CHEMISTRY

BOOKS - NAGEEN CHEMISTRY (ENGLISH)

CHEMICAL THERMODYNAMICS

Example

1. State whether each of the following will increase or decrease the total energy content of the system.

heat transferred to the surroundings.

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2. State whether each of the following will increase or decrease the total energy content of the system.

Work done by the system.

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3. State whether each of the following will increase or decrease the total energy content of the system.

Work done on the system.

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4. Heat transferred from surroundings to the system will increase or decrease the total energy content of the system.

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5. A system absorbs 400 J of heat and does work equivalent to 150 J on the surroundings. Calculate the change in the internal energy of the system.

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6. A gas expands against a constant pressure of 1 atm from a volume of 5L to 10L. During the process, system absorbs 400 J of heat from the surroundings. Calculate the change in the internal energy of the system.

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7. A 5.0 litres cylinder contained 10 moles of hydrogen gas at 27°C. Due to leakage, entire gas escaped into the atmosphere. The atmospheric pressure is 1.0 atm. Calculate the work done by the gas assuming hydrogen to be an ideal gas.

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8. The enthalpy change (ΔH) 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 ? $\left(R = 8.314 jK^{-1} mol^{-1}\right)$

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9. The difference between heats of reaction at constant pressure and constant volume for the reaction,

$2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$

at $25^\circ C$ in kJ is

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10. The heat of combustion of methane $CH_4(g)$ is measured in a bomb calorimeter at 298.2 K and is found to be $-885.50 kJ mol^{-1}$. Find the value of enthalpy change $\Delta \mathrm{H}$.

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11. 0.16 g of methane was subjected to combustion at 27°C in a bomb calorimeter. The temperature of the calorimeter system (including water) was found to rise by 0.5°C. Calculate the heat of combustion of methane (i) at constant volume and (ii) at constant pressure. The thermal capacity of the calorimeter system is $17.7kJK^{-1}\left(R=8.314JK^{-1}mol^{-1}\right)$.

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12. 10 moles of a gas are heated at constant volume from $20^{\circ}C$ to $30^{\circ}C$. Calculate the change in the internal energy of the gas. The molar heat capacity of the gas at constant pressure, $C_p=6.82calK^{-1}mol^{-1}$ and $R=1.987calK^{-1}mol^{-1}$.

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13. A gas expands from $3dm^3$ to $5dm^3$ against a constant pressure of 3.0 atm. The work done during expansion is used to heat 10 moles of water at temperature 290 K. Calculate the final temperature of water. Specific heat of water $= 4.184JK^{-1}g^{-1}$.

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14. The enthalpy change for the transition of liquid water to steam $\Delta_{vap}H$ is 40.8 kJ mol^{-1} at $100^{\circ}C$. Calculate the entropy change $(\Delta_{vap}S)$ for the process.

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15. What will be the melting point of KCl if enthalpy change for the reaction is $7.25\ \text{J mol}^{-1}$ and entropy change is $0.007\ \text{J K}^{-1}\text{mol}^{-1}$?

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16. Calculate the entropy change (ΔS) for the following reaction at $25^\circ C$.

$$SO_2(g) + \frac{1}{2}O_2(g) \rightarrow SO_3(g)$$

The absolute entropies at $25^\circ C$ and 1 atm pressure for $SO_2(g), O_2(g)$ and $SO_3(g)$ are 248.5, 205.0 and 256.2 J K^(-1) mol^(-1)` respectively.

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17. 1 mole of α-tin at 1 atm and $13^\circ C$ changes to 1 mole of β-tin at 1 atm and $13^\circ C$. If the enthalpy of transition is $2090 Jmol^{-1}$, calculate the entropy of transition.

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18. For the reaction, $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$ at $25^\circ C$, enthalpy change $\Delta H = +177 kJmol^{-1}$ and entropy change

$\Delta S = +285 Jmol^{-1}K^{-1}$. Calculate the free energy change ΔG at $25^\circ C$ and predict whether the reaction is spontaneous or not.

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19. At $0^\circ C$, ice and water are in equilibrium and $\Delta H = 6.0 kJmol^{-1}$ for the process

$H_2O(s) \Leftrightarrow H_2O(l)$

What will be ΔS and ΔG for the conversion of ice to liquid water?

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20. The enthalpy change (ΔH) for the reaction

$Ag_2O(s) \Leftrightarrow 2Ag(s) + \frac{1}{2}O_2(g)$

is $30.54 kJmol^{-1}$ and entropy change (ΔS) is $0.06 kJK^{-1}mol^{-1}$ at 1 atm. Calculate the temperature at which ΔG is equal to zero. Also predict the direction of reaction at a temperature below the calculated temperature.

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21. For a reaction, $K_p = 1.8 \times 10^{-7}$ at 300K. What is the value of ΔG° at this temeprature ?

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

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22. Calculate the standard free energy change for the following reaction

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

Given : $\Delta_f G^\circ \left[Cu^{2+}(aq)\right] = 65.0 kJ mol^{-1}$

$\Delta_f G^\circ \left[Zn^{2+}(aq)\right] = -147.2 kJ mol^{-1}$

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23. Calculate the equilibrium constant for the following reaction at 298 K:

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

Given : $\Delta_f G^\circ [H_2O(l)] = -273.2 kJmol^{-1} R = 8.314 Jmol^{-1} K^{-1}$.

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24. Calculate the enthalpy change for the reaction

$H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g)$

if the bond energies of $H - H, O = O$ and $O - H$ bonds are 104, 118 and 11 kcal mol^(-1)` respectivley.

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25. Calculate the standard enthalpy change for the reaction

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l),$

given that the standard heatds of formation of $CH_4(g, CO_2(g)$ and $H_2O(l)$ are $-74.91 mol^{-1}$, $-394.12 kJmol^{-1}$ and $-286.31 kJmol^{-1}$ respectivley.

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26. Calculate the standard heat of formation of $C_2H_5OH(l)$ from the following data:

(a) $C_2H_5OH(l) + 2O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$,

$\Delta H^\circ = -1366.5kJ$

(b) $\Delta_f H^\circ[CO_2] = -393.5kJmol^{-1}$,

$\Delta_f H^\circ[H_2O(l)] = -285.5kJmol^{-1}$.

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27. Calculate the calorific value of methane if it burns according to the equation

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta H = -890.0kJ$

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28. An average person eats carbohydrates equivalent to 0.350 kg of glucose and 0.200 kg of fats every day. The person needs about 10000 kJ per day. If the body consumes carbohydrates preferentially, how much will his weight increase per year assuming that only 50% of the excess fats are excreted. Give that the heat of combustion of glucose is 2900 kJ and combustion of fats produces energy equivalent to $39000kJkg^{-1}$?

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29. Calculate G° for conversion of oxygen to ozone 3/2 O2 ⇌ O3(g) at 298 Kp, if K for this conversion is 2.47 x 10-29 in standard pressure units.

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30. What would be the heat released when 0.5 mole of HCl in solution is neutralised by 0.25 mole of KOH?

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31. What would be the heat released when 0.6 mole of HNO_3 in solution is mixed with 0.4 mole of NaOH ?

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32. What would be the heat released when $250cm^3$ of 0.1 M HCl solution is mixed with $300cm^3$ of 0.1 M of NaOH solution?

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33. What would be the heat released when $200cm^3$ of 0.1 M H_2SO_4 solution is mixed with $150cm^3$ of 0.2 M KOH solution ?

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34. Calculate the heat of formation of glucose from the following data,

$C(s) + O_2(g) \rightarrow CO_2(g), \Delta H = -395.0kJ$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -269.4kJ$

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l), \Delta H = -2900kJ$

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35. The molar heats of combustion of $C_2H_2(g)$, C (graphite), and H_2 are -310.62kcal, -94.05 kcal and -68.32 kcal respectively. Calculate the standard heat of formation of $C_2H_2(g)$.

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36. Calculate the heat of the following reaction at $25^\circ C$.

$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

The heats of combustion of ethylene, hydrogen and ethane are-1410 kJ, -286.2 kJ and -1560.6 kJ respectively at$25^\circ C$.

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37. Calculate the heat of formation of anhydrous Al_2Cl_6 from the following data:

(i) $2Al + 6HCl(aq) \rightarrow Al_2Cl_6(aq) + 3H_2(g), \Delta H = -239.76kcal$

(ii) $Al_2Cl_6(s) + aq \rightarrow Al_2Cl_6(aq), \Delta H = -153.69kcal$

(iii) $H_2(g) + Cl_2(g) \rightarrow 2HCl(g), \Delta H = -44kcal$

(iv) $HCl(g) + aq \rightarrow HCl(aq), \Delta H = -17.31kcal$

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38. Calculate the C—C bond energy from the following data:

$2C(\text{graphite}) + 3H_2(g) \rightarrow C_2H_6(g), \Delta H = -84.67kJ$

$C(\text{graphite}), \rightarrow C(g)\Delta H = 716.7kJ$

$H_2(9g), \rightarrow 2H(g)\Delta = 435.9kJ$

Assume 416 as the C - H bond energy.

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39. Calculate the enthalpy of the following reaction :

$CH_2 = CH_2(g) + H_2(g) \rightarrow CH_3 - CH_3(g)$

The bond energies of C-H, C-C, C=C and H-H bonds are 414, 347, 615 and 435 kJ mol^{-1} respectively.

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Review Exercises

1. Define thermodynamics. Describe the significance and limitations of thermodynamics.

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2. What do you understand by the terms system and surroundings? Discuss with examples the various types of systems.

