accumulates in 1 mol cytosolic glucose molecules $C_6H_{12}O_6$ biochemically in glycolise and Krebs cycle mitochondria by **oxygen** creates concentration gradients of HCO_3^- and H_3O^+ for osmosis and homeostasis.

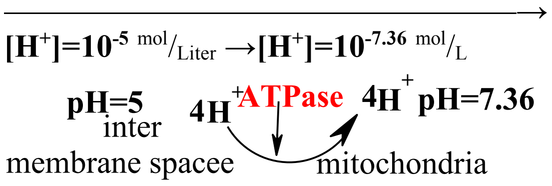

direct reaction

combustion
reverse reaction
← Glycolysis,
Oxidative
Phosphorylation

Plant Enzymes
Photo synthetic
←/ **Reaction**
Center
glucose + **oxygen**
$C_6H_{12}O_6 + 6\,O_2 +$
$+6H_2O$
biochemical
„**combustion**"
Krebs cycle in
mitochondria

The Membrane potential 3rd page http://aris.gusc.lv/BioThermodynamics/MembraneElektrodsAM.pdf
(page 9 http://aris.gusc.lv/BioThermodynamics/OxRedBiologicalW.pdf)

2. ATPase driven **ATP**$^{4-}$ **synthesis** (adenosine triphosphate **ATP**$^{4-}$ anion pH=7.36 in mitochondria)
Mitochondrial under proton gradient **[H$^+$]** 229 over 1 **[H$^+$]**. The one mole of glucose $C_6H_{12}O_6$ produces glycolytical totally **36 ATP**$^{4-}$ molecules. Membrane integral enzyme **ATPase** nano engine per produced **ATP**$^{4-}$ mole to transfer **free** energy $\Delta G_{Lehninger}$=**+30,5** $^{kJ}/_{mol}$ for **Ribosome** Enzyme Complex reaction for synthesis: $ADP^{3-}+HPO_4^{2-}+H_3O^+ => ATP^{4-}+2H_2O$;


$[H^+]=10^{-5}\ ^{mol}/_{Liter} \rightarrow [H^+]=10^{-7.36}\ ^{mol}/_{L}$

$\Delta G_{Leninger}$=30,5 $^{kJ}/_{mol}$; Biochemical conditions with concentrations $[H_3O^+]=10^{-7,36}$ M un $[H_2O]$=55,3 M

Unfavored , non spontaneous process: $K_{Leninger2}=K_{eq2}*[H_3O^+]/[H_2O]^2=0,000004535143=\frac{[ATP^{4-}]}{[HPO_4^{2-}]\cdot[ADP^{3-}]}$
$ATP^{4-}+2H_2O => ADP^{3-}+HPO_4^{2-}+H_3O^+$; $\Delta G_{Leninger3}$= -30,5 $^{kJ}/_{mol}$; favored hydrolyse

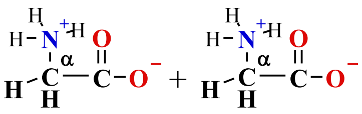
Favored , spontaneous process: $K_{Leninger3}=K_{eq3}*[H_2O]^2/[H_3O^+]=220500,2=\frac{[HPO_4^{2-}]\cdot[ADP^{3-}]}{[ATP^{4-}]}$
gly+gly=>gly-gly+H$_2$O; $\Delta G_{Leninger3}$ = 9,2; homeostasis unfavored synthesis $K_{Leninger3} < 1$
Unfavored , non spontaneous process: $K_{Leninger3}= K_{eq3}/[H_2O]$= 0,02446= $\frac{[H_3N^+GlyGlyCOO^-]GG}{[H_3N^+CH_2COO^-]Gly\ 2}$
$K_{LeningerSum} = K_{LeningerATP} * K_{Leninger\_glygly}$ = 220500*0,02446 = 5390,4;

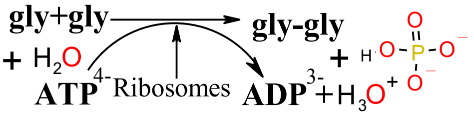
Favored , spontaneous process: $\Delta G_{LehningerSum}$= 9,2-30,5 = -21,3 $^{kJ}/_{mol}$;

