Pauli exclusion and the Sommerfeld Model

Arnold Sommerfeld
1868-1951

Peter Debye (Nobel Prize 1936)
Ludwig Hopf
Rudolf Seeliger
Wilhelm Lenz
Paul Peter Ewald
Paul Sophus Epstein
Alfred Landé
Erwin Fues
Adolf Kratzer
Wolfgang Pauli (Nobel Prize 1945)
Gregor Wentzel
Werner Heisenberg (Nobel Prize 1932)
Otto Laporte

Karl Bechert
Edward Condon
Ernst Guillemin
Helmut Hönl
Ernst Stückelberg
Hans Bethe (Nobel Prize 1967)
Hermann Brück
Herbert Fröhlich
Werner Romberg
Walter Franz
Heinrich Welker
William Allis
Carl Eckart

Eugene Feenberg
Walter Heitler
William V. Houston
Edwin C. Kemble
Walther Kossel
Max von Laue (Nobel Prize 1914)
Karl Meissner
Philip M. Morse
Linus Pauling (Nobel Prizes 1954 & 1962)
Rudolf Peierls
Howard P. Robertson
Walter Rogowski
Wojciech Rubinowicz

Edmund Stoner
1899-1968

Wolfgang Pauli
1900-1958
Nobel Prize in 1945

Enrico Fermi
1901-1954
Nobel Prize in 1938

Paul Dirac
1902-1984
Nobel Prize in 1933

Table 2.3

SOME ROUGH EXPERIMENTAL VALUES FOR THE COEFFICIENT OF THE LINEAR TERM IN T OF THE MOLAR SPECIFIC HEATS OF METALS, AND THE VALUES GIVEN BY SIMPLE FREE ELECTRON THEORY

ELEMENT	FREE ELECTRON γ (in 10^{-4} cal-mole^{-1}-K^{-2})	MEASURED γ (in 10^{-4} cal-mole^{-1}-K^{-2})	RATIO[a] (m^*/m)
Li	1.8	4.2	2.3
Na	2.6	3.5	1.3
K	4.0	4.7	1.2
Rb	4.6	5.8	1.3
Cs	5.3	7.7	1.5
Cu	1.2	1.6	1.3
Ag	1.5	1.6	1.1
Au	1.5	1.6	1.1
Be	1.2	0.5	0.42
Mg	2.4	3.2	1.3
Ca	3.6	6.5	1.8
Sr	4.3	8.7	2.0
Ba	4.7	6.5	1.4
Nb	1.6	20	12
Fe	1.5	12	8.0
Mn	1.5	40	27
Zn	1.8	1.4	0.78
Cd	2.3	1.7	0.74
Hg	2.4	5.0	2.1
Al	2.2	3.0	1.4
Ga	2.4	1.5	0.62
In	2.9	4.3	1.5
Tl	3.1	3.5	1.1
Sn	3.3	4.4	1.3
Pb	3.6	7.0	1.9
Bi	4.3	0.2	0.047
Sb	3.9	1.5	0.38

[a] Since the theoretical value of γ is proportional to the density of levels at the Fermi level, which in turn is proportional to the electronic mass m, one sometimes defines a specific heat effective mass m^* so that m^*/m is the ratio of the measured γ to the free electron γ. Beware of identifying this specific heat effective mass with any of the many other effective masses used in solid-state theory. (See, for example, the index entries under "effective mass.")

