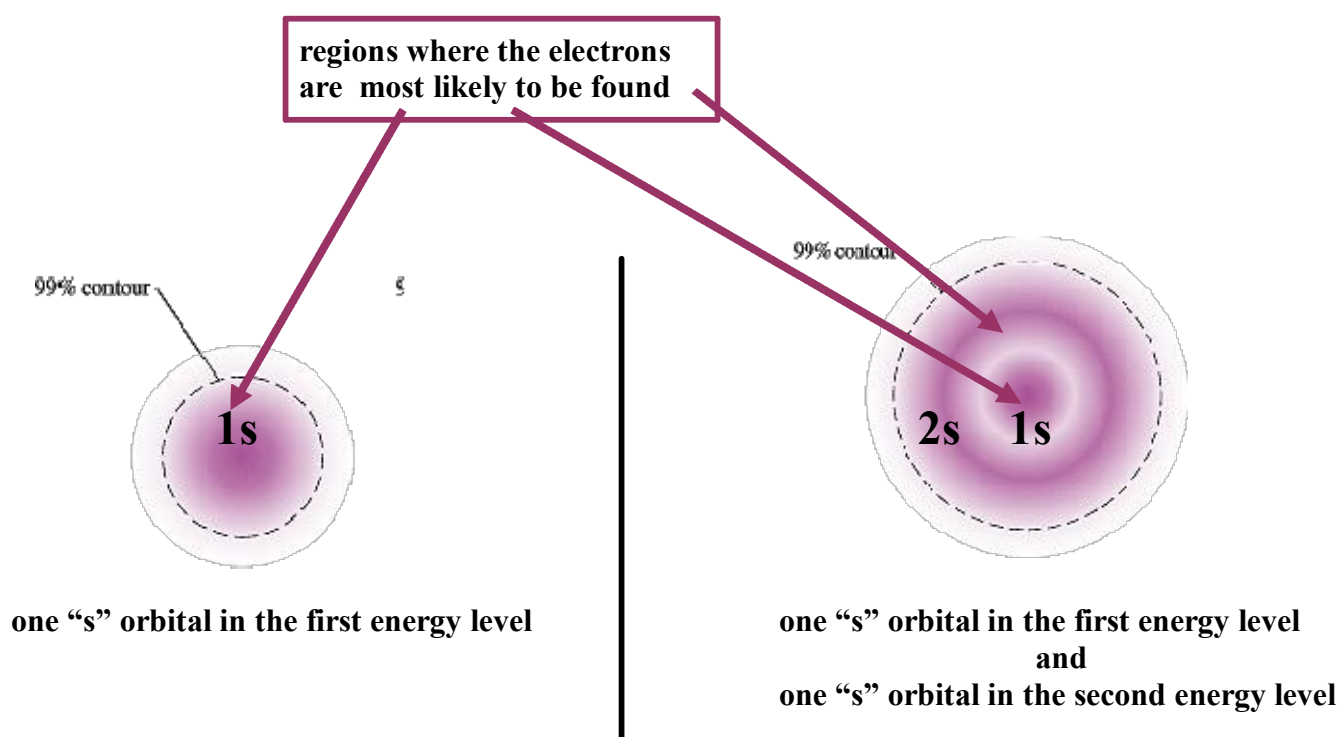


ATOMIC ORBITALS

- Atomic orbitals are regions in space where the electron is most likely to be found.
- Atomic Orbitals are of 4 types that differ in:
 - their shape
 - the number of orbitals that group together
 - their energy

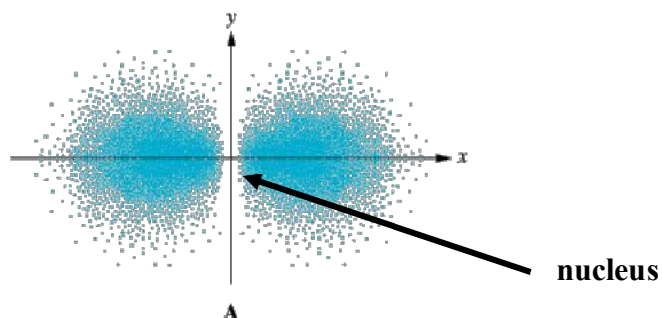
I. **"s" Orbitals** are the simplest orbitals

