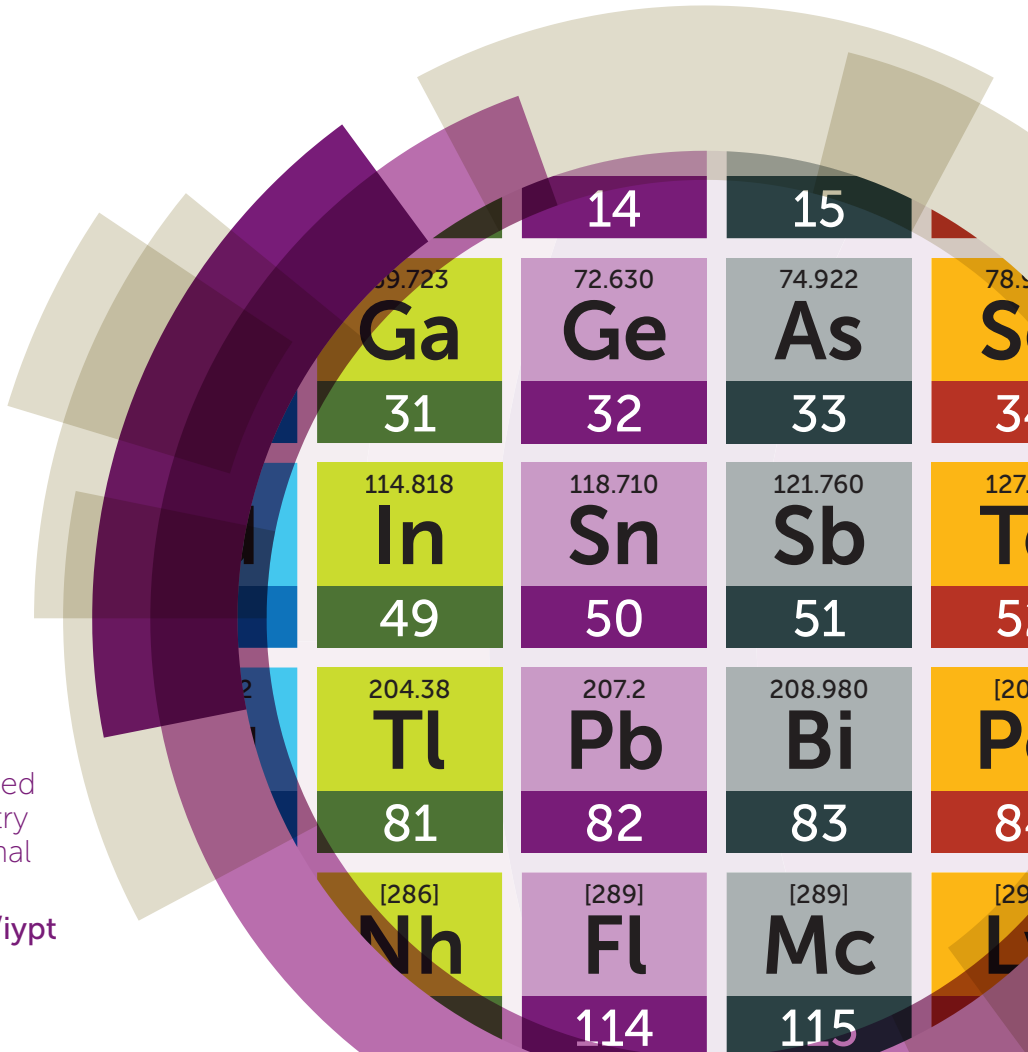
ROYAL SOCIETY OF CHEMISTRY | Celebrating IYPT 2019

Build an Atom Simulator



These activities have been created by the Royal Society of Chemistry to help celebrate the International Year of the Periodic Table.

Find out more at: **www.rsc.org/iypt**

Why are elements in groups?

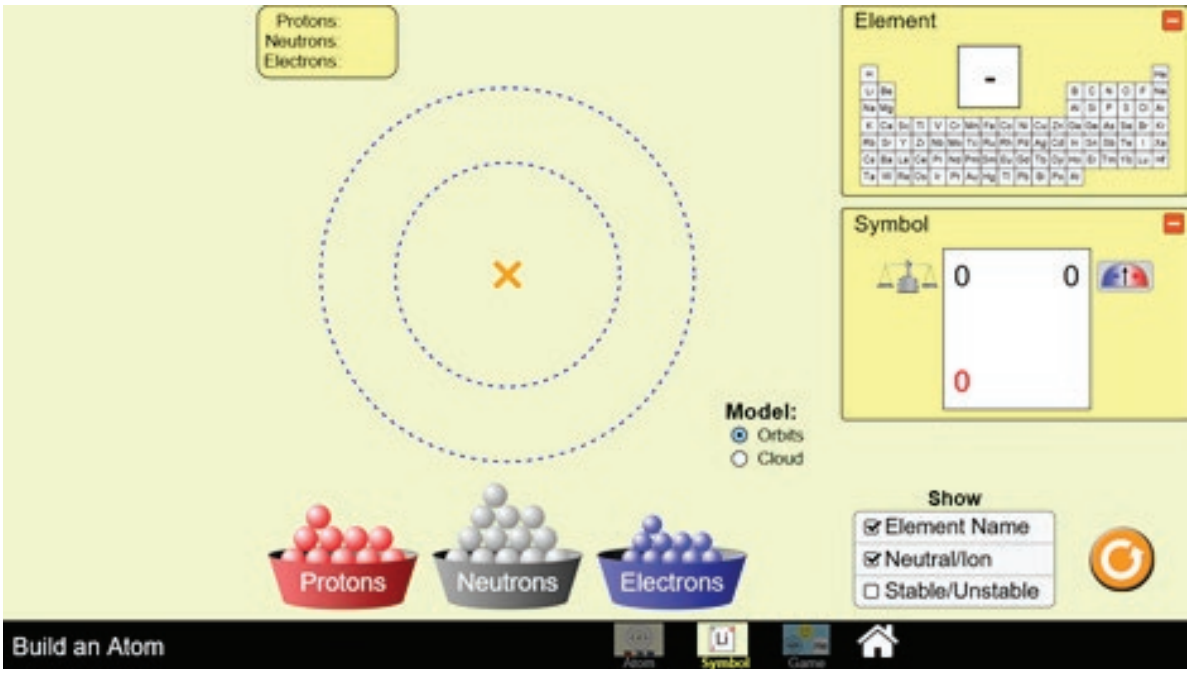
The pupils will discover why elements are in groups.

Learning outcome:

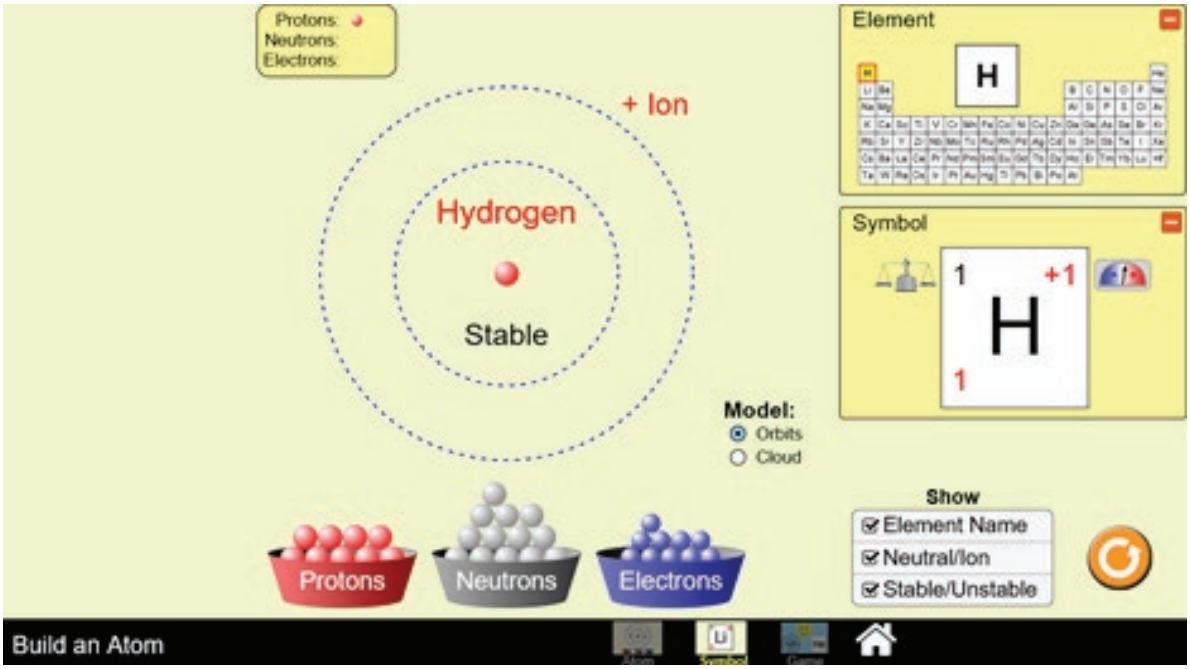
The pupils will discover that number of outer shell electrons are an indication of the group for a neutral atom.

