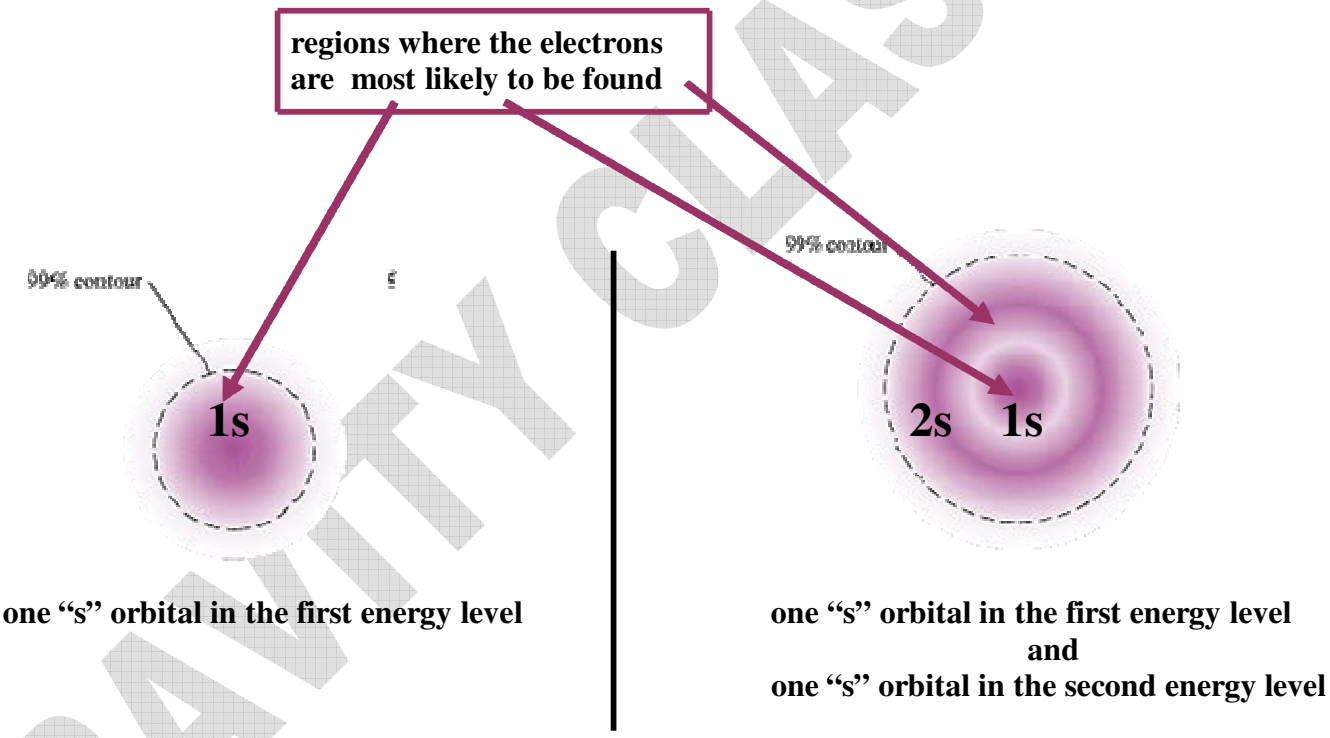
ATOMIC ORBITALS

- 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 occursalone (there is only one "s" orbital in any particular energy level)

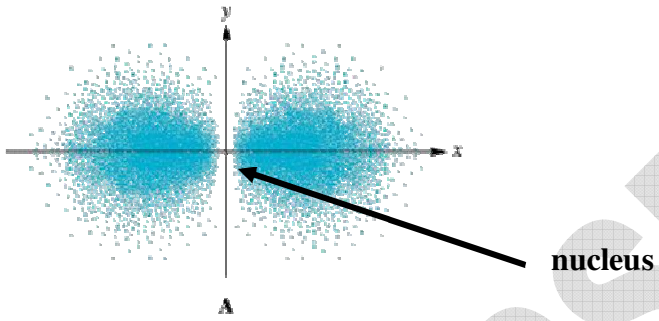


one "s" orbital in the first energy level

one "s" orbital in the first energy level and one "s" orbital in the second energy level