- The shape of an "s" orbital is **spherical**.
- An "s" orbital **occurs alone** (there is only one "s" orbital in any particular energy level)

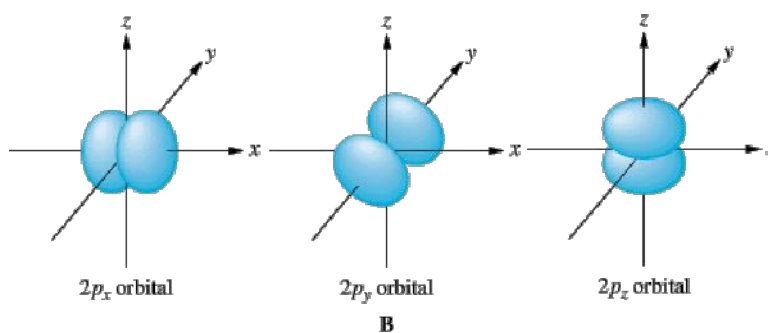


II. "p" orbitals

- The shape of a "p" orbital is like a **dumbbell** (two lobes arranged along a straight line with the nucleus between the lobes)

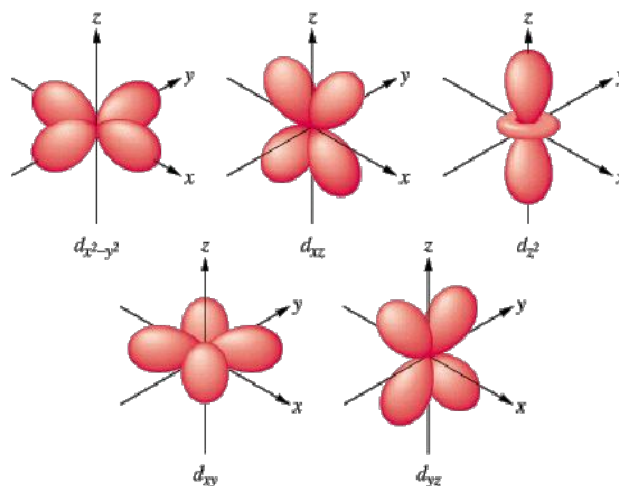


- "p" orbitals occur in group of three set at right angles to each other (there are three "p" orbitals in any particular energy level)



III. "d" orbitals

- These orbitals have complex shapes
- They occur in group of five (there are **five "d" orbitals** in any particular energy level)

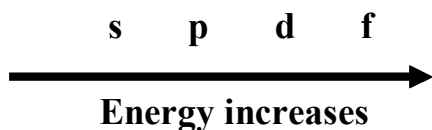


IV. "f" orbitals

- These orbitals have complex shapes
- They occur in group of seven (there are **seven "f" orbitals** in any particular energy level)

IMPORTANT POINTS TO REMEMBER ABOUT ORBITALS:

- The energy of the different types of orbitals increases in the following order**



- Remember the type of orbitals in increasing energy order:

