

## Thermodynamics & Thermochemistry

### 1. Zeroth law of Thermodynamics, Heat

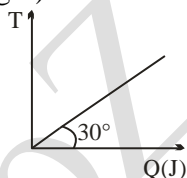
- Q 1. Thermodynamics is a/an
- (A) Experimental science in which conversion of thermal energy into electrical energy is studied
- (B) Experimental science in which conversion of thermal energy into mechanical energy is studied
- (C) Theoretical science in which conversion of thermal energy into electrical energy is studied
- (D) None of these

- Q 2. Thermodynamics is NOT concerned about
- [NCERT Exemplar]**
- (A) Energy change involved in a chemical reaction
- (B) the extent to which a chemical reaction proceeds.
- (C) the rate at which a reaction proceeds.
- (D) the feasibility of a chemical reaction.

- Q 3. Zeroth law of thermodynamics define
- (A) heat (B) Temperature
- (C) Work (D) Enthalpy

- Q 4. The unit of specific heat capacity is
- (A) Joule/Kelvin (B) Joule/mol-k
- (C) Joule/Kg-k (D) None of these

- Q 5. For the T-Q diagram given below for substance having mass of 3kg, the specific heat capacity value in (J/kg-k)



- (A)  $\frac{1}{\sqrt{3}}$  (B)  $\sqrt{3}$
- (C)  $3\sqrt{3}$  (D)  $\frac{1}{3\sqrt{3}}$

- Q 6. During phase change, the value of molar heat capacity is
- (A) Zero (B) Infinity
- (C) Constant (D) None of these

- Q 7. Latent heat of substance increase
- (A) Energy of substance
- (B) Temperature of substance
- (C) Entropy of substance
- (D) Internal energy of substance

- Q 8. Find the change in temperature when 8.5 Kcal of heat is given to 2 kg substance with specific heat capacity 500 cal/kg.K.
- (A) 17 K (B) 8.5 K
- (C) 4.25 K (D) 34 K

- Q 9. The amount of heat require to convert 10g of ice at  $-20^{\circ}\text{C}$  to water at  $80^{\circ}\text{C}$  is

Given:  $S_{\text{ice}} = 0.5\text{cal/g}^{\circ}\text{C}$ ,  $S_{\text{water}} = 1\text{cal/g}^{\circ}\text{C}$

$\ell_f = 80\text{cal/g}$ ,  $\ell_v = 500\text{cal/g}$

- (A) 1700 Cal (B) 1000 Cal
- (C) 800 Cal (D) 6700 Cal

- Q 10. The amount of heat require to increase temp. of 10g of Al from  $20^{\circ}\text{C}$  to  $70^{\circ}\text{C}$  is moles heat capacity Al = 2.7 J/mol/k

- (A) 500 J (B) 100 J (C) 50 J (D) 200 J

- Q 11. Which of the following substance has maximum value of specific heat capacity value

- (A) Al (B) Fe
- (C) Diamond (D)  $\text{H}_2\text{O}$

- Q 12. The volume of a gas is reduced to half from its original volume. The specific heat will be

**[NCERT Exemplar]**

- (A) reduced to half (B) be doubled
- (C) remain constant (D) increase four times

- Q 13. Calculate the number of KJ of heat necessary to raise the temperature of 60 g of Al from  $35^{\circ}\text{C}$  to  $55^{\circ}\text{C}$ . Molar heat capacity of Al is 24 J/mol.K

**[NCERT]**

- Q 14. Heat capacity ( $C_p$ ) is an extensive property but specific heat capacity ( $c$ ) is an intensive property. What will be the relation between  $C_p$  &  $C$  for 1 mole of  $\text{H}_2\text{O}$ .

**[NCERT Exemplar]**

- Q 15. Molar heat capacity of water at constant pressure is 75 J/mol.K, when 1 KJ of heat is supplied to 100 g water, which is free to expand, the increase in temperature of water is
- [CBSE PMT 2003]**
- (A) 4.8 K (B) 6.6 K (C) 1.2 K (D) 2.4 K

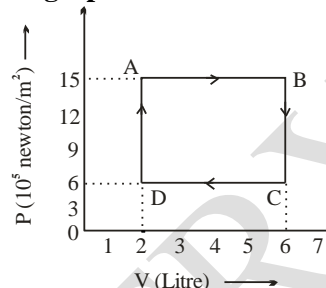
## 2. System, Surroundings, Properties, Process

- Q 1. According to first law of thermodynamics  
 (A) Energy of a closed system is conserved  
 (B) Energy of an open system is conserved  
 (C) Energy of an isolated system is conserved  
 (D) Energy of all type of system is conserved
- Q 2. Choose the correct answer. A thermodynamic state function is a quantity [NCERT]  
 (A) used to determine heat change  
 (B) whose value is independent of path  
 (C) used to determine pressure volume work  
 (D) whose value depends on temperature only
- Q 3. Example of open System is  
 (A) Thermal Flask (B) Pressure cooker  
 (C) Steel glass (D) None
- Q 4. Which of the following is an extensive property?  
 (A) Temperature (B) Volume  
 (C) Refractive Index (D) Viscosity
- Q 5. Which of the following is an Intensive property?  
 (A) Molar conductivity & heat capacity  
 (B) Emf & Resistance  
 (C) Molar conductivity & emf  
 (D) Heat capacity & Resistance
- Q 6. In a change of state from State A to State B  
 (A) q depends on only initial & final State  
 (B) w depends on only initial & final State  
 (C)  $\Delta E$  depends on only initial & final state  
 (D)  $\Delta E$  depends on path adopted by A to B
- Q 7. Which of the following is not a thermodynamic functions?  
 (A) Internal Energy (B) Work Done  
 (C) Enthalpy (D) Entropy
- Q 8. A system is called in equilibrium if it has  
 (A) Thermal equilibrium  
 (B) Mechanical equilibrium  
 (C) Concentration equilibrium  
 (D) None of these
- Q 9. Possible no. of thermodynamics process is  
 (A) 4 (B) 5  
 (C) 6 (D) Infinite
- Q 10. The reaction  $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$  is an example of  
 (A) Reversible reaction (B) Reversible process  
 (C) Both A & B (D) None of these
- Q 11. Reversible process take place when  
 (A) driving force has highest magnitude than opposing force  
 (B) Opposing force has higher magnitude than driving force  
 (C) Driving force has equal magnitude than opposing force  
 (D) Can happen in any case
- Q 12. During irreversible process, pressure of system is  
 (A) Constant  
 (B) Not defined  
 (C) Equal to external pressure  
 (D) Can't predict
- Q 13. Maximum work is done by system in  
 (A) Isobaric process  
 (B) Isochoric process  
 (C) reversible process  
 (D) cyclic process
- Q 14. Warming ammonium chloride with sodium hydroxide in a test tube is an example of  
 (A) Closed system (B) isolated system  
 (C) Open system (D) none of these
- Q 15. Which of the following statements is correct? [NCERT Exemplar]  
 (A) The presence of reacting species in a covered beaker is an example of open system.  
 (B) There is an exchange of energy as well as matter between system & surrounding in close system.  
 (C) The presence of reactants in a closed vessel made of Cu is an example of close system.  
 (D) The presence of reactant in a thermos flask or any other closed insulated vessel is an example of closed system.
- Q 16. The state of a gas can be described by quoting the relationship between [NCERT Exemplar]  
 (A) P, V & T (B) T, n & P  
 (C) n, V & T (D) P, V, T & n

### 3. First Law of Thermodynamics, Isobaric & Isochoric Process, Work

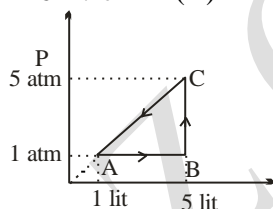
- Q 1. The change in internal energy of a system depends on
- Initial & final state of the system only
  - whether path is reversible
  - whether path is irreversible
  - None of these
- Q 2. Regarding the internal energy, which of the following statement is correct?
- it is the sum of vibrational & rotational energies
  - Its absolute value can't be determined
  - its absolute value can be calculated
  - None of these
- Q 3. Internal energy change when system goes from state A to state B is 40 kJ/mol. If the system goes from A to B by reversible path and returns to state A by irreversible path, what would be net change in internal energy ?
- 40 kJ
  - > 40 kJ
  - < 40 kJ
  - Zero
- Q 4. Express the change in internal energy of a system when **[NCERT solved]**
- No heat is absorbed by the system from the surroundings, but work(w) is done on the system. What type of wall does the system have?
  - No work is done on the system, but q amount of heat is taken out from the system and given to the surroundings. What type of wall does the system have?
  - W amount of work is done by the system and q amount of heat is supplied to the system. What type of system would it be?
- Q 5. In chemistry, for work done, we take
- Surrounding point of view
  - System point of view
  - Negative point of view
  - positive point of view
- Q 6. In chemistry, heat gives to system is taken as
- +ve
  - ve
  - can be +ve or -ve
  - None
- Q 7. Work done by gas in expansion against vacuum
- +ve
  - ve
  - zero
  - None of these

In the adjoining diagram, the P-V graph of ideal gas is shown. Answer 39 to 42 question from the graph:

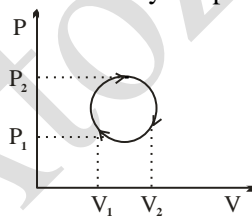


- Q 8. Work done in taking the gas from the state A  $\rightarrow$  B
- $36 \times 10^2 \text{ J}$
  - $-36 \times 10^2 \text{ J}$
  - $60 \times 10^2 \text{ J}$
  - $-60 \times 10^2 \text{ J}$
- Q 9. Work done in taking the gas from B  $\rightarrow$  C
- zero
  - $1.5 \times 10^2 \text{ J}$
  - $3.0 \times 10^2 \text{ J}$
  - $3.0 \times 10^{-2} \text{ J}$
- Q 10. Work done in a complete cycle (1 lit =  $10^{-3} \text{ m}^3$ )
- $36 \times 10^2 \text{ J}$
  - $-36 \times 10^2 \text{ J}$
  - $60 \times 10^2 \text{ J}$
  - $-60 \times 10^2 \text{ J}$
- Q 11. The temperature of 1 mole of a gas is increased by  $1^\circ\text{C}$  at constant pressure. The work done is
- R
  - $-2R$
  - $-R/2$
  - $-3R$
- Q 12. For 5 mole ideal gas,  $C_p - C_v$  is equal to
- R
  - 5F
  - 2R
  - None
- Q 13. Pressure of a fluid is a linear function of volume  $P = a + bV$ . Find work for change in state (100 Pa,  $3\text{m}^3$ ) to ( $400\text{Pa}, 6\text{m}^3$ )
- $-250\text{J}$
  - $-1950\text{J}$
  - $-650\text{J}$
  - $-750\text{J}$
- Q 14. Work done in expansion from  $3\text{m}^3$  to  $5\text{m}^3$  against a variable pressure  $(10 + 5V)$  Pa
- $-120\text{J}$
  - $-60\text{J}$
  - $-80\text{J}$
  - $-100\text{J}$
- Q 15. Calculate the work done when 1.0 mole of  $\text{H}_2\text{O}$  at 373 K vaporizes against an atmospheric pressure of 1.0 atm
- $-3102\text{J}$
  - $-3062\text{J}$
  - $-22.48\text{J}$
  - None