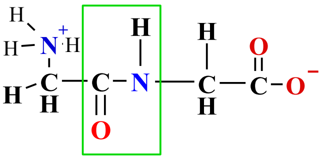
3. ATP^{4-} free energy transfer and accumulation $\Delta G_{Lehninger}$=**+9,2** $^{kJ}/_{mol}$ in Peptide Bond through Reaction is the **Ribosomal** cofactor for protein synthesis: **gly+ gly→gly-gly+ H$_2$O.**
Ionic force =0,2 M conditions in each reaction alone in separate pathways and as sum in one according the law.
to transfer from **ATP**$^{4-}$ liberate and store **free energy** $\Delta G_{Lehninger}$=**+9.2** $^{kJ}/_{mol}$ per one mole of **peptide bond**.
$K_{LeningerSumma} = K_{LeningerATP} * K_{Leninger\_glygly}$ = 220500 * 0,02446 = 5390,4;
Ribosome joint **peptide** synthesis with **ATP**$^{4-}$ hydrolyze: **free energy** $\Delta G_{Lehninger}$= **-30,5** $^{kJ}/_{mol}$ allows to **store** $\Delta G_{Lehninger}$ =+9,2 $^{kJ}/_{mol}$ free energy **in reaction per one** mole peptide bond.

Gly [G]
Glycine

Gly [G]
Glycine







ATP^{4-} hydrolyze is **spontaneous**
$\Delta G_{Lehninger}$= -30,5 $^{kJ}/_{mol}$;

and sumary **reaction is spontaneous** , as sum $\Delta G_{total} < 0$ is negative ΔG_{eq} = **9,2**–30,5 = **-21,3** $^{kJ}/_{mol}$

Synthesis and Decomposition reactions four types

1. EXOTHERMIC, EXOERGIC DECOMPOSITION REACTION of hydrolysis and bio oxidation

Oxidoreductases E.1 classes enzymes, as oxidative phosphorylation summary:

$$C_6H_{12}O_6 + 6O_{2aqua} + 6H_2O \Rightarrow 6HCO_3^- + 6H_3O^+ + \Delta G + Q;\ \Delta G_{Hess} = -2570{,}4\ {}^{kJ}/_{mol};\ \Delta H_{Hess} = -2805.27\ {}^{kJ}/_{mol}$$

E.3 class degrading enzymes Hydrolases-digestive peptidases : exoergic exothermic

$$\text{Gly-Gly}_{aqua} + H_2O \overset{peptidase}{\Rightarrow} \text{Gly}_{aqua} + \text{Gly}_{aqua} + Q + \Delta G;\ \Delta G_{Lehninger} = -9{,}2\ {}^{kJ}/_{mol};\ \Delta H_{Hess} = -32{,}8\ {}^{kJ}/_{mol}$$

This type of reaction can be written in a general way as: exoergic exothermic::

$$AB \Rightarrow A + B,\ \Delta G = \Delta H - T \bullet \Delta S < 0,\quad \Delta S>0 \quad \text{and} \quad \Delta H<0\ ;$$

one can see, that the first component of it (**ΔH**) is negative. **ΔS** itself is positive, but as there is a minus sign before it, the second component of it (**- T•ΔS**) is also negative. This means, that **ΔG** is always negative for this type of reactions.. **Conclusion**: an exothermic decomposition reaction is spontaneous at all conditions.

2. EXOTHERMIC REACTIONS OF SYNTHESIS

An **EXOTHERMIC REACTION OF SYNTHESIS** in a general way can be written as:

$$A + B \Rightarrow AB,\qquad \Delta H<0 \text{ and } \Delta S<0;\ \Delta G = \Delta H - T\bullet\Delta S$$

the first component **ΔH** of the equation is negative, but the second one - positive (**ΔS** is itself negative, but there is a minus sign before it). As one of the components is positive, but the other negative, the result **ΔG** can be negative, if the negative component **ΔH** by its absolute value is greater, than the positive component (**-TΔS**):

$$|\Delta H| > |T\bullet\Delta S|$$

This is possible, if the temperature is low enough human body temperature 310.15 K

Conclusion: A synthesis reaction, that is exothermic, is spontaneous at low enough temperatures.

3. ENDOTHERMIC , EXOERGIC REACTION OF DECOMPOSITION

An example of an endothermic reaction of decomposition in a general form can be written as:

$$AB \Rightarrow A + B \qquad \Delta H>0 \text{ and } \Delta S>0;\ \Delta G = \Delta H - T\bullet\Delta S$$

Thus, the first component (**ΔH**) in the equation is positive, but the second one (**-T•ΔS**) - negative as entropy change itself is a positive value, but the minus sign in the equation turns the second component of equation negative.

In such a way, the change of Gibbs's Energy **ΔG** can be negative (and the reaction can be spontaneous), if the negative component is greater, than the positive one: $|T\bullet\Delta S| > |\Delta H|$

An endothermic reaction of decomposition occurs spontaneously at high enough temperatures.

