XI - CHEMISTRY - WORK SHEET

UNIT- 7 THERMODYNAMICS

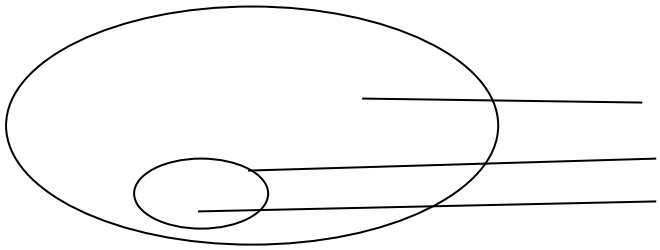
IMPORTANT TERMS :

- System, surrounding and boundary
- Types of systems - Properties of the system - Thermodynamic processes
- State functions and path functions - Internal energy
- Heat , Work and Pressure – volume work
- Zeroth law of thermodynamics – First law of thermodynamics
- Enthalpy - Enthalpy changes for different types of reactions
- Thermo chemical Equations
- Standard enthalpy of reaction - standard enthalpy of formation
- Molar heat capacities - Relation between Cp and Cv for an ideal gas.
- Heat of combustion - Bomb calorimeter – Coffee cup calorimeter
- Applications of the heat of combustion
- Heat of solution - Heat of neutralization -Molar heat of fusion - Molar heat of vapourisation
- Molar heat of sublimation -Heat of transition
- Hess's law of constant heat summation
- Lattice energy - Born - Haber cycle
- Various statements of Second law of thermodynamics
- Entropy- Unit of entropy - Spontaneity and Randomness - Standard Entropy Change
- Entropy of fusion - Entropy of vapourisation - Entropy of transition
- Gibbs free energy - Gibbs free energy and the net work done by the system
- Effect of Temperature on Spontaneity of Reactions
- Relationship between standard free energy change and equilibrium constant
- Third law of Thermodynamics

www.Padasalai.Net

ANSWER THE FOLLOWING

1. **Label the parts of the universe**



(system, surrounding, boundary)

2.Define the following terms:

System	Surrounding	Boundary

3. **List out the types of thermodynamic systems depending on the nature of the boundary**.
   1.
   2.
   3.

3. Match the following;

i) Isolated system - All living things and chemical reactions
ii) Closed system - Hot water contained in a closed beaker
iii) Open system - Hot water contained in a thermos flask
i)_____ ii)_____ iii) _____

3. **Fill the gaps with appropriate answer**

a) The property that _____on the _____ or_____ of the system is called an extensive property.
b) The property that is _____ of the _____or _____ of the system is called an intensive property.

4.Arrange the following examples:
volume, mass, molar volume, molarity ,amount of substance (mole), specific heat capacity, energy, enthalpy, molality, entropy, free energy, heat capacity,density, molar ,mole fraction, molar mass.

Extensive properties	Intensive properties

www.Padasalai.Net

6. Fill the following missing terms :

Process	**Condition**
Adiabatic	
	dT=0
Cyclic	
	dV =0
Isobaric	

7. Pick out the odd one out and give the proper reason:
Pressure (P), Volume (V), Work **(*w*)**, Temperature(T), Internal energy (U),Enthalpy (H),
Odd one:

Reason:

8. Give the proper sign conventions of the following:
1. Work done by the system =
2. Heat released by the system =
3. Work on the system =
4. Heat absorbed by the system =

(+q, -q, +w, -w)

9. Define Zeroth law of thermodynamics.

10. Define First law of thermodynamics.

11. The mathematical statement of the first law of thermodynamics is $\Delta U=q+W$, and write the different values of ΔU for different processes.