- Q 16. In a closed vessel, 50 g of iron is reacted with HCl at 25°C. The work done by gas is  
 (A) zero (B) -2212.4J  
 (C) -500J (D) None
- Q 17. In an open vessel, 50g of iron is reacted with HCl at 25°C. The work done by gas is ( $P_{\text{atm}} = 1 \text{ atm}$ )  
 (A) Zero (B) -2212.4 J  
 (C) -500 J (D) None
- Q 18. 1 mole each of  $\text{CaC}_2$ ,  $\text{Al}_4\text{Cl}_3$  reacts with  $\text{H}_2\text{O}$  in separate open flask. Numerical value of work done by the system is in order  
 (A)  $\text{CaC}_2 < \text{Al}_4\text{Cl}_3$  (B)  $\text{CaCl}_2 > \text{Al}_4\text{Cl}_3$   
 (C)  $\text{CaC}_2 = \text{Al}_4\text{Cl}_3$  (D) None of these
- Q 19. 1.2 L of oxygen at a constant pressure of 2.00 atm. Was kept in a cylinder and provided 10.00 K cal of heat. The volume of oxygen increases to 1.8 L. The value of  $\Delta E$  is  
 (A) 9.970 K cal (B) 0.9970 K cal  
 (C) 10.100 K cal (D) 10.970 K cal
- Q 20. A system is provided 50 J of heat and work done on the system is 10J. The change in internal energy during the process  
 (A) 40 J (B) 60 J  
 (C) 80 J (D) 50 J
- Q 21. The work done in cyclic process given below  
 (A) + 810.6 J (B) -810.6 J  
 (C) +1621.2J (D) -1621.2J



- Q 22. The work done. In cyclic process



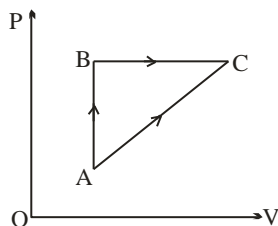
- (A)  $-\pi \left( \frac{v_2 - v_1}{2} \right)^2$  (B)  $-\pi \left( \frac{P_2 - P_1}{2} \right)^2$   
 (C)  $-\pi \left( \frac{P_2 - P_1}{2} \right) \left( \frac{v_2 - v_1}{2} \right)$  (D) All

#### 4. Isothermal Process, Thermodynamics Curve

- Q 1. In isothermal process, moles heat capacity has value equal to  
 (A) zero (B) Infinity  
 (C) one (D) can't predict
- Q 2. One mole of an ideal gas at 300 K is expanded isothermally from an initial volume of 1 litre to 10 litre  
 The  $\Delta E$  for this process is [ $R = 2 \text{ calK}^{-1} \text{ mol}^{-1}$ ]  
 (A) 163.7 cal (B) 1381.1 cal  
 (C) 9 litre - atm (D) zero
- Q 3. The maximum work done in expanding 16g oxygen at 300 K and occupying a volume of  $5 \text{ dm}^3$  isothermally until the volume becomes  $25 \text{ dm}^3$  is  
 (A)  $-2.01 \times 10^3 \text{ J}$  (B)  $+2.81 \times 10^3 \text{ J}$   
 (C)  $-2.01 \times 10^{-3} \text{ J}$  (D)  $+2.01 \times 10^{-6} \text{ J}$
- Q 4. The minimum work which must be done to compress 16 gm of oxygen at 300 K from a pressure of  $1.01325 \times 10^3 \text{ N/m}^2$  to  $1.01325 \times 10^5 \text{ N/m}^2$  is  
 (A) 5744 J (B) 8622 J  
 (C) 3872 J (D) 7963 J
- Q 5. 1 mole of an ideal gas is expanded isothermally and reversibly from 2 L to 4 L. if 3 moles of this, doing same work, gas expands from 2 L to x L, then the value of X will be [AIIMS 2018]  
 (A)  $(4)^{2/3}$  (B) 4  
 (C)  $(8)^{1/3}$  (D) 2
- Q 6. 2 mole of a gas at 1 bar & 298 K is compressed at constant temperature using of a constant pressure of 5 bar. How much work is done on gas?  
 (A) 9800 J (B) 19820 J  
 (C) 29800J (D) None of these
- Q 7. A gas expands against a constant external pressure of 2.00 atm, increasing its volume by 3.40 L. Simultaneously, the system absorbs 400 J of heat from its surroundings. What is  $\Delta E$ , in joules, for this gas ?  
 (A) -689 (B) -289  
 (C) +400 (D) +289
- Q 8. A thermodynamic process is shown in the following figure. In the process AB, 600J of heat is added to the system and in BC, 200 J of heat is

added to the system and in BC, 200J of heat is added to the system. The change in internal energy of the system in the process AC would be

Given:  $P_A = 3 \times 10^4$  Pa,  $P_B = 8 \times 10^4$  Pa,  
 $V_A = 2 \times 10^{-3} \text{ m}^3$ ,  $V_D = 5 \times 10^{-3} \text{ m}^3$

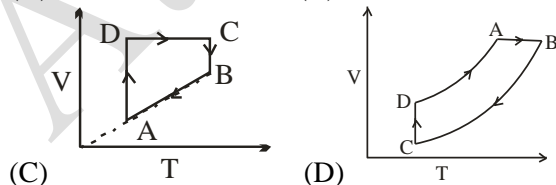
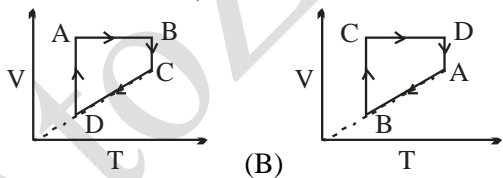
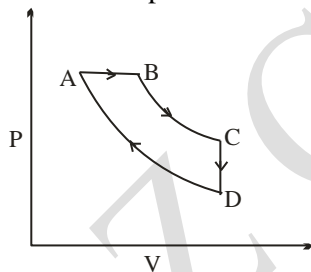


- (A) 560 J      (B) 800 J  
 (C) 600 J      (D) 640 J

Q 9. A sample of liquid in a thermally insulated container (a calorimeter) is stirred for 2 hr. by a mechanical linkage to a motor in the surrounding, for this process:

- (A)  $w < 0; q = 0; \Delta U = 0$   
 (B)  $w > 0; q > 0; \Delta U > 0$   
 (C)  $w < 0; q > 0; \Delta U = 0$   
 (D)  $w > 0; q = 0; \Delta U > 0$

Q 10. A cyclic process ABCD is shown in P-V diagram for an ideal gas. Which of the following diagram represents the same process ?



Q 11. A piston filled with 0.04 mole of an ideal gas expands reversibly from 50.0 mL to 375 mL at a

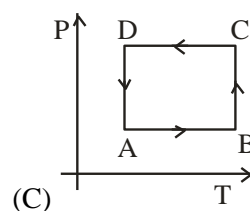
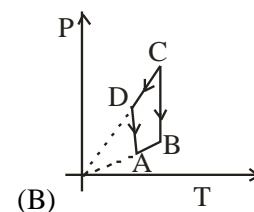
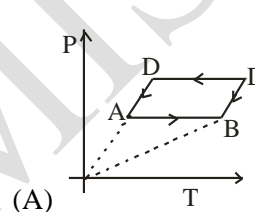
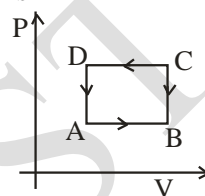
constant temperature of  $37.0^\circ\text{C}$ . As it does so, it absorbs 208 J of heat. The values of  $q$  and  $W$  for the process will be

[JEE Main 2013]

( $R = 8.314 \text{ J/mol.K}$ ,  $\ln 7.5 = 2.01$ )

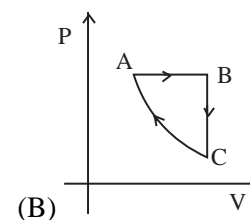
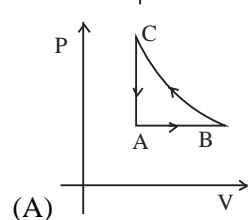
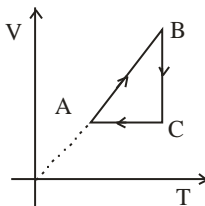
- (A)  $q = +208 \text{ J}, W = -208 \text{ J}$   
 (B)  $q = -208 \text{ J}, W = -208 \text{ J}$   
 (C)  $q = -208 \text{ J}, W = +208 \text{ J}$   
 (D)  $q = +208 \text{ J}, W = +208 \text{ J}$

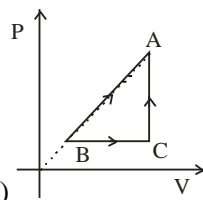
Q 12. The correct P-T curve for the thermodynamics P-V curve is



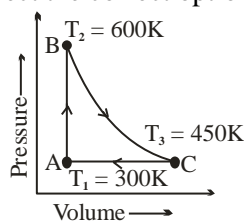
(D) None of these

Q 13. The correct P-V curve for the given V-T curve is





- (C)  $\frac{1}{2}$  (D) None of these
- Q 14. In which of the following cases, there is least difference between reversible & irreversible process  
 (A) 1 step expansion (B) 2 step expansion  
 (C) 5 step expansion (D) 10 step expansion
- Q 15. A heat engine carries one mole of an ideal monoatomic gas around the cycle as shown in the figure. Select the correct option



- (A)  $q_{AB} = 450R$  and  $q_{CA} = -450R$   
 (B)  $q_{AB} = 450R$  and  $q_{CA} = -225R$   
 (C)  $q_{AB} = 450R$  and  $q_{CA} = -375R$   
 (D)  $q_{AB} = 375R$  and  $q_{CA} = -450R$
- Q 16. The pressure volume work for an ideal gas can be calculated by using expression  $w = -\int_{V_i}^{V_f} P_{ext} \cdot dv$ .