4. ENDOTHERMIC, ENDOERGIC REACTION OF SYNTHESIS.

Oxidoreductase class E.1 enzymes, as for photosynthesis: endoergic endothermic:

$$6HCO_3^- + 6H_3O^+ + \Delta G + Q \Rightarrow C_6H_{12}O_6 + 6O_{2aqua} + 6H_2O;\ \Delta G_{Hess} = +2570{,}4\ {}^{kJ}/_{mol};\ \Delta H_{Hess} = +2805.27\ {}^{kJ}/_{mol}$$

Protein peptide bond synthesis hydrolase class E.3 enzymes, as for Ribosomes: endoergic endothermic:

$$\text{Gly}_{aqua} + \text{Gly}_{aqua} + Q + \Delta G \overset{ribosome}{\Rightarrow} \text{Gly-Gly}_{aqua} + H_2O;\ \Delta G_{Lehninger} = +9{,}2\ {}^{kJ}/_{mol};\ \Delta H_{Hess} = +32{,}8\ {}^{kJ}/_{mol}$$

This kind of reactions can be generally expressed as: **A + B => AB** ; **ΔS<0** and **ΔH>0** . Both components of **ΔG** are positive and therefore **ΔG** is positive at any temperature. It means, that this type of reaction can never be spontaneous, *an endothermic reaction of synthesis is **thermodynamically forbidden***.

We can easily notice, that cases 1 and 4 and cases 2 and 3 are reverse reactions to each other.

Two more **conclusions** can be done:

1) If the direct reaction is always spontaneous, the reverse one is forbidden.(cases 1 and 4).

2) If the direct reaction is spontaneous at high temperatures, the reverse one must be carried out at low temperatures.

Biochemical Thermodynamics

Thermodynamics is the quantitative study of the energy **G** transductions in living organisms the pathways and functions of the **chemical** processes by Ilya Prigogine defined dissipative structure consisting complex systems. Irreversible processes working, with certain attractors driven Brownian molecular engines.

Enzymes and its complexes .

Attractors aspiration to equilibrium drive

enzyms complexes reactions irreversibility in homeostasis**.**

Five type enzymes reactions complexes

sustaining life **homeostasis** of attractors - **equilibria**.

Five type complexes reaction order versus chaos of non enzymatic reactions:

1. Gradual-sequential reactions, versus unorganized chaos;
2. ENZYMES **specificity** 100% efficiency of product **singularity**; PARALLEL reactions chaos;
3. Joint-tandem reactions, versus inactive, non reactive, silencing reactants stiff;
4. Competitive-regulatory metabolites complexes versus chaos and contamination;
5. Enzyme radical reactivity for life resources, versus destructive contamination.

5 complex Enzyme reactions

Enzyme governed complexe reactions drive the LIFE in 5 ways

Versus non Enzymatic reactions

chaos and contamination

7th page : Velocity KINETICS of REACTION dependence on Attractors create molecules functional Activity

1. GRADUAL-CONSECUTIVE organized favored reaction sequence of **ENZYME** complexes for Glycolysis, Krebs cycle; Polycondensation: Replication, Polymerisation, Proteins Translation Synthesis

1. Chaotic

2. ENZYMES specificity 100% efficiency of product **singularity**

2. PARALLEL reaction preseeding in chemistry as side products

3. JOINT-TANDEM SYNTHESIS Ribosomes for polypeptides, proteins Photosynthesis glucose and oxygen

3. Thermodynamic forbidden, impossible reaction unfavored has positive free energy change $\Delta G=\Delta H-\Delta S \cdot T>0$

1 st 5 th page:

Thermodynamic attractor with functionally active O_{2aqua}, CO_{2aqua}

4. COMPETITIVE regulation as **inhibition** and **allostery** sensitive to concentration O_{2aqua}, HCO_3^-, H^+ (**Le Chatelier** principle)

His63,58 as for hemoglobin, His64 as for myoglobin as regulated back response prevent (hypo amount) deficiency and (hyper amount) overproduction

4. Chaotic

so stabilises Physiologic pH=7.36, arterial $[O_{2aqua}]=6\cdot10^{-5}$ M and venous $[O_{2aqua}]=0{,}426\cdot10^{-5}$ M.

Photosynthesis global stabilises oxygene concentration $[O_{2AIR}]$= 20,95% in Earth Atmosphere.

5. Enzyme radical driven reactivity the process for maintanance of homeostasis producing resources

5. Contamination destructive chemistry with the chaotic radical chain reactions in multiple parallel products

Homeostasis instruments