“Some People Don’t Forget” s p d f

- Orbitals occur in a specific number in a group:**

ORBITALS	OCCUR IN GROUP OF
s	1 (alone)
p	3
d	5
f	7

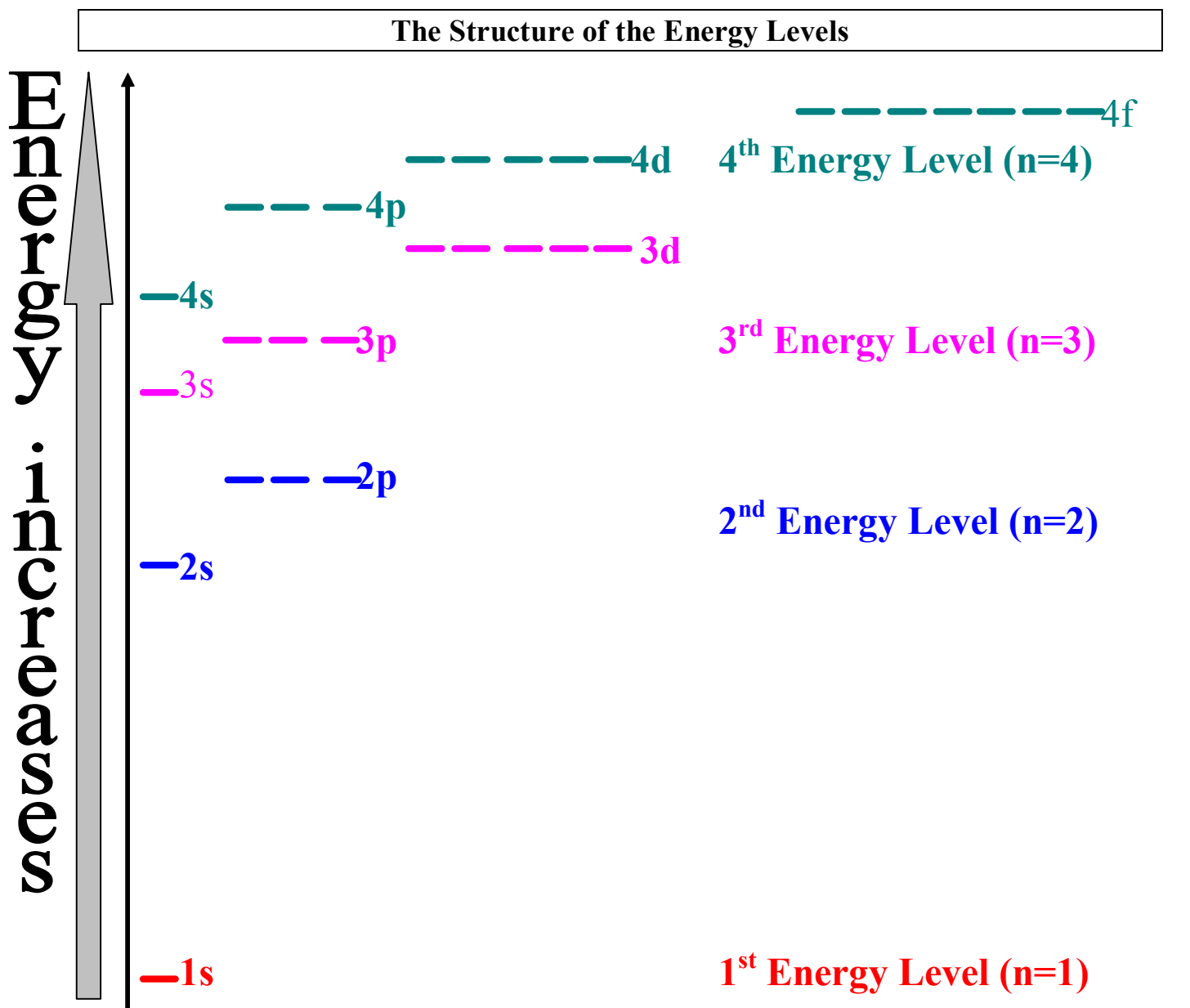
- Several orbitals of the same type form (constitute) an Energy Sublevel (sometimes called a Subshell)**

There are several types of sublevels, depending on the types of orbitals they contain:

an	“s sublevel”	contains:	one s orbital
a	“p sublevel”	contains:	three p orbitals
a	“d sublevel”	contains:	five d orbitals
an	“f sublevel”	contains:	seven f orbital

- Several sublevels with close values of energy form (constitute) an Energy Level (sometimes called an Electron Shell)**

1st Energy Level contains: one sublevel : 1s
2nd Energy Level contains: two sublevels : 2s 2p
3rd Energy Level contains: three sublevels: 3s 3p 3d
4th Energy Level contains: four sublevels: 4s 4p 4d 4f
5th Energy Level contains; five sublevels: 5s 5p 5d 5f, 5g



Note: - Energy values increase with increasing values of “ n ”.

As “ n ” increases:

- the spacing between successive levels decreases
- the structure of the energy levels becomes more complex

Result: From the “3rd Energy Level”, the sublevels start to overlap:

4s is lower than 3d
 5s is lower than 4d
 6s is lower than 5d

6s is lower than 4f
 7s is lower than 5f

QUANTUM NUMBERS AND ATOMIC ORBITALS

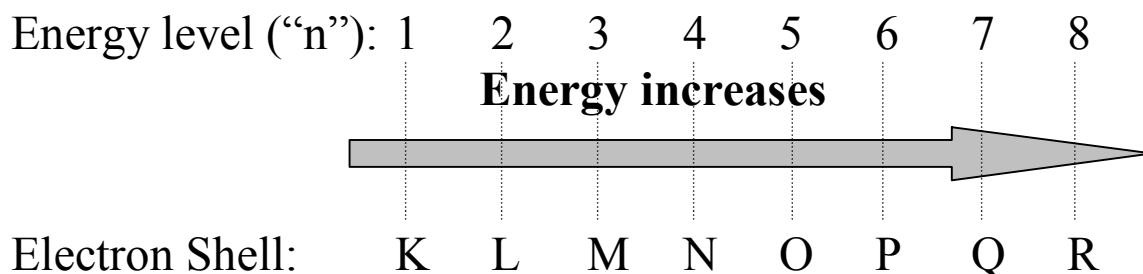
Each orbital is described by 3 quantum numbers:

1. PRINCIPAL QUANTUM NUMBER (“n”)

- Identifies the **Energy Level** in which the orbital is found
- n can have only positive values; **n = 1, 2, 3, 4, 5, 6, 7, 8,∞**
 - the smaller “n” is, the lower the energy
- n also determines the **Size of the Orbital**:

For example:

- An orbital in a 3rd energy level (“n=3”) is larger than an orbital in the 2nd energy level (“n=2”)
- An orbital in the second energy level is larger than an orbital in the first energy level (n=1)
- Energy Levels** are sometimes also referred to as **“Electron Shells”** and designated by letters (starting from K, in alphabetical order)



- The **First Energy Level (n=1)** is also referred to as the **K shell**
- The **Second Energy Level (n=2)** is also referred to as the **L shell**, and so on.

2. SECONDARY QUANTUM NUMBER (“l”)

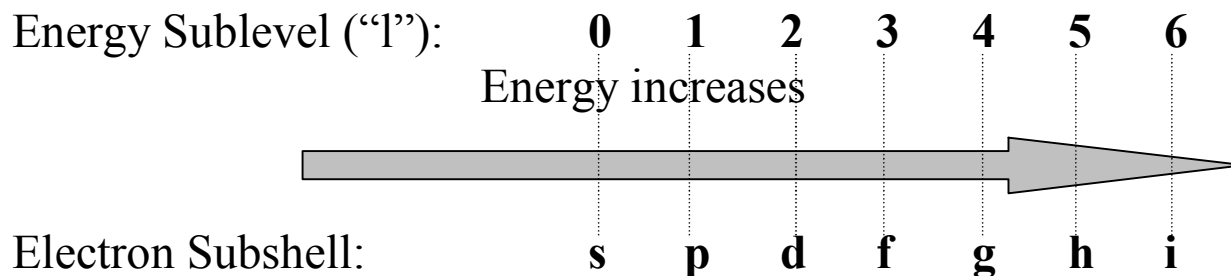
- Also called Angular momentum Quantum Number or Azimuthal Quantum Number
- “l” distinguishes orbitals of different shapes
- “l” identifies different sublevels (also referred to as “subshells”)
- For a given “n” (a specific energy level): “l” can have the following values: **0, 1, 2, 3,(n-1)**

For example:

- For **n = 1** (1st energy level)
 - l = 0** (only one type of orbital shape exists which is spherical)
(identifies the **1s sublevel**)
- For **n = 2** (2nd energy level)
 - l = 0** : one spherical orbital is identified (**2s sublevel**)
 - l = 1** : three dumbbell orbital are identified (**2p sublevel**)

Note: “l” cannot be 2, since its largest value is (n-1), which is 1

- **Sublevels (subshells)** are commonly designated by **Letters**:



It follows:

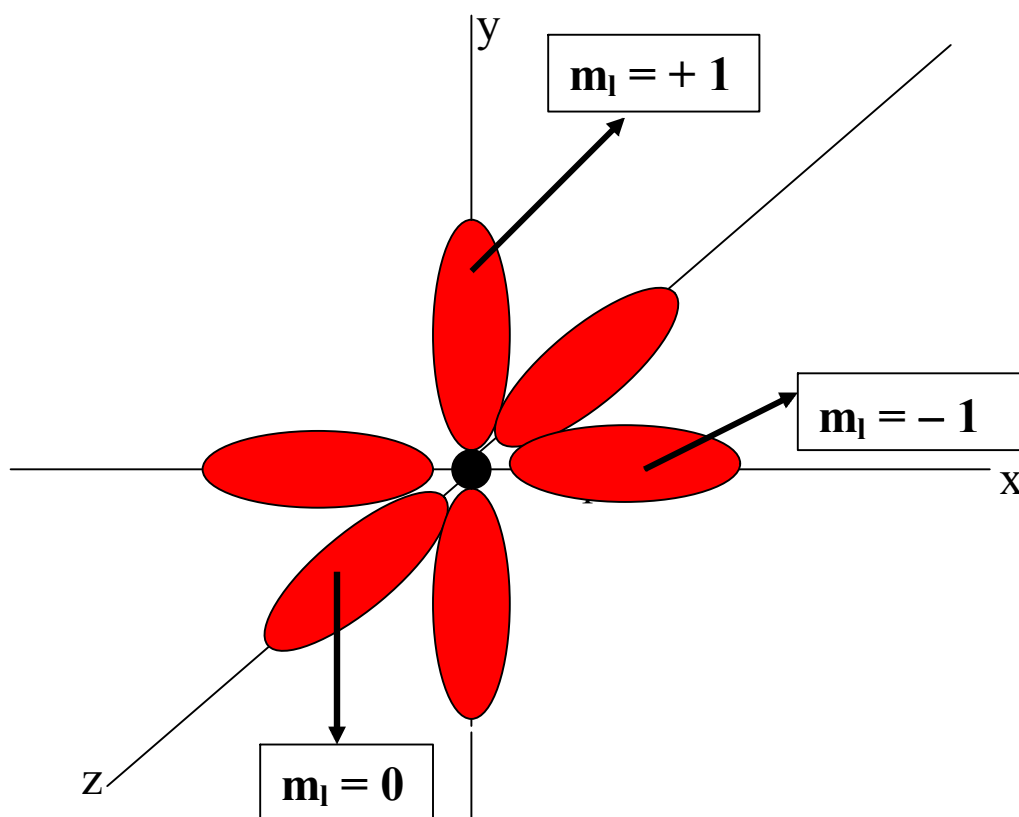
1st Energy Level	(n = 1) l = 0	An “ 1s ” sublevel	1 sublevel
2nd Energy Level	(n = 2) l = 0 l = 1	A “ 2s ” sublevel A “ 2p ” sublevel	2 sublevels
3rd Energy Level	(n = 3) l = 0 l = 1 l = 2	A “ 3s ” sublevel A “ 3p ” sublevel A “ 3d ” sublevel	3 sublevels
4th Energy Level	(n = 4) l = 0 l = 1 l = 2 l = 3	A “ 4s ” sublevel A “ 4p ” sublevel A “ 4d ” sublevel A “ 4f ” sublevel	4 sublevels
5th Energy Level	(n = 5) l = 0 l = 1 l = 2 l = 3 l = 4	A “ 5s ” sublevel A “ 5p ” sublevel A “ 5d ” sublevel A “ 5f ” sublevel A “ 5g ” sublevel	5 sublevels

3. MAGNETIC QUANTUM NUMBER (“ m_l ”)

- Indicates the orientation in space of different orbitals that belong
 - to the same energy sublevel (same “ l ”), and
 - to the same energy level (same “ n ”)
- The allowed values for “ m_l ” are integers ranging from “ $-l$ ” to “ $+l$ ”