The work can be also calculated from PV- plot by using area under the curve within specified limit.

When an ideal gas is compressed (a) reversibly (b) irreversibly from volume  $V_i$  to  $V_f$ , choose the correct statement [NCERT Exemplar]

- (A)  $W_{rev} = W_{irr}$  (B)  $W_{rev} < W_{irr}$   
 (C)  $W_{rev} > W_{irr}$  (D)  $W_{rev} = W_{irr} + P_{ext} \Delta V$
- Q 17. Two litre of an ideal gas at a pressure of 10 atm expands isothermally. Calculate  $q$  [NCERT solved]
- If expand Into a vacuum until its total volume is 10 litres.
  - If expand Against a constant external pressure of 1 atm.
  - If expand reversibly to a final volume of 10 lit.

### 5. Adiabatic Process

- Q 1. For mono atomic gas,  $C_v$  value is  
 (A)  $\frac{5}{2}R$  (B)  $\frac{3}{2}R$  (C)  $\frac{7}{2}R$  (D)  $3R$
- Q 2. No. of degree of freedom. (at moderate temp) for  $CO_2(g)$   
 (A) 6 (B) 9 (C) 5 (D) 3
- Q 3. In an adiabatic process, no heat transfer take place between system & surroundings. Choose the correct option for free expansion of an ideal gas under adiabatic condition from the following [CBSE PMT 2011]  
 (A)  $q \neq 0, \Delta T \neq 0, w = 0$   
 (B)  $q \neq 0, \Delta T = 0, w = 0$   
 (C)  $q = 0, \Delta T = 0, w = 0$   
 (D)  $q = 0, \Delta T < 0, w \neq 0$
- Q 4. The temperature of an ideal gas increases in an  
 (A) adiabatic expansion  
 (B) isothermal expansion  
 (C) adiabatic compression  
 (D) isothermal compression
- Q 5. If  $w_1, w_2, w_3$  and  $w_4$  for an ideal gas are magnitude of work done in isothermal, adiabatic, isobaric and isochoric reversible expansion processes, the correct order will be  
 (A)  $w_1 > w_2 > w_3 > w_4$   
 (B)  $w_3 > w_2 > w_1 > w_4$   
 (C)  $w_3 > w_2 > w_4 > w_1$   
 (D)  $w_3 > w_1 > w_2 > w_4$
- Q 6. A gas expands adiabatically at constant pressure such that  $T \propto V^{-1/2}$ . The value of  $\gamma(C_{p,m}/C_{v,m})$  for gas is  
 (A) 1.30 (B) 1.50 (C) 1.70 (D) 2
- Q 7. During an adiabatic process, the pressure of a gas is found to be proportional to cube of its absolute temperature. The Poisson's ratio of gas is  
 (A)  $\frac{3}{2}$  (B)  $\frac{7}{2}$   
 (C)  $\frac{5}{3}$  (D)  $\frac{9}{7}$

Q 8. Calculate average molar heat capacity at constant volume of a mixture contained 2 mole of each of ideal gases A  $\left(C_{v,m} = \frac{3}{2}R\right)$  and  $\left(C_{v,m} = \frac{5}{2}R\right)$

- (A) R (B) 2R  
(C) 3R (D) 8R

Q 9. 2 mole of an ideal monoatomic gas is mixed with 3 mole of an ideal diatomic gas, at room temperature. Determine  $\gamma$  for the mixture.

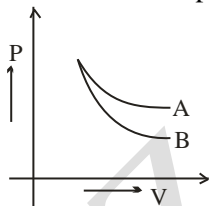
- (A)  $\frac{31}{21}$  (B)  $\frac{25}{21}$   
(C)  $\frac{17}{15}$  (D)  $\frac{17}{21}$

Q 10. If the ratio  $\frac{C_p}{C_v} = \gamma$ , the change in internal energy

for given mass of an ideal gas, when volume changes from V to 2V at constant pressure, P, is

- (A)  $\frac{R}{\gamma-1}$  (B) PV  
(C)  $\frac{PV}{\gamma-1}$  (D)  $\frac{\gamma PV}{\gamma-1}$

Q 11. P-V plot for two gases (assuming ideal) during adiabatic processes are given in the fig. Plot A and plot B should correspond respectively:



- (A) He and H<sub>2</sub> (B) H<sub>2</sub> and He  
(C) He and Ne (D) H<sub>2</sub> and Cl<sub>2</sub>

Q 12. The average degree of freedom per molecule for a gas is 6. The gas perform 25J of work when it expands at constant pressure. Find the heat absorbed by the gas

- (A) 25 J (B) 50 J  
(C) 75 J (D) 100J

Q 13. One mole of an ideal gas  $\left(C_{v,m} = \frac{5}{2}R\right)$  at 300 k and 5 atm is expanded adiabatically to a final

pressure of 2 atm against a constant pressure of 2 atm. Final temperature of the gas is

- (A) 270 K (B) 273 K  
(C) 248.5 K (D) 200 K

Q 14. 10 litres of a monoatomic ideal gas at 0°C and 10 atm pressure is suddenly released to 1 atm pressure and the gas expands adiabatically against this constant pressure. The final temperature & volume of the gas respectively are

- (A) T = 184.9 K, V = 64L  
(B) T = 153 K, V = 57 L  
(C) T = 165.4 K, V = 78.8L  
(D) T = 161.2 K, V = 68.3L

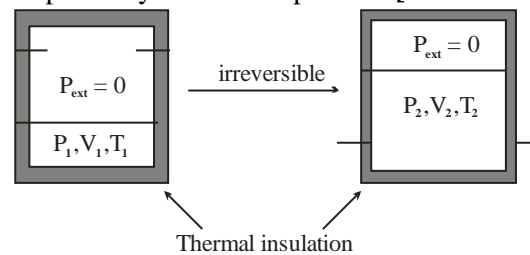
Q 15. One mole of Argon is heated using  $PV^{5/2} = \text{constant}$ . By what amount heat is absorbed during the process, when temperature changes by  $\Delta T = 26$  K

- (A) 100 J (B) 200 J  
(C) 180 J (D) 208 J

Q 16. Find the molar specific heat of the process  $P = \frac{C}{T}$  for a monoatomic gas where C is constant

- (A)  $\frac{7}{2}R$  (B)  $\frac{5}{2}R$  (C)  $\frac{9}{2}R$  (D)  $\frac{3}{2}R$

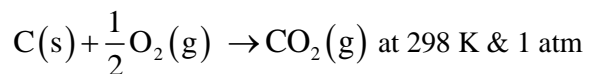
Q 17. An ideal gas in thermally insulated vessel at internal pressure =  $P_1$ , volume =  $V_1$  and absolute temperature =  $T_1$  expands irreversibly against zero external pressure, as shown in the diagram. The final internal pressure, volume and absolute temperature of the gas are  $P_2, V_2$  and  $T_2$ , respectively. For this expansion [JEE Adv.2014]



- (A)  $q = 0$  (B)  $T_2 = T_1$   
(C)  $P_2V_2 = P_1V_1$  (D)  $P_2V_2^\gamma = P_1V_1^\gamma$

### 6. Thermochemistry, Enthalpy Properties, Hess's Law, Krichoff's Law

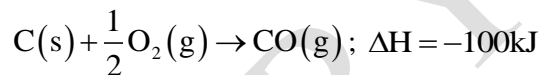
- Q 1. We study heat change in a chemical reaction in terms of enthalpy because  
 (A) Enthalpy is a state friction property  
 (B) Enthalpy is an extensive property  
 (C) Enthalpy is an intensive property  
 (D) Enthalpy is a path function property
- Q 2. Enthalpy is defined at  
 (A) Constant volume  
 (B) Constant pressure  
 (C) Constant Temperature  
 (D) In all conditions
- Q 3. One mole of a non – ideal gas undergoes a change of state (2.0 atm, 3.0L, 95K) → (4.0 atm, 5.0L, 245 K) with a change in internal energy,  $\Delta U = 30.0L \text{ atm}$ . The change in enthalpy ( $\Delta H$ ) of the process in L atm is **[IIT JEE 2002S]**  
 (A) 40.0 (B) 42.3  
 (C) 44.0  
 (D) not defined, because pressure is not constant
- Q 4. In a chemical reaction at constant temperature,  $\Delta \varepsilon$  is  
 (A) zero (B) +ve (C) –ve (D) all of these
- Q 5.  $\Delta H$  for  $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$  is 176 kJ mol<sup>-1</sup> at 1240K. The  $\Delta E$  for the change is equal to  
 (A) 160 kJ (B) 165.6 kJ  
 (C) 186.3 kJ (D) 180.0 kJ
- Q 6. For the reaction,  $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l})$  at constant temperature,  $\Delta H - \Delta E$  is **[CBSE PMT 2003]**  
 (A) +RT (B) –3RT  
 (C) +3RT (D) –RT
- Q 7. If water vapour is assumed to be a perfect gas, molar enthalpy change for vaporization of 1 mole of water at 1 bar and 100°C is 41 KJ/mol. Calculate the internal energy change when  
 (1). 1 mole of water is vaporized at 100°C & 1 bar pressure **[NCERT Solved]**  
 (2). 1 mole of water is converted into ice.
- Q 8. For the reaction



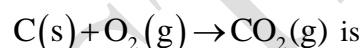
$\Delta H = -26416 \text{ cal}$ . If molar volume of C(s) is 0.0053 lit. The value of  $\Delta E$  is

- (A) –26416 cal (B) –26516 cal  
 (C) –26616 cal (D) –26716 cal

- Q 9. The  $\Delta H$  values for the reaction,

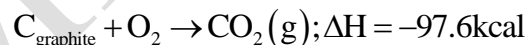
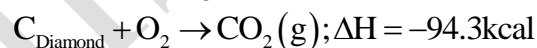


The heat of reaction for

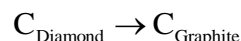


- (A) –50 kJ (B) –100kJ  
 (C) –150kJ (D) –300Kj

- Q 10. For the following reaction,

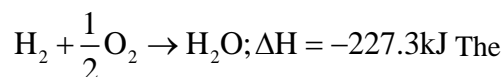
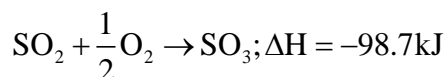


