

# ТЕРМОДИНАМИКА АКИКЕТАМ

## 4. ПРИКЛАД

$$\Delta T = 1^\circ\text{C}$$

$$P = \rho \cdot h \rightarrow Q_p = \Delta H$$

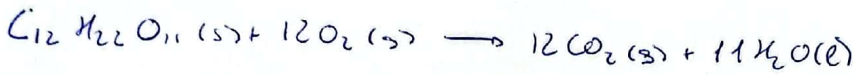
$$1\text{g H}_2\text{O} \cdot \frac{1\text{mol}}{18\text{g}} = 0.055\text{mol}$$

$$1\text{cal} = 4.184\text{J} = Q_p$$

$$Q_p = n \cdot \bar{C}_p \cdot \Delta T \rightarrow 4.184 = 0.055 \cdot \bar{C}_p \cdot 1$$

$$\bar{C}_p = 76.07 \frac{\text{J}}{\text{molK}}$$

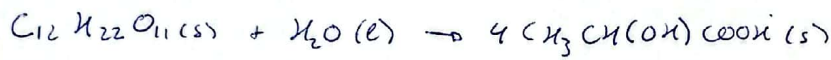
## 5. ПРИКЛАД



$$\Delta_r H_{298}^\circ = \sum_n \Delta_f H_{298}^\circ \text{prod} - \sum_m \Delta_f H_{298}^\circ \text{react} = 12 \Delta_f H_{298}^\circ \text{CO}_2 + 11 \Delta_f H_{298}^\circ \text{H}_2\text{O} - \Delta_f H_{298}^\circ \text{C}_{12}\text{H}_{22}\text{O}_{11} - \cancel{\Delta_f H_{298}^\circ \text{O}_2}$$

hitarmenee = 0

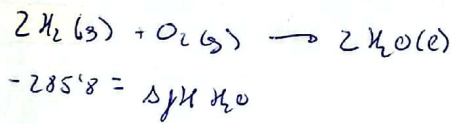
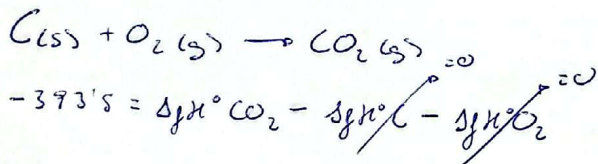
$$\Delta_r H_{298}^\circ = 12 \cdot (-393.5) + 11 \cdot (-285.8) + 2221.7 = -5644.4 \text{ kJ/mol (aerobio)}$$



$$\Delta_r H_{298}^\circ = 4 \cdot (-694) + 285.8 + 2221.7 = -268.5 \text{ kJ/mol (anaerobio)}$$

$$\Delta H_{298}^\circ (\text{aerobio}) - \Delta H_{298}^\circ (\text{anaerobio}) = -5644.4 - (-268.5) = -5375.9 \text{ kJ/mol}$$

## 6. ПРИКЛАД



$$-890.8 = \Delta_f H_{298}^\circ \text{CO}_2 + 2 \cdot \Delta_f H_{298}^\circ \text{H}_2\text{O} - \Delta_f H_{298}^\circ \text{CH}_4$$

$$-890.8 = -393.5 + 2 \cdot (-285.8) - \Delta_f H_{298}^\circ \text{CH}_4$$

$$\Delta_f H_{298}^\circ \text{CH}_4 = -74.3 \text{ kJ/mol}$$

## 9. ПРИКЛАД

$$C_p = 1.85 \frac{\text{J}}{\text{K}}$$

$$0.5\text{M HCl}, 250\text{cm}^3$$

$$0.65\text{M NaOH}, 200\text{cm}^3$$

$$\rho = 1\text{g/cm}^3$$

$$c = 4.184 \frac{\text{J}}{\text{gK}}$$

$$\Delta T = 3.45^\circ\text{C}$$

$$\left\{ \begin{array}{l} \rightarrow n = 0.25 \cdot 0.5 = 0.125 \text{ mol} \cdot 36.45 = 4.55\text{g} \rightarrow \text{mass of HCl} \\ \rightarrow n = 0.65 \cdot 0.2 = 0.13 \text{ mol} \cdot 39.99 = 5.19\text{g} \end{array} \right.$$

$$Q_{\text{HCl}} + Q_{\text{NaOH}} = 0$$

$$Q_x = C_p \Delta T + m \cdot c \cdot \Delta T$$

$$Q_x = 1.85 \cdot 3.45 + 0.456 \cdot \frac{1000\text{g}}{1\text{L}} \cdot 3.45 \cdot 4.184$$

$$Q_x = 7133.91\text{J} \rightarrow Q_{\text{NaOH}} = -7133.91\text{J}$$

$$\frac{-7133.91}{0.125} = -57071.28 \frac{\text{J}}{\text{mol}} = -57.1 \text{ kJ/mol}$$