Student outcome:

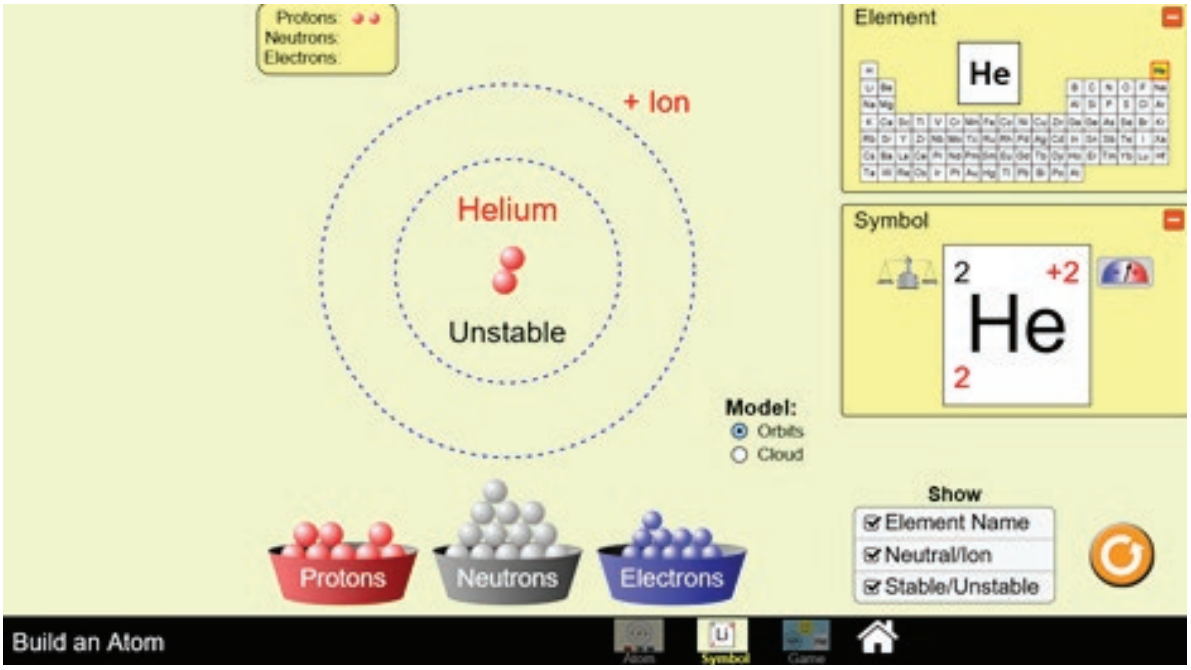
The pupils will then write down their rules and be able to predict the next ten neutral elements for outer shell electrons and groups.



This exercise is to allow the pupils to discover and to reinforce where the electrons, neutrons and protons are in the atom. It will also allow the pupils to discover how the electrons, neutrons and protons are linked to the different type of elements and the formation of ions or neutral atoms.



Ask the pupils to add protons to observe how the name of the element changes when they are added.

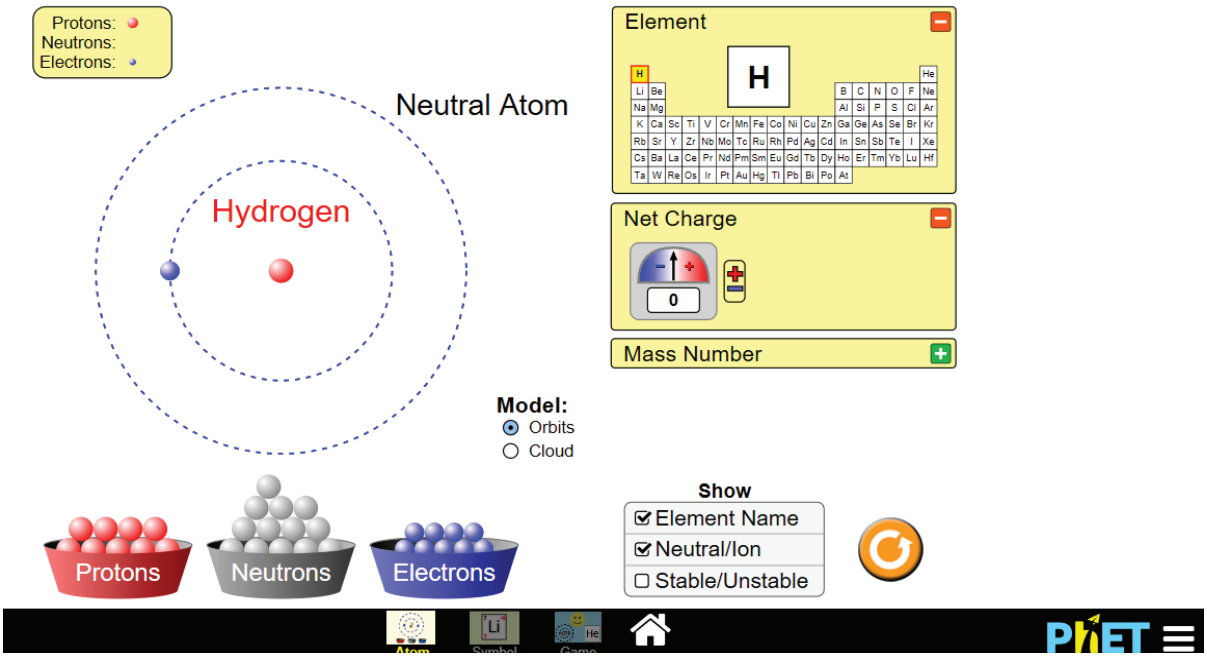


As more protons are added the pupils will discover that there are many changes; name of the element, the atomic number increases, the mass number (atomic mass) increases and the overall net charge changes. The pupils will also observe that the atom becomes unstable when we add protons only.

Why are elements in certain groups?

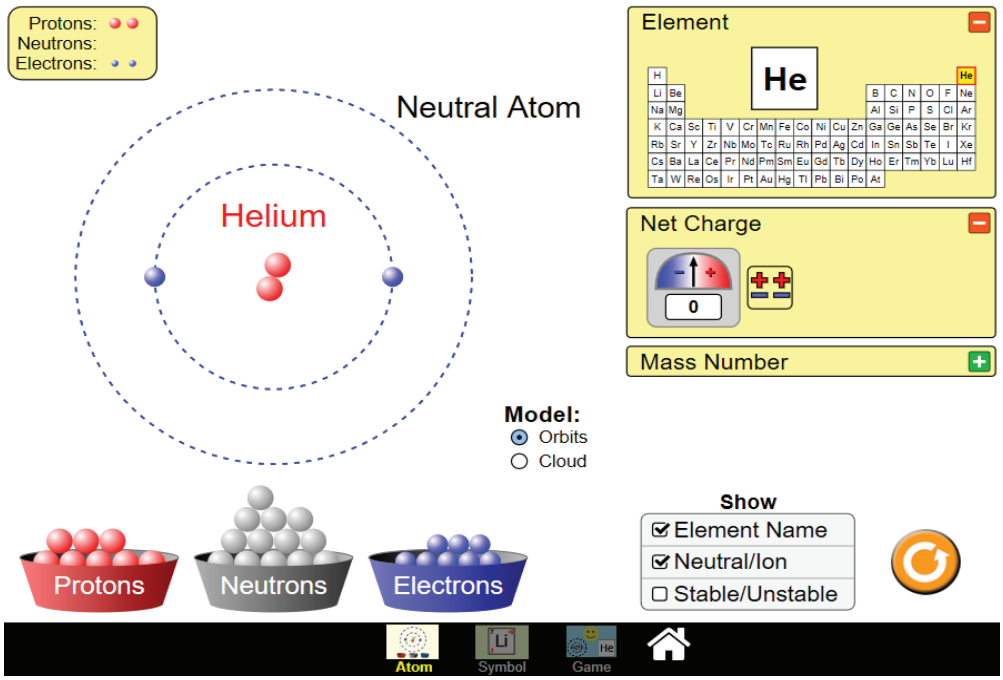
The positioning of the element in a group is based on evidence and understanding.

