

**QUESTION BANK**

**CLASS: III- B.Sc., CHEMISTRY, SEMESTER-V**

**SUBJECT: EQUILIBRIUM THERMODYNAMICS OF GASEOUS SYSTEMS**

**SUBJECT CODE: CH511S**

**UNIT-1**

**1 MARK QUESTIONS**

1. Which type of system can exchange both energy and matter with surrounding?

Ans Open System

2. When work is done by the system, the thermodynamic notation is

Ans  $-w$

3. Which is true for an isothermal process?

a)  $q = 0$  b)  $q < 0$  c)  $T > 0$  d)  $q = T$

4. For an Adiabatic process

Ans  $q = 0$

5. Which type of system can neither exchange energy nor matter with surrounding?

Ans Isolated system

6. The work arises due to absorption of heat from surrounding by the system is

Ans PDV

7. When a compound is formed from its elements, the heat associated

is called enthalpy of

a) Reaction b) Combustion

c) Formation d) Dissociation

8. A thermos flask is an example for which type of system?

Ans Isolated System

9. Which of the following process holds goods for adiabatic process?

Ans  $dq=0$

10. In exothermic process, the internal energy of the product is \_\_\_\_\_ then that of reactants.

a)  $q>0$  b)  $q<0$  c)  $q = 0$  d)  $q = w$

11. Both matter and energy cannot be exchanged in \_\_\_\_\_ system.

Ans Isothermal

12. for an adiabatic process?  $q= 0$

13.  $E=Q+W$  - I law of thermodynamics

14. Which out of the following is incorrect, for an ideal gas?

a)  $PV=nRT$  b)  $V=nRT/P$  c)  $P=nRT/V$  d) All are correct

15. Which type of system can exchange energy but not exchange matter with surrounding?

Ans closed System

16. for isobaric process

Ans  $dp=0$

17. When work is done on the system, the thermodynamic notation is

Ans  $+w$

18. First law of thermodynamics is

Ans  $\Delta U=E-W$

19. What are all the state function?

Ans  $p, V, T, U, H$

20. The system absorbed heat the symbol is

Ans  $+q$  the system is endothermic

21. The system emitted heat the symbol is

Ans  $-q$  the system is exothermic

22. For 1 law of thermodynamics workdone is

Ans  $W=PdV$

23. At constant volume  $\Delta H =$

Ans  $\Delta E$

24. For adiabatic process  $\Delta E =$

Ans  $\Delta E=-W$

25. A property which does not depend on the quality or size of matter present in the system is-----  
-----

Ans intensive property

26. A property which depend on the quality or size of matter present in the system is-----

Ans Extensive property

27. Condition for adiabatic process is-----

28. Condition for cyclic process is -----

29. The difference between  $C_p$  and  $C_v$  equal to-----

30. One litre atmosphere is approximately equal to -----

31. Potential and kinetic energy totally called as -----

32.  $q$  is state function (or) path function?

33. For monoatomic gases the ratio  $C_p/C_v$  is -----

34.  $\Delta H=\Delta E+$ -----

35. Human body is an example of -----

36. The process for which  $\Delta T$  as well as  $\Delta E=0$  is called-----

37. The property which depends on quantity on matter is -----

38. Intensive property ----- on quantity on matter.

39. For a gas expanding in vacuum the value of  $w$  is -----

40. First law of thermodynamics equation -----

41. Work is state function (or) path function

### 2& 3 Marks

1. 'H' is a state function, but 'q' is not a state function. Why?
2. 5 moles of an ideal gas expand isothermally and reversibly from a pressure of 10 atm to 2 atm at 300K. Calculate the work done in this case.
3. Calculate the enthalpy change for the transition of rhombic sulphur into monoclinic sulphur,  $\Delta H^\circ_{\text{comb}}$  values of -393.5 and -395.4 kJmol<sup>-1</sup> for rhombic and monoclinic respectively
4. What is meant by homogeneous system?
5. Calculate the internal energy changes for a chemical change, if the heat of change is 38.5 kJ and work done is 2800 J.mol<sup>-1</sup>.
6. Define internal energy and enthalpy.
7. The heat of combustion of ethane is -337 kJ, what is the heat of reaction when 3 g of ethane burnt completely?
8. What is meant by heterogeneous system?
9. Calculate the work done in 10g of iron reacts with HCl in a closed Vessel of a fixed volume.
10. Calculate the internal energy changes for a chemical change, if the heat of change is 40670 J and work done is 3100 J.mol<sup>-1</sup>.
11. A chemical reaction takes place in a container of cross-sectional area 50.0 cm<sup>2</sup>. As a result of the reaction, a piston is pushed out through 15 cm against an external pressure of 121 kPa. Calculate the work done by the system.
12. Define molar heat capacity?
13. What is system and surroundings?

14. What is homogeneous and heterogeneous system?
15. What are adiabatic system?
16. What is state function and path function?
17. Write the difference between reversible and irreversible reaction.
18. Define heat and work.
19. Write first law of thermodynamics.
20. Define internal energy.
21. Define enthalpy and how it related to internal energy?
22. What is heat capacity at constant pressure?
23. What is heat capacity at constant volume?
24. Distinguish between isothermal and adiabatic process.
25. Under what condition  $\Delta E = \Delta H$  for chemical reaction.
26. Distinguish between intensive and extensive property.
27. Derive pressure volume work relation.
28. What are the limitations of first law of thermodynamics?
29. A system does 394J of work and at the same time absorbs 701J of heat .what is the change in internal energy.