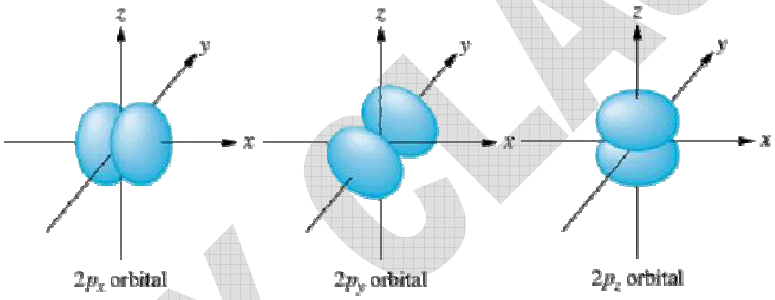
II. "p" orbitals

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



A

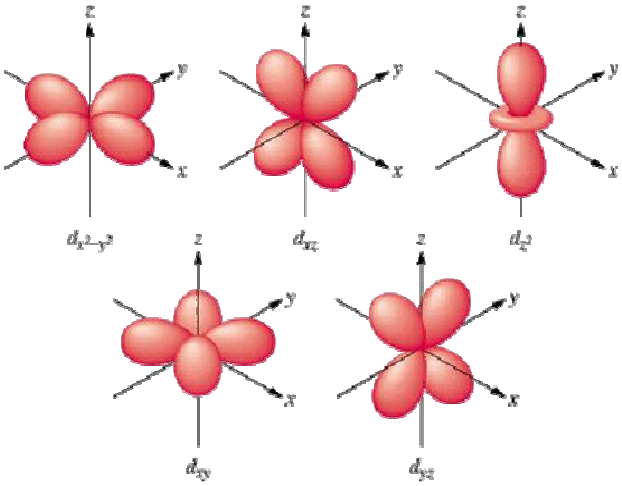
- "p" orbitals occur in group of three set at right angles to each other
  (there are three "p" orbitals in any particular energy level)



B

III. "d" orbitals

- These orbtals 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)

IMPORTANTPOINTSTOREMEMBERABOUTORBITALS:

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

s p d f

Energy increases

- **Remember the type of orbitals in increasing energy order:**

"Some People Don't Forget" s p d f

2. **Orbitals occur in a specific number in a group:**

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

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

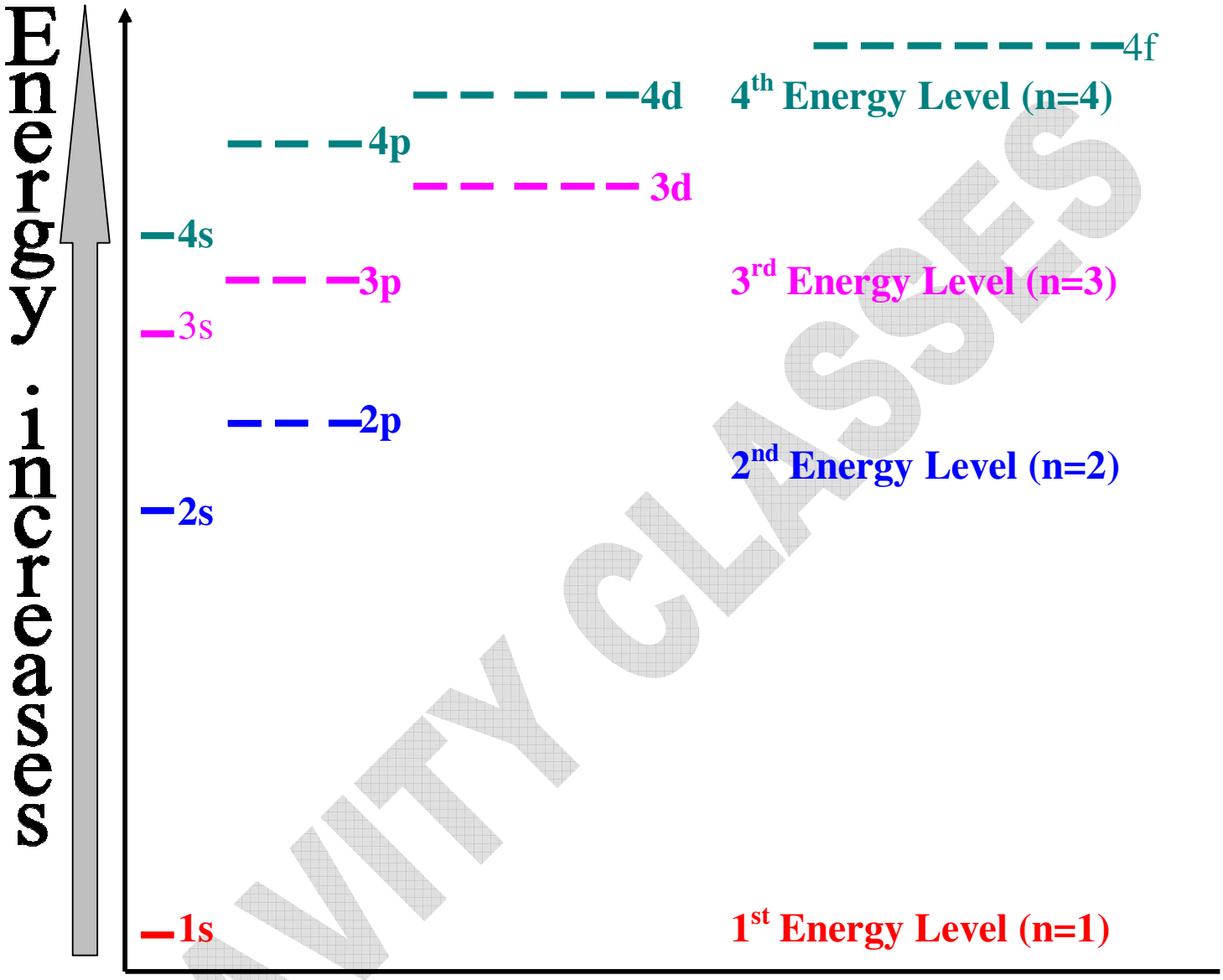
There are several types of sublevels, depending on the types of orbitals they contain:

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**

4. 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**

The Structure of the Energy Levels



Note: - **Energyvaluesincreasewithincreasingvaluesof"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

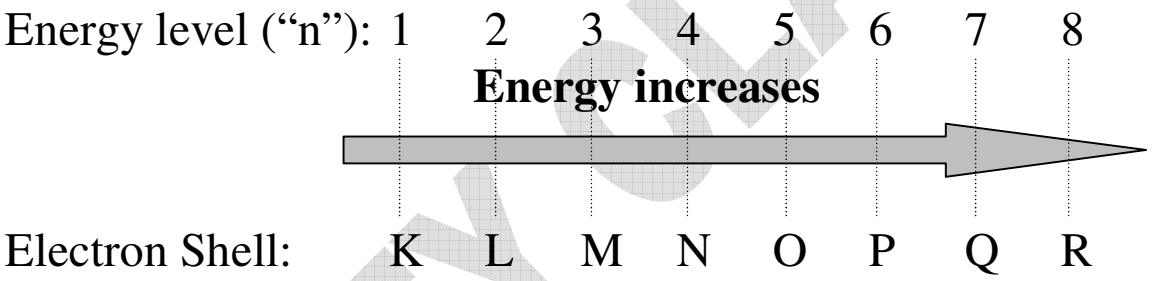
Each orbital is described by 3 quantum numbers:

1. PRINCIPAL QUANTUM NUMBER ("n")

- Identifies the **EnergyLevel** 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 **SizeoftheOrbital**:

Forexample:

- 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)
- **EnergyLevels** are sometimes also referred to as **"ElectronShells"** and designated by letters (starting from K, in alphabetical order)



- The **FirstEnergyLevel(n=1)** is also referred to as the **Kshell**
- The **SecondEnergyLevel(n=2)** is also referred to as the **Lshell**, and so on.

2. SECONDARYQUANTUMNUMBER("l")

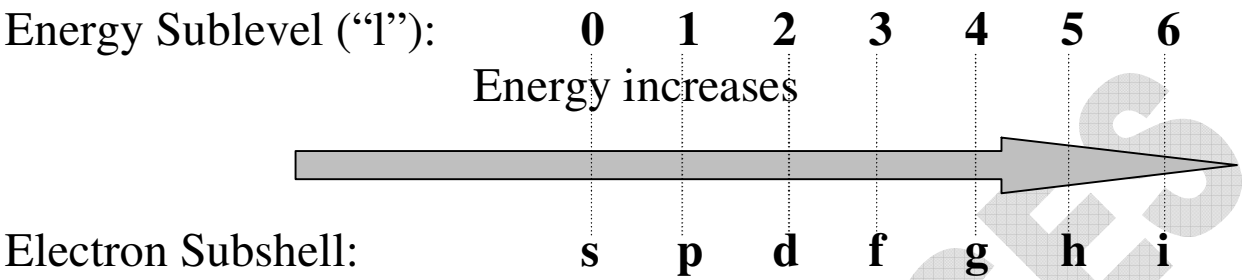
- Also called Angular momentum Quantum Number or Azimuthal Quantum Number
- "l" distinguishes orbitals of different shapes
- "l" identifies different sublevels (also referred to as "subshells)
- For a given "n" (a specific energy level): "l" can have the following values: 0,1,2,3,…..(n-1)

