CHEMISTRY

BOOKS - MAXIMUM PUBLICATION

THERMODYNAMICS

Example

1. Hot coffee in a thermosflask is an example of _____ system.

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2. Which of the following statement is incorrect about internal energy? a) The absolute value of internal energy cannot be determined b) The internal energy of one mole of a substance is same at any temperature or pressure c) The measurement of heat change during a reaction by bomb calorimeter is equal to the internal energy change d) Internal energy is an extensive property

A. The absolute value of internal energy cannot be determined

B. The internal energy of one mole of a substance is same at any temperature or pressure

C. The measurement of heat change during a reaction by bomb calorimeter is equal to the internal energy change

D. Internal energy is an extensive property

Answer: B

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3. For which of the following the standard enthalpy is not zero?

A. C (Diamond)

B. C (Graphite)

C. Liquid mercury

D. Rhombic sulphur

Answer: A

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4. Say TRUE or FALSE?

Any spontaneous process must lead to a net increase

in entropy of the universe.

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5. The ΔH for a reaction is-30kJ. On the basis of this fact, we can conclude that the reaction

    A. Gives off thermal energy

    B. Is fast

    C. Is slow

    D. Is spontaneous

Answer: A

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6. Write the type of system in each of the following:

a) Hot water taken in an open vessel

b) Hot water taken in a closed metallic vessel

c) Hot water taken in a thermos flask

7. In a reversible process the total change in entropy is ΔS (universe) is

8. For the reaction $Ag_2O \rightarrow 2Ag + \dfrac{1}{2}O_2(g)$ ΔS and ΔH are $6.66 JK^{-1}mol^{-1}$ and $30.56 kJmol^{-1}$ respectively. The reaction will not be spontaneous at what temperature

A. 4579K

B. 4589K

C. 3589K

D. 4599K

Answer:

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9. One mole of methane undergoes combustion to form CO_2 and water at 25^oC. The difference between ΔU & ΔH will be

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10. A gas expands from 1l to 6l against a constant pressure of 1 atm and it absorbs 500J of heat ΔU is

11. Born Haber cycle is to find out _____

12. a) Explain enthalpy of fusion.

b) Give illustration of fusion of ice.
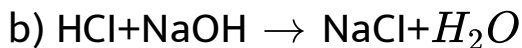
13. a) What do you meant by enthalpy of vapourisation?

b) Explain enthalpy of sublimation.

14. One equivalent of an acid reacts completely with one equivalent of a base in dilute solution.

a) Which type reaction is this?

b) HCl+NaOH $\rightarrow$ NaCl+H_2O

On the basis of above equation, explain enthalpy of neutralisation.

15. a) What is the different between system and surroundings?

b) There are different types of systems. What are they? Explain.
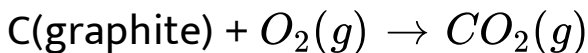
c) Give example for different types of systems.

16. a) What is meant by enthalpy?
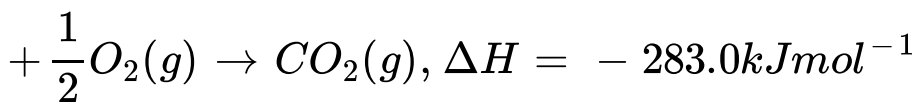
b) Derive an equation for enthalpy change.

c) What is enthalpy change?
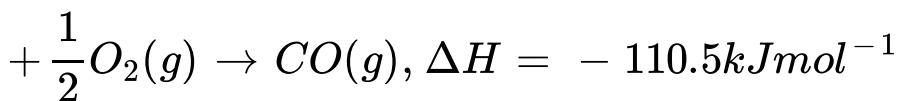
17. a) Find the enthalpy of the reaction,

C(graphite) + $O_2(g) \rightarrow CO_2(g)$

Given,

i) C(graphite)

$+ \dfrac{1}{2}O_2(g) \rightarrow CO(g), \Delta H = -110.5 kJmol^{-1}$

ii) CO(g)

$+ \dfrac{1}{2}O_2(g) \rightarrow CO_2(g), \Delta H = -283.0 kJmol^{-1}$

b) Melting of ice is a spontaneousnprocess. What are the criteria for spontaneity of a process?

18. Explain the following:

i) Enthalpy of atomization

ii) Enthalpy of solution at infinite dilution

19. The enthalpy change for the reaction,

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ Is -92.38 kJ at 298 K.

What is ΔU at 298 K?

