Electronic Configurations of Ions
Representative Elements

P When atoms form ions, electrons are gained or lost in the valence shell.

P To form an anion, electrons are added to the lowest energy available orbitals.

$_{9}F$	$1s^2 2s^2 2p^5$	F^-	$1s^2 2s^2 2p^6 = [Ne]$
$_{8}O$	$1s^2 2s^2 2p^4$	O^{2-}	$1s^2 2s^2 2p^6 = [Ne]$
$_{7}N$	$1s^2 2s^2 2p^3$	N^{3-}	$1s^2 2s^2 2p^6 = [Ne]$

P To form a cation of a non-transition element, electrons are lost from the highest-energy occupied orbitals.

$_{11}Na$	$[Ne]3s^1$	Na^+	$[Ne]3s^0 = [Ne]$
$_{12}Mg$	$[Ne]3s^2$	Mg^{2+}	$[Ne]3s^0 = [Ne]$
$_{13}Al$	$[Ne]3s^2 3p^1$	Al^{3+}	$[Ne]3s^0 = [Ne]$
$_{31}Ga$	$[Ar]3d^{10} 4s^2 4p^1$	Ga^{3+}	$[Ar]3d^{10}$

U Cations of elements in groups 13, 14, and 15 in the fourth or higher periods do not have noble gas configurations, because they have completely filled *nd* subshells.

Electronic Configurations of Ions
Heavy Elements in Groups 13, 14, 15

P Heavier elements in these groups sometimes form cations with charges two less than the group-characteristic charge. In these cases the ns^2 electrons of the valence configuration are retained:

$_{81}$Tl [Xe]$4f^{14}5d^{10}6s^26p^1$ $\quad$ Tl^+ [Xe]$4f^{14}5d^{10}6s^2$ = [Hg]
Tl^{3+} [Xe]$4f^{14}5d^{10}$ = [Hg^{2+}]

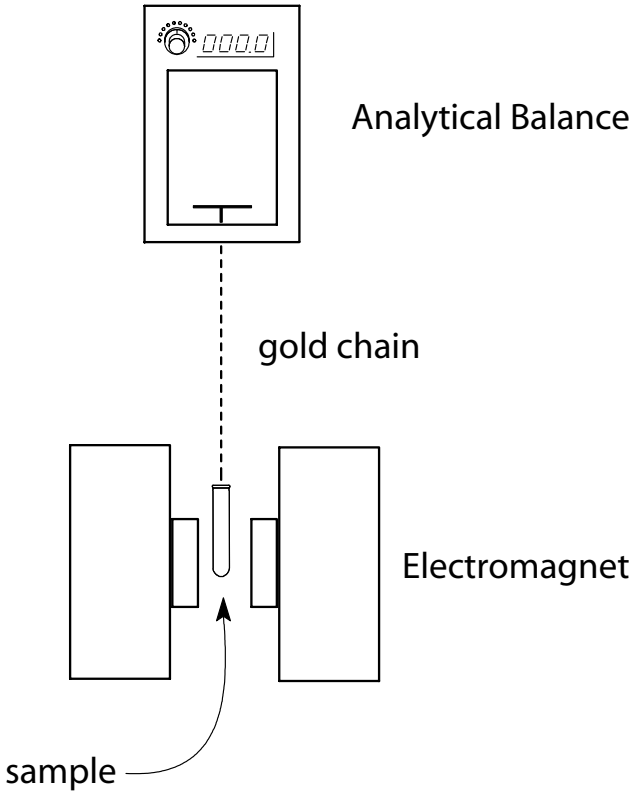
Electronic Configurations of Transition Metal Cations

P When forming cations of transition elements, ***the outermost ns electrons are lost before any electrons in the (n - 1)d subshell***.

$_{26}Fe$	$[Ar]3d^6 4s^2$	Fe^{2+}	$[Ar]3d^6$
		Fe^{3+}	$[Ar]3d^5$
$_{29}Cu$	$[Ar]3d^{10} 4s^1$	Cu^{+}	$[Ar]3d^{10}$
		Cu^{2+}	$[Ar]3d^9$

Magnetic Properties and Electronic Structure

U The magnetic properties of a substance can be measured with apparatus such as the **Gouy balance**.



P Paired electrons in a substance cause a weak repulsion for the magnetic field, due to an induced magnetic moment, making the sample appear to be lighter.

P Unpaired electrons have a permanent magnetic moment, which is attracted to the magnetic field, making the sample appear to be heavier.

Diamagnetic or Paramagnetic

$_{10}$Ne $1s^2 2s^2 2p^6$ all paired Y diamagnetic

$_{11}$Na $1s^2 2s^2 2p^6 3s^1$ one unpaired electron Y paramagnetic

$_{9}$F $1s^2 2s^2 2p^5$ one unpaired electron Y paramagnetic

$_{29}$Cu [Ar]$3d^{10} 4s^1$ one unpaired electron Y paramagnetic

$_{30}$Zn [Ar]$3d^{10} 4s^2$ all paired Y diamagnetic

U Atoms with even numbers of electrons are not necessarily diamagnetic:

$_{8}$O $1s^2 2s^2 2p^4$ ¼¿ ¼ ¼

2 unpaired Y paramagnetic

$_{26}$Fe [Ar]$3d^6 4s^2$ ¼¿ ¼ ¼ ¼ ¼

4 unpaired Y paramagnetic

Diamagnetism and Paramagnetism of Ions

U All ions that have an electronic structure isoelectronic with one of the noble gases or have any other closed-subshell configuration are diamagnetic.

O^{2-} = [Ne] Cl^{-} = [Ar]
Na^{+} = [Ne] Mg^{2+} = [Ne]
$Ga^{3+} = [Ar]3d^{10}$ $Tl^{+} = [Xe]4f^{14}5d^{10}6s^{2}$

U Transition element ions are most often paramagnetic, because they have incompletely filled *d* subshells.

Fe^{2+} $[Ar]3d^{6}$ ¼¿ ¼ ¼ ¼ ¼

4 unpaired Y paramagnetic

Fe^{3+} $[Ar]3d^{5}$ ¼ ¼ ¼ ¼ ¼

5 unpaired Y paramagnetic