The heat of transition for

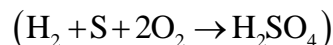


- (A) 3.3 Kcal (B) –3.3 Kcal  
 (C) –191.9 Kcal (D) None of these

- Q 11. If,  $\text{S} + \text{O}_2 \rightarrow \text{SO}_2; \Delta H = -298.2\text{kJ}$



The enthalpy of formation of  $\text{H}_2\text{SO}_4$  at 298 K will be

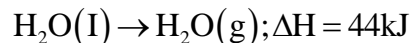
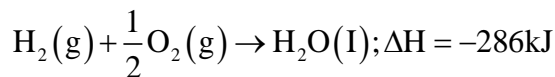
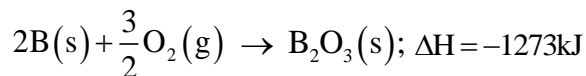


- (A) –754.4 kJ (B) +320.5 kJ  
 (C) –650.3 kJ (D) –433.7kJ

- Q 12. Diborane is a potential rocket fuel which undergoes combustion according to the reaction,  
 $\text{B}_2\text{H}_6(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow \text{B}_2\text{O}_3(\text{s}) + 3\text{H}_2\text{O}(\text{g})$   
 From the following data, calculate the enthalpy change for the combustion of diborane

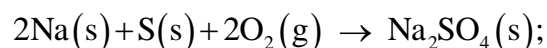
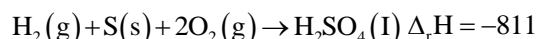
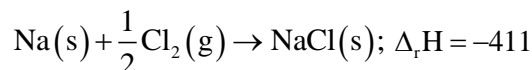
**[IIT – JEE 2000]**



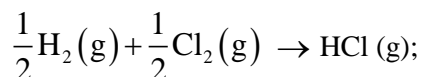


- (A) -2035kJ (B) +2035 kJ  
(C) -1825 kJ (D) None of these

Q 13. The enthalpy changes (KJ/mol) of the following reactions at 27°C are

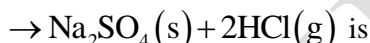


$$\Delta_r H = -1382\text{kJ/mol}$$



$$\Delta_r H = -92\text{kJ/mol}; R = 8.3\text{J/K-mol}$$

From these data, the heat change of reaction at constant volume (in kJ/mol) at 27°C for the process  $2\text{NaCl}(s) + \text{H}_2\text{SO}_4(l)$



- (A) -62.02 kJ (B) +62.02 kJ  
(C) -31.04 kJ (D) None of these

Q 14. For the reaction  $\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)$

$$\Delta H_{300\text{K}} = -40\text{kJ} \text{ If } C_{\text{PN}_2} = 32\text{J/mol-k},$$

$$C_{\text{PH}_2} = 82\text{J/mol,k}, C_{\text{PNH}_3} = 40\text{J/mol.K},$$

Calculate  $\Delta H$  for above reaction at 600 K

- (A) -19.4 kJ (B) 99.4 kJ  
(C) -99.4 kJ (D) 19.4 kJ

Q 15. For the reaction:  $\text{C}_{\text{graphite}} \rightarrow \text{C}_{\text{diamond}}; \Delta H = 2\text{KJ}$  at 298 K. If specific heat capacity of graphite & diamond are 720 & 505 J/kg-K then  $\Delta H$  at 273 K is

- (A) 1.9255 KJ (B) 2.0645 KJ  
(C) 2.254 KJ (D) None of these

Q 16. The standard enthalpy is defined as

- (A) 1 bar (B) 1 atm  
(C) 1 bar & 298 K (D) 1 atm & 298 K

## 7. Enthalpy of Formation & Combustion, Calorimeter

Q 1. Given  $\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g);$

$\Delta H^\circ = -22\text{kcal}$ . The standard enthalpy of formation of  $\text{NH}_3$  gas is

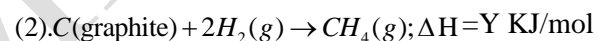
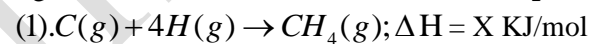
- (A) -11 kcal/mol (B) 11 kcal/mol  
(C) -22 kcal/mol (D) 22 kcal/mol

Q 2.  $\Delta_f U^0$  of formation of  $\text{CH}_4(g)$  at a certain

temperature is  $-393\text{KJ/mol}$ . The value of  $\Delta_f H^0$  is [NCERT Exemplar]

- (A) zero (B)  $< \Delta_f U^0$  (C)  $> \Delta_f U^0$  (D)  $= \Delta_f U^0$

Q 3. Consider the following reaction given below. On this basis of these reactions find out which of the algebraic relation is correct. [NCERT Exemplar]



- (A)  $X = Y$  (B)  $X = 2Y$  (C)  $X > Y$  (D)  $X < Y$

Q 4. Given enthalpy of formation of  $\text{CO}_2(g)$  and

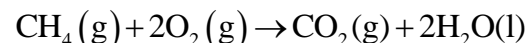
$\text{CaO}(s)$  are  $-94.0\text{kJ}$  and  $-152\text{kJ}$  respectively and then enthalpy of the reaction:

$\text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g)$  is  $42\text{kJ}$ . The enthalpy of formation of  $\text{CaCO}_3(s)$  is

- (A) -42 kJ (B) -202 kJ  
(C) +202 kJ (D) -288 kJ

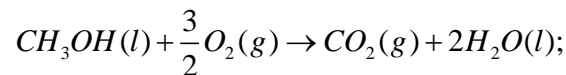
Q 5. Standard heat of formation of  $\text{CH}_4(g), \text{CO}_2(g)$

and water at 25° are  $-17.9, -94.1$  and  $-68.3\text{kcal mol}^{-1}$  respectively. The heat change (in kcal) in the following reaction at 25°C is

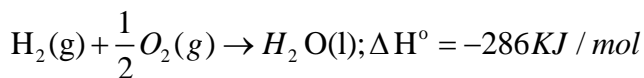
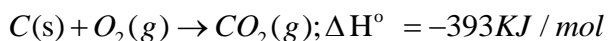


- (A) -144.5 (B) -180.3  
(C) -248.6 (D) -212.8

Q 6. Calculate the standard enthalpy of formation of  $\text{CH}_3\text{OH}(l)$  from the following data: [NCERT]



$$\Delta H^\circ = -726 \text{ KJ/mol}$$



- Q 7. Which of the species has  $\Delta H^\circ_f$  equal to zero  
 (A)  $\text{H}_2\text{O}(\ell)$  (B)  $\text{CH}_4(\text{g})$   
 (C)  $\text{Br}_2(\text{g})$  (D)  $\text{Cl}_2(\text{g})$
- Q 8. Which of the following species has  $\Delta H^\circ_f$  zero  
 (A) diamond (B)  $\text{CO}_2(\text{g})$   
 (C) graphite (D)  $\text{NH}_3(\text{g})$
- Q 9. Which of the following species has  $\Delta H^\circ_f > 0$   
 (A)  $\text{CO}_2(\text{g})$  (B) benzene  
 (C)  $\text{N}_2\text{O}(\text{g})$  (D)  $\text{NH}_3(\text{g})$
- Q 10. Which of the following value of heat of formation indicates that product is least stable?  
 (A) -94 Kcal (B) -231.6 Kcal  
 (C) +21.4 Kcal (D) +64.8 Kcal
- Q 11. The standard enthalpy of formation of A, B, C & D are -46.19, -393.4, +24.94 & -296.9 KJ/mole respectively. The increasing order of their stability is  
 (A)  $\text{B} < \text{D} < \text{A} < \text{C}$  (B)  $\text{C} < \text{A} < \text{D} < \text{B}$   
 (C)  $\text{D} < \text{B} < \text{C} < \text{A}$  (D)  $\text{A} < \text{C} < \text{D} < \text{B}$
- Q 12. Given that  
 $\text{C(s)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}); \Delta H^\circ = -x \text{ KJ}$   
 $2\text{CO(g)} + \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}); \Delta H^\circ = -y \text{ KJ}$   
 Then  $\Delta H^\circ_f$  of  $\text{CO}(\text{g})$  is  
 (A)  $\frac{2x-y}{2}$  (B)  $\frac{y-2x}{2}$   
 (C)  $2x-y$  (D)  $y-2x$
- Q 13.  $\Delta U^\circ$  of combustion of Methane is  $-X \text{ KJ/mol}$ . Find the value of  $\Delta H^\circ$  [NCERT]  
 (A)  $= \Delta U^\circ$  (B)  $> \Delta U^\circ$  (C)  $< \Delta U^\circ$  (D)  $= 0$
- Q 14. The enthalpy of combustion of methane, graphite & dihydrogen at 298 K is  $-890.3 \text{ KJ/mol}$ ,  $-393.5 \text{ KJ/mol}$  &  $-285.8 \text{ KJ/mol}$  respectively. Enthalpy of formation of  $\text{CH}_4(\text{g})$  will be [NCERT]

- (A)  $-74.8 \text{ KJ/mol}$  (B)  $-52.27 \text{ KJ/mol}$   
 (C)  $74.8 \text{ KJ/mol}$  (D)  $52.26 \text{ KJ/mol}$

- Q 15. Equal volume of  $\text{C}_2\text{H}_2$  and  $\text{H}_2$  are combusted under identical condition. The ratio of their heat of combustion is  $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$   
 $\Delta H = -241.8 \text{ kJ}$   $\text{C}_2\text{H}_2(\text{g}) + 2\frac{1}{2} \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g}); \Delta H = -1300 \text{ kJ}$   
 (A) 5.37/1 (B) 1/5.37 (C) 1/1 (D) None
- Q 16. Combustion of carbon forms two oxides CO and  $\text{CO}_2$ . Heat of formation of  $\text{CO}_2$  is 94.3 kcal and that of CO is 26.0 kcal. Heat of combustion of carbon is  
 (A) 26.0 kcal (B) -94.3 kcal  
 (C) 68.3 kcal (D) -120.3 kcal
- Q 17. **Assertion(A):** Combustion of all organic compounds is an exothermic reaction  
**Reason(R):** The enthalpy of all elements in their standard state is zero. [NCERT Exemplar]  
 (A) Both A & R are true and R is the correct explanation of A  
 (B) Both A & R are true but R is not the correct explanation of A  
 (C) A is true but R is false  
 (D) A is false but R is true.
- Q 18. Find fuel value of  $\text{C}_2\text{H}_6(\text{g})$  if  
 $\Delta H^\circ_f |_{\text{C}_2\text{H}_6(\text{g})} = -300 \text{ KJ/mol}$   
 $\Delta H^\circ_f |_{\text{H}_2\text{O}} = -90 \text{ kJ/mol}$  &  $\Delta H^\circ_f |_{\text{CO}_2} = -80 \text{ KJ/mol}$   
 (A) 4.33 KJ/g (B) 4 KJ/g  
 (C) 5.33 KJ/g (D) 5 KJ/g
- Q 19. Find calorific value (fuel value) per unit volume of the intimate mixture of  $\text{Fe}_2\text{O}_3$  & Al [IIT JEE 1988]  
 Given:  $\Delta H^\circ_f |_{\text{Fe}_2\text{O}_3} = -199 \text{ KJ/mol}$ ,  
 $\Delta H^\circ_f |_{\text{Al}_2\text{O}_3} = -399 \text{ KJ/mol}$   
 $\rho_{\text{Fe}_2\text{O}_3} = 5.2 \text{ g/cc}$  &  $\rho_{\text{Al}} = 2.7 \text{ g/cc}$   
 (A) 2.39 KJ/cc (B) 3.94 KJ/cc  
 (C) 2.94 KJ/cc (D) None of these

