Quantum number

Prof. DR. Amer A. Taqa

There are 4 quantum numbers to consider:
The Principal Quantum number (n) which defines the shell number. The Angular Momentum Quantum Number (l) which defines the size and energy of the orbital. The magnetic Quantum Number (ml) which defines the information about the number of orbitals in a sub-shell and their orientation. The Spin Quantum Number (ms) which defines the direction of spin of an electron within an orbital

The Principal Quantum Number (n)
The larger the value of 'n' the further the shell is from the nucleus. As the value of 'n' increases the energy gap between successive shells decreases.

The Angular Momentum Quantum Number (l)
l = 0,1,2….(n -1)e.g.

when n= 2, l = 0,1

and when n=4, l = 0,1,2,3

When l = 0 the subshell is an 's' subshell

lWhen l = 1, the subshell is a 'p' subshell

When l = 2, the subshell is a 'd' subshell

When l = 3, the subshell is an 'f' subshell

Hence in the first shell where n = 1, l = 0 and so the first shell consists of only an s-subshell and in the third shell

where n = 3, l = 0,1 & 2 and so the third shell consists of an s, a p and a d-subshell.

Heisenberg's Uncertainty Principle
Electrons can not only be thought of as particles with a negative charge and almost zero mass but as also having the properties of waves. Heisenberg's Uncertainty Principle states that it is impossible to define with absolute precision, simultaneously, both the position and momentum of an electron'. This means that the electron can be described in terms of probability rather than by definite position. An atomic orbital is defined as a region in space in which the probability of finding the electron is greater than 90%.

The Magnetic Quantum Number (ml)
ml = -l to +le.g. for an s-subshell, l = 0 and so ml = 0 i.e. in an s-subshell, there is only one orbital as there is only one value for ml. e.g. for a p-subshell, l = 1 and so ml = -1, 0, +1i.e. in an p-subshell, there are three orbitals as there are three values for ml

Calculate the number of orbitals in a d-subshell and a f-subshell.

.

Exercise Calculate the number of orbitals in a d-subshell and a f-subshell

OrbitalsAlthough subshells have different energies (see the Aufbau Principle), orbitals within a sub-shell are degenerate i.e. they have equal energy e.g. all five orbitals within a d-subshell are degenerate. Each orbital can hold a maximum of two electrons hence, an s-subshell, made up of only one orbital, can hold a maximum of 2 electrons and a p-subshell made up of three orbitals can hold a maximum of 6 electrons. How many electrons can a d and f-subshell hold?

The Spin Quantum Number (ms)
The Pauli Exclusion principle states that no two electrons can have the same four Quantum Numbers.This means that if an orbital is holding two electrons then the electrons must be spinning in opposite directions to one another.ms has two values: +½ and -½

consider the quantum numbers of the two electrons in the 1s orbital: 1s For 1 electron For the second electron n = 1 n = 1 l = 0 l = 0 ml = 0 ml = 0 ms = +½ ms = -½

Orbitals and Quantum Numbers Practice Questions

1. What are the shapes of s, p, and d orbitals respectively

s= spherical p = dumbbell d = cloverleaf

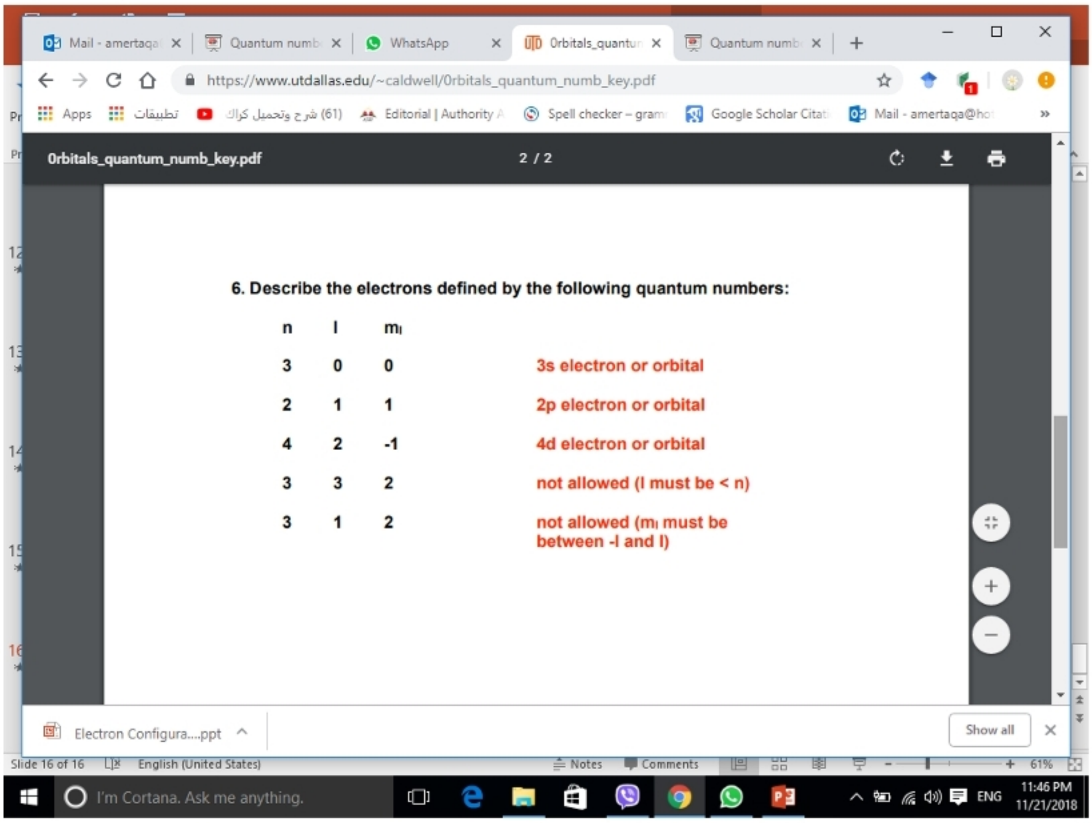
2. How many 1s orbitals are there in an atom? 4p orbitals? 4d orbitals?

1s: 1 4p: 3 4d: 5

Write a set of quantum numbers for a 4f orbital

n = 4 l = 3 ml = 3, 2, 1, 0, -1, -2, -3

Describe the electrons defined by the following quantum numbers



6. Describe the electrons defined by the following quantum numbers:

n	l	m_l	
3	0	0	3s electron or orbital
2	1	1	2p electron or orbital
4	2	-1	4d electron or orbital
3	3	2	not allowed (l must be < n)
3	1	2	not allowed (m_l must be between -l and l)