CASE	PROCESS	ΔU
1	Cyclic	
2	Isothermal	
3	Adiabatic	
4	Isobaric	

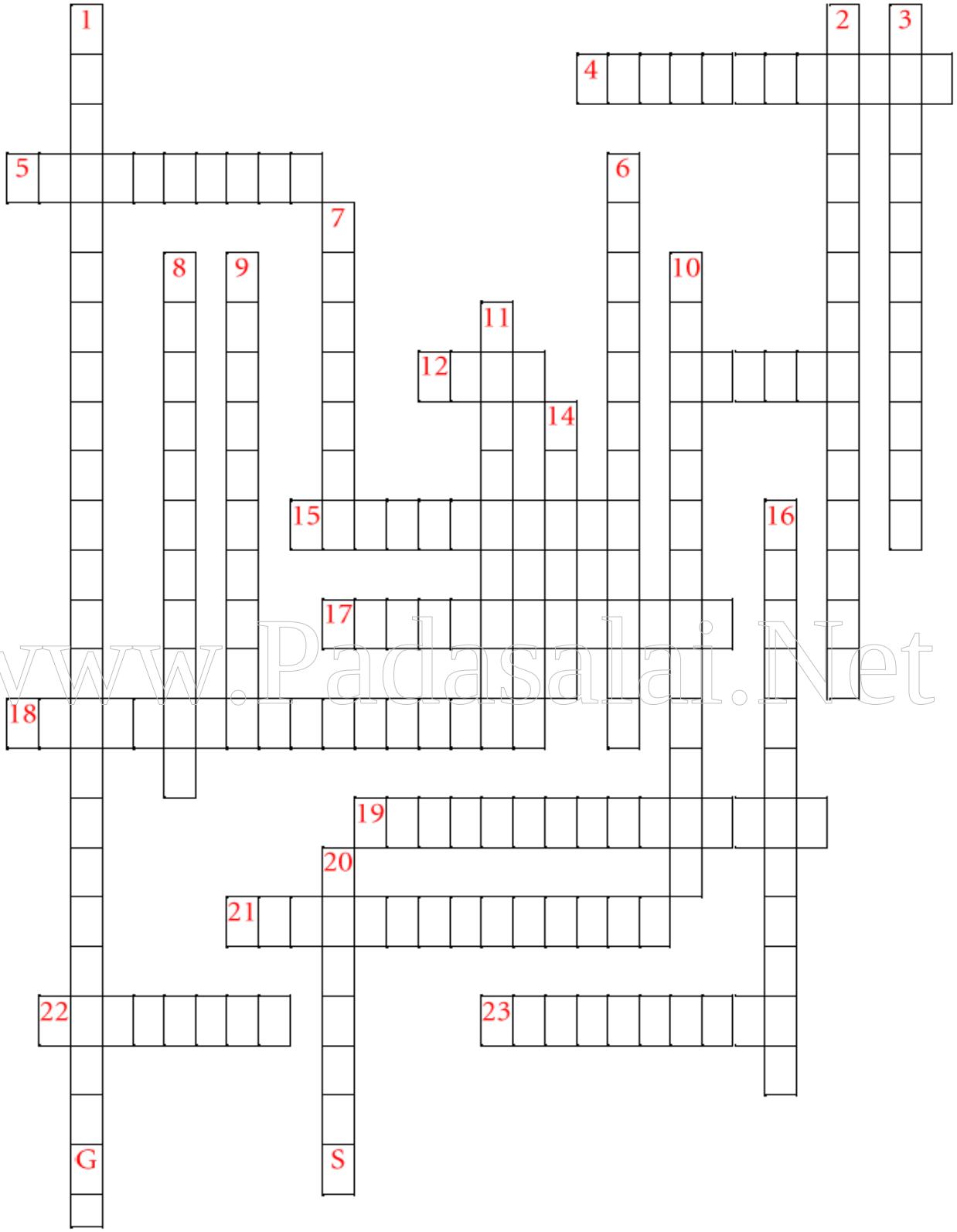
($\Delta U=w$, $\Delta U=0$, $\Delta U= q_v$, $\Delta U= q- P\Delta V$)

