CHEMISTRY

BOOKS - JEEVITH PUBLICATIONS CHEMISTRY (KANNADA ENGLISH)

CHEMICAL THERMODYNAMICS

One Marks Questions And Answers

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1. What is thermodynamics ?

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2. What you mean be enthalpy ?

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3. Write the relationship between ΔH and ΔE.

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4. Define (Heat of reaction) Enthalpy of reaction.

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5. Define heat (Enthalpy) of formation.

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6. Define heat capacity .

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7. Define specific heat of a substance

8. Define system and surroundings.

9. What is entropy ?

10. What is the unit of entropy ?

11. What is Gibbs - Helmholtz equation ?

12. Give an expression for the work done in a reversible isothermal expansion of an ideal gas.

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13. Explain : Heat of formation of acetylene is +54 kcal.

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14. What is a closed system ?

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15. What is an isolated system ?

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16. What is state of a system ?

17. What is a state function ?

18. What is standard state ?

19. Define standard enthalpy of formation .

20. Define enthalpy of combustion.

21. Write the thermochemical equation for the combustion of glucose.

22. The enthalpy of combustion of graphite and diamond are -393.5 kJ and -395 kJ respectively. Which of them is more stable ?

23. Define intensive properties.

24. Define internal energy [U].

25. Write the mathematical form of the first law of thermodynamics.

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26. Define heat of enthalpy of a solution.

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27. Give one difference between an isolated system and a closed system.

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28. Which of the following is an intensive property : Surface tension, mass, volume, enthalpy, density?

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29. What happens to the internal energy of the system if :

(a) Works is done on the system

(b) Work is done by the system.

30. For the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, predict whether the work is done on the system or by the system.

31. What is the tell us the direction on the process.

32. Which of the following is an extensive property ?

(a) Volume, (b) Surface tension, (c) Viscosity , (d) Density.

33. Write the relation between standard free energy change and equilibrium constant K_p for a reversible reaction.

34. Write the expression for ΔU under an adiabatic process.

35. Write the expression for ΔU under an isothermal process.

36. Write the expression for work done during an isothermal irreversible reaction for an ideal gas.

37. Define Enthalpy [H].

38. What is the unit of enthalpy ?

39. Define Born-Haber cycle.

40. Define absolute entropy.

41. State the third law of thermodynamics.

Two Marks Questions And Answers

1. What is an exothermic reaction ? Give an example.

2. What is an endothermic reaction ? Give an example.

3. Enumerate different types of processes.

4. What is open system ? Give an example.

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5. What is an Extensive property? Give an example.

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6. Write any two differences between isothermal process and adiabatic process.

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7. Mention the fractors affecting enthalpy of reaction.

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8. State and illustrate Hesse's law.

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9. Write the relation between ΔH and ΔU.

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10. Explain heat of neutralisation with an example.

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11. With example explain the term 'Heat of transition'.

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12. Define heat (enthalpy) of transition.

13. What do you understand by the following statements ?

enthalphy of formation of nitric oxide is +9.7 kJ.

14. What do you understand by the following statements ?

enthalpy of combustion of carbon disulphide is = -1065.2 kJ.

15. Give an example for the relation between ΔH and ΔU.

16. What are exothermic and endothermic chemical reactions?

17. State and explain the first law of thermochemistry.

18. Explain standard enthalpy of reaction.

19. Explain standard enthalpy of sublimation $[\Delta_{sub} H^\circ)$.

20. Explain standard enthalpy of formation $(\Delta_f H^\circ)$.

21. Explain standard enthalpy of combustion $(\Delta_c H^\circ)$.

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22. Explain bond dissociation enthalpy.

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23. Justify the following statements :

An exothermic reaction is always thermodyamically spontaneous.

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24. Justify the following statements :

The entropy of a substance increases on changing from liquid to vapour

state at any temperature.

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25. Evaporation of water is an endothermic process but spontaneous. Explain.

26. Explain standard enthalpy of solution $(\Delta_{sol}H^{\circ})$.

27. At a certain temperature 'T', endothermic reaction $A \rightarrow B$ proceeds virtually to the end. Determine the sign of ΔS for the reaction $A \rightarrow B$ and ΔG for the reverse reaction $B \rightarrow A$.