Ask the pupils to make all the first ten elements with only protons and electrons (turn off the stability function to help reduce the formation of misconceptions). The pupils will need to use a periodic table with the suitable group numbers.



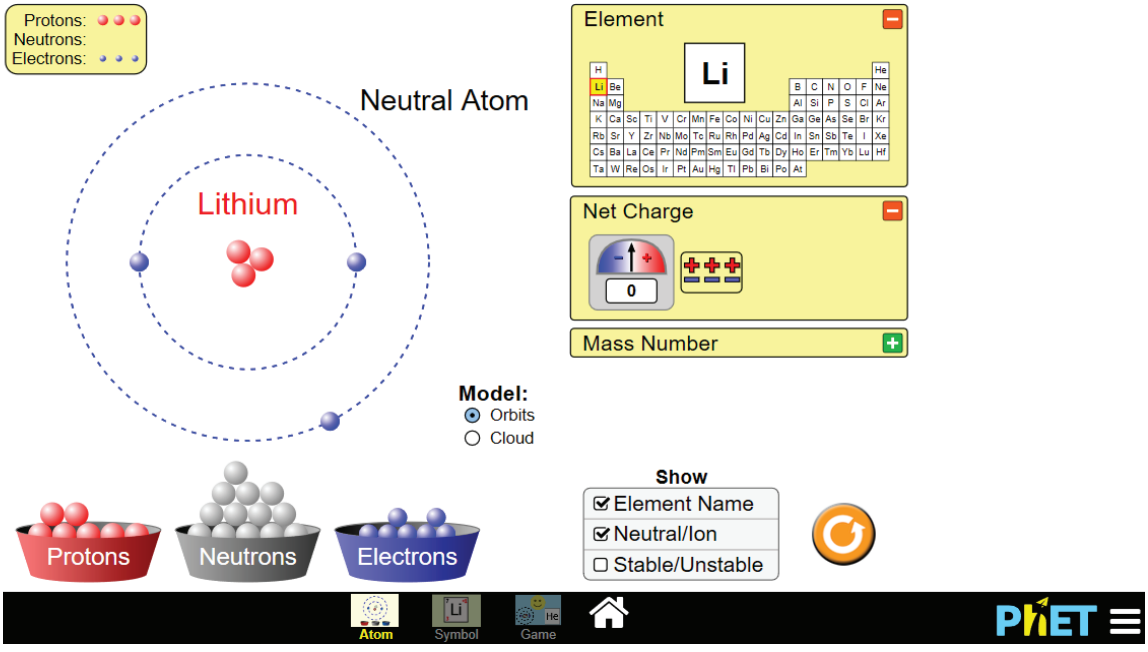
A neutral hydrogen atom (Group I). There are one electron in the outermost used shell. Since there are only one electron in the outermost shell the element is placed in Group I.

The pupils will have the opportunity to discover or reinforce the rules related to electron positioning.



A neutral helium atom (Known as Group 8 or Group 0).

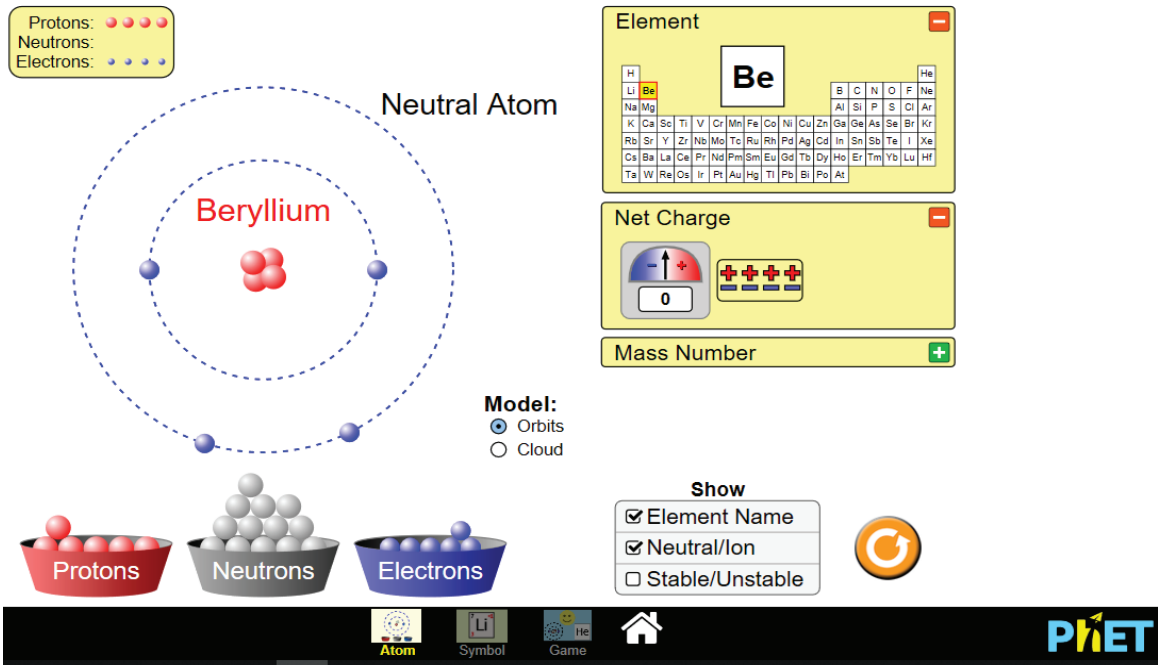
This shell can only hold two electrons. The outer most shell, that contains electrons, is said to be a "full shell". When more electrons are added then they must go into the next shell. A rule in chemistry states that when an outer shell is full then it becomes unreactive (KS3 and KS4).



A neutral lithium atom (Group I).

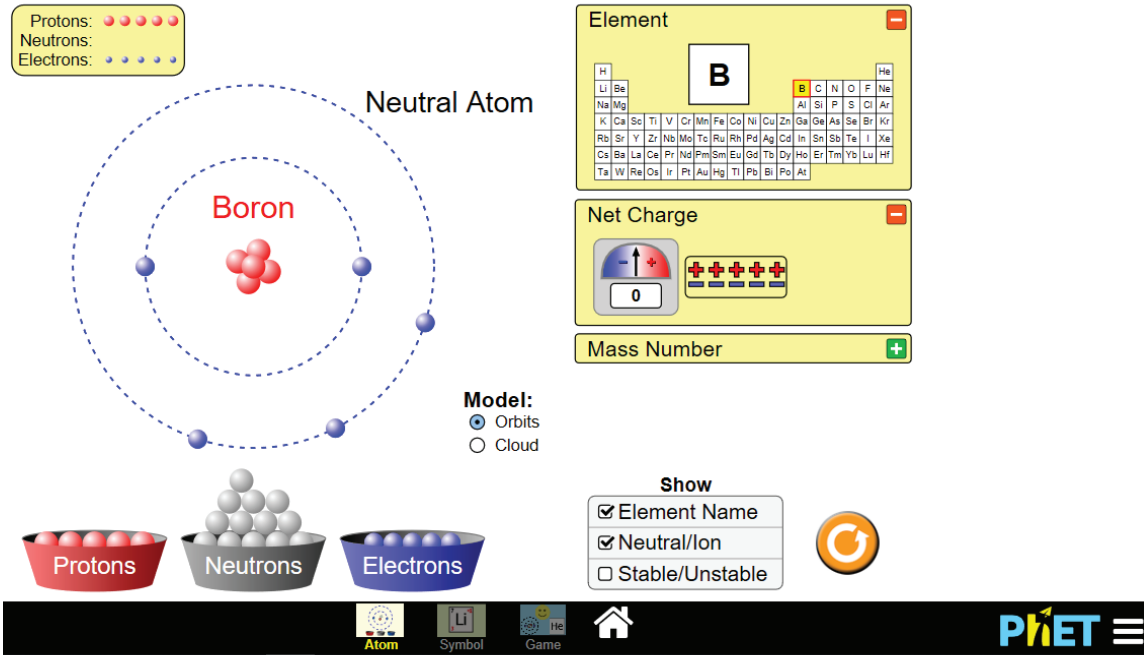
There are three electrons in this atom however there are only one electron is in the outermost used shell. Since there is one electron in the outermost shell the element is placed in Group I.