- Q 20. 0.16g CH<sub>4</sub> was subjected to combustion at 300 K in a bomb calorimeter. The temperature of calorimeter was found to rise by 0.5°C. Calculate the heat of combustion of CH<sub>4</sub> at constant pressure. The thermal capacity of the calorimeter system is 17.7 KJ/K [JEE Main 2016]  
 (A) -889.99kJ/mol (B) -885 kJ/mol  
 (C) -88.5 kJ/mol (D) -442.5 kJ/mol
- Q 21. In a constant volume calorimeter, 3.5 g of a gas with molecular weight 28 was burnt in excess oxygen at 298 K. The temperature of the calorimeter was found to increase from 298 K to 298.45 K due to the combustion process. Given that heat capacity of the calorimeter is 2.5 KJ/K, find the numerical value of the enthalpy of combustion of the gas in KJ/mol [JEE Adv. 2009]  
 (A) 6 (B) 9 (C) 3 (D) None of these
- Q 22. In coffee cup calorimeter, 8g NH<sub>4</sub>NO<sub>3</sub> undergo dissociation & it decreases temperature of 125 g H<sub>2</sub>O from 24.2°C to 18.2°C. Find enthalpy of dissociation of NH<sub>4</sub>NO<sub>3</sub> for H<sub>2</sub>O: Specific heat capacity = 4.2 J/g- °C  
 (A) 31.5 KJ (B) 42 KJ  
 (C) 315 KJ (D) 420 KJ
- Q 23. The reaction of cyanamide, NH<sub>2</sub>CN(s), with dioxygen was carried out in a bomb calorimeter, and ΔU was found to be -742.7 KJ/mol at 298 K. Calculate the enthalpy change for the reaction at 298 K. [NCERT]  

$$NH_2CN(g) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(l)$$
- Q 24. 1 g of graphite is burnt in excess of oxygen in bomb calorimeter at 298K & 1 atm according to the equation. C(graphite) + O<sub>2</sub>(g) → CO<sub>2</sub>(g)  
 During the reaction temperature increases from 298 K to 299 K. if the heat capacity of calorimeter is 20.7 KJ/K. what is the enthalpy change at 298K & 1 atm. [NCERT Solved]
- Q 25. What will be the heat of formation of Methane, if the heat of combustion of carbon is - X KJ/mol, heat of formation of water is - Y KJ/mol & heat of combustion of CH<sub>4</sub> is Z KJ/mol [AIIMS 2008]  
 (A) (-X-Y+Z) KJ/mol (B) (-X+2Y-Z) KJ/mol  
 (C) (-X-2Y-Z) KJ/mol (D) (-X-2Y+Z) KJ/mol

### 8. Enthalpy of Hydrogenation, Polymerisation, Neutralisation

- Q 1. Enthalpy of sublimation of a substance is equal to [NCERT Exemplar]  
 (A) Enthalpy of fusion + Enthalpy of vaporisation  
 (B) Enthalpy of fusion  
 (C) Enthalpy of vaporisation  
 (D) twice of enthalpy of vaporisation
- Q 2. A swimmer coming out from a pool is covered with a film of water weighing about 18 g. How much heat must be supplied to evaporate this water at 298 K. calculate internal energy of vaporization at 100 °C. [NCERT Solved]  
 Δ<sub>vap</sub>H<sup>o</sup> for water at 373 K = 40.66 KJ/mol
- Q 3. Enthalpy of hydrogenation is  
 (A) always positive  
 (B) always negative  
 (C) after positive  
 (D) often Negative
- Q 4. Enthalpy of formation of ethane & ethane & Acetylene are -210 KJ/mol & -140 KJ/mol respectively. Find Enthalpy of hydrogenation of acetylene  
 (A) -350 KJ/mol (B) -210 KJ/mol  
 (C) -70 KJ/mol (D) None of these
- Q 5. At Constant volume at 27°C  

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

$$\Delta E = -1600Kcal$$

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l); \Delta E = -620Kcal$$
 Then heat of polymerization of acetylene into benzene at constant pressure is  
 (A) -110 Kcal (B) -131.2 Kcal  
 (C) -120 Kcal (D) -90 Kcal
- Q 6. In which of the following reaction, energy released represents lattice energy of NaCl (s)  
 (A)  $Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$   
 (B)  $Na(g) + Cl(g) \rightarrow NaCl(s)$   
 (C)  $Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$

- (D)  $\text{Na}^+(\text{ags}) + \text{Cl}^-(\text{ags}) \rightarrow \text{NaCl}(\text{s})$
- Q 7. If lattice energy of  $\text{AlCl}_3(\text{s})$  is 5135 KJ/mol & enthalpy of hydration of  $\text{Al}^{3+}(\text{g})$  &  $\text{Cl}^-(\text{g})$  are  $-4850$  KJ/mol &  $-331$  KJ/mol respectively, then nature of  $\text{AlCl}_3$  in  $\text{H}_2\text{O}$  is [IIT-JEE 1997]
- (A) Covalent (B) Ionic  
(C) Amphoteric (D) Basic
- Q 8. For  $\text{H}_2\text{SO}_4$  &  $\text{NaOH}$  reaction, Enthalpy of neutralization is defined for reaction between
- (A) 1 mole  $\text{H}_2\text{SO}_4$  & 1 mole  $\text{NaOH}$   
(B) 1 mole  $\text{H}_2\text{SO}_4$  & 2 mole  $\text{NaOH}$   
(C)  $\frac{1}{2}$  mole  $\text{H}_2\text{SO}_4$  & 1 mole  $\text{NaOH}$   
(D) None of these
- Q 9. A base is neutralized with four acids HA, HB, HC & HD with enthalpy of neutralization  $-10.2$  Kcal/eq,  $-5.4$  Kcal/eq,  $-11.5$  Kcal &  $-12.1$  Kcal/eq. The correct acidic strength order is
- (A)  $\text{HA} > \text{HB} > \text{HC} > \text{HD}$   
(B)  $\text{HD} > \text{HC} > \text{HA} > \text{HB}$   
(C)  $\text{HB} > \text{HC} > \text{HD} > \text{HA}$   
(D) None of these
- Q 10. The heat of neutralization of  $\text{HCl}$  by  $\text{NaOH}$  is  $-55.9$  kJ/mol. If the heat of neutralization of  $\text{HCN}$  by  $\text{NaOH}$  is  $-12.1$  kJ/mol. The energy of dissociation of  $\text{HCN}$  is
- (A)  $-43.8$  kJ (B)  $43.8$  kJ  
(C)  $68$  kJ (D)  $-68$  kJ
- Q 11. The enthalpy of formation of  $\text{H}_2\text{O}(\text{l})$  is  $-285.83$  kJ  $\text{mol}^{-1}$  and enthalpy of neutralization of a strong acid and a strong base is  $-55.84$  kJ  $\text{mol}^{-1}$ . The enthalpy of formation of  $\text{OH}^-$  ions is
- (A)  $341.67$  kJ  $\text{mol}^{-1}$  (B)  $229.99$  kJ  $\text{mol}^{-1}$   
(C)  $-229.99$  kJ  $\text{mol}^{-1}$  (D)  $-341.67$  kJ  $\text{mol}^{-1}$
- Q 12. Under the same conditions, how many mL of 1M  $\text{KOH}$  and 0.5 M  $\text{H}_2\text{SO}_4$  solutions when mixed to form a total volume of 100 mL will produce the highest rise in temperature ?
- (A) 67, 33 (B) 33, 67  
(C) 40, 60 (D) 50, 50
- Q 13. The molar enthalpy of neutralization between  $\text{KOH}$  &  $\text{HNO}_2$  as compared to that of  $\text{NaOH}$  &  $\text{HCl}$  is
- (A) less (B) More  
(C) equal (D) depends on pressure
- Q 14. The enthalpy of neutralization of a strong acid with strong base is  $-57.0$  KJ/mol. The amount of heat released when 0.5 mole of  $\text{HNO}_3$  is mixed with 0.2 mole of  $\text{KOH}$  is
- (A) 570 KJ (B) 11.4 KJ  
(C) 28.5 KJ (D) 349 KJ
- Q 15. If temp of 5ml of a strong acid solution increases by  $5^\circ\text{C}$  when 5 ml of a strong base is added to it. If 10 ml of each is mixed, the temperature should increase by
- (A)  $5^\circ\text{C}$  (B)  $10^\circ\text{C}$   
(C)  $15^\circ\text{C}$  (D) Can't be known
- Q 16. Equal volume of molar  $\text{HCl}$  and  $\text{H}_2\text{SO}_4$  are neutralized by dilute  $\text{NaOH}$  solution & X Kcal & Y Kcal of heat are liberated respectively. Which of the following is true? [CBSE PMT 1991]
- (A)  $X = Y$  (B)  $2X = Y$   
(C)  $X = 2Y$  (D) None of these