20. What are the two types of heat capacities? How they are related?

21. Enthalpy and Entropy changes of two reactions are given below: Find out whether they are spontaneous or not at $27^{o}C$. Justify.

a) ΔH = 26 kJ/mole, ΔS = 8.3 J/K/mole

b) $\Delta H = -393.4$ kJ/mole, ΔS = 6 J/K/mole

22. a) What is enthalpy of solution?

b) What is enthalpy of dilution?
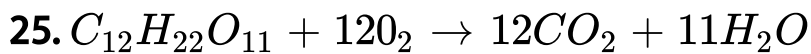
23. What is the significance of the second law of thermodynamics in the spontaneity of exothermic and endothermic reactions?

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24. Explain the importance of third law of thermodynamics.

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25. $C_{12}H_{22}O_{11} + 12O_2 \rightarrow 12CO_2 + 11H_2O$

Consider this equation and answer the following questions.

a) Thermodnamically, which type reaction is this?

b) What is enthalpy of combustion?

c) Give another example.

26. Bond dissociation energies of hydrogen and nitrogen are 430 kJ and 941.8 kJ respectively and the enthalpy of formation of NH_3 is - 46 kJ. What is the bond energy of N-H bond?

27. In 1840, G.H.Hess (a Russian chemist) proposed an important generalisation of thermochemistry which is known after his name as Hess's law.

a) State Hess's law.

b) Give illustration of Hess's law.

28. $\Delta U = q - p\Delta V$. If the process is carried out at constant volume, then $\Delta V = 0$. Answer the following questions.

a) Give the equation for ΔU.

b) 1000J was supplied to a system at constant volume. It resulted in the increase of temperature of the system from 45^oC to 50^oC. Calculate the change in internal energy.

29. Thermodynamics deals with macroscopic properties.

a) What is the difference between extensive and intensive properties?

b) Classify the following properties into extensive and intensive.

Pressure, Mass, Volume, Temperature, Density, Heat capacity, Viscosity, Surface tension, Internal energy, Molar heat capacity, Refractive index, Enthalpy, Specific heat capacity.

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30. a) What is meant by state of the system and state variables?

b) Give any four examples for state variables/state functions.

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31. a) Explain the Zeroth law of thermodynamics.

b) What are the important modes of transference of energy. Explain.

32. a) Explain the symbols and sign conventions of heat and work.

b) Explain internal energy.

33. Fill in the blanks.

a) If heat is released, 'q' is ....

b) For exothermic process $'\Delta H'$ is ....

c) If work is done on the system, 'w' is ....

d) For endothermic process $'\Delta H'$ is ....

e) If work is done by the system, 'w' is ....

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34. a) What is meant by enthalpy of formation?

b) What is the value of standard enthalpy of formation $(\Delta_f H^o)$ of an element?

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35. First Law of thermodynamics is the law of conservation of energy.
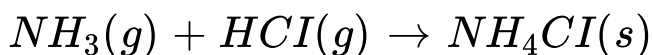
a) Give the mathematical form of the first law.

b) Write the Gibb's equation.

c) What is the sign for ΔG for a spontaneous process?

36. a) Predict the sign of ΔS for the reaction,

$$NH_3(g) + HCI(g) \rightarrow NH_4CI(s)$$

b) The reaction between gaseous hydrogen and

chlorine is

$$H_2(g) + CI_2(g) \rightarrow 2HCI(g), \Delta_r H = -1840kJ$$

i) What is the enthalpy of formation of HCl?

ii) How much heat will be liberated at 298 K and 1 atm for the formation of 365 g of HCl?

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37. Derive the Meyer's relationship.

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38. a) In a process 701 J of heat is absorbed by a system and 394 J of work is done by the system. What

is the change in internal energy for the process?

b) What is free expansion? What is the work done during free expansion of an ideal gas?

39. a) Name the instrument used for measuring the ΔU of a process.

b) What is the value of ΔG for a reaction at equilibrium?

c) ΔH and ΔS of a reaction are 30.56 and 0.666 kJ/mol respectively at 1 atm pressure. Calculate the temperature at which the reaction is in equilibrium.

40. Thermodynamic process differ based on the manner in which it is carried out.

a) Distinguish between reversible and irreversible processes.

b) Calculate the amount of work done when 2 moles of a gas expands from a volume of 2 L to 6 L isothermally and irreversibly against a constant external pressure of 1 atm.

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41. a) What are thermochemical equations?

b) Give an example for a thermochemical equation.

42. a) Define lattice enthalpy of an ionic compound.

b) What is Born-Haber cycle?

43. Predict what happens to entropy in the following changes:

a) Metal is converted into alloy.

b) Solute crystallizes from solution.

c) Hydrogen molecule dissociates.

44. a) Give the relation between change in enthalpy and change in free energy.
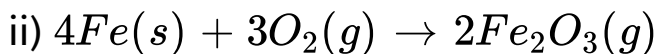
b) Name the above relation.

c) What is the significance of the above relation?