$$C_{\text{mol}} = \gamma T + \beta T^3 + \cdots$$

$$\frac{m^*}{m_\text{e}} = \frac{\gamma(m^*)}{\gamma(m_\text{e})}$$

Data: Ashcroft & Merlin, chap. 2

Wilson Ratio for NFE/sp-metals

Element	"Wilson Ratio"	Ratio (m*/m)
Li	0.634	2.3
Na	0.841	1.3
K	0.731	1.2
Rb	0.534	1.3
Cs	0.675	1.5
Be	-3.88	0.42
Mg	0.75	1.3
Ca	1.11	1.8
Sr	0.187	2
Ba	3.34	1.4
Al	0.903	1.4

$$\chi = \chi_{\text{Pauli}} + \dots$$

$$R_{\text{W}} = \frac{\pi^2 k_{\text{B}}^2}{3\mu_0\mu_{\text{B}}^2}\frac{\chi}{\gamma}$$

$$C_{\text{mol}} = \gamma T + \beta T^3$$

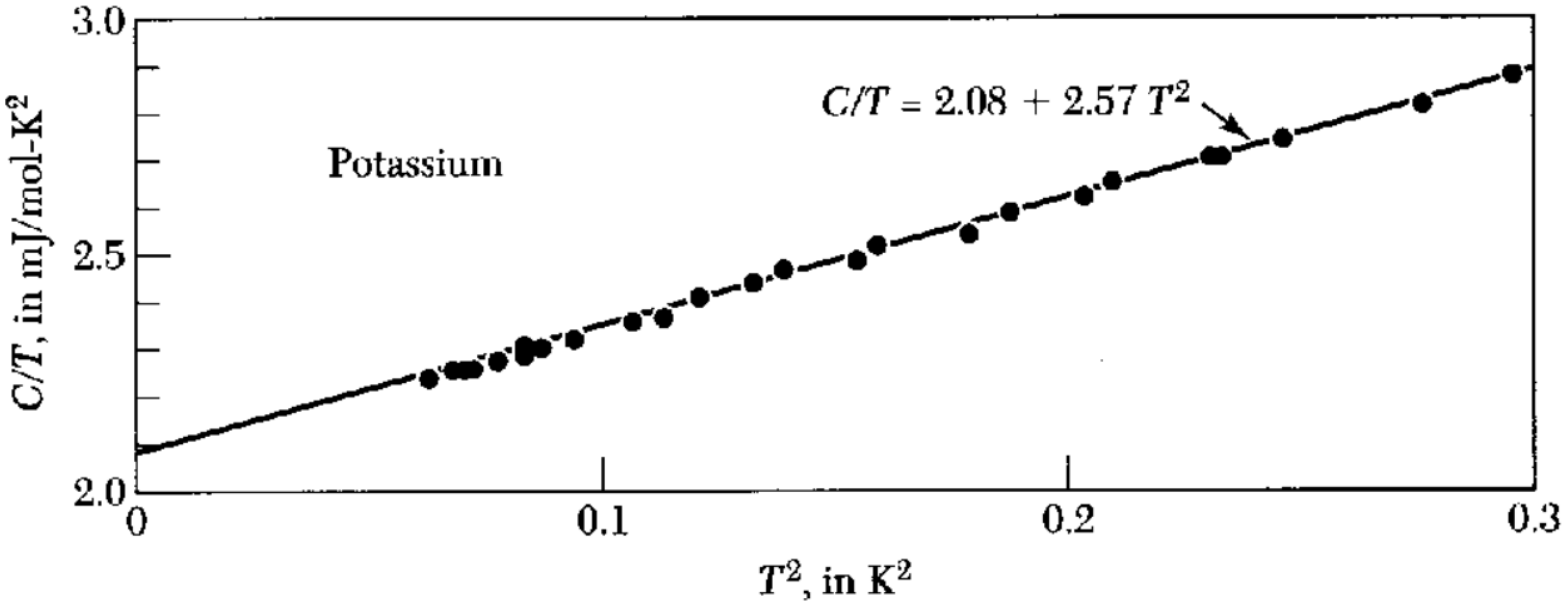
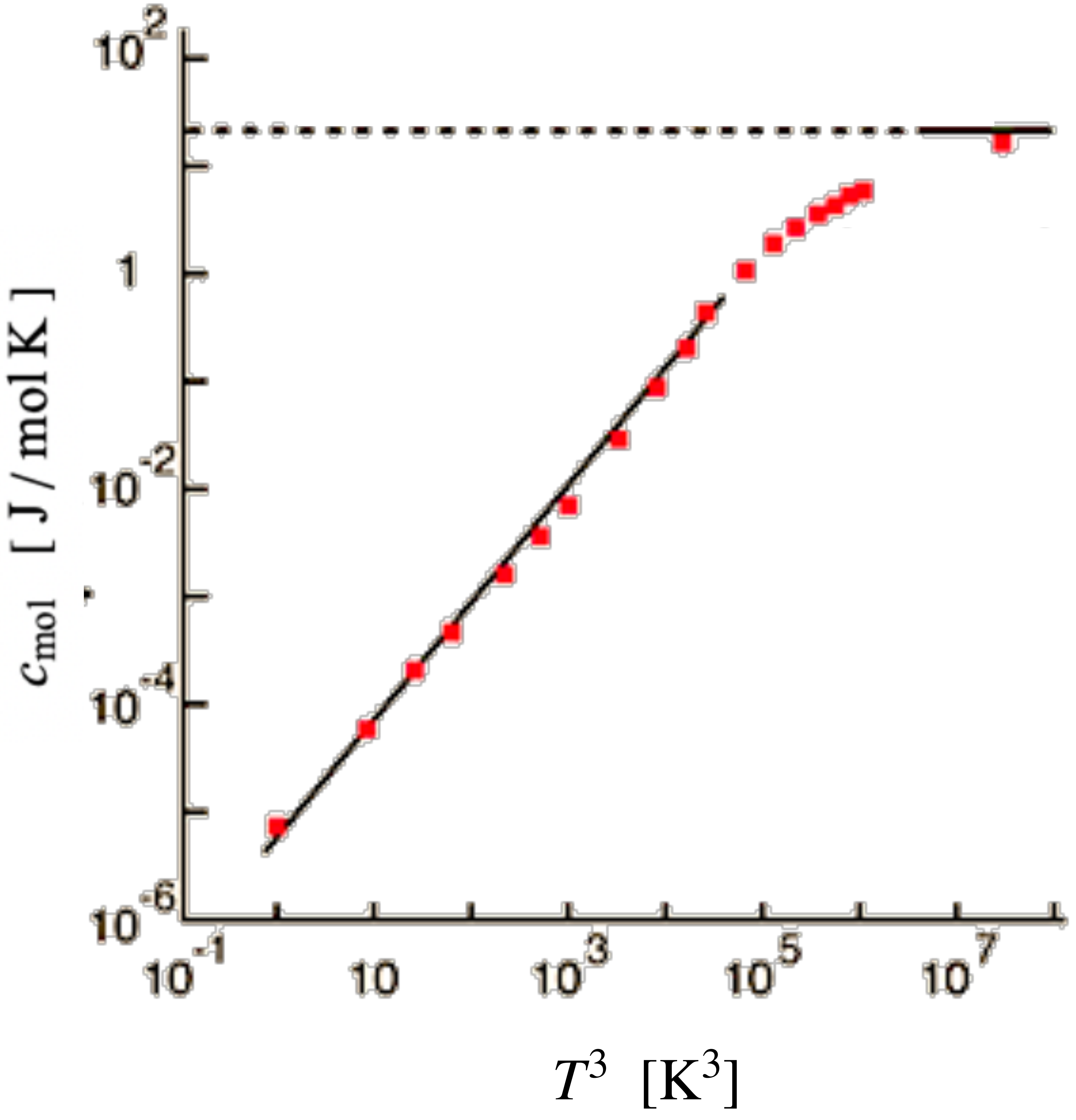


Figure 9 Experimental heat capacity values for potassium, plotted as C/T versus T^2. (After W. H. Lien and N. E. Phillips.)

