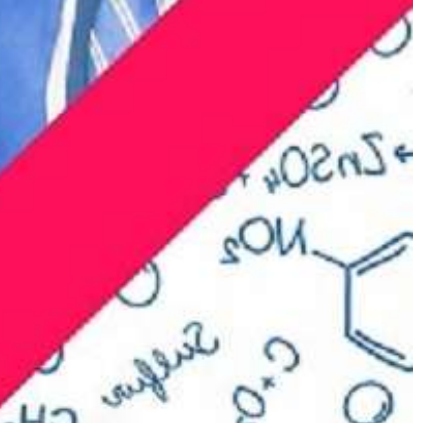




**CHANAKYA ACADEMY OF  
PROFESSIONAL STUDIES**

**JEE MAIN / NEET**

**CHEMISTRY**



## THERMODYNAMICS

### Introduction and Concepts Thermodynamics

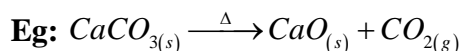
- The subject dealing with Quantitative relation between heat energy and other forms of energy in physico - Chemical processes is called Thermodynamics.

### Chemical Thermodynamics

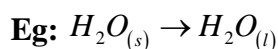
- The branch of thermodynamics which deals with the study of process in which chemical energy is involved is called chemical thermodynamics.
- These results are formulated into four law's namely Zero, First, second and third laws of thermodynamics.
- These laws are based on experimental facts but not on the theoretical facts.
- Thermodynamics predicts the energy transformations and feasibility of a process.
- Thermodynamics deals heat changes occurring between system and surroundings.

#### Types of rection

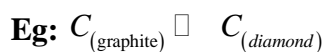
- Chemical change reactions;



- Physico change reactions



- Allotropic change reactions



**Phase :** It is homegenious portion which has identical physical & chemical properties through out it & physically distinctable & mechanical separable from other portions.

- Both Physico change & Allotropic change reactions are phase change reactions.
- In solid mixture, number of phases is equal to number of individual solids.

**Eg:**  $C_{(graphite)} \rightleftharpoons C_{(diamond)}$ , number of phases is equal to two.

- Thermodynamics deals with the calculation of Q, E,  $\Delta E$ ,  $\Delta H$ ,  $\Delta S$  &  $\Delta G$  in all type of reactions and gas in cylinder system based on all alws of thermodynamics.

#### The terms used in thermodynamics:

##### System:

- It is any part of universe that is under thermodynamic study at that instant.

**Eg:** a) A crystal (for a crystallographer)

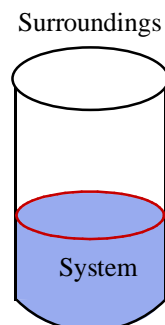
b) A physical process (for a physicist)

c) Chemical reaction (for a chemist)

##### Surroundings

- The remaining part of the universe, other than system is called surroundings.

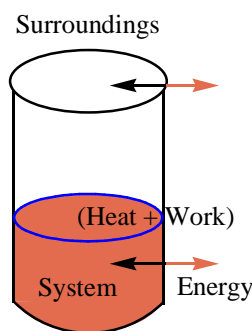
**Universe = system + surroundings**



- **Boundary:** Any real (or) imaginary, rigid (or) non-rigid surface that separates system and surroundings.
- **Diathermic wall:** which allows heat exchanging between system and surroundings.
- Adiabatic wall:** which does not allow heat exchanging between system and surroundings.

### Types of system:

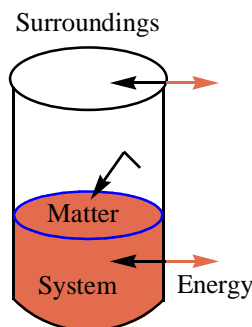
- Systems are classified on the basis of their interaction with the surroundings as follows:
- 1. Open System:** The system where matter and energy are exchanged with surroundings. Boundary is not sealed and not insulated.



(A) Open System

**Eg:** All living beings, Reactants in open vessel.

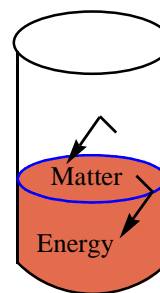
**2. Closed system:** The system where only the energy but not the matter is exchanged with the surroundings. Boundary is sealed but not insulated.



(B) Closed System

**Eg:** A closed steel container having hot water.

**3. Isolated system:** The system which does not exchange either the matter or energy with the surroundings. Boundary is sealed and insulated



(C) Isolated System

- **Eg:** A perfectly insulated, closed flask containing water.
- Universe is treated as an isolated system.
- On the basis of composition, there are two types of systems.

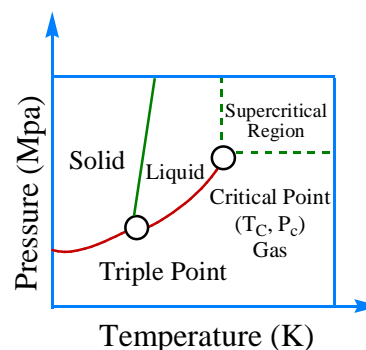
**1) Homogeneous system:** A system consisting of one phase.

**Eg:** Pure solid, a liquid or a mixture of gases.

**2) Heterogeneous system:** A system consisting of two or more phases.

**Eg:** a solid in contact with liquid state, solid in solid mixture

**Eg:** water at triple point consists three phases.



- On the basis of number of particles, there are two types of systems.

**1) Micro system:** Which consists less number of constituent particles.

**2) Macro system:** Which consists huge number of constituent particles.

- Any system in thermodynamics is macroscopic system.

- Thermodynamics deal with energy changes of macroscopic systems involving a large number of molecules rather than microscopic systems containing a few molecules. Thermodynamics is not concerned above how and at what rate these energy transformation are carried out, but is based on initial

and final states of a system undergoing the change. Laws of thermodynamics apply only when a system is in equilibrium or moves from one equilibrium state to another equilibrium state.

### Limitations of Thermodynamics

- These laws donot give any idea about the rates of the processes.
- It fails to explain the systems away from equilibrium.

### State of a system

- **Macroscopic properties** : These are the properties which are associated with the macroscopic system.

**Eg:** P, V, T, n, G, H, E etc

- The system is said to be in a certain state, when it's macroscopic properties have definite values. It is defined in terms of its state functions such as P, V, T etc.

- If any one of the state functions is changed, the state of that system is said to be changed.

**Eg:** at 1atm pressure H<sub>2</sub>O is

- solid below 0°C
- liquid between 0°C - 100°C and
- gas above 100°C.

### State functions or state variables

- The Thermodynamic properties whose values depend only upon the initial and final states of the system and are independent of the path are called state functions.

**Eg:** Internal energy (E), Enthalpy (H), Entropy (S), Gibb's energy (G), Pressure (P), Temperature (T), Volume (V), Helmholtz energy (A) reversible isothermal work done, chemical potential ( $\mu$ )

### Path Function:

- The property of a system that depends on the path of the process.

**Eg:** work, heat.

- Internal energy (E), enthalpy (H), entropy (S), Gibb's energy (G), Helmholtz energy (A) are the direct forms of energies of the system.
- Heat (Q) and work done are the indirect form of energies and appear at the boundary of the system.

### Thermodynamic Process:

- The operation which brings about the changes in the state of the system is termed as thermodynamic process.

### Isothermal Process :

- A process in which temperature of system does not change throughout the studies. For an isothermal process  $dT=0$  and  $dU=0$ . An isothermal process is achieved by using thermostatic control.

### Adiabatic Process:

- A process in which exchange of heat between system and surroundings does not take place. For an adiabatic process  $q = 0$ . It can be achieved by insulating the boundaries of system.

