

# The potassium atom philosophy essay



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The Potassium atom is a member of the group one family of alkali metals. Due to the fact that group one metals have only one electron in their outer shell, means that potassium is an extremely reactive and electropositive element. A gentleman named Sir Humphrey Davy was the first to isolate this element in the year 1807 through the electrolysis of immensely dry molten caustic potash, otherwise known as Potassium Hydroxide (KOH). Its named after the the old Dutch word ‘ potaschen’ meaning potash’. Its symbol on the periodic table is the letter ‘ K’ which stands for the Latin word ‘ kalium’ also meaning ‘ pot ash’.

When calculating the electron number of Potassium, we can refer to its atomic number on the periodic table as shown in the following diagram:

<http://exchangedownloads.smarttech.com/public/content/e4/e4296d16-d0f9-4787-bb8a-0695e616c828/previews/small/0001.png>

## **Atomic number**

Graphic taken from exchange.smarttech.com

The atomic number will always display the figure of positively charged protons in an atom. The number of protons within the nucleus of an atom will always attract an equal number of negatively charged electrons. Potassium has an atomic number of ‘19’ which means it has 19 protons that are attracting 19 negatively charged electrons in its neutral state.

Strontium ion

The Strontium atom which has lost 2 electrons is known as a Strontium ion. Strontium is a member of the group 2 alkaline earth metals. Having only two

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electrons in its outer shell, Strontium is highly reactive like all other group 2 metals. This element was discovered in Scotland by a gentleman named Adair Crawford in the year 1790 as the mineral strontianite. It was given its name after the Scottish village “ Strontian” in which it was found in.

However, in the year 1808, Sir Humphrey Davy was first to isolate Strontium on its own through the process of electrolysis. This comprised a mixture of mercuric oxide (HgO) and strontium chloride (SrCl<sub>2</sub>).

When calculating the electron number of the Strontium ion, we can refer to the atomic number of the Strontium atom as shown on the periodic table.

**Atomic number**[http://t2.gstatic.com/images?q=tbn:ANd9GcTh8Q\\_XgZHS23iyIAsk1w9tJ-oRnsIYnF6uVBLk2hNksebU7BKY](http://t2.gstatic.com/images?q=tbn:ANd9GcTh8Q_XgZHS23iyIAsk1w9tJ-oRnsIYnF6uVBLk2hNksebU7BKY)

Graphic taken from [www.glogster.com](http://www.glogster.com)

We can see from the diagram above that the atomic number of Strontium is 38. This represents 38 positively charged protons in the nucleus that are attracting 38 negatively charged electrons in its neutral state.

Strontium has 2 valence electrons in its outermost shell. The Strontium ion has a 2+ charge (Sr<sup>2+</sup>) which means it has lost two of its valence electrons. It is much easier for Strontium to lose these 2 electrons in order to achieve a noble gas state than it would be for it to gain 6 electrons to get an octet configuration.

By subtracting 2 electrons from the electron number of Strontium (38), we are now able to calculate the Strontium ion as having an electron number of 36.

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## **Francium atom**

The Francium atom was discovered in France by a lady named Marguerite Pere in the year 1939 who named the element after her country. The element is extremely radioactive and is a member of the Group 1 alkali metals, having only one valence electron in its outer shell. Francium (Fr) is a positively charged element and is willing to lose its outermost electron to achieve its noble gas state, otherwise known as a cation.

Atomic number [https://www.store.acs.org/eweb/images/ACSStore/PT6498\\_thumb.jpg](https://www.store.acs.org/eweb/images/ACSStore/PT6498_thumb.jpg)

Graphic taken from [www.store.acs.org](http://www.store.acs.org)

By referring to the periodic table, one is able to see that a neutrally charged Francium atom (Fr) has an atomic number of 87. This means that it has 87 positively charged protons in the nucleus which will attract 87 negatively charged electrons.

## **Bromide ion**

The Bromine atom which has gained an electron is known as a Bromine ion. It was discovered in France by a gentleman named Antoine J Balard in the year 1826. Bromine has a particularly unpleasant smell and was therefore named after the Greek word “ bromos” meaning stench. It is a member of the group 17 family of Halogens which are incredibly reactive, non-metal elements. Bromine, including all other elements in this group, will borrow an electron to complete its octet configuration.