45. a) Predict in each of the following whether entropy increses or decreases.

i) Sublimation of camphor

ii) $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(g)$

b) The equilibrium constant for a reaction at $30^\circ C$ is 2.5×10^{-29}. What will be the value of ΔG^o?

46. a) Explain the effect of temperature on the spontaneity of a process based on Gibbs equation.

b) For a reaction $2A(g) + B(g) \rightarrow 2D(g)$, enthalpy and entropy changes are $-20.5kJmol^{-1}$ and $-50.4JK^{-1}mol^{-1}$ respectively. Predict whether the reaction occurs at $25^\circ C$.

47. a) Explain the first, second and third laws of thermodynamics.

b) What do you meant by entropy?

c) Explain the spontaneous process.

48. U_1, q, w, U_2 are given. U_1 is internal energy, q is absorbed heat, w is work done and U_2 is final energy.

a) Derive an equation for ΔU.
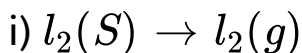
b) Give the equation for w.

c) Calculate the change in internal energy of a system

which absorbs 200 J of heat and 315 J of work is done

by the system.

49. a) Predict whether entropy increases or decreases

in the following changes:

i) $l_2(S) \rightarrow l_2(g)$

ii) Temperature of a crystalline solid is raised from 0 K

and 115 K.

iii) Freezing of water

b) Calculate the enthalpy of combustion of methane.

Given that standard enthalpies of formation of

CH_4, CO_2 and H_2O are -75.2, -394 and -285.6 kJ/mol respectively.

50. In a process, 701 J of heat is absorbed by a system and 394 J of work is done by the system. What is the change in internal energy for the process?

51. The reaction of cyanamide, $NH_2CN(s)$ with oxygen was carried out in a bomb calorimeter and ΔU was found to be $-742.7 kJmol^{-1}$ at 298 K.

Calculate the enthalpy change for the reaction at 298 K.

52. Calculate the number of kJ of heat necessary to raise the temperature of 60 g of aluminium from 35^oC to 55^oC. Molar heat capacity of Al is 24 J $mol^{-1}K^{-1}$.

53. The enthalpy of formation of CO(g), $CO_2(g)$, $N_2O(g)$, $N_2O_4(g)$ are -110, -393, 81 and 9.7 kJ

mol^{-1} respectively.N_2O_4+3CO(g) $\rightarrow$ $N_2O(g)$+3CO_2 (g). Find *the value of* ΔrH for the reaction:

A. 666.6kJ mol^{-1}

B. -777.7kjmol^{-1}

C. 777.7kjmol^{-1}

D. -666.6kJ mol^{-1}

Answer:

54. The equilibrium constant for the reaction is 10. Calculate the value of ΔG^o , Given R = 8 J $K^{-1}mol^{-1}$

, T = 300 K.

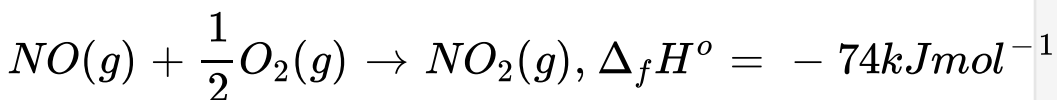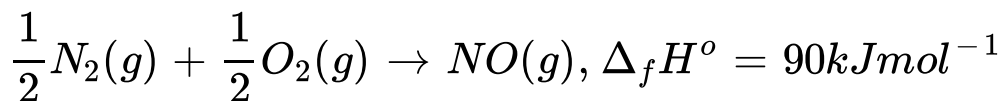**55.** Calculate the entropy change in surrounding when 1.0 mol of $H_2O(l)$ is formed under standard conditions. Given $\Delta_f H^o = -286 kJmol^{-1}$.

56. Comment on the thermodynamic stability of NO(g) and $NO_2(g)$ given :

$$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g), \Delta_f H^o = 90 kJmol^{-1}$$

$$NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g), \Delta_f H^o = -74 kJmol^{-1}$$

57. a) State Hess's Law of constant heat summation.

b) The equilibrium constant for a reaction is 5. What will be tha value of ΔG^0.

Given that R = 8.314 $JK^{-1}mol^{-1}$, T=300K.

R = 8.314 $JK^{-1}mol^{-1}$

T = 300K

58. A system in thermodynamics refers to that part of the universe in which observation are made.

a) What do you mean by an isolated system? Given an example.

b) Distinguish between intensive and extensive properties. Give two examples for each.

59. Lattice enthalpy of an ionic salt is a factor that determine its stability.

a) Define the lattice enthalpy.

b) Draw the Born-Haber cycle for the calculation of lattice enthalpy of the ionic crystal NaCl.

