Key for Practice Problem for AVEE

The table below gives the valence shell ionization energies and electron configurations for the first 10 transition metals. Note that the electron configurations use a short-hand notation that identifies the core electrons by using the symbol for the appropriate nobel gas. Note, also, that the electron configurations for Cr and Cu are unusual. The AVEE for scandium is shown. Complete the table and comment on any interesting trends you see in the results.

metal	IE_{4s} (kJ/mol)	IE_{3d} (kJ/mol)	electron configuration	AVEE (kJ/mol)
Sc	630	770	[Ar]$4s^2 3d^1$	677
Ti	680	959	[Ar]$4s^2 3d^2$	820
V	707	1158	[Ar]$4s^2 3d^3$	978
Cr	652	836	[Ar]$4s^1 3d^5$	805
Mn	764	1380	[Ar]$4s^2 3d^5$	1204
Fe	805	1418	[Ar]$4s^2 3d^6$	1265
Co	644	1525	[Ar]$4s^2 3d^7$	1329
Ni	867	1640	[Ar]$4s^2 3d^8$	1486
Cu	745	1027	[Ar]$4s^1 3d^{10}$	1001
Zn	906	1669	[Ar]$4s^2 3d^{10}$	1542

The general trend in AVEE values for the first row of transition metals is an increase as we move from scandium, Sc, to zinc, Zn. The two noticeable exceptions to this trend are chromium, Cr, for which the AVEE is less than that for vanadium, V, and copper, Cu, for which the AVEE is less than that for nickel, Ni. Chromium and copper, of course, are the two cases where a $4s$ electron shifts into the $3d$ orbital. It appears that there is a special stability provided by a half-filled or completely filled $3d$-orbital.