The pupils will have the opportunity to discover or reinforce the rules related to electron positioning.



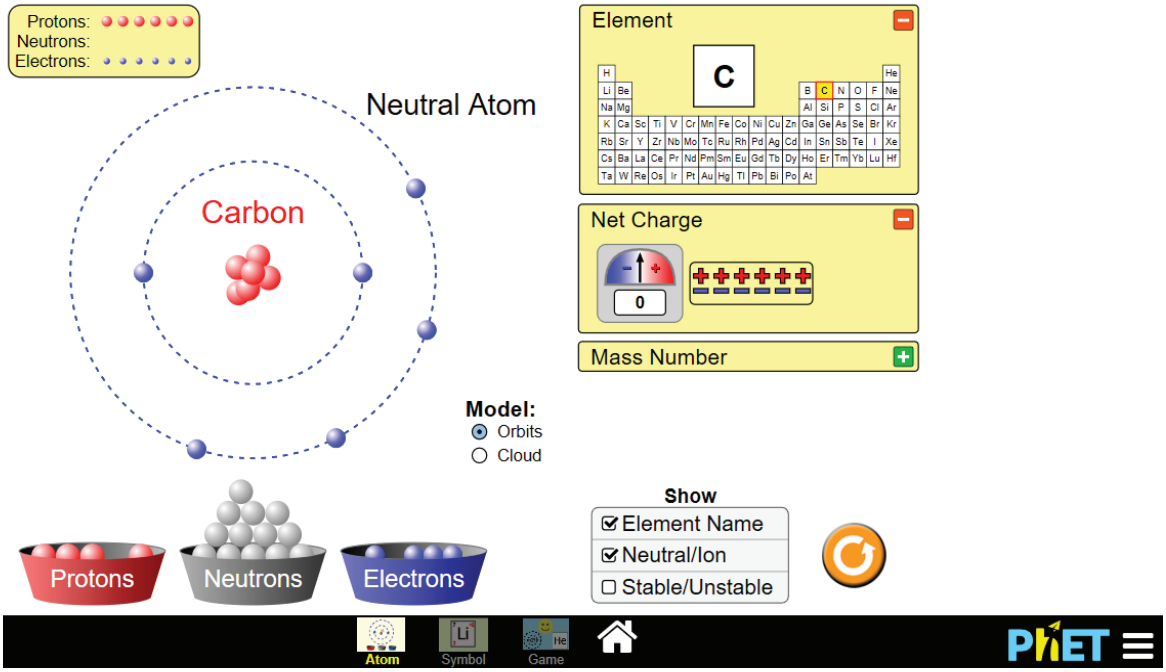
Explain the relationship between the number of outer electrons in the neutral atom and its group.

Beryllium:



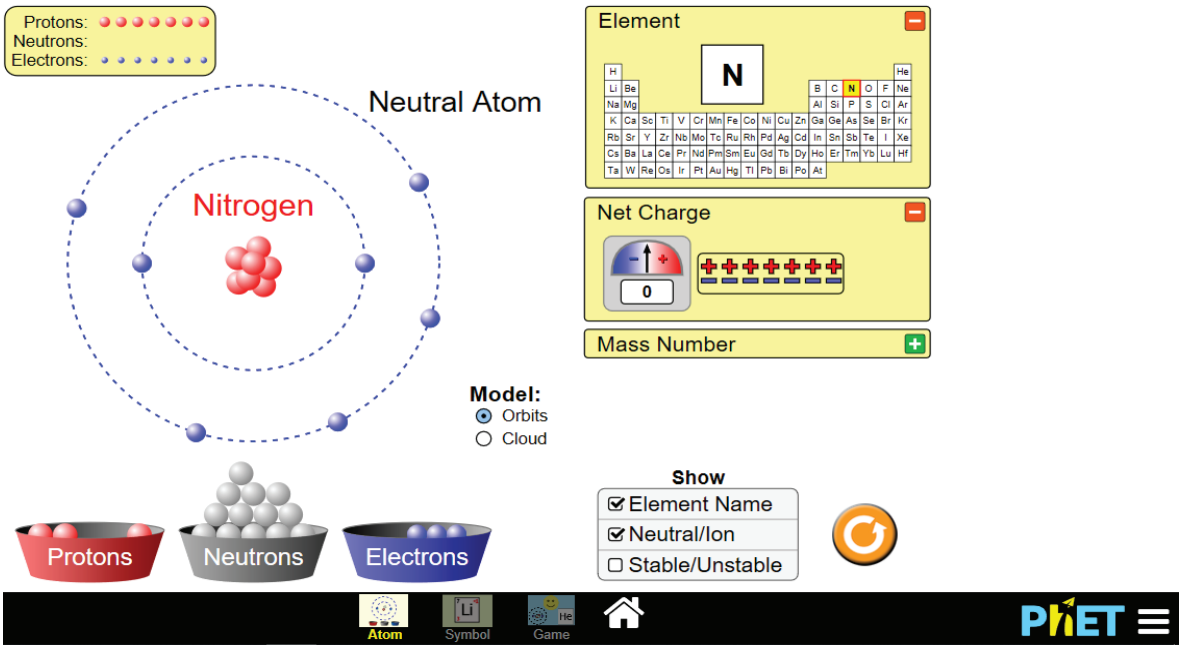
Explain the relationship between the number of outer electrons in the neutral atom and its group.

Boron:



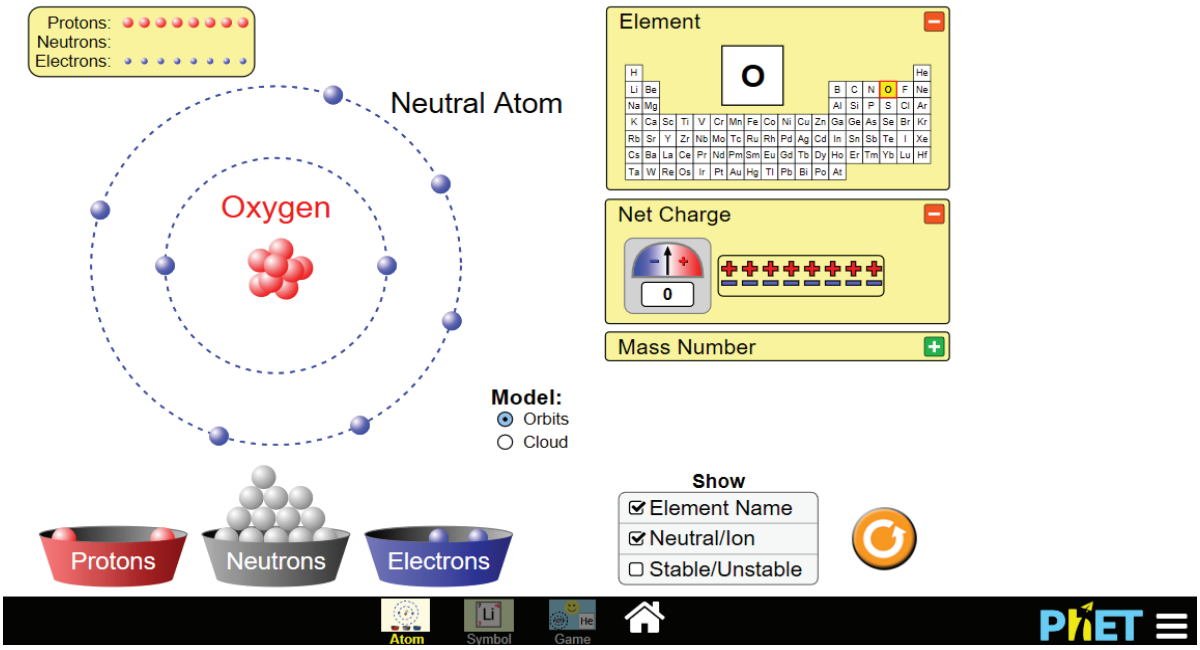
Explain the relationship between the number of outer electrons in the neutral atom and its group.