### **FIVE MARK QUESTIONS**

1. Derive the relationship connecting the pressure and volume of one mole of an ideal gas undergoing reversible adiabatic expansion.
2. Derive the relationship  $\Delta H = \Delta E + \Delta nRt$ .
3. Explain what is meant by closed, open, and isolated system.
4. Derive the relation  $C_p - C_v = R$ .
5. Derive isothermal reversible expansion of an ideal gas.
6. Derive work done in adiabatic reversible expansion.

7. Explain the following

Isothermal, isobaric, isochoric, cyclic, adiabatic, reversible and irreversible processes.

8. Calculate the number of KJ necessary to raise the temperature of 60 g of aluminium from 35-55°C. Molar heat capacity of aluminium is  $24 \text{ J mol}^{-1} \text{ K}^{-1}$ .

9. Assuming ideal behavior calculate the work done when 1.6 mole of water evaporate at 373K against the atmospheric pressure of 1 atm.

10. One mole of an ideal gas expands isothermally and reversibly from 1 litre to 100 litre at 27°C calculate  $W, q, \Delta E, \Delta H$ .

## UNIT-II

1. The sign of  $\Delta H$  and  $\Delta E$  for combustion reaction-----

2. The value of  $\Delta H$  for the process  $2F$  gives  $F_2$  be-----

3. For a substance  $\Delta H_{\text{fusion}} + \Delta H_{\text{vap.}} =$ -----

4. The enthalpy of all the elements in their standard state is -----

5.  $\Delta U$  of combustion reaction of methane is  $-X \text{ KJ mol}^{-1}$  the value of  $\Delta H$  is-----

6. The enthalpy of neutralisation of HCl and NaOH is -----

7. In an endothermic reaction the value of  $\Delta H$  is always -----

8. The enthalpy of fusion of ice is -----

9.  $\Delta H_{\text{vap.}}$  of a substance is always -----

10.  $\Delta H$  for every reaction can be measured by bomb calorimeter TRUE/FALSE.

## 2 & 3 MARKS

1. What is thermochemical equation with example?

2. What is exothermic and endothermic reaction?

3. What is heat of formation?

4. What is standard heat of formation?

5. What is heat of fusion?

6. What is heat of sublimation?
7. What is heat of neutralization?
8. What is heat of vapourisation?
9. What is heat of transition?
10. What is bond energy and how it is calculated?

### **FIVE MARK QUESTIONS**

1. Derive kirchoffs equation.
2. Write the application of Hess's law.
3. How to measure the heat of reaction by bomb calorimeter.
4. Heat of combustion of benzoic acid at constant pressure is  $-771400$  calorie at  $25^{\circ}\text{C}$ . Calculate the heat of combustion at constant volume.
5. Calculate the heat of formation of acetic acid if its heat of combustion is  $-869$  KJ. Heat of formation of  $\text{CO}_2$  (g)  $\text{H}_2\text{O}$  (l) are  $-390$  and  $-285$  KJ respectively.
6. a) How heat energy is measured?  
b) Define system. How are they classified?  
c) Find out the internal energy changes for a chemical change, if the heat of change is  $38500$  J and work done is  $2800$  J.mol<sup>-1</sup>.
7. a) Define system and surrounding.  
b) Establish the relationship between  $q_p$  and  $q_v$  in the haber's process assuming that gaseous reactants and products are ideal.  
c) Is 'q' is a state function?
8. a) Define internal energy and enthalpy.  
b) Define system and surrounding.  
c) Is 'G' is a state function?
9. a) Calculate the workdone in  $50\text{g}$  of iron reacts with HCl in an open beaker at  $25^{\circ}\text{C}$ .

- b) What is adiabatic process and closed system?
10. Isothermal reversible expansion work on an ideal gas.
11. Isothermal irreversible expansion work on an ideal gas.
12. Define enthalpy of a system? Relationship of  $\Delta H$  and  $\Delta E$
13. What is the Sign conversion of work?
14. What is the Sign conversion of heat?

