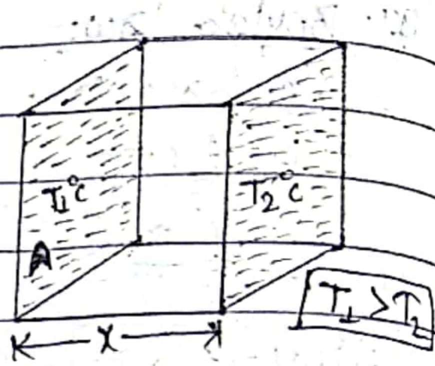
CHAPTER 12 RATE OF HEAT FLOW

Thermal Conductivity:-

↳ Let us Consider a Cube having side 'x' and area of each face 'A'. Also Let, left end be at temperature T_1°c and right end be at temperature T_2°c such that $T_1 > T_2$ so, flow of heat takes place from left end to right end.



Experimently, It has been found that the amount of heat (Q) transfer between two faces in time 't' is found to be

i) directly proportional to area of each face,

i.e. $Q \propto A$ ---- (i)

ii) directly proportional to temperature difference between two face,

i.e. $Q \propto (T_1 - T_2)$ ---- (ii)

iii) directly proportional to time for which heat flow,

i.e. $Q \propto t$ ---- (iii)

iv) inversely proportional to distance between two faces,

i.e. $Q \propto 1/x$ ---- (iv)

Combining all equations;

$$\Rightarrow Q \propto \frac{A(T_1 - T_2)t}{x}$$

$$\Rightarrow Q = \frac{KA(T_1 - T_2)t}{x} \quad \text{---- (v)}$$

Where, K is proportionality constant called thermal Conductivity which Value depends upon nature of material.

Also, $\frac{Q}{t} = \frac{KA(T_1 - T_2)}{x}$

If $A = 1m^2$, $T_1 - T_2 = 1°c/1K$ and $x = 1m$, Then,

$$\Rightarrow \boxed{K = Q/t}$$

Thus, Thermal Conductivity of material is numerically equal to the rate of flow of heat between two faces having area of each faces $1 m^2$ separated by distance 1m and maintained at temperature difference of $1°C/1K$.

Mode of transfer of heat

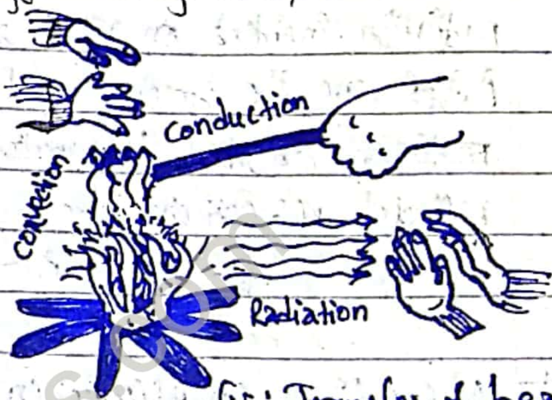


fig: Transfer of heat

[1] Conduction:-

↳ The mode of transfer of heat in which heat is transfer between two points without actual movement of particle is called Conduction.
In this mode heat is transfered to neighbouring particles and transfer of heat between successive particle takes place.

for e.g. heat transfer in solid.

[2] Convection:-

↳ The mode of transfer of heat in which heat is transfer between two points by actual movement of particle is called Convection.
for e.g. heat transfer in liquid and gas.

[3] Radiation:-

↳ The mode of transfer of heat without presence of any medium in the form of infrared wave is called radiation.

e.g. transfer of heat from Sun to earth Surface or sun light.

Absorbtion, transmission & Reflection co-efficient:-

↳ When heat radiation incident of a body, it is partially absorbed, partially transmitted & partially reflected.