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3. Define State variables.

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4. Define State of a system.

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5. Define Intensive properties.

Watch Video Solution

6. Define Extensive properties.

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7. What type of systes are the following system?

Hot tea placed in a cup.

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8. What type of systes are the following system?

Hot tea placed in a sealed metallic tea pot.

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9. What type of systes are the following system?

Hot tea placed in a thermos flask.

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10. The equilibrium constant at 298 K for the reaction Cu(s) + 2Ag+ (aq) ⇌ Cu2+ (aq) + 2Ag(s) is 2.0 × 1015 . The concentrations of Cu2+ and Ag+

ions are 1.8 × 10-2 mol L-1 and 3.0 x 10-19 mol L-1 respectively. Is this reaction at equilibrium?

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11. Define heat and work.

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12. What do you mean by saying that the work done by a system is a path function?"

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13. Assign the proper sign to q and w in the following cases :

A system transfers 10 kJ of energy to the surroundings.

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14. Assign the proper sign to q and w in the following cases :

Surroundings transfer 25kJ of energy to the system.

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15. Assign the proper sign to q and w in the following cases :

15 kJ of energy is transferred to the system by doing work on it.

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16. Assign the proper sign to q and w in the following cases :

30 kJ of energy is lost by the system on account of the work done by the system on the surroundings.

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17. What do you understand by pressure-volume work? Derive an expression for it.

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18. Caclulate DeltaU, internal enegry change of a system, if it absorbs 25 kJ of heat and does 5kJ of work.

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19. A system absorbs 20kJ heat and also does 10kJ of work. The net internal enegry of the system

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20. Predict the mode of energy transference in the following processe.

(i) Cooking of food

(ii) Photosynthesis

(iii) Setting a cracker to fire.

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21. What is the mode of transference of energy when one plays on a piano?

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22. Sort out the intensive and extensive properties among the following: volume, pressure, mass, density, refractive index.

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23. Classify the following into open, closed and isolated system.

Boiling of milk in a pan.

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24. Classify the following into open, closed and isolated system.

Boiling tea kept in a thermos.

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25. Classify the following into open, closed and isolated system.

Hot food kept in a sealed metallic container.

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26. Explain first law of thermodynamics. What'is its physical significance ?

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27. Define internal energy and enthalpy of a system.

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28. Why is the enthalpy considered more useful than internal energy in chemical reactions ?

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29. Derive the following equation :

$\Delta H = \Delta U + (\Delta n)RT$

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30. One mole of an ideal gas is expanded from a volume of 3L to 5L under a constant pressure of 1 atm. Calculate the work done by the gas.

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31. During a process, a system absorbs 710 kJ of heat and does 250 J of work. Calculate the change in the internal energy of the system.

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32. Two moles of an ideal gas at 2 atm and $25^{\circ}C$ are compressed isothermally to one third of its volume by an external pressure of 6 atm. Calculate q, w and ΔU.

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33. A system has internal energy U_1. If 500 J of heat is supplied to it and at the same time it does 300 J of work. Calculate the internal energy of the system in the new state,

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34. Heat of combustion of CH_4(g) at constant volume and at 298 K has been found to be -885$kJmol^{-1}$, calculate the enthalpy of its combustion under constant pressure condition ($R = 8.31JK^{-1}mol^{-1}$).

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35. When 2 g of benzene are burnt in a bomb calorimeter, the heat produced is 83.6 kJ at 298 K. Calculate the enthalpy of combustion of benzene.

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36. The enthalpy change (ΔH) of the reaction at 298 K

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

is found to be -326.7 kcal. Calculate ΔE for the given reaction.

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37. $400cm^3$ of a gas are compressed to half of its volume by applying a pressure of 0.5 atm. During the process 6.5 J of heat flows out to the surroundings. Calculate ΔU of the system.

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38. Calculate the work done (w) and internal energy change (ΔU), when one mole of water at $100^\circ C$ vaporises against an atmospheric pressure of 1 atm assuming ideal gas behaviour. Heat of vapourisation of water at $100^\circ C$ is $1020calmol^{-1}$.

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39. Calculate the work done in calories when 5 moles of an ideal gas are compressed isothermally and reversibly from a pressure of 1.5 atm to 15 atm at $27^\circ C$.

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40. In a reaction 2.5KJ of heat is released from the system and 5.5 KJ of work is done on the system.Calculate 'DeltaU'.

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41. Define specific heat capacity and molar heat capacity of a substance.

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42. Prove that $C_p - C_v = R$.

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43. What do you understand by C_p and C_v ?

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44. Establish a relationship between C_v and C_p?

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45. Define the term 'entropy'. How does $T\Delta S$ determine the spontaneity of a process?

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46. What is meant by the term 'free energy'? What was the necessity of introducing such a function ?

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47. State the second law of thermodynamics. Predict the sign of ΔS in the following change at constant temperature and pressure. Give reason

in support of your answer.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

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48. State and explain the second law of thermodynamics. Mention the essential conditions for the spontaneity of a chemical reaction.

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49. What inferences do you draw on the basis of the values of Gibbs free energy change? How is it related to the enthalpy and entropy changes of a system at constant temperature and pressure?

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50. The enthalpy change for the transition of liquid water to steam $\Delta_{vap}H$ is 40.8 kJ mol^{-1} at $100^{\circ}C$. Calculate the entropy change

$(\Delta_{\text{vap}}S)$ for the process.

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51. At 373 K, the entropy change for the transition of liquid water to steam (ΔS_{vap}) is $109JK^{-1}mol^{-1}$. Calculate the enthalpy change $(\Delta_{\text{vap}}H)$ for the process.

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52. For the chemical equilibrium

$PCl_5(g) \Leftrightarrow PCl_3(g) + Cl_2(g)$ at $298K, K_c = 1.8 \times 10^{-7}$.

Calculate $\Delta_r G^{\Theta}$ for the forward reaction $R = 8.31JK^{-1}\text{mol}^{-1}$

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53. For a reaction, $K = 1.958 \times 10^{-4}$ at 400 K, what is the value of ΔG° at this temepratuure ?$\left(R = 8.314JK^{-1}mol^{-1}\right)$.

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54. Calculate ΔG° for the reaction

$2HCl(g) + F_2(g) \rightarrow 2HF(g) + Cl_2(g)$at $25^{\circ}C$

at Given : $\Delta_f G^{\circ}[HCl(g)] = -95.30kJmol^{-1}$.

$\Delta_f G^{\circ}[HF(g)] = -273kJmol^{-1}$. Also calculate the equilibrium constant the reacton at $25^{\circ}C$. Given, gas constant $R = 8.314JK^{-1}mol^{-1}$.

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55. Calculate the equilibrium constant for the following reaction at 298 K and 1 atm pressure.C(graphite)+H2O(l)=CO(g)+H2(g)

Given : 'Delta_f H^@ , [H_2O (l)] = -286.0 kJ mol^(-1), Delta_f H^@ [CO (g)] = - 110.5 kJ mol^(-1), DeltaS^@ $at298Kf$ or $thereaction = 252.6Jk^{-1}mol^{-1}$. Gas constant $R = 8.31Jk^{-1}mol^{-1}$.

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56. Calculate the equilibrium constant for the following reaction at 298 K and 1 atm pressure.C(graphite)+H2O(l)=CO(g)+H2(g)

Given : 'Delta_f H^@ , [H_2O (l)] = -286.0 kJ mol^(-1), Delta_f H^@ [CO (g)] = - 110.5 kJ mol^(-1), DeltaS^@ $at 298 K f \text{ or } the reaction = 252.6 Jk^{-1} mol^{-1}$. Gas constant $R = 8.31 Jk^{-1} mol^{-1}$.

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57. Calculate the standard free energy change for the reaction

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$

Given that the standard free energy of formation $\left(\Delta_f G^\circ\right)$ for $NH_3(g) NO(g)$ and $H_2O(l)$ are -16.8, + 86.7 and $-237.2 kJ mol^{-1}$ respectively. Predict the feasibility of the above reaction at the standard state.

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58. Calculate the standard entropy change for the reaction $X \Leftrightarrow Y$ if the value of $\Delta H^{\circ} = 28.40kJ$ and equilibirum constant is 1.8×10^{-7} at 298 K.

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59. Calculate the entropy change when 20.0 g of ice changes to liquid water at 0°C. The heat of fusion is $80.0calg^{-1}$.

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60. From the following values of ΔH and ΔS, decide whether or not these reaction are feasible at 298 K.

Reaction A : $\Delta H = -10.5 \times 10^{3} Jmol^{-1}, \Delta S = +31 JK^{-1}mol^{-1}$

Reaction B : $\Delta H = -11.7 \times 10^{3} Jmol^{-1}, \Delta S = -105 JK^{-1}mol^{-1}$

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61. Determine standard free energy ΔG° at $25^{\circ}C$ for the reaction

$N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$

Given: $\Delta H^{\circ} = -91.8kJ, \Delta S^{\circ} = -198JK^{-1}$

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62. For a hypothetical reaction $nX \rightarrow mY$, the value of $\Delta H = -133kJ$ and $\Delta S = -145JK^{-1}$. Calcualte the value of ΔG at 700 K.

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63. For a hypothetical reaction $nX \rightarrow mY$, the value of $\Delta H = -133kJ$ and $\Delta S = -145JK^{-1}$. Calcualte value of $\Delta S_{\text{surr.}}$ and ΔS_{univ}

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64. Compute the standard free energy of the reaction at $27^{\circ}C$ for the combustion of methane

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

using the following data :

Species	CH_4 (g)	O_2 (g)	CO_2 (g)	$H_2O(l)$
$\Delta_f H^{\circ}$ (kJ mol^{-1})	-74.8	—	-393.5	-285.8
S° (J K^{-1} mol^{-1})	186	205	214	70

Also comment on the feasibility of the reaction.

