Electron Hotel

Name______________

Period_____________

Answer these questions from the reading…

1) Define Aufbau principle, Pauli Exclusion Principle, and Hund's Rule.

Aufbau principle –

Pauli Exclusion Principle

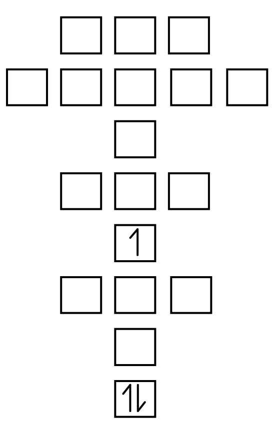
Hund's Rule

2) List and describe the four quantum numbers.

1-2) The Atomic Hotel[1]

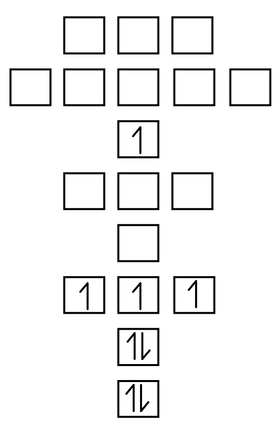
I. The Atomic Hotel is a special hotel designed for electrons. The hotel has a strict policy called the Aufbau principle that states "ground" floors must be filled first *and in order*. It costs more to get rooms on higher floors. In the atomic world energy is money so "excited" electrons get rooms on higher floors, thus the exception to hotel policy.

Looking back through the old guest logs the following layouts can be sketched. **Determine which electrons had more "money". Label those electrons as excited.**



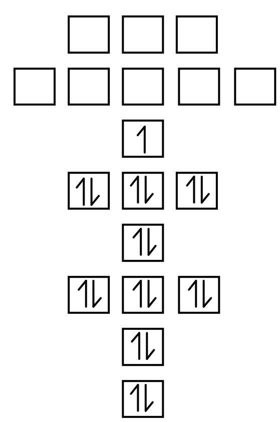
May 23, 1998

A



June 19, 1999

B



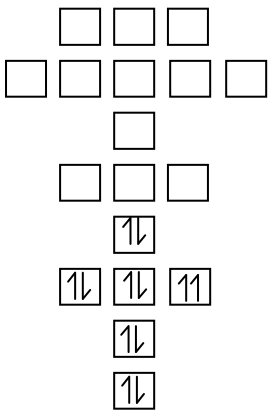
September 10, 1991

C

[1] Taken directly from NC State's Scale-up chemistry (http://scale-up.ncsu.edu/)

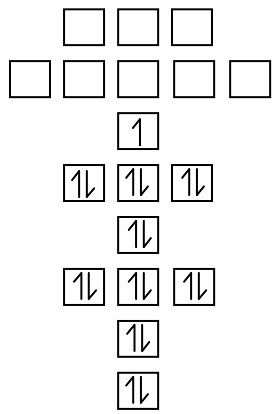
II. Another policy that the hotel enforces is called the Pauli Exclusion Principle. It was determined in 1925 that electrons can occupy the same room, but only if they have opposite spins so they do not interfere with one another.

Which electrons below did not follow the Pauli exclusion principle?



