CHEMISTRY

JEE (MAIN AND ADVANCED) CHEMISTRY

CHEMICAL THERMODYANMICS

Problem

1. A closed steel Mask contains hot tea. What type of system is this?

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2. Does the temperature remain constant in an adiabatic process ?

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3. 10 grams of steam at 100° C is mixed with 50 gm of ice at 0° C then final temperture is

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4. A chamber contains $77gofCO_2$. The chamber was divided into three compartments X, Y and Z as shown below. Suggest the relation between the internal energies of the gas in the three compartments X, Y and Z.

$X\ 11gCO_2 \quad y22gCO_2 \quad Z44gCO_2$

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5. What are the values of w and ΔE, when a system absorbs 250J of heat by expanding from 1 lit to 10 lit against 0.5 atm pressure and at constant temperature.

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6. A system absorbs 10kJ of heat at constant volume and its temperature rises from 27^0C to 37^0C. The DE of reaction is

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7. From the observations given below, suggest the relation between X, Y and Z

Experiment	Heat supplied	Work done	ΔE
I	100J Supplied to the system	200J done by the system	X Joules
II	200J Supplied to the system	200J done on the system	Y Joules
III	400J lost to the system	100J done by the system	Z Joules

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8. What is Mayer's relation?

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9. $N_{2(g)} + O_{2(g)} + 180.6kJ \rightarrow 2NO_{(g)}$, calculate (a) heat of reaction, (b) heat of formation of nitric oxide and (c) heat required to form one litre of nitric oxide at $25^\circ C$.

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10. ΔH^0 for a reaction $F_2 + 2HCl \rightarrow 2HF + Cl_2$ is given as $-352.8kJ$. ΔH_f^0 for HF is $-268.3KJmol^{-1}$, then ΔH_f^0 of HCl would be

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11. $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}, \Delta H = -286.2KJ$

$H_2O_{(l)} \rightarrow H^+_{(aq)} + OH^-_{(aq)}, \Delta H = +57.3KJ$

Enthalpy of ionization OH^- in aqueons solution is

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12. 4.184g of benzoic acid was burnt in bomb calorimeter. The rise in the temperature is 10°. The heat capacity of calorimeter and its contents is $2.644 kcal K^{-1}$. Calculate the heat of combustion of benzoic acid.

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13. $H_2SO_4(aq) + 2NaOH_{(aq)} \rightarrow Na_2SO_4(aq) + 2H_2O_{(l)}$. Suggest the hest of this reaction.

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14.

$HCN_{(aq)} + NaOH_{(aq)} \rightarrow NaCN_{(aq)} + H_2O_{(1)}, \Delta H = -12.13 KJ$

Calculate heat of ionisation of HCN .

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15. For the reaction $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$. What is the realation between $\Delta H$and ΔE ?

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16. One mole of solite AB dissolved in 20 moles of water absorbed 15.9 KJ of heat. When one male of same se is dissolved in 250 moles of water $18.58KJ$of heat is absorbed. Calculate the enthalpy of dilution

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17. ΔH for the formation of XY is $-200kJmol^{-1}$.The bond enthalpies of $X_2, Y_2,$ and XY are in the ratio 1:0.5:1. Then determine the bond enthalpies.

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18. Heats of combustion of garphite carbon and carbon monoxide are respectively -393.5 KJ mol^{-1} and -110.5mol^{-1}. Then determine the bond enthalpies.

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19. Heats of combustion diamond carbon and garphite carbon are respectively -395.4 KJ mol^{-1} and -393.5 KJ mol^{-1}. Calculate the heat of transition of dimand carbon into garphite carbon.

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20. Heats of combustion of benzene, carbon and hydrogen are $-782,\ -94,\ -68kcalmol^{-1}$ respectively. Calculate heat of formation of benzene.

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21. The bond enthalpies of D-D and O-O and D-O are respectively +440 ,+498 and +491.5KJ mol^{-1} calculation ΔH for the reaction $D_2(g) + \frac{1}{2}O_2(g) \rightarrow D_2O(l)$

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22. The heat of formation of crystalline sodium chloride is $-410kJmol^{-1}$. The heat of sublimation of sodium metal is $180.8kJmol^{-1}$. The heat of dissociation of chlorine gas into atoms is $242.7kJmol^{-1}$. The ionisation energy of Na and electron affinity of Cl are $493.7kJ$ and $-368.2kJ$ respectively. Calculate the lattice energy of NaCl.