12. Write the definitions of the following terms.

TERMS	DEFINITION	EXAMPLE
Heat of solution		
Heat of neutralisation		
Molar heat of fusion		
Molar heat of vapourisation		

www.Padasalai.Net

13. Puzzles of Thermodynamics: Find out the answers using the clues given.



www.Padasalai.Net

Across

4. The quantity of energy needed to raise the temperature of 1 kg of a substance by 1°C at constant pressure

5. Energy flows out of a system

12. A flow of energy due to a temperature difference

13. The ability to do work or produce heat

15. A measure of the random motions of the components of a substance

17. Energy due to the motion of the object

18. Kinetic energy transferred to a surface as heat

19. Energy due to position or composition

21. Sum of the kinetic and potential energies of all "particles" in the system

22. To measure how much energy is produced or absorbed by a given reaction

23. Heat that is transferred by movement of a fluid

Down

1. Energy can be converted from one form to another but can be neither created nor destroyed

www.Padasalai.Net

2. the study of heat energy

3. Used to determine the heat associated with a chemical reaction

6. The lowest possible temperature on the Kelvin scale where all molecules would stop

7. Amount of energy (heat) required to raise the temperature of one gram of water by one degree Celsius

8. Energy flows into a system

9. Heat transferred method between objects in contact as a result of temperature difference

10. 1 atm pressure, water freezes at 0 degrees Celsius

11. A transfer of heat energy through space by means of electromagnetic waves

14. 4.184 _____ = 1 calorie

16. 1 atm pressure, liquid water always changes to gaseous water at 100 degrees Celsius

20. a unit of measurement that was once called Centigrade because there are 100 degrees between the freezing and boiling points of water in this scale

14.What is molar heat of sublimation?Give an example.

15. Define heat of transition. Give an example.

16. State Hess's law

The enthalpy change of a reaction either at constant _____ or constant _____ is the same whether it takes place in a single or _____ steps provided the initial and _____states are same

17. What is Lattice Energy?

18.Define Entropy.

Entropy is a measure of _____

www.Padasalai.Net

Unit of entropy :

Entropy is a _____ function.

19.What is Gibbs free energy?

G = H- ?

G is a _____ function.

20. Identify the conditions for spontaneity.

$\Delta S=0$, $\Delta S>0$, $\Delta S<0$, $\Delta H=0$, $\Delta H>0$, $\Delta H<0$,$\Delta G<0$, $\Delta G=0$, $\Delta G>0$

21. Define Third law of thermodynamics.

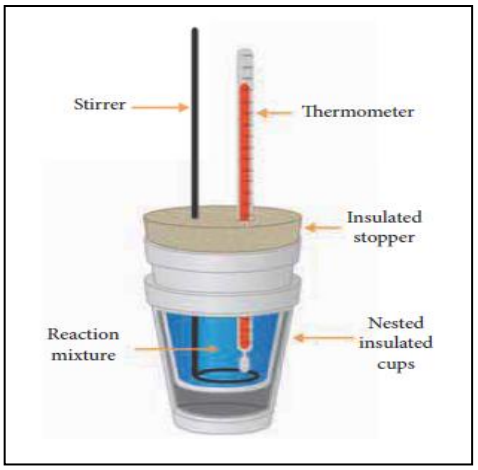
22.What is Heat of combustion?

"The change in enthalpy of a system when one mole of the substance is completely burnt in excess of air or oxygen".

Example: $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ ΔH_C = _____

23. Explain ΔH measurements by Coffee cup calorimeter.

- Heat change at constant pressure (at atmospheric pressure) can be measured using a **coffee cup calorimeter.**
- Instead of bomb, a ***styrofoam cup*** is used in this calorimeter.
- It acts as good adiabatic wall and doesn't allow transfer of heat produced during the reaction to its surrounding.
- This entire heat energy is absorbed by the water inside the cup.
- This method can be used for the reactions where there is no appreciable change in volume.