### 9. Bond Energy, Resonance Energy

- Q 1. Bond energies of  $(\text{H}-\text{H})$ ,  $(\text{O}=\text{O})$  and  $(\text{O}-\text{H})$  are 105, 120 and 220 kcal/mol respectively than  $\Delta\text{H}$  in the reaction,  $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$
- (A)  $-115$  (B)  $-130$   
(C)  $-118$  (D)  $-550$
- Q 2. Energy required to dissociate 4 g of gaseous hydrogen into free gaseous atom is 208 kcal at  $25^\circ\text{C}$ . The bond energy of H-H bond per mole will be
- (A) 104 kcal (B) 10.4 kcal  
(C) 1040 kcal (D) 1.04 cal
- Q 3. Heat evolved in the reaction,  $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$  is 182 kJ. Bond energies of H-H and Cl-Cl are 430 and 242 kJ/mol respectively. The H-Cl bond energy is

- (A) 245kJ mol<sup>-1</sup> (B) 427kJ mol<sup>-1</sup>  
 (C) 336kJ mol<sup>-1</sup> (D) 154kJ mol<sup>-1</sup>
- Q 4. The bond energies of C–C, C=C, H–H and C–H linkages are 350, 600, 400 and 410 kJ per mole respectively. The heat of hydrogenation of ethylene is  
 (A) –170kJ mol<sup>-1</sup> (B) –260kJ mol<sup>-1</sup>  
 (C) –400kJ mol<sup>-1</sup> (D) –450kJ mol<sup>-1</sup>
- Q 5. The enthalpy change ( $\Delta H$ ) of the reaction,  
 $2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g)$   
 Given average bond energies of various bonds, C–H, C≡C, O=O, C=O, O–H as 414, 814, 499, 724 and 640 kJ mol<sup>-1</sup> respectively  
 (A) –7632 kJ (B) –186.1 kJ  
 (C) –2573 kJ (D) –763.2 kJ
- Q 6. If the enthalpy change for the reaction  
 $CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$ ;  
 $\Delta H = -25\text{kcal}$   
 Bond energy of C–H is 20 kcal mol<sup>-1</sup> greater than the bond energy of C–Cl and bond energies of H–H and H–Cl are same in magnitude, then for the reaction:  
 $\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$ ;  $\Delta H = ?$   
 (A) –22.5 kcal/mol (B) –20.5 kcal/mol  
 (C) –32.5 kcal/mol (D) –12.5 kcal/mol
- Q 7. Using bond energy data, calculate heat of formation of isoprene.  
 $5\text{C}(\text{graphite}) + 4H_2(g) \rightarrow \begin{array}{c} H_2C=C-C=CH_2(g) \\ | \quad | \\ CH_3 \quad H \end{array}$   
 Given: C–H = 98.8kcal; H–H = 104kcal  
 C–C = 83kcal; C=C = 147kcal &  
 $C(s) \rightarrow C(g) = 171\text{kcal}$   
 (A) 20.6 kcal (B) 25 kcal  
 (C) –20.6 kcal (D) 40 kcal
- Q 8. Enthalpy change with the help of B.E. data  
 (A) valid for gaseous phase reaction only  
 (B) valid for all phase reactions  
 (C) Valid for solid & liquid phase reactions  
 (D) None of these
- Q 9. Calculate the enthalpy change for the process  
 $CCl_4(g) \rightarrow C(g) + 4Cl(g)$  [NCERT]  
 And calculate the bond enthalpy of C–Cl in CCl<sub>4</sub>  
 $\Delta_{\text{vap}}H^\circ CCl_4 = 30.5\text{KJ/mol}$   
 $\Delta_f H^\circ CCl_4 = -135.5\text{KJ/mol}$   
 $\Delta_a H^\circ C = 715.0\text{KJ/mol}$   
 $\Delta_a H^\circ Cl_2 = 242.0\text{KJ/mol}$
- Q 10. Heat of dissociation of benzene in to gaseous atoms is 5535 K/mol. The bond enthalpies of C–C, C=C & C–H bonds are 347.3, 615 & 416.2 kJ respectively. Resonance energy of benzene is  
 (A) 1.51 KJ (B) 15.1 KJ  
 (C) 151 KJ (D) –1511 KJ
- Q 11. For N<sub>2</sub>O,  $\Delta H_f^\circ$  is 82 KJ/mol. If B.E. of N≡N, N=N=O=O & N=O are 946, 418, 498 & 607 KJ/mol respectively then Resonance energy of N<sub>2</sub>O is  
 (A) –170 KJ (B) –180 KJ  
 (C) –80 kJ (D) –88 KJ
- Q 12. For the gas phase reaction  $CH_3COCH_3 + 2O_2 \rightarrow CH_3COOH + CO_2 + H_2O$   
 Find  $\Delta H$  of the reaction if  
 B.E. of C–H, C–C, C=O, O=O, O–H & C–O are 415, 348, 725, 495, 462 & 468 KJ/mol respectively & Resonance energies of –COOH & CO<sub>2</sub> are .118 & 138 KJ/mol respectively  
 (A) –554 kJ (B) –977 kJ  
 (C) –1521 kJ (D) +554 kJ
- Q 13. From the given data  
 $C_2H_4 + H_2 \rightarrow C_2H_6$ ;  $\Delta H = -32.7\text{Kcal}$   
 $C_6H_6 + 3H_2 \rightarrow C_6H_{12}$ ;  $\Delta H = -49.2\text{Kcal}$   
 The Resonance energy of benzene is  
 (A) –16.5 Kcal (B) –81.9 Kcal  
 (C) –48.9 Kcal (D) None
- Q 14. The standard molar enthalpies of formation of cyclohexane & benzene ( $\ell$ ) at 25°C are –156 & +49 kJ/mol respectively. If Enthalpy of

hydrogenation of cyclohexene ( $\ell$ ) at  $25^\circ\text{C}$  is  $-119\text{ kJ/mol}$ , then Resonance energy of benzene is

[IIT – JEE 1996]

- (A)  $-112\text{ kJ/mol}$  (B)  $-152\text{ kJ/mol}$   
(C)  $-357\text{ kJ/mol}$  (D) None of these

### 10. Second Law of T.D. Entropy Calculation

- Q 1. In spontaneous process, entropy of system  
(A) always increases  
(B) Always decreases  
(C) May increase or decrease  
(D) None of these
- Q 2. Positional entropy depends on  
(A) Phase of substance  
(B) External pressure, temp. & volume  
(C) Internal structure  
(D) All of these
- Q 3. At  $25^\circ\text{C}$ , which of the following substance has the highest molar entropy?  
(A) Al (s) (B)  $\text{C}_6\text{H}_6(\text{l})$   
(C)  $\text{C}_2\text{H}_6(\text{g})$  (D)  $\text{CH}_4(\text{g})$
- Q 4. Predict in which of the following, entropy increases/decreases: [NCERT Solved]  
(1). A liquid crystallizes into a solid  
(2). Temperature of a crystalline solid is raised from 0 K to 115 K  
(3).  $2\text{NaHCO}_3(\text{s}) \rightarrow \text{Na}_2\text{CO}_3(\text{s}) + \text{H}_2\text{O}(\text{g}) + \text{CO}_2(\text{g})$   
(4).  $\text{H}_2(\text{g}) \rightarrow 2\text{H}(\text{g})$
- Q 5. **Assertion(A):** A liquid crystallizes into a solid and is accompanied by decrease in entropy  
**Reason(R):** In crystals, molecules organize in more ordered manner. [NCERT Exemplar]  
(A) Both A & R are true and R is the correct explanation of A  
(B) Both A & R are true but R is not the correct explanation of A  
(C) A is true but R is false  
(D) A is false but R is true.
- Q 6. A reaction that is spontaneous can be described as  
(A) releasing heat to the surroundings

- (B) having the same rate in both the forward and reverse directions  
(C) proceeding in both the forward and reverse directions  
(D) proceeding without external influence once it has begun

Q 7. What are the signs of  $\Delta H$  and  $\Delta S$  for this reaction ?

- |     | $\Delta H$ | $\Delta S$ |
|-----|------------|------------|
| (A) | -          | -          |
| (B) | -          | +          |
| (C) | +          | +          |
| (D) | +          | -          |

Q 8. For which of the following processes would  $\Delta S^\circ$  be expected to be most positive ?

- (A)  $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$   
(B)  $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$   
(C)  $\text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{NaCl}(\text{s})$   
(D)  $\text{Cl}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$

Q 9. The entropy change when two moles of ideal monoatomic gas is heated from 200 to  $300^\circ\text{C}$  reversibly and isochorically

- (A)  $\frac{3}{2}R \ln\left(\frac{300}{200}\right)$  (B)  $\frac{5}{2}R \ln\left(\frac{573}{273}\right)$   
(C)  $3R \ln\left(\frac{573}{473}\right)$  (D)  $\frac{3}{2}R \ln\left(\frac{573}{473}\right)$

Q 10. 1 mole of an ideal gas at  $25^\circ\text{C}$  is subjected to expand reversibly ten times of its initial volume. The change in entropy of the system is

- (A)  $19.15\text{JK}^{-1}\text{mol}^{-1}$  (B)  $16.15\text{JK}^{-1}\text{mol}^{-1}$   
(C)  $22.15\text{JK}^{-1}\text{mol}^{-1}$  (D) None of these

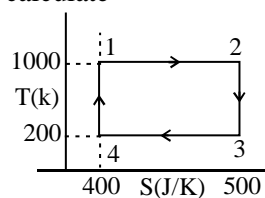
Q 11. When 1 mole of gas is compressed to half of its initial volume and simultaneously heated to twice its initial temperature, change in entropy of the system is