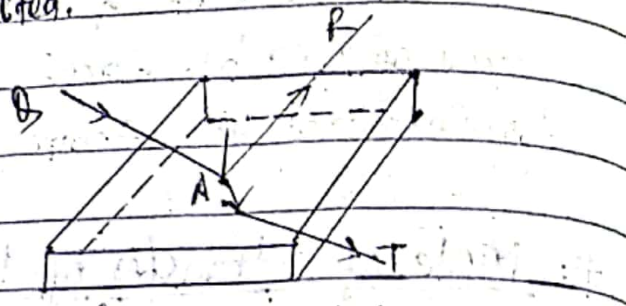


fig: reflection (R), transmision (T) & absorbtion (A) of heat radiation (Q)

★ let, Q be the amount of heat radiation incident on a body and A, T & R are the amount of heat ~~radiation~~ absorbed, transmitted & reflected respectively. Then,

$$Q = A + T + R \text{ ——— (i)}$$

Absorbtion co-efficient (a):-

↳ The ratio of amount of heat radiation absorbed to the amount of heat radiation incident is called absorbtion co-efficient.

i.e., $a = \frac{A}{Q}$

$$\Rightarrow A = aQ \text{ ——— (ii)}$$

Transmission co-efficient (t):-

↳ The ratio of amount of heat radiation transmitted to the amount of heat radiation incident is called transmission co-efficient.

i.e. $t = \frac{T}{Q}$

$$\Rightarrow T = tQ \text{ ——— (iii)}$$

Reflection co-efficient (r):-

↳ The ratio of amount of heat radiation reflected to the amount of heat radiation incident is called reflection co-efficient.

i.e., $r = R/Q$

$$\Rightarrow R = rQ \text{ ——— (iv)}$$

Using eq^n (ii), (iii) & (iv) in eq^n (i)

$\Rightarrow Q = aQ + tQ + rQ$

$\Rightarrow \boxed{a + t + r = 1}$.

Black body:-

↳ Which completely absorbs the heat radiations of all wave length falling on it is known as perfectly black body.
Its absorbtion co-efficient is unity. The sun emits radiation of all wave-lengths. So, it may regarded as black body even though it looks white.
Black body absorbs 96% to 98% of incident radiation.

Ferry's Black Body:-

↳ Ferry's black body is made for experimental verification. This is made with closed double walled hollow sphere having a tiny hole O. and Conical projection P opposite to hole. as shown in figure below:-

There is a projection P which reflect the incident radiation passing through hole O and reflections occur in inner wall and almost all radiation is absorbed into the wall.

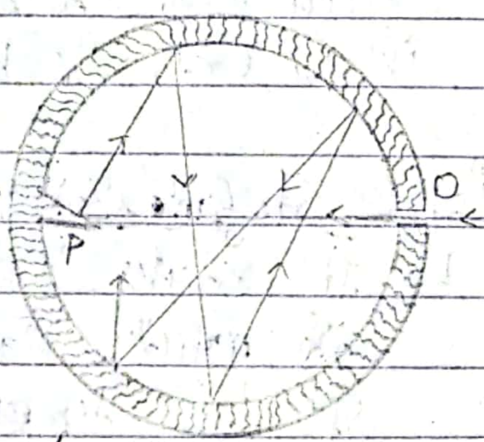


fig: Ferry's Black Body

When the black body is heated, absorbed radiation emerges from the hole O.

Emissive power:-

↳ The emissive power of a body is defined as the amount of heat radiation emitted per second per unit area by the body of all wave length of heat radiation.

It is denoted by E & given by;

$$E = \frac{Q}{At}$$

It SI unit is W/m^2.

Emissivity (e):-

↳ The ratio of emissive power of a body to the emissive power of perfectly black body is called emissivity.

i.e.

$$e\,[\text{Emissivity}] = \frac{\text{Emissive power of a body}}{\text{Emissive power of perfectly black body}}$$

i) For $e<1$, the black body is not perfectly black.
ii) For $e=1$, the black body is perfectly black body.
iii) For $e>1$, the black body is impossible.

imp # Stefan's-Boltzmann's law:-

↳ It states, "The heat radiation emitted per second per unit area by the perfectly black body is directly proportional to the fourth power of its temperature.

If 'E' be the amount of heat radiation emitted by perfectly black body per second per unit area and T be its temperature. Then, according to Stefan's-Boltzmann's law,

$$E \propto T^4$$

$\Rightarrow E = \sigma T^4$

Where 'σ' is proportionality constant called Stefan-Boltzmann constant and its value is equal to $5.67 \times 10^{-8}\ W/m^2 K^4$.

