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Status of the Lanthanides and Actinides in the Periodic Table.

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I. Introduction.

In extended discussions and correspondence with Ekkehard Fluck, I was made aware of a problem with the Periodic Table, i.e. which element should be shown in the main table as the representative of the lanthanide series and the actinide series. In earlier discussion, I came to the conclusion that lanthanium and actinium are not the elements which should appear, but rather lutetium and lawrencium are more appropriate for inclusion in their place. This paper will attempt to justify the reasons for the above conclusions.

II. Arguments for the Lanthanides.

Lev Landau[1] had made the point in 1948, that all elements in the platinum group have a complete 4f shell except for lanthanum, while lutetium also has a complete 4f shell.

On the basis of density data, the group 4 element density is the average of the density values for the group 3 and the group 5 elements to within 5% for the first two d–shells. This would imply that the group 3 element in the platinum group should have a density value of about 10. Lutetium, with a density value of 9.4, is much closer to following this pattern than is lanthanum, with a density value of 6.15.

In terms of crystalline structure[2], it is noted that scandium, yttrium and lutetium all have a hexagonal close–packed crystalline structure at room temperature, while lanthanum has a double c–axis hexagonal close–packed structure. In addition, the sesquioxides of scandium, yttrium and lutetium have a different crystalline structure from that of lanthanum.

The melting points[2] for scandium, at 1541°C, yttrium, at 1522°C, and lutetium, at 1663°C, are about 50% larger than the melting point for lanthanum, at 918°C. At normal pressures, scandium, yttrium and lutetium are not superconducting[3], while lanthanum is superconducting. In terms of some other physical quantities[4], the shear modulus and the Young's modulus data for scandium, yttrium and lutetium are a factor of two larger than the corresponding values of these quantities for lanthanum. For the coefficient of thermal expansion[2], the values of scandium, yttrium and lutetium are about the same, while the value for the

coefficient for lanthanum is about 20% larger than the others.

II. Arguments for the Actinides.

The physiciochemical data for the actinides similar to the data analyzed above for the lanthanide elements are not available. However, by analogy I would argue that the same situation should hold for these elements.

III. Conclusions.

The strongest argument in my estimation is that of Landau. In both the case of lutetium and lawrencium, the group elements have $4f^{14}$ and $5f^{14}$ configurations, respectively. Neither lanthanum nor actinium would be appropriate group members as a result.

IV. Acknowledgement.

This problem was first brought to my attention by Ekkehard Fluck. His persistence in seeking an answer to the problem forced me to find data to support my position. The above analysis is directly due to his refusal to accept an off-the-top-of-the-head estimate of which elements were the appropriate candidates for inclusion in the main table.

V. References.

1. L.Landau and E.Lifshitz, Course of Theoretical Physics, volume 3, 245 (1958). translated by J.B.Sykes and J.S.Bell, Addison-Wesley Publishing Co, Mass. USA.
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