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On 9th 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.

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Question 1

Calculate the standard entropy change for the following chemical reactions.

1. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$,

   If $S^o(C_3H_8) = 270$ J/mol·K,

   $S^o(O_2) = 205$ J/mol·K,

   $S^o(CO_2) = 214$ J/mol·K,

   $S^o(H_2O) = 189$ J/mol·K

2. $CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$

   if $S^o(CO) = 198$ J/mol·K,

   $S^o(H_2) = 131$ J/mol·K,

   $S^o(CH_3OH) = 240$ J/mol·K

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Question 2

Calculate ΔG^o at 298 K for the reaction in

$$C_3H_{8(l)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(l)}$$

If $\Delta G^o(C_3H_8) = -23.56$ kJ/mol

$\Delta G^o(CO_2) = -394.4$ kJ/mol

$\Delta G^o(H_2O) = -237.2$ kJ/mol

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

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Question 3

For the reaction: $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$,

ΔH^o = 206 kJ/mol and ΔS^o = 216 J/mol·K

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

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

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Question 4

Consider the following system at equilibrium at 25 °C.

$$PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g) \quad \Delta G° = -92.50 \text{ kJ}$$

What will happen to the ratio of partial pressure of PCl_5 to partial pressure of PCl_3 if the temperature is raised? Explain.

Question 5

If $2Fe(s) + 3/2\ O_2(g) \rightarrow Fe_2O_3(s)$; $\Delta G^o = -740$ kJ

and $2Al(s) + 3/2\ O_2(g) \rightarrow Al_2O_3(s)$; $\Delta G^o = -1582$ kJ

Calculate ΔG^o for the reaction:

$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(s) + Al_2O_3(s)$

Question 6

1. Find the activation energy (in kJ/mol) of the reaction if the rate constant at 600 K is 3.4 $M^{-1}s^{-1}$ and 31.0 at 750 K.

2. Find the new temperature if the rate constant at that temperature is 15 $M^{-1}s^{-1}$ while at temperature 389 K the rate constant is 7 $M^{-1}s^{1,}$ the activation energy is 600 kJ/mol.

Question 7

What is the equilibrium constant for the following reaction?

$2\ NO_2(g) \leftrightarrow 2\ N_2O_4(g)$

The concentrations at equilibrium are $[NO_2]$ = 0.025 moles/liter; $[N_2O_4]$ = 0.0869 moles/liter. What is the equilibrium concentration for NO_2 if the concentration of N_2O_4 is 0.12 moles/liter?

Question 8

Consider the reaction: $N_2(g) + 3H_2(g) \leftrightarrow 2NH_3(g)$,

1. Write the expression of the equilibrium constant K_p
2. What is the value of ΔG at standard conditions
3. What is the value of ΔG at 250 ^oC and P_{N2} = 5.0 atm, P_{H2} = 15 atm, and P_{NH3} = 5.0 atm

ΔG^o at 25 ^oC is -33 kJ/mol, at 250 ^oC is 12 kJ/mol.

Question 9

For a gas phase reaction, A(g) + 2B(g) ↔ 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

$2SO_2 + O_2 \leftrightarrow 2SO_3$

is 4×10^{22} kPa^{-1} at 298 K, SO_2 does not react readily with oxygen at this temperature. Explain why this reaction does not occur readily.