Carbon:



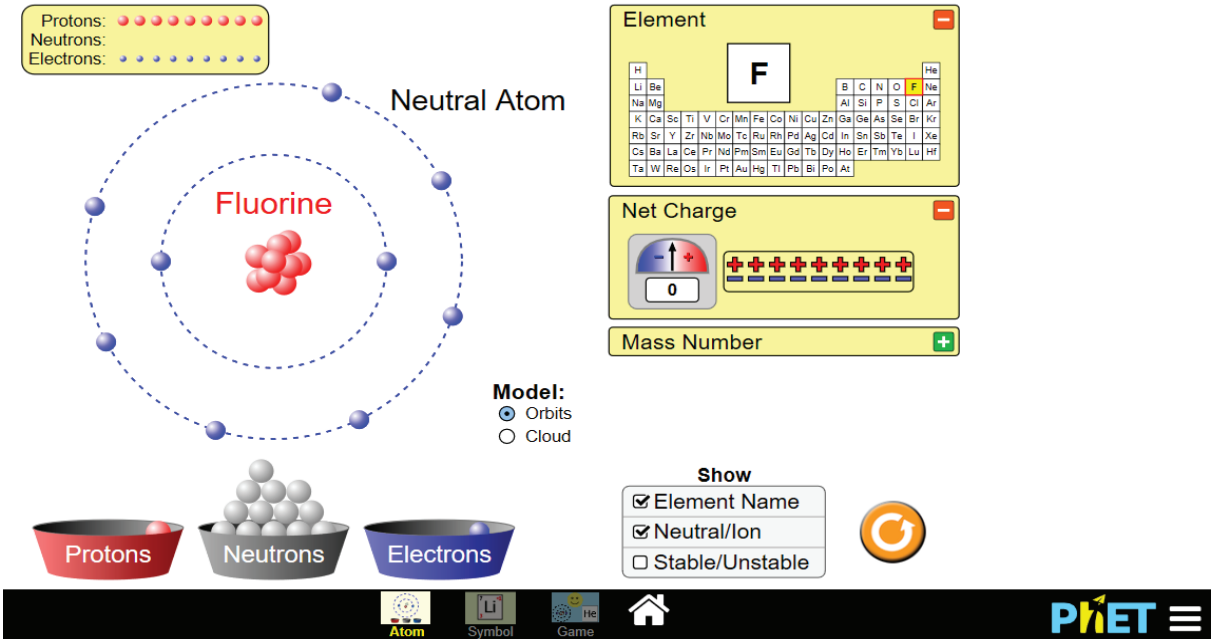
Explain the relationship between the number of outer electrons in the neutral atom and its group.

Nitrogen:



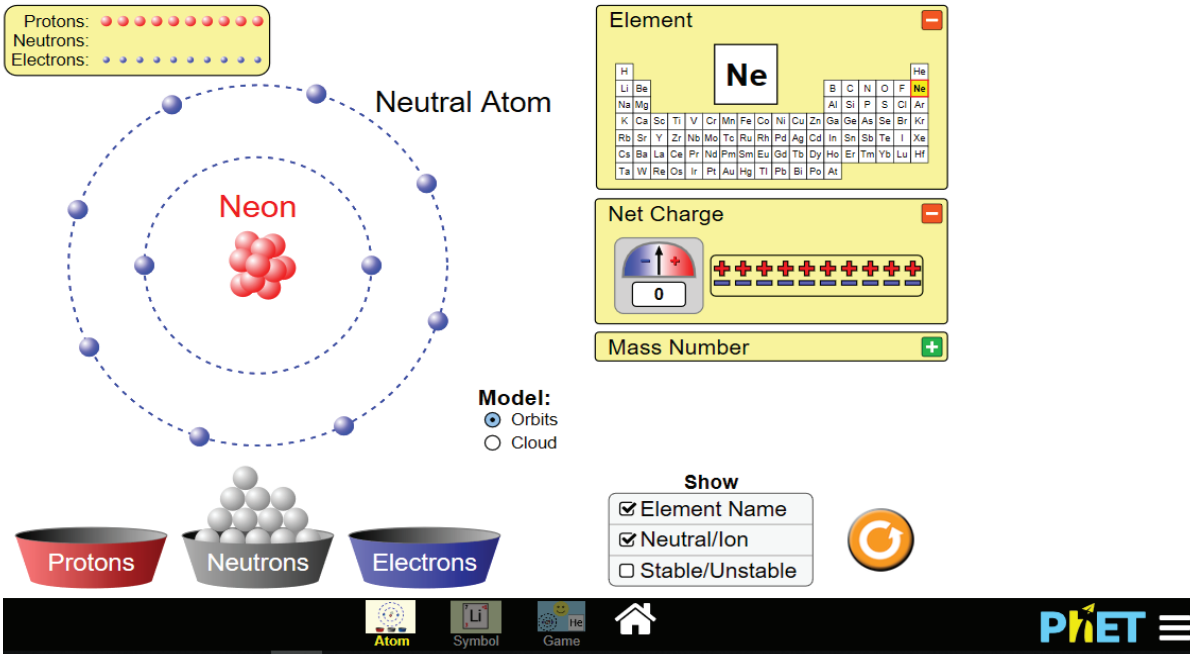
Explain the relationship between the number of outer electrons in the neutral atom and its group.

Oxygen:



Explain the relationship between the number of outer electrons in the neutral atom and its group.

Fluorine:



Explain the relationship between the number of outer electrons in the neutral atom and its group.

Neon:

1. Up to how many electrons can be fitted into the first shell and why?

2. Up to how many electrons can be fitted into the second shell?

3. What does the term "outer shell" mean?

4. What is the relationship between the number of outer electrons in a neutral atom and the group number of the element?

5. Complete the table.

Neutral element	Number of outer electrons	Element Group Number
Lithium		
Beryllium		
Boron		
Carbon		
Nitrogen		
Oxygen		
Fluorine		