### UNIT-3

#### 1 MARK:

- 1) The series of change in a cycle are conducted at constant temperature is called \_\_\_\_\_ ( **Isothermal cycle** )
- 2) The equation for the first law of thermodynamics \_\_\_\_\_ (  $\Delta u = q + w$  )
- 3) Entropy is denoted by the symbol as \_\_\_\_\_ ( **S** )
- 4) Unit of entropy = \_\_\_\_\_ (  $\text{JK}^{-1}$  ) or ( **Joules per degree Kelvin** )
- 5) The Boltzmann entropy equation = \_\_\_\_\_ ( **S = K ln W** )
- 6) ----- is a thermodynamic state quantity that is a measure of the randomness or disorder of the molecules of the system. ( Entropy )
- 7) A process accompanied by an increase in entropy tends to be ----- ( spontaneous )
- 8) In the SI system, the units are ----- (  $\text{J mol}^{-1} \text{K}^{-1}$  ).
- 9) Entropy is a measure of \_\_\_\_\_ of the molecules of the system. (a) concentration (b) velocity (c) zig-zag motion (d) randomness or disorder Answer. (d)
- 10) The second law of thermodynamics states that (a) whenever a spontaneous process occurs, it is accompanied by an increase in the total energy of the universe (b) the entropy of the system is constantly increasing (c) neither of the above (d) both (a) and (b) Answer. (d)
- 11) The entropy is measured in (a)  $\text{cal K}^{-1} \text{mol}^{-1}$  (b)  $\text{JK}^{-1} \text{mol}^{-1}$  (c) entropy unit (d) all of these Answer. (d)
- 12) The standard entropy,  $S^\circ$ , of a substance is (a) its entropy at  $0^\circ\text{C}$  and 1 atm pressure (b) its entropy at 0 K and 1 atm pressure (c) its entropy at  $25^\circ\text{C}$  and 1 atm pressure (d) its entropy at 25 K and 1 atm pressure Answer. (c)
- 13) The change in entropy of a reaction is given by (a)  $\Delta S = \sum S_{\text{Reactants}} + \sum S_{\text{Products}}$  (b)  $\Delta S = \sum S_{\text{Products}} - \sum S_{\text{Reactants}}$  (c)  $\Delta S = \sum S_{\text{Reactants}} - \sum S_{\text{Products}}$  (d) none of these Answer. (b)
- 14) Which of the following is true for a cyclic process? (a)  $\Delta E = 0$  (b)  $\Delta E = q - w$  (c)  $q = w$  (d) all of these Answer. (d)



- 15) A machine that can do work by using heat which flows out spontaneously from a high-temperature source to a low-temperature sink is called (a) Carnot machine (b) cyclic machine (c) heat machine (d) heat engine Answer. (d)
- 16) The efficiency of a heat engine is the ratio of (a) work obtained in a cyclic process (w) to the heat taken from the high temperature reservoir (q) (b) heat taken from the high temperature reservoir (q) to the work obtained in a cyclic process (c) work obtained in a cyclic process (w) to the heat taken from the low temperature sink (q) (d) none of the above Answer. (a)
- 17) The cycle of processes which occurs under reversible conditions is referred to as (a) cyclic process (b) closed process, c) Carnot cycle (d) reversible cycle Answer. (c)
- 18) The second law of thermodynamics may be stated as (a) it is impossible to take heat from a hotter reservoir and convert it completely into work by a cyclic process without transferring a part of heat to a cooler reservoir. (b) it is impossible to transfer heat from a body at a lower temperature to one at higher temperature (c) the efficiency of heat engine is always less than 1 (d) all of the above Answer. (d)
- 19) The efficiency of a heat operating between 400 K and 300 K is (a) 1.0 (b) 0.75 (c) 0.50 (d) 0.25 Answer. (d)
- 20) The efficiency of heat engine operating between 1000 K and 300 K is \_\_\_\_\_ the engine operating between 1000 K and 500 K. (a) greater than (b) lesser than (c) is equal to (d) none of these Answer. (a)
- 21) The entropy of the system increases in the order (a) gas < liquid < solid (b) solid < liquid < gas (c) gas < solid < liquid (d) none of these Answer. (b)
- 22) The efficiency of an irreversible Carnot cycle is always \_\_\_\_\_ that of a reversible one operating between the same two temperatures (a) less than (b) greater than (c) equal to (d) none of these. Answer a)

### 2&3 MARKS

- 1) Define Carnot cycle.
- 2) Define heat efficiency with formula.
- 3) State Kelvin's second law of thermodynamics.
- 4) Define Entropy.
- 5) Derive the unit of Entropy.
- 6) Define Boltzmann entropy equation
- 7) An engine operating between 150°C and 25°C takes 500 J heat from a high temperature reservoir. Assuming that there are no frictional losses, calculate the work that can be done by this engine.
8. Calculate the entropy change in the evaporation of 1 mole of water at 100°C. Latent heat of evaporation of water is 9,650 cal per mole

9. Calculate the increase in entropy when one gram molecular weight of ice at  $0^{\circ}\text{C}$  melts to form water. Latent heat of fusion of ice = 80 calories.
10. Calculate the entropy change when 1 mole of ethanol is evaporated at 351 K. The molar heat of vaporisation of ethanol is  $39.84 \text{ kJ mol}^{-1}$ .
11.  $30.4 \text{ kJ}$  is required to melt one mole of sodium chloride. The entropy change during melting is  $28.4 \text{ J mol}^{-1} \text{ K}^{-1}$ . Calculate the melting point of sodium chloride.
12. Calculate the entropy of vapourization of water at  $100^{\circ}\text{C}$ .

**5 MARK:**

- 1) Explain with neat diagram for the four strokes of Carnot cycle?
  - 2) Define Carnot theorem with an example?
  - 3) State and explain the entropy to measure randomness and probability.
  - 4) The boiling point of water at a pressure of 50 atmosphere is  $265^{\circ}\text{C}$ . Compare the theoretical efficiencies of a steam engine operating between the boiling point of water at (i) 1 atmosphere (ii) 50 atmosphere, assuming the temperature of the sink to be  $35^{\circ}\text{C}$  in each case.
5. Define or explain the following terms : (a) Entropy (b) Second law of thermodynamics (c) Carnot cycle
6. Derive the concept of entropy from the Second law of Thermodynamics. Show that entropy is a state function
7. Explain the variation of entropy with temperature.
8. Explain entropy of fusion and entropy of vapourization.