### Isobaric Process:

- A process in which pressure of the system remains constant throughout the studies. For an isobaric process ( $\Delta P = 0$ ).

### Isochoric Process:

- A process in which volume of the system remains constant throughout the studies. For an isochoric process  $\Delta V = 0$ .

### Cyclic Process:

- A process in which initial state of system is regained after a series of operations. For a cyclic process  $\Delta U = 0$  and  $\Delta H = 0, \dots$  etc.  $\Delta$  (State function) = 0,  $\Delta$  (path function)  $\neq 0$

### Thermodynamic Equilibrium :

- When a system exists simultaneously in a thermal equilibrium, mechanical equilibrium and chemical equilibrium, is said to be in thermodynamic equilibrium.

Equilibrium	Condition
Thermal Equilibrium	$\Delta T=0$ i.e constant temperature
Chemical Equilibrium	$\Delta C=0$ i.e constant concentration
Mechanical Equilibrium	$\Delta P=0, F=0, W=0$ i.e constant pressure

### Reversible Process:

- A reversible process (or quasistatic process) is one in which all changes occurring at any part of the process are exactly reversed when change is carried out in opposite direction. It gives rise to maximum work.
- Driving force is Infinitesimal greater than that of

opposing force.

→ In reversible expansion of gas in cylinder system,

$$P_{gas} = P_{external} + dP$$

→ In reversible compression of gas in cylinder system,

$$P_{gas} = P_{external} - dP$$

$dP$  = Infinitesimal change pressure

→ It is unreal process

→ Which is achieved by considering ideal gas is placed in cylinder fitted with weight less and frictionless piston.

### Irreversible Process:

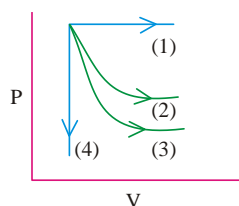
→ An irreversible process is one in which direction of the change cannot be reversed by small change in variables.

An irreversible process is a real one and all process which naturally occur are irreversible.

It involves

- A fast change during investigation
- Driving force is much higher than opposing force
- $|W_{rev.}| > |W_{irrev.}|$  (Expansion)
- $|W_{rev.}| > |W_{irrev.}|$  (Compression)

→ Graphical representation of thermodynamic processes



$$W_{Isobaric} > W_{Isothermal} > W_{Adiabatic} > W_{Isochoric}$$

- Isobaric process
- Isothermal process
- Adiabatic process
- Isochoric process

### Extensive Property

→ It is the property of a substance that depends on the quantity or size of matter present in the system.

**Eg:** Mass, volume of a gas, Internal energy, Enthalpy, entropy, heat capacity, Gibbs energy, heat content, no of moles etc.

### Intensive Property

→ It is the property of a substance that does not depend on the quantity or size of matter present in the system.

**Eg:** Density, molar properties (such as molar volume, molar entropy, molar heat capacity) surface

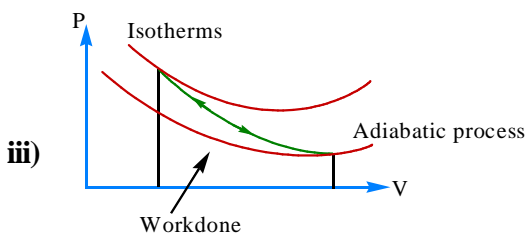
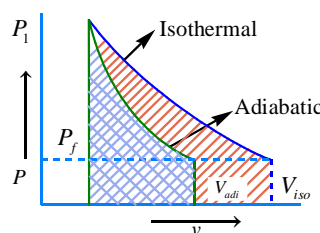
tension, viscosity, specific heat, refractive index, pressure, temperature, boiling point, freezing point, vapour pressure etc.,

→ Extensive property is additive property

→ Intensive property is non-additive property.

x=extensive property y=extensive property	x=extensive property y=intensive property	x=intensive property y=intensive property
$x + y = \text{Ext.} (\Delta E = Q + W)$	$x + y = \text{Ext.}$	$x + y = \text{Int.}$
$x - y = \text{Ext.} (Q = \Delta E - W)$	$x - y = \text{Ext.}$	$x - y = \text{Int.}$
$\frac{x}{y} = \text{Int.} \left( d = \frac{M}{V} \right)$	$\frac{x}{y} = \text{Ext.}$	$\frac{x}{y} = \text{Int.}$
$\frac{dx}{dy} = \text{Int.} \left( T \Delta S = \Delta H, T = \frac{\Delta H}{\Delta S} \right)$	$xy = \text{Ext.}$	$xy = \text{Int.}$
$x \cdot y = \text{Ext}$		

### Comparison of isothermal and adiabatic process till same final pressure



## THEORY BITS

### Introduction and Types Of Systems

#### 1. Thermodynamic laws speak about

- rates of chemical changes
- feasibility and energy transformations of a process
- Both the rate and energy changes of a process
- Energy changes in chemical reactions only

#### 2. The object under thermodynamical study is called

- System
- Universe
- Surrounding
- Boundary

#### 3. Which of the following are true about a

“system”

- 1) Will do not have definite amount of substance
- 2) Energy and matter may not be exchanged with surroundings
- 3) (Universe+surroundings)
- 4) (Universe-surroundings)

4. **Hot water in a thermos flask is an example for**

- 1) Isolated system
- 2) Open system
- 3) Closed system
- 4) Adiabatic system

5. **In open system, system and surroundings exchange**

- 1) Energy only
- 2) Matter only
- 3) Energy and matter
- 4) Neither energy nor matter

6. **In a closed system**

- 1) Energy is not exchanged
- 2) Matter is exchanged
- 3) Energy is only exchanged
- 4) Energy and matter are exchanged

7. **“Closed system” is**

- 1) Perfectly sealed
- 2) Perfectly insulated
- 3) Both 1 & 2
- 4) Neither insulated nor sealed

### State Functions and Path Functions:

8. **Which one of the following statement is false**

- 1) Work is a state function
- 2) Temperature is a state function
- 3) Change in the state is completely defined when the initial and final states are specified
- 4) Work appears at the boundary of the system

9. **Which of the following is a path function**

- 1) Internal energy
- 2) Enthalpy
- 3) Work
- 4) Entropy

10. **Which of the following statement is correct ?**

- 1) Only internal energy is a state function but not work
- 2) Only work is a state function but not internal energy
- 3) Both internal energy and work are state functions
- 4) Neither internal energy nor work is a state function

### Thermo Dynamical Processes

11. **A process in which no heat change takes place is called**

- 1) An isothermal process
- 2) An adiabatic process

3) An isobaric process

4) An isochoric process

12. **A gaseous system changes from state A( $P_1, V_1, T_1$ ) to B ( $P_2, V_2, T_2$ ), B to C ( $P_3, V_3, T_3$ ) and finally from C to A. The whole process may be called**

- 1) Cyclic process
- 2) Reversible process
- 3) Isobaric process
- 4) Spontaneous process

13. **For a cyclic process, the condition is**

- 1)  $\Delta U = 0$
- 2)  $\Delta H = 0$
- 3)  $\Delta U > 0$  and  $\Delta H > 0$
- 4) both  $\Delta U = 0$  and  $\Delta H = 0$

14. **An adiabatic expansion of an Ideal gas always has**

- 1) Constant in Temperature
- 2)  $q=0$
- 3)  $w=0$
- 4)  $\Delta H = 0$

**THEORY BITS KEY**

01) 2    02) 1    03) 4    04) 1    05) 3    06) 3  
07) 1    08) 1    09) 3    10) 1    11) 2    12) 1  
13) 4    14) 2