6. What is the rule for these elements?

7. What is different with helium and neon with this rule? Why?

SUMMARY POSTERS

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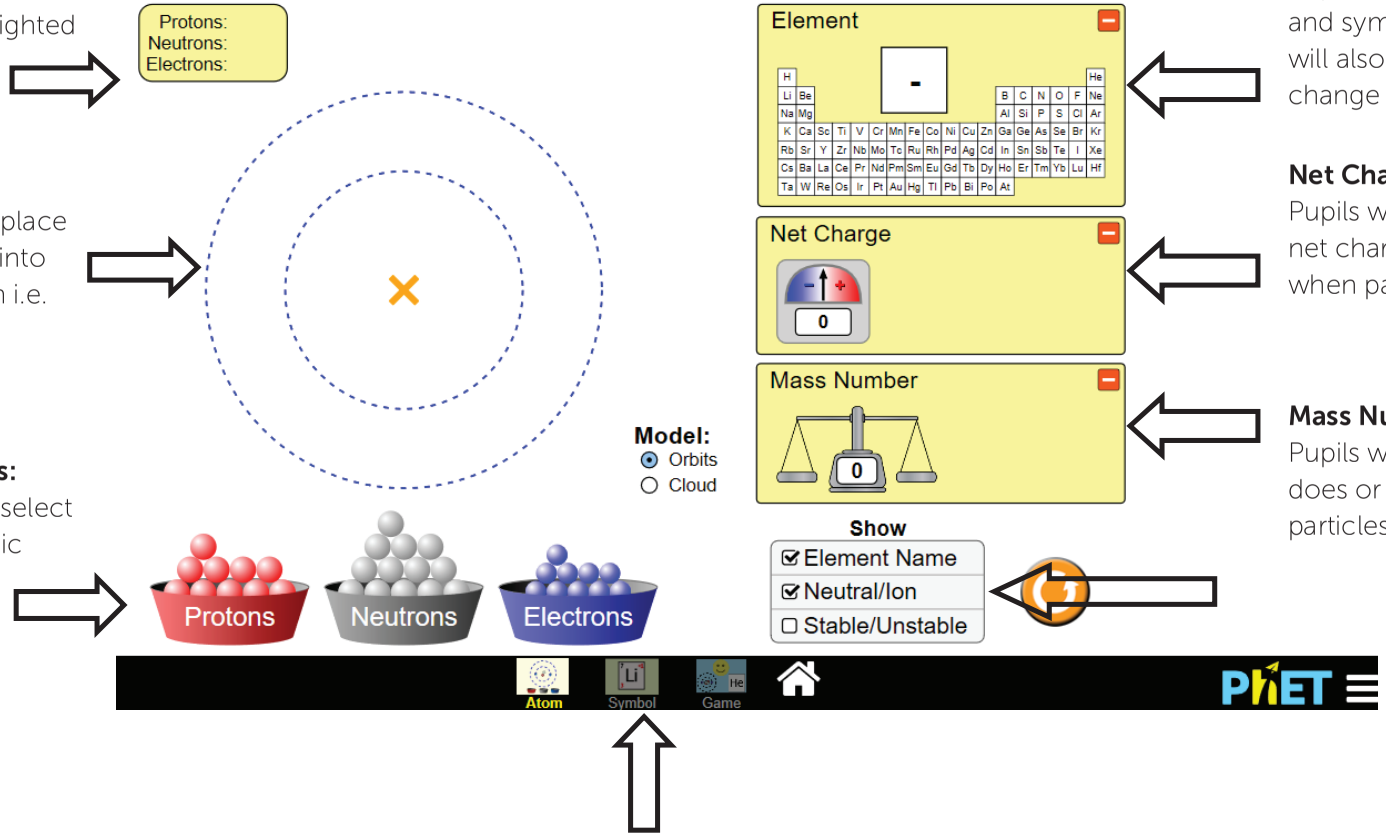
The number of subatomic particles will be highlighted and counted here.



Periodic table:
Pupils will be able see the name and symbol of the element. They will also see how they do/do not change when particles are added.

Atomic structure:
Pupils will be able to place sub-atomic particles into the areas of the atom i.e. nucleus and shells

Net Charge:
Pupils will be able see the how the net charge does/does not change when particles are added.

Mass Number:
Pupils will be able see the mass does or does not change when particles are added.

Sub-atomic particles:
Pupils will be able to select the type of sub-atomic particle they want to investigate.

Variety of simulations:
Pupils will be able see to choose the option of simulation.
Knowledge based and assessment of knowledge through games.

Key terms

Protons:

Are located in the centre (nucleus) and when a proton is added then the element changes. Hydrogen has one proton; when another proton is added the it is helium (two protons).

Neutron:

Are located in the centre (nucleus) of the atom. When neutrons are added, they will not change the element.

Electron:

Are located outside the nucleus in areas called shells or orbits.

Sub-atomic particles:

This is the group name for protons, neutrons, and electrons.

Nucleus:

This is at the "centre" of the atom. The main misconception is relating the word nucleus of the atom to the nucleus of a cell. The nucleus in the atom contains two types of sub-atomic particles only.

Atomic number:

This is the number of protons located in the nucleus. A proton has a relative mass of one (these are atomic units and are not measured in the normal units: kg, g, etc.) A periodic table will have a key that explains where to find the atomic number.

Atomic mass:

Atomic mass and mass number are the same concept however with different names. This the dual name is a common cause of confusion and creation of a misconception.

Atomic mass (mass number) is the mass of the entire atom. A neutron has a mass of one, similar to the proton. However, the neutron will not change the element but only change the mass. The electron has a very small mass. It is 1/1840th the mass of a proton or neutron. The mass can be described as 1/1840 or negligible. It must never be described a zero or nothing. When looking at the periodic table and at the elements this is the larger number located at the element symbol.

Charges:

There are positive and negative charges in the atom. All the positive charges are in the nucleus (centre of the atom) and all the negative charges are in the shells/orbits outside the nucleus.

The neutron has no charge, be it either positive or negative. The neutron is not involved when looking at charges in the atom. It does have mass but it does not have a positive or negative charge. The proton has a charge of +1. When protons are added then their charge is accumu-lative: an atom with one proton has a charge of +1, an atom with two protons has a charge of +2 etc.

The electron has a charge of -1. When electrons are added then their charge is accumulative: an atom with one electron has a charge of -1, an atom with two electrons has a charge of -2 etc.

In a neutral atom, the number of positive charges (protons) are equal to the number of negative charges (electrons).

Examples:
An atom with five protons (+5) and has five electrons (-5) then the overall/net charge of zero (neutral).

Overall charged atoms are called ions, sometimes called charged particles, and they can be overall/net negatively or positively charged.

Atoms with five protons (+5) and four electrons (-4) has an overall/net charge of +1 (positively charged atom). An atom with an overall positively charged is referred as a cation.

Atoms with five protons (+5) and six electrons (-6) has an overall charge of -1 (negatively charged atom). An atom with an overall negatively charged is referred as an anion.

Isotope:

Isotopes are atoms where the number of protons (atomic number) remains the same and therefore they remain the same element [remember the number of protons dictates what the element is] and the number of neutrons can vary. In the natural world some combinations of neutrons with the protons produce stable atoms and other combinations produce unstable atoms.

An isotope is an element with the same atomic number but varying atomic mass (mass number).

Active Learning:
Sub-atomic positioning in the atom

The pupils will discover the positions of the sub-atomic particles. By this active learning method, the pupils will achieve vital knowledge. The incorrect placing of the sub-atomic particles will not be permitted.

Learning outcome:

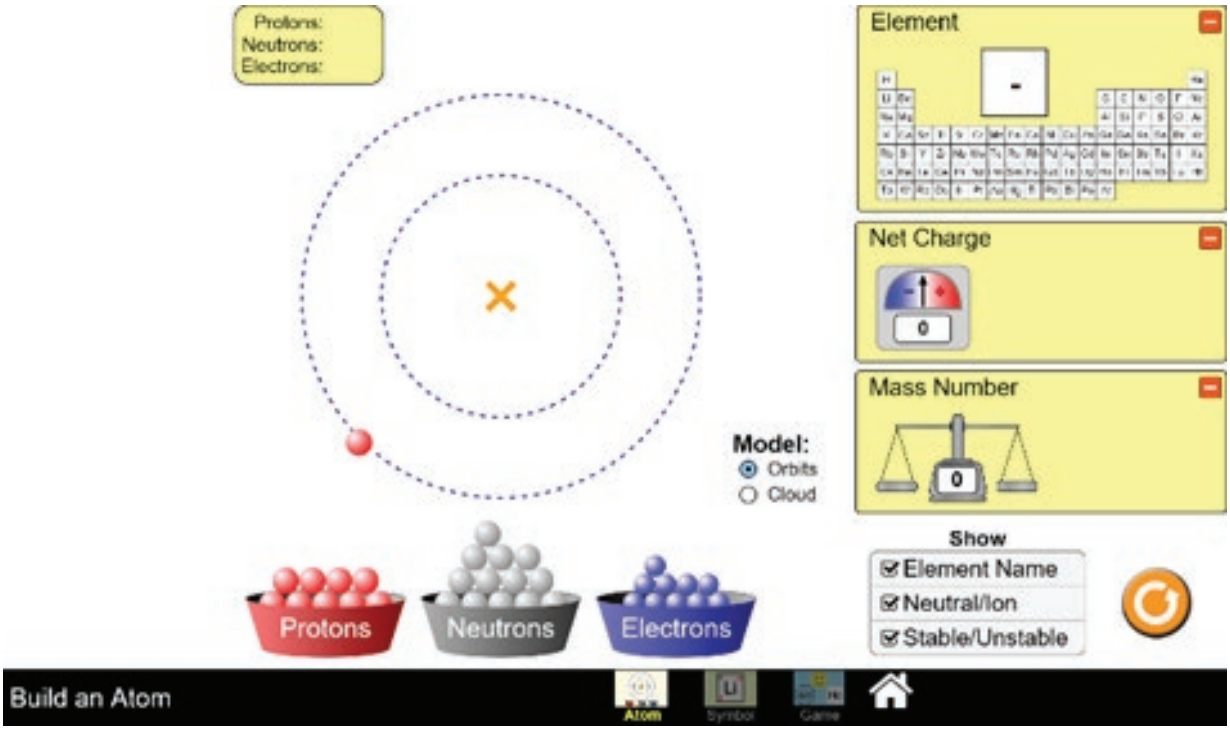
The pupils will discover the position of the sub-atomic particles in the atomic structure.