If 'e' be the emissivity of a body then Stefan's-Boltzmann's law can be written as,

$$E = e\sigma T^4$$

Again, If a body at temperature 'T_1' is enclosed by another body at temperature 'T_2' then Stefan's-Boltzmann law can be written as,

$$\boxed{E = e\sigma(T_1^4 - T_2^4)}$$

Measurement of thermal conductivity of a solid by Shearle's method:-

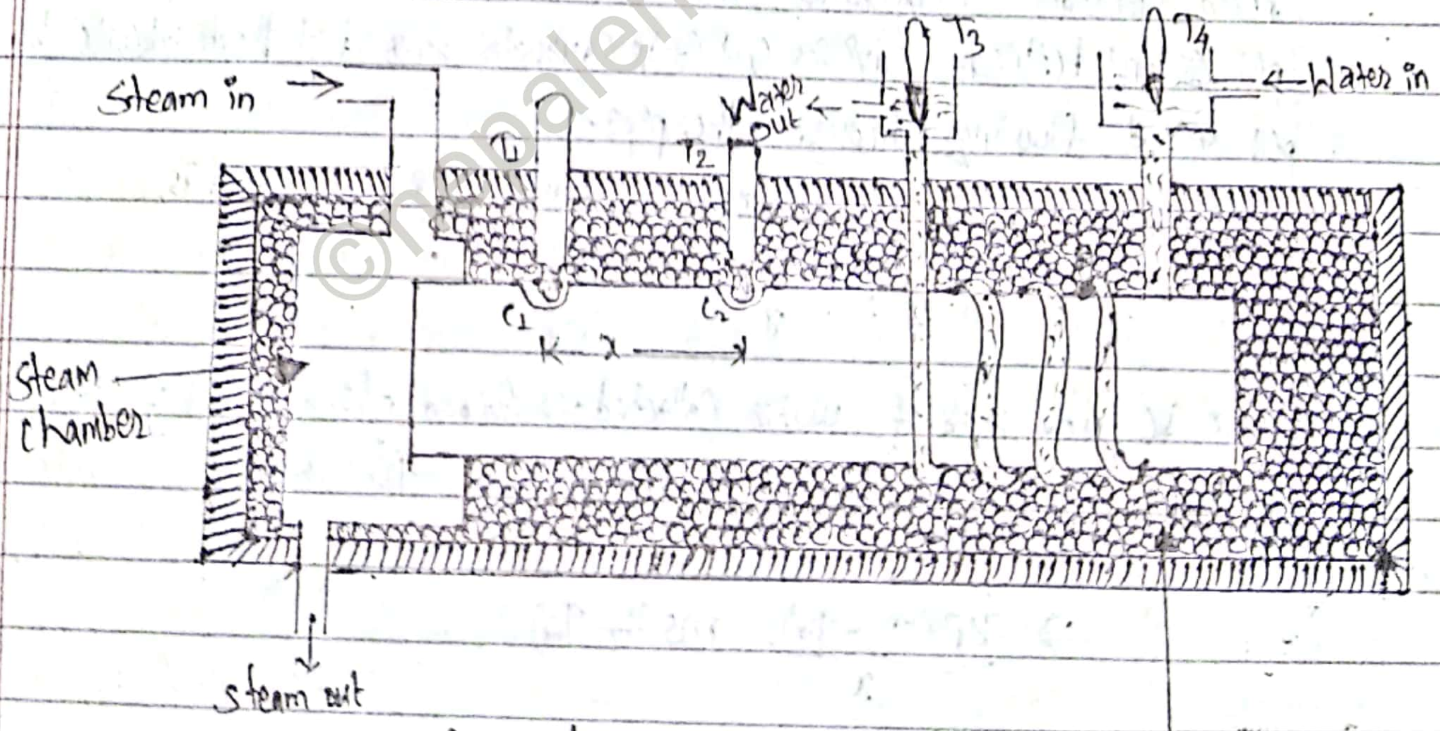


fig: Shearle's apparatus:-

The measurment of thermal Conductivity of Solid by Shearle's method consist experimental rod with uniform cross sectional area (A) in which there two cavities C_1 & C_2 Separated by distance 'x' in left end. At right end of the rod the conducting pipe is rounded through which water is passed continuously. The left end of the rod is heated by passing the steam. The thermometers T_1 & T_2 measure the temperature of Cavites C_1 & C_2 and also T_3 & T_4 measure the temperature of water out & water in respectively. The experimental rod is enclosed by insulating material Such as wool, cutton, paper to prevent from exchange of heat with surrounding.

