H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

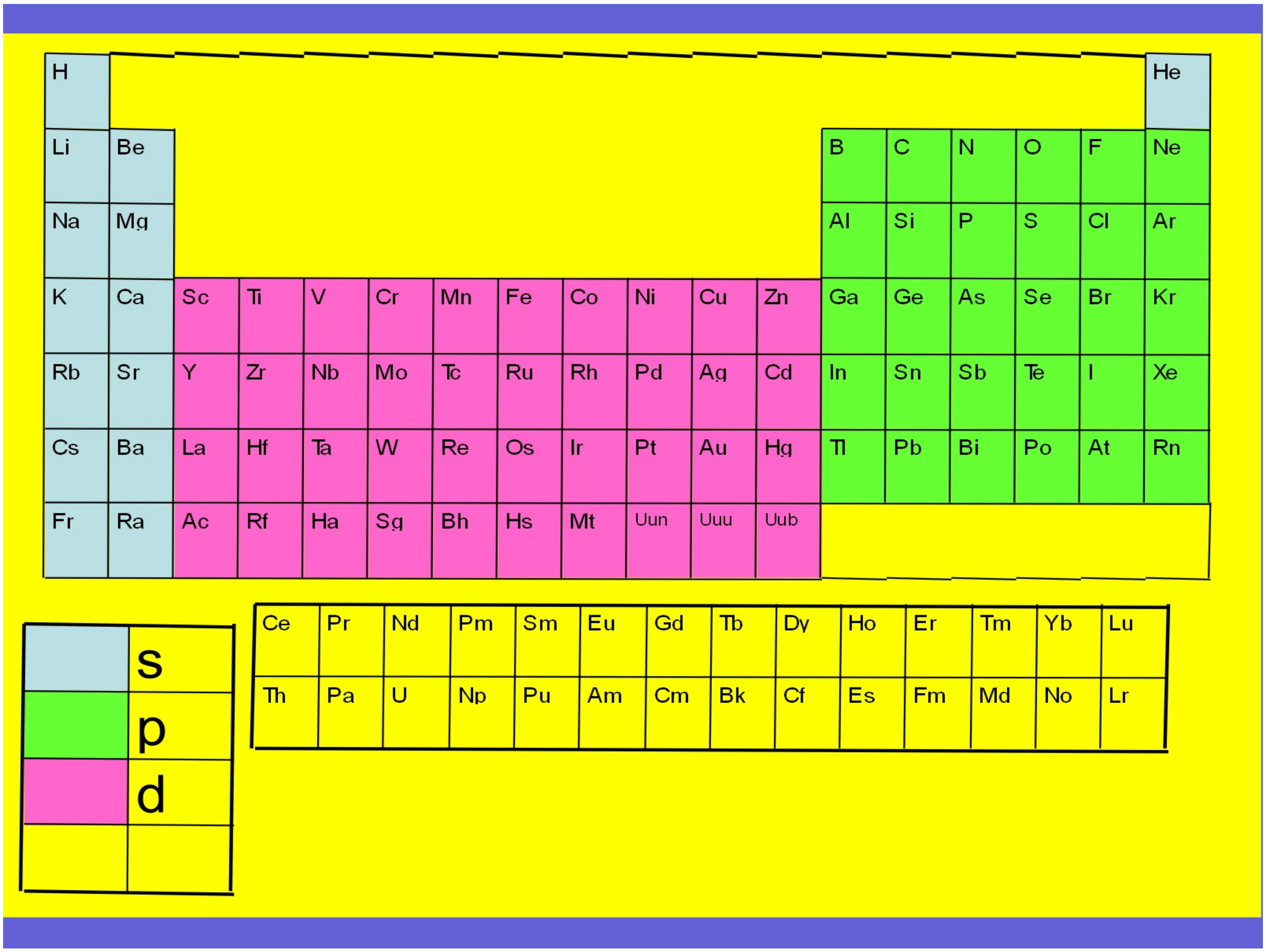
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