28. Explain standard enthalpy of atomisation $(\Delta_{s}H^{\circ})$

29. Explain with the help of an example, the difference between bond dissociation energy and bond energy.

30. What is meant by free energy of a system ? What will be the direction of the chemical reaction when (i) $\Delta G = 0$ (ii) $\Delta G > 0$ (iii) $\Delta G < 0$?

31. Why most of the exothermic process (reaction) are spontaneous ?

32. The enthalpy of combustion of sulphur is 297 kJ. Write the thermochemical equation for combustion of sulphur. What is the value of

$\Delta_f H$ of SO_2 ?

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33. What is the most important condition for a process to be reversible in thermodynamics ?

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34. Why the absolute value of enthalpy cannot be determined ?

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35. What are the applications of Hess's Law of constant heat summation?

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36. Explain standard enthalpy of dilution.

37. Define Molar enthalpy of fusion.

38. Define Molar enthalpy of vapourisation ?

39. Define : (a) Enthalpy of atomization (b) Lactic enthalpy.

40. Explain Laplace-Lavoisier law.

41. If the enthalpy of combustion of diamond and graphite are $-395.4kJmol^{-1}$ and $-393.6kJmol^{-1}$ what is the enthalpy change for the C (graphite) $\rightarrow$ C (diamond) conversion ?

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42. $H_2(g) + \dfrac{1}{2}O_2(g) \rightarrow H_2O(g)\Delta H = -242kJmol^{-1}$. Bond energy of H_2 and O_2 are $436mol^{-1}$ and $500mol^{-1}$ respectively. What is the bond energy of the O-H bond ?

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43. What is a spontaneous process ? Give an example.

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44. Define a non-spontaneous process.

45. Explain standard enthalpy of ionization.

46. State the second law of thermodynamics.

47. Define Gibbs energy.

Three Mark Questions And Answers

1. Classify the following processes as reversible or irreversible :

Dissolution of sodium chloride.

2. Classify the following processes as reversible or irreversible :

Evaporation of water at 373 K and 1 atm pressure.

3. Classify the following processes as reversible or irreversible :

Mixing of two gases by diffusion.

4. Classify the following processes as reversible or irreversible :

Melting of ice without rise in temperature.

5. When an ideal gas expands in vaccum, there is neither absorption nor

evolution of work ? Why ?

6. Justify the following statements :

Reaction with $\Delta G < 0$ always have an equilibrium constant greater than

1.

7. Justify the following statements :

Many thermodynamically feasible reactions do not occur under ordinary

conditions.

8. Justify the following statements :

At low temperatures, enthalpy change dominates the ΔG expression and at high temperatures it is the entropy which dominates the value of ΔG.

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9. Explain internal energy as a state function.

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10. Describe the measurement of ΔU by bomb calorimeter.

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11. Consider the reaction. $A + B \rightarrow C + D$

If the reaction is endothermic and spontaneous in the direction indicated, comment on the sign of ΔG and ΔS.

12. Consider the reaction. $A + B \rightarrow C + D$

If the reaction is exothermic and spontaneous in the direction indicated, can you comment on the sign of ΔG and ΔS ?

13. Consider the reaction. $A + B \rightarrow C + D$

If the reaction is exothermic and spontaneous only in the direction opposite to the indicated one coment on the sign of ΔG and ΔS for the direction indicated in the equation.
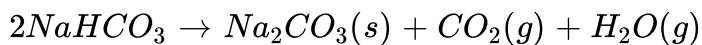
14. Predict in which of the following reactions, entropy increases/decreases

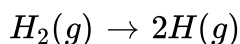Temperature of a crystalline solid is raised from 0 K to 115 K