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65. The reaction

$$CH_3COOH(l) + C_2H_5OH(l) \Leftrightarrow CH_3COOC_2H_5(l) + H_2O(l)$$

was carried out at 27°C by taking one mole each of the reactants. The reaction reached equilibrium when 2/3rd of the reactants were consumed. Calculate the free energy change for the reaction.

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66. A system loses 120) of heat and does 80 J of work. Calculate the change in the internal energy of the system.

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67. Calculate the enthalpy change for the reaction

$CH_2 = CH_2(g) + H_2(g0 \rightarrow CH_3 - CH_3(g).$

The bond energies of $C - C, C - H, H - H$ and C = C bonds are 83 kcal, 99 kcal 104 kcal and 145 kcal respectivley.

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68. Sort out the exothermic and endothermic reactions among the following:

(i) $C(s) + 2H_2(g) \rightarrow CH_4(g), \Delta H = -17.89cal$

(ii) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g) = +284.5kJ$

(iii) $2HCl(g) \rightarrow 2H(g) + 2Cl(g), \Delta H = +857kJ$

(iv) $Cl_2(g) + 242kJ \rightarrow 2Cl(g)$

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69. Calculate the standard enthalpy change for the reaction

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$,

given that the standard heatds of formation of $CH_4(g, CO_2(g)$ and $H_2O(l)$ are $-74.91 mol^{-1}$, $-394.12 kJmol^{-1}$ and $-286.31 kJmol^{-1}$ respectivley.

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70. Calculate the standard heat of formation of propane if its heat of combustion is $-2220.2 kjmol^{-1}$. The heats of formation of $CO_2(g)$ and $H_2O(l)$ are -394.12 and $-286.31 kJmol^{-1}$ respectively.

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71. When 14.9 g of solid KCl is dissolved in large excess of water, the amount of heat liberated is 3.72 kJ. Calculate the heat of solution of KCI.

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72. what is entropy change for reaction 2H2(g) + O2 (g) -----?2H2O(l). Standard entropies of H2(g) , O2(g) and H2O(l) are 126.6, 201.20,68.0 J/k mol respectively

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73. Calculate the amount of heat liberated when $500cm^3$ of $\frac{N}{10}H_2SO_4$ react with $400cm^3$ of $\frac{N}{15}$ NaOH.

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74. The standard molar heat of formation of ethane, carbon dioxide and water (liquid) are -21.1, -94.1 and -68.3 kcal respectively. Calculate the standard heat of the following reaction :

$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$

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75. The ΔH° for the reaction

$H_2(g) + I_2(g) \rightarrow 2HI(g)$

is +53.6 kJ. Mention whether the reaction is exothermic or endothermic and calculate the standard heat of formation of HI.

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76. The heat of combustion of butane is 2658 kl. A cylinder of LPG gas (containing only butane) is assumed to contain 14.2 kg of butane. If a

normal family needs 18000 kJ of energy per day for cooking, how long the cylinder will last?

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77. The calorific value of milk is $3.2kJg^{-1}$. A child needs about 4000 kJ per day. If the child survives on milk only, how much milk (in mass) should be given to him every day?

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78. Sucrose undergoes combustion as

$C_{12}H_{22}O_{11} + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(l), \Delta H = -5643kJ$

How much energy will be liberated when 3.42 g of sucrose are burnt ?

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79. Calculate the heat of formation of methanol (CH_3OH) from thhe following data:

$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l), \Delta = -726kJ$

$C(s) + O_2(g) \rightarrow CO_2(g),$

$\Delta H = -394kJ$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -286kJ$

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80. Calculate the heat of formation of $MgCO_2$ (s) from the following data

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

$2Mg(s) + O_2(g) \rightarrow 2MgO(s), \Delta H = -1203.6kJ$

$MgO(s) + CO_2(g) \rightarrow MgCO_3(s), \Delta H = -117.7kJ$

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81. Calculate the bond energy of H-Cl bond, given that the bond energies of H–H, Cl—Cl bonds are $433kJmol^{-1}$ and $242kJmol^{-1}$ respectivly. The ΔH_f for HCl is -91 $kJ \quad mol^{-1}$.

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82. Calculate the heat of combustion of ethyl alcohol from the following data :

(i) Heat of formation of ethyl alcohol = -64.1 kcal

(ii) Heat of formation of water = -68.5 kcal

(iii) Heat of formation of CO2 =- 94.3 kcal.

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83. What would be the complications if Hess's law were not true?

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84. What is bond enthalpy and how is it calculated?

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Review Exercises Fill In The Blanks

1. $H_2(g) + Cl_2(g) \rightarrow 2HCl(g) + 185kJ$

This reaction is ..... Thermic and $\Delta H = \ldots kJ.$

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2. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -286kJ$

$2H_2(g) + O_2(g) \rightarrow 2H_2O(l), \Delta H = \ldots kJ$

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3. $H_2(g) + I_2(g) \rightarrow 2HI(g), \Delta H = 52.2kJ$

$2HI(g) \rightarrow H_2(g) + I_2(g), \Delta H = kJ$

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4. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g), \Delta H = -809kJ$

The calorific value of 1 kg of $CH_4(g)$ is ..... kJ/kg.

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5. $C(s) \rightarrow C(g), \Delta H = 716.7kJ$

ΔH is the heat of ..... of graphite.

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6. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g), \Delta H = -92.3kJ$

$2NH_3(g) \rightarrow N_2(g) + 3H_2(g), \Delta H = \ldots\ldots kJ$

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Very Short Answer Type Questions

1. Define thermodynamics.

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2. What type of systes are the following system?

Hot tea placed in a thermos flask.

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3. Sort out the intensive and extensive properties among the following:

Temperature, mass, specific heat, density, enthalpy, entropy, concentration, free energy.

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4. Which of the following are not state functions ?

Temperature, entropy, heat, work, enthalpy, internal energy.

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5. Distinguish between isobaric and isochoric process.

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6. What is the sign convention for heat ?

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7. A system transfers 20 kJ of heat to the surroundings. Write the value of q for both the system and surroundings.

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8. What is the sign convention for work?

Watch Video Solution

9. A gas expands by a volume ΔV against a constant pressure P. What is the work done by the system?

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10. Assertion : There is no change in internal energ in a cyclic process.

Reason : Internal energy is a state function.

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11. Write the mathematical statement of first law of thermodynamics.

Watch Video Solution

12. What happens to the internal energy of a system if work is done on the system.

Watch Video Solution

13. What happens to the internal energy of a system if work is done by the system?

Watch Video Solution

14. For the reaction, `N_2(g) + 3H_2(g) to 2NH_3(g) , predict whether the work is done by the system or on the system.

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15. Define internal energy of a system.

Watch Video Solution

16. What is the value of ΔE when the work done by the system is equal to the heat absorbed by the system?

Watch Video Solution

17. Define internal energy and enthalpy of a system.

Watch Video Solution

18. Derive the following equation :

$\Delta H = \Delta U + (\Delta n)RT$

Watch Video Solution

19. What is the value for ΔH for the given process,

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$?

Watch Video Solution

20. What do you understand by a spontaneous process ? Give two examples

Watch Video Solution

21. Which of the following processes are spontaneous and which are non-spontaneous ?

(i) Flow of air from high pressure to low pressure.

(ii) Formation of ice in a refrigerator.

(iii) Spreading of a drop of ink in water kept in a beaker.

(iv) Reverse osmosis.

(v) Burning of coal in air.

(vi) Dissolution of Cu in $ZnSO_4$ solution.

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22. In which direction does a spontaneous process proceed ?

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23. Dissolution of ammonium chloride in water is an endothermic reaction, yet it is a spontaneous process. This is due to the fact that

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24. Explain the term 'entropy'.

Watch Video Solution

25. If a system absorbs q amount of heat at temperature T, what would be the change in the entropy of the system?

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26. Define the term absolute entropy.

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27. Is the entropy of the universe constant ?

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28. Amongst a gaseous substance and a liquid substance, which is expected to possess higher entropy and why?

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29. For a process to be spontaneous :

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30. Which of the following are expected not to have zero entropy even at absolute zero ?

$NaCl, NO, CO_2, CO$

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31. What is the sign of ΔS for a spontaneous reaction ?

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32. How does the entropy change occur in the process of melting of a solid ?

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33. Write the expression which gives the entropy of vapourisation of a liquid.

Watch Video Solution

34. State and explain the second law of thermodynamics.

Watch Video Solution

35. Gibbs Free Energy

Watch Video Solution

36. What is the enthalpy of formation of the most stable form of an element in its standard state ?

Watch Video Solution

37. What does the term $T\Delta S_{\text{total}}$ total represent ?

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38. What is the free energy criterion for a process to occur spontaneously?

Watch Video Solution

39. The free energy change $\Delta G = 0$, when

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40. An endothermic process involves an increase in the entropy of the system. Predict the condition under which the process would be feasible.

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41. An exothermic reaction involves a decrease in the entropy of the system. Will the process be spontaneous ?

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42. How is standard free energy change related to equilibrium constant ?

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43. State the third law of thermodynamics.

Watch Video Solution

44. What do you understand by the term thermochemistry ?

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45. Can chemical energy be transferred into electrical energy? If yes, give an example.