Initially the T_1 & T_2 shows rise in temperature after passing steam and also thermometer T_3 initially shows the rise in temperature.

After continuousely circulating Steam & water, at certain stage thermometers T_1, T_2 & T_3 read constant temperature and at that condition, amount of heat transfer per second between cavities C_1 & C_2 is equal to amount of heat absorbs by water per second flowing through the pipe.

Now, amount of heat transfer between C_1 & C_2 per second is,

$$\frac{Q}{t} = \frac{KA(T_1 - T_2)}{x} \quad \text{--- (i)}$$

If m be the mass of water collected per second then amount of heat absorbs per second by water is; $Q/t = ms(T_3 - T_4)$ --- (ii)

At equilibrium, eq^n(i) = eq(ii)

$$\Rightarrow \frac{KA(T_1 - T_2)}{x} = ms(T_3 - T_4)$$

$$\Rightarrow K = \frac{ms(T_3 - T_4)x}{A(T_1 - T_2)} \quad \text{--- (iii)}$$

Using this relation we can calculate thermal conductivity of solid.

Numericals:-

Q.1[A] A bar 0.2 m in length and 2.5 cm^2 in cross section is ideally lagged. One end is maintained at 100°c and the other end is maintained at 0°c by immersing in melting ice. Calculate the mass of ice melt in one hour. Thermal conductivity of the material of the bar is $4\times10^{-2}\ Wm^{-1}K^{-1}$.

☆ Solⁿ:-

$x = 0.2\ m$, $A = 2.5 cm^2 = \frac{2.5}{10000} = 2.5\times10^{-4} m^2$, $T_1 = 100°c$, $T_2 = 0°c$, $m_i = ?$, $t = 1$ hour $= 3600$ sec.

$K = 4\times10^{-2}\ Wm^{-1}K^{-1}$

Now, We have, $\frac{Q}{t} = \frac{KA(T_1-T_2)}{x}$

or, $\frac{m_i L_f}{t} = \frac{KA(T_1-T_2)}{x} \Rightarrow m_i = \frac{KA(T_1-T_2)t}{x L_f} = \frac{4\times10^{-2}\times2.5\times10^{-4}(100-0)3600}{0.2\times336000}$

$\Rightarrow m_i = \frac{3.6}{67200} = 5.36\times10^{-5}$ Kg

Hence, 5.36×10^{-5} Kg of ice is melt.

Q.1[B] A rod 1.3m long consists of a 0.8m length of aluminium joined end to end to a 0.5 m length of brass. The free end of the aluminium section is maintained at 150°c and the free end of the brass piece is maintained at 20°c. No heat is lost through the sides of the rod. At a steady state, what is the temperature at the point where the two metals are joined? [$K_{al} = 205$, $K_b = 110$ W/m...

☆ Solⁿ:- $x_1 = 0.8m$ $\quad x_2 = 0.5m$

$T_{1a} = 150°c$ $\quad T_{1b} = ? = T$ (Let)

$T_{2a} = ?$ equal $\quad T_{2b} = 20°c$, $A_1 = A_2$

Now, $(Q/t)_1 = (Q/t)_2$

or, $\frac{K_1 \cancel{A_1}(T_{1a} - T_{2a})}{x_1} = \frac{K_2 \cancel{A_2}(T_{1b} - T_{2b})}{x_2}$

or, $\frac{205(150-T)}{0.8} = \frac{110(T-20)}{0.5}$

or, $256.25(150-T) = 220(T-20)$

or, $38437.5 - 256.25T = 220T - 4400$

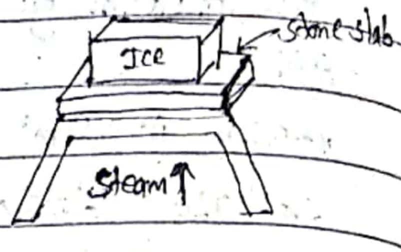
Or, $42837.5 = 476.25T$

$\Rightarrow T = 89.94°c$ = approx. 90°c

∴ tempʳ of joining point is 90°c #

Q.1[C] A slab of Stone of area $0.36\,m^2$ and thickness 10cm is exposed on the lower Surface to steam at 100°c. A block of ice at 0°c rests on the upper Surface of the slab. In one hour, 4.8 kg of ice is melted. Calculate the 'K' of Stone.

