

Topic 6.

CHEMICAL THERMODYNAMICS

Theoretical QUESTIONS for preparation:

1. The First Law of Thermodynamics

- A. A system, surroundings, work, heat
- B. The first law of thermodynamics
- C. Internal energy
- D. Endothermic and exothermic processes

2. Enthalpy

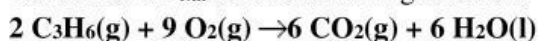
- A. Reaction enthalpy
- B. Hess' law and standard enthalpy of formation

3. The second law of thermodynamics and entropy

4. Free-energy changes

TASKS

1. Calculate ΔH^0_{rxn} for the following reaction:



If $\Delta H^0(\text{C}_3\text{H}_{6(\text{g})}) = 20.9 \text{ kJ/mol}$, $\Delta H^0(\text{CO}_{2(\text{g})}) = -393.2 \text{ kJ/mol}$, $\Delta H^0(\text{H}_2\text{O}_{(\text{l})}) = -286 \text{ kJ/mol}$.

GIVEN:

QUESTION: _____

FORMULA:

CALCULATIONS:

ANSWER: _____

2. Calculate ΔH^0 for $2\text{Al(s)} + \text{Cr}_2\text{O}_3\text{(s)} \rightarrow \text{Al}_2\text{O}_3\text{(s)} + 2\text{Cr(s)}$.
If $\Delta H^0(\text{Cr}_2\text{O}_3\text{(s)}) = -1128 \text{ kJ/mol}$; $\Delta H^0(\text{Al}_2\text{O}_3\text{(s)}) = -1676 \text{ kJ/mol}$.

GIVEN:

QUESTION: _____

FORMULA:

CALCULATIONS:

ANSWER: _____

3. Given the following entropy values ($\text{Al}_2\text{O}_3(\text{s})$ is $51.00 \text{ J/K}\cdot\text{mol}$; $\text{Al}(\text{s})$ is $28.32 \text{ J/K}\cdot\text{mol}$; $\text{H}_2\text{O}(\text{g})$ is $188.7 \text{ J/K}\cdot\text{mol}$; $\text{H}_2(\text{g})$ is $130.6 \text{ J/K}\cdot\text{mol}$), determine ΔS for the reaction:
 $\text{Al}_2\text{O}_3(\text{s}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{Al}(\text{s}) + 3\text{H}_2\text{O}(\text{g})$

GIVEN:

QUESTION: _____

FORMULA:

CALCULATIONS:

ANSWER: _____

4. Reaction at 25C: **6C(graphite) + 3H₂(g) → C₆H₆(l).**

Entropy contents (S) (J/mol*K):

C(graphite) = 5.74

H₂(gas) = 130.68

C₆H₆(l)= 172.8

Calculate entropy change.

GIVEN:

QUESTION: _____

FORMULA:

CALCULATIONS:

ANSWER: _____

5. Calculate ΔG° for the reactions of complete glucose oxidation ($\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$) under standard conditions if ΔG° for each reaction are given:

$\Delta G^\circ(\text{C}_6\text{H}_{12}\text{O}_6) = -910 \text{ kJ/mol}$

$\Delta G^\circ(\text{O}_2) = 0 \text{ kJ/mol}$

$\Delta G^\circ(\text{CO}_2) = -394 \text{ kJ/mol}$

$\Delta G^\circ(\text{H}_2\text{O}) = -237 \text{ kJ/mol}$

Will the process run spontaneously?

GIVEN:

QUESTION: _____

FORMULA:

CALCULATIONS:

ANSWER: _____

6. Reaction has a $\Delta H = +5600$ calories. The entropy change is -4.6 calories /Kelvin at 298 Kelvin. Is this reaction spontaneous?

GIVEN:

QUESTION: _____

FORMULA:

CALCULATIONS:

ANSWER: _____

7. Calculate the free energy change for the complete combustion of one mole of methane, $\text{CH}_4(\text{g})$, the main component of natural gas: $\text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l})$. Use the table below. Is this reaction spontaneous?

Substance	ΔH , kJ/mol	ΔS , J/K $\cdot$ mol
CH ₄ (g)	-74.86	186.19
O ₂ (g)	0	205.03
CO ₂ (g)	-393.5	213.7
H ₂ O (l)	-285.84	69.96

GIVEN:

QUESTION: _____

FORMULA:

CALCULATIONS:

ANSWER: _____