**UNIT IV**

**ONE MARK QUESTIONS**

1. The free energy function (G) is defined as (a)  $G = H + T S$  (b)  $G = H - T S$  (c)  $G = T S - H$  (d) none of these Answer. (b)
2. The change in free energy is a measure of : (a) net work done (b) net change in entropy (c) net change in enthalpy (d) net change in internal energy Answer. (a)
3. The change in free energy of a system is given by (a)  $\Delta G = \Delta A + P \Delta V$  (b)  $\Delta G = \Delta H - T \Delta S$  (c)  $\Delta G = \Delta E + P \Delta V - T \Delta S$  (d) all of these Answer. (d)
4. Which out of the following is not a state function? (a) free energy (b) work function (c) entropy (d) work done Answer. (d)

5. The variation of free energy with temperatures at constant pressure is given by the relation -----.
6. The change in free energy in an isothermal process for n moles of the gas is given by-----  
-----
7. The Gibb's Helmholtz equation is applicable to (a) all processes, chemical or physical (b) all process, chemical or physical but in a closed system (c) all chemical processes in a closed system (d) all physical processes in a closed system Answer. (b)
8. For a spontaneous process (a)  $\Delta G > 0$  (b)  $\Delta G < 0$  (c)  $\Delta G = 0$  (d) none of these Answer. (b)
9. A process is in the equilibrium state when (a)  $\Delta G > 0$  (b)  $\Delta G < 0$  (c)  $\Delta G = 0$  (d) none of these Answer. (c)
10. Which of the following equation is used to calculate the heats of reaction when  $\Delta G$  at two temperature are given? (a) Gibbs Helmholtz equation (b) Clapeyron equation (c) Kirchoff's equation (d) none of these Answer. (a)
11. The third law of thermodynamics states that in the limit  $T \rightarrow 0$ , ----- ( $S=0$ )
12. In the limit  $T \rightarrow 0$ , for a crystal,  $S_T = \text{-----} (C_p/3)$

### **TWO & THREE MARK QUESTIONS**

1. Explain the Nernst heat theorem. How does it lead to the enunciation of the third law of thermodynamics.
2. State and explain the third law of thermodynamics.
3. What is standard reaction entropy?
4. Derive Gibbs Duhem equation.
5. Derive the variation of chemical potential with temperature and pressure.(3+3)
6. Write a note on chemical potential in systems of ideal gases.
7. Calculate the standard reaction entropy for the synthesis of ammonia.
8. Write a note on Duhem Margules equation.

## **UNIT V**

### **ONE MARK QUESTIONS**

1. Gibbs phase rule is -----.
2. Reduced form of Gibbs phase rule is -----.
3. If degree of freedom  $F=1$ , that system is called-----.
4. If  $F=$ -----, then the system is called bivariant.
5. In water system,----- is the point where all the three phases are at equilibrium
6. What is the temperature and pressure value of triple point?
7. ----- is the mathematical representation of lever rule.
8. Zone refining method is used to -----.
9. ----- is an example for low boiling azeotrope.

10. Ethanol/water is an example for ----- azeotrope.
11. Triple point marks the lowest temperature at which----- can exist.

## **TWO & THREE MARK QUESTIONS**

1. Define the following terms, i) Phase, ii) Component, iii) Degree of freedom
2. Write a note on condition of stability.
3. Give the variation of Gibbs energy with Pressure and temperature.
4. Explain cooling curve.
5. Explain Triple point.
6. Explain the equilibriums present in water system.
7. Explain one component system.
8. Give the significance of vapour pressure curve, sublimation curve and freezing curve.
9. Explain different solid phases of water.
10. Explain the phase diagrams of CO<sub>2</sub> and helium-4.
11. Explain the locations of phase diagrams.
12. Calculate the degrees of freedom values for various curves in water system.

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### **St. Joseph's College of Arts & Science (Autonomous)**

### **CH511S - Equilibrium Thermodynamics of Gaseous Systems**

**Time : 3 hrs**

**Max Marks :75**

#### **SECTION A (10x2=20)**

**Answer ALL the questions.**

I. Choose the correct answer (10x1=10)

1. Which type of system can exchange energy but not matter with surrounding?

a) open b) closed c) isolated d) all of them

2. When heat is given to system from surrounding, the thermodynamic notation is

a) +q b) -q c) ±q d) q=0

3. Inversion temperature is

a)  $\frac{2a}{b}$  b)  $\frac{2a}{R}$  c)  $\frac{2a}{Rb}$  d)  $\frac{2a}{Rb^2}$

4. The value of  $\Delta_{\text{fus}}H$  for iodine is  $15.5 \text{ kJ mol}^{-1}$ . To which process does this value refer?

a)  $\text{I(l)} \rightarrow \text{I(s)}$  b)  $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{l})$  c)  $\text{I}_2(\text{l}) \rightarrow \text{I}_2(\text{s})$  d)  $\text{I(s)} \rightarrow \text{I(l)}$