15. Predict in which of the following reactions, entropy increases/decreases

$$2NaHCO_3 \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

16. Predict in which of the following reactions, entropy increases/decreases

$$H_2(g) \rightarrow 2H(g)$$

17. Describe the measurement of ΔU by bomb calorimeter.

18. Explain change in enthalpy.

19. Write the Born-Haber cycle for NaCl.

20. Show that entropy as a state function.

21. Explain change in entropy of a system during a reversible process $\Delta S = \dfrac{q_{rev}}{T}$

22. Derive Gibb's Helmholtz equation.

23. Show that free energy (ΔG) as a criterion for spontaneous and non-spontaneous processes.

24. Write the relation between ΔG° and equilibrium constant.

A. $\Delta G^\circ = -2.303RT \log K$

B. $\Delta G^\circ = -RT \log K$

C. $\Delta G^\circ = 2.303RT \log K$

D. $\Delta G^\circ = -2.303 \log K$

Answer: A

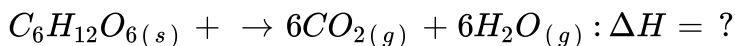**25.** Explain Gibb's energy change and equilibrium.

Numerical Problems

1. Calculate the hest of reaction of the following reaction :

$$C_6H_{12}O_{6(s)} + \ \rightarrow 6CO_{2(g)} + 6H_2O_{(g)} : \Delta H = \ ?$$

2. Calculate the heat of reaction of the following reaction :

$$CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$$
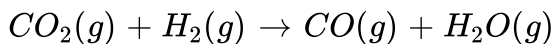
Given that the $\Delta_f H^\circ$ of $CO(g) = \ -110.5 kJ, \Delta_f H^\circ$ of $CO_2(g) = \ -393.8 kJ, \Delta_f H^\circ$ of $H_2O(g) = \ -241.8 kJ$ respectively
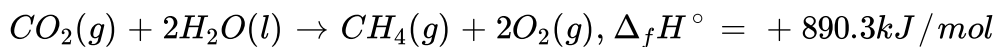
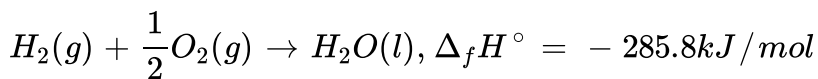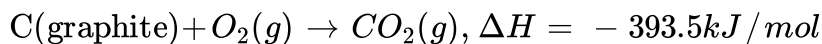**3.** $1m^3$ of C_2H_4 at STP is burnt in oxygen, according to the thermochemical reaction :

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l), \Delta H = -1410 kJmol^{-1}.$$
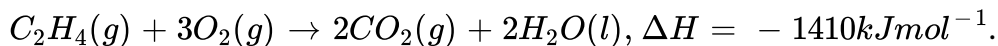
Assuming 70% efficients, determine how much of useful heat is evolved in the reaction.
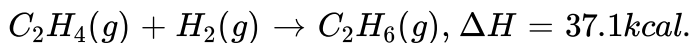
4. With the help of a thermochemical equation, calculate $\Delta_f H^\circ$ at 298 K for the following reactions :

$$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g), \Delta H = -393.5 kJ/mol$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta_f H^\circ = -285.8 kJ/mol$$

$$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g), \Delta_f H^\circ = +890.3 kJ/mol$$

5. The heat of combustion of C_2H_6 is $-368.4 kcal$. Calculate the heat of combustion of C_2H_2, when the heat of combustion of H_2 is $68.32 kcalmol^{-1}$.

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g), \Delta H = 37.1 kcal.$$

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6. The following thermochemical equations represent combustion of ammonia and hydrogen.

$$4NH_3(g) + 3O_2(g) \rightarrow 6H_2O(l) + 2N_2(g), \Delta H = -1516 kJ$$

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l), \Delta H = -572 kJ$$
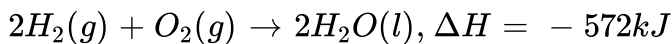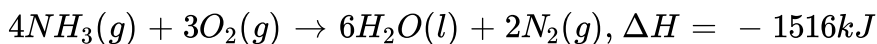
Calculate enthelpy of formation of ammonia.

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7. The equilibrium constant at $25°C$ for the process

$$CO^{3+}(aq) + 6NH_3(aq) \Leftrightarrow [CO(NH_3)_6]^{3+}(aq) \text{ is } 2.5 \times 10^6. \text{ Calculate}$$
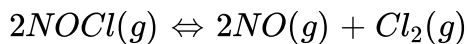
the value of ΔG° at $25^\circ C$. $(R = 8.314 JK^{-1}mol^{-1})$. In which direction is the reaction spontaneous under standard conditions ?