10. ANÁLISIS

$$\left. \begin{aligned} \Delta t_{\text{fs}} &= 14'8 \text{ } ^\circ\text{C} \\ c &= 3'55 \text{ J/g} \end{aligned} \right\} Q_{\text{sur}} \\ 1 \text{ mol } \text{NH}_4\text{Cl}$$

$$1000 \text{ mL } \text{H}_2\text{O} \cdot \frac{1 \text{ g } \text{H}_2\text{O}}{1 \text{ mL}} \cdot \frac{1 \text{ mol}}{18 \text{ g}} \cdot \frac{1 \text{ mol } \text{NH}_4\text{Cl}}{200 \text{ mL } \text{H}_2\text{O}} = 0'27 \text{ mol}$$

$$0'27 \text{ mol } \text{NH}_4\text{Cl} \cdot \frac{53'5 \text{ g}}{1 \text{ mol } \text{NH}_4\text{Cl}} = 14'45 \text{ g } \text{NH}_4\text{Cl}$$

$$\left. \begin{aligned} 200 \text{ mL } \text{H}_2\text{O} \\ 1 \text{ dm}^3 \text{H}_2\text{O} \text{ } 1:200 \\ \Delta T = -1'1 \text{ } ^\circ\text{C} \end{aligned} \right\} Q_{\text{sol}}$$

$$Q_x = 0'27 \text{ mol } \text{NH}_4\text{Cl} \cdot \frac{14'8 \text{ kJ}}{1 \text{ mol}} = 4 \text{ kJ}$$

$$Q_{\text{sol}} + Q_{\text{sur}} = 0$$

$$Q_{\text{sol}} = -4 = C_p \cdot \Delta T + (m_{\text{H}_2\text{O}} + m_{\text{NH}_4\text{Cl}}) \cdot c \cdot \Delta T$$

$$-4 = C_p (-1'1) + (1000 + 14'4) \cdot 3'5 \cdot 10^{-3} (-1'1)$$

$$C_p = 0'215 \text{ kJ/}^\circ\text{C}$$

$$\left. \begin{aligned} 500 \text{ cm}^3 \text{H}_2\text{O} \text{ } 1:400 \\ \Delta T = -1'4 \text{ } ^\circ\text{C} \\ c = 1'95 \text{ J/g} \end{aligned} \right\}$$

$$500 \text{ cm}^3 \cdot \frac{1 \text{ g}}{1 \text{ cm}^3} \cdot \frac{1 \text{ mol } \text{H}_2\text{O}}{18 \text{ g}} \cdot \frac{1 \text{ mol } \text{Na}_2\text{CO}_3}{400 \text{ g } \text{H}_2\text{O}} = 6'94 \cdot 10^{-2} \text{ mol } \text{Na}_2\text{CO}_3$$

$$6'94 \cdot 10^{-2} \text{ mol} \cdot \frac{106 \text{ g } \text{Na}_2\text{CO}_3}{1 \text{ mol}} = 7'36 \text{ g}$$

$$Q_{\text{sol}} = 0'215 (-1'4) + (500 + 7'36) \cdot 1'9 \cdot 10^{-3} (-1'4)$$

$$Q_{\text{sol}} = -1'65 \text{ kJ} \rightarrow Q_{\text{sol}} + Q_x = 0 \rightarrow Q = \frac{1'65}{6'94 \cdot 10^{-2}} = 23'78 \text{ kJ/mol}$$

11. ANÁLISIS

$$P_{\text{ong}} \rightarrow Q_r = \Delta U$$

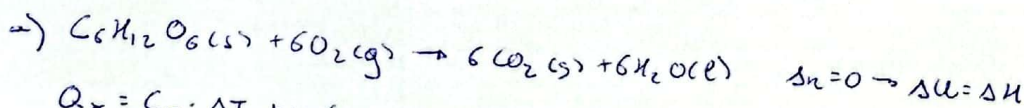
$$C_p = 3612 \text{ J/}^\circ\text{C}$$

$$5 \text{ kg } \text{H}_2\text{O}$$

$$0'75 \text{ g } \text{C}_6\text{H}_{12}\text{O}_6$$

$$\Delta T = +0'48 \text{ } ^\circ\text{C}$$

$$\rightarrow Q_{\text{sur}} (\text{resina} + \text{H}_2\text{O})$$



$$Q_x = C_p \cdot \Delta T + n \cdot C_p \cdot \Delta T$$

$$Q_x = 3612 \cdot 0'48 + \frac{5000}{18} \cdot \frac{75'35}{1 \text{ mol}} \cdot 0'48 = 11'78 \text{ kJ}$$