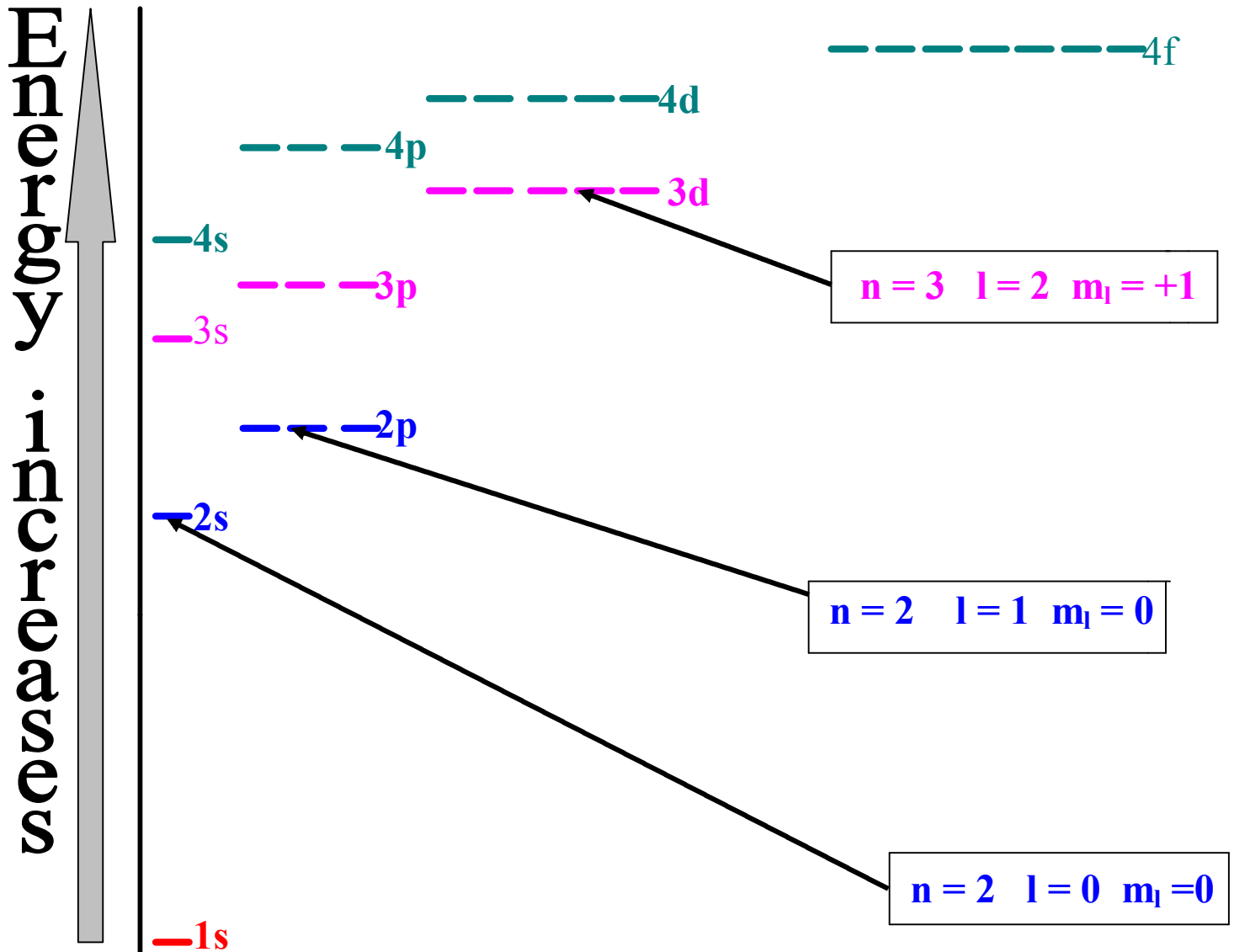
For example:

For $l = 0$	(“s” subshell)	$m_l = 0$
There is only one orbital in the “s” subshell		
For $l = 1$	(“p” subshell)	$m_l = -1$ $m_l = 0$ $m_l = +1$
There are three orbitals in the “p” subshell		



n Principal Quantum #	l Secondary Quantum #	m_l Magnetic Quantum #	Subshell Notation	# of Orbitals in Sublevel	# of Orbitals in Energy Level
1	0	0	1s	1	1
2	0	0	2s	1	4
	1	-1 0 +1	2p	3	
3	0	0	3s	1	9
	1	-1 0 +1	3p	4	
	2	-2 -1 0 +1 +2	3d	5	
4	0	0	4s	1	16
	1	-1 0 +1	4p	3	
	2	-2 -1 0 +1 +2	4d	5	
	3	-3 -2 -1 0 +1 +2 +3	4f	7	
n	n subshells				n² orbitals

ASSIGNING QUANTUM NUMBERS



Examples:

- If the “n” quantum number of an atomic orbital is 4, what are the possible values of “l”?
- Give the notation (using letter designations for “l”) for the subshells denoted by the following quantum numbers:

$$n = 6 \quad l = 2 \quad \rightarrow$$

$$n = 5 \quad l = 0 \quad \rightarrow$$

$$n = 4 \quad l = 3 \quad \rightarrow$$

$$n = 6 \quad l = 1 \quad \rightarrow$$