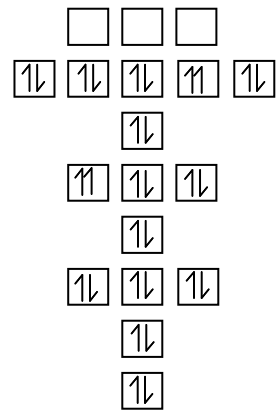
April 2, 1995

A



December 1, 2000

B

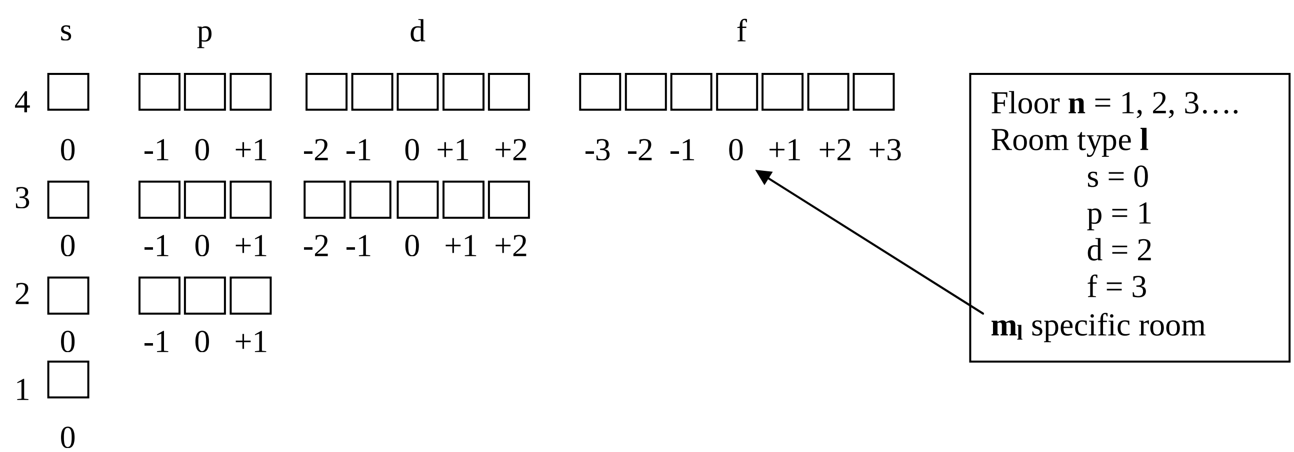


July 4, 1988

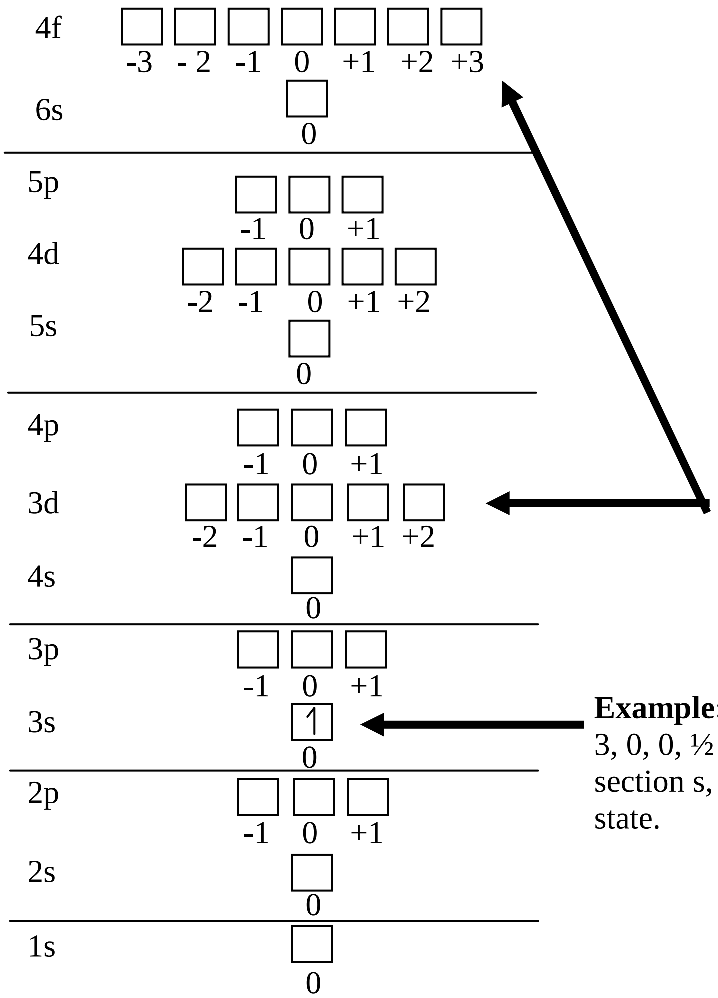
C

III. The Pauli Exclusion Principle serves to identify each electron. Four numbers (n, l, m_l, and m_s) are assigned to each guest in the hotel. The number n, is the principle quantum number which corresponds to the "floor" the electron is on. The letter l describes the room layout or the "floor area" in which the electron is staying (s = 0, p = 1, d = 2, etc.). There is only one s type room on each floor; there are three p type rooms on each floor from the second up; there are five d type rooms on each floor starting with the third floor and going up; and there are seven f type rooms on each floor starting with the fourth floor and moving upwards. The letter m_l describes the specific room (most analogous to a room number.) Figure 1 shows a diagram of the hotel rooms available by floor.