- (A)  $C_v \ln 2$  (B)  $C_p \ln 2$   
(C)  $R \ln 2$  (D)  $(C_v - R) \ln 2$

- Q 12. Calculate entropy change in surroundings when 1.00 mole of  $\text{H}_2\text{O}(\text{l})$  is formed under standard conditions.  $\Delta_f H^\circ = -286 \text{ kJ/mol}$  [NCERT]
- Q 13. Calculate the change in entropy in reservoirs when 4000 Joule of heat is transferred from reservoir at temperature 500 K to 300 K  
 (A)  $5.33 \text{ JK}^{-1}$  (B)  $-5.33 \text{ JK}^{-1}$   
 (C)  $10.36 \text{ JK}^{-1}$  (D)  $-10.36 \text{ JK}^{-1}$
- Q 14. The entropy change can be calculated by using the expression,  $\Delta S = \frac{q_{\text{rev}}}{T}$ , when water freezes in glass beaker, choose the correct statement amongst the following [NCERT Exemplar]  
 (A)  $\Delta S$  (sys) decreases but  $\Delta S$  (surr) remain same  
 (B)  $\Delta S$  (sys) increases but  $\Delta S$  (surr) decreases  
 (C)  $\Delta S$  (sys) decreases but  $\Delta S$  (surr) increases  
 (D)  $\Delta S$  (sys) &  $\Delta S$  (surr) both decreases
- Q 15. A system is expand  $V_1$  to  $V_2$  adiabatically & reversible  $\Delta S_{\text{sys}}$  X, Now if the system expand  $V_1$  to  $V_2$  adiabatically and irreversibly  $\Delta S_{\text{sys}}$  is Y.  
 (A)  $X = 0, Y > X$   
 (B)  $X = 0, Y = 0$   
 (C)  $Y = 0, X > Y$   
 (D)  $X = Y \neq 0$
- Q 16. Calculate the change in entropy if 2 mole of  $\text{N}_2$ , 3 mole of  $\text{H}_2$  and 2 mole of  $\text{NH}_3$  are mixed at constant temperature. Assuming no chemical reaction  
 (A)  $45.8 \text{ JK}^{-1}$  (B)  $84.7 \text{ JK}^{-1}$   
 (C)  $150 \text{ JK}^{-1}$  (D)  $62.8 \text{ JK}^{-1}$
- Q 17. 1 mole of an ideal gas at 300 K in thermal contact with surroundings expands isothermally from 1.0L to 2.0 L against a constant pressure of 3.0 atm. In this process, the change in entropy of surroundings ( $\Delta S_{\text{surr}}$ ) in J/K is (1L.atm=101.3 J)  
 (A) 5.763 (B) 1.013  
 (C) -1.013 (D) -5.763

**Subjective questions:**

- Q 18. One mole of an ideal gas is expanded isothermally at 300 K from 10 atm to 1 atm. Find the value of  $\Delta S_{\text{sys}}$ ,  $\Delta S_{\text{surr}}$  &  $\Delta S_{\text{total}}$  under the following conditions  
 (i) Expansion is carried out reversibly  
 (ii) Expansion is carried out irreversibly at 1 atm pressure  
 (iii) Expansion is free against vacuum
- Q 19. One mole of a non linear triatomic ideal gas is expanded adiabatically at 300 K from 16 atm to 1 atm. Find the values of  $\Delta S_{\text{sys}}$ ,  $\Delta S_{\text{surr}}$  &  $\Delta S_{\text{total}}$  under the following conditions  
 (i) Expansion is carried out reversibly  
 (ii) Expansion is carried out irreversibly at  $P_{\text{ext}} = 1 \text{ atm}$   
 (iii) Expansion is free
- Q 20. From the T-S diagram of a reversible carnot engine, calculate

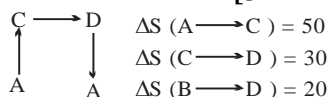


- (i) efficiency  
 (ii) work done per cycle  
 (iii) Heat taken from the source and rejected to sink  
 (iv) In order to illuminate 10000 bulbs of 40 watt power each calculate the no. of cycle per second the above must go through
- Q 21. Calculate the entropy change when 10g of water at  $80^\circ\text{C}$  is converted to steam at  $120^\circ\text{C}$   
 $S_w = 1 \text{ cal/g} \cdot ^\circ\text{C}$ ,  $\ell_v = 500 \text{ cal/g}$ ,  
 $S_{\text{steam}} = 0.25 \text{ cal/g} \cdot ^\circ\text{C}$
- Q 22. For an isolated system,  $\Delta E = 0$ , then [AIIMS 96]  
 (A)  $\Delta S = 0$  (B)  $\Delta S < 0$   
 (C)  $\Delta S > 0$  (D) can't be predicted

## 11. Properties of Entropy, Free Energy

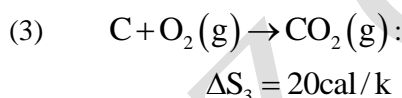
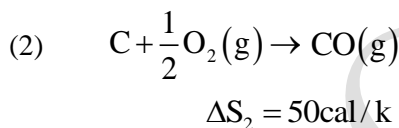
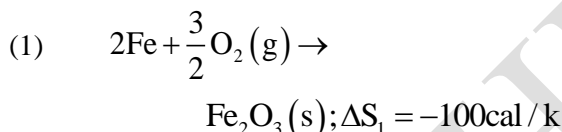
- Q 1. A process  $A \rightarrow B$  is difficult to occur directly instead it takes place in three successive steps

[JEE Main 2006]



The entropy change for the process  $A \rightarrow B$  is

- (A) 100 (B) -60  
(C) -100 (D) +60
- Q 2. The entropy change for reaction given below is  
 $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$   
 Is ..... at 300K. Standard entropies of  $H_2(g)$ ,  
 $O_2(g)$  and  $H_2O(l)$  are 126.6, 201.20 and  
 $68.0 JK^{-1} mol^{-1}$  respectively  
 (A)  $-318.4 JK^{-1} mol^{-1}$  (B)  $318.4 JK^{-1} mol^{-1}$   
 (C)  $31.84 JK^{-1} mol^{-1}$  (D) None
- Q 3. Calculate  $\Delta S$  for the reaction  
 $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$  if



- (A) 220 Cal/K (B) +10 Cal/K  
(C) 70 Cal/K (D) None of these
- Q 4. Standard entropy of formation of  $O_2(g)$  at  $25^\circ C$  is  
 (A) zero (B) Negative  
(C) Positive (D) Can't say
- Q 5. Free energy is defined at  
 (A) Constant temperature  
(B) Constant enthalpy  
(C) Constant entropy  
(D) In any case
- Q 6. Free energy is equal to work done by a system in  
 (A) reversible process  
(B) Irreversible process

- (C) In all process  
(D) In thermodynamics process

- Q 7. In which case, reaction is possible at any temperature ?

- (A)  $\Delta H < 0, \Delta S > 0$   
(B)  $\Delta H < 0, \Delta S < 0$   
(C)  $\Delta H > 0, \Delta S > 0$   
(D) In none of the cases

- Q 8. **Assertion(A):** spontaneous process is an irreversible process and may be reversed by external agency. [NCERT Exemplar]

**Reason(R):** Decrease in enthalpy is a contributory factor for spontaneity.

- (A) Both A & R are true and R is the correct explanation of A  
(B) Both A & R are true but R is not the correct explanation of A  
(C) A is true but R is false  
(D) A is false but R is true.

- Q 9. If both  $\Delta H$  &  $\Delta S$  have +ve value ..... in which case reaction should be spontaneous ?

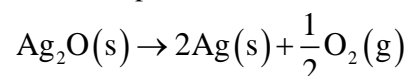
- (A)  $\Delta H > T\Delta S$   
(B)  $T\Delta S > \Delta H$   
(C)  $\Delta H = T\Delta S$   
(D) None of these

- Q 10. What is minimum temperature at which the process below will be spontaneous, given the  $\Delta H = +85 kJ$  and  $\Delta S_{rxn}^0 = 198 J/K$  for the reaction  $N_2F_4(g) \rightarrow NF_2(g)$

- (A)  $T = 144 K$  (B)  $T = 298 K$   
(C)  $T = 429.3 K$  (D)  $T = 2330 K$

- Q 11. For reaction at  $27^\circ C$  enthalpy change ( $\Delta H$ ) & entropy change ( $\Delta S$ ) are  $-11.7 \times 10^3 J mol^{-1}$  and  $-100 J/mol.K$  respectively. The reaction is  
 (A) Spontaneous (B) non-spontaneous  
(C) instantaneous (D) None

- Q 12. The temperature at which the reaction,



Is at equilibrium is .....; Given

- $\Delta H = 30 kJ mol^{-1}$  and  $\Delta S = 0.05 kJ K^{-1} mol^{-1}$   
 (A) 600 K (B) 362.12 K



- (C) 262.12 K (D) 562.12 K
- Q 13. Determine  $\Delta G^\circ$  for the following reaction  
 $\text{CO(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$  [AIIMS 2016]  
 $\Delta H^\circ = -282.84\text{kJ}$ ;  $S^\circ_{\text{CO}_2} = 213.8\text{J/mol.K}$   
 $S^\circ_{\text{CO}} = 197.9\text{J/mol.K}$ ;  $S^\circ_{\text{O}_2} = 205.8\text{J/mol.K}$   
 (A) -157.33 KJ (B) 201.033 KJ  
 (C) -257.033 KJ (D) 257.033 KJ
- Q 14. If the enthalpy of vapourisation of water is 186.5 KJ/mol at 373 K its entropy of vapourisation is  
 (A)  $0.5\text{KJk}^{-1}\text{mol}^{-1}$  (B)  $1.0\text{KJk}^{-1}\text{mol}^{-1}$   
 (C)  $1.5\text{KJk}^{-1}\text{mol}^{-1}$  (D)  $2.0\text{KJk}^{-1}\text{mol}^{-1}$
- Q 15. For the reaction at 300 K  
 $\text{X}_2\text{O}_4\text{(g)} \rightarrow 2\text{XO}_2\text{(g)}$ ,  $\Delta E = -2.1\text{cal}$   
 $\Delta S = 20\text{cal/K}$  value of  $\Delta G$  is  
 (A) 2.7 Kcal (B) -2.7 Kcal  
 (C) -9.3 Kcal (D) -3.48 Kcal
- Q 16. For the reaction at 300 K  
 $\text{A(g)} + \text{B(g)} \rightarrow \text{C(g)}$   $\Delta E = -3.0\text{kcal}$ ;  
 $\Delta S = -10.0\text{cal/K}$  value of  $\Delta G$  is  
 (A) -600 cal (B) -6600cal  
 (C) -6000 cal (D) None
- Q 17. For the reaction  
 $2\text{A(g)} + \text{B(g)} \rightarrow 2\text{D(g)}$ ;  $\Delta U^\circ = -10.5\text{kJ}$ ;  
 $\Delta S^\circ = -44.1\text{J/K}$  [NCERT]  
 Calculate the value of  $\Delta G^\circ$  for the reaction and predict whether the reaction may occur spontaneously.
- Q 18. What is the free energy charge ( $\Delta G$ ) when 1.0 mole of water at  $100^\circ\text{C}$  and 1 atm pressure is converted into steam at  $100^\circ\text{C}$  & 1 atm pressure?  
 (A) 80 cal (B) 540 cal  
 (C) 620 cal (D) zero