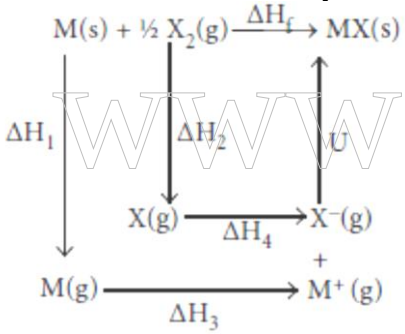


The change in the temperature of water is measured and used to calculate the amount of heat that has been absorbed or evolved in the reaction using the following expression.

$$q = m_w C_w \Delta T$$

where, m_w is the molar mass of water and
C_w is the molar heat capacity of water (4184 kJ K^{-1} mol^{-1})

24.The formation of a simple ionic solid such as an alkali metal halide MX, the following steps are considered and complete the given data.



ΔH_1=

ΔH_2=

ΔH_3=

ΔH_4 =

ΔH_f =

www.Padasalai.Net

25.Write the mathematical expressions for the following terms.

First law of thermodynamics	ΔU = _____
Enthalpy change	ΔH = ΔU + _____ ΔH = ΔU + $\Delta n_{(g)}$ _____
Molar heat capacities	C = q / _____
Relation between C_p and C_v	C_p - C_v = ___
% Efficiency	ɧ =
Gibbs free energy	G =
Gibbs free energy change	ΔG =
Third law of thermodynamics	limT--->0 S=
Internal energy	U = ___ + ___ + ___ + ___ +___ + ___

26,**The First Law of Thermodynamics helps you to understand the**

a.conservation of entropy. b.conservation of energy.

c. perpetual motion. d. enthalpy.

Ans:_____

27. Which of the following expressions correctly describes Gibb's free energy change for a chemical reaction that is carried out at constant temperature?

i)$\Delta G=\Delta H-T\Delta S$ ii)$\Delta G=\Delta H+T\Delta S$ iii)$\Delta G=\Delta H\div T\Delta S$ iv)$\Delta G=\Delta H\times T\Delta S$

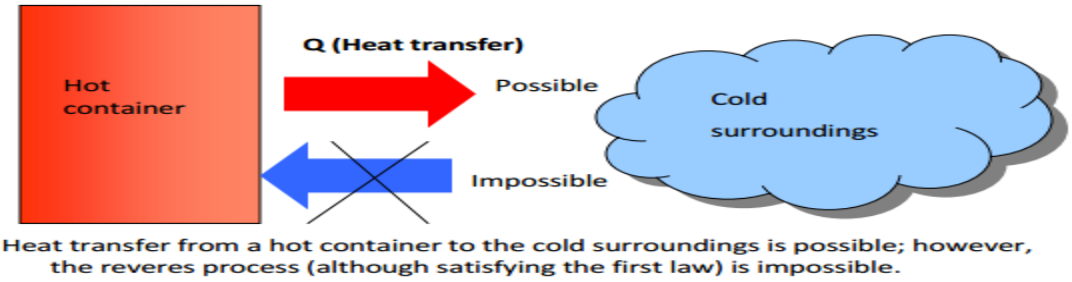
Ans: _____

ΔG = Gibb's free energy change

ΔH = Change in _____

ΔS = Change in entropy of the system

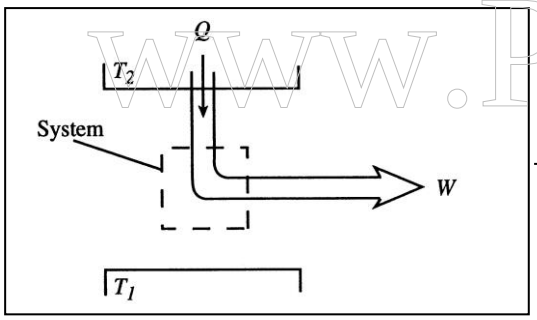
28. The following picture refers to which statement of Second law of thermodynamics?