$$Q_{\text{sol}} = -11'78 \text{ kJ}$$

$$1 \text{ mol} = \frac{180 \text{ g} \cdot (-11'78 \text{ kJ})}{0'75 \text{ g}} = -2824 \text{ kJ/mol}$$

$$3) \Delta H_{310\text{K}} = \Delta H_{298} + \int_{298}^{310} (6C_p \text{CO}_2 + 6C_p \text{H}_2\text{O} - 6C_p \text{O}_2 - C_p \text{glu}) dT$$

$$\Delta H_{310\text{K}} = -2825'8 + [0'247]_{298}^{310} = -2822'8 \text{ kJ/mol}$$

$$1 \text{ g} \cdot \frac{1 \text{ mol}}{180 \text{ g}} \cdot \frac{-2822'8 \text{ kJ}}{1 \text{ mol}} \cdot \frac{40}{100} = -6'27 \text{ kJ}$$

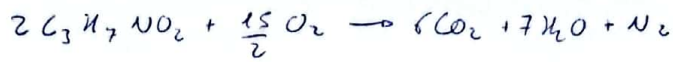
13. April 2019

$$\Delta_c H_{\text{Suder}} = -1350 \text{ kcal/mol}$$

$$\Delta_c H_{\text{Sonder}} = -7086 \text{ kcal/mol}$$

$$\Delta_f H_{\text{CO}_2} = -393'5 \text{ kcal}$$

$$\Delta_f H_{\text{H}_2\text{O}} = -285'8 \text{ kcal/mol}$$



$$\Delta_c H_{\text{al}} = 6(-393'5) + 7(-285'8) - 2(-560'5)$$

$$\Delta_c H_{\text{al}} = -3210'6 \text{ kcal/mol}$$

$$-3240'6 \frac{\text{kcal}}{\text{mol}} \cdot \frac{1 \text{ kcal}}{4'184 \text{ kJ}} = -774'52 \text{ kcal/mol}$$

$$6'8 \text{ g} \cdot \frac{1 \text{ mol}}{89'09 \text{ g}} = 0'076 \text{ mol} \cdot 774'52 \frac{\text{kcal}}{\text{mol}} = 58'8 \text{ kcal}$$

$$75 \text{ g} \cdot \frac{1 \text{ mol}}{342'3 \text{ g}} = 0'21 \text{ mol} \cdot 1350 = 297 \text{ kcal}$$

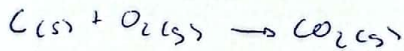
$$15'5 \text{ g} \cdot \frac{1 \text{ mol}}{88'44 \text{ g}} = 0'17 \text{ mol} \cdot 7086 = 120'46 \text{ kcal}$$

476 kcal

15. April 2019



$$\Delta_c H_{298}^\circ = 2(-393'5) + 2(-285'85) - 482'41 = -1841'11 \text{ kcal/mol} \cdot \frac{1 \text{ kcal}}{4'184 \text{ kJ}} = -440'03 \text{ kcal/mol}$$



$$-94'05 = \Delta_f H_{\text{CO}_2}$$

$$-94'05 \text{ kcal/mol} \cdot 4'184 = 393'5 \text{ kcal/mol}$$



$$2(-68'32) = 2 \Delta_f H_{\text{H}_2\text{O}} \rightarrow \Delta_f H_{\text{H}_2\text{O}} = -68'32$$

$$-68'32 \cdot 4'184 = 285'85 \text{ kcal/mol}$$

$$-115'3 \text{ kcal/mol} \cdot 4'184 = 482'4 \text{ kcal/mol}$$

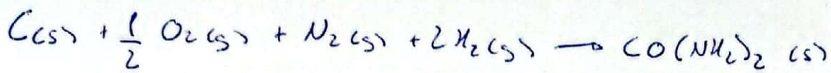
$$\Delta H_{328} = -440'035 + \int_{298}^{328} [2 \cdot (7 + 7'1 \cdot 10^{-3} \cdot 328) + 2'18 - 2 \cdot (6'5 + 0'001 \cdot 328) - 30] dT$$

$$\Delta H_{328} = -440'035 + \int_{298}^{328} 11'0016 dT \rightarrow -440'035 + (328 - 298) \cdot 11'0016 = -209 \text{ kcal/mol}$$

16. April 2019

$$\Delta G = \Delta H - T \Delta S \quad \left\{ \begin{array}{l} \Delta G = -285'83 - 298 \cdot 69'91 \cdot 10^{-3} = 306'66 \text{ kcal/mol} \\ \Delta G = 0 - 298 \cdot 205'138 \cdot 10^{-3} = -61'43 \text{ kcal/mol} \end{array} \right.$$