Soln:-



$A = 0.36\,m^2$, $x = 10cm = 0.1\,m$, $T_1 = 100°c$, $T_2 = 0°c$

$t = 1$ hour $= 3600$ sec., $m_i = 4.8\,kg$, $K_s = ?$

Now, $$\frac{Q}{t} = \frac{K_s(A)(T_1 - T_2)}{x}$$

or, $$\frac{m_i L_f}{t} = \frac{K_s A(T_1 - T_2)}{x}$$

or, $$\frac{4.8 \times 336000}{3600} = \frac{K_s \times 0.36(100-0)}{0.1}$$

or, $448 = K_s\, 360 \Rightarrow \boxed{K_s = 1.244 \text{ Watt } m^{-1}K^{-1}}$

Hence, thermal Conductivity of Stone slab is 1.244 watt $m^{-1}K^{-1}$. #

Q.1[D] A metal of rod of length 20cm and cross sectional area $3.14\,cm^2$ is Covered with non-conducting substance. One of its end is maintained at 100°c, while the other end is put in ice at 0°c. It is found that 25gm of ice melts in 5 minutes. Calculate the thermal Conductivity of the metal.

Soln:- $x = 20cm = 0.2\,m$

$A = 3.14\,cm^2 = 3.14 \times 10^{-4}\,m^2$

$T_1 = 100°c$, $T_2 = 0°c$

$m_i = 25gm \rightarrow 25 \times 10^{-3}\,kg$, $t = 5$ min $= 300$ sec

$K_m = ?$

We have,

$$\Rightarrow \frac{m_i L_f}{t} = \frac{K_m A(T_1 - T_2)}{x}$$

or, $$\frac{25 \times 10^{-3} \times 336000}{300} = \frac{K_m \times 3.14 \times 10^{-4}(100)}{0.2}$$

or, $28 = K_m \times 0.157$

$\Rightarrow K_m = 178.34$ W/mK #

Hence, thermal Conductivity of metal is 178.34 W/mK #

lower face

Q.1[E] Estimate the rate of heat loss through a glass window of area $2m^2$ and thickness 4mm. When the tempr of the room is 300K & tempr outside is 5°c.

★ Soln:- Given, $K = 1.2\ Wm^{-1}K^{-1}$

$A = 2\ m^2$, $x = 4mm = 4\times10^{-3}\ m$, $T_1 = 300K = 27°c$, $T_2 = 5°c$

Now, $\frac{Q}{t} = \frac{KA(T_1 - T_2)}{x} = \frac{1.2\times2(27.5-5)}{4\times10^{-3}} = 13.2\times10^3\ J/s = 132\times10^3\ W = 13200\ W$ #

Hence, rate of heat loss $= 13200\ W$ #

Q.1[E] An ice box is made of wood 1.75 cm. thick lined inside with cork 2 cm. thick. If the tempr of inner Surface of the wood is steady at 12°c, What is the tempr of the interface? The thermal conductivity of wood is five times that of cork.

★ Soln:-

$x_1 = 1.75cm = 0.0175\ m$, $T_{1c} = 12°c$, $K_w = 5K_c$

$x_2 = 2cm = 0.02m$, $T_{2c} = 0°c$

At steady state, $\left(\frac{Q}{t}\right)_1 = \left(\frac{Q}{t}\right)_2$

or, $\frac{K_c \cancel{A}(T_{1c} - T_{2c})}{x_1} = \frac{K_w \cancel{A}(T_{1w} - T_{2w})}{x_2}$