5. The amount of heat exchanged with surrounding at constant pressure is

a)  $\Delta S$  b)  $\Delta H$  c)  $\Delta G$  d)  $\Delta E$

6. Which true for an adiabatic process?

a)  $\Delta E = q$  b)  $P\Delta V = 0$  c)  $q = 0$  d)  $q = w$

7. For spontaneous process,  $\Delta G$  will be

a) positive b) negative c) positive or negative d) zero

8. Gibb's free energy is a

a) state function b) path function c) both d) neither

9. Which is the mathematical form of Gibb's phase rule?

a)  $F = C + P - 2$  b)  $P = C - F + 2$  c)  $C = F + P + 2$  d)  $F = C - P$

10. At the triple point of water, the number of degrees of freedom is

a) 1 b) 2 c) 3 d) 0

11. Which type of system can exchange both energy and matter with surrounding?

a) Isolated b) Closed c) Open d) All of them

12. When work is done by the system, the thermodynamic notation is

a)  $+w$  b)  $-w$  c)  $\pm w$  d)  $w=0$

13. Measure of disorderliness is called

a) Enthalpy b) Entropy c) Free energy d) Internal energy

14. The value of  $\Delta_{\text{fus}}H$  for iodine is  $15500 \text{ J mol}^{-1}$ . To which process does this value refer?

a)  $\text{I(s)} \rightarrow \text{I(l)}$  b)  $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{l})$  c)  $\text{I}_2(\text{l}) \rightarrow \text{I}_2(\text{s})$  d)  $\text{I(l)} \rightarrow \text{I(s)}$

15. When a engine operates between  $50^\circ\text{C}$  and  $100^\circ\text{C}$ , the efficiency will be

a)  $<1$  b)  $>1$  c)  $= 1$  d)  $= 0$

16. Which true for an isothermal process?

a)  $q = 0$     b)  $q \neq 0$     c)  $T \neq 0$     d)  $q = T$

17. For spontaneous process,  $\Delta G$  will be

a) Negative    b) Positive    c) Positive or negative    d) Zero

18. Entropy is a

a) State function    b) Path function    c) Both    d) Neither

19. Which is the mathematical form of reduced phase rule?

a)  $F = C - P + 2$     b)  $F = C - P + 2$     c)  $F = C - P + 1$     d)  $F = C - P + 3$

20. At the triple point of water, the number of phases are

a) 0    b) 1    c) 2    d) 3

21. Which type of system can neither exchange energy nor matter with surrounding?

a) Closed    b) Open    c) Isolated    d) All of them

22. The work arises due to absorption of heat from surrounding by the system is

a)  $P\Delta V$     b)  $V\Delta P$     c)  $-P\Delta V$     d)  $P\Delta T$

23. When a compound is formed from its elements, the heat associated is called enthalpy of

a) Reaction    b) Combustion    c) Formation    d) Dissociation

24. The value of  $\Delta_{\text{fus}}H$  for monoclinic sulphur is  $88.3 \text{ kJ mol}^{-1}$ . To which process does this value refer?

a)  $S(l)$

$\rightarrow S(s)$     b)  $S(s)$

$\rightarrow S(l)$     c)  $S(s)$

$\rightarrow S(g)$     d)  $S(g)$

$\rightarrow S(s)$

25. The amount of heat exchanged with surrounding at constant pressure is

a)  $\Delta S$     b)  $\Delta E$     c)  $\Delta G$     d)  $\Delta H$

26. Which true for an adiabatic process?

a)  $q > 0$     b)  $q < 0$     c)  $q = 0$     d)  $q = w$

27. For an equilibrium process,  $\Delta G$  will be

- a) Positive    b) Negative    c) Positive or negative    d) Zero

28. Entropy is a

- a) State function    b) Path function    c) Both a and b    d) Neither a or b

29. For ice in equilibrium with water,

- a)  $P=2$     b)  $P=1$     c)  $P=0$     d)  $P=3$

30. At the congruent melting point for any system, the value of 'F' will be

- a) 1    b) 2    c) 3    d) 0

31. In any spontaneous process

- a) Entropy increases                      b) Entropy decreases  
c) Entropy does not change              d) Free energy increases

**II Fill in the blanks            (5X1=5)**

1. \_\_\_\_\_ equation relates the variation of enthalpy of reaction with temperature.

2. If an electric motor produced 15 kJ of energy each second as mechanical work and lost 2 kJ as heat to the surroundings, the change in the internal energy of the motor each second \_\_\_\_\_

3. The change in entropy when 25kJ of energy is transferred reversibly and isothermally as heat to a large block of iron at  $0^\circ\text{C}$  is \_\_\_\_\_.

4. Sulphur system is a \_\_\_\_\_ component system.

5. At the melting of sodium metal, the entropy \_\_\_\_\_

6. Kirchhoff's equation relates the variation of enthalpy of reaction with \_\_\_\_\_.

7. The Gibb's free energy and enthalpy are related as \_\_\_\_\_.

8. Compared to ice, the entropy of water is \_\_\_\_\_.

9. Pb-Ag system is a \_\_\_\_\_ component system.

10. The unit of entropy is \_\_\_\_\_.
11. The Gibb's free energy and enthalpy are related as \_\_\_\_\_
12. \_\_\_\_\_ equation relates the variation of enthalpy of reaction with temperature.
13. During an spontaneous exothermic reaction, the sign of  $\Delta H$  will be \_\_\_\_\_
14. H<sub>2</sub>O system is a \_\_\_\_\_ component system.
15. During dissolution of sugar in water, the entropy \_\_\_\_\_

