

# Theoretical Study about the Specific Heat Capacity of Different Metals for Different Temperatures in Three Dimensions

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**ABSTRACT:** The specific heat capacity is one of the electronic properties and this property was explained theoretically and this clearly shows that it depends on temperature. In this work this was found for different metals of different temperatures.

**KEYWORDS :** Specific heat capacity, temperature, Li, Na , Cu, K, Ag.

## I.INTRODUCTION

Heat capacitor thermal capacity is the measurable physical quantity of heat energy required to change the temperature of an object or body by a given amount. For quantum mechanical reasons, at any given temperature, some of these degrees of freedom may be unavailable, or only partially available, to store thermal energy [1, 2, 4]. In such cases, the specific heat capacity is a fraction of the maximum. As the temperature approaches absolute zero, the specific heat capacity of a system also approaches zero, due to loss of available degrees of freedom. Quantum theory can be used to quantitatively predict the specific heat capacity of simple systems. In solid-state physics, the electron gas [3,5,6] is a simple model for the behavior of valence electrons in a crystal structure of a metallic solid.[7]

## II.SPECIFIC HEAT CAPACITY IN 3DIMENSIONS

Specific heat capacity is defined as the amount of heat required to raise the temperature of unit mass of the substance through one Kelvin.

$$C_v = \left[ \frac{\partial E}{\partial T} \right]_v$$

Where  $C_v$  is the Specific heat at constant volume.

For a non interacting electron gas,

$$E = \frac{\int dE D(E) f(E) E}{\int dE D(E) f(E)}$$

Where  $D(E)$  is the density of states.

Density of states of an electron gas in 3D is

$$D_3(E) = \frac{\sqrt{2Em^2}}{\pi^2 \hbar^3}$$

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F(E) is the Fermi Dirac distribution function. Let U be the total energy of the system of N electron when heated from 0 to T. [8,9]

$$U = \int_0^\infty dE D(E) f(E) E - \int_0^{E_f} dE D(E) E$$

$$\text{Number of particles } N = \int_0^\infty dE D(E) f(E)$$

$$C_V = \left[ \frac{\partial U}{\partial T} \right]$$

$$C_V = \int_0^\infty dE D(E) df(E) (E - E_f)$$

Differentiating and Integrating we get,

$$C_V = \frac{\sqrt{2E} m^{\frac{3}{2}} K_B^2}{3\hbar^3} T$$

i.e.,  $C_V \propto T$ , at temperature very much lower than Fermi temperature.

### III. EXTENSION TO TWO DIMENSIONS

In 2D, density of states of an electron gas in 2D is,

$$D_2(E_f) = 2m/\pi\hbar^2$$

Specific heat capacity for 2D is

$$C_V = \frac{2\pi m K_B^2}{9\hbar^2} T$$

i.e.,  $C_V \propto T$ , at low temperature

### IV. EXTENSION TO ONE DIMENSION

In 1D, density of states of an electron gas in 1D is,

$$D_1(E) = 1/C E^{-1/2}$$

Specific heat capacity for 1D is

$$C_V = \frac{3\pi m^{\frac{1}{2}} K_B^2}{2\sqrt{2E}\hbar} T$$

$C_V \propto T$ , at low temperature

### V. RESULT

Specific heat capacity is defined as the amount of heat required to raise the temperature of unit mass of the substance through one kelvin. Using the values of density of states for one, two and three dimensions the expression for specific heat capacity in one, two and three dimensions have been studied. The results are [10,11]

For 3 dimensions,

$$C_V = \frac{\sqrt{2E} m^{\frac{3}{2}} K_B^2}{3\hbar^3} T$$

Hence  $C_V \propto T$ , at temperature very much lower than Fermi temperature.

For 2 dimensions,

$$C_V = \frac{2\pi m K_B^2}{9\hbar^2} T$$

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Hence.,  $C_v \propto T$ , at low temperature.  
For 1 dimension,

$$C_v = \frac{3\pi m^{\frac{1}{2}} K_B^2}{2\sqrt{2E}\hbar} T$$

Hence  $C_v \propto T$ , at low temperature.

From this it is concluded that the heat capacity at very low temperature is proportional to the temperature irrespective of the dimensions.

The metals like Lithium, Sodium, Copper, Potassium, Silver is considered and its specific heat capacity is calculated for different temperatures and its values are tabulated and the results are shown in graph.[12].

### Calculated values of specific heat capacity for different metals for different temperatures in three dimensions.

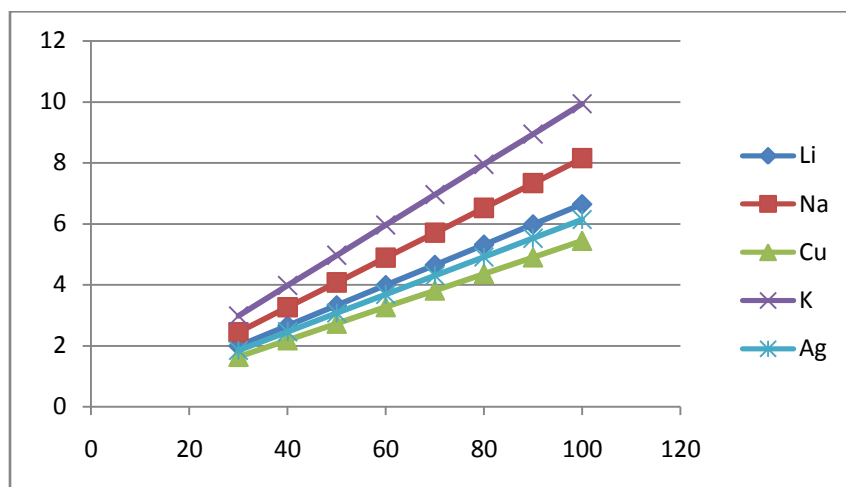
Temperature	Specific heat Capacity				
	Lithium	Sodium	Copper	Potassium	Silver
30	1.99222	2.44373	1.63244	2.98041	1.84164
40	2.65629	3.25831	2.17658	3.97388	2.45552
50	3.32036	4.07288	2.72073	4.96735	3.06940
60	3.98443	4.88746	3.26487	5.96082	3.68327
70	4.64850	5.70204	3.80902	6.95429	4.29715
80	5.31258	6.51601	4.35316	7.94776	4.91103
90	5.97665	7.33119	4.89731	8.94123	5.52491
100	6.64072	8.14577	5.44146	9.93469	6.13879

From this it is concluded that the heat capacity at very low temperature is proportional to the temperature irrespective of the dimension.

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