

Thermodynamics in living systems

What is the principle of coupled reaction?

- we can use a thermodynamically favorable reaction to derive an unfavorable one.
- Consider an industrial process, suppose we wish to extract Zinc from the ore sphalerite (ZnS)

The following reaction will not work?!

Because it has a large Positive ΔG° Value

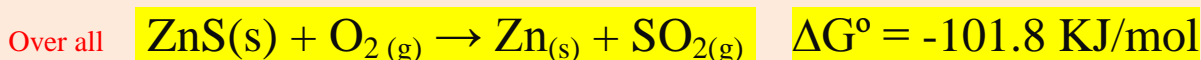


The combustion of sulfur to form sulfur dioxide is Favored ?!

Because of its large negative ΔG° Value



by coupling two processes we can bring about the separation of Zinc from Zinc Sulfide



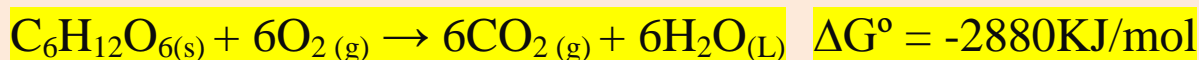
So, coupled reactions play an important role in our survival.

In biological systems

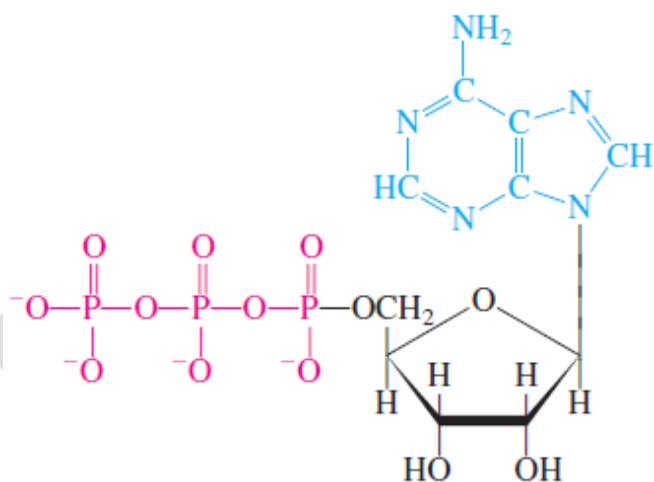
Enzymes facilitate a wide variety of non-spontaneous reactions.

Examples

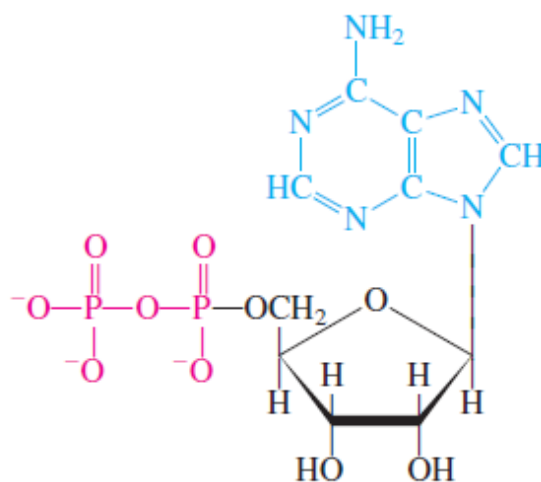
In human body: glucose ($C_6H_{12}O_6$) are converted to carbon dioxide and water during metabolism with a substantial release of free energy.



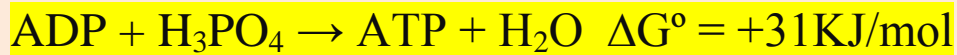
- ✓ This reaction doesn't take place in a single step, but glucose molecule is broken down by the aid of enzymes in a series of steps.
- ✓ Much of the free energy released is used to synthesize **ATP** from **ADP** and **Phosphoric acid**



Adenosine triphosphate
(ATP)



Adenosine diphosphate
(ADP)



What is the function of ATP ?! store free energy until it needed by the cell.

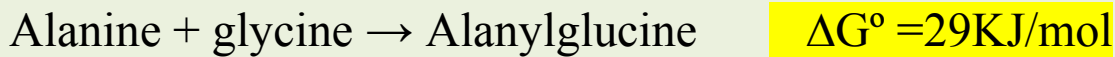
- ATP under goes hydrolysis to give ADP and phosphoric acid with a release of 31KJ/mol of free energy.

Proteins

Proteins → are polymers made of Joining of individual amino acids.

