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Final Exam Assessment

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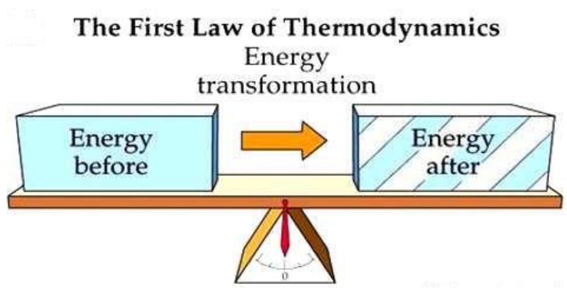
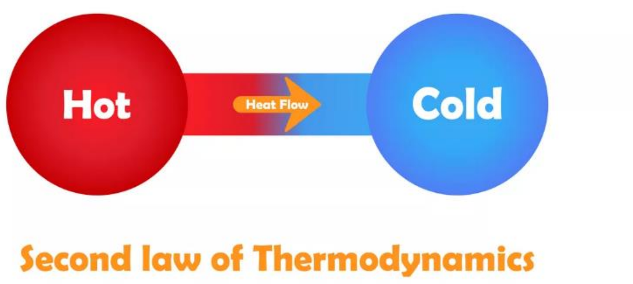
Answer to the question no 1(a)

 # a) State the First and Second Law of Themo-dynamics.



First law of thermodynamics:

1. This law states that "Energy can neither be created nor destroyed. It can only be converted from one form to another".
2. It is also called the law of conservation of energy.
3. The first law of thermodynamics is a thermodynamic adaptation of the law of conservation of energy that distinguishes between three types of energy transfer: heat, thermodynamic work, and energy-related with matter transfer.
4. It also relates each type of energy transfer to an aspect of a body's internal energy.



Second law of thermodynamics:

1. This law states that "Heat does not flow from a colder object to a hotter object except by the application of energy".

2. A physical law of thermodynamics, the second law of thermodynamics deals with heat and the loss that occurs during its conversion.
3. In some interpretations, the concept of entropy is established as a physical characteristic of a thermodynamic system by the second law of thermodynamics. It offers necessary criteria for spontaneous processes and can be used to determine whether processes are prohibited even when they comply with the first rule of thermodynamics' requirement for energy conservation.
4. The observation that isolated systems left to spontaneous development cannot experience a decrease in entropy can be used to formulate the second law.

Answer to the question no 1(b)

 # b) State the five fundamental assumptions of the kinetic theory of gases.

Answer:
Basics of Kinetic Theory of Gases
As per the basics of the kinetic theory of gases, the molecules move in random motion and keep on colliding with each other as well as the walls of the container they are kept in. Since these collisions remain elastic in nature, both the total momentum as well as total kinetic energy are conserved easily. Thus, you will find that neither the energy is preserved nor lost during this collision of molecules.

(In the image above, you can see the kinetic theory of gases formula. The different aspects of the formula are P = pressure of gas; V = volume of gas; T = temperature; N = moles of gas which are present; and R is the constant, which is known as the universal gas constant)

Here: PV = nRT;

Where:

P is the pressure of gas;

V is the volume of the gas;

T is the temperature which is measured in kelvin;

N is regarded as the moles of gas that are present;

R is the constant, which is known as the universal gas constant.

five fundamental assumptions of the kinetic theory of gases

- These gas molecules move in constant random motion, and most of these molecules are moving in one single direction than other molecules.
- During the process, these said molecules present in the gas are not exerting any kind of attractive or repulsive forces on each other. During the collision, they do exert pressure on each other. However, when they are not colliding, they keep on moving in straight lines.
- The division between these molecules is much more in size than the molecules' actual size.
- All kinds of collisions occurring between these molecules, as well as between the molecules and the wall, are elastic in nature.
- All these molecules present in the said gas diligently obey Newton's law of motion.