Heat transfer from a hot container to the cold surroundings is possible; however, the reveres process (although satisfying the first law) is impossible.

Name of the Statement and its definition:

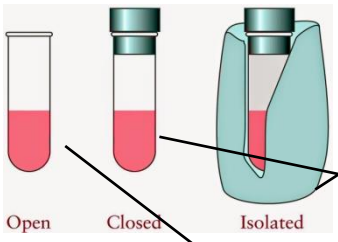
29. The following picture describes the Kelvin- Planck statement of second law of thermodynamics,



Kelvin- Planck statement:

www.Padasalai.Net

30. Explain the following pictures of system :



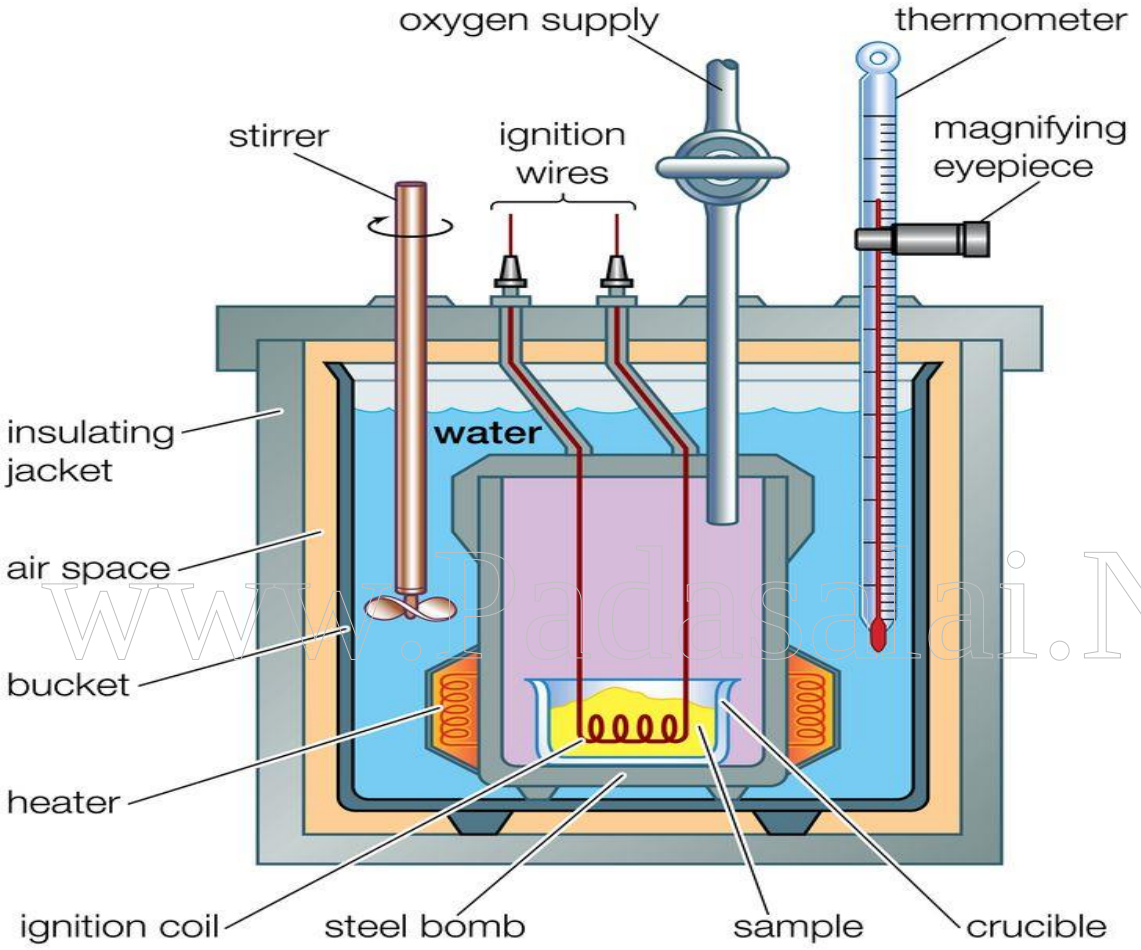
31.What is reversible process?