Watch Video Solution

46. Assertion : ΔH for an exothermic reaction is negative nad for an endothermic reaction is positive.

Reason : Enthalpy is an extensive property.

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47. Why is it necessary to mention the physical state of substances in a thermochemical equation ?

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48. Define heat of reaction.

Watch Video Solution

49. Is calorific value of a food or a fuel is equal to its heat of combustion ?

Watch Video Solution

50. State whether each of the following processes is exothermic or endothermic : $KCl(s) + aq \rightarrow KCl(aq), \Delta H = +18.6kJ$

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51. State whether each of the following processes is exothermic or endothermic :

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l), \Delta H = -57.1kJ$

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52. State whether the following processes is exothermic or endothermic : $H_2O(l) \rightarrow H_2O(s), \Delta H = -6.01kJ$

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53. State whether each of the following processes is exothermic or endothermic : $H_2O(l) \rightarrow H_2O(g), \Delta H = +40.7kJ.$

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54. Name the heat that is involved in the conversion of one allotropic form into the other.

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55. What would be the complications if Hess's law were not true?

Watch Video Solution

56. What would be the bond formation energy of C-H bond if its bond energy is $+416.18 kJ mol^{-1}$?

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Short Answer Type Questions

1. Define thermodynamics. Describe the significance and limitations of thermodynamics.

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2. Define the System.

Watch Video Solution

3. Define State of a system.

Watch Video Solution

4. Define State variables.

Watch Video Solution

5. Explain with examples the various types of systems.

Watch Video Solution

6. What do you understand by intensive and extensive properties of a system ? Explain with examples.

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7. In an adiabatic process

Watch Video Solution

8. Define the Cyclic process.

Watch Video Solution

9. Define the Reversible process.

Watch Video Solution

10. Define heat and work and mention their sign conventions.

Watch Video Solution

11. State and explain the first law of thermodynamics. Derive its mathematical form.

Watch Video Solution

12. Give the limitations of the first law of thermodynamics.

Watch Video Solution

13. Define internal energy of a system.

Watch Video Solution

14. Using the first law of thermodynamics, Show that $\Delta U = q_v$.

Watch Video Solution

15. Define enthalpy and enthalpy change. Show that $\Delta H = q_p$.

Watch Video Solution

16. Define enthalpy. Show that the change in enthalpy at constant pressure for a reaction involving gases is given by the expression, $\Delta H = \Delta U + \Delta n_g . RT$.

Watch Video Solution

17. Establish a relationship between ΔH and ΔU. Under what conditions is $\Delta H = \Delta U$?

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18. Predict whether the reaction, $H - H(g) + Cl - Cl(g) \rightarrow 2H - Cl(g)$, will be exothermic or

endothermic. Give reason for your answer.

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19. State and explain the second law of thermodynamics.

Watch Video Solution

20. State a chemical reaction in which ΔH and ΔU are equal.

Watch Video Solution

21. What is meant by the term 'free energy'? What was the necessity of introducing such a function ?

Watch Video Solution

22. Define enthalpy and enthalpy change. Show that $\Delta H = q_p$.

Watch Video Solution

23. What is the free energy criterion for a process to occur spontaneously?

Watch Video Solution

24. Explain the term 'entropy'.

Watch Video Solution

25. State giving reason whether the following reaction would involve an increase, a decrease or no change in entropy.

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

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26. What do you understand by a spontaneous process ? Give two examples

Watch Video Solution

27. What do you understand by the spontaneity of a process ? Discuss the spontaneity of a process in terms of entropy and free energy.

Watch Video Solution

28. Can ΔH be regarded as the sole criterion to explain the spontaneity of a process? If no, explain why?

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29. With the help of at least two examples show that randomness increases in a spontaneous process.

Watch Video Solution

30. What is entropy and in what units is it expressed ? Discuss the physical significance of entropy.

Watch Video Solution

31. For the reaction $2H(g) \rightarrow H_2(g)$, the sign of ΔH and ΔS respectively are :

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32. What happens to the entropy when a gas undergoes expansion ? Explain.

Watch Video Solution

33. Is the entropy of the universe constant ?

Watch Video Solution

34. State and explain the second law of thermodynamics. Mention the essential conditions for the spontaneity of a chemical reaction.

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35. Show that the entropy changes in a reversible isothermal process is zero.

Watch Video Solution

36. Show that the entropy change in an irreversible process is always positive.

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37. Define 'entropy of fusion' and 'entropy of vapourisation and write expressions to represent them.

Watch Video Solution

38. State and explain the second law of thermodynamics.

Watch Video Solution

39. Gibbs Free Energy

Watch Video Solution

40. Derive the equation, $\Delta G = \Delta H - T\Delta S$.

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41. Give 2 points of difference between molarity and molality.

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42. What is the free energy criterion for a process to occur spontaneously?

Watch Video Solution

43. For the process $A + B \rightarrow C + D$, ΔG is positive. Comment on the spontaneity of the process.

Watch Video Solution

44. What are spontaneous processes ? Mention the conditions for a reaction to be spontaneous at constant temperature and pressure.

Watch Video Solution

45. What is entropy ? State the effect of increased temperature on the entropy of a substance.

Watch Video Solution

46. State the thermodynamic conditions for spontaneous occurrence of a process.

Watch Video Solution

47. ΔH and ΔS are positive for a chemical reaction. Under what conditions is the reaction expected to occur spontaneously?

Watch Video Solution

48. What is meant by free energy of a substance ? How is it related to its enthalpy and entropy?

Watch Video Solution

49. Define and explain the term entropy of a system. Illustrate it using a spontaneous irreversible change.

Watch Video Solution

50. Comment on the spontaneity of a process when

$\Delta H > 0, T\Delta S > 0$ and $T\Delta S < \Delta H$

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51. Comment on the spontaneity of a process when

$\Delta H > 0, T\Delta S < 0$

Watch Video Solution

52. Comment on the spontaneity of a process when

$\Delta H > 0, T\Delta S > 0 \text{ and } T\Delta S < \Delta H$

Watch Video Solution

53. Comment on the spontaneity of a process when

$\Delta H > 0, T\Delta S > 0 \text{ and } T\Delta S < \Delta H$

Watch Video Solution

54. Discuss the effect of temperature on the spontaneity of a process.

Watch Video Solution

55. How is standard free energy change related to equilibrium constant ?

Watch Video Solution

56. Discuss the relation between free energy and EMF.

Watch Video Solution

57. State the third law of thermodynamics.

Watch Video Solution

58. Why is heat evolved or absorbed in a chemical reaction ?

Watch Video Solution

59. What do you understand by exothermic and endothermic reactions ? How are they related to the change in enthalpy?

Watch Video Solution

60. What do you understand by standard enthalpy of a reaction and how is it represented ?

Watch Video Solution

61. Define heat of formation.How is it useful in the calculation of the heat of a reaction ?

Watch Video Solution

62. Calculate the calorific value of sugar if its heat of combustion is $5645 kJ mol^{-1}$.

Watch Video Solution

63. Why is heat of neutralisation for a strong acid and strong base constant ?

Watch Video Solution

Essay Long Answer Type Questions

1. What do you understand by the terms system and surroundings? Discuss with examples the various types of systems.

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2. What do you understand by pressure-volume work? Derive an expression for it.

Watch Video Solution

3. Derive an expression for the work done during an isothermal process.

Watch Video Solution

4. State and explain the first law of thermodynamics. Derive its mathematical form.

Watch Video Solution

5. What is internal energy and internal energy change? What is its significance ?

Watch Video Solution

6. Establish a relationship between ΔH and ΔU. Under what conditions is $\Delta H = \Delta U$?

Watch Video Solution

7. Define enthalpy of reaction.

Watch Video Solution

8. Discuss the relationship between $\Delta U, \Delta H, q_p$ and w for the dissociation of ammonia carried out under constant pressure.

$2NH_3(g) \xrightarrow{\text{heat}} N_2(g) + 3H_2(g)$

Watch Video Solution

9. Show that the heat absorbed at constant volume is equal to the increase in the internal energy of the system, whereas that at constant pressure is equal to the increase in the enthalpy of the system.

Watch Video Solution

10. State and explain the second law of thermodynamics.

Watch Video Solution

11. What do you understand by spontaneous and non spontaneous processes ? What are the important features of a spontaneous process ?

Watch Video Solution

12. What do you understand by the spontaneity of a process ? Discuss the spontaneity of a process in terms of entropy and free energy.

Watch Video Solution

13. What is entropy and how is it related to the spontaneity of a process?

Watch Video Solution

14. Show that the entropy changes in a reversible isothermal process is zero.

Watch Video Solution

15. Define the following and write expressions for calculating each of them. Entropy of fusion

Watch Video Solution

16. Define the following and write expressions for calculating each of them. Entropy of vapourisation.

Watch Video Solution

17. Define the following and write expressions for calculating each of them. Entropy of sublimation.

Watch Video Solution

18. How would you calculate the entropy change in a chemical reaction ? How is it helpful in discussing the spontaneity of the reaction ?

Watch Video Solution

19. What is Gibbs free energy ? Derive the relation, $\Delta_G = \Delta H - T\Delta S$. Discuss the free energy criterion for the spontaneity of a process.

Watch Video Solution

20. What is the status of a process when (i) $\Delta G < 0$ (ii) $\Delta G = 0$ (iii) $\Delta G > 0$?

In which of the above cases, the process can be used for obtaining useful work?

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21. Discuss the effect of temperature on the spontaneity of a process when for the process both ΔH and ΔS are negative.