**III. Match the following (5x1 = 5)**

1. Surrounding - Second law of thermodynamics
2. Water Freezing - Zero variant
3. Kelvin-Planck Statement -  $q \neq 0$
4. Congruent melting point - Rest of the system
5. Isothermal process - decrease in entropy
6. Energy conservation - Can never be sent percentage
7. Ice melting - Zero variant
8. Efficiency of machine -  $q = 0$
9. Eutectic point - First law of thermodynamics
10. Adiabatic process - Increase in entropy
11. System - Second law of thermodynamics
12. Global warming - Uni-variant
13. Clausius Statement - State function
14. Icewater - Part under thermodynamic consideration
15. Free energy - Increase in entropy

**SECTION B (5x5=25)**



### Answer ALL the questions

1. Calculate the internal energy changes for a chemical change, if the heat of change is 40670 J and work done is 3100 J.mol<sup>-1</sup>P. (2)
2. A chemical reaction takes place in a container of cross-sectional area 50.0 cm<sup>2</sup>. As a result of the reaction, a piston is pushed out through 15 cm against an external pressure of 121 kPa. Calculate the work done by the system. (2)
3. The standard reaction enthalpy for the hydrogenation of propene  $\text{CH}_2=\text{CHCH}_3(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{CH}_3\text{CH}_2\text{CH}_3(\text{g})$  is  $-124 \text{ kJ mol}^{-1}$ . The standard reaction enthalpy for the combustion of propane,  $\text{CH}_3\text{CH}_2\text{CH}_3(\text{g}) + 5 \text{ O}_2(\text{g}) \rightarrow 3 \text{ CO}_2(\text{g}) + 4 \text{ H}_2\text{O}(\text{l})$  is  $-2220 \text{ kJ mol}^{-1}$ . Calculate the standard enthalpy of combustion of propene. (2)
4. Calculate the enthalpy of formation of OHP-Pions at 25°C, if  $\text{HR}_2\text{ROR}(\text{l}) \text{R} \rightarrow \text{HP} + \text{PR}(\text{aq})\text{R} + \text{OHP-PR}(\text{aq})\text{R}$ ;  $\Delta H^\circ = 57.3 \text{ kJ}$  and  $\text{HR}_2(\text{g})\text{R} + \frac{1}{2}\text{OR}_2(\text{g})\text{R} \rightarrow \text{HR}_2\text{ROR}(\text{l})\text{R}$ ;  $\Delta H^\circ = 285.9 \text{ kJ}$ . (2)
5. A sample of argon of mass 6.56 g occupies 18.5 dm<sup>3</sup>P at 305 k. Calculate the work done when the gas expands isothermally reversibly until its volume has increased by 2.5 dm<sup>3</sup>P. (2)
6. How to calculate the % efficiency of machine and engine according to second law of thermodynamics? (2)
7. Heat supplied to Carnot engine is 1897.8 kJ. Calculate the work done if it operates between 0° and 100°C. (2)
8. In Carnot cycle, show how work done is calculated for adiabatic reversible expansion. (2)
9. CRvR for uranium metal is 3.04 J.KP-1P.molP-1P at 20K. Find its absolute entropy. (2)
10. When a mole of solid chemical changes from one allotropic form into another at 220 K, the enthalpy change is 45 kJ/mol. Calculate the corresponding entropy change. (2)
11. Calculate  $\Delta G$ , when 1 mole of ideal gas expands reversibly and isothermally at 37°C from an initial volume of 55 lit to 1000 lit. (2)
12. As super cooled water freezes spontaneously, its temperature rises to 0°C. What is the source of heat for the process:  
 $\text{HR}_2\text{ROR}(\text{l})\text{R} (-10^\circ\text{C}) \rightarrow \text{HR}_2\text{ROR}(\text{s})\text{R} (0^\circ\text{C})$  (2)
13. 'H' is a state function, but 'q' is not a state function. Why? (2)
14. 5 moles of an ideal gas expand isothermally and reversibly from a pressure of 10 atm to 2 atm at 300K. Calculate the work done in this case. (2)

15. Calculate the enthalpy change for the transition of rhombic sulphur into monoclinic sulphur,  $\Delta H^\circ_{\text{comb}}$  values of -393.5 and -395.4 kJmol<sup>-1</sup> for rhombic and monoclinic respectively (2)
16. Calculate the enthalpy of formation of OH<sup>-</sup> ions at 25°C, if  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}^+(\text{aq}) + \text{OH}^-(\text{aq})$ ;  $\Delta H^\circ = 57.3 \text{ kJ}$  and  $\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l}); \Delta H^\circ = -285.9 \text{ kJ}$ . (2)
17. Write the mathematical form Trouton's rule. (2)
18. How to calculate the % efficiency of machine and engine according to second law of thermodynamics? (2)
19. Heat supplied to Carnot engine is 2500 kJ. Calculate the work done if it operates between 0° and 100°C. (2)
20. In Carnot cycle, show how work done is calculated for isothermal reversible expansion. (2)
21.  $C_v$  for polonium metal is 3.040 J.K<sup>-1</sup>.mol<sup>-1</sup> at 20K. Find its absolute entropy. (2)
22. State third law of thermodynamics. (2)
23. Determine the number of degrees of freedom for  $\text{H}_2\text{O}(\text{liq})$   $\text{H}_2\text{O}(\text{vap})$  and  $\text{H}_2\text{O}(\text{liq})$   $\text{H}_2\text{O}(\text{vap})$  under 1 atm pressure. (2)
24. Define phase and component of a system. (2)
25. What is meant by homogeneous system?
26. Calculate the internal energy changes for a chemical change, if the heat of change is 38.5 kJ and work done is 2800 J.mol<sup>-1</sup>.
27. Write Gibbs-Duhem equation. What is its significance?
28. The heat evolved on dissolving  $\text{CuSO}_4$  in water is 6.6 kJmol<sup>-1</sup>. If standard enthalpies of formation of  $\text{Cu}^{2+}$  and  $\text{CuSO}_4$  were 64.4 and 770 kJmol<sup>-1</sup> respectively. Calculate the enthalpy of formation of  $\text{SO}_4^{2-}$ .
29. How to calculate the % efficiency of machine and engine according to second law of thermodynamics?
30. Write the mathematical form for entropy with its unit.
31. Heat supplied to Carnot engine is 2020 kJ. Calculate the work done if it operates between 0° and 200°C.
32. Determine the number of degrees of freedom for  $\text{H}_2\text{O}(\text{liq})$   $\text{H}_2\text{O}(\text{vap})$  and  $\text{H}_2\text{O}(\text{liq})$   $\text{H}_2\text{O}(\text{vap})$  under 1 atm pressure.
33. Calculate the standard entropy change for the reaction  $\text{C}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{CO}(\text{g}) + \text{H}_2(\text{g})$ . Given that the absolute entropies for  $\text{C}(\text{s})$ ,  $\text{H}_2\text{O}(\text{l})$ ,  $\text{CO}(\text{g})$ ,  $\text{H}_2(\text{g})$  are 5.6, 70.3, 197.9, 130.6 kJ/mol respectively.

