



University of  
Stavanger

---

On 9<sup>th</sup> April we will have a team session 14:30 – 15:00 where each student will come to present their answers to one of the questions, and we will discuss the solutions together.

# Question 1

---

Calculate the standard entropy change for the following chemical reactions.

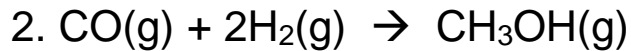


if  $S^\circ(\text{C}_3\text{H}_8) = 270 \text{ J/mol}\cdot\text{K},$

$S^\circ(\text{O}_2) = 205 \text{ J/mol}\cdot\text{K},$

$S^\circ(\text{CO}_2) = 214 \text{ J/mol}\cdot\text{K},$

$S^\circ(\text{H}_2\text{O}) = 189 \text{ J/mol}\cdot\text{K}$



if  $S^\circ(\text{CO}) = 198 \text{ J/mol}\cdot\text{K},$

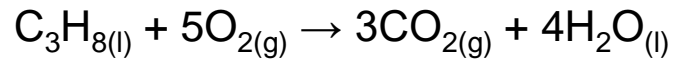
$S^\circ(\text{H}_2) = 131 \text{ J/mol}\cdot\text{K},$

$S^\circ(\text{CH}_3\text{OH}) = 240 \text{ J/mol}\cdot\text{K}$

## Question 2

---

Calculate  $\Delta G^\circ$  at 298 K for the reaction in



If  $\Delta G^\circ(\text{C}_3\text{H}_8) = -23.56 \text{ kJ/mol}$

$\Delta G^\circ(\text{CO}_2) = -394.4 \text{ kJ/mol}$

$\Delta G^\circ(\text{H}_2\text{O}) = -237.2 \text{ kJ/mol}$

Is the reaction spontaneous at 298 K? Calculate the equilibrium constant at 298 K for this reaction.

## Question 3

---

For the reaction:  $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{CO}(\text{g}) + 3\text{H}_2(\text{g})$ ,  
 $\Delta H^\circ = 206 \text{ kJ/mol}$  and  $\Delta S^\circ = 216 \text{ J/mol}\cdot\text{K}$

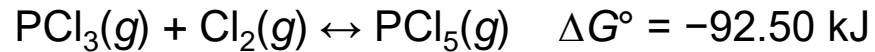
Is the reaction spontaneous at 298 K? at 1200 K?

What is the transition temperature for this reaction from nonspontaneous to spontaneous?

## Question 4

---

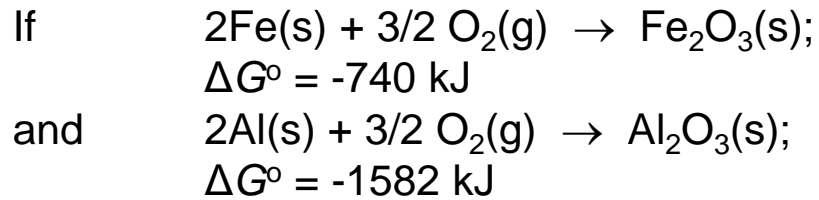
Consider the following system at equilibrium at 25 °C.



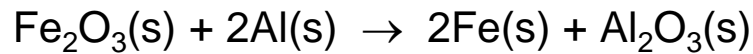
What will happen to the ratio of partial pressure of  $\text{PCl}_5$  to partial pressure of  $\text{PCl}_3$  if the temperature is raised? Explain.

## Question 5

---



Calculate  $\Delta G^\circ$  for the reaction:





## Question 6

---

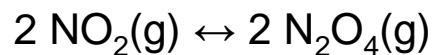
1. Find the activation energy (in kJ/mol) of the reaction if the rate constant at 600 K is  $3.4 \text{ M}^{-1}\text{s}^{-1}$  and 31.0 at 750 K.
2. Find the new temperature if the rate constant at that temperature is  $15 \text{ M}^{-1}\text{s}^{-1}$  while at temperature 389 K the rate constant is  $7 \text{ M}^{-1}\text{s}^{-1}$ , the activation energy is 600 kJ/mol.



## Question 7

---

What is the equilibrium constant for the following reaction?



The concentrations at equilibrium are  $[\text{NO}_2] = 0.025$  moles/liter;  $[\text{N}_2\text{O}_4] = 0.0869$  moles/liter. What is the equilibrium concentration for  $\text{NO}_2$  if the concentration of  $\text{N}_2\text{O}_4$  is 0.12 moles/liter?



## Question 8

---

Consider the reaction:  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \leftrightarrow 2\text{NH}_3(\text{g})$ ,

1. Write the expression of the equilibrium constant  $K_p$
2. What is the value of  $\Delta G$  at standard conditions
3. What is the value of  $\Delta G$  at 250 °C and  $P_{\text{N}_2} = 5.0 \text{ atm}$ ,  $P_{\text{H}_2} = 15 \text{ atm}$ , and  $P_{\text{NH}_3} = 5.0 \text{ atm}$

$\Delta G^\circ$  at 25 °C is -33 kJ/mol, at 250 °C is 12 kJ/mol.



## Question 9

---

For a gas phase reaction,  $A(g) + 2B(g) \leftrightarrow C(g) + D(g)$

Explain what will happen to the equilibrium when

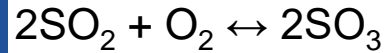
1. Adding C to the reaction system
2. When the volume of the mixture is reduced
3. Adding an inert gas into the gas-phase equilibrium at constant volume



## Question 10

---

Although the equilibrium constant,  $K_p$ , for the reaction



is  $4 \times 10^{22} \text{ kPa}^{-1}$  at 298 K,  $\text{SO}_2$  does not react readily with oxygen at this temperature. Explain why this reaction does not occur readily.