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**8.** What is the value of the equilibrium constant for the following reaction at 400 K ?

$$2NOCl(g) \Leftrightarrow 2NO(g) + Cl_2(g)$$

$$\Delta H^\circ = 77.5 kJmol^{-1}, R = 8.3124 Jmol^{-1}K^{-1}, \Delta S = 135 JK^{-1}mol^{-1}$$
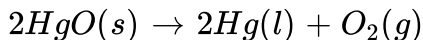
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9. 1.250 g of a sample of octane (C_8H_{18}) is burnt in excess of oxygen in a bomb calorimeter. The temperature of the calorimeter rises from 298 K to 304.73 K. If heat capacity of calorimeter is 8.93 kJ/K. Calculate the heat transferred. Also calculate ΔU and ΔH of the reaction at 298 K. The reaction involved is

$$C_8H_{18(l)} + \frac{25}{2}O_{2(g)} \rightarrow 8CO_{2(g)} + 9H_2O_{(l)}.$$
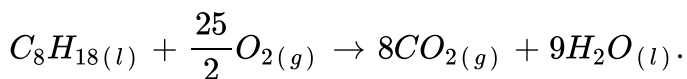
10. Calculate the standard free energy change ΔG° for the reaction,

$$2HgO(s) \rightarrow 2Hg(l) + O_2(g)$$

$\Delta H^\circ = 91 kJmol^{-1}$ at $298K$, $S^\circ_{(HgO)} = 72.0 JK^{-1}mol^{-1}$.

11. From the data given below at 298 K for the reaction :

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$
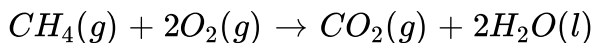
Calculate the enthalpy of formation of $CH_4(g)$ at 298 K.

Enthalpy of reaction is = -893.5 kJ

Enthalpy of formation of $CO_2(g) = 393. \, kJmol^{-1}$

Enthalpy of formation of $H_2O(l) = 286.0 kJmol^{-1}$.

12. Calculate the free energy change when 1 mole of NaCl is dissolved in water at 298 K. (Given : Lattice energy of NaCl $= -777.8 kJmol^{-1}$), Hydration energy $-774.1 kJmol^{-1}$ and $\Delta S = 0.043 kJmol^{-1}mol^{-1}$ at 298 K).

13. For the equilibirum, $PCl_5(g) \Leftrightarrow PCl_3(g) + Cl_2(g)$ at 298 K, $K = 1.8 \times 10^{-7}$. Calculate ΔG° for the reaction $(R = 8.314 JK^{-1}mol^{-1})$.

14. Calculate the entropy change involved in convertion of 1 mole of water at 373 K to vapours at the same temperature. Latent heat of vaporisation of water $= 2.257 kJg^{-1}$.

15. Calculate ΔH_f of HCl if bond energy of H-H bond is 437 kJ Cl-CL bond is 244, and H-C is $433kJmol^{-1}$.

16. Calculate the Gibb's energy change for the formation of propane, $C_3H_{8(g)}$ at 298 K. Given that

$\Delta_f H$ for propane $= -103.85kJmol^{-1}$

ΔS for the reaction is $-269.74JK^{-1}$.

17. For the reaction, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g), \Delta H = -95.2kJ$ and $\Delta S = -198.1JK^{-1}$. Calculate the temperature at which Gibb's energy change of the reaction (ΔG) becomes equal to zero.

18. For a water gas reaction, $C_{(s)} + H_2O_{(g)} \Leftrightarrow CO_{(g)} + H_{2(g)}$ at 1000 K, the standard Gibb's energy change is $-8.1 kJmol^{-1}$. Calculate the value of equilibrium constant.

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19. Calculate the standard free energy for a reaction $X \Leftrightarrow Y$, if the value of equilibrium constant is 1.8×10^{-7} at 298 K.

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20. Calculate the standard Gibb's energy change for a reaction at 298 K, if its equilibrium constant is 50.

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21. Equilibrium constant of a reaction is 0.008. Calculate the standard Gibb's energy change at 298 K.

