Solutions Manual for *Modern Physical Metallurgy*, Eighth Edition

Chapter 1

[1.1] (i) K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni

(ii) K^+ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$
Br^- $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$

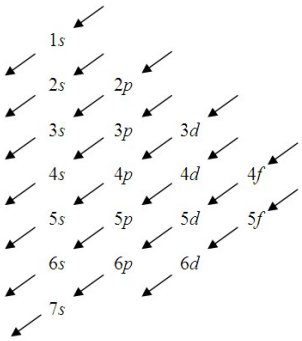
[1.2] The electronic configurations of the Lanthanides are as follows:

	Z	1 *s*	2 *s*	2 *p*	3 *s*	3 *p*	3 *d*	4 *s*	4 *p*	4 *d*	4*f*	5 *s*	5 *p*	5 *d*	5 *f*	6 *s*	6 *p*	6 *d*	6 *f*
La	57	2	2	6	2	6	10	2	6	10		2	6	1		2			
Ce	58	2	2	6	2	6	10	2	6	10	2	2	6			2			
Pr	59	2	2	6	2	6	10	2	6	10	3	2	6			2			
Nd	60	2	2	6	2	6	10	2	6	10	4	2	6			2			
Pm	61	2	2	6	2	6	10	2	6	10	5	2	6			2			
Sm	62	2	2	6	2	6	10	2	6	10	6	2	6			2			
Eu	63	2	2	6	2	6	10	2	6	10	7	2	6			2			
Gd	64	2	2	6	2	6	10	2	6	10	7	2	6	1		2			
Tb	65	2	2	6	2	6	10	2	6	10	8	2	6	1		2			
Dy	66	2	2	6	2	6	10	2	6	10	10	2	6			2			
Ho	67	2	2	6	2	6	10	2	6	10	11	2	6			2			
Er	68	2	2	6	2	6	10	2	6	10	12	2	6			2			
Tm	69	2	2	6	2	6	10	2	6	10	13	2	6			2			
Yb	70	2	2	6	2	6	10	2	6	10	14	2	6			2			
Lu	71	2	2	6	2	6	10	2	6	10	14	2	6	1		2			

Those of the Actinides are:

	Z	1 *s*	2 *s*	2 *p*	3 *s*	3 *p*	3 *d*	4 *s*	4 *p*	4 *d*	4*f*	5 *s*	5 *p*	5 *d*	5*f*	6 *s*	6 *p*	6 *d*	6 *f*	7 *s*
Ac	89	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	1		2
Th	90	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	2		2
Pa	91	2	2	6	2	6	10	2	6	10	14	2	6	10	2	2	6	1		2
U	92	2	2	6	2	6	10	2	6	10	14	2	6	10	3	2	6	1		2
Np	93	2	2	6	2	6	10	2	6	10	14	2	6	10	5	2	6			2
Pu	94	2	2	6	2	6	10	2	6	10	14	2	6	10	6	2	6			2
Am	95	2	2	6	2	6	10	2	6	10	14	2	6	10	7	2	6			2
Cm	96	2	2	6	2	6	10	2	6	10	14	2	6	10	7	2	6	1		2
Bk	97	2	2	6	2	6	10	2	6	10	14	2	6	10	7	2	6	2		2
Cf	98	2	2	6	2	6	10	2	6	10	14	2	6	10	9	2	6	1		2
Es	99	2	2	6	2	6	10	2	6	10	14	2	6	10	11	2	6			2
Fm	100	2	2	6	2	6	10	2	6	10	14	2	6	10	12	2	6			2
Md	101	2	2	6	2	6	10	2	6	10	14	2	6	10	13	2	6			2
No	102	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6			2
Lr	103	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	1		2

The filling of the shells basically follows the order below, with a few exceptions:



In Gd, Cm and Bk, maintaining a half-filled state of the outermost *f* shell by 7 electrons is preferred. The other deviations from the above rule are due to the proximity of energies between the shells.

[1.3] (i) $F = \dfrac{dU}{dr} = \dfrac{1.436}{r^2} - \dfrac{8\times 7.32\times 10^{-6}}{r^9}$ eV/nm.

At equilibrium, $\dfrac{1.436}{r_o^2} = \dfrac{8\times 7.32\times 10^{-6}}{r_o^9}$

$r_o^7 = 4.078\times 10^{-5}$ nm

$r_o = 0.236\,\text{nm}$

(ii) Young's modulus $E = \dfrac{1}{r_o}\left(\dfrac{d^2U}{dr^2}\right)_{r_o} = \dfrac{1}{r_o}\left(\dfrac{-2\times 1.436}{r_o^3} + \dfrac{9\times 8\times 7.32\times 10^{-6}}{r_o^{10}}\right)$

$= 3241$ eV/nm^3

$= 3241\times 1.6\times 10^{-19}\times 10^{27} = 5.2\times 10^{11}\,\text{Pa}$.

(iii) Bonding energy per ion pair:

$U_o = -\dfrac{1.436}{0.236} + \dfrac{7.32\times 10^{-6}}{(0.236)^8} = -6.08 + 0.76 = -5.3\,\text{eV}$.

[1.4] (i) $F = \dfrac{b}{r^2} - \dfrac{c}{r^{10}}$ and at equilibrium, $\dfrac{b}{r_o^2} = \dfrac{c}{r_o^{10}}$, so $r_o^8 = c/b = \dfrac{1.8\times 10^{-105}}{1.2\times 10^{-28}}$

$r_o = (1.5\times 10^{-77})^{1/8} = 2.49\times 10^{-10}\,\text{m}$.

(ii) $\displaystyle\int_{r_o}^{\infty}\left(\frac{b}{r^2} - \frac{c}{r^{10}}\right)dr = \left[-\frac{b}{r} + \frac{c}{9r^9}\right]_{r_o}^{\infty} = \frac{b}{r_o} - \frac{c}{9r_o^9}$

$= \dfrac{1.2\times 10^{-28}}{2.49\times 10^{-10}} - \dfrac{1.8\times 10^{-105}}{9\times (2.49\times 10^{-10})^9} = 4.3\times 10^{-19}\,\text{J} = 2.7\,\text{eV}$.

(iii) Properties include lattice parameter (XRD) and heat of sublimation (calorimetry).

[1.5] Consider the tensile pulling of a crystal with unit cross-section by stress σ as shown. The linking bonds are stretched from the initial length r_0 to r as a result.