	S

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

	s
	p

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr


H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Ac Rf Ha Sg Bh Hs Mt Uun Uuu Uub
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr
s
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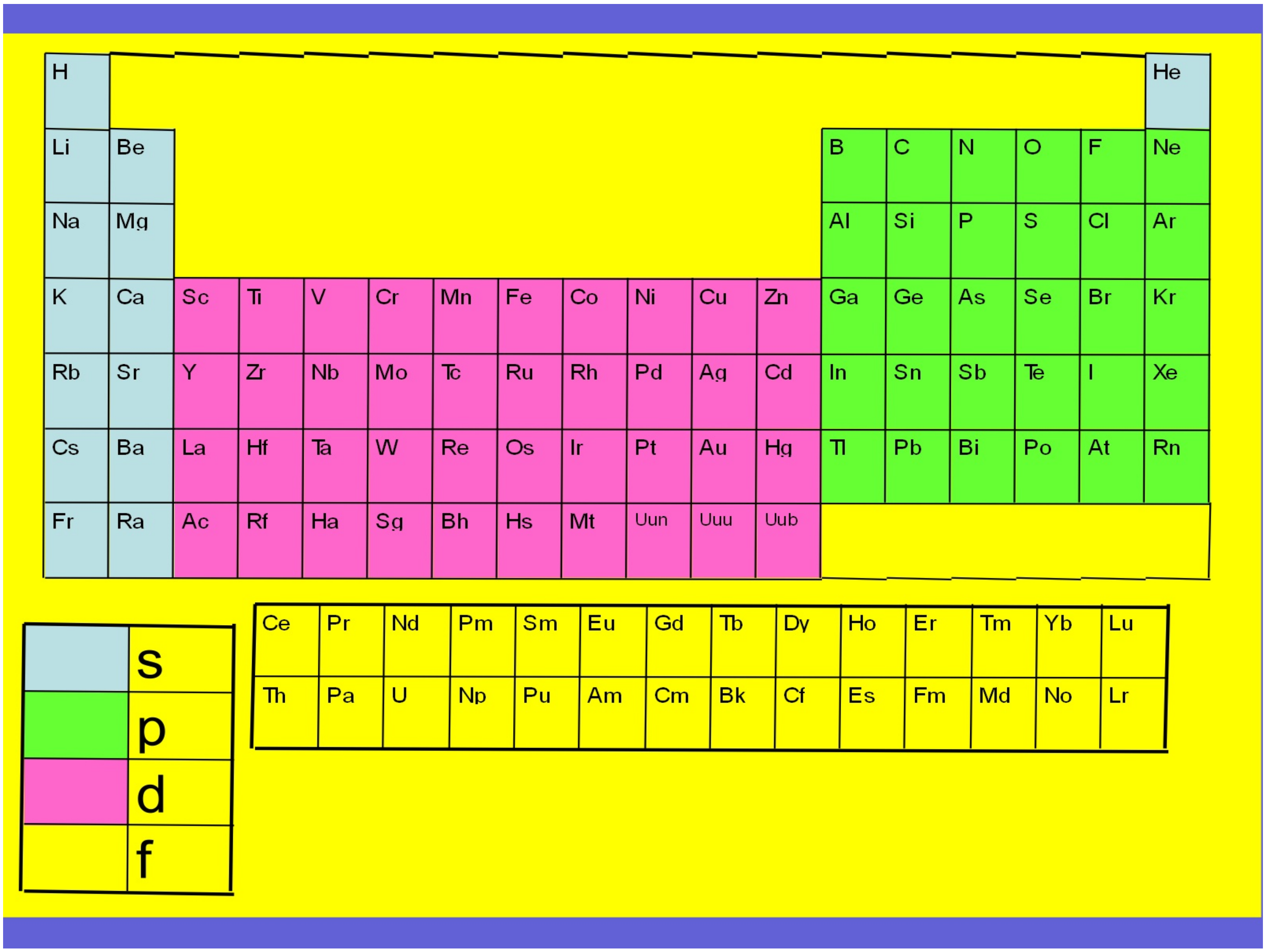
H He
Li Be B C N O F Ne
Na Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Ac Rf Ha Sg Bh Hs Mt Uun Uuu Uub
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr
s
p
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f

1	H																	He
2	Li	Be											B	C	N	O	F	Ne
3	Na	Mg											Al	Si	P	S	Cl	Ar
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6	Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7	Fr	Ra	Ac	Rf	Ha	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

s
p
d
f

Electron Configurations (2.3.4 & 12.1.6)

