Ramashray Baleshwar College

Dalsingsarai, Samastipur(Bihar)

A Constituent Unit of L. N. Mithila University, Darbhanga

AFFILIATED TO L.N. MITHILA UNIVERSITY, DARBHANGA

Assignment

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COURSE :	BSC
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STUDENT SIGNATURE

Physics Department

Bsc. 3rd Sem MJC-III (Theory) 2024-28.

Note Attempt any four questions.

Question 1: Describe the first Law of Thermodynamics. What are the physical significance and limitations of first Law of Thermodynamics.

Question 2: Explain the Internal Energy of a Thermodyamical System.

Question 3: What do you mean by Heat Engine? Describe its working and efficincy.

Question 4: Define Entropy. What is its physical significance? Show that the Entropy of a perfect gas remains constant in reversible process.

Question 5: Establish Maxwell's four Thermodynamical Relation.

P.T.O

Answer of Question number 1.

First law of thermodynamics :-
When a certain amount of Heat is supplied to a system, which does not external work w in passing from state 1 to state 2 the amount of heat is equal to the sum of the increase in internal energy of the system and the external work done by the system as

$$\boxed{Q = (U_2 - U_1) + W} \quad \text{------ (1)}$$

for verry small change in the state of a system is

$$dQ = dU + dW$$

$$\Rightarrow \boxed{dQ = dU + PdV} \quad \text{------ (2)}$$

↳ All quantities are in energy units.

* Physical interpretation of first law of thermodynamics.
  1. it is based on the law of conservation of energy.
  2. it introduce the concept of internal energy.
  3. it provides the method for determining the change in internal energy.

P.T.O

* Limitation of first law of thermodynamics:
The first law of thermodynamice is based on the law of conservation of energy. Those which is applicable to every process in nature it does not specify the condition under which a system can use its energy to produce a supply of mechanical work. it also does not say how much of heat is converted into work.

Answer of Question number 2.

Internal energy :-
it is the sum of molecular kinetic and potential energyies in the frame of refrence relative to which the centre of mass of the system is at rest it does not include the over-all kinetic energy of the system denoted by - U

Internal energy = K.e + P.e of body

P.T.O

Answer of Question number 8.

Heat engine: A heat engine is device that converts thermal energy (heat) into useful mechanical work. it operates in a repetitive cycle by taking heat from a hot source, converting a portion of it into work, and rejecting the remainder to a cold sink.

1. The Three Essential Parts:-
To understand how it works, we can look at its three main components.

1. The Source : A high-temperature reservoir (T_1) that provides heat energy (Q_1).
2. The Working Substance : Usually a gas or liquid (like steam in a power plant or air/fuel in a car engine) that undergoes changes in pressure and volume.
3. The Sink : A low-temperature reservoir (T_2) where the engine exhausts unused heat (Q_2).

2. How It works
The operation of a heat engine is cyclic process. Because it is a cycle. the working substance eventually returns to its original state, meaning its total change in internal energy (ΔU) over one full cycle is zero.

P.T.O

According to the first Law of Thermodynamics.

$$Q_{net} = W + \Delta U$$

Since $\Delta U = 0$, the net work done (W) is simple the difference between the heat absorbed and the heat rejected.

$$W = Q_1 - Q_2$$

3. Thermal Efficiency (η)

Efficiency is a measure of how much of the heat you" paid for" (Q_1) actually turned into "useful work" (W). It is expressed as:

$$\eta = \frac{\text{Net Work Done}}{\text{Heat Absorbed from Source}}$$

Substituting $W = Q_1 - Q_2$

$$\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1}$$

Answer of Question number 5..

Maxwell's relations are a set of four equations in thermodynamics that connect the partial derivatives of the state variables: Pressure (P), Volume (V), Temperature (T), and Entropy (S).

P.T.O

The Mathematical foundation :-

The derivation relies on the Euler Reciprocity Relation. If a state function z depends on x and y such that its total differential is

$$dz = M\,dx + N\,dy$$

And if dz is a perfect differential, then the mixed second-order partial derivatives must be equal.

$$\left(\frac{\partial M}{\partial y}\right)_x = \left(\frac{\partial N}{\partial x}\right)_y$$

The four Thermodynamic Potentials

To derive the four relations, we apply this mathematical rule to the four fundamental thermodynamic potentits.

1. Internal Energy = $dU = Tds - PdV$
2. Enthalpy = $dH = Tds + Vdp$
3. Helmholtz free Energy = $dF = -SdT - PdV$
4. Gibbs free Energy = $dG = -SdT + Vdp$

Let's Derive the first Relation

Let's walk through the first one using Internal Energy (U). from the combined first and second laws of thermodynamice, we know:

$$dU = Tds - PdV$$

P.T.O

1. Here, $M = T$ and $N = -P$.
2. The independents variables are $x = S$ and $y = V$.
3. Applying the reciprocity rule:

$$\boxed{\left(\frac{\partial T}{\partial V}\right)_S = \left(\frac{\partial P}{\partial S}\right)_V}$$

This is Maxwell's first Relation.

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