or, $\frac{K_c(12-0)}{0.0175} = \frac{K_w(12-T)}{0.02}$

or, $12\cancel{K_c}\times0.02 = 5\cancel{K_c}\times0.0175(12-T_1)$

or, $0.24 = 0.0875(12-T_1)$

or, $2.74 = 12 - T_1$

$\Rightarrow T_1 = 9.25°c$

Hence, the temperature of the interface is 9.25°c #

Q.1(G) Assuming that the thermal insulation provided by a woolen glove is equivalent to a layer of quiescent air 3 mm thick, determine that heat loss per minute from a man's hand, surface area 200 cm^2 on a winter day when the atmospheric air temperature is $-3°c$. The skin temp^r is to be taken as $35°c$ & thermal conductivity of air as $24 \times 10^{-3}\ Wm^{-1}K^{-1}$.

Soln:- $x = 3mm = 3 \times 10^{-3}m$.

$A = 200\ cm^2 = 0.02\ m^2$, $T_1 = 35°$, $T_2 = -3°c$, $k_a = 24 \times 10^{+3}\ Wm^{-1}K^{-1}$

Now,

$$\frac{Q}{t} = \frac{KA(T_1 - T_2)}{x} = \frac{24 \times 10^{3}(35+3) \times 0.02}{3 \times 10^{-3}} = 6080000\ J/sec = 364.8\ J/min$$

Hence, Heat loss per minute from man's hand is 364.8 J/min #

Q.1(H) Estimate the rate of heat loss through a glass window of area 2m^2 & thickness 3mm when the temperature of the room is 20°c and that of air outside is 5°c. Given $K = 1.2\ Wm^{-1}K^{-1}$.

Soln:- $Q/t = ?$

$A = 2\ m^2$, $x = 3 \times 10^{-3}\ m.$, $T_1 = 20°c$, $T_2 = 5°c$, $K = 1.2\ Wm^{-1}K^{-1}$.

Now,

$$\frac{Q}{t} = \frac{KA(T_1 - T_2)}{x} = \frac{1.2 \times 2(20-5)}{3 \times 10^{-3}} = 12000\ J/s = 12000\ W = 12\ KW$$

Hence, Rate of heat loss is 12 KW #

Q.1[I] Estimate the rate at which ice would melt in a wooden box 2.5 cm thick of inside measurement 100 cm × 60 cm × 40 cm, assuming that the external temperature is 35°C & thermal conductivity of wood is 0.168 W/mK.

A Soln:-

$x = 2.5\,cm = 2.5\times10^{-2}\,m$, $l = 100\,cm = 1\,m$, $b = 60\,cm = 0.6\,m$ & $h = 40\,cm = 0.4\,m$

$\therefore A = 2(lb+bh+lh) = 2[(1\times0.6)+(0.6\times0.4)+(1\times0.4)] = 2.48\,m^2$

$T_1 = 35°$, $T_2 = 0°C$, $K_W = 0.168\,W/mK$

Now, $\frac{Q}{t} = \frac{KA(T_1-T_2)}{x}$

Or, $\frac{m_i}{t} = \frac{KA(T_1-T_2)}{x L_f} = \frac{0.168\times2.48\times(35)}{2.5\times10^{-2}\times336000} = \frac{14.5824}{8400} = 0.001736\,kg/sec$
$= 1.736\times10^{-3}\,kg/s$

Hence, rate of ice melt is $1.736\times10^{-3}\,kg/sec$ #

Q.4[J] A bar 0.2 m in length and of cross-sectional area $2.5\times10^{-4}\,m^2$ is ideally lagged. One end is maintained at 373 K while the other is maintained at 273 K by immerging in melting ice. Calculate the rate at which the ice melts owing to the flow of heat along the bar.