- It is helpful to know how the electrons are arranged within an atom.
  - This explains and predicts much of the chemistry involved, such as reactions that will occur and ions that will be formed.
- Energy levels –
  - Horizontal rows correspond to energy levels
  - 1-7

- Energy Sublevels (s,p,d,f) (12.1.3)
  - Within each energy level are sublevels (12.1.4)
  - Energy level 1 has s only.
  - Energy level 2 has s and p.
  - Energy level 3 has s, p, and d.
  - Energy levels 4 and above have s, p, d, and f.
- Orbitals – contain up to 2 electrons each.
  - s sublevels have 1 orbital
  - p sublevels have 3 orbitals
  - d sublevels have 5 orbitals
  - f sublevels have 7 orbitals

Writing Electron Configurations

Examples – write electron congurations:

1 O
2 Al
3 Cl
4 Ni
5 Fe^{2+}
6 F^-

Orbital Filling Diagrams

- This is a visual representation of an electron configuration:
  - Each orbital is represented by a box (□)
  - Each electron is represented by an arrow (□ or □)
  - All orbitals in the same sublevel are drawn together (ex. 3p □□□)

Hund's Rule

- An electron configuration tells us in which orbitals the electrons for an element are located.
- Three rules:
- electrons fill orbitals starting with lowest *n* and moving upwards;
- no two electrons can fill one orbital with the same spin (**Pauli Exclusion Principle**);
- for degenerate orbitals, electrons fill each orbital singly before any orbital gets a second electron (**Hund's rule**).

Examples

Draw orbital filling diagrams:

1 O

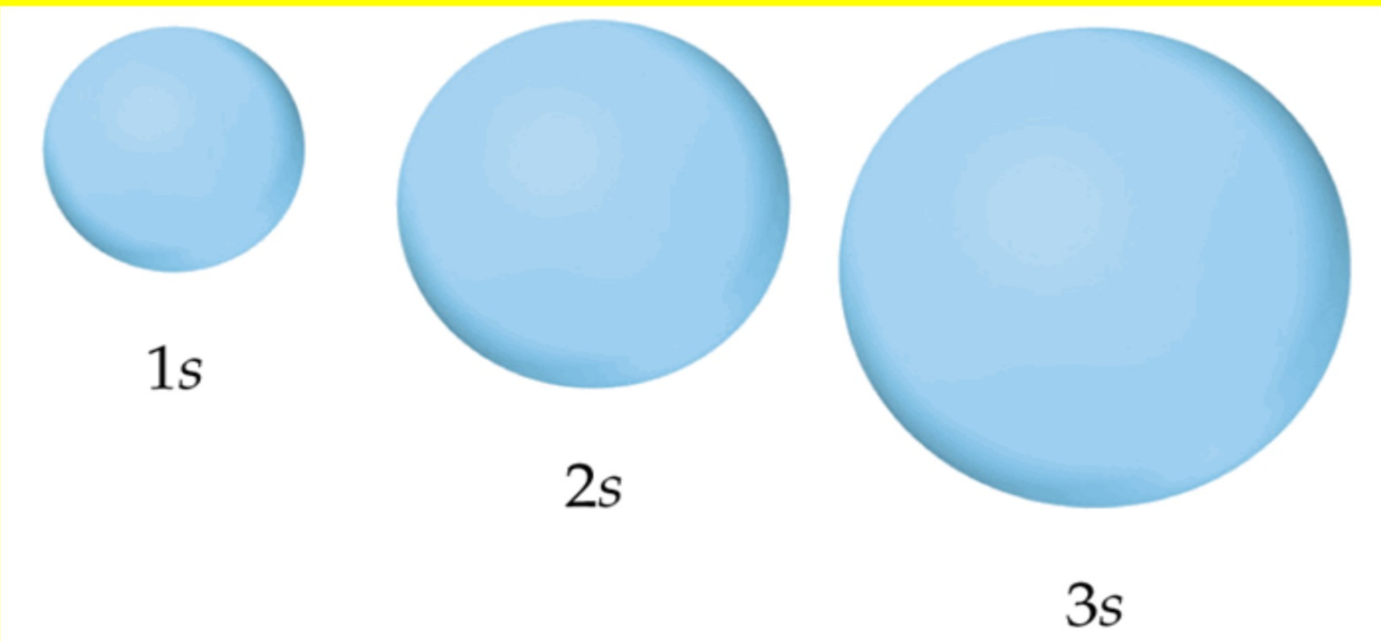
2 Al

3 Cl

4 Ni

Representations of Orbitals (12.1.5)