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22. Discuss the effect of temperature on the spontaneity of a process when for the process both ΔH and ΔS are positive.

Watch Video Solution

23. State the third law of thermodynamics.

Watch Video Solution

24. What do you understand by enthalpy and change in enthalpy? Why does a chemical reaction involve a change in enthalpy?

Watch Video Solution

25. What are thermochemical equations and what is their significance in the study of chemical energetics ? State and explain the conventions used for writing a thermochemical equation.

Watch Video Solution

26. What is heat of reaction and on what factors does it depend?

Watch Video Solution

27. Write shot notes on the Heat of formation.

Watch Video Solution

28. Write shot notes on the Heat of combustion.

Watch Video Solution

29. Write shot notes on the Heat of solution.

Watch Video Solution

30. Write shot notes on the Heat of transition.

Watch Video Solution

31. Why is heat of neutralisation for a strong acid and strong base constant ?

Watch Video Solution

32. State and explain Hess's law of constant heat summation. Illustrate it with examples. Discuss its important applications.

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Objective Multiple Choce Type Questions

1. Thermodynamics is concerned with

A. total energy of the system

B. energy changes in a system

C. rate of a chemical change

D. mass changes in nuclear reactions.

Answer: B

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2. Thermodynamic equilibrium involves

A. chemical equilibrium

B. thermal equilibrium

C. mechanical equilibrium

D. all the three.

Answer: D

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3. During the isothermal expansion of an ideal gas, its

internal energy increases

enthalpy decreases

enthalpy remains unaffected

enthalpy reduces to zero.

A. internal energy increases

B. enthalpy decreases

C. enthalpy remains unaffected

D. enthalpy reduces to zero.

Answer: C

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4. Evaporation of water is:

a process in which heat is neither evolved nor absorbed

a process accompanied by chemical reaction

an exothermic change

an endothermic change.

A. a process in which heat is neither evolved nor absorbed

B. a process accompanied by chemical reaction

C. an exothermic change

D. an endothermic change.

Answer: D

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5. Which of the following reactions is endothermic ?

$CaCO_3(s) \rightarrow CaO(s) + CO_2(s)$

$Fe(s) + S(s) \rightarrow FeS(s)$

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

$CH_4(g) + 2O_2(g) \rightarrow CO_{29}g) + 2H_2O(l).$

A. $CaCO_3(s) \rightarrow CaO(s) + CO_2(s)$

B. $Fe(s) + S(s) \rightarrow FeS(s)$

C. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

D. $CH_4(g) + 2O_2(g) \rightarrow CO_{29}g) + 2H_2O(l).$

Answer: A

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6. For the reaction, $N_2[g] + 3H_2[g] \Leftrightarrow 2NH_3[g]$, $\Delta H = \ldots$

A. $\Delta U - 2RT$

B. $\Delta U + 2RT$

C. $\Delta U + RT$

D. $\Delta U - RT$.

Answer: A

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7. The difference between heats of reaction at constant pressure and constant volume for the reaction,

$2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$

at $25^\circ C$ in kJ is

A. $+7.43$

B. $+3.72$

C. -7.43

D. -3.72

Answer: C

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8. A spontaneous change is one in which the system suffers:

an increase in internal energy

lowering in entropy

lowering in free energy

no energy change

A. an increase in internal energy

B. lowering in entropy

C. lowering in free energy

D. no energy change

Answer: C

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9. In which of the following changes does entropy decrease ?

A. Crystallisation of sucrose from solution

B. Dissolving sucrose in water

C. Melting of ice

D. Vapourisation of camphor.

Answer: A

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10. For which reaction among the following, is ΔS maximum ?

A. $Ca(s) + \frac{1}{2}O_2(g) \rightarrow CaO(s)$

B. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

C. $C(s) + O_{29}g) \rightarrow CO_2(g)$

D. $N_2(g) + O_2(g) \rightarrow 2NO(g)$

Answer: B

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11. The free energy change for a reversible reaction at equilibrium is:

zero

small positive

small negative

large positive.

A. zero

B. small positive

C. small negative

D. large positive.

Answer: A

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12. The spontaneous nature of a reaction is impossible if

A. ΔH is $+ve$, ΔS is also +ve

B. ΔH is $-ve$, ΔS is also - ve

C. ΔH is $-ve$, ΔS is + ve

D. ΔH is $+ve$, ΔS is -ve

Answer: D

Watch Video Solution

13. Which is an extensive property of the system?

Temperature

Volume

Refractive index

Viscosity.

A. Temperature

B. Volume

C. Refractive index

D. Viscosity.

Answer: B

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14. Which is not a state function of a thermodynamic system?

Internal energy (U)

Free energy (G)

Enthalpy (H)

Work (W).

A. Internal energy (U)

B. Free energy (G)

C. Enthalpy (H)

D. Work (W).

Answer: D

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15. Is the entropy of the universe constant ?

A. is increasing and tending towards a maximum value

B. is decreasing and tending towards zero

C. remains constant

D. decreasing and increasing with a periodic rate.

Answer: A

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16. Decrease in free energy of a reacting system indicates:

an exothermic reaction

an endothermic reaction

a spontaneous reaction

a slow reaction.

A. an exothermic reaction

B. an endothermic reaction

C. a spontaneous reaction

D. a slow reaction.

Answer: C

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17. Gibbs free energy G, enthalpy H and entropy S are related as

A. G = H + TS

B. G = H - TS

C. G - TS = H

D. S = H - G .

Answer: B

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18. A system is provided 50 J of heat and work done on the system is 10 J.

The change in internal energy during the process is

A. 40 J

B. 60 J

C. 80 J

D. 50 J.

Answer: B

Watch Video Solution

19. The entropy change for vapourisation of liquid water to steam $100^{\circ}C$ is .... $JK^{-1}mol^{-1}$. Given that heat of vapourisation is $40.8kJmol^{-1}$.

A. 109.38

B. 100.38

C. 110.38

D. 120.38

Answer: A

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20. The entropy change at a given temperature is expressed as:

$q = T\Delta S$

$\Delta S = q/\Delta T$

$\Delta S = q - T$

$S = q/T$

A. $q = T\Delta S$

B. $\Delta S = q/\Delta T$

C. $\Delta S = q - T$

D. $S = q/T$

Answer: A

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21. For an adiabatic process, which of the following is correct ?

$P\Delta V = 0$

$q = +w$

$\Delta E = q$

$q = 0$

A. $P\Delta V = 0$

B. $q = +w$

C. $\Delta E = q$

D. $q = 0$

Answer: D

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22. The amount of heat measured for a reaction in a bomb calorimeter corresponds to

A. ΔG

B. ΔH

C. ΔU

D. $P\Delta V.$

Answer: C

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23. The work done in ergs for the reversible expansion of one mole of an ideal gas from a volume of 10 litres to a volume of 20 litres at $25^{\circ} C$ is

A. $2.303 \times 298 \times 0.082 \log_{10} 2$

B. $298 \times 10^{7} \times 8.31 \times 2.303 \log_{10} 2$

C. $2.303 \times 289 \times 0.082 \log_{10} 0.5$

D. $2.303 \times 298 \times 2 \log_{10} 2.$

Answer: B

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24. Which of the following values of heat of formation does indicate that the product is least stable ?

- 94 kcal

- 231.5 kcal

+64.8 kcal.

+21.4 kcal

A. - 94 kcal

B. - 231.5 kcal

C. +21.4 kcal

D. +64.8 kcal.

Answer: D

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25. The heat of neutralisation is highest in

A. $NaOH + CH_3COOH$

B. $HCl + NaOH$

C. $NH_4OH + HCl$

D. $CH_3COOH + NH_4OH.$

Answer: B

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26. The heat of neutralisation of NaOH and HCl is $57.3kJmol^{-1}$ then the amount of heat liberated if 2 moles each of NaOH and HCl are reacted is

A. 57.3 kJ mol

B. 114.6 kJ mol

C. 28.65 kJ mol

D. 215.2 kJ mol

Answer: B

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27. In a flask colourless N_2O_4 is in equilibrium with brown coloured NO_2 . At equilibrium, when the flask is heated at $100^\circ C$ the brown colour

deepens and on cooling it becomes less coloured. The change in enthalpy, ΔH for this system is

A. negative

B. positive

C. zero

D. undefined

Answer: B

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28. The process of evaporation of a liquid is accompanied by:

increase in enthalpy

decrease in entropy

no change in free energy

increase in entropy.

A. increase in enthalpy

B. decrease in entropy

C. no change in free energy

D. increase in entropy.

Answer: D

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29. The heats of combustion of carbon and carbon monoxide are -393.5 and -283.5 kJ mol^{-1}, respectively. The heat of formation (in kJ) of carbon monoxide per mole is :

A. 668 kJ

B. - 668 kJ

C. 112 kJ

D. - 112 kJ.

Answer: D

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30. The standard enthalpy of formation of NH3 is -46.0 kJ mol^{-1}. If the enthalpy of formation of H_2 from its atoms is -436 kJ mol and that of N_2 is -712 kJ mol, the average bond enthalpy of N - H bond in NH_3 is

A. $-964kJmol^{-1}$

B. $+352kJmol^{-1}$

C. $+1056kJmol^{-1}$

D. $-1102kJmol^{-1}$

Answer: B

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31. The entropy change involved in the isothermal reversible expansion of 2 moles of an ideal gas from a volume of 10 dm3 a volume of 100 dm3 at $27^{\circ}C$ is

A. $38.3 Jmol^{-1}k^{-1}$

B. $35.8 Jmol^{-1}K^{-1}$

C. $32.3 Jmol^{-1}K^{-1}$

D. $42.3 Jmol^{-1}K^{-1}$

Answer: A

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32. In view of the signs of $\Delta_r G^\circ$ for the following reactions

$PbO_2 + Pb \rightarrow 2PbO, \Delta_r G^\circ < 0$

$SnO_2 + Sn \rightarrow 2SnO, \Delta_r G^\circ > 0$

Which oxidation states are more characteristic for lead and tin?