**MODULE-1**  
(CLASS WORK)

### Thermo Dynamical Processes:

1. **Which is an irreversible process ?**

- A) Mixing of two gases by diffusion
- B) Evaporation of water at 373K and 1atm pressure
- C) Dissolution of NaCl in water
- D) Burning of Coal

**The correct answer**

- 1) A,B
- 2) B,C
- 3) A,B,C
- 4) A,C,D

2.  **$\Delta U = 0$  for**

- 1) Cyclic process, Adiabatic process
- 2) Isothermal, Adiabatic process
- 3) Cyclic process, Isothermal process
- 4) Isochoric process, Isothermal process

### Internal Energy, Enthalpy and Work done :

3. **The work done when a gas is compressed by an average pressure of 0.50 atm so as to decrease its volume from 400 cm<sup>3</sup> to 200cm<sup>3</sup>**

- 1) 10.13 J
- 2) 20.13J
- 3) 30.13 J
- 4) 40.13 J

4. **Temperature of 1 mol of a gas is increased by 1° at constant pressure. Work done is :**

- 1) R      2) 2R      3) R/2      4) 3R
5. A certain electric motor produced 15 KJ of energy each second as numerical work and lost 2KJ as heat to the surroundings. What is the change in the internal energy of the motor and its power supply each second.  
 1) -17 KJ    2) -17 J    3) 27 KJ    4) 23 KJ
6. Two liters of N<sub>2</sub> at 0°C and 5atm are expanded exothermally against a constant external pressure of 1atm until the pressure of gas reaches 1atm. Assuming gas to be ideal. Calculate work of expansion  
 1) 400 J    2) -810 J    3) -810 KJ    4) 600 KJ
7. When work done by a system was 10J, the increase in the internal energy of the system was 30J. The heat 'q' supplied to the system was:  
 1) -40J    2) +20J    3) 40J    4) -20J
8. The work done when 6.5g of zinc reacts with dil HCl in an open beaker at 298 K is  
 1) -495.52 J                      2) 247.76 J  
 3) -247.76 J                      4) -123.88 J
9. The work done in heating one mole of an ideal gas at constant pressure from 15°C to 25°C is  
 1) 1.987 cal                      2) 198.7 cal  
 3) 9.935 cal                      4) 19.87 cal
10. A gas expands from 1.5 to 6.5 L against a constant pressure of 0.5 atm and during this process the gas also absorbs 100 J of heat. The change in the internal energy of the gas is  
 1) 153.3J                      2) 353.3J  
 3) -153.3J                      4) -353.3J
11. 10 g of argon gas is compressed isothermally and reversibly at a temperature of 27°C from 10 L to 5 L. Calculate q and ΔH for this process. Atomic wt. of Ar = 40.  
 1) + 103.99 cal, 0              2) + 39.99 cal, 3 J  
 3) - 39.99 cal, 3 J              4) -103.99 cal, 0

### First Law of Thermo dynamics :

12. A system absorbs 20 KJ of heat and also does 10KJ of work. The net internal energy of the system  
 1) Increases by 10 KJ    2) Decreases by 10 KJ  
 3) Increases by 30 KJ    4) Decreases by 30 KJ
13. If a gas absorbs 200 J of heat and expands by 500 cm<sup>3</sup> against a constant pressure of 2 x 10<sup>5</sup> Nm<sup>-2</sup>, then change in internal energy is

- 1) -300 J    2) -100 J    3) +100J      4) +300 J
14. In an insulated container 1 mole of a liquid. molar volume 100 ml at 1 bar. Liquid is steeply taken to 100 bar, when volume of liquid decreases by 1 ml. Find ΔH for the process.  
 1) 7900 bar ml                      2) 8900 bar ml  
 3) 9900 bar ml                      4) 10900 bar ml

### MODULE-1 KEY (CLASS WORK)

- 01) 4    02) 3    03) 1    04) 1    05) 1    06) 2  
 07) 3    08) 3    09) 4    10) 3    11) 1    12) 1  
 13) 3    14) 3

### MODULE-1 HINTS (CLASS WORK)

- All natural processes are thermodynamically irreversible.
- $\Delta U = 0$  for isothermal and cyclic processes
- $W = -P\Delta V$
- $PV = RT$  at TK  
 $P(V + \Delta V) = R(T + 1)$  at  $(T + 1)K$   
 $\therefore P\Delta V = R$
- $Q = \Delta U - W$
- $W = P(V_2 - V_1)$       7.  $Q = \Delta U - W$
- $Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$
- Rise of 10°C → 1.987 × 10 = 19.87 cal
- $Q = \Delta U - W$
- $W = -P(V_2 - V_1)$        $\Delta H = \Delta U + P\Delta V$
- $\Delta U = Q + W$
- $\Delta U = Q + W$        $\Delta U = Q + W$
- Volume of 1 mole liquid  
 = 100 ml at pressure one bar  
 = 99 ml at pressure 100 bar  
 $W = -P(V_2 - V_1)$        $\Delta H = \Delta U + P\Delta V$



MODULE-2  
(CLASS WORK)

Internal Energy, Enthalpy and Work Done, First Law

- The workdone in ergs for the reversible expansion of one mole of an ideal gas from a volume of 10 litres to 20 litres at 25°C is
  - $2.303 \times 298 \times 0.082 \log 2$
  - $-298 \times 10^7 \times 8.31 \times 2.303 \log 2$
  - $2.303 \times 298 \times 0.082 \log 0.5$
  - $-2.303 \times 298 \times 2 \log 2$
- An ideal gas expands from  $10^{-3} \text{m}^3$  to  $10^{-2} \text{m}^3$  at 300K against a constant pressure of  $10^5 \text{Nm}^{-2}$ . The workdone is
  - $-10^3 \text{ kJ}$
  - $10^2 \text{ kJ}$
  - $-0.9 \text{ kJ}$
  - $-900 \text{ kJ}$
- A system has internal energy equal to  $E_1$ , 450J of heat is taken out of it and 600J of work is done on it. The final energy of the system will be
  - $(E_1+150)$
  - $(E_1+1050)$
  - $(E_1-150)$
  - None of these
- If the internal energy of 22g  $\text{CO}_2$  at 273K is 'U', internal energy of which of the following is '4U' at same T ?
  - 5.5  $\text{CO}_2$
  - 88g  $\text{CO}_2$
  - 1 mol  $\text{CO}_2$
  - 33.6 lit  $\text{CO}_2$
- A system is provided with 50 Joules of heat and the work done on the system is 10 Joules. What is the change in internal energy of the system in Joules ?
  - 60
  - 40
  - 50
  - 10

Heat Capacity and Specific Heat

- The  $\gamma$  for inert gases is
  - 1.33
  - 1.66
  - 2.13
  - 1.99
- The molar heat capacity of water is
  - $4.184 \text{ JK}^{-1}$
  - $75.3 \text{ JK}^{-1}$
  - $185 \text{ JK}^{-1}$
  - $1 \text{ JK}^{-1}$

Measurement of  $\Delta H$  And  $\Delta E$

- For a reaction  $2A(s) + 2B(g) \rightarrow 2C(g) + D(g)$ . If heat of reaction at constant pressure is -28 K.cal. The heat of reaction at constant volume at 27°C is
  - 27.4 K.cal
  - 27.4 K.cal
  - 28.4 K.cal
  - 28 K.cal
- A sample of  $\text{CH}_4$  of 0.08g was subjected to

combustion at 27°C in a bomb calorimeter. The temperature of the calorimeter system was found to be raised by 0.25°C. If heat capacity of calorimeter is 18KJ,  $\Delta H$  for combustion of  $\text{CH}_4$  at 27°C is

