

# The Weird Ones

aka, the Transition Metals

Sc	$[\text{Ar}]4s^23d^1$
Ti	$[\text{Ar}]4s^23d^2$
V	$[\text{Ar}]4s^23d^3$
Cr	$[\text{Ar}]4s^13d^5$
Mn	$[\text{Ar}]4s^23d^5$
Fe	$[\text{Ar}]4s^23d^6$
Co	$[\text{Ar}]4s^23d^7$
Ni	$[\text{Ar}]4s^23d^8$
Cu	$[\text{Ar}]4s^13d^{10}$
Zn	$[\text{Ar}]4s^23d^{10}$

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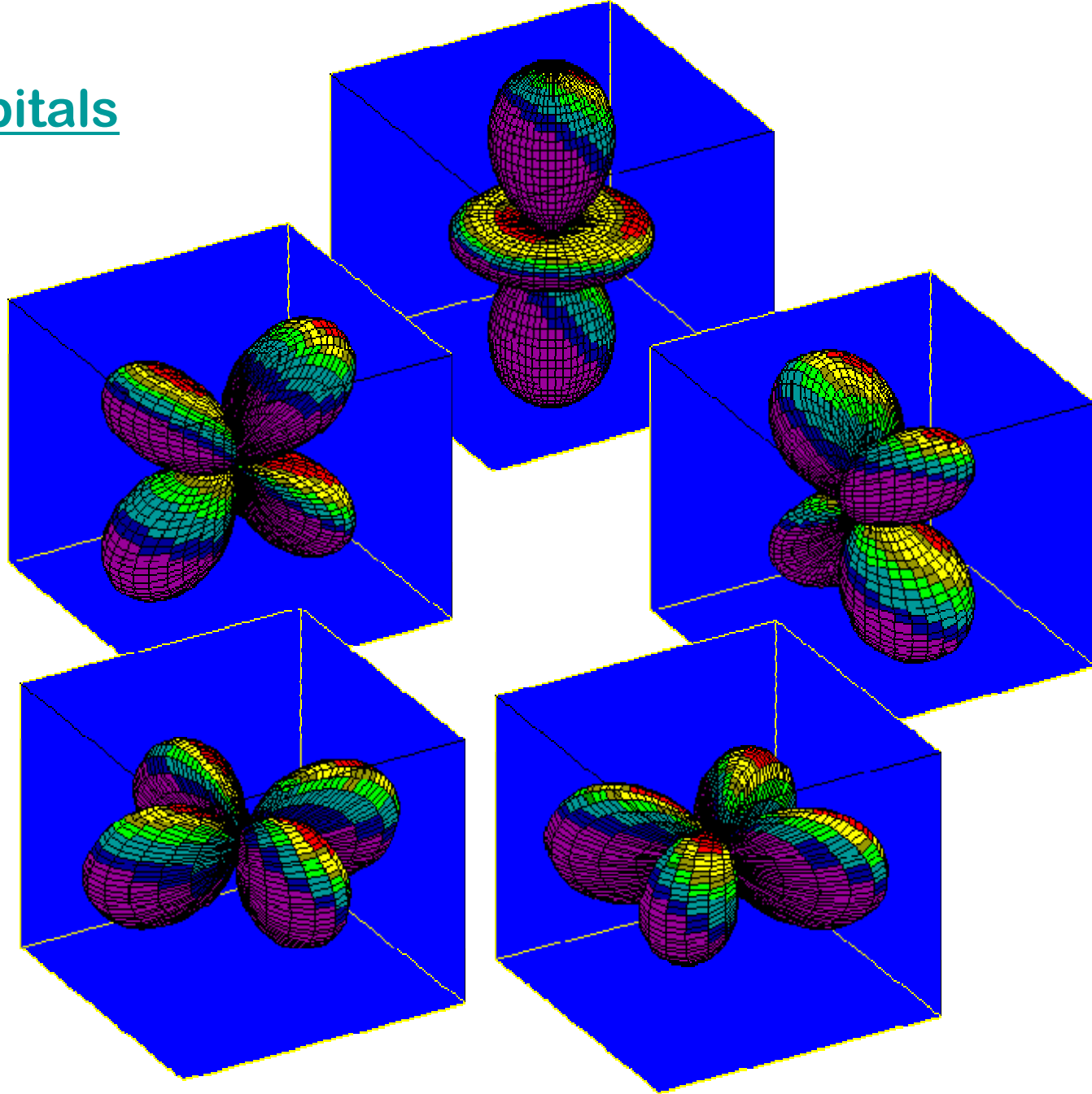
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**A half-full or full 3d orbital is better\* than a full 4s orbital!**