Answer to the question no 2(a)

 # a) Distinguish between elastic and plastic materials.

Answer:

Comparison between Plastic and Elastic:

	Plastic	**Elastic**
Definition	The property on account of which a body does not regain its original size and shape on removal of applied force is called as plastic body.	The property on account of which a body regains its original size and shape on removal of external deforming force is called as elastic body.
Process	It is irreversible.	It is reversible.
Ductility	They are highly ductile in nature.	It is less ductile in nature.
Resilience	They have low yield strength.	They have high yield strength.
Modulus of elasticity (ratio)	The ratio of stress to strain is high.	The ratio of stress to strain is low or equal.
Toughness	They do not have the ability to absorb energy up to a fracture.	They have the ability to absorb energy up to a fracture.

Bonds	The molecular bonds are fractured.	The molecular bonds do not get fractured.
Shape and size	The shape and size changes permanently.	The shape and size does change permanently,
Example	Plasticine.	Rubber.

Answer to the question no 2(b)

 # b) If Y, K and represent the Young's modulus, bulk modulus and modulus of rigidity then show that Y=9ηK/(3K+η)

Answer:
We know

$Y = 3K(1 - 2\sigma)$ .... (1)

$Y = 2\eta(1 + \sigma)$ .... (2)

Eliminating σ

from (2), $\{(Y / 2\eta) - 1\} = \sigma$

Putting in eq^n (1),

$Y = 3k\ [1 - 2\{(Y / 2\eta) - 1\}]$

$Y = 3k\ [1 - (Y/\eta) + 2]$

$Y = 3k\ \{3 - (Y/\eta)\}$

$Y = 9k - (3kY / \eta)$

$Y + (3kY / \eta) = 9k$

∴ $\eta Y + 3kY = 9\eta k$

∴ **$Y = 9\eta K/(3K+\eta)$**

Answer to the question no 4(a)

 # a) Define the term stress, strain and elastic limit.

Stress : Stress is defined as force per unit area within materials that arises from externally applied forces, uneven heating, or permanent deformation and that permits an accurate description and prediction of elastic, plastic, and fluid behaviour.
Stress is given by the following formula:

$$\sigma = \frac{F}{A}$$

where, σ is the stress applied, **F** is the force applied and **A** is the area of the force application.

The unit of stress is N/m^2.

Types of Stress

Stress applied to a material can be of two types as follows:

- **Tensile Stress**
- **Compressive Stress**

Strain: Strain is the amount of deformation experienced by the body in the direction of force applied, divided by the initial dimensions of the body.

The following equation gives the relation for deformation in terms of the length of a solid:

$$\epsilon = \frac{\delta l}{L}$$

where ε is the strain due to the stress applied, δl is the change in length and **L** is the original length of the material.

The strain is a dimensionless quantity as it just defines the relative change in shape.

Types of Strain

Strain experienced by a body can be of two types depending on stress application as follows:

- ***Tensile Strain***
- ***Compressive Strain***

Elastic limit: elastic limit, maximum stress or force per unit area within a solid material that can arise before the onset of permanent deformation. When stresses up to the elastic limit are removed, the material resumes its original size and shape. Stresses beyond the elastic limit cause a material to yield or flow. For such materials the elastic limit marks the end of elastic behavior and the beginning of plastic behavior. For most brittle materials, stresses beyond the elastic limit result in fracture with almost no plastic deformation.

Answer to the question no 4(b)

 # b) Derive the relations η=Y /2(1+σ)

The given the relation between Y, η and σ

Young's modulus (Y)

It is a measure of a solid's stiffness or resistance to elastic deformation under load. It relates stress and strain along an axis or line.

When Stress – force per unit area

Strain – proportional deformation

$$Y = \frac{longitudinal\ stress}{longitudinal\ strain}$$

$$Y=\frac{FL}{A.\Delta L}$$

Modulus of rigidity (η)

Shear modulus is also known as modulus of rigidity is the measure of the rigidity of the body, given by the ratio of shear stress to shear strain. Often denoted by G sometimes by S or η.

$$\eta=\frac{Shear\ stress}{shear\ strain}$$

$$\eta=\frac{T}{r}$$

Poisson radio (σ)

Ratio of lateral contraction to linear elongation is called Poisson's radio. It also can be defined because the ratio of unit transverse strain to unit longitudinal strain. The formula for Poisson's ratio σ is given as, Poisson's ratio =σ= lateral contraction/ linear elongation.

$$\sigma = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

By using stress relation on the unit solid element, these relations are often derived:

$$\eta=\frac{Y}{2(1+\sigma)}$$

Hence, the young's modulus of rigidity and Poisson radio is given by

$Y=2\eta(1+\sigma)$

$$\eta=\frac{Y}{2(1+\sigma)}$$

Answer to the question no 5(a)

 # a) What is the difference between a heat engine and a refrigerator?

Answer:
When talking about the difference between refrigerators and heat engines, both the systems and devices have many differences since they perform exactly opposite operations. Moreover, a heat pump is another machine that is frequently used in such scenarios. In brief, a heat pump is a sort of refrigerant. Let's see the differences between these in detail.