## Atomic number

Atomic number [http://t3.gstatic.com/images?q=tbn:](http://t3.gstatic.com/images?q=tbn:ANd9GcS8QR1k8J5qhYBNWA25hCmFuCcgOWd-FetYlcmXlaFV1J8v7qz6FCLyBA)

[ANd9GcS8QR1k8J5qhYBNWA25hCmFuCcgOWd-](http://t3.gstatic.com/images?q=tbn:ANd9GcS8QR1k8J5qhYBNWA25hCmFuCcgOWd-FetYlcmXlaFV1J8v7qz6FCLyBA)

[FetYlcmXlaFV1J8v7qz6FCLyBA](http://t3.gstatic.com/images?q=tbn:ANd9GcS8QR1k8J5qhYBNWA25hCmFuCcgOWd-FetYlcmXlaFV1J8v7qz6FCLyBA)

We can see from the diagram above that the atomic number of a neutrally charged Bromine atom is 35. This shows that there are 35 positively charged protons inside the nucleus which will therefore attract 35 negatively charged electrons.

Bromine has 7 valence electrons in its outermost shell. This gives the Bromide ion a -1 charge (Br -1) because it has only needed to gain 1 valence electron to get an octet configuration. It is easier for Bromine to gain one electron in order to achieve a noble gas state than it would be for it to lose 7 electrons to achieve the same result. This is why Bromine is considered to be an anion.

If we add the extra one electron gained by Bromine, to its electron number of 35, we will then have the electron number for the Bromide ion which will be 36.

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The Mass Spectrometer is a device designed especially to separate ions via a mass to charge ratio. It deflects and detects ions and can record their intensities. A typical device is comprised of three main parts. These parts are the ion source, a mass analyser and a detector. Once the molecule within a sample has been broken down into a gaseous state, the atoms of the sample go through a further 4 main stages. These stages are called ionisation ( the <https://assignbuster.com/the-potassium-atom-philosophy-essay/>

production of positively charged ions), acceleration (positively charged ions accelerated by an electric field), deflection (positively charged ions are deflected in proportion to their mass/charge ratio) and finally the detection stage (positive ions of a particular mass/charge ratio are detected).

## 1.2

EXPLAIN THE MEANING OF ATOMIC ORBITAL, AND DESCRIBE THE DISTRIBUTION, SHAPES AND RELATIVE ENERGY OF ELECTRON ORBITALS WITHIN THE FIRST FOUR SHELLS.

Explain what you understand by the term atomic orbital. Describe the distribution, shapes and relative energy of atomic orbitals found within the first four shells in terms of the s, p, d and f orbitals

An atomic orbital refers to the region of space where there is a high probability of finding an electron. It describes the movement of a single electron or a pair of electrons within the atom.

Each atom is comprised of its main electron shells (hydrogen having only one main electron shell). These shells are known as ‘ quantum levels’ and can be broken down into sub energy level shells. The sub energy level shells can then be broken down into orbitals. Each main quantum level (identified as the K, L, M, N shells), consists of one or more sub shells. The K quantum level has only one Sub shell (S sub shell). The L quantum level has two sub shells (S and P sub shells). The M quantum level has three sub shells (S, P and D sub shells) and the N quantum level has 4 subshells (S, P, D and F sub shells).

Each electron has a negative charge which means that they repel one another. Due to this repulsion, energy from these electrons is then separated into different orbitals found around the nucleus. An atomic orbital can hold up to 2 electrons with opposing spins. The S sub shell has 1 orbital and can hold up to 2 electrons. The P sub shell has 3 orbitals and can hold up to 6 electrons. The D sub shell has 5 orbitals and can hold up to 10 electrons and the F sub shell has 7 orbitals, holding up to 14 electrons.

Electrons can behave as a particle and as a wave and this makes it impossible to accurately determine a pathway for an electron orbital. Werner Heisenberg was a theoretical physicist who developed 'The Heisenberg uncertainty principle' in 1927. The Uncertainty Principle was to describe the impossibility of knowing both the position of an electron and the velocity of an electron simultaneously. Louis de Broglie was a French physicist who thought that anything which had a mass will also behave like a wave.