Data: Kittel, chap. 6

Silicon



Copper

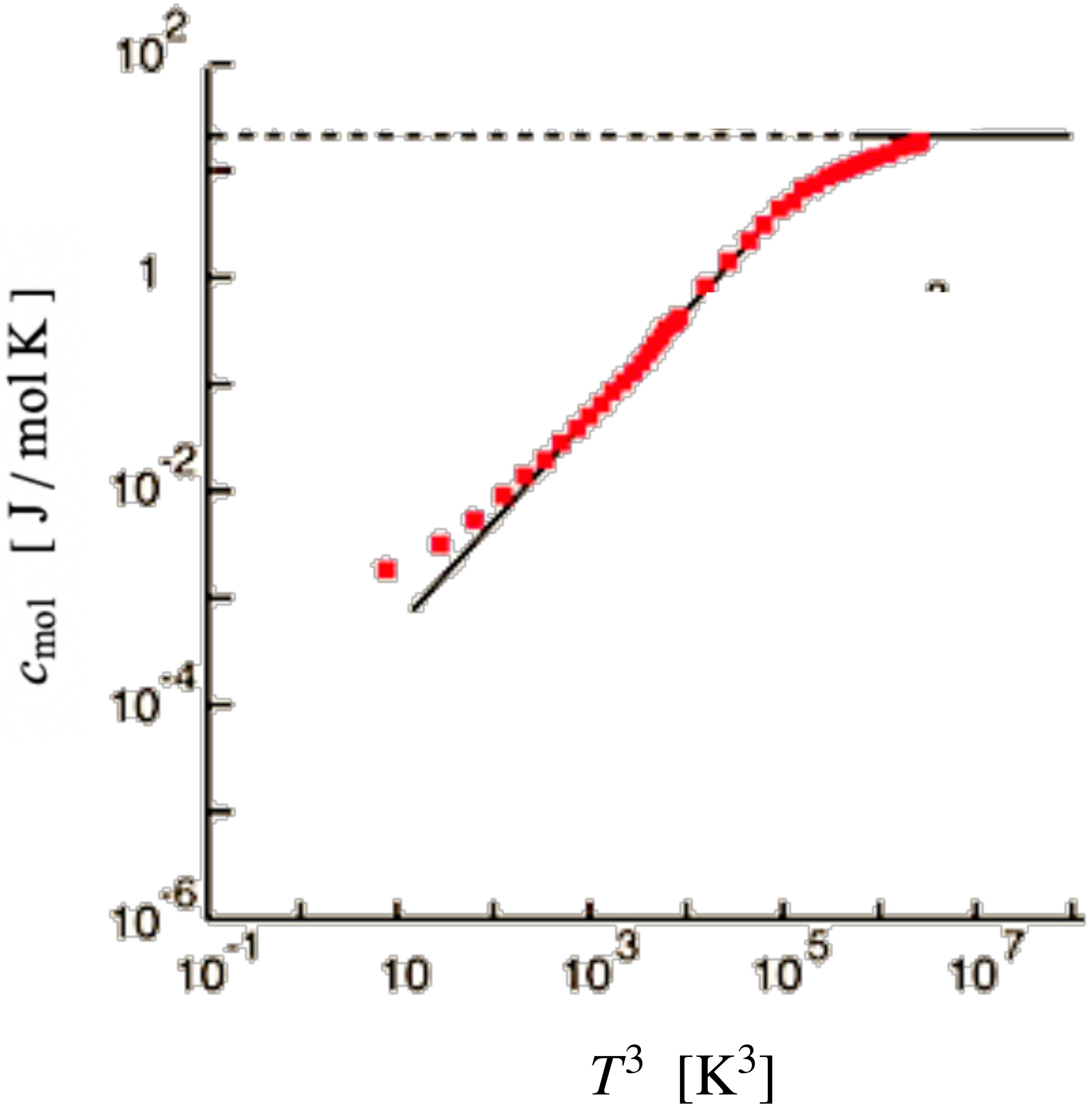


Image from: http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/Debye.html