Heat Engine

- It requires a lot of energy as compared to Refrigerators.
- As the fuel burns very furiously, heat engines are sometimes unable to operate at too high temperatures.
- In one leg of the constant cycle, the working substance receives heat Q1 from the supply at a high-temperature T1. It transfers heat Q2 to a drain in the other leg at a low-temperature T2. The engine completes work W in a full cycle.
- The amount of work accomplished on the power consumed from the supply is the performance of a heat engine.

Refrigerator

- Refrigerators can remain colder than most heating systems and Heat pumps as they use a huge amount of ice or water to maintain objects cooler as compared to Heat engines.
- Refrigerators use less energy than heat engines to function.
- Refrigerators are frequently used to keep food, and heat engines are commonly utilised to generate energy.

- Refrigerators create cold air with a compressor, whereas heat engines create hot air with a fan.
- Unlike a combustion engine, a refrigerator (or heat pump) operates in the other direction.
- At temperature T2, a refrigerator's operating substance absorbs heat Q2 from a cold region. It also does external work W on it and discharges high-temperature T1 heat Q1 to the catchment.
- The Refrigerator's coefficient of performance is the ratio of the heat removed to work done.

Heat Engine	**Refrigerator**
More energy is required to do work	Less energy is required
Cannot do work at higher temperatures since the surroundings will get too warm and affect the system	Can do work at higher temperatures since the system is cool.
n= WQ ⁄ 1 **= 1 –** Q2 ⁄ Q1	∝= Q2 ⁄ W **=** Q2 ⁄ Q1-Q2
It is used to generate heat.	It is used to generate cold air.

Answer to the question no 5(b)

 # b) What do you mean by efficiency Of a heat engine?

Definition of the efficiency of the Heat Engine

Generally, we know that efficiency is capability. However, here the efficiency of a heat engine is the ratio of difference between the hot source and sink to the temperature of the hot source. It can also be termed as the thermal efficiency of the heat engine. The maximum efficiency of a heat engine is possible if there is a highest difference between hot and cold reservoirs. Efficiency does not have any unit.

The thermal efficiency may vary from one heat engine to another heat engine. To understand more about this, let's take the reliable heat engines and their efficiencies. The efficiencies of various heat engines are as follows:
It is just 3% efficient for ocean thermal energy conservation.

Automotive gasoline engines are nearly 25% efficient.

Similarly, coal-fired power stations have 49% efficiency.

It is around 60% efficient for the combined cycle gas turbine.

The Efficiency of a Heat Engine Formula

As the efficiency of the heat engine is a fraction of heat and the obtained useful work, it can be expressed using a formula and a symbol. The efficiency of heat energy formula is,

$\eta = \frac{W}{\mathrm{QH}}$

Where,

η = Thermal efficiency.

W = Useful work obtained.

QH = Given amount of heat energy.

This is known as the heat engine formula.

According to the second law of thermodynamics, it is impossible to get 100 percent of the thermal efficiency. It always ranges between 30% and 60% of thermal efficiency because of the environmental changes and other factors. We can also consider the work attained to be the difference between the initially absorbed amount of heat and the heat released. It can be expressed as

$(\eta) = \frac{[Q1-Q2]}{Q1}$

The heat engine concept was first introduced and discovered by a French Physicist Carnot in 1824. The Carnot engine is the ideal heat engine. As it is the most efficient heat engine, its efficiency is $\frac{[T1-T2]}{T1}$. It can be measured for every Carnot cycle.

From the formula and diagram, we can understand that the efficiency of an ideal heat engine also depends on the difference between the hot and cold reservoirs.

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