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23. The standard molar heat for formation of ethane, carbondioxide and water are respectively, -21.1,-94.1 and -68.3 Kacal mol^{-1}. What is the standard molar heat of combustion of ethane ?

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24. The entropy change for vaporisation of a liquid is $109.3JK^{-1}mol^{-1}$. The molar heat of vaporisation of that liquid is $40.77kJmol^{-1}$. Calculate the boiling point of that liquid.

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25. Based on entropy Change predict a spontaneous reaction among the following.

$(A):(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + CO_2(g) + H_2O(l)$ and $(B):NH_3(g)$

.

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26. Latent heat of fusion of ice is $6kJmol^{-1}$. Calculate the entropy change in the fusion of ice.

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27. The vapour pressures of benzene at 303k and 333k are respectively 1.53×10^4 and $5.2 \times 10^4 Nm^{-2}$ Calculate the latent heat of evaporation of benzene over this temperature.

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28. $Zn_{(s)} + Fe^{2+}_{aq} \Leftrightarrow Zn^{2+}_{aq} + Fe_{(s)}$. The vale of $K_c$for this reaction is `10^(23). Calculate the standard free energy change.

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29. The reaction, $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$, is spontaneous. The $\Delta S^\circ = -163.1 Jmol^{-1}K^{-1}$. The absolute entropies of $H_{2(g)}$ and $O_{2(g)}$ are $130.6 JK^{-1}mol^{-1}$ and $205 JK^{-1}mol^{-1}$ respectively. Calculate the absolute entropy of water.

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30. How entropy change in the following process.

(a) boiling of egg , (b) stretching of rubber: (c) Formation of micells

(d)$CH_3COOH_{(aq)} \Leftrightarrow CH_3COO^-_{(aq)} + H^+_{(aq)}$.

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31. The formula $\Delta S = \frac{q_{rev}}{T}$ can be isothermal irreversble expansion or not ?

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32. Calculate $DetlaG^\circ$ for the following reaction, $Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$. ΔG°_f of $Zn^{2+}_{(aq)}$ and $Cu^{+2}_{(aq)}$ is -147.2 kJ mol^(-1) and 65kJmol^(-1)` .

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33. The equilibrium constant of a reaction is 73. Calculate standard free energy change.

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Exercise 3 1 1

1. What are the types of systems? Explain give one example each?

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2. What are intensive and extensive properties?

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3. Discuss on internal energy and enthalpy?

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4. State the first law of thermodynamics.

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5. Define heat capacity. What are C_p and C_v? Show that $C_p - C_v = R$.

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6. Differentiate exothermic and endothermic reactions.

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7. What is a thermochemical equation ? Write its significance.

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8. An ideal gas expands from $500cm^3$ to $700cm^3$ against 1 atm pressure, by absorbing 2J of energy. Calculate change in internal energy of the ideal gas.

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Exercise 3 1 2

1. What is heat of a reaction? Discuss the factors on which it is dependent.

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2. Define heat of formation. Write suitable examples.

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3. What is combustion ?

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4. Define heat of neutralisation. Write the basic equation. Why the heat liberated by the neutralisation of a weak acid is less than $57.3 kJ mol^{-1}$?

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5. Heat of neutralisation of $CH_3COOH_{(aq)}$ with $NaOH_{(aq)}$ is - 55.2kJ. What is heat of ionisation of CH_3COOH ?

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6. Heats of ionisation of acetic acid and ammonium hydroxide are $x kJ mol^{-1}$ and $y kJ mol^{-1}$. Heat of neutralisation of HCl and NaOH is

$zkJmol^{-1}$. Calculate the heat when acetic acid is neutralised with ammonium hydroxide. $\left(z-(x+y)kJmol^{-1}\right)$

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7. State and explain Hess law. Write its important applications

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8. 500mL of IM HCl and 500mL of 1M NaOH are mixed in Dewar flask. Then rise in temperature is T_1. In another experiment $1000mL1MHCl$ and $1000mLof1MNaOH$are mixed in Dewar flask. Then rise in temperature is T_2. What is the relation between T_1 and T_2 ?