- 900 KJ/mole
  - 905 KJ/mole
  - 895KJ/mole
  - 890KJ/mole
- 100ml of water at 20°C and 100ml of water at 40°C are mixed in calorimeter until constant temperature reached. Now temperature of the mixture is 28°C. Water equivalent of calorimeter is
    - 50J
    - 104.5 J
    - 24.2J
    - 209J
  - Heat of combustion of benzoic acid ( $\text{C}_6\text{H}_5\text{COOH}$ ) at constant volume at 25°C is -3233KJ/mole. When 0.5g of benzoic acid is burnt in bomb calorimeter, the temperature of calorimeter increased by 0.53°C. Now in the same bomb calorimeter 1g of  $\text{C}_2\text{H}_6$  burnt then temperature increased by 2.04°C.  $\Delta H$  for combustion of  $\text{C}_2\text{H}_6$  is
    - 1530KJ/mole
    - 1536.2 KJ/mole
    - 1522.8KJ/mole
    - +1536.2KJ/mole

Exothermic and Endothermic Reactions

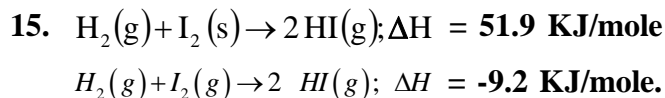
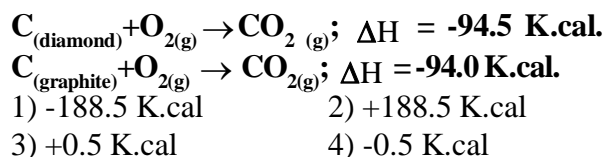
- Which of the following is an exothermic reaction?
  - $\text{N}_{2(g)} + \text{O}_{2(g)} + 180.8 \text{ kJ} \rightarrow 2\text{NO}_{(g)}$
  - $\text{N}_{2(g)} + 3\text{H}_{2(g)} - 92 \text{ kJ} \rightarrow 2\text{NH}_{3(g)}$
  - $\text{C}_{(\text{graphite})} + \text{H}_2\text{O}_{(g)} \rightarrow \text{CO}_{(g)} + \text{H}_{2(g)} - 131.3 \text{ kJ}$
  - $\text{C}_{(\text{graphite})} + 2\text{S}_{(s)} \rightarrow \text{CS}_{2(l)} - 91.9 \text{ kJ}$
- Which of the following is an exothermic reaction?
  - $\text{H}_{2(g)} + \text{Cl}_{2(g)} \rightarrow 2\text{HCl}_{(g)}; \Delta H = -184.6 \text{ KJ}$
  - $\text{N}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{NO}_{(g)}; \Delta H = +180.8 \text{ KJ}$
  - $\text{C}_{(\text{graphite})} + \text{H}_2\text{O}_{(g)} \rightarrow \text{CO}_2 + \text{H}_{2(g)} - 131.4 \text{ KJ}$
  - $\text{C}_{(\text{graphite})} + 2\text{S}_{(g)} + 91.9 \text{ KJ} \rightarrow \text{CS}_{2(l)}$

Enthalpy of Reaction

(Enthalpy of Phase Transitions)

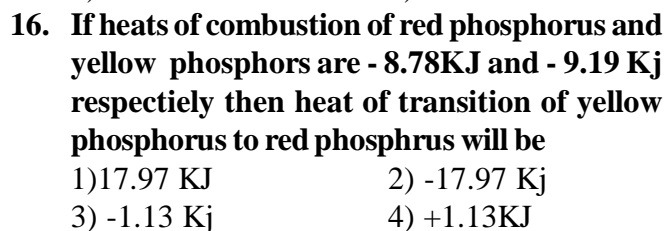
- The  $\Delta H$  for the conversion of  $\text{C}_{(\text{diamond})}$  to  $\text{C}_{(\text{graphite})}$  when the following reactions are given



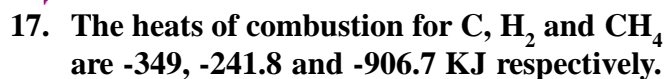


The heat of reaction of  $I_2(s) \rightarrow I_2(g)$

- 1) -61.1 KJ                              2) +61.1 KJ  
 3) +31.1 KJ                            4) 50.1 KJ

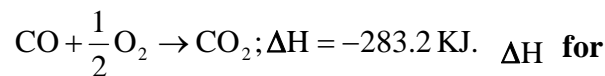
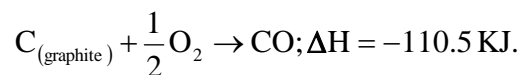


### Enthalpy of Formation



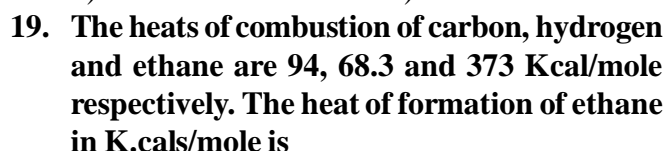
The heat of formation of CH<sub>4</sub> is

- 1) 174.1 KJ                              2) 274.1 KJ  
 3) 374.1 KJ                              4) 74.1 KJ

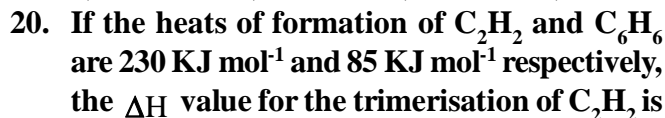


the reaction,  $C_{(\text{graphite})} + O_2 \rightarrow CO_2$  is

- 1) -393.7 KJ                              2) +393.7 KJ  
 3) -172.7 KJ                              4) +172.7 KJ



- 1) +19.9    2) -19.9    3) +39.8    4) -39.8



- 1) -605 KJ                              2) -205 KJ  
 3) 205 KJ                                4) 605 KJ

## MODULE-2 KEY (CLASS WORK)

- 01) 2    02) 3    03) 1    04) 2    05) 1    06) 2  
 07) 2    08) 1    09) 2    10) 4    11) 2    12) 2  
 13) 1    14) 4    15) 2    16) 3    17) 4    18) 1  
 19) 2    20) 1

## MODULE-2 HINTS (CLASS WORK)

- $W = -2.303nRT \log \frac{V_2}{V_1}$
- $W = P\Delta V$
- $\Delta U = -q + w$
- 22 gm  $\rightarrow U$   
 $x? \leftarrow 4U$
- $\Delta U = q + w$
- $\Delta H = \Delta U + \Delta nRT$
- $\Delta U = Z \times \theta \times \frac{M}{W}$   
 $\Delta H = \Delta U + \Delta nRT$
- $W = \left[ \frac{m_2(t_2 - t_3)}{t_3 - t_1} - m_1 \right]$
- $\Delta U = Z \times \theta \times \frac{M}{W}$                        $\Delta H = \Delta U + \Delta nRT$
- $\Delta H = H_{\text{Graphite}} - H_{\text{Diamond}}$
- $\Delta H = H_{I_2(g)} - H_{I_2(s)}$     16.  $\Delta H = H_{\text{Red P}} - H_{\text{Yellow P}}$
- $\Delta H = H_R - H_P$      $C + 2H_2 \rightarrow CH_4$
- $\Delta H = H_P - H_R$
- $2C + 3H_2 \rightarrow C_2H_6$                        $\Delta H = H_R - H_P$
- $3C_2H_2 \rightarrow C_6H_6$                                $\Delta H = H_P - H_R$



