Government of Tamilnadu

Department of Employment and Training

Course : TNPSC Group II Exam

Subject : Physics

Topic : **Heat and Thermodynamics**

Commissioner,
Department of Employment and Training.

HEAT AND THERMODYNAMICS

Heat

- Temperature is the thermal state of the body, that decides the direction of flow of heat.
- "Heat is a form of energy transfer between two systems or between a system and its surroundings due to temperature difference between them.

Specific heat capacity

Specific heat capacity of a substance is defined as the quantity of heat required to raise the temperature of 1 kg of the substance through 1K. Its unit is J $kg^{-1}K^{-1}$.

- The specific heat capacity of water is the highest for any substance, 4180 J/kg K. It is 30 times the specific heat capacity of mercury which is about 140J/kg K.

Specific Latent Heat

Specific Latent Heat of fusion of any substance is the quantity of heat energy required to melt one kilogram of a substance without change in temperature. The symbol used is L. The unit for specific latent heat is Joule/kilogram or J/kg

The Gas Laws

- **Boyle's Law**

  "Temperature remaining constant, the pressure of a given mass of gas is inversely proportional to its volume". [Temp remaining constant] It can also be stated as PV = a constant

Charles' law

- **Charles' Law**

  States that "Pressure remaining constant, the volume of a given mass of gas is directly

Mercury boils at 357 °C

proportional to the absolute temperature". This is referred to as the law of volumes. A constant [Pressure remaining constant]

It can also be stated as V α T

V/T = a constant

Kelvin Scale or Absolute Temperature

- The zero of the Kelvin scale corresponds to -273°C and is written as 0K (without the degree symbol). One division on the Kelvin scale has the same magnitude of temperature as one division of the Celsius or Centigrade scale. Thus 0°C corresponds to +273K.

Kelvin scale(K) = Celsius scale (0°C) + 273

Celsius scale (0°C) = Kelvin scale (K) – 273

Adiabatic process

In Greek, adiabatic means "nothing passes through". The process in which pressure, volume and temperature of a system change in such a manner that during the change no heat enters or leaves the system is called adiabatic process. Thus in adiabatic process, the total heat of the system remains constant

Carnot engine

- Heat engine is a device which converts heat energy into mechanical energy.

Refrigerator

- A refrigerator is a cooling device. An ideal refrigerator can be regarded as Carnot's heat engine working in the reverse direction. Therefore, it is also called a heat pump

Transfer of heat

- There are three ways in which heat energy may get transferred from one place to another. These are conduction, convection and radiation

Conduction

- Heat is transmitted through the solids by the process of conduction

Applications

i. The houses of Eskimos are made up of double walled blocks of ice. Air enclosed in between the double walls prevents

Land and sea breeze are due to convection of heat

transmission of heat from the house to the coldest surroundings.

ii. Birds often swell their feathers in winter to enclose air between their body and the feathers. Air prevents the loss of heat from the body of the bird to the cold surroundings.

iii. Ice is packed in gunny bags or sawdust because, air trapped in the saw dust prevents the transfer of heat from the surroundings to the ice. Hence ice does not melt

Convection

- It is a phenomenon of transfer of heat in a fluid with the actual movement of the particles of the fluid

Application

- It plays an important role in ventilation and in heating and cooling system of the houses.

Radiation

- It is the phenomenon of transfer of heat without any material medium. Such a process of heat transfer in which no material medium takes part is known as radiation.

Thermal radiation

- The energy emitted by a body in the form of radiation on account of its temperature is called thermal radiation.

  It depends on,

  (i) Temperature of the body,

  (ii) Nature of the radiating body

- The wavelength of thermal radiation ranges from 8×10^{-7}m to 4×10^{-4}m. They belong to infra-red region of the electromagnetic spectrum.

Properties of thermal radiations

1. Thermal radiations can travel through vacuum.
2. They travel along straight lines with the speed of light.
3. They can be reflected and refracted. They exhibit the phenomenon of interference and diffraction.
4. They do not heat the intervening medium through which they pass.
5. They obey inverse square law.

Emissive power

- Emissive power of a body at a given temperature is the amount of energy emitted per unit time per unit area of the surface for a given

The colour of a star is an indication of its temperature

wavelength. It is denoted by e_λ. Its unit is W m^{-2}.

Perfect black body

- A perfect black body is the one which absorbs completely heat radiations of all wavelengths which fall on it and emits heat radiations of all wavelengths when heated. Since a perfect black body neither reflects nor transmits any radiation, the absorptive power of a perfectly black body is unity.

Kirchoff's Law

- According to this law, the ratio of emissive power to the absorptive power corresponding to a particular wavelength and at a given temperature is always a constant for all bodies.

$$\frac{e_\lambda}{a_\lambda} = \text{constant} = E_\lambda$$

Stefan's law

- Stefan's law states that the total amount of heat energy radiated per second per unit area of a perfect black body is directly proportional to the fourth power of its absolute temperature.

(i.e) $E \alpha T^4$ or $E = \sigma T^4$

- Where σ is called the Stefan's constant. Its value is 5.67×10^{-8} W m^{-2} K^{-4}.

NEWTON'S LAW OF COOLING

Newton's law of cooling states that the rate of cooling of a body is directly proportional to the temperature difference between the body and the surroundings

Solar constant

- The solar constant is the amount of radiant energy received per second per unit area by a perfect black body on the Earth with its surface perpendicular to the direction of radiation from the sun in the absence of atmosphere. It is denoted by S and its value is 1.388×10^3 W m^{-2}. Surface temperature of the Sun can be calculated from solar constant.

Angstrom Pyrheliometer

- Pyrheliometer is an instrument used to measure the quantity of heat radiation and solar constant.

Sea water turns into ice at 4 ˚C