34. When a mole of solid chemical changes from one allotropic form into another at 196 K, the enthalpy change is 3800 J/mol. Calculate the corresponding entropy change.

35. In phase diagram of one component system exhibiting solid, liquid and gas, calculate P,C,F values in areas and alone curves.

36. Define internal energy and enthalpy.

### SECTION – C(5 X 7 = 35)

#### Answer any FIVE questions

1. a) 10 moles of an ideal gas expand isothermally and reversibly from a pressure of 10 atm to 2 atm at 300K. Calculate the work done in this case (3)

b) Calculate the final temperature, the work done, and the change of internal energy when ammonia is used in a reversible adiabatic expansion from 0.50 dm<sup>3</sup> to 2.00 dm<sup>3</sup>, the other initial conditions being the same. (2)

2. a) Given the equation  $3 \text{O}_2(\text{g}) \rightarrow 2 \text{O}_3(\text{g}) \Delta H = +285.4 \text{ kJ}$ , calculate  $\Delta H$  for the following reaction.  $3/2 \text{O}_2(\text{g}) \rightarrow \text{O}_3(\text{g})$ . (2)

b) What is the enthalpy change when 12.8g H<sub>2</sub>(g) reacts with excess Cl<sub>2</sub>(g) to form HCl(g)? ;  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \Delta H = -184.6 \text{ kJ}$  (3)

c) The standard enthalpy of formation of gaseous H<sub>2</sub>O at 298 K is -241.82 kJ mol<sup>-1</sup>. Estimate its value at 100°C given the following values of the molar heat capacities at constant pressure: H<sub>2</sub>O(g): 33.58 J K<sup>-1</sup> mol<sup>-1</sup>; H<sub>2</sub>(g): 28.84 J K<sup>-1</sup> mol<sup>-1</sup>; O<sub>2</sub>(g): 29.37 J K<sup>-1</sup> mol<sup>-1</sup>. Assume that the heat capacities are independent of temperature. (2)

3. a) The boiling point of chloroform is 61.5 °C. Calculate the molar heat of vaporization using Trouton's rule. (2)

b) 5 moles of an ideal gas expand reversibly from a volume of 8 dm<sup>3</sup> to 80 dm<sup>3</sup> at a temperature of 27°C. Calculate the change in entropy. (2)

c) Calculate the change in entropy accompanying the heating of one mole of helium gas from 298 K to 1000K at constant pressure. Assume  $C_{V,m} = 3/2R$ . (3)

4. a) State third law of thermodynamics. (2)

b) Write Gibbs-Duhem equation. What is its significance? (2)

c) Show that the entropy of any substance at very low temperature ( $0 < T < 20\text{K}$ ), where Debye's relation for heat capacities of crystals is valid, is one-third of the molar heat capacity. (3)