The process in which the system and surrounding can be _____to the _____ state from the_____ state without producing any changes in the thermodynamic properties of the universe is called a reversible process.

32. What is irreversible process?

The process in which the system and surrounding _____restored to the _____ state from the_____ state without producing any changes in the thermodynamic properties of the universe is called a reversible process.

33. Eeplain ΔU Measurements for chemical reactions, by *bomb calorimeter*.



www.Padasalai.Net

- The inner vessel (the bomb) and its cover are made of strong steel. The cover is fitted tightly to the vessel by means of metal lid and screws
- weighed amount of the substance is taken in a platinum cup connected with electrical wires for striking an arc instantly to kindle combustion.
- The bomb is then tightly closed and pressurized with excess oxygen. The bomb is immersed in water, in the inner volume of the calorimeter.
- A stirrer is placed in the space between the wall of the calorimeter and the bomb, so that water can be stirred, uniformly.
- The reaction is started by striking the substance through electrical heating. A known amount of combustible substance is burnt in oxygen in the bomb.

- Heat evolved during the reaction is absorbed by the calorimeter as well as the water in which the bomb is immersed.
- The change in temperature is measured using a Beckman thermometer.
- The bomb is sealed its volume does not change and hence the heat measurements is equal to the heat of combustion at a constant volume $(\Delta U)_c$.
- The amount of heat produced in the reaction $(\Delta U)_c$ is equal to the sum of the heat abosrbed by the calorimeter and water.
- Heat absorbed by the calorimeter **$q_1 = k.\Delta T$**
  where k is a calorimeter constant equal to $m_c C_c$ (m_c is mass of the calorimeter and C_c is heat capacity of calorimeter)
- Heat absorbed by the water **$q_2 = m_w C_w \Delta T$**
  where m_w is molar mass of water C_w is molar heat capacity of water (4,184 kJ K^{-1} mol^{-1})

Therefore **$\Delta U_c = q_1 + q_2$**

= _____

= _____

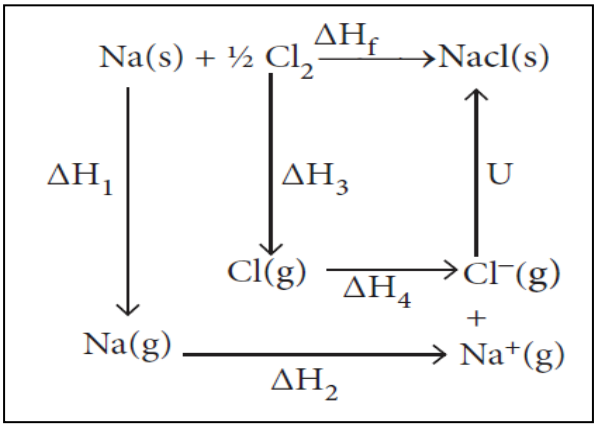
Calorimeter constant can be determined by burning a known mass of standard sample (benzoic acid) for which the heat of combustion is known (-3227 $kJmol^{-1}$)

www.Padasalai.Net

- The enthalpy of combustion at constant pressure of the substance is calculated from the equation **$\Delta H^0_{c(pressure)} = \Delta U^0_{c(volume)} + \Delta n_g RT$**

34. calculate the lattice energy of sodium chloride using Born-Haber cycle.