**\*more stable, or lower energy**

## 3d orbitals



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Sc	$[\text{Ar}]4s^23d^1$	Y	$[\text{Kr}]5s^24d^1$
Ti	$[\text{Ar}]4s^23d^2$	Zr	$[\text{Kr}]5s^24d^2$
V	$[\text{Ar}]4s^23d^3$	<b>Nb</b>	<b><math>[\text{Kr}]5s^14d^4</math></b>
<b>Cr</b>	<b><math>[\text{Ar}]4s^13d^5</math></b>	<b>Mo</b>	<b><math>[\text{Kr}]5s^14d^5</math></b>
Mn	$[\text{Ar}]4s^23d^5$	Tc	$[\text{Kr}]5s^24d^5$
Fe	$[\text{Ar}]4s^23d^6$	<b>Ru</b>	<b><math>[\text{Kr}]5s^14d^7</math></b>
Co	$[\text{Ar}]4s^23d^7$	<b>Rh</b>	<b><math>[\text{Kr}]5s^14d^8</math></b>
Ni	$[\text{Ar}]4s^23d^8$	<b>Pd</b>	<b><math>[\text{Kr}] 4d^{10}</math></b>
<b>Cu</b>	<b><math>[\text{Ar}]4s^13d^{10}</math></b>	<b>Ag</b>	<b><math>[\text{Kr}]5s^14d^{10}</math></b>
Zn	$[\text{Ar}]4s^23d^{10}$	Cd	$[\text{Kr}]5s^24d^{10}$

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- Some of the electrons in the d-orbitals can act as valence electrons
- The 5s and 4d energy levels are very close
- ! Some can form ions with different charges
- ! Some have multiple oxidation numbers