The Formation of dipeptide

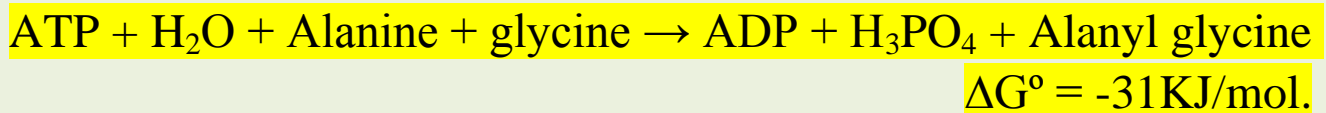
1) The first step



This reaction doesn't favor the formation of product.

2) Second step

With the aid of an enzyme, the reaction is coupled to the hydrolysis of ATP as follows



over all free energy

$$\Delta G^\circ = -31 + 29 = -2 \text{ KJ/mol}$$

the formation of product.

The coupled reaction now Favors

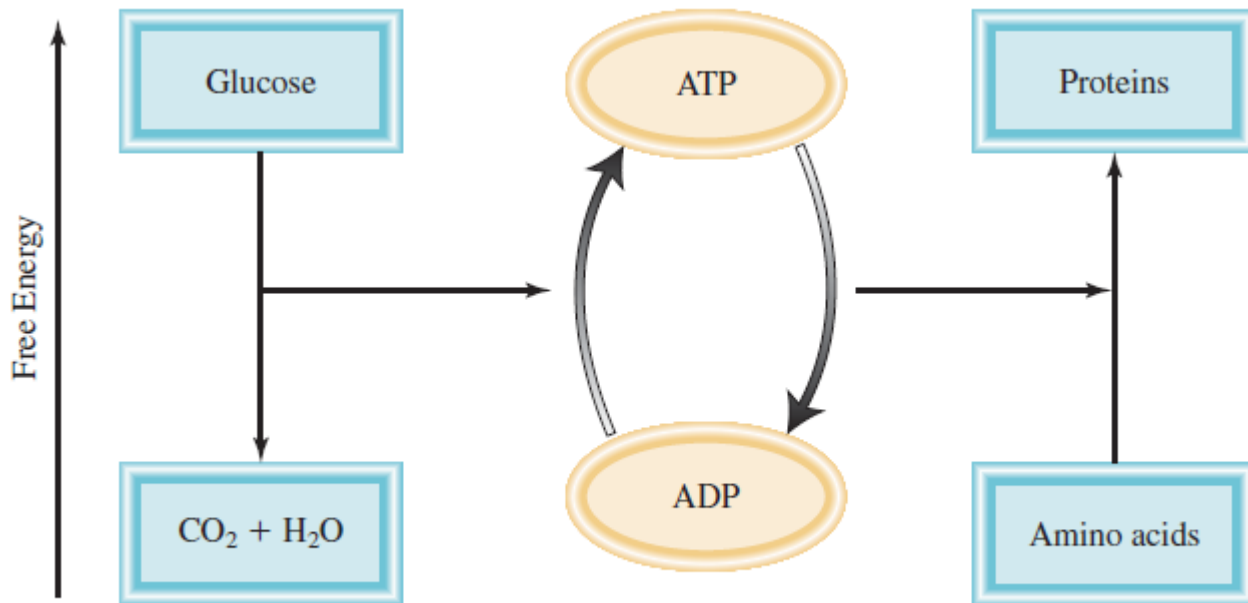


Figure show:

Schematic representation of ATP synthesis and coupled reactions in living systems.

The conversion of glucose to carbon dioxide and water during metabolism releases free energy.

The released free energy is used to convert ADP into ATP.

The ATP molecules are then used as an energy source to drive unfavorable reactions, such as protein synthesis from amino acids.

Choose

1) The using of thermodynamically favorable reaction to derive an unfavorable one is the principle of.....

- A) tripled reaction
B) thermodynamic reaction
C) coupled reaction
D) single reaction

2) The energy is stored in until it needed by the cell.

- A) ADP
B) ATP
C) DNA
D) none of them

3) Are polymers made up of joining of individual amino acid.....

- A) Proteins
B) Fats
C) Carbohydrate
D) all of above

4) This reaction $ZnS_{(s)} \rightarrow Zn + S$ doesn't occur because.....

- A) It has Large positive ΔG°
B) It has Large negative ΔG°
C) ΔG° is equal zero
D) none of them

5) glucose + $\text{HPO}_4 \rightarrow$ glucose6- phosphate + H_2O $\Delta G^\circ = 13.4 \text{KJ/mol}$
because ΔG° is positive, then.....

- A) the reaction doesn't favor the formation of product C) the reaction doesn't favor the formation of reactant
- B) the reaction favor the formation of product D) none of them

6) By coupling this reaction



with the hydrolysis of ATP , the ΔG° for the coupled process equal....

- A) 17.6 C) 19.5
- B) -17.6 D) -9.5

Solution

ΔG° for hydrolysis of ATP = -31KJ/mole

ΔG° for The process = $-31 + 13.4 = -17.6 \text{KJ/mole}$