Forexample:

- For **n = 1** (1st energy level)
  l = 0 (only one type of orbital shape exists which is spherical)
  (identifies the **1ssublevel**)
- 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**	A "**2s**" sublevel	
	l = 1	A "**2p**" sublevel	2 sublevels
3rd Energy Level	**(n = 3) l = 0**	A "**3s**" sublevel	
	l = 1	A "**3p**" sublevel	3 sublevels
	l = 2	A "**3d**" sublevel	
4th Energy Level	**(n = 4) l = 0**	A "**4s**" sublevel	
	l = 1	A "**4p**" sublevel	
	l = 2	A "**4d**" sublevel	4 sublevels
	l = 3	A "**4f**" sublevel	
5th Energy Level	**(n = 5) l = 0**	A "**5s**" sublevel	
	l = 1	A "**5p**" sublevel	
	l = 2	A "**5d**" sublevel	5 sublevels
	l = 3	A "**5f**" sublevel	
	l = 4	A "**5g**" sublevel	

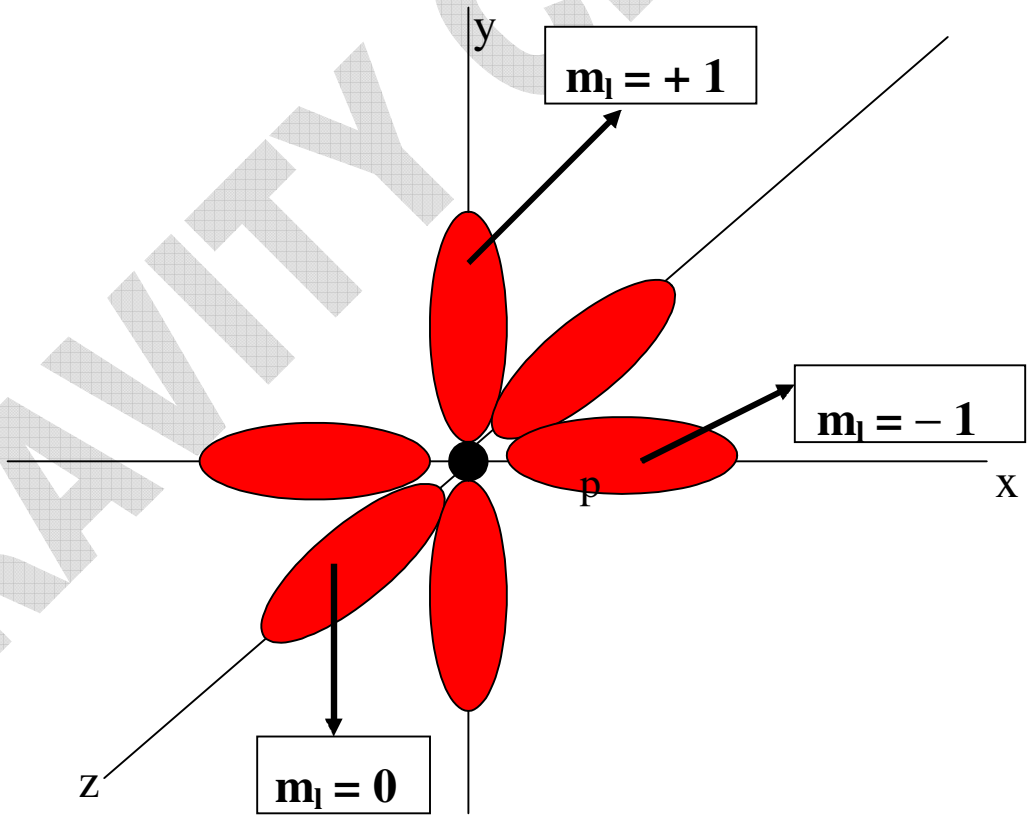
3. MAGNETICQUANTUMNUMBER("m_l")__

- 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"**

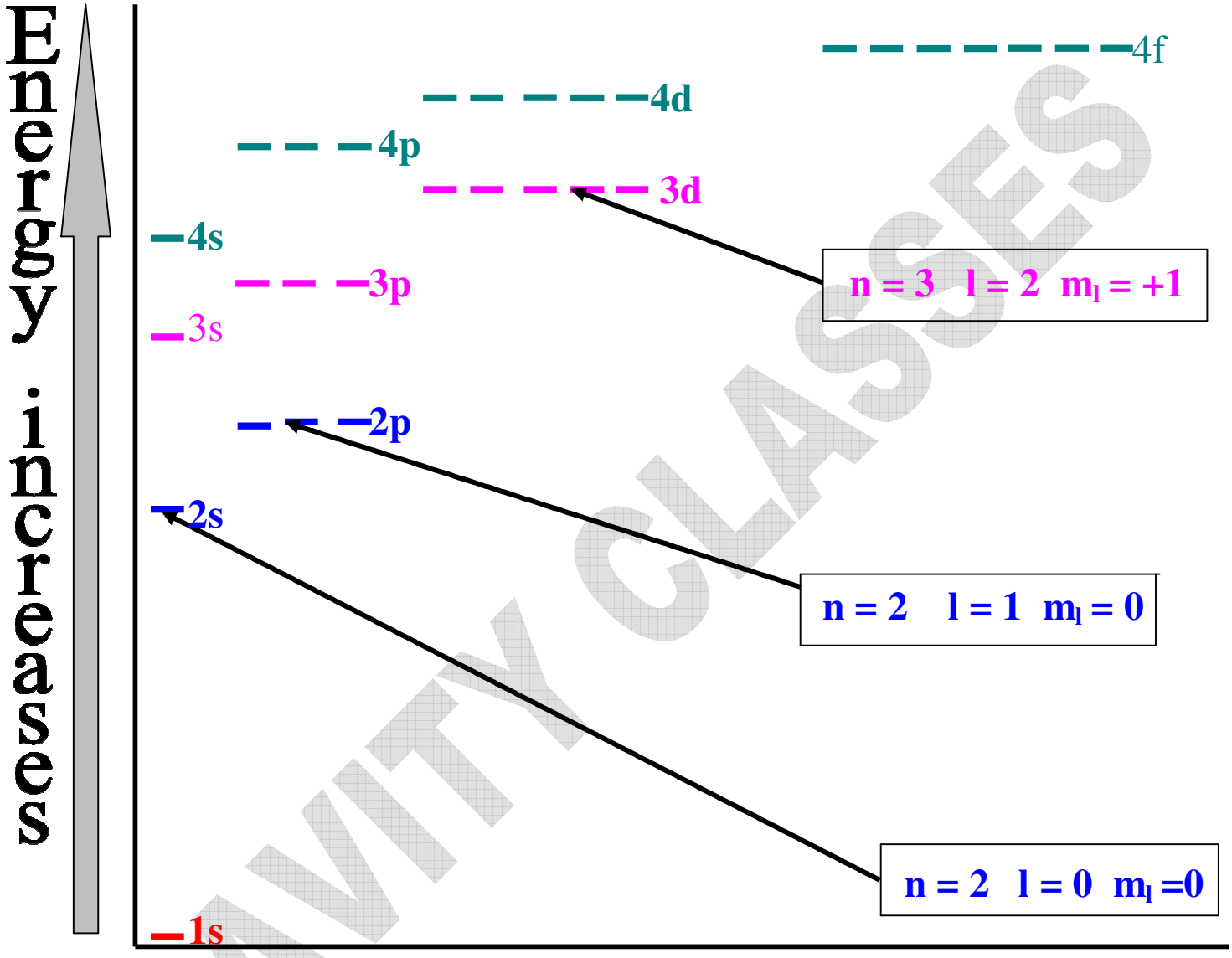
Forexample:

For	**l = 0**	**("s" subshell)**
There is only one orbital in the "s" subshell		
For	**l = 1**	**("p" subshell)**
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				n^2 orbitals

ASSIGNING QUANTUM NUMBERS



Examples:

1. If the "n" quantum number of an atomic orbital is 4, what are the possible values of "l"?

2. Give the notation (using letter designations for "l") for the subshells denoted by the following quantum numbers:

n = 6 l = 2 →

n = 4 l = 3 →

n = 5 l = 0 →

n = 6 l = 1 →