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9. Heats of atomisation of chlorine and hydrogen are $243kJmol^{-1}$ and $435kJmol^{-1}$ respectively. Heat of formation of HCl is

$-92kJmol^{-1}$. Calculate the bond energy of HCL.

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10. Define heat of bond dissociation. How are bond enthalpies useful in the determination of heat of reaction ?

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11. Heats of formation of $CH_3COOH(l), CO_2(g)$ and $H_2O(l)$ are respectively -487, -394 and -286 kJ mol^{-1}. Calculate the heat of combustion of acetic acid.

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12. When 2.4g of carbon reacted with X g of oxygen to form CO and CO_2, 50.4 kJ of heat was released and no reactant is left over. Standard heats of

formation of carbon monoxide and carbon- dioxide are -110.5 kJ mol^{-1} and -393.5 kJ mol^{-1} respectively, Calculate X.

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Exercise 3 1 3

1. Discuss the following:

(a) entropy and (b) entropy change.

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2. Explain whether a reaction occurs on its own, by considering the entropy change of the reaction.

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3. Do all exothermic reactions occur spontaneously?

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4. The absolute entropies of $H_{2(g)}, O_{2(g)}$ and $H_2O_{(l)}$ are respectively $130.6, 205.1$ and $69.9 JK - mol^{-1}$. Calculate the value of ΔS for the formation of one mole liquid water.

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Exercise 3 1 4

1. Define Gibbs energy. How is it related to enthalpy and entropy?

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2. What are the criteria for the spontaneity of chemical reaction?

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3. How are absolute entropy values of substances determined ?

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4. At 300K, heat of dissociation of lime stone is $+180kJmol^{-1}$. Entropies of $CaCO_3, CaO$ and Co_2 are respectively $93, 39$ and $213Jmol^{-1}K^{-1}$. Calculate ΔS_{total}

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5. $4Fe(s) + 3O_{2(g)} \rightarrow 2Fe_2O_3(g)$. The value of ΔS is $-550JK^{-1}$ and the value of DH is $-1650kJ$ at 298 K. Does the process is spontaneous or not?

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6. For the equilibrium system, $2NOCI_{(g)} \Leftrightarrow 2NO_{(g)} + Cl_2(g)$ the value of ΔG° is 28.4 KJ.Calculate the value of equilibrium constant, K_e.

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7. The e.m.f. of the cell reaction

$Zn_{(s)} + Cu^{+2}_{(aq)} \rightarrow Zn^{+2}_{(aq)} + Cu_{(s)}$ is 1.1 V. Calculate the free energy of the cell reaction.

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Questions For Descriptive Answers

1. How does heat of neutralisation value change with the chemical nature of acid and base?

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2. How does entropy changes with the transformation at different temperature?

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3. At 400K, 5 moles of an ideal gas expands isothermally and reversibly from $10dm^3$ to $20dm^3$. Calculate the work done by the gas.

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4. The molar heat capacity at constant volume of a system is 12.41J. mol^{-1}. In an adiabatic expansion the temperature of one mole of that gas falls from 298K to 288K. Calculate the work done by the gas.

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5. Enthalpy of ammonia and water are $-46.19KJ.\,mol^{-1}$ and $-285.9KJ.\,mol^{-1}$. Calculate AH for the reaction, $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$.

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6.

$H_2 + Cl_2 \rightarrow 2HCl, \Delta H_1, N_2 + 3H_2 \rightarrow 2NH_3, \Delta H_2$ and $NH_3 + 3Cl_2$

Then calculate the heat of formation of nitrogen trichloride.

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7. The heat of combustion a sugar is $-790KJmol^{-1}$. A person requires 2370KJ of energy for his daily activities and he consumed 540 g of sugar to meet his activities. Calculate the molecular weight of the given sugar.

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8. Given that bond energies of N=N,H-H and N-H bonds as 945, 436 and 391 kJ/ mol respectively ,the enthalpy of the reaction $N_2(g) + 3H_2(g) + \rightarrow 2NH_3(g)$, is

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9. At constant pressure, the heat of combustion of carbon monoxide at 17^0C is –284.5 kJ. Calculate its heat of combustion at constant volume

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10. What is the work done in a open vessel at $27^\circ C$, when 92 grams of sodium metal reacts with water.