MODULE-3

Internal Energy, Enthalpy, Work Done And First Law Of Thermo Dynamics

- The enthalpy change involved in the oxidation of glucose is  $-2880 \text{ KJ mol}^{-1}$  25% of this energy is available for muscular work. If 100 KJ of muscular work is needed to walk one kilometer, what is the maximum distance that a person will be able to walk after consuming 120 gm of glucose?  
 1) 4.8 km    2) 9.6 km    3) 2.4 km    4) 7.2 km
- Three statements are given below  
 i) The enthalpy of any element is zero in their standard state  
 ii) The heat of neutralisation for any strong acid and strong base at  $25^\circ\text{C}$  is  $-13.7 \text{ kJ/mole}$   
 iii)  $Q = \Delta E + W$  is a mathematical form of first law of thermodynamics if work is done by the system according IUPAC  
 1) i only correct    2) ii and iii are correct  
 3) i and iii are correct    4) all are correct
- I:  $H_2O_{(s)}$     II:  $H_2O_{(l)}$     III:  $H_2O_{(g)}$   
 For the above compounds the correct of internal energy content is  
 1)  $I > II > III$     2)  $I = II = III$   
 3)  $I < II > III$     4)  $III > II > I$
- A gas contained a cylinder fitted with a friction less piston expands against a constant pressure 1atm from a volume of 4litre to volume of 14litre. In doing so, it absorbs 800J thermal energy from surrounding. then the  $\Delta E$  for the process is  
 1)  $-213.7 \text{ J}$     2)  $-112 \text{ J}$     3)  $-50 \text{ J}$     4)  $-25 \text{ J}$
- The amount of work done by 2mole of an ideal gas at 298K in reversible isothermal expansion from 10litre to 20litre is  
 1)  $-120 \text{ J}$     2)  $-2452 \text{ J}$     3)  $-3434.9 \text{ J}$     4)  $2200 \text{ J}$
- 5moles of an ideal gas at  $27^\circ\text{C}$  expands isothermally and reversibly from a volume of 6L to 60L. The work done in KJ is  
 1)  $-14.7$     2)  $-28.72$     3)  $+28.72$     4)  $-56.72$
- 1mole of a gas is heated at constant pressure to raise its temperature by  $1^\circ\text{C}$ . The work done in Joules is

- 1)  $-4.3$     2)  $-8.314$   
 3)  $-16.62$     4) Unpredictable
- 3.0 moles of ideal gas is heated at constant pressure from  $27^\circ\text{C}$  to  $127^\circ\text{C}$ . then the work expansion of gas is  
 1)  $-2.494 \text{ KJ}$     2)  $+2.494 \text{ KJ}$   
 3)  $-10.5 \text{ KJ}$     4)  $+10.5 \text{ KJ}$
- An ideal gas occupying a volume of  $2 \text{ dm}^3$  and a pressure of 5 bar undergoes isothermal and irreversible expansion against external pressure of 1 bar. The final volume of the system and the work involved in the process is  
 1)  $10 \text{ dm}^3, 1000 \text{ J}$     2)  $8 \text{ dm}^3, -800 \text{ J}$   
 3)  $10 \text{ dm}^3, -800 \text{ J}$     4)  $10 \text{ m}^3, -1000 \text{ J}$
- A position filled with 0.04 mol 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 208J of heat. The values of q and w for the process will be: ( $R=8.314 \text{ J/molK}$ ) ( $\ln 7.5=2.01$ ) (AIEEE-2013)  
 1)  $q = +208 \text{ J}, w = +208 \text{ J}$   
 2)  $q = +208 \text{ J}, w = -208 \text{ J}$   
 3)  $q = -208 \text{ J}, w = -208 \text{ J}$   
 4)  $q = -208 \text{ J}, w = +208 \text{ J}$
- 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  
 1) Violates 1<sup>st</sup> law of thermodynamics  
 2) Violates 1<sup>st</sup> law of thermodynamics if  $Q_1$  is -ve  
 3) Violates 1<sup>st</sup> law of thermodynamics if  $Q_2$  is -ve  
 4) Does not violate 1<sup>st</sup> law of thermodynamics
- $(\Delta H - \Delta U)$  for the formation of carbonmonoxide from its elements at 298K is  
 1)  $-2477.57 \text{ J mol}^{-1}$     2)  $2477.57 \text{ J mol}^{-1}$   
 3)  $-1238.78 \text{ J mol}^{-1}$     4)  $1238.78 \text{ J mol}^{-1}$
- The gas in a refrigerator causes cooling on expansion because:  
 1) Work done by the gas is converted into heat  
 2) Heat of the gas is lost as work is done by the gas  
 3) The heat is spread over a large space  
 4) None of the above
- Heat Capacity and Specific Heat
- 5moles of oxygen are heated at constant volume from  $10^\circ\text{C}$  to  $20^\circ\text{C}$ . the change in internal energy of a gas.

$$[C_p = 7.03 \text{ cal mol}^{-1} \text{ deg}^{-1} \text{ and } R = 8.31 \text{ J mol}^{-1} \text{ deg}^{-1}]$$

- 1) 125cal 2) 252cal 3) 50cal 4) 500cal

15. The molar heat capacity of water is  $75 \text{ JK}^{-1} \text{ mole}^{-1}$ . What is the amount of heat required to raise the temperature of 100g of water from 300K to 302.4 K ?

- 1) 10J 2) 1000 J 3) 375 J 4) 10 J

### MODULE-3 KEY

- 01) 1 02) 3 03) 4 04) 1 05) 3 06) 2  
 07) 2 08) 1 09) 3 10) 2 11) 4 12) 4  
 13) 2 14) 2 15) 2

### MODULE-3 HINTS

- $\frac{-2880}{180} \times \frac{25}{100} \times \frac{120}{100}$
- The heat of neutralization for any strong acid and strong base is  $-13.7 \text{ k Cal/mole}$  at  $25^\circ\text{C}$
- Gas > liquid > solid

4 to 6.  $W = -12.303nRT \log \frac{V_2}{V_1}$

8.  $W = -nR\Delta T$

7, 9.  $W = P\Delta V$  10.  $\Delta U = Q - W$

11. First law of thermodynamics

12.  $\Delta H = \Delta U + \Delta nRT$

13. Heat of the gas is lost as work is done by the gas

14.  $C_p - C_v = R$ ;  $q = C_v \Delta T$

Since  $W = 0$   $\Delta U = q + W$ ;  $\Delta U = q$

15.  $C_p = \frac{q}{\Delta T}$

### MODULE-4

- Thermodynamics is not concerned about
  - energy changes involved in a chemical reaction
  - the extent to which a chemical reaction proceeds
  - the rate at which a reaction proceeds
  - the feasibility of chemical reaction
- Which of the following statements is correct?

