Subject: **“The First law of thermodynamics”**

Theoretical part

Vocabulary

- Найдите соответствие, запишите слова в словарную тетрадь.

to be concerned with	энергия	equilibrium	связанна с
efficiency	внутренняя энергия	a biological cell	распределение
immense	сохранение	energy	эффективность
to deal with	окружающая среда	conservation	объединяться в
assemble into	разложение соединений в организме	nutrient	теплоемкость при постоянном давлении/объеме
The First law	стандартная теплота сгорания	an open/ a closed/ isolated system	иметь дело с
deployment	питательные вещества	the surroundings	функция состояния
bioenergetics	открытая/ закрытая/ изолированная система	exothermic/endothermic process	огромный, обширный
to distinguish	теплоемкость	heat capacity	биоэнергетика
the enthalpy	энтальпия связи	bond enthalpy	различать
a state function	экзотермический/ эндотермический процесс	the standard enthalpy of combustion	обмен веществ
metabolism	биологическая клетка	catabolism	энтальпия
constant-pressure/volume heat capacity	равновесие	internal energy	Первое начало термодинамики

- Составьте 3 предложения, употребляя словарные слова.

Examples: *Energy is the capacity to do work.*

In biological cells, nutrients, ions, and electrons are constantly moving across membranes and from one cellular compartment to another.

The energy that produces all this work in our bodies comes from food.

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Main laws, equations and definitions

- Прочитайте и запишите русские аналоги (воспользуйтесь конспектами лекций, учебником, интернетом).

The First Law of thermodynamics: the internal energy of an isolated system is constant.

Kirchhoff ’s law

$$\Delta_r H^{\ominus}(T') = \Delta_r H^{\ominus}(T) + (T' - T)\Delta_r C_p^{\ominus} \qquad \text{Kirchhoff's law} \qquad (1.24)$$

where $\Delta_r C_p^{\ominus}$ is the difference between the weighted sums of the standard molar heat capacities of the products and the reactants:

$$\Delta_r C_p^{\ominus} = \sum \nu C_{p,m}^{\ominus}(\text{products}) - \sum \nu C_{p,m}^{\ominus}(\text{reactants}) \qquad (1.25)$$

Practical part

Example 1.6 *Using Kirchhoff's law*

The enzyme glutamine synthetase mediates the synthesis of the amino acid glutamine (Gln, **8**) from the amino acid glutamate (Glu, 7) and ammonium ion:

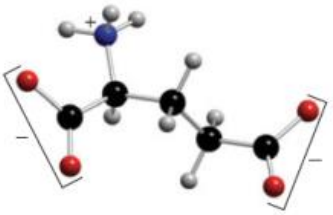
$\Delta_r H^\ominus = +21.8\ \text{kJ mol}^{-1}$ at 25°C

The process is endothermic and requires energy extracted from the oxidation of biological fuels and stored in ATP (*Case study* 1.1). Estimate the value of the reaction enthalpy at 60°C by using data found in this text (see the *Resource section*) and the following additional information: $C_{p,m}^\ominus(\text{Gln, aq}) = 187.0\ \text{J K}^{-1}\ \text{mol}^{-1}$ and $C_{p,m}^\ominus(\text{Glu, aq}) = 177.0\ \text{J K}^{-1}\ \text{mol}^{-1}$.

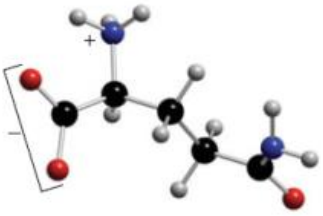
Strategy Calculate the value of $\Delta_r C_p^\ominus$ from the available data and eqn 1.25 and use the result in eqn 1.24.

Solution From the *Resource section*, the standard molar constant-pressure heat capacities of $H_2O(l)$ and $NH_4^+(aq)$ are 75.3 J K^{-1} mol^{-1} and 79.9 J K^{-1} mol^{-1}, respectively. It follows that

$$\begin{aligned}\Delta_r C_p^\ominus &= \{C_{p,m}^\ominus(\text{Gln, aq}) + C_{p,m}^\ominus(H_2O, l)\} - \{C_{p,m}^\ominus(\text{Glu, aq}) + C_{p,m}^\ominus(NH_4^+, \text{aq})\}\\ &= \{(187.0\ \text{J K}^{-1}\ \text{mol}^{-1}) + (75.3\ \text{J K}^{-1}\ \text{mol}^{-1})\} - \{(177.0\ \text{J K}^{-1}\ \text{mol}^{-1})\\ &\quad + (79.9\ \text{J K}^{-1}\ \text{mol}^{-1})\}\\ &= +5.4\ \text{J K}^{-1}\ \text{mol}^{-1} = +5.4 \times 10^{-3}\ \text{kJ K}^{-1}\ \text{mol}^{-1}\end{aligned}$$



7 Glutamate ion



8 Glutamine

Then, because $T' - T = +35$ K, from eqn 1.24 we find

$$\begin{aligned}\Delta_r H^\ominus(333\ \text{K}) &= (+21.8\ \text{kJ mol}^{-1}) + (5.4 \times 10^{-3}\ \text{kJ K}^{-1}\ \text{mol}^{-1}) \times (35\ \text{K})\\ &= (+21.8\ \text{kJ mol}^{-1}) + (0.19\ \text{kJ mol}^{-1})\\ &= +22.0\ \text{kJ mol}^{-1}\end{aligned}$$

Home work

Self-test 1.7 Estimate the standard enthalpy of combustion of solid glycine at 340 K from the data in Self-test 1.6 and the *Resource section*.

Answer: −9683 kJ mol^{-1}

Hess's law:_____

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Standard reaction enthalpy (equation):