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11. Certain amount of argon at 1 atm and 300 K expands reversibly and adiabatically from 1.25 Lto 2.5 L. If C_v for Ar is $12.48JK^{-1}mol^{-1}$, calculate the enthalpy charge.

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12. In an insulated container, 1 mole of a liquid of molar volume 100 mL is at 1 bar. If the liquid is steeply taken to 100 bar, the volume of liquid

decreases by 1 mL. Find the work done and ΔH.

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13. HCI is a strong acid, but HF is a weak acid. The enthalpy of neutralisation of HCl is -57.3 kJ mol^{-1} and of HF is -68.3 kl. mol^{-1}. Explain.

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14. The enthalpy of vapourisation of water is 37.3 kl mol^{-1}. Calculate the molar entropy of vapourisation of water.

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15. The standard enthalpy of hydrogenation of cyclohexene is119 kJmol^{-1} . If enthalpies for formation of cyclohexane and benzene at $25^{\circ}C$ are

respectively -156 and + 49 kJ mol^{-1} , estimate the magnitude of resonance energy of benzene.

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16. Calculate the number of calories of energy released when 1 L of HCl is formed at 1 atm and $25^{\circ}C$. The dissociation energies of gaseous H_2, Cl_2 and HCl are respectively 104, 58 and 103 K cal mol^{-1}.

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17. Heats of atomisation of NH_3 and NH_2H_4 are $xKJmol^{-1}$ and $yKJmol^{-1}$respectively. What is the average energy of $N-N$ bond ?

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18. Standard enthalpies of $C_6H_6(l), H_2O(g)$ and $CO_2(g)$ are respectively 11.7, -68.3 and -94 kCal. Calculate the calorific value of benzene.

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19. Heat of formation of water and heats of combustion of ethylene and acetylene are respectively $286, -1410$ and $-1299 kJmol^{-1}$, Calculate the heat of the reaction,

$C_2H_{2(g)} + H_{2(g)} \rightarrow C_2H_{4(g)}$.

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20. At $427^\circ C$, for a given change the values of ΔG and ΔH are $-11,500 Jmol^{-1}$ and $-11,300 Jmol^{-1}$ respectively. Calculate the value of ΔS.

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21. Calculate the entropy change when one kg of water is heated from $27^\circ C$ to $200^\circ C$ forming super heated steam under constant pressure. Specific heat of water and systems are respectively 4180 and $1670 + 0.49\frac{J}{kg} - K.$

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22. Standard entropies of$H_2(g), O_2(g)$ and $H_2O(l)$ are respectively 126.6, 201.2 and $68JK^{-1}mol^{-1}$ Determine ΔS for $2H_2(g) + O_2(g) \to 2H_2O(l)$ at $25^\circ C.$

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23. At $127^\circ C, K_c$ for $2A \Leftrightarrow 2B + C$ is 2×10^{-4}. Calculate ΔG° for the reaction.

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24. The standard heats of formation values of $SF_6(g), S(g)$ and $F(g)$ are respectively -100, 275 and 80 kJ mol^{-1}. Estimate the averuge S-F bond energy sulphur herafluoride.

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25. Iodine molecule dissociates into atoms after absorbing light of 4500Å. If one quantum of radiation is absorbed by each molecule, calculate the kinetic energy of iodine atoms. Bond energy of I_2 is $240kJmol^{-1}$

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26. Suggest the conditions for the spontaneity the thermal decomposition of lime stone.

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27. The reaction $A + B \Leftrightarrow C$ has the value of ΔH and value of ΔS respectively -12.52kJ and $313 Jmol^{-1}K^{-1}$.At What temperature the reaction attains equilibrium state.

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28. For the reaction, $HC_2H_2ClO_2(aq) \Leftrightarrow H^+ + C_2H_2ClO_2^-(aq)HCH, C/O(aq) = H + CHC$ the equillibrium constant at $25^\circ C$ is $1.35 \times 10^{-3} M$. Calculate ΔG°.

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