A. For lead + 4, for tin + 2

B. For lead + 2, for tin + 2

C. For lead + 4, for tin + 4

D. For lead + 2, for tin + 4.

Answer: D

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33. The value of enthalpy change (ΔH) for the reaction

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

at $27^\circ C$ is $-1366.5 kJ mol^{-1}$. The value of internal energy change for the above reaction at this temperature will be

A. $-1371.5 kJ$

B. $-1369.0 kJ$

C. $-1364.0 kJ$

D. $-1361.5 kJ$

Answer: C

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34. If the enthalpy change for the transition of liquid water to steam is $30kJmol^{-1}$ at $27^{\circ}C$ the entropy change for the process would be

A. $1.0Jmol^{-1}K^{-1}$

B. $0.1Jmol^{-1}K^{-1}$

C. $100Jmol^{-1}K^{-1}$

D. $10Jmol^{-1}K^{-1}$.

Answer: C

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35. Which of the following is correct option for free expansion of an ideal gas under adiabatic condition?

A. $q \neq 0, \Delta T = 0, W = 0$

B. $q = 0, \Delta T = 0, W = 0$

C. $q = 0, \Delta T < 0, W \neq 0$

D. $q = 0, \Delta T \neq 0, W = 0$

Answer: B

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36. Enthalpy change for the reaction,

$4H(g) \rightarrow 2H_2(g)$ is -869.6 kJ

The dissociation energy of H - H bond is

A. $-869.6kJ$

B. $+434.8kJ$

C. $+217.4kJ$

D. $-434.8kJ$

Answer: B

Watch Video Solution

37. The enthalpy of fusion of water is 1.435 kcal/mol. The molar entropy change for the melting of ice at 0°C is ?

A. 10.52 cal/(mol K)

B. 21.04 cal/(mol K)

C. 5.260 cal/(mol K)

D. 0.526 cal/(mol K).

Answer: C

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38. Standard enthalpy of vapourisation $\Delta_{vap}H^{-}$ for water at $100^{\circ}C$ is $40.66kJmol^{-1}$. The internal energy of vapourisation of water at $100^{\circ}C$ (in kJ mol^{-1}) is (Assume water vapour to behave like an ideal gas).

A. 37.56

B. -43.76

C. 43.76

D. + 40.66.

Answer: A

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39. In which of the following reactions, standard reaction entropy changes (ΔS) is positive and standard Gibbs energy change ('DeltaG`) decreases sharply with increasing temperature?

A. $C(\text{graphite}) + \frac{1}{2}O_2(g) \rightarrow CO(g)$

B. $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

C. $Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(g)$

D. $\frac{1}{2}C(\text{graphite}) + \frac{1}{2}O_2(g) \rightarrow \frac{1}{2}CO_2(g)$

Answer: A

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40. A piston filled with 0.04 mole of an ideal gas expands reversibly from $50.0mL$ at a constant temperature of $37.0^{\circ}C$. As it does so, it absorbs $208J$ of heat. The value of q and W for the process will be $(R = 8.314J/molK, 1n7.5 = 2.01)$

A. $q = +208J, W = -208J$

B. $q = -208J, W = -208J$

C. $q = -208J, W = +208J$

D. $q = +208J, W = +208J$

Answer: A

Watch Video Solution

41. For complete combustion of ethanol, $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$, the amount of heat

produced as measured in bomb calorimeter , is $1364.47kJmol^{-1}$ at 25^0C. Assuming ideality the Enthalpy of combustion, $\Delta_C H$, for the reaction will be: $\left(R = 8.314kJmol^{-}\right)$.

A. $-1366.95kJmol^{-1}$

B. $-1361.95kJmol^{-1}$

C. $-1460.50kJmol^{-1}$

D. $-1350.50kJmol^{-1}$

Answer: A

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42. A gas is allowed to expand in a well insulated container against a constant external pressure of 2.5 atm from an initial volume of 2.50 L to a final volume of 4.50 L. The change in internal energy ΔU of the gas in joules will be

A. 1136.25 J

B. $-500J$

C. -505 J

D. +505 J

Answer: C

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43. For a given reaction, $\Delta H = 35.5kJmol^{-1}$ and $\Delta S = 83.6JK^{-1}mol^{-1}$. The reaction is spontaneous at (Assume that ΔH and ΔS do not vary with temperature)

A. T lt 425 K

B. Tgt 425 K

C. All temperatures

D. Tgt 298 K

Answer: B

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44. Given $C_{(\text{graphite})} + O_2(g) \rightarrow CO_2(g)$,

$\Delta_r H^0 = -393.5kJ \quad mol^{-1}$

$H_2(g) = +\frac{1}{2}O_2(g) \rightarrow H_2O(1)$,

$\Delta_r H^0 = -285.8 \text{ kJ } mol^{-1}$

$CO_2(g) + 2H_2O(1) \rightarrow CH_4(g) + 2O_2(g)$,

$\Delta_r H^0 = +890.3kJ \quad mol^{-1}$

Based on the above thermochemical equations, the value of $\Delta_r H^0$ at at 298 K for the reaction

$C_{(\text{graphite})} + 2H_2(g) \rightarrow CH_4(g)$ will be:

A. $-74.8kJmol^{-1}$

B. $-144.0kJmol^{-1}$

C. $+74.8kJmol^{-1}$

D. $+144.0kJmol^{-1}$

Answer: A

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45. ΔU is equal to

A. adiabatic work

B. isothermal work

C. isochoric work

D. isobaric work

Answer: A

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46. The bond dissociation energies of X_2, Y_2 and XY are in the ratio of $1:0.5:1$. ΔH for the formation of XY is -200 kJ mol^(-1) . $Thebonddissociatione \neq rgyofX\_2$` will be

A. $200kJmol^{-1}$

B. $100kJmol^{-1}$

C. $800kJmol^{-1}$

D. $400kJmol^{-1}$

Answer: C

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47. The combustion of benzene(/) gives $CO_2(g)$ and $H_2O(l)$ Given that heat of combustion of benzene at constant volume is $-3263.9kJmol^{-1}$ at $25^\circ C$, heat of combustion (in kJ mol^{-1}) of benzene at constant pressure will be

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

A. 4152.6

B. -452.46

C. 3260

D. -3267.6

Answer: D

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48. For the cell reaction

$2Fe^{3+}(aq) + 2l^{-1}(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$

$E^{\Theta}_{\text{cell}} = 0.24V$ at 298 K. The standard Gibbs energy $\left(\Delta_r G^{\Theta}\right)$ of the cell reaction is

[Given that Faraday constnat $F = 96500 Cmol^{-1}$]

A. $46.32 kJmol^{-1}$

B. $23.16 kJmol^{-1}$

C. $-46.32 kJmol^{-1}$

D. $-23.16 kJmol^{-1}$

Answer: C

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49. Under isothermal condition, a gas at 300 K expands from 0.1 L to 0.25 L against a constant external pressure of 2 bar. The work done by the gas is (Given that 1 L bar = 100 J)

A. 25 J

B. 30 J

C. -30 J

D. 5 kJ.

Answer: C

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50. In which case change in entropy is negative?

A. Sublimation of solid to gas

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

C. Evaporation of water

D. Expansion of a gas at constant temperature.

Answer: B

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51. For a cell involving one electron $E^0_{cell} = 0.59V$ and 298K, the equilibrium constant for the cell reaction is:

[Given that $\frac{2.303RT}{F} = 0.059V$ at $T = 298K$]

A. 1.0×10^5

B. 1.0×10^{10}

C. 1.0×10^{30}

D. 1.0×10^2

Answer: B

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52. The INCORRECT match in the following is

A. $\Delta G^{\circ} = 0, K = 1$

B. $\Delta G^{\circ} < 0, K < 1$

C. $\Delta G^{\circ} > 0, K < 1$

D. $\Delta G^{\circ} < 0, K > 1$

Answer: B

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53. During compression of a spring the work done is 10 kJ and 2 kJ escaped to the surroundings as heat. The change in internal energy ΔU (in kj) is

A. 12

B. -8

C. 8

D. -12

Answer: C

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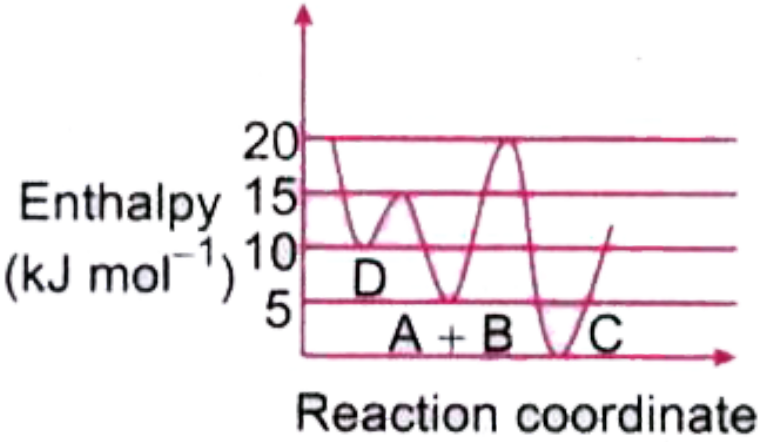
54. Consider the given plot of enthalpy of the following reaction between A and B. $A + B \rightarrow C + D$. Identify the incorrect statement.