22. Standard Gibb's energy change of a reaction is 62 kJ/mole. Calculate the equilibrium constant at 300 K.

23. For a reaction $A + B \rightarrow C + D$, the entropy change is $+68.4JK^{-1}$ and the enthalpy change is -124.6 kJ. Calculate the Gibb's energy change at 298 K.

24. Enthalpy change and entropy change of a chemical reaction are $-10.5kJmol^{-1}$ and $-31.5JK^{-1}mol^{-1}$ respectively. Predict whether the reaction is spontaneous or not at 300 K.

25. For the reaction, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, $\Delta H = -95.2kJ$ and $\Delta S = -198.1JK^{-1}$. Calculate the temperature at which Gibb's energy change of the reaction (ΔG) becomes equal to zero.

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26. One mole of an ideal gas at $27°C$ undergoes isothermal expansion reversible from a volume of $10dm^3$ to a volume of $20dm^3$. Calculate the work done on the gas.

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27. Three moles of an ideal gas at $27°C$ are compressed reversibly and isothermally from a volume of $10dm^3$ to $5dm^3$. Calculate the work done on the gas.
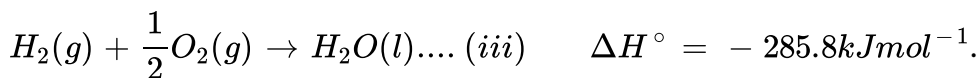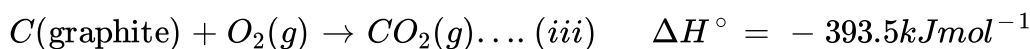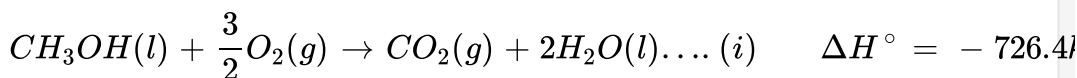
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28. Three moles of helium gas at one atmosphere are compressed reversibly and isothermally at $127°C$ to 5 atmospheres. Calculate the work done.

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29. One mole of an ideal gas expands isothermally and reversibles from 5 atmospheres to 1 atmosphere at $50°C$. Calculate the work done.

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30. Calculate the enthalpy of formation of methanol from the following data,

$CH_3OH(l) + \dfrac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$.... (i) $\quad \Delta H° = -726.4$

$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g)$.... (iii) $\quad \Delta H° = -393.5 kJmol^{-1}$

$H_2(g) + \dfrac{1}{2}O_2(g) \rightarrow H_2O(l)$.... (iii) $\quad \Delta H° = -285.8 kJmol^{-1}$.

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31. When one mole of gaseous methane s burnt in excess of gaseous oxygen, 890 kJ of heat is evolved in addition to the formation of gaseous CO_2 and liquid water. (a) Write the thermochemical equation for this reaction. (b) Calculate the amount of heat evolved when 10 grams of methane is burnt.

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32. Calculate $\Delta_r G^\circ$ for the conversion of oxygen to ozone, $\frac{3}{2}O_2(g) \rightarrow O_3$ at $298K$, given partial pressure equilibrium constant is 2.47×10^{-29}.

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33. Calculate ΔH for the reaction $2O_2(g) \rightarrow 3O_2(g)$ at 298 K and 1 atmosphere pressure given that $\Delta U = -287.9kJ$ and $R = 8.314JK^{-1}mol^{-1}$.

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34. Calculate the ΔH at 298 K for the reaction $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$ given that ΔH for the formation of NH_3 has a valve of $-46.0 kJmol^{-1}$ $(R = 8.314 JK^{-1}mol^{-1})$.

35. Enthalpy of combustion of benzene is $-3267 kJmol^{-1}$. Calculate enthalpy of formation of benzene, given enthalpy of formation of CO_2 and water are $-393.5 kJmol^{-1}$ and $-285.83 kJmol^{-1}$.

36. Calculate $\Delta_r G^\circ$ for the reaction for which the value of K_p is 1.5×10^{10} at 300 K.

37. ΔG° of a reaction is $120 kJmol^{-1}$. Calculate the K_p at $20^\circ C$.

38. Standard free energy change of a reaction is $+150 kJmol^{-1}$. Calculate K_p at $30^\circ C$.