Additional Problem for Average Valence Electron Energies

The table of AVEE values provided in class did not include data for transition metals beyond scandium because determining precise gas phase ionization energies for a transition metal's valence electrons are experimentally less precise. Despite the lack of precision, data does exist for these elements and is provided in the table below. Complete the table by writing the valence shell electron configuration using the noble gas shorthand for the core electrons and calculating the AVEE. Comment on any interesting trends you see in the results.

metal	4*s* (kJ/mol)	3*d* (kJ/mol)	electron configuration	AVEE (kJ/mol)
scandium	630	770	[Ar]$4s^2 3d^1$	677
titanium	680	959	[Ar]$4s^2 3d^2$	820
vanadium	707	1158	[Ar]$4s^2 3d^3$	978
chromium	652	836	[Ar]$4s^1 3d^5$	805
manganese	764	1380	[Ar]$4s^2 3d^5$	1204
iron	805	1418	[Ar]$4s^2 3d^6$	1265
cobalt	644	1525	[Ar]$4s^2 3d^7$	1329
nickel	867	1640	[Ar]$4s^2 3d^8$	1486
copper	745	1027	[Ar]$4s^1 3d^{10}$	1001
zinc	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 4*s* electron shifts into the 3*d* orbital.