## 12. Properties of Free Energy, Efficiency of system

- Q 1. For the reaction  
 $\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \rightleftharpoons 2\text{NH}_3\text{(g)}$   
 $\Delta G^\circ = -33.32\text{KJ}$  then standard free energy of formation of  $\text{NH}_3\text{(g)}$  is  
 (A) +33.32 KJ (B) -16.66KJ  
 (C) 16.66 KJ (D) None of these
- Q 2. From the following data, calculate free energy of formation of  $\text{AgCl}$  at  $25^\circ\text{C}$   
 (1)  $\text{Ag}_2\text{O(s)} + 2\text{HCl(g)} \rightarrow 2\text{AgCl(s)} + \text{H}_2\text{O(l)}$ ;  $\Delta G_1^\circ = -77.61\text{KJ}$   
 (2)  $2\text{Ag(s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{Ag}_2\text{O(s)}$ ;  $\Delta G_2^\circ = -73.1\text{KJ}$   
 (3)  $\frac{1}{2}\text{H}_2\text{(g)} + \frac{1}{2}\text{Cl}_2\text{(g)} \rightarrow \text{HCl(g)}$ ;  
 $\Delta G_3^\circ = -22.06\text{KJ}$   
 (4)  $\text{H}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{H}_2\text{O(l)}$ ;  
 $\Delta G_4^\circ = -68.32\text{KJ}$   
 (A) -63.20 KJ (B) +63.20 KJ  
 (C) -163.50 KJ (D) +163.50 KJ
- Q 3. In irreversible process taking place at constant T and P and in which only pressure-volume work is being done, the change in Gibbs free energy ( $dG$ ) and change in entropy ( $dS$ ), satisfy the criteria [IIT JEE 2003S]  
 (A)  $(ds)_{V,E} < 0, (\Delta G)_{T,P} < 0$   
 (B)  $(ds)_{V,E} > 0, (\Delta G)_{T,P} < 0$   
 (C)  $(ds)_{V,E} = 0, (\Delta G)_{T,P} = 0$   
 (D)  $(ds)_{V,E} = 0, (\Delta G)_{T,P} > 0$
- Q 4. Calculate free energy of an isothermal reversible expansion process if a pressure of one mole of ideal gas drops 100 atm to 20 atm at a temperature  $25^\circ\text{C}$   
 (A) -3.988 KJ (B) -7.966 KJ

- Q 5. The Gibbs free energy change accompanying the compression of 1 mole of an ideal gas at 27°C from 25 to 250 atm taking  $R = 2 \text{ cal K}^{-1} \text{ mol}^{-1}$  is for  
 (A) 600 Cal/mol (B) -1216.2 Cal/mol  
 (C) +1381.8 Cal mol<sup>-1</sup> (D) 1200 Cal mol<sup>-1</sup>
- Q 6. The maximum efficiency of a heat engine operating between 100°C and 25°C is  
 (A) 20% (B) 22.2%  
 (C) 25% (D) None
- Q 7. A heat engine operating between 227°C and 27°C absorbs 2 Kcal of heat from the 227°C reservoir reversibly per cycle. The amount of work done in one cycle is  
 (A) 0.4 Kcal (B) 0.8 Kcal  
 (C) 4 Kcal (D) 8 Kcal
- Q 8. A reversible heat engine A (based on Carnot cycle) absorbs heat from a reservoir at 1000K and rejects heat to a reservoir at  $T_2$ . A second reversible engine B absorbs the same amount of heat as rejected by the engine A, from the reservoir at  $T_2$  and rejects energy to a reservoir at 360K.  
 If the efficiencies of engines A and B are the same then the temperature  $T_2$  is  
 (A) 680 K (B) 640 K  
 (C) 600 K (D) None
- Q 9. A Carnot cycle has an efficiency of 40%. Its low temperature reservoir is at 7°C. What is the temperature of source?  
 (A) 193.67°C (B) 163.67°C  
 (C) 173.67°C (D) 185.67°
- Q 10. A heat engine absorbs 760 kJ heat from a source at 380K. It rejects (i) 650 kJ, (ii) 560kJ, (iii) 504 kJ of heat to sink at 280 K. State which of these represent a reversible, an irreversible and an impossible cycle  
 (A) (i) reversible, (ii) irreversible, (iii) impossible  
 (B) (i) impossible, (ii) reversible, (iii) irreversible  
 (C) (i) irreversible, (ii) reversible, (iii) impossible  
 (D) (i) irreversible, (ii) impossible, (iii) reversible
- Q 11. A heat engine absorbs heat  $Q_1$  at temperature  $T_1$  and heat  $Q_2$  at temperature  $T_2$ . Work done by the engine is  $(Q_1 + Q_2)$ . This data  
 [JEE Main 2002]  
 (A) violates 1<sup>st</sup> law of thermodynamics  
 (B) violates 2<sup>nd</sup> law of thermodynamics  
 (C) violates Joule's equivalent law of thermodynamics  
 (D) None of these
- Q 12. In a fuel cell of  $\text{CH}_3\text{OH}(\ell)$  [JEE Main 2014]  

$$\text{CH}_3\text{OH}(\ell) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\ell)$$
 At 298K, the  $\Delta G_f^\circ$  for  $\text{CH}_3\text{OH}(\ell)$ ,  $\text{H}_2\text{O}(\ell)$  &  $\text{CO}_2(\text{g})$  are -166.2, -237.2 & -394.4 KJ/mol respectively. If standard enthalpy of combustion of  $\text{CH}_3\text{OH}(\ell)$  is -726KJ/mol, then efficiency of the fuel is  
 (A) 87% (B) 90%  
 (C) 97% (D) 80%

## Answer Key

## 1. Zeroth law of Thermodynamics, Heat

- (1). A      (2). C      (3). B  
 (4). C      (5). A      (6). B  
 (7). C      (8). B      (9). A  
 (10). C      (11). D      (12). C  
 (13). 1.06667 KJ      (14).  $C_p = 18.c$   
 (15). D

## 2. System, Surroundings, Properties, Process

- (1). C      (2). B      (3). C  
 (4). B      (5). C      (6). C  
 (7). B      (8). D      (9). D  
 (10). A      (11). C      (12). B  
 (13). C      (14). C      (15). C  
 (16). D

## 3. First Law of Thermodynamics, Isobaric &amp; Isochoric Process, Work

- (1). A      (2). B      (3). D  
 (4). (1).  $\Delta U = W$ , Wall is adiabatic  
       (2).  $\Delta U = -q$ , wall is diathermal  
       (3).  $\Delta U = q - w$ , closed system  
 (5). B      (6). A      (7). C  
 (8). D      (9). A      (10). B  
 (11). A      (12). A      (13). D  
 (14). B      (15). A      (16). A  
 (17). B      (18). A      (19). A  
 (20). B      (21). A      (22). C

## 4. Isothermal Process, Thermodynamics Curve

- (1). B      (2). D      (3). A  
 (4). A      (5). A      (6). B  
 (7). B      (8). A      (9). D  
 (10). C      (11). A      (12). A  
 (13). A      (14). D      (15). C  
 (16). B  
 (17). (1). 0      (2). 8 lit.atm      (3). 16.1 lit.atm

## 5. Adiabatic Process

- (1). B      (2). C      (3). C  
 (4). C      (5). D      (6). B  
 (7). A      (8). B      (9). A  
 (10). C      (11). B      (12). D  
 (13). C      (14). A      (15). C  
 (16). A      (17). A,B,C

## 6. Thermochemistry, Enthalpy Properties, Hess's Law, Krichoff's Law

- (1). A      (2). D      (3). C  
 (4). D      (5). B      (6). B  
 (7). 1). 37.904 KJ/mol      2). 41 KJ/mol  
 (8). D      (9). D      (10). A  
 (11). A      (12). A      (13). B  
 (14). D      (15). B      (16). A

## 7. Enthalpy of Formation &amp; Combustion, Calorimeter

- (1). A      (2). B      (3). C  
 (4). D      (5). D      (6). - 239 KJ/mol  
 (7). D      (8). C      (9). C  
 (10). D      (11). B      (12). B  
 (13). C      (14). A      (15). A  
 (16). D      (17). B      (18). A  
 (19). B      (20). A      (21). B  
 (22). A      (23). - 741 KJ/mol  
 (24). - 248 KJ/mol      (25). D

## 8. Enthalpy of Hydrogenation, Polymerisation, Neutralisation

- (1). A      (2). 37.56 KJ/mol      (3). B  
 (4). C      (5). B      (6). C  
 (7). B      (8). C      (9). B  
 (10). B      (11). C      (12). D  
 (13). B      (14). B      (15). A  
 (16). B

**9. Bond Energy, Resonance Energy**

- (1). D      (2). A      (3). A  
 (4). A      (5). C      (6). A  
 (7). A      (8). A      (9). 326 KJ/mol  
 (10). C      (11). D      (12). B  
 (13). C      (14). B

**10. Second Law of T.D. Entropy Calculation**

- (1). C      (2). D      (3). C  
 (4). Decreases, increases, increases, increases  
 (5). A      (6). D      (7). B  
 (8). A      (9). C      (10). A  
 (11). D      (12). 959 J/mol.K  
 (13). A      (14). C      (15). A  
 (16). C      (17). C  
 (18).

	$\Delta S_{\text{sys}}$	$\Delta S_{\text{surr}}$	$\Delta S_{\text{total}}$
1	$R \ln 10$	$-R \ln 10$	0
2	$R \ln 10$	$-9R/10$	$R \ln 10 - 9R/10$
3	$R \ln 10$	0	$R \ln 10$

(19).

	$\Delta S_{\text{sys}}$	$\Delta S_{\text{surr}}$	$\Delta S_{\text{total}}$
1	0	0	0
2	$4R \ln 147 - 3R \ln 192 - R \ln 12$	0	$4R \ln 147 - 3R \ln 192 - R \ln 12$
3	$R \ln 16$	0	$R \ln 16$

- (20). (i) 80 %    (ii). - 80 KJ    (iii).  $10^5$  J, 20 KJ  
 (iv). 5

(21).  $10 \ln \left( \frac{373}{353} \right) + \frac{5000}{373} + 2.5 \ln \left( \frac{393}{373} \right)$

(22). C

**11. Properties of Entropy, Free Energy**

- (1). D      (2). A      (3). B  
 (4). C      (5). D      (6). A  
 (7). A      (8). B      (9). B  
 (10). C      (11). B      (12). A  
 (13). C      (14). A      (15). B  
 (16). C      (17). 0.164 KJ (18). D

**12. Properties of Free Energy, Efficiency of system**

- (1). B      (2). A      (3). B  
 (4). A      (5). C      (6). A  
 (7). B      (8). C      (9). A  
 (10). C      (11). D      (12). C