- The presence of reacting species in a covered beaker is an example of open system
- There is an exchange of energy as well as matter between the system and the surroundings in a closed system
- The presence of reactants in a closed vessel made up of copper is an example of closed system
- The presence of reactants in a thermos flask or any other closed insulated vessel is an example of a closed system

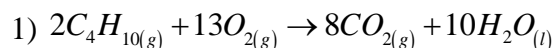
3. The state of gas can be described by quoting the relationship between

- pressure, volume, temperature
- temperature, amount, pressure
- amount, volume, temperature
- pressure, volume, temperature, amount

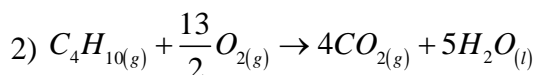
4. The volume of gas is reduced to half from its original volume. The specific heat will

- reduce to half
- be doubled
- remain constant
- increase four times

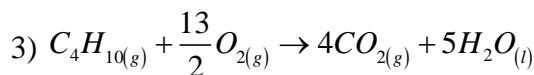
5. During complete combustion of one mole of butane, 2658KJ of heat is released. The thermochemical reaction for above change is



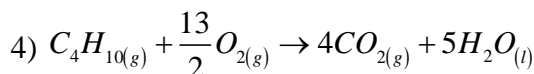
$$\Delta H_c = -2658.0 \text{ kJ mol}^{-1}$$



$$\Delta H_c = -1329.0 \text{ kJ mol}^{-1}$$



$$\Delta H_c = -2658.0 \text{ kJ mol}^{-1}$$



$$\Delta H_c = +2658.0 \text{ kJ mol}^{-1}$$

6.  $\Delta_f U^0$  of combustion of  $CH_{4(g)}$  at certain temperature is  $-393 \text{ kJ mol}^{-1}$ . The value of  $\Delta_f H^0$  is

- zero
- $< \Delta_f U^0$
- $> \Delta_f U^0$
- equal to  $\Delta_f U^0$

7. In an adiabatic process, no transfer of heat takes place between system and surroundings. Choose the correct option for free expansion of an ideal gas under adiabatic condition from the following.

- 1)  $q = 0, \Delta T \neq 0, w = 0$
- 2)  $q \neq 0, \Delta T = 0, w = 0$
- 3)  $q = 0, \Delta T = 0, w = 0$
- 4)  $q = 0, \Delta T < 0, w \neq 0$

8. The pressure-volume work for an ideal gas can be calculated by using the expression

$$w = - \int_{V_i}^{V_f} p_{ex} dV. \text{ The work can also be}$$

calculated from the PV plot by using the area under curve within the specified limits. When an ideal gas is compressed 1) reversibly or 2) irreversibly from  $V_1$  to  $V_2$ , choose the correct option

- 1)  $w$  (reversible) =  $w$  (irreversible)
- 2)  $w$  (reversible) <  $w$  (irreversible)
- 3)  $w$  (reversible) >  $w$  (irreversible)
- 4)  $w$  (reversible) =  $w$  (irreversible) +  $p_{ex} \Delta V$

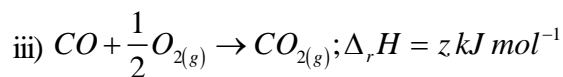
9. The entropy change can be calculated by using

the expression  $\Delta S = \frac{q_{rev}}{T}$  when water freezes in a glass beaker choose the correct statement among the following

- 1)  $\Delta S_{(system)}$  decreases but  $\Delta S_{(surroundings)}$  remains the same
- 2)  $\Delta S_{(system)}$  increases but  $\Delta S_{(surroundings)}$  decreases
- 3)  $\Delta S_{(system)}$  decreases but  $\Delta S_{(surroundings)}$  increases
- 4)  $\Delta S_{(system)}$  decreases but  $\Delta S_{(surroundings)}$  also decrease

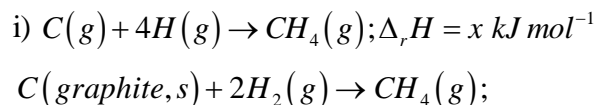
10. On the basis of thermochemical equation (i), (ii) and (iii), find out which of the algebraic relations given in options (1) to (4) is correct

- i)  $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}; \Delta_r H = x \text{ kJ mol}^{-1}$
- ii)  $C_{(graphite)} + \frac{1}{2} O_{2(g)} \rightarrow CO_{(g)}; \Delta_r H = y \text{ kJ mol}^{-1}$



- 1)  $z = x + y$
- 2)  $x = y = z$
- 3)  $x = y + z$
- 4)  $y = 2z - x$

11. Consider the reactions given below. On the basis of these reactions find out which of the algebraic relations given in options (1) to (4) is correct?



$$\text{ii) } \Delta_r H = y \text{ kJ mole}^{-1}$$

- 1)  $x = y$
- 2)  $x = 2y$
- 3)  $x > y$
- 4)  $x < y$

12. The enthalpies of elements in their standard states are taken as zero. The enthalpy of formation of a compound

- 1) is always negative
- 2) is always positive
- 3) may be positive or negative
- 4) is never negative

13. Enthalpy of sublimation of a substance is equal to

- 1) enthalpy of fusion + enthalpy of vapourisation
- 2) enthalpy of fusion
- 3) enthalpy of vapourisation
- 4) twice the enthalpy of vapourisation

14. Which of the following is not correct?

- 1)  $\Delta G$  is zero for a reversible reaction
- 2)  $\Delta G$  is positive for a spontaneous reaction
- 3)  $\Delta G$  is negative for a spontaneous reaction
- 4)  $\Delta G$  is positive for a non-spontaneous reaction

**MORE THAN ONE OPTION CORRECT**

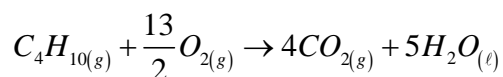
15. Thermodynamics mainly deals with

- 1) interrelation of various forms of energy and their transformation from one form to another
- 2) energy changes in the processes which depends only on initial and final states of the microscopic systems containing a few molecules
- 3) how and at what rate these energy transformations are carried out
- 4) the system in equilibrium state or moving from one equilibrium state to another equilibrium state

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

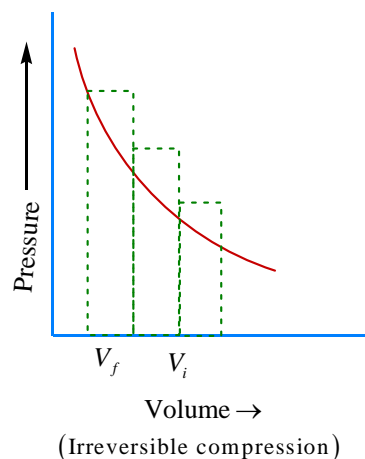
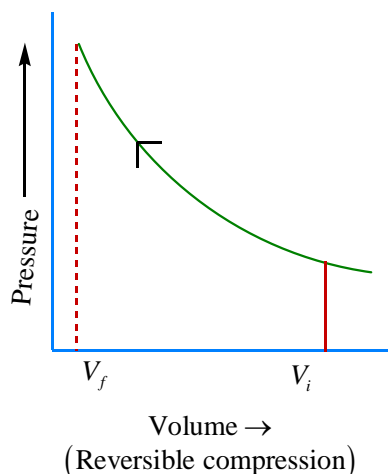
### MODULE-4 HINTS

1. Thermodynamics is not concerned with rate at which a reaction proceeds. The rate of reaction is dealt by kinetics
2. For a closed vessel made up of copper, no matter can be exchanged between the system and the surrounding but energy exchange can occur through its walls
3. State of a gas can be described by state function or state variables which are pressure, volume, temperature and amount of the gas (PV = nRT)
4. The specific heat of a substance is the heat required to raise the temperature of 1 gram of a substance by one degree (1K or 1°C). It is an intensive property and is independent of the volume of the substance
5. Exothermic reaction for combustion of one mole of butane is represented as:



$$\Delta H_c = -2658.0 \text{ kJ mol}^{-1}$$

6.  $\Delta_f H^0 = \Delta_f U^0 + \Delta n_g RT$
7. For free expansion  $w = 0$   
 For adiabatic process  $q = 0$   
 From first law of thermodynamics,  
 $\Delta U = q + w = 0$   
 Since there is no change of internal energy, hence temperature will also remain constant, i.e.,  $\Delta T = 0$
8.  $w$  (reversible) <  $w$  (irreversible)  
 Area under the curve is greater in irreversible compression than that of reversible compression