5. a) Draw the phase diagram of a simple eutectic system. (2)
- b) Define phase and component of a system. (3)
- c) Determine the number of degrees of freedom for  $\text{H}_2\text{O}(\text{liq})$ ,  $\text{H}_2\text{O}(\text{vap})$  and  $\text{H}_2\text{O}(\text{liq})$ ,  $\text{H}_2\text{O}(\text{vap})$  under 1 atm pressure. (2)
6. a) What is meant by eutectic point in a phase diagram. How many phases will exist at that point? (2)
- b) In the following phase diagram, calculate the number of degrees of freedom at points B, X, Y and how many phases exist along AB, BC, & BD. (3)
- c) Write Clausius statement of second law of thermodynamics (2)
7. a) When 1 mole of a gas absorbs 3710 J heat at the temperature of 100K. Calculate the corresponding entropy changes. (2)
- b) Give the thermodynamic conditions for non-spontaneity in terms of free energy, enthalpy and entropy changes (3) c) What is reduced phase rule? When it should be applied? (2)
8. a) How heat energy is measured? (2)
- b) Define system. How they are classified. (3)
- c) Find out the internal energy changes for a chemical change, if the heat of change is 38500 J and work done is 2800 J.mol<sup>-1</sup>.(2)
9. a) Given the equation  $6 \text{O}_2(\text{g}) \rightarrow 4 \text{O}_3(\text{g}) \Delta H = +570.8 \text{ kJ}$ , calculate  $\Delta H$  for the following reaction.  $3/2 \text{O}_2(\text{g}) \rightarrow \text{O}_3(\text{g})$ . (2)
- b) What is the enthalpy change when 12.8g  $\text{H}_2(\text{g})$  reacts with excess  $\text{Cl}_2(\text{g})$  to form  $\text{HCl}(\text{g})$ ? ;  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g}) \Delta H = -184.6\text{kJ}$  (3)
- c) Write Kirchhoff equation. (2)
10. a) The boiling point of carbon tetrachloride is 76.7 °C. Calculate the molar heat of vaporization. (2)
- b) 10 moles of an ideal gas expand reversibly from a volume of 8 dm<sup>3</sup> to 80 dm<sup>3</sup> at a temperature of 27°C. Calculate the change in entropy. (2)
- c) Calculate the change in entropy accompanying the heating of one mole of helium gas from 298 K to 1000K at constant pressure. Assume  $C_v = 3/2R$ . (3)
11. a) When carbon undergoes transition at 185 K, the enthalpy change is 28 kJ/mol. Calculate the corresponding entropy change. (2)
- b) Write Gibbs-Duhem equation. What is its significance? (2)

c) Show that the entropy of any substance at very low temperature ( $0 < T < 20\text{K}$ ), where Debye's relation for heat capacities of crystals is valid, is one-third of the molar heat capacity. (3)

12. a) Draw the phase diagram of water system. (3)

b) As super cooled water freezes spontaneously, its temperature rises to  $0^\circ\text{C}$ . What is the source of heat for the process:  $\text{H}_2\text{O}(\text{l}) (-10^\circ\text{C}) \rightarrow \text{H}_2\text{O}(\text{s}) (0^\circ\text{C})$ . (2)

c) Calculate  $\Delta G$ , when 5 mole of ideal gas expands reversibly and isothermally at  $37^\circ\text{C}$  from an initial volume of 55 lit to 1000 lit. (2)

13. a) What is meant by congruent melting point in a phase diagram. How many phases will exist at that point? (2)

b) In the following phase diagram, calculate the number of degrees of freedom at points B, X, Y and how many phases exist along AB, & BC. (3)

c) Write Kelvin-Planck statement of second law of thermodynamics. (2)

14. a) When 1 mole of a gas absorbs 3 kJ heat at the temperature of 273K. Calculate the corresponding entropy changes. (2)

b) Give the thermodynamic conditions for spontaneity in terms of free energy, enthalpy and entropy changes. (3)

c) What is Gibb's phase rule? (2)

15. a) Define system and surrounding. (3)

b) Establish the relationship between  $q_p$  and  $q_v$  in the haber's process assuming that gaseous reactants and products are ideal. (3)

c) Is 'q' is a state function? (1)

16. a) Given the equation  $3 \text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightarrow 2 \text{NH}_3(\text{g})$   $\Delta H = +360.3 \text{ kJ}$ , calculate  $\Delta$

H for the following reaction,  $\text{H}_2(\text{g}) + 1/3 \text{N}_2(\text{g}) \rightarrow 2/3 \text{NH}_3(\text{g})$ . (2)

b) Write the integrated Kirchhoff equation. (2) c) For an oxidation reaction,  $\Delta H$  at  $27^\circ\text{C}$  was found to be  $-91.9 \text{ kJ}$ . Find  $\Delta H$  at  $50^\circ\text{C}$ . (given that  $\Delta C_p$  is  $-39.3 \times 10^{-3} \text{ kJ K}^{-1}$ ) (3)

17. a) The boiling point of dichloroethane is  $68.3^\circ\text{C}$ . Calculate the molar heat of vaporization using Third law of thermodynamics. (2)

b) 5 moles of an ideal gas expand reversibly from a volume of  $8 \text{ dm}^3$  to  $80 \text{ dm}^3$  at a temperature of  $27^\circ\text{C}$ . Calculate the change in entropy. (2)

- c) Calculate the change in entropy accompanying the heating of one mole of helium gas from 298 K to 1000K at constant pressure. Assume  $C_v = 3/2R$ . (3)
18. a) State third law of thermodynamics with its mathematical form. (3)
- b) Show that the entropy of any substance at very low temperature ( $0 < T < 20K$ ), where Debye's relation for heat capacities of crystals is valid, is one-third of the molar heat capacity. (4)
19. a) Draw the phase diagram of a simple eutectic system. (3)
- b) Write Clausius statement of second law of thermodynamics. (2)
- c) In Carnot cycle, show how work done is calculated for isothermal reversible expansion. (2)
20. a) What is meant by eutectic point in a phase diagram. How many phases will exist at that point? (3)
- b) Define degree of freedom and component of a system. (4)
21. a) Give the thermodynamic conditions for non-spontaneity in terms of free energy, enthalpy and entropy changes. (3)
- b) When 1 mole of a gas absorbs 2850 J heat at the temperature of 80K. Calculate the corresponding entropy changes. (3)
- c) Write the mathematical form of reduced phase rule? (1)