However, it didn't seem as though objects with mass such as basket balls and people, actually had any wave properties at all. This is because the wave property is inversely proportional to the mass, so an object with a very tiny mass like an electron will have a very significant wave property. In 1927 an Austrian physicist name Erwin Schrodinger defined what an electron was doing inside of an atom based on it being a wave and not as a particle. He formulated "The Schrödinger equation ( $H\psi = E\psi$ )'. The equation allowed one to obtain a set of mathematical equations known as wave functions ( $\psi$ ) and by knowing these wave functions; one could describe the probable location and velocity of an electron at a certain energy level within the atom. From the equation, four quantum numbers were derived. These numbers are

used to pin point the probable location of an electron and describe the orbital it is occupying. It is rather like a postal code, even though it doesn't give its precise location, it does provide one with an electron's general location in space. The 4 quantum numbers correspond to the principle quantum level number ( $n$ ) which can be any integer from 1-7, the subshell quantum number ( $l$ ) which can be any integer from 0 to  $n-1$ , the orbital quantum number ( $m_l$ ) which has integral values between  $l$ , 0,  $-l$  and the electron spin quantum number ( $m_s$ ) which has two possible values of  $+1/2$  and  $-1/2$ . By referring to these 4 numbers, one can predict the distance the electron is from the nucleus, the shape of the orbital, the position of the orbital and the spin of the electron.

## **S orbital**

Graphic used from [angelfire.com](http://angelfire.com)

## **B**

## **C**

The diagram on the left displays the S orbital occupying the first 3 energy levels. Each main energy level has an S orbital. Diagram 'a' is the 1s orbital. The number '1' informs us that the orbital is in the energy level closest to the nucleus. Diagram 'b' is the 2s orbital. This orbital is in the second energy level. Diagram 'c' is the 3s orbital and is in the third energy level. The "s" describes the orbitals shape, with all S orbitals having a spherically symmetric (non directional) shape around the nucleus. The 2s and 3s electrons have a higher energy than the 1s electrons. This means that the 2s and 3s electrons are on average, further away from the nucleus and this increases the size of the orbital making the 2s and 3s orbitals larger than the

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1s orbital. The corresponding (l) value of the S orbital is 0 which means that the value of (ml) is also 0. <http://t3.gstatic.com/images?q=tbn:ANd9GcTTNij4IHuR9TGSUhTt1dd1JKleilD3u2hiHKkrjZ7sTKQVPM3A1To8hEn8FA>

A

## **P orbital**

Graphic used from [chemtube3d.com](http://chemtube3d.com)

The P orbitals appear different to S orbitals and this is because they follow a certain direction, unlike the non-directional (spherical) S orbital. The P orbital appears on the second energy level also with the 2s orbital and can inhabit 6 electrons whilst the 2s orbital is only able to inhabit 2 electrons. There are three 2p orbitals which are all oriented perpendicular to one another. These orbitals are given the symbols  $p_x$ ,  $p_y$  and  $p_z$  to correspond to their position on the x, y, z axis. A P orbital consists of 2 lobes which can inhabit 2 electrons. However, once each P orbital has a single electron, then they will start to form pairs and fill each orbital with 2 electrons. As the energy levels increase, the P orbitals will get bigger in size (2p, 3p, 4p) which means that the space where the electron is likely to be found is a further distance away from the nucleus. The P orbital has an (l) value of 1 and an (ml) value of -1, 0, +1 because there are three possible orientations of the orbital in 3d space. <http://www.chemtube3d.com/images/porbitals.png>

## **D orbital**

Graphic used from [angelfire.com](http://angelfire.com)

<http://t3.gstatic.com/images?q=tbn:>

ANd9GcTN3yvcX0Bp8IIWJ80LaCj1mXYKffA\_yQ\_1UPwKpCEPLy38DAy92paVou  
DU

Presented in the diagram on the left are five D orbitals on an x, y, z axis. The D orbitals ( $dyz$ ,  $dxy$ ,  $dz^2$ ,  $dxz$ ,  $dx-y^2$ ) exist at the third energy level also with the 3s orbital and the 3px, 3py, 3pz orbitals. Each individual D orbital has a different orientation in 3 dimensional space and can inhibit up to 2 electrons, which is a total of 10 electrons between them. The surface of the D orbital and all of the space within it constitutes the space in which one is most likely to find the electron. The D orbital has an (l) value of 2 and as there are five different possible orientations of this orbital in 3d space, it has an (ml) value of -2, -1, 0, +1, +2.