9. During the process of freezing energy is released, which is absorbed by the surroundings

$$\therefore \Delta S_{\text{system}} = \frac{-q_{\text{rev}}}{T}; \Delta S_{\text{surroundings}} = \frac{q_{\text{rev}}}{T}$$

Therefore the entropy of the system decreases and that of surroundings increases

11.  $x > y$  because same bonds are formed in reactions (i) and (ii) but bonds between reactant molecules are broken, only in reactions (ii). As energy is absorbed when bonds are broken energy released in reaction (i) is greater than that in reaction (ii)
12. Heat of formation of a compound may be positive or negative.
13. Since sublimation = fusion + Vapourisation
15. Thermodynamics deals with interrelation of various forms of energy and their transformation into each other. It also deals with thermal or mechanical equilibrium. However, it does not tell anything about the rate of reaction

### MODULE-1 (HOME WORK)

#### Thermo Dynamical Processes

1. **Boiling water in a closed steel tank is an example of**
  - 1) Closed system
  - 2) Insulated system
  - 3) Open system
  - 4) Adiabatic system
2. **Which parameter is not constant in an adiabatic process**
  - 1) Temperature
  - 2) Enthalpy
  - 3) Internal energy
  - 4) 1 and 3
3. **In isothermal process if heat is evolved from**

the system then

- 1) Internal energy remains constant
- 2) Change in internal energy is zero
- 3) Change in entropy is zero
- 4) Change in free energy is zero

### Internal Energy, Enthalpy and Work done & 1<sup>st</sup> Law:

4. One mole of an ideal gas is allowed to expand reversibly and adiabatically from temperature of  $27^{\circ}\text{C}$ . If the work done during the process is 3KJ, the final temperature will be equal to ( $C_v = 20\text{JK}^{-1}$ )

- 1) 100K    2) 150K    3) 295    4)  $26.85^{\circ}\text{C}$

5. Work done on a system when one mole of an ideal gas at 500 K is compressed isothermally and reversibly to 1/10th of its original volume. ( $R = 2\text{cal}$ )

- 1) 1 Kcal                                    2) 2.303 Kcal  
3) 4.606 Kcal                                4) 2.303 cal

6. 2.8g of  $\text{N}_2$  gas at 300 K and 20 atm was allowed to expand isothermally against a constant external pressure of 1 atm. Calculate W for the gas.

- 1) + 236.95 J                                2) + 136.95 J  
3) - 236.95 J                                4) + 136.95 J

7. When a sample of gas expands from 4.0L to 12.0 L against a constant pressure of 0.30 atm, the work involved is

- 1) 243.19 J                                    2) -243.19 J  
3) 234.19 J                                    4) -234.19 J

8. 5 mol of gas at 5 atmospheric pressure contained in a 100 L cylinder absorbed 30.26 KJ of heat when it expanded to 200 L at 2 atmospheric pressure. The change in the internal energy of gas is

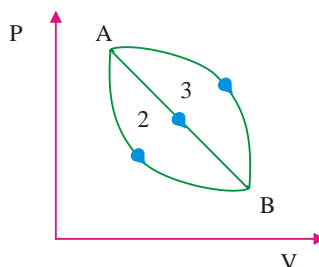
- 1) +20.26J                                    2) +20.26Kj  
3) -20.26 KJ                                4) 10Kj

9. Frictionless and weightless piston was fitted into a cylinder containing a gas This gas was allowed to expand from one litre to 5 litre against a constant pressure of one atmosphere in doing so, 200 J of heat was absorbed from the surrounding. The change in the internal energy of the system is:

- 1) +205.2 J                                    2) +205.2 KJ

- 3) -205.2 J                                    4) -405.2J

10. A given mass of gas expands from the state A to the state b by three paths 1, 2 and 3 as shown in the figure. If  $w_1, w_2$  and  $w_3$  respectively be the work done by the gas along three paths then.



- 1)  $w_1 > w_2 > w_3$                         2)  $w_1 < w_2 < w_3$   
3)  $w_1 = w_2 = w_3$                         4)  $w_2 < w_3 < w_1$

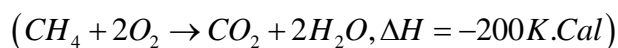
### First Law of Thermodynamics

11. One mole of liquid water at its boiling point vaporises against a constant external pressure of 1 atm. at the same temperature. Assuming ideal behaviour and initial volume of water vapours are zero, the work done by the system nearly

- 1) -3102 J    2) +3102 J    3) -4268 J    4) + 4268 J

### Heat Capacity and Specific Heat

12. Heat capacity of water is  $18\text{ cal-degree}^{-1}\text{-mol}^{-1}$ . The quantity of heat needed to rise temperature of 18g water by  $0.2^{\circ}\text{C}$  is X cal. Then amount of  $\text{CH}_4(\text{g})$  to be burnt to produce X cal heat is



- 1)  $1.8 \times 10^{-3}\text{ mol}$                         2)  $3.6 \times 10^{-5}\text{ mol}$   
3) 0.0288 g                                    4) 0.288 mg

13. Heat capacity ( $C_v$ ) of an ideal gas is X KJ/mole/K. To rise its temperature from 298K to 318K, heat to be supplied per 10g gas will be (in KJ) [MW=16]

- 1) 16X    2) 6.25X    3) 32X    4) 12.5X

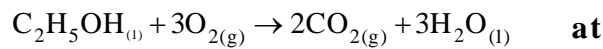
### Mesurement Of $\Delta H$ And $\Delta E$

14. The relationship between  $\Delta H$  and  $\Delta E$  for the reaction  $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{PCl}_5(\text{g})$  is given as

- 1)  $\Delta H = \Delta E + RT$                         2)  $\Delta H = \Delta E - RT$

3)  $\Delta H = \Delta E - 2RT$       4)  $\Delta H = \Delta E + 2RT$

15. If  $\Delta E$  is the heat of reaction for



constant volume, the  $\Delta H$  (Heat of reaction at constant pressure) at constant temperature is

1)  $\Delta H = \Delta E + 2RT$     2)  $\Delta H = \Delta E - 2RT$

3)  $\Delta H = \Delta E + RT$     4)  $\Delta H = \Delta E - RT$

**MODULE-1 KEY**  
(HOME WORK)

- 01) 1    02) 4    03) 12    04) 2    05) 2    06) 3  
 07) 2    08) 4    09) 3    10) 2    11) 1    12) 4  
 13) 4    14) 2    15) 4

**MODULE-1 HINTS**  
(HOME WORK)

- Closed vessel
- In adiabatic process work is done at the cost of internal energy
- $U = f(T)$  for ideal gas
- $C_v = \frac{q}{\Delta T}$  For adiabatic Process  $q=0$ ,  
 $\Delta E = W$  ;  
 $\Delta U = W = nC_v \Delta T$   
 $-3000J = 1 \times 20J \cdot \Delta T$   
 $T_2 = 150 K$
- $W = 2.303nRT \log \frac{V_2}{V_1}$
- $W_{irr} = -P_{ex}(V_2 - V_1)$   
 $= -P_{ex} \left( \frac{nRT}{P_2} - \frac{nRT}{P_1} \right)$   
 $= -P_{ex} nRT \left( \frac{1}{P_2} - \frac{1}{P_1} \right)$
- $W = -P\Delta V$
- $\Delta U = q + W$
- $\Delta U = q + W$
- More the area under the curve, more is the work done