Student outcome:

The pupils will write their own rules for placement of the sub-atomic particle.

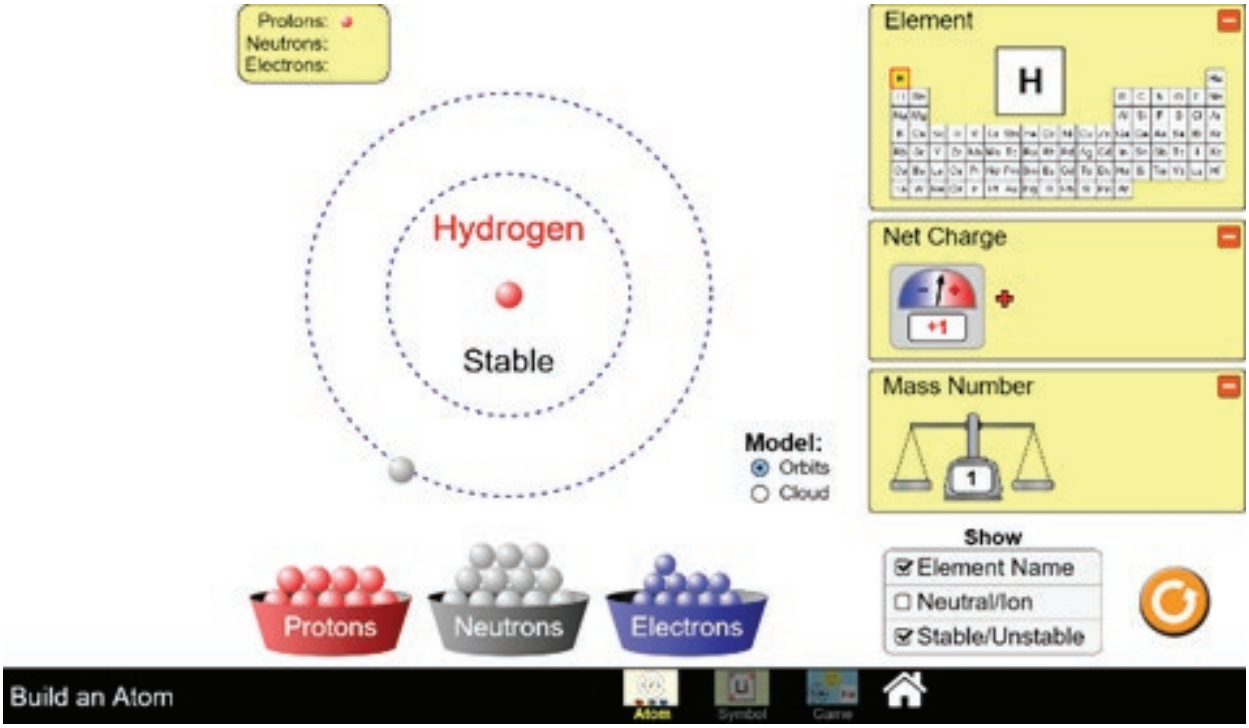
Data and Technology:

Pupils will be able to present their rules via technology media and/or displays.

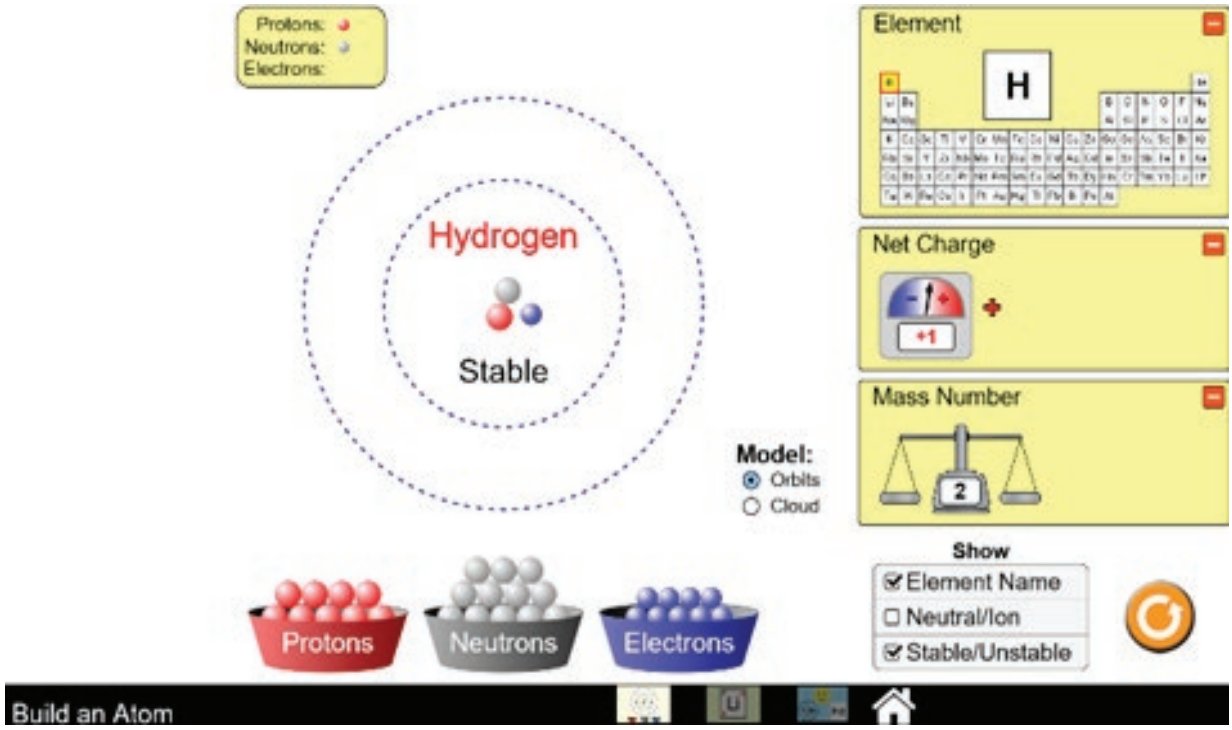


Where does the proton go in the atom?

Through trial and error, the pupils will discover that the protons can only go in one place.



Where does the neutron go in the atom?
Through trial and error, the pupils will discover that the neutrons can only go in one place.



Where does the electron go in the atom?
Through trial and error, the pupils will discover that the electrons can only go in one place.

Active Learning:
How adding protons affects the atom

The pupils will discover how adding protons to the nucleus in the atom can change the atoms vital knowledge.

Learning outcome:

The pupils will discover that adding protons have a direct effect on the type of element it is.