60. The spontaneity of a process is expressed in terms of a change in Gibbs energy.

a) What is meant by a change in Gibbs energy of a system?

b) How is it related to the enthalpy and entropy of a system?

c) How is it useful in predicting the feasibility of a process?

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61. A spontaneous process is an irreversible process and may only by reserved by some external agency.

a) Decrese in enthalpy is the only criterion for spontaneity. Do you agree? Why?

b) Calculate the work done for the reversible isothermal expansion of 1 mole of an ideal gas at 27^oC , from a volume of 10 dm^3 to a volume of 20 dm^3.

62. Thermodynamics deals with energy changes of macroscopic system.

a) Consider a chemical reaction taking place in a closed insulated vessel. To which type of thermodynamic system does it belong?

b) State the first law of thermodynamics.

c) 3 mol of an ideal gas at 1.5 atm and $25^{o}C$ expands isothermally in a reversible manner to twice its original volume against an external pressure of 1 atm. Calculate the work done.

$$\left[R = 8.314 JK^{-1}mol^{-1} \right]$$

63. Enthalpy and entropy changes of a reaction are 40.63 kJ/mol and 108.8 $Jk^{-1}mol^{-1}$. Predict the feasibility of the reaction atr $27^{o}C$.

64. Most of the naturally occurring processes are spontaneous.

a) Give the criteria for spontaneity of a process in terms of free energy change (ΔG)

b) Exothermic reactions associated with a decrease in entropy are sponaneous at lower temperatures. Justify on the basis of Gibbs equation.

c) Find the temperature above which the reactin

$$MgO_{(s)} + C_{(s)} \rightarrow$$

$Mg_{(s)} + CO_{(g)}$ becomes spontaneous.

(Given   (

$\Delta_r H^\theta = 490 kJmol^{-1} \& \Delta_r S^\theta = 198 JKmol^{-1})$

65. **a)** The enthalpy of combustion of $CH_{4(g)}$, $C_{graphte}$ and $H_{2(g)}$ at 298 K are - 890.3 kJ mol^{-1}, - 393.5 kJ mol^{-1} and -285.8 kJ mol^{-1} respectively. Calculate the enthalpy of formation of $CH_{4(g)}$.

b) Match the following:

W = - Δu	- Enthaly change
Δu = O	- Universal gas constant
C_p - C_v	- Adiabatic process
q_p	- Isothermal process
	- Cyclic process

66.   a)   For   the   oxidation   of   iron   4

$Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)}$, entropy change is

$-549.4 JK^{-1}mol^{-1}$ at 298 K. Inspite of the negative

entropy change of this reaction, why is the reaction

spontaneous?

(ΔH_r^0 for the reaction is $-1648 \times 10^3 Jmol^{-1}$).

b) Write the difference between extensive and

intensive properties. Give one example of each.

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67. a) ΔG gives a criteria for spontaneity of reactions

at a constant pressure and temperature. How is ΔG

helpful in precting the spontaneity of the reaction?

b) State and explain Hess's law of constant heat summation.

68. a) Classify the following into intensive and extensive properties.

i) Inernal energy ii) Density

iii) Heat Capacity iv) Temperature

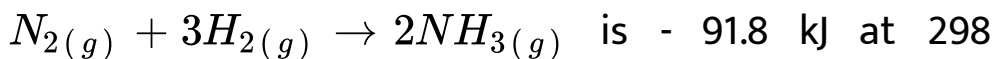b) Calculate the standard free energy change (ΔG^{θ}) for the conversion of oxygen to ozone $\frac{3}{2}O_{3(g)} \rightarrow O_{3(g)}$ at 298 K if the equilibrium

constant for the conversion is 2.47×10^{-29}.

(Given R = 8.314 $JK^{-1}mol^{-1}$)

69. The enthalpy change for the reaction.

$N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ is - 91.8 kJ at 298
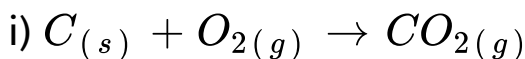
K.what is ΔU at 298K?

$(R = 8.314 JK^{-1}mol^{-1})$

70. The enthalpy change in a process is the same, whether the process is carried out in a single step or
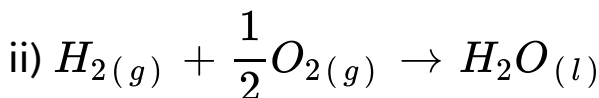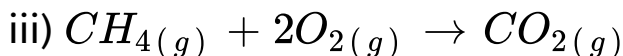
inseveral steps.

a) Identify tha law stated here.

b) Calculate the enthalpy of formation of CH_4 from the following data :

i) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

ΔH = -393.7kJ/mol

ii) $H_{2(g)} + \dfrac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$

ΔH = -285.8kJ/mol

iii) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)}$

ΔH=-890.4kJ/mol