and ytterbium appear to have a 6s band (containing about 1.5 electrons) which overlaps the 5d band (containing about 0.5 electron). A virtual 4f bound state model which had been proposed for cerium and ytterbium does not appear to be applicable to γ-Ce and ytterbium, but may be valid for α-Ce.

1. INTRODUCTION

A number of the physical properties from which we can obtain both direct and indirect information concerning the band structures of metals, have been measured for most of the rare earth metals. It was thought that it would be desirable to review and examine these data and try to tie them together. For this purpose the very low and room temperature heat capacities, Hall coefficients, magnetic susceptibilities, spectral data and electrical resistivities of these metals and some of their alloys were examined.

2. MAGNETIC MEASUREMENTS

The magnetic susceptibility measurements of the rare earth metals indicate directly the number of 4f electrons a particular element may have. By subtracting the number of 4f electrons from the number of electrons outside of the xenon rare gas core, one arrives at the number of electrons available for bonding, i.e. the number of valence electrons. Examination of the magnetic susceptibility data of the rare earth metals, as summarized by Arajs and Colvin [1] and Gschneidner [2], shows that all of the rare earth metals are trivalent, except for europium and ytterbium (which are divalent), and possibly cerium and samarium. A critical analysis of the magnetic behavior and other properties (metallic radii, diffuse neutron scattering values and Hall coefficients) of the cerium allotropes by Gschneidner and Smoluchowski [3] led them to conclude that the valence for both the normal face-centered cubic cerium (γ) and hexagonal cerium (β) is 3.05. For the collapsed face-centered cubic cerium (α) they found that the valence varies from 3.54 to 3.67 depending on the pressure and temperature. The room temperature magnetic susceptibility for samarium is in reasonable agreement with a $4f^5\ 5d^1\ 6s^2$ configuration (where the 5d and 6s electrons are the valence electrons), but the behaviors at both low and high temperatures cannot be explained by any simple model. [1, 4, 5, 6]

It should be noted that recent positron annihilation studies by Gustafson and Mackintosh [7] also confirm the trivalency of normal cerium (γ) and gadolinium, and the divalency of ytterbium.

3. VERY LOW TEMPERATURE SPECIFIC HEAT DATA

The specific heat of a metal in general is given

$$C_p = C_v^l + C_v^e + C_v^n + C_v^m + C^d \qquad (1)$$

where C_p is the heat capacity at constant pressure, the subscript v designates the heat capacity at constant volume, the superscript l refers to the lattice, e the electronic, n the nuclear and m the magnetic contributions to the specific heat

TABLE I. Electronic Specific Heat Constants [9]

Rare Earth	$\gamma \times 10^4$ (cal/g-at. deg.^{2})	Rare Earth	$\gamma \times 10^4$ (cal/g-at. deg.^{2})
La	24.1	Tb	21.6
α-Ce	138[a] (50.2)[b]	Dy	22.1
γ-, β-Ce	17.3 (25.1)[b]	Ho	62
Pr	52.3	Er	31
Nd	21.3 (53.7)[c]	Tm	47.1 (42.9)[d]
Pm	24	Yb	6.93
Sm	25.3	Lu	24.4
Eu	13.8 ± 2.4[b]	Sc	25.8
Gd	24[e]	Y	24.1

a. This paper, see text concerning α-Ce (Section 7.2).
b. After Lounasmaa, [10].
c. After Lounasmaa, [11].
d. After Lounasmaa, [12].
e. Estimated value.