A. C is the thermodynamically stable product.

B. Formation of A and B from C has highest enthalpy of activation.

C. Activation enthalpy to form C is 5 kJ mor less than that to form D.

D. D is kinetically stable product.

Answer: C

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55. The standard Gibbs energy for the given cell reaction in kJ mol^{-1} at 298 K is

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s), E^{\circ} = 2V \text{ at } 298K$

(Faraday's constant, $F = 96000 Cmol^{-1}$)

A. -192

B. 192

C. -384

D. 384

Answer: C

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56. Among the following, the set of parameters that represents path functions is

(A) q + w (B) q (C) w (D) H - TS

A. (A), (B) and (C)

B. (B) and (C)

C. (A) and (D)

D. (B), (C) and (D).

Answer: B

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57. Which one of the following equations does not correctly represent the first law of thermodynamics for the given processes involving an ideal gas ? (Assume non-expansion work is zero)

A. Adiabatic process : $\Delta U = -w$

B. Cyclic process : $q = -w$

C. Isothermal process : $q = -w$

D. Isochoric process : $\Delta U = q$.

Answer: A

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58. For silver, $C_P\left(JK^{-1}\text{mol}^{-1}\right) = 23 + 0.01T$. If the temperature (T) of 3 moles of silver is raised from $300K$ to $1000K$ at 1 atm pressure, the value of ΔH will be close to :

A. 13 kJ

B. 16 kJ

C. 62 kJ

D. 21 kJ

Answer: C

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59. 5 moles of an ideal gas at 100 K are allowed to undergo reversible compression till its temperature becomes 200 K. If $C_V = 28JK^{-1}mol^{-1}$, calculate ΔU and ΔpV.

A. $\Delta U = 14J, \Delta(pV) = 0.8J$

B. $\Delta U = 14kJ, \Delta(pV) = 4kJ$

C. $\Delta U = 14kJ, \Delta(pV) = 18J$

D. $\Delta U = 2.8kJ, \Delta(pV) = 0.8kJ.$

Answer: B

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True Or False Type Questions

1. Thermodynamics mainly deals with

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2. An animal is an open system.

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3. Volume is an intensive property.

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4. Which of the following are not state functions ?

Temperature, entropy, heat, work, enthalpy, internal energy.

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5. For an isobaric process, $\Delta P = 0$.

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6. What is the sign convention for work?

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7. Work done in the isothermal reversible expansion of a gas is always greater than that done in isothermal irreversible expansion of the gas.

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8. The total energy of the universe is increasing day by day.

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9. $\Delta E = E_{\text{initial state}} - E_{\text{final state}}$

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10. The heat absorbed in a reaction at constant temperature and constant volume is____

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11. A bomb calorimeter measures ΔG of a combustion process.

Watch Video Solution

12. For the reaction,

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$, ΔH is equal to ΔE.

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13. Decomposition of $CaCO_3$ is a reversible reaction when carried out in an open kiln.

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14. State True/False

All spontaneous process proceed in one direction only.

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15. The units of ΔS are $JK^{-1}mol^{-1}$.

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16. The absolute entropy of a liquid is less than of the solid.

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17. Is the entropy of the universe constant ?

Watch Video Solution

18. A process is non-spontaneous when $\Delta S_{\text{total}} < 0$.

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19. For an irreversible process, $\Delta S > 0$.

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20. Heat can be converted completely into equivalent amount of work without producing changes elsewhere.

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21. A chemical process always proceeds in the direction in which the Gibbs free energy of the system decreases.

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22. A process is feasible if ΔH is positive and ΔS is negative

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23. ΔG is a measure of the net work done by a system. True/False.

Watch Video Solution

24. At absolute zero, the entropy of a pure crystal is zero. This is

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Fill In The Blanks Type Questions

1. Thermodynamics mainly deals with

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2. A closed system is that which

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3. A system is said to be in ..... equilibrium when the system and the surroundings are at the same temperature.

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4. When the work is done by the system, w is taken as .....

Watch Video Solution

5. Is the entropy of the universe constant ?

Watch Video Solution

6. Define isolated system.

Watch Video Solution

7. The sum of ..... energy and ..... energy of a system is called enthalpy of the system.

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8. For the process occurring at constant ..... $\Delta H = \Delta U$.

Watch Video Solution

9. A spontaneous process is also called a ..... process.

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10. Dissolution of sugar in water is accompanied by ..... of entropy of the system.

Watch Video Solution

11. A spontaneous process is an ..... process and occurs in ..... direction only.

Watch Video Solution

12. The force responsible for the spontaneity of a reaction is called .....

Watch Video Solution

13. The total entropy change $(\Delta S_{\text{total}})$ for the system and surrounding of a spontaneous process is given by

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14. If ΔS_{total} is positive the process is ..... and occurs in the ..... as mentioned. The reverse process is .....

Watch Video Solution

15. Whenever a spontaneous process takes place, it is accompanied by an increase in the total ..... of the .....

Watch Video Solution

16. When $\Delta G = 0$, the process is .....

Watch Video Solution

17. When ΔH is ngative nad $T\Delta S$ is positive, the process is .....at all.....

Watch Video Solution

18. The enthalpy change for a reaction does not depend upon the____

Watch Video Solution

19. The greater the free energy change, the greater is the amount of ..... work that can be obtained from the process.

Watch Video Solution

20. At absolute zero, the entropy of a pure crystal is zero. This is

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Assertion Reason Type Questions

1. The heat absorbed during the isothermal expansion of an ideal gas against vacuum is zero.

The volume occupied by the molecules of an ideal gas is zero.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: B

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2. Assertion : The total energy of the universe is constant.

Reason : When a quantity of some form of energy disappears, an exactly equivalent amount of some other form of energy is produced.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: A

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3. Assertion : The heat of a reaction does not depend upon the temperature at which reaction is carried out.

Reason : Temperature is a state function.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: D

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4. Assertion : The heat of neutralisation for a strong acid and a weak base is always equal to -57.1 kJ.

Reason : One gram equivalent of a strong acid always neutralises one gram equivalent of a weak base.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: D

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5. Assertion : The bond energy and bond formation energy of a particular bond are equal in magnitude but opposite in sign.

Reason : The process of bond formation requires absorption of energy but the process of breaking of bond involves liberation of energy.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: C

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6. Assertion : The sun is the ultimate source of all types of energies and sustains life on earth.

Reason : The solar energy gets converted into all types of energies present on the earth.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: A

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7. Assertion : A perpetual machine can produce work continuously without consuming energy.

Reason : Energy can be converted from one form to another.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: D

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8. Assertion : Burning of coal is a spontaneous process.

Reason : Coal when ignited burns of its own accord without any outside assistance.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: A

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9. Assertion : All spontaneous processes are thermodynamically irreversible.

Reason : In a reversible isothermal process, there is no net change in entropy.

A. If both Assertion and Reason are CORRECT and Reason is the CORRECT explanation of the Assertion.

B. If both Assertion and Reason are CORRECT but Reason is not the CORRECT explanation of the Assertion.

C. If Assertion is CORRECT but Reason is INCORRECT.

D. If Assertion is INCORRECT but Reason is CORRECT.

Answer: B

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Numberical Problems

1. Calculate the free energy change when one mole of sodium chloride is dissolved in water at 298 K. (Given : Lattice energy of NaCl $= -777.8 kJ mol^{-1}$, Hydration energy of NaCl $= 774.1 kJ mol^{-1}$ and ΔS at $298K = 0.043 kJ mol^{-1}$.

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2. Calculate the value of equilibrium constant, K for the following reaction at 400 K.

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

$\Delta H^\circ = 80.0 kJ mol^{-1}, \Delta S^\circ = 120 KJ^{-1} mol^{-1}$ at 400 K, R = $8.31 JK^{-1} mol^{-1}$.

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3. Calculate the standard free energy change for the following reaction at $27^\circ C$.

$H_2(g) + I_2(g) \rightarrow 2HI(g), \Delta H^\circ = +51.9 kJ$

[Given : $\Delta S^\circ_{H_2} = 130.6 JK^{-1} mol^{-1}$

$\Delta S^\circ_{I_2} = 116.7 JK^{-1} mol^{-1}$

$\Delta S^\circ_{HI} = 206.3 JK^{-1} mol^{-1}]$.

Predict whether the reaction is feasible at 27°C or not.

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4. Using the data given below, calculate the value of equilibrium constant for the reaction

$$\underset{\text{acetylene}}{3HC \equiv CH(g)} \Leftrightarrow \underset{\text{benzene}}{C_6H_6(g)}$$

at 298 K, assuming ideal behaviour.

$\Delta_f G^\circ HC \equiv CH(g) = 2.09 \times 10^5 Jmol^{-1}$,

$\Delta_f G^\circ C_6H_6(g) = 1.24 \times 10^5 Jmol^{-1}$

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

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5. Give the reaction for preparing benzene.

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6. A gas expands from $3dm^3$ to $5dm^3$ against a constant pressure of 3.0 atm. The work done during expansion is used to heat 10 moles of water at temperature 290 K. Calculate the final temperature of water. Specific heat of water $= 4.184 JK^{-1}g^{-1}$.