A Soln:-

$x = 0.2\,m$, $A = 2.5\times10^{-4}\,m^2$, $T_1 = 373K$, $T_2 = 273K$, $Q/t = \frac{m_i L_f}{t}$ then, $\frac{m_i}{t} = ?$

We have,

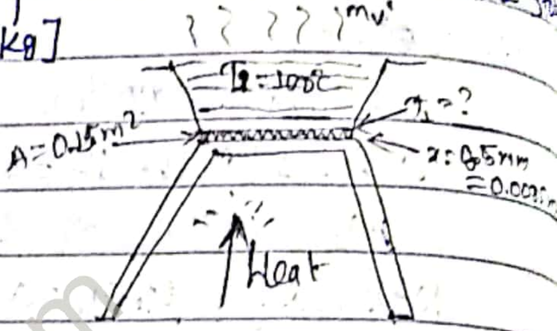
$$\frac{Q}{t} = \frac{KA(T_1-T_2)}{x}$$

$$\frac{m_i}{t} = \frac{KA(T_1-T_2)}{x L_f} = \frac{4\times10^{-2}\times2.5\times10^{-4}(373-273)}{0.2\times336000} = 1.48\times10^{-8}\,kg/sec.$$

#

Q.1[K] A pot with a steel bottom 8.5 mm thick rest on the hot stove. The area of the bottom of the pot is $0.15 m^2$. The water inside the pot is at 100°C & 390 g of water is evaporated every 3 minutes. Find the temp^r of lower surface of the pot which is contact with the stove. [$K = 50.2$ W/mK, $L_V = 2256 \times 10^3$ J/Kg]

A Sol^n:-



$x = 8.5mm = 0.0085 m$

$A = 0.15 m^2$, $m_V = 390 gm = 0.39 Kg$

$t = 3 min = 180 sec$, $T_1 = ?$ $T_2 = 100°C = 373 K$

Now, $\frac{Q}{t} = \frac{KA(T_1 - T_2)}{x} = \frac{m_V L_V}{t}$

or. $\frac{50.2 \times 0.15 (T_1 - 373)}{0.0085} = \frac{0.39 \times 2256 \times 10^3}{180}$

or. $T_1 - 373 = 5.52$

$\Rightarrow T_1 = 378.52 K = 105.52°C$ #

Hence, temp^r of the bottom of the pot is 105.52°C. #

Q.2[A] The element of a electric fire with an output of 1.5 KW is a cylinder of 0.3m long & 0.04 m in radius. Calculate its temp^r if it behaves as a black body.

A Sol^n:- $P = 1.5 KW = 1500 W$, $l = 0.3 m$, $r = 0.04 m$

Area of cylinder(A) $= 2\pi r l = 2\pi \times 0.04 \times 0.3 = 7.5 \times 10^{-2} m^2$, $T = ?$

Now, $P = A \sigma T^4$

Or, $1500 = 7.5 \times 10^{-2} \times 5.67 \times 10^{-8} \times T^4$

Or, $T^4 = \frac{1500}{4.27 \times 10^{-9}} = 3.50 \times 10^{11}$

Or, $T^2 = 592343.3851$

$\Rightarrow \boxed{T = 769.6384}$ K

Thus, its temp^r is 769.6384 K. #

Q.2[B] The Sun is a black body of surface temp^r about 6000K. If Sun's radius is 7×10^8 m, calculate the energy per second radiated from its surface. The earth is about 1.5×10^{11} m from the Sun. Assuming all the radiation from the sun falls on the surface of sphere of this radius, estimate the energy per second per meter² received by the earth?

Soln:- $T = 6000K$

$R_s = 7\times10^8 m$, $A = 4\pi R_s^2 = 4\pi(7\times10^8)^2 = 196\pi\times10^{16}\ m^2$

Now,

$P = \sigma A T^4 = 5.67\times10^{-8}\times196\pi\times10^{16}\times(6000)^4 = 4.52\times10^{26}$ Watt.

Again,

$A' = 4\pi(d)^2 = 4\pi(1.5\times10^{11})^2 = 9\pi\times10^{22}\ m^2$

So, $\frac{Q}{At} = \frac{P}{A} = \frac{4.52\times10^{26}}{9\pi\times10^{22}} = 1598.62\ W/m^2$. #

Hence, power $= 4.52\times10^{26}$ watt & Energy per second per m² $= 1598.62\ W/m^2$. #

Q.2[C] A sphere of radius 2.00 cm with a black surface is cooled & then suspended in a large evacuated enclosure with black walls maintained at 27°c. If the rate of change of thermal energy of sphere is 1.85 J/s when its temp^r is −73°c, Calculate the value of Stefan's Constant.

