**Activity Oriented Lesson plan 6 T**

I. **Preliminary Details**

Name of the Teacher : Shanavas K. E Standard : XI Science

Name of the Institution : JHSS Thandekkad. Time : 45 Minutes

Subject : Chemistry

Unit : VI

Chapter : Thermodynamics

Topics : Fourth Thermodynamic function Gibbs free energy, G,

Free energy and spontaneity, Third Law of Thermodynamics

**II. Types of knowledge**

## **i. Factual knowledge**

Terms : Gibbs free energy G, spontaneity, Third law of Thermodynamics.

Facts: 1. Gibbs energy, G is an extensive property and a state function.

2. Gibbs free energy change ΔG is the net energy available to do useful work.

## ii. **Conceptual knowledge**

Concepts : Fourth Thermodynamic function Gibbs free energy G, Free energy

and spontaneity, Third law of Thermodynamics.

Definitions : 1. Gibbs tree energy G is defined as maximum amount of energy

available to the system that can be converted into useful work.

2. Third law of T.D states that at absolute zero, the entropy of all perfectly

crystalline solid may be taken as zero.

**iii. Procedural Knowledge**

1. To define Gibbs free energy and derive Gibbs Helmholtz equation.

## Steps

1. Definition of Gibbs free energy, G

b) Give mathematical equation of Gibbs free energy. G = H-TS

c) Substitution for Enthalpy H = U+PV

1. Charge in Gibbs free energy at Constant temperature and pressure.

ΔG = ΔU+PΔV – TΔS

1. Formation of Gibbs Helmholtz equation **ΔG = H - TΔS**

2. Gibbs free energy and spontaneity. That is physical Significance of Gibbs free energy.

1. Applying First law of T.D. **ΔU= q + w**
2. Pressure-volume expansion of gas is the work done. That is Wexp = PΔV
3. Substitution for change enthalpy ΔH = ΔU + PΔV
4. Reversible and isothermal process (2nd law of T.D) qrev = TΔS
5. we know free energy change ΔG = ΔH – TΔS Thus we get ΔG = Wnonexp.

## **iv. Meta cognitive knowledge**

The students can acquire the awareness of knowledge, thinking and learning strategies in above-mentioned facts and concepts.

## **III Instructional objectives and learning outcomes**

The students will be able to list, choose, recall, define, explain solves, draws, applies, infer, assess and create the above-mentioned facts and concepts.

# **IV. Previous knowledge**

The students have the knowledge about the thermodynamic function U, H, S are all extensive properties and state functions.

# **V. Learning Aids**

1. Work sheets: Worksheet contain definition of Gibbs free energy G and Third Law of Thermodynamics.
2. Charts : 1. Physical significance of Gibb's free energy or Gibbs free energy and spontaneity

2. Derivations of Gibbs Helmholtz equation.

Constructivist Learning Design

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| **Activity** | **Student response with Assessment** | |
| **Phase I situation**  Students, can you give the first, second and third Thermodynamic functions in Thermodynamics.    Are all Thermodynamic functions being extensive properties and state functions.  **Phase II Grouping**  Who discovered the fourth Thermodynamic function and give the name  The students are grouped into 3 groups on the basis of the scientist who discovered Gibbs free energy. | Students share their experiences.  Ist Internal Energy U  2nd Enthalpy H  3rd Entropy S  Yes. All Thermodynamic functions are extensive properties which depend on mass and state function which depend on initial and final state of the system.  Josiah Willard Gibbs  Gibbs free energy  The students are grouped into 3 groups as Josiah group, Willard group and Gibbs group. | |
| **Factual knowledge**  The students recognize the fourth thermodynamic function Gibbs free energy G is extensive property and state function. | | |
| **Phase III Bridging**  Can you define Gibbs free energy G  Give the equation for Gibbs free energy G | Josiah group shows the worksheet  1. Definitions of Gibbs free energy  It is defined as the maximum amount of energy available to the system that can be converted into useful work. It is the capacity of a system to do useful work.  G = H – TS | |
| **Conceptual knowledge**  The students able to define the concept, Gibbs free energy G | | |
| How will you derive the Gibbs Helmholtz equation  Change in Gibbs free energy at constant temperature and pressure | Willard group hang the chart of the derivation of Gibbs Helmholtz equation  G = H – TS 1  Enthalpy, H Since H = U+PV  Substitute for H in equation 1  ∴ G = U + PV –TS 2  ΔGT,P = ΔU +PΔV - TΔS 3  ΔG = ΔH – TΔS  Gibbs Helmholtz equation | |
| **Procedural knowledge**  The students solve and derive the Gibbs Helmholtz equation | | |
| **Phase IV Questions**  Can you explain the physical Significance of Gibbs free energy  The Gibbs free energy decreases in a system for a spontaneous process. **Phase V Exhibit** How ΔG to be spontaneous.Using Gibbs Helmholtz equation to predict the spontaneity of Gibbs free energy.Then how ΔG is spontaneous.  **Phase VI Reflections**    What is the entropy of Solid? What about the entropy of perfectly crystalline solid?  Then can you define 3rd law of Thermodynamics. | Gibbs group hang the chart of Gibbs free energy  and spontaneity  From 1st law of T.D ΔU = q + w 1  ∴ΔU = qrev + Wexp + Wnonexp 2  At Constant pressure, Wexp = \_PΔV  ΔU = q –PΔV – Wnonexp    qrev = ΔU + PΔV –Wnonexp  qrev = ΔH – Wnonexp 3    Since ΔH = ΔU+PΔV  For reversible, isothermal process  ΔS = qrev/ T  TΔS =qrev  ∴ equation 3 becomes  TΔS = ΔH – Wnonexp  ∴   |  | | --- | | ΔG = Wnonexp |     ΔG = Wuseful = Wmax  Josiah group is given the answer and exhibit for others  ΔG = -ve Spontaneous  ΔG = +ve Non-spontaneous  ΔG = 0 Equilibrium  ΔG = ΔH – TΔS  Where ΔH is Enthalpy factor  TΔS is Entropy factor   1. Both factors favour ΔH=-ve, ΔG=-ve   Spontaneous at all Temperatures  b) Enthalpy factor opposes ΔH is -ve  Entropy factor opposes ΔS is-ve  ΔG=-ve Spontaneous if ΔH>TΔS at low  temperature  c) Enthalpy factor opposes AH is + ve  Entropy factor favours ΔS is +ve  ΔG=-ve Spontaneous if TΔS > ΔH  Very minimum    Entropy is zero    Willard group shows the worksheet 2.  The third Law of T.D states that at absolute zero, the entropy of all perfectly crystalline solid may be taken as zero. | |
| **Meta Cognitive knowledge**  The students can acquire the awareness of knowledge, thinking and learning strategies in Gibbs free energy and its spontaneity and Third Law of Thermodynamics. | | |
| **Follow up activities**  Can you give one application of third Law of T.D | | Student group present their findings on thechart and explains the application of 3rd law ofT.D Calculation of absolute entropies of pure substance at different temperatures.  **𝛥S0 = ∑ 𝛥S0 f(P) - ∑𝛥S0 f(R)** |