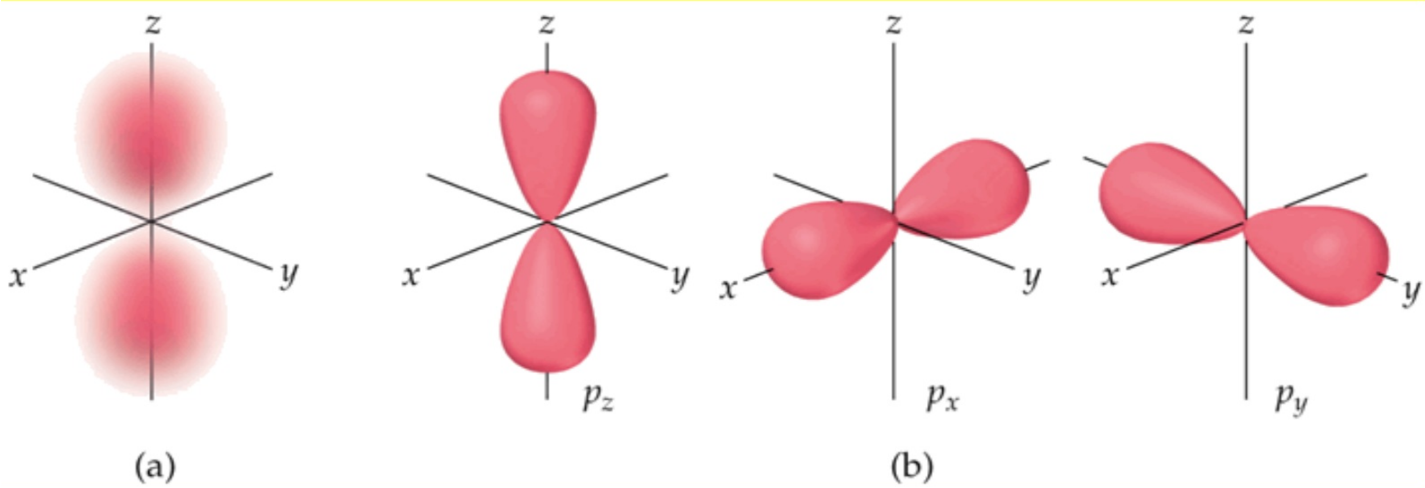
The s-Orbitals



The p-Orbitals

- There are three *p*-orbitals p_x, p_y, and p_z.
- The three *p*-orbitals lie along the *x*-, *y*- and *z*- axes of a Cartesian system.
- The letters correspond to allowed values of m_l of -1, 0, and +1.
- The orbitals are dumbbell shaped.
- As *n* increases, the *p*-orbitals get larger.
- All *p*-orbitals have a node at the nucleus.

The p-Orbitals



Ionization Energy

- The first ionization energy, I_1, is the amount of energy required to remove an electron from a gaseous atom:

$$Na(g) \longrightarrow Na^{+}(g) + e^{-}.$$

- The second ionization energy, I_2, is the energy required to remove an electron from a (+1) gaseous ion:

$$Na^{+}(g) \longrightarrow Na^{2+}(g) + e^{-}.$$

- The larger ionization energy, the more difficult it is to remove the electron.

Variations in Successive Ionization Energies (12.1.1 & 12.1.2)

TABLE 7.2 Successive Values of Ionization Energies, *I*, for the Elements Sodium through Argon (kJ/mol)

Element	I_1	I_2	I_3	I_4	I_5	I_6	I_7
Na	496	4560			(inner-shell electrons)		
Mg	738	1450	7730				
Al	578	1820	2750	11,600			
Si	786	1580	3230	4360	16,100		
P	1012	1900	2910	4960	6270	22,200	
S	1000	2250	3360	4560	7010	8500	27,100
Cl	1251	2300	3820	5160	6540	9460	11,000
Ar	1521	2670	3930	5770	7240	8780	12,000

- Notice that I_1 values show the existence of energy levels and sublevels.
- Notice where ionization energy "jumps" for each individual element. How is this related to electron configuration?