Figure 1: The Atomic Hotel by Floor



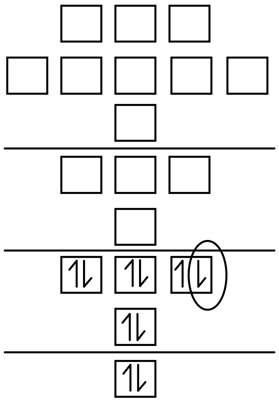
The preferred hotel diagram is one which shows the hotel rooms by cost (which, as stated in part I is the also the order in which the rooms are filled. Generally, the most inexpensive rooms are on the first floor, with prices increasing with floor. Note that d rooms are more expensive than the s or p rooms on the next floor. Electrons can pair up in a single room, therefore, the hotel has to have a way of identifying each one separately. This is done with m_s, the spin quantum number which is +½ or -½.



NOTE: d and f suites are more expensive than the s rooms on the next floor/s (3d > 4s).

Example: an electron with the numbers 3, 0, 0, ½ is staying on the 3rd floor, in section s, in room #0, and is in + ½ spin state.

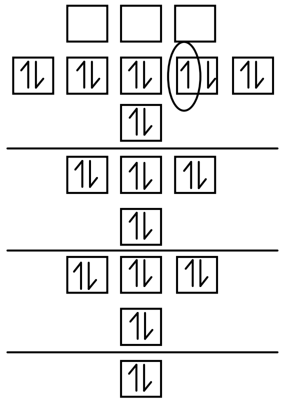
Using the above pattern, identify the circled electrons using the four quantum numbers.