17. АНАЛИЗ



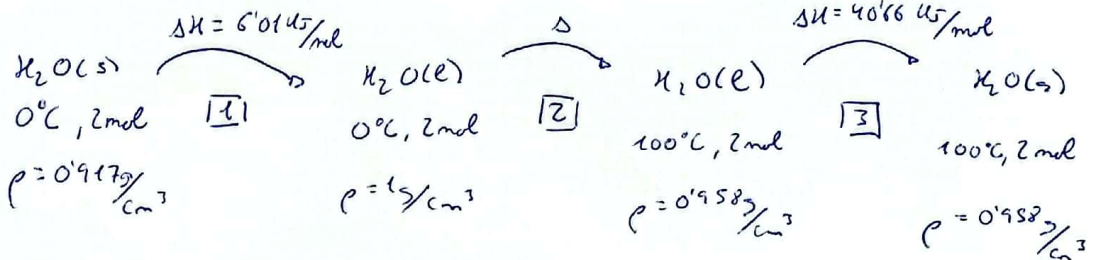
$$\Delta S^\circ = S^\circ(CO(NH_2)_2) - (S^\circ(C) + \frac{1}{2} S^\circ(O_2) + S^\circ(N_2) + 2S^\circ(H_2))$$

$$\Delta S^\circ = 104.6 - (5.740 + \frac{1}{2} \cdot 205.138 + 191.61 + 2 \cdot 130.684) = -456.387 \text{ Дж/моль К}$$

$$\Delta G = -333.51 + 298 \cdot 456.387 \cdot 10^{-3} = -197.545 \text{ Дж/моль}$$

21. АНАЛИЗ

$P = 1 \text{ атм} = 101325 \text{ Па}$   
 $0^\circ\text{C}$   
 $\bar{C}_p = 75.4 \text{ Дж/моль}$



$P = \rho k, Q_p = \Delta H, \Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$

$\Delta H_1 = 6.0145 \text{ Дж/моль} \cdot 2 \text{ моль} = 12.029 \text{ кДж}$

$\Delta H_2 = 75.4 \cdot 10^3 \cdot 2 \cdot 100 = 15.08 \text{ кДж}$

$\Delta H_3 = 40.66 \text{ Дж/моль} \cdot 2 \text{ моль} = 81.32 \text{ кДж}$

$Q = \Delta H = 108.429 \text{ кДж}$

$W = -P\Delta V, W = W_1 + W_2 + W_3$

$W_1 = -1.013 \cdot 10^5 (V_{l,0^\circ\text{C}} - V_{s,0^\circ\text{C}}) = 1.013 \cdot 10^5 (-3.25 \cdot 10^{-6}) = -0.3335 \text{ Дж}$

$V_1 = 2 \text{ моль} \cdot \frac{18 \text{ г}}{\text{моль}} \cdot \frac{1 \text{ Л}}{1 \text{ г}} = 36 \text{ Л}$

$V_2 = 2 \text{ моль} \cdot \frac{18 \text{ г}}{\text{моль}} \cdot \frac{1 \text{ Л}}{0.917 \text{ г}} = 39.25 \text{ Л}$

$W_2 = -1.013 \cdot 10^5 (V_{l,100^\circ\text{C}} - V_{l,0^\circ\text{C}}) = -1.013 \cdot 10^5 (1.58 \cdot 10^{-6}) = -0.16165 \text{ Дж}$

$V_3 = 2 \text{ моль} \cdot \frac{18 \text{ г}}{\text{моль}} \cdot \frac{1 \text{ Л}}{0.958 \text{ г}} = 37.58 \text{ Л}$

$W_3 = -\frac{nRT}{P} = -\frac{2 \cdot 8.314 \cdot 373}{1.013 \cdot 10^5} = -6.202 \text{ Дж}$

$W = -6.2029 \text{ Дж} = -6.203 \text{ Дж}$

$\Delta U = Q + W = -6.2 + 108.429 = 102.229 \text{ кДж}$

$\Delta S = \Delta S_1 + \Delta S_2 + \Delta S_3$

$\Delta S_1 = \frac{\Delta H}{T} = \frac{6.0145 \cdot 10^3 \cdot 2}{273} = 44.025 \text{ Дж/К}$

$\Delta S_2 = n \cdot C_p \cdot 2 \cdot \frac{T_2}{T_1} = 2 \cdot 75.4 \cdot 10^3 \cdot 2 \cdot \frac{373}{273} = 47.063 \text{ Дж/К}$

$\Delta S_3 = \frac{\Delta H}{T} = \frac{40.66 \cdot 10^3 \cdot 2}{373} = 218.02 \text{ Дж/К}$

$\Delta S = 309.109 \text{ Дж/К}$