11.  $W = -P_{ex}(V_2 - V_1) = -P_{ex} \left( \frac{nRT}{P_2} - 0 \right)$

12.  $\Delta U = Zx\theta x \frac{M}{W}$  ;  $\Delta H = \Delta U + \Delta nRT$  ;  $Q = mst$

13.  $q_v = nC_v \Delta T = \frac{10}{16} \times x \times 20 = 12.5x$

14.  $\Delta n = 1 - 2 = -1$

15.  $\Delta n = 2 - 3 = -1$

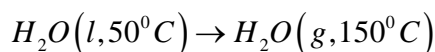
**MODULE-2**  
(HOME WORK)

Internal Energy, Enthalpy and Work Done, First Law

- A gas is allowed to expand reversibly under adiabatic conditions. What is zero for such a process ?  
 1)  $\Delta G$     2)  $\Delta T$     3)  $\Delta S$     4) None of these

Heat Capacity and Specific Heat

- One mole of an ideal diatomic gas absorbs 1831.4J of heat and does 1000J of work at 27°C. What is the change in temperature observed ?  
 1) 25°C    2) 40°C    3) 37°C    4) 67°C
- Calculate the change in enthalpy for the following process at 1 atm



given that  $\Delta H_v$  at 100°C is 40.7 kJ mol<sup>-1</sup>

$C_p(H_2O, l) = 75.0 Jmol^{-1}K^{-1}$

$C_p(H_2O, g) = 33.3 Jmol^{-1}K^{-1}$

- 1) 64.8 kJ                      2) 52.4 kJ  
 3) 48.6 kJ                      4) 46.1 kJ

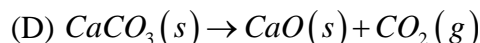
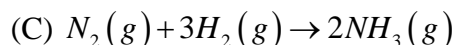
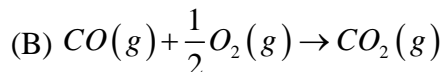
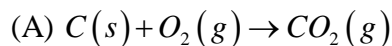
Measurement of  $\Delta H$  and  $\Delta E$

- 16 g of O<sub>2</sub> at 28°C is compressed to half of its initial volume under reversible isothermal conditions. If this gas behaves ideally, the workdone and change in internal energy in this process are  
 1)  $\Delta U = 0$  and  $w = -1247.1 \ln 2 J$   
 2)  $\Delta U = 0$  and  $w = +1247.1 \ln 2 J$

3)  $w = \Delta U = +1247.1 \ln 2J$

4)  $\Delta U = -1247.1 \ln 2J$  and  
 $w = +1247.1 \ln 2J$

5. In the following process/es  $\Delta H < \Delta U$



The correct answer is

- 1) A,B      2) B,C,D      3) A,B,C      4) B,C

### Exothermic and Endothermic Reactions

6. Which of the following will involve evolution of heat ?

- 1) Dissolution of conc.  $H_2SO_4$  in water
- 2) Formation of NO in atmosphere
- 3) Conversion of molecular hydrogen to atomic hydrogen
- 4) Formation of water gas from coal and steam

### Enthalpy of Reaction

(Enthalpy of Phase Transitions)

7. The sublimation energy of  $I_2$  (solid) is 57.3 KJ/mole and enthalpy of fusion is 15.5 KJ/mole.

The enthalpy of vapourisation of  $I_2$  is

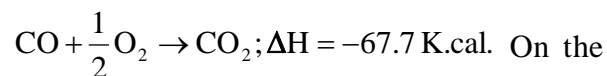
- 1) 48.1 KJ/mole      2) -48.1 KJ/mole
- 3) 72.8 KJ/mole      4) -72.8 KJ/mole

### Enthalpy of Formation

8. Given the enthalpy of formation of  $CO_2(g)$  is -94.0 KJ, of  $CaO(s)$  is -152 KJ, and the enthalpy of the reaction  $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$  is 42 KJ, the enthalpy of formation of  $CaCO_3(s)$  is

- 1) -268 KJ      2) +202 KJ
- 3) -202 KJ      4) -288 KJ

9.  $C + O_2 \rightarrow CO_2; \Delta H = -94 \text{ K.cal};$



basis of the above data, the heat of formation of 'CO' is

- 1) -26.3 K.cals      2) +26.3 K.cals
- 3) +52.6 K.cals      4) +13.2 K.cals

### Hess Law

10. What is the heat of formation of  $C_6H_6$ , given that the heats of combustion of Benzene, carbon and Hydrogen are 782, 94 and 68 K.Cal respectively

- 1) +14 K.Cal      2) -14 K.Cal
- 3) +28 K.Cal      4) -28 K.Cal

11. How much energy is released when 6 mole of octane is burnt in ? Given that the heat of formation of  $CO_2$ ,  $H_2O$  and  $C_8H_{18}$  respectively are -390, -240, and +160 KJ/mole.

- 1) -32.6 MJ      2) -37.4 MJ
- 3) -35.5 MJ      4) -20.0 MJ

### Enthalpy of Combustion

12. The heat of combustion of methane is -880 KJ  $mol^{-1}$ . The quantity of heat liberated in the combustion of 3.2 g methane is

- 1) -88 KJ      2) +88 KJ
- 3) +176 KJ      4) -176 KJ

13. When 6 g carbon is burnt in a sufficient amount of oxygen, the heat evolved is x KJ. The heat of combustion of carbon is

- 1) -x KJ      2) -2x KJ
- 3) -4x KJ      4) -8x KJ

14. The heats of combustion of  $C_2H_4$ ,  $C_2H_6$  and  $H_2$  gases are -1409.5 KJ, -1558.3 KJ and -285.6 KJ respectively. The heat of hydrogenation of ethene is

- 1) -136.8 KJ      2) -13.68 KJ
- 3) 273.6 KJ      4) 1.368 KJ



- 1) 3    2) 2    3) 4    4) 2    5) 4    16) 1
- 7) 1    8) 4    9) 1    10) 1    11) 1    12) 3
- 13) 2    14) 1

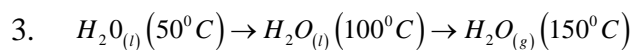


1.  $q = 0 \quad \Delta S = \frac{q}{T} = 0$

2.  $q_v = C_v \Delta T$

$$\Delta T = \frac{q_v}{C_v} = \frac{831.4J}{\frac{5}{2}R}$$





Total heat absorbed

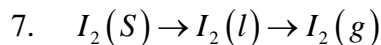
$$= \Delta_{temp.rise} H (50 \rightarrow 100)$$

$$+ \Delta_{vap} H + \Delta_{temp.rise} H_{(100 \rightarrow 150)}$$

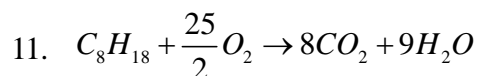
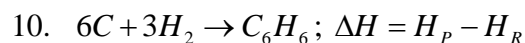
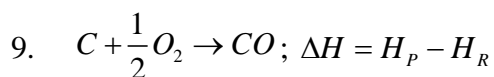
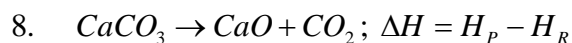
$$= C_p \Delta T + \Delta_{vap} H + C_p \Delta T$$

4.  $\Delta U = Q + W$                       5.  $\Delta H = \Delta U + \Delta nRT$

6. Dissolution of sulphuric acid in water is exothermic



$$\Delta H_{SE} = \Delta H_{Fusion} + \Delta H_{Eva}$$



$$\Delta H = H_p - H_R$$