ΔH_f = heat of formation of sodium chloride = – 411.3 kJ mol^{-1}
ΔH_1 = heat of sublimation of $Na_{(S)}$ = 108.7 kJ mol^{-1}
ΔH_2 = ionisation energy of $Na_{(S)}$ = 495.0 kJ mol^{-1}
ΔH_3 = dissociation energy of $Cl_{2(S)}$ = 244 kJ mol^{-1}
ΔH_4 = Electron affinity of $Cl_{(S)}$= – 349.0 kJ mol^{-1}
U = lattice energy of NaCl



$\Delta H_f = \Delta H_1 + \Delta H_2 + 1/2\Delta H_3 + \Delta H_4 + U$

Therefore $U = (\Delta H_f) - (\Delta H_1 + \Delta H_2 + 1/2\Delta H_3 + \Delta H_4)$

U = (-411.3) – (108.7+ 495.0+_____ - 349.0)

U = _____ - _____

U = _____ $KJmol^{-1}$

35. Calculate the standard entropy change for the following reaction(ΔS^0_f),given the standard entropies of $CO_{2(g)}$,$C_{(s)}$,$O_{2(g)}$ as 213.6 , 5.740 and 205 JK^{-1} respectively.

$$C_{(g)} + O_{2(g)} \rightarrow CO_{2(g)}$$

$\Delta S^0_r = \Sigma S^0_{products} - \Sigma S^0_{reactants}$

$\Delta S^0_r = \{S^0_{CO2}\} - \{S^0_C + S^0_{O2}\}$

= _____ -_____ + _____

=_____ - _____

= _____ JK^{-1}

36. Calculate the entropy change during the melting of one mole of ice into water at 0^0 C and 1 atm pressure. Enthalpy of fusion of ice is 6008 J mol^{-1}.

Given,

ΔH_{fusion} = 6008 J mol^{-1}

$T_f = 0^0C = 273K$

$H_2O(s) \rightarrow H_2O(s)$

$\Delta S_{fusion} = \Delta H_{fusion}$ / _____

ΔS_{fusion} = _____ / 273

ΔS_{fusion} = _____

www.Padasalai.Net

37. An engine operating between 127^0 C and 47^0 C takes some specified amount\ of heat from a high temperature reservoir. Assuming that there are no frictional losses, calculate the percentage efficiency of an engine.

Given,

$T_h = 127 + 273 = 400K$

$T_c = 47 + 273 = 320$ K

Solution

% Efficiency = $[T_h - T_c / T_h] X100$

= _____

= _____ %

38. Calculate the work done when 2 moles of an ideal gas expands reversibly and isothermally from a volume of 500 ml to a volume of 2 L at 25°C and normal pressure.

Given,

n = 2 moles

V_i = 500 ml = 0.5 lit

V_f = 2 lit

$T = 25^0C = 298$ K

$w = -2.303\ n\ RT \log (V_f / V_i)$

w = _____

w =_____

w =_____ KJ

39. For the reaction at 298 K : 2A +B → C ΔH=400 J mol^{-1} ; ΔS = 0.2 JK^{-1} mol^{-1} Determine the temperature at which the reaction would be spontaneous.

Given :

T = 298 K

ΔH = 400 J mol^{-1} = 400 J mol^{-1}

ΔS = 0.2 J K^{-1} mol^{-1}

Solution:

$\Delta G = \Delta H - T\Delta S$

ΔG =

40. You are given normal boiling points and standard enthalpies of vapourisation. Calculate the entropy of vapourisation of liquids listed below.

S. No	Liquid	Boiling points (^{0}C)	ΔH (kJ mol^{-1})
1.	Ethanol	78.4	+ 42.4
2.	Toluene	110.6	+ 35.2

For ethanol :

Given :

T_b = 78.4^0 C = (78.4 + 273) = 351.4 K

ΔH_V(ethanol) = + 42.4 kJ mol^{-1}

Solution:

$\Delta S_v = \Delta H_V / T_b$

For Toluene:

T_b = 110.6^{0}C = 110.6=273=383.6K

ΔH_V(Toluene) = +35.2kJmol^{-1}

Solution

$\Delta S_v = \Delta H_V / T_b$

www.Padasalai.Net

B. UTHRAKUMAR
PGT CHEMISTRY
VMHSS
CHENNAI - 66

www.Padasalai.Net