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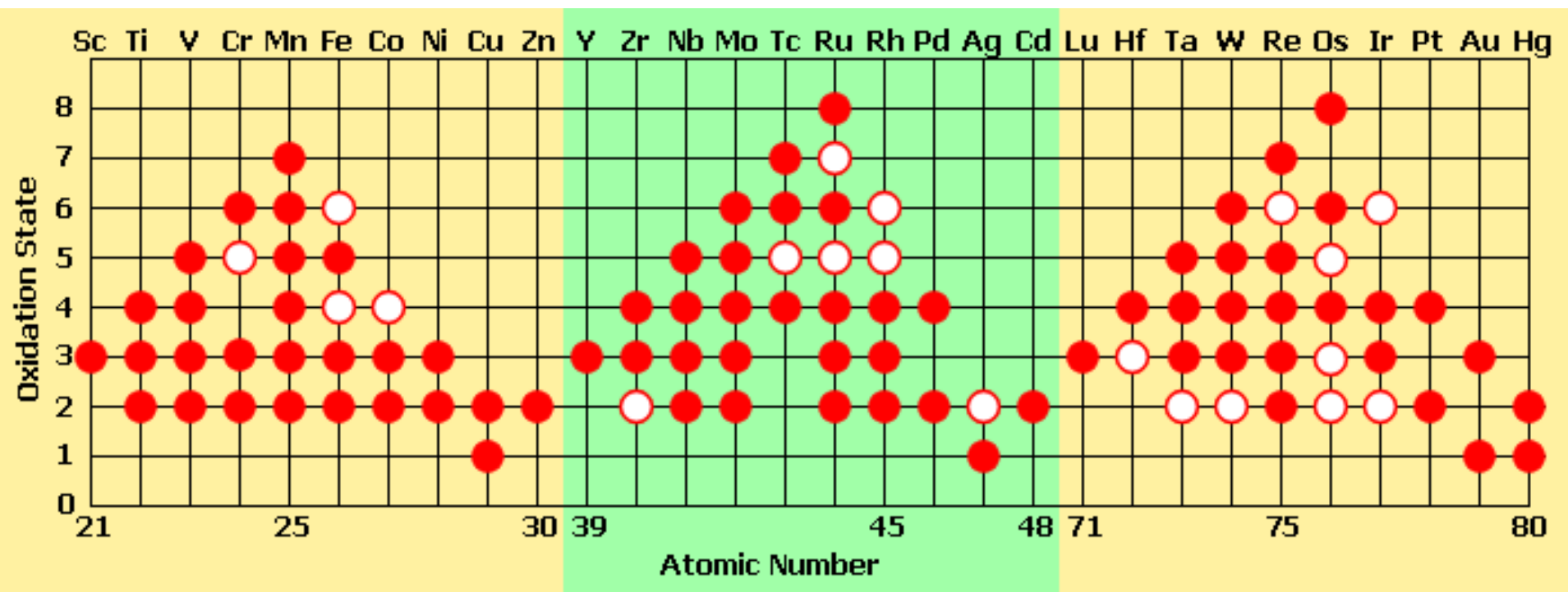
Sc	$[\text{Ar}]4s^23d^1$			$\text{Sc}^{3+}$
Ti	$[\text{Ar}]4s^23d^2$			
V	$[\text{Ar}]4s^23d^3$		$\text{V}^{2+}$	
Cr	$[\text{Ar}]4s^13d^5$			$\text{Cr}^{3+}$
Mn	$[\text{Ar}]4s^23d^5$		$\text{Mn}^{2+}$	
Fe	$[\text{Ar}]4s^23d^6$		$\text{Fe}^{2+}$	$\text{Fe}^{3+}$
Co	$[\text{Ar}]4s^23d^7$		$\text{Co}^{2+}$	$\text{Co}^{3+}$
Ni	$[\text{Ar}]4s^23d^8$		$\text{Ni}^{2+}$	
Cu	$[\text{Ar}]4s^13d^{10}$	$\text{Cu}^+$	$\text{Cu}^{2+}$	
Zn	$[\text{Ar}]4s^23d^{10}$		$\text{Zn}^{2+}$	

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Sc	$[\text{Ar}]4s^23d^1$		Sc(III)
Ti	$[\text{Ar}]4s^23d^2$		
V	$[\text{Ar}]4s^23d^3$	V(II)	
Cr	$[\text{Ar}]4s^13d^5$		Cr(III)
Mn	$[\text{Ar}]4s^23d^5$	Mn(II)	
Fe	$[\text{Ar}]4s^23d^6$	Fe(II)	Fe(III)
Co	$[\text{Ar}]4s^23d^7$	Co(II)	Co(III)
Ni	$[\text{Ar}]4s^23d^8$	Ni(II)	
Cu	$[\text{Ar}]4s^13d^{10}$	Cu(I)	Cu(II)
Zn	$[\text{Ar}]4s^23d^{10}$	Zn(II)	

# Multiple Oxidation Numbers





# Historical Note

	Lower Charge <i>latin root + ous</i>	Higher Charge <i>latin root + ic</i>
Fe	Fe(II) = Ferrous	Fe(III) = Ferric
Cu	Cu(I) = Cuprous	Cu(II) = Cupric
Sn	Sn(II) = Stannous	Sn(IV) = Stannic

**Ferric Oxide**  
**Stannous Fluoride**