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7. The enthalpy change involved in the oxidation of glucose is $-2880kJmol^{-1}$. Twenty five per cent of this energy is available for muscular work. If 100 kJ of muscular work is needed to walk one kilometre, what is the maximum distance that a person will be able to walk eating 120 g of glucose ?

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8. 10 g of argon is compressed isothermally and reversibly at a temperature of $27^{\circ}C$ from 10 L to 5L. Calculate , w, ΔE and ΔH for the process. $R = 2.0calK^{-1}mol^{-1}$, $\log 2 = 0.30$, At. Wt. of argon = 40.

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9. Using data (all values are in kilocalorie per mole at $25^{\circ}C$) given below, calculate the bond energy of $C-C$ and $C-H$ bonds.

ΔH^{Θ} combustion of ethane $= -372.0$

ΔH^{Θ} combustion of propane $= -530.0$

ΔH^{Θ} for C(garphite) $\rightarrow C(g) = +172.0$

Bond enegry of $H-H$ bond $= +104.0$

$\Delta_f H^{\Theta} of H_2O(l) = -68.0$

$\Delta_f H^{\Theta} of CO_2(g) = -94.0$

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10. An athlete is given 100 g of glucose ($C_6H_{12}O_6$) of energy equivalent to 1560 kJ. He utilises 50% of this gained energy in the event. In order to avoid the storage of energy in the body, calculate the weight of water he would need to perspire. The enthalpy of evaporation of water is $44kJmol^{-1}$.

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11. The standard enthalpy of formation of H 2 O(l) and Fe 2 O 3 (s) are respectively −286 kJ mol −1 and −824 kJ mol −1 . What is the standard

enthalpy change for the following reaction?

$Fe_2O_3(s)+3H_2(g)\longrightarrow 3H_2O(l)+2Fe(s)$

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12. The enthalpies of formation of $CO_2(g)$, $H_2O(l)$ and $C_2H_4(g)$ are respectively -393.5, -286 and $+52.3 kJmol^{-1}$. The enthalpy change for the combustion of $C_2H_4(g)$ is ?

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13. The heat of combustion of acetylene is 312 kcal. If the heat of formation of CO_2 is 94.38 kcal and that of water is 63.38 kcal, calculate $C \equiv C$ bond energy assuming that the bond energy of C-H is 93.6 kcal. Heat of atomisation of carbon and hydrogen are 150 and 51.5 kcal respectively.

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14. If a man submits to a diet of 9500 kJ per day and expands energy in all forms to a total of 12000 kJ per day, what is the change in internal energy per day? If the energy lost was stored as sucrose (1632 kJ per 100 g), how many days should it take to lose 1 kg ? (Ignore water loss for this problem.)

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15. $C(s) + O_2(g) \rightarrow CO_2(g) + 394kJ$

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO + 111kJ$

In an oven using coal (assume the coal is 80% C in weight), insufficient oxygen is supplied such that 60% of carbon is converted to CO_2 and 40% of carbon is converted to CO. Find out the heat generated when 10 kg of coal is burnt in this fashion.

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16. $C(s) + O_2(g) \rightarrow CO_2(g) + 394kJ$

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO + 111kJ$

Calculate the heat generated if efficiency of oven is 10.8% and a fully efficient oven converts all the carbon to CO_2

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17. $C(s) + O_2(g) \rightarrow CO_2(g) + 394kJ$

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO + 111kJ$

Calculate the percentage loss in heating value for the inefficient oven.

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18. Gobar gas obtained by bacterial fermentation of animal refuse contains mainly methane. The heat of combustion of methane to CO_2 and water (gas) is given by

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + 809kJ.$

How much gobar gas would have to be produced per day for a small village community of 100 families, if we assume that each family has to be supplied 20,000 kJ of energy per day to meet all its needs and that the methane content in gobar gas is 80% by weight?

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Ncert Text Book Exercises

1. Choose the correct answer.

A thermodynamic state function is a quantity.

(a) used to determine heat changes.

(b) whose value is independent of path.

(c) used to determine pressure volume work.

(d) whose value depends on temperature only.

A. used to determine heat changes

B. whose value is independent of path

C. used to determine pressure volume work

D. whose value depends on temperature only.

Answer: B

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2. For the process to occur under adiabatic conditions, the correct condition is

A. $\Delta T = 0$

B. $\Delta p = 0$

C. $\Delta q = 0$

D. $w = 0$

Answer: C

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3. The enthalpies of all elements in their standard states are

A. unity

B. zero

C. < 0

D. different for each element.

Answer: B

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4. ΔU° of combustion of methane is $-XkJmol^{-1}$. The value of ΔH° is

A. $= \Delta U^{\circ}$

B. $> \Delta U^{\circ}$

C. $< \Delta U^{\circ}$

D. $= 0$

Answer: C

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5. The enthalpy of combustion of methane, graphite and dihydrogen at 298 K are, $-890.3kJmol^1 - 393.5kJmol^{-1}$, and $-285.8kJmol^{-1}$ espectively. Enthalpy of formation of $CH_4(g)$ will be

A. $-74.9kJmol^{-1}$

B. $-52.27kJmol^{-1}$

C. $+74.8kJmol^{-1}$

D. $+52.26kJmol^{-1}$

Answer: A

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6. A reaction $A + B \rightarrow C + D + q$ is found to have a positive entropy change. The reaction will be

A. possible at high temperature

B. possible only at low temperature

C. not possible at any temperature

D. possible at any temperature.

Answer: D

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7. 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 of the process?

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8. The reaction of cyanamide, $NH_2CN(s)$, with dioxygen was carried out in a bomb calorimeter, and ΔU was found to be $-742.7kJmol^{-1}$ at 298 K. Calculate enthalpy change for the reaction at 298 K.

$$NH_2CH(g) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(1)$$

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9. Calculate the number of kJ of heat necessary to raise the temperature of 60.0 g of aluminium from $35^\circ C \text{ to } 55^\circ C$. Molar heat capacity of Al is 24 J $mol^{-1}K^{-1}$.

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10. The enthalpy change on freezing of 1 mol of water at 5°C to ice at -5°C is :

(Given $\Delta_{\text{fus}}H = 6KJ\text{mol}^{-1} \text{ at } 0^\circ C$,

$C_p(H_2O, l) = 75.3 J \text{mol}^{-1} K^{-1}$,

$C_p(H_2O, S) = 36.8 J \text{mol}^{-1} K^{-1}$)

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11. Enthalpy of combustion of carbon to CO_2 is $-393.5 kJ mol^{-1}$

Calculate the heat released upon formation of 35.2 g of CO_2 from carbon and dioxygen gas.

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12. Enthalpies of formation of $CO(g). CO_2(g)$ and N_2O_4 are $-110, -393, 81$ and $9.7 kJ mol^{-1}$ respectively. Find the value of $\Delta_r H$ for the reaction :

$N_2O_4(g) + 3CO(g) \rightarrow N_2O(g) + 3Co_2(g)$

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13. Given

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g), \Delta_r H^{\ominus} = -92.4 kJmol^{-1}$

What is the standard enthalpy of formation of NH_3 gas?

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14. Calculate the standard enthalpy of formation of $CH_3OH(l)$ from the following data

$CH_3OH(i) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(1), \Delta_r H^{\ominus} = -726 kJmol^{-1}$

C(graphite) $+ O_2(g) \rightarrow CO_2(g), \Delta_c H^{\ominus} = -393 kJmol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(1), \Delta(f)H^{\ominus} = -286 kJmol^{-1}$

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15. Calculate the enthalpy change for the process

$CCI_4(g) \rightarrow C(g) + 4CI(g)$

and calculate bond enthalpy of C - Cl in $CCI_4(g)$.

$\Delta_{vap}H^{\ominus}(CCI_4) = \quad 30.5kJmol^{-1}$

$\Delta_f H^{\ominus}(CCI_4) = -135.5kJmol^{-1}$

$\Delta_a(C) = 715.0kJmol^{-1}$, where $\Delta_a H^{\ominus}$ is enthalpy of atomisation

$\Delta_a H^{\ominus}(CI_2) = 242kJmol^{-1}$

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16. For an isolated system, $\Delta U = 0$, what will be ΔS?

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17. For the reaction at 298 K,

2A + B $\rightarrow$ C

$\Delta H = 400KJmol^{-1}$ and $\Delta S = 0.2kJK^{-1}mol^{-1}$

At what temperature will the reaction become spontaneous considering

ΔH and ΔS o be constant over the temperature range.

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18. For the reaction, $2Cl(g) \rightarrow Cl_2(g)$, what are the signs of ΔH and ΔS ?

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19. For the reaction

$2A(g) + B(g) \rightarrow 2D(g)$

$\Delta U^{\theta} = -10.55KJ$ and $\Delta S^{\theta} = -44.1JK^{-1}$

Calculate $\Delta G^{\ominus}$ for the reaction, and predict whether the reaction may occur spontaneously

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20. The equilibrium constant for a reaction is 10. What will be the value of ΔG° ? $R = 8.314JK^{-1}mol^{-1}, T = 300K.$

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21. Comment on the thermodynamic stability of $NO_{(g)}$, given

$$\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g) \quad : \quad \Delta_r H^{\theta} = 90kJmol^{-1}$$

$$NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g) \quad : \quad \Delta_r H^{\theta} = -74kJmol^{-1}$$

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22. Calculate the entropy change in surroundings when 1.00 mole of $H_2O(l)$ is formed under standard conditions.

$$\Delta_f H^{\circ} = -286kJmol^{-1}$$

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