March 9, 1992

__ __ __ __
n l m_l m_s

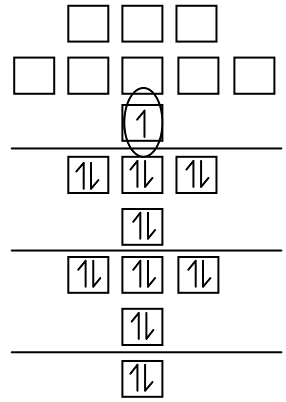
A



August 22, 1994

__ __ __ __
n l m_l m_s

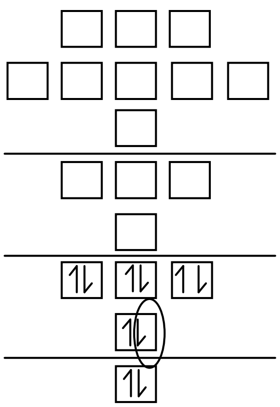
B



January 17, 1980

__ __ __ __
n l m_l m_s

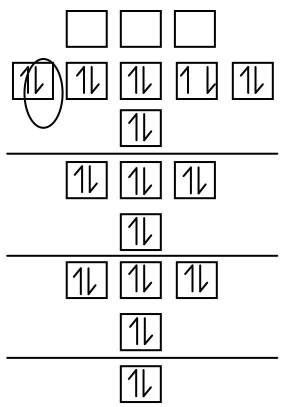
C



March 9, 1992

__ __ __ __
n l m_l m_s

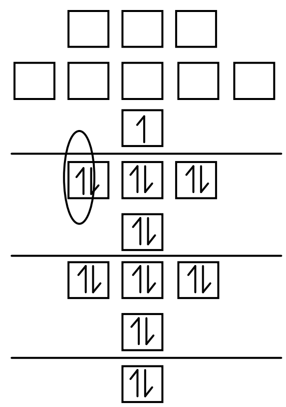
D



August 22, 1994

__ __ __ __
n l m_l m_s

E



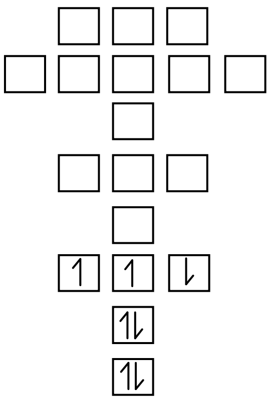
January 17, 1980

__ __ __ __
n l m_l m_s

F

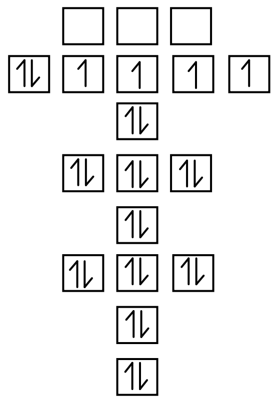
IV. There is one more policy that helps the hotel run smoothly and keep customers happy. Hund's Rule states that if electrons are being placed in the same section of a floor (rooms that cost the same) then each one gets their own room and has the same spin until the floor is half-filled. If any more electrons want to stay in that same section, then they must pair up with another electron and assume the opposite spin. This does not necessarily apply to electrons that have purchased more expensive rooms.

In the diagrams below identify the areas in which Hund's Rule was broken. **Describe how the rule is being broken in each case.**



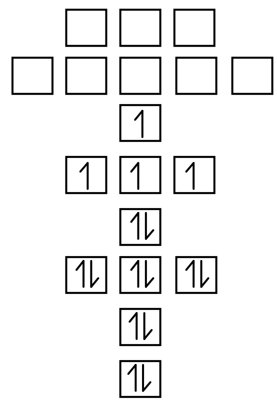
February 12, 1997

A



November 26, 1995

B



July 10, 1983

C

V. OBSERVATIONS:

A. How many "rooms" are there in an "s" suite of a floor? _____

B. How many "rooms" are there in a "p" suite of a floor? _____

C. How many "rooms" are there in a "d" suite of a floor? _____

D. How many electrons can stay on the first floor? _____

second floor? _____

third floor? _____

E. Describe how the rooms in each section are numbered.

F. In diagram C (Section IV above), describe why the electron could go into the 4s orbital instead of the 3p.

G. Why might section 3d fall between section 4s and 4p?

Draw hotels for and write out the electron configurations and orbital filling diagrams for each of the following elements:

B, N, F, Na, Fe, W, U

Then identify the atoms whose atomic hotels were drawn in IC, IIB, IIIA, IIIB, IIIC, and IVB

3-4) Valence electrons: Electrons in an atom's highest occupied shell (s and p electrons)

Example 1: K (potassium) has the electron configuration $1s^2 2s^2 2p^6 3s^2 3_p{}^6 4s^1$ Its highest occupied shell is 4 and it has one electron in the 4s orbital so it has one valence electron.

Example 2: S (sulfur) has the electron configuration $1s^2 2s^2 2p^6 3s^2 3_p{}^4$. Its highest occupied shell is 3 and it has two electrons in the 3s orbital and four electrons in the 3p orbital. Sulfur has six total valence electrons.

Example 3: Co (cobalt) has the electron configuration $1s^2 2s^2 2p^6 3s^2 3_p{}^6 4s^2 3d^7$. Its highest occupied shell is 4 and it has two electrons in the 4s orbital. Cobalt has a total of two valence electrons

Example 4: Se (selenium) has the electron configuration $1s^2 2s^2 2p^6 3s^2 3_p{}^6 4s^2 3d^{10} 4p^4$. Its highest occupied shell is 4. Selenium has two electrons in the 4s orbital and four electrons in the 4p orbital. Selenium has 3d orbitals that filled after 4s, but since they are in the third energy level these ten electrons are NOT valence electrons. Selenium has six total valence electrons.

How many valence electrons do the following elements have?

F _____	**Mo _____**	**Y _____**
Sb _____	**Rb _____**	**Fr _____**
Nd _____	**Ag _____**	**Co_____**

Electron configurations can get cumbersome (think about the 107 electrons in Bohrium). They can be abbreviated using the noble gas (group 8) core notation to abbreviate most of the configuration.

Example1:
Mg as the electron configuration: $\mathbf{1s^2 2s^2 2p^6}3s^2$; Ne has the electron configuration $\mathbf{1s^2 2s^2 2p^6}$
The electron configuration of Mg can be abbreviated: [Ne] $3s^2$

Example 2:
Ru $\mathbf{1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6}5s^2 4d^6$ which can be abbreviated: [Kr]$5s^2 4d^6$

Using the noble gas core notation, write the electron configurations for:

Al

Sr

Eu

Mo

Po