## **F orbitals**

Graphic used from [angelfire.com](http://angelfire.com)

There are seven F orbitals that exist on the fourth energy level as well as the 4s orbital, the 4px, 4py, 4pz orbitals and the 4dyz, 4dxy, 4dz<sup>2</sup>, 4dxz, 4dx-y<sup>2</sup> orbitals. Each individual F orbital can hold up to 2 electrons which is a total of 14 electrons between them. If we were to plot the positions of the electron within the F orbital in all of the different locations it was found, we would start to form a 3 dimensional map of the places that the electron has travelled in. These 3 dimensional maps are described in the diagrams shown on the right hand side. Each of these shapes represent where the electron is most likely to be found 90% of the time. The F orbital has an (l) value of 3 and as <http://www.angelfire.com/falcon2/dirgni/f.gif>

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There are seven different possible orientations of this orbital in 3d space,

It has an (ml) value of -3, -2, -1, 0, +1, +2, +3.

### 1.3

APPLY THE AUFBAU PRINCIPLE, HUNDS RULE AND PAULI PRINCIPLE TO THE WRITING OF THE FULL ELECTRONIC CONFIGURATIONS FOR ANY ELEMENT WITH AN ATOMIC NUMBER BETWEEN 1 AND 36

**Describe what you understand by the Aufbau Principle, Hund's Rule and Pauli Principle. In terms of the above, show the full electronic configuration of any element with an atomic number between 12 and 36**

When it comes to filling electron energy diagrams, one has to obey three different rules. These rules are known as The Aufbau Principle, Hund's Rules and the Pauli Exclusion Principle.

The Aufbau Principle explains that orbitals of lowest energy are filled first from the bottom and then upwards. Hund's rule principle states that if we were to have multiple orbitals of the same energy, then one should place an orbital in each before they double up. The Pauli Principle states that no two electrons in an atom have the same four quantum numbers. All three rules are explained in further detail below.

### **Aufbau Principle**

The Aufbau Principle was founded by two physicists named Neils Bohr and Wolfgang Pauli in the 1920's. The name originates from a German expression, meaning to "build out". The principle describes the way electrons are added to an atom or a molecule and shows that orbitals of a

lower energy are filled before orbitals of a higher energy. It shows us that an orbital can only inhibit 2 electrons at most with no two electrons having the same four quantum numbers within an atom.

## **Pauli Exclusion Principle**

The Pauli Exclusion Principle was formulated by a Gentleman named Wolfgang Pauli in the year 1925. Fermions are any particles such as electrons, protons and neutrons which have an odd half spin. The Pauli Exclusion Principle explains that no two fermions can occupy the same quantum state. However, Bosons which are particles that have an integer spin (0, 1, 2, 3..) and carry force, do not obey the Pauli Exclusion Principle. Test results described fermions as being repelled by the Pauli Exclusion Principle when the temperature dropped whilst Boson particles were not repelled. The Principle explains why electrons are kept increasingly further away from the nucleus when quantum states fill up, balanced by the attractive electric force between the electron and the positively charged nucleus. It has been discovered that some stars are held up by degenerate pressure which resulted from the Pauli Exclusion Principle.

## **Hund's Rules**

The Hund's Rules were a set of formulated rules developed by a German Physicist named Friedrich Hund in 1927. The Hund's rule of maximum multiplicity explains the particular order that electrons fill subshells. The Rule says that the electron will inhabit orbitals of an equal energy level in order to create the largest multitude of orbitals having an electron within them. It clearly states that when one is to fill up a subshell, they should start by putting electrons in the individual orbitals of 2p (such as 2p<sub>x</sub> then 2p<sub>y</sub>, then <https://assignbuster.com/the-potassium-atom-philosophy-essay/>

2pz) instead of filling each orbital up with two electrons before continuing on to the next orbital of the axis. “ Simply, the orbitals of a subshell must be occupied singly and with parallel spins before they occupy in pairs.” The Hund’s rule teaches that the greater the total spin state of the electron will result in making the atom a lot more stable, manifested most commonly in a lower energy state. This is due to the fact that it forces the unpaired electrons to inhabit in different spatial orbitals.

Below is the a diagram showing the application of the three rules (Aufbau Principle, PEP, Hund’s Rule) when building the electron configuration for Sulphur (S) in group 6 on the periodic table.

1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>4</sup><http://img174.imageshack.us/img174/9436/electronicconfigurationv8.jpg>

3P

3S

2P

Above is a diagram of the Bohr model of sulphur atom taken from [mugging-chocobos.blogspot.com](http://mugging-chocobos.blogspot.com)

In the diagram above, we can see that all 3 rules have been applied. The Aufbau principle (building from the bottom upwards), the Pauli Exclusion Principle (2 electrons with opposing spin within each orbital) and the Hund’s Rule (each individual electron will inhabit a spatial orbital separate from one another before pairing up in the same orbital).

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1S

2S