Soln:- $r = 2\ cm = 0.02\ m$, $T_1 = 27°c = 300K$, $P = 1.85\ J/s$, $T_2 = -73°c = 200K$

Now, $E = \sigma(T_1^4 - T_2^4)$

$P = \sigma A(T_1^4 - T_2^4)$

$\Rightarrow \sigma = \frac{P}{A(T_1^4 - T_2^4)} = \frac{1.85}{4\pi(0.02)^2[(300)^4-(200)^4]} = \frac{1.85}{32672563.6} = 5.66\times10^{-8}\ W/m^2K^4$

Hence, Stefan's Constant is $5.66\times10^{-8}\ W/m^2K^4$ #

Q.2[D] Estimate the power loss through unit area from a perfectly black body at 327°c to the Surrounding environment at 27°c.

☆ Soln:- $P = ?$, $A = 1\,m^2$, $T_1 = 600\,K$, $T_2 = 300\,K$

Now,

$\Rightarrow P = \sigma A(T_1^4 - T_2^4) = 5.67 \times 10^{-8} \times \{(600)^4 - (300)^4\} = 6889.05$ Watt. #

Hence, power loss = 6889.05 watt. ☆

Q.2[E] A spherical blackbody of radius 5cm has its tempr 127°c & its emissivity is 0.6. Calculate its radiant power:-

☆ Solution:-

Here, $A = 4\pi r^2 = 4\pi\left(\frac{5}{100}\right)^2 = 0.01\pi\, m^2$, $T = 127°c = 400K$, $e = 0.6$, $P = ?$

Now,

$P = e\sigma A T^4 = 0.6 \times 5.67 \times 10^{-8} \times 0.01\pi (400)^4 = 27.36$ Watt. #

Hence, radiant power is 27.36 Watt. #

Q.2[F] Estimate the radiant power loss from a human body at a tempr 38.5°c to the environment at 0°c if the surface area of the body is 1.5m² & its emissivity is 0.6.

☆ Soln:- $P = ?$, $T_1 = 38.5°C = 311.5\,K$, $T_2 = 0°c = 273K$, $A = 1.5\,m^2$, $e = 0.6$

Now,

$$P = e\sigma A(T_1^4 - T_2^4)$$
$$= 0.6 \times 5.67 \times 10^{-8} \times 1.5[(311.5)^4 - (273)^4]$$
$$= 5.103 \times 10^{-8}[3860685699]$$

$\Rightarrow P = 197.01$ Watt. #

Hence, Radiant power loss = 197.01 watt.

Q.2 [G] A man, the surface are of whose skin is $2m^2$ is sitting in a room where the air temp^r is 20°c. If his skin temp^r is 37°c, find the rate at which his body loses heat. The emissivity of his skin is 0.97.

A Sol^n:- $A = 2m^2$, $T_2 = 20°c = 293K$, $T_1 = 37°c = 310K$, $\frac{Q}{t} = P = ?$, $e = 0.97$

Now,

$$P = A.\sigma.e(T_1^4 - T_2^4)$$

$$= 2 \times 0.97 \times 5.67 \times 10^{-8} \times [(310)^4 - (293)^4]$$

$$= 1.0864 \times 10^{-07} [1885159190]$$

$$\Rightarrow P = 205.16 \text{ Watt.}$$

Hence, rate of heat loss is 205.16 Watt. #

Q.2 [H] What is the ratio of the energy per second radiated by the filament of a lamp at 2500K to that radiated at 2000 K, assuming the filament is a black body radiator?

A Sol^n: $T_1 = 2500K$, $T_2 = 2000K$, $P_1 : P_2 = ?$

Now $P_1 = A\sigma(T_1)^4$ & $P_2 = A\sigma(T_2)^4$

Here, $P_1 : P_2 = \frac{P_1}{P_2}$

$$\text{or, } \frac{A\sigma(T_1)^4}{A\sigma(T_2)^4} = \frac{T_1^4}{T_2^4} = \frac{25^4 \times \cancel{100^4}}{20^4 \times \cancel{100^4}} = \left(\frac{5 \times 5}{5 \times 4}\right)^4 = \frac{2.44}{1}.$$

$\therefore$ ratio of energy per seconds is (2.44 : 1) #