SPECIFIC HEAT OF SOLIDS

Before moving to the practical lets see the basic terms and definition for proper understanding:

Specific Heat (Cv):

It is the amount of heat required to raise the temperature of a unit mass of a substance by one degree Celsius (or one Kelvin, as the difference in temperature is the same for all scales). It has the SI unit of joules per kilogram per kelvin $(\mathrm{J \cdot kg^{-1} \cdot K^{-1}})$.

Dulong-Petit Law:

He assumed particles as classical oscillators and the particles are vibrating independent of each other. He calculated the specific heat independent of the temperature as

$$C_v = 3R$$

where:
- R is the ideal gas constant

It was valid at high temperatures but failed at low temperatures.

Einstein Model:

It is proposed by Albert Einstein to explain the temperature dependence of specific heat with temperatures. He assumed particles as harmonic oscillators but they are oscillating independently of each other. He calculated the specific heat expression as:

$$C_V = 3Nk_B \left(\frac{\Theta_E}{T}\right)^2 \frac{e^{\Theta_E/T}}{(e^{\Theta_E/T} - 1)^2}$$

where:
- N is the number of atoms in the solid.
- k_B is the Boltzmann constant.
- Θ_E is the Einstein temperature, defined as $\Theta_E = \frac{h\nu}{k_B}$, with h Planck's constant and ν as frequency.
- T is the absolute temperature.

It was valid for high temperatures and failed at low temperatures. It showed that at low temperatures the graph is exponential which was not true.

Debye Model:

It is proposed by Peter debye to explain the temperature dependence of specific heat with temperatures. He assumed particles as harmonic oscillators and are oscillating with a range of frequencies and said that the atoms vibrate collectively. It introduces the concept of a Debye temperature T_D and gives the expression of specific heat as:

$$C_v = 9Nk\left(\frac{T}{T_D}\right)^3 \int_0^{T_D/T} \frac{x^4 e^x}{(e^x-1)^2}\,dx$$

for temperatures below T_D. For high temperatures, it converges to the Dulong-Petit law.

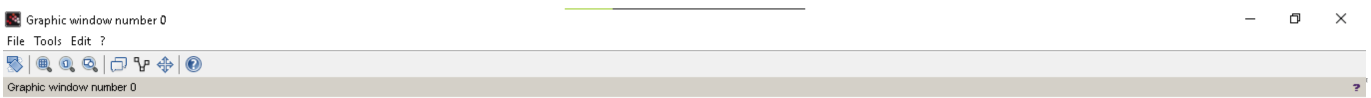
EXPERIMENT 6

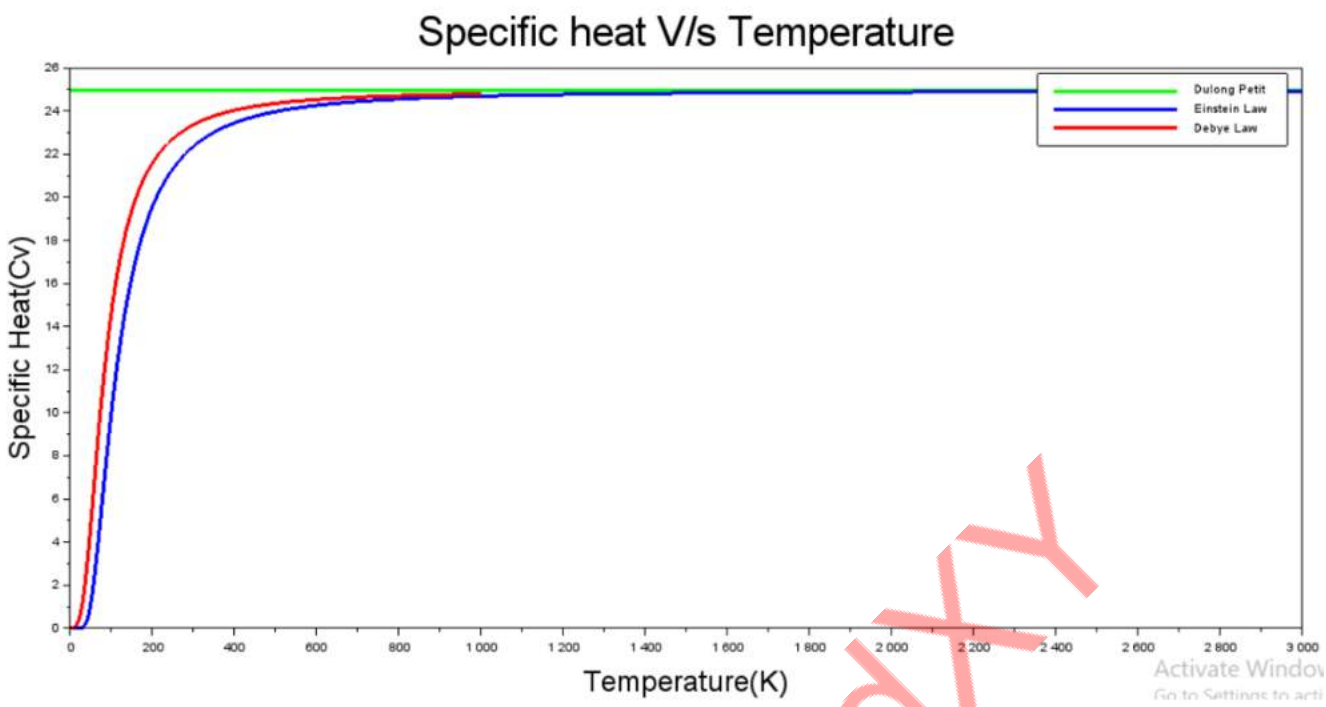
AIM: Plot Specific Heat of Solids w.r.t temperature for Dulong-Petit law, Einstein distribution function and Debye distribution function and compare them.

CODE:

```
clc;clear;clf
N = 6e23, h=6.626e-34, k=1.38e-23, //initialising the constants
Te = 1240; Td = 2400;
T = 0: 2*Td
for i = 1:length(T)
    Cvdp(i)=3*N*k; //Dulong Petit’s law
    if T(i)==0 then
        Cve(i)=0;Cvd(i)=0;  //for T=0
    else
        x = (Te/T(i))
        Cve(i) = (3*N*k*(x^2)*exp(x))/((exp(x)-1)^2)  //Einstein’s Law
        if T(i)>Td/50 then
            I = integrate('((y^4)*exp(y))/((exp(y)-1)^2)','y',0,Td/T(i))
            Cvd(i) = 9*k*N*I*((T(i)/Td)^3)  //Debye’s Law for high temp
        else
            Cvd(i)= ((12*3.14^4)/5)*N*k*((T(i)/Td)^3)  //Debye’s Law for low temp
        end
    end
end
plot(T',[Cvdp Cve Cvd],'lineWidth',3)   //Plotting the graph
title('Specific heat V/s Temperature','fontsize',6)
xlabel('Temperature(K)','fontsize',5)
ylabel('Specific Heat(Cv)','fontsize',5)
legend(['Dulong Petit', 'Einstein Law','Debye Law'])
```


OUTPUT:




Specific heat V/s Temperature
Dulong Petit
Einstein Law
Debye Law
Specific Heat(Cv)
Temperature(K)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
200
400
600
800
1 000
1 200
1 400
1 600
1 800
2 000
2 200
2 400
2 600
2 800
3 000