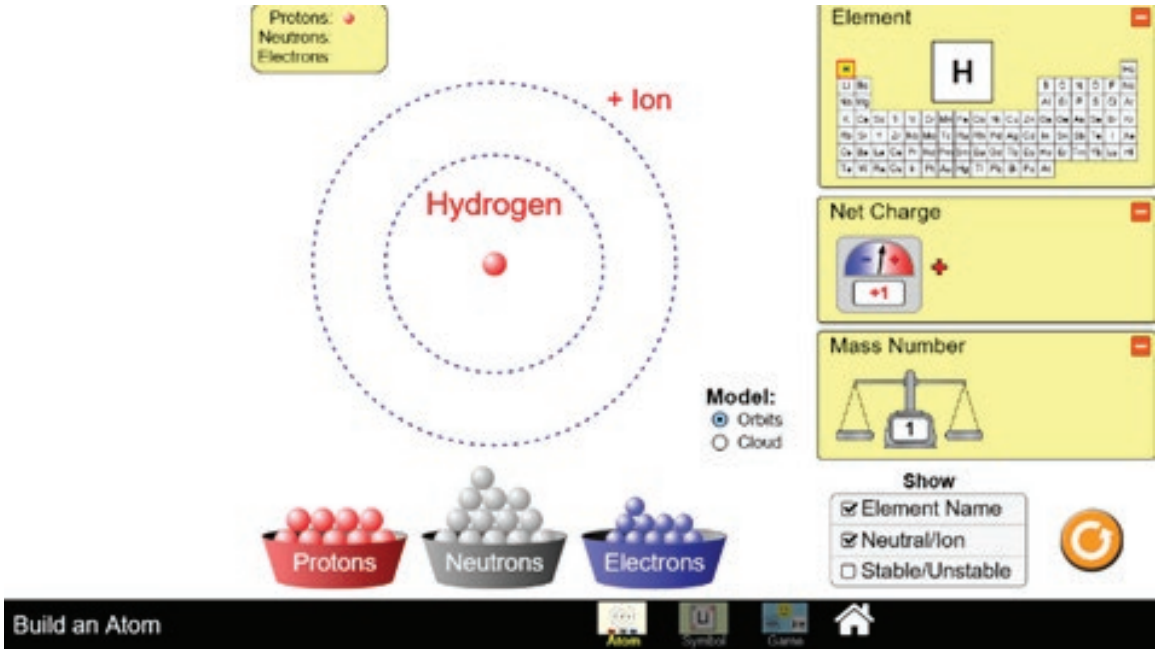
Student outcome:

The pupils will write their own rules for the consequences of adding protons to the type of element.

Data and Technology:

Pupils will be able to present their rules via technology media and/or displays

Adding protons: When adding a proton, what will happen when a proton are added to the name of the element?



When adding a proton what will happen to the name of the element?

The pupils will discover that the type of element changes when protons are added to the nucleus. The pupils will observe this by the changing symbol in the periodic table section. The pupils will notice that the mass number is increased by one.

Possible scaffolded questions for the pupils:
When adding a proton, what will happen to the name of the element?
What will happen to the atomic mass (mass number) of the element?
What will happen to the overall charge (net charge) of the element?

Active Learning: How adding neutrons affects the name of the atom

The pupils will discover whether adding neutrons affects the properties of the element.

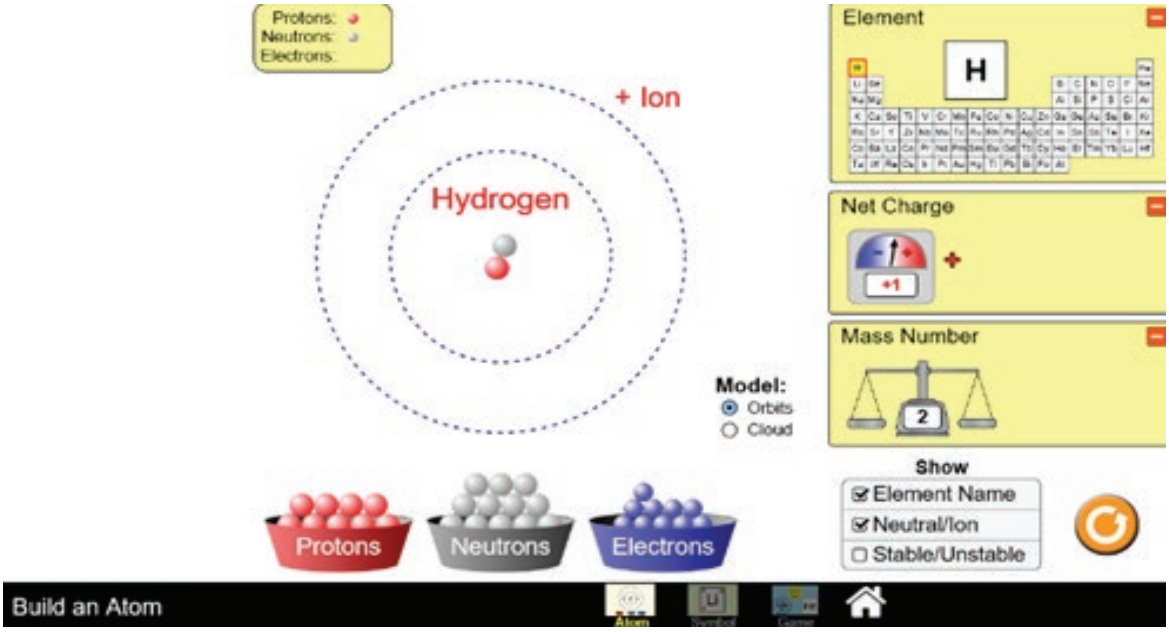
Learning outcome:

The pupils will discover the purpose of the neutron.

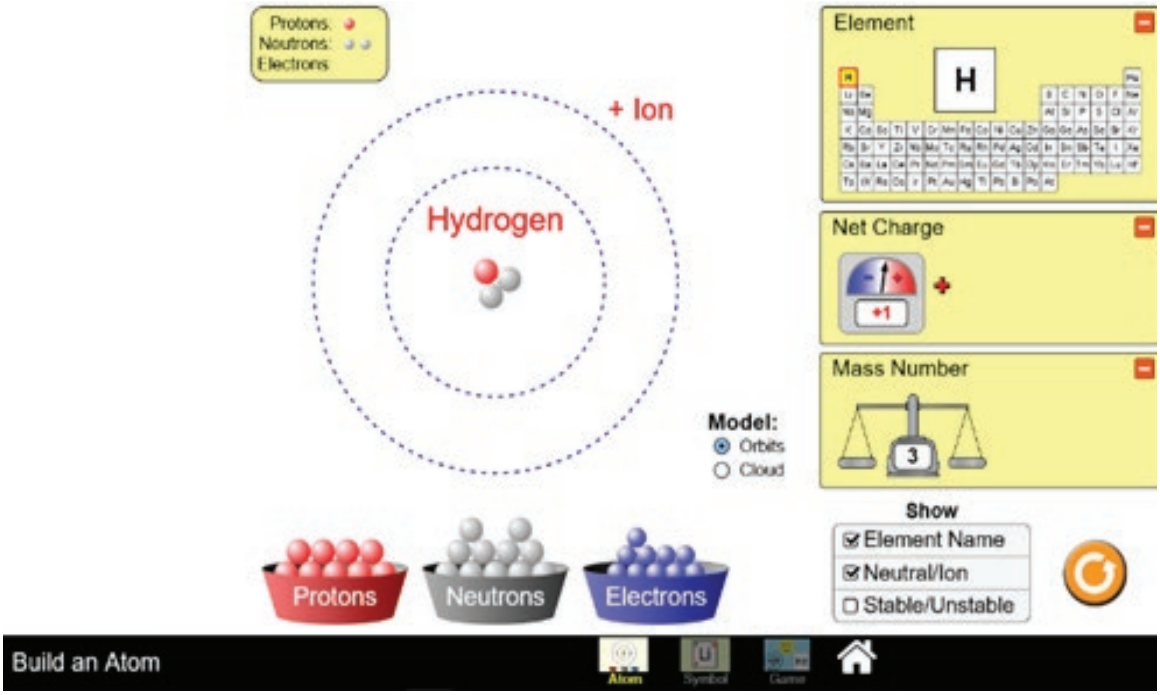
Student outcome:

The pupils will write their own rules for the consequences of adding neutrons to an atom.

Adding neutrons: When adding a neutron, what will happen when a proton are added to the name of the element?



The pupils will observe this by the symbol not changing in the periodic table section. The pupils will also observe the mass number (atomic mass) will increase by one since the neutron has a mass of one.



Possible scaffolded questions for the pupils:

What happens when another neutron is added?
What happens to the element name?
What happens to the charge of the atom?
What happens to the atomic mass (mass number)?

Active Learning: How adding neutrons affects the stability of the atom

The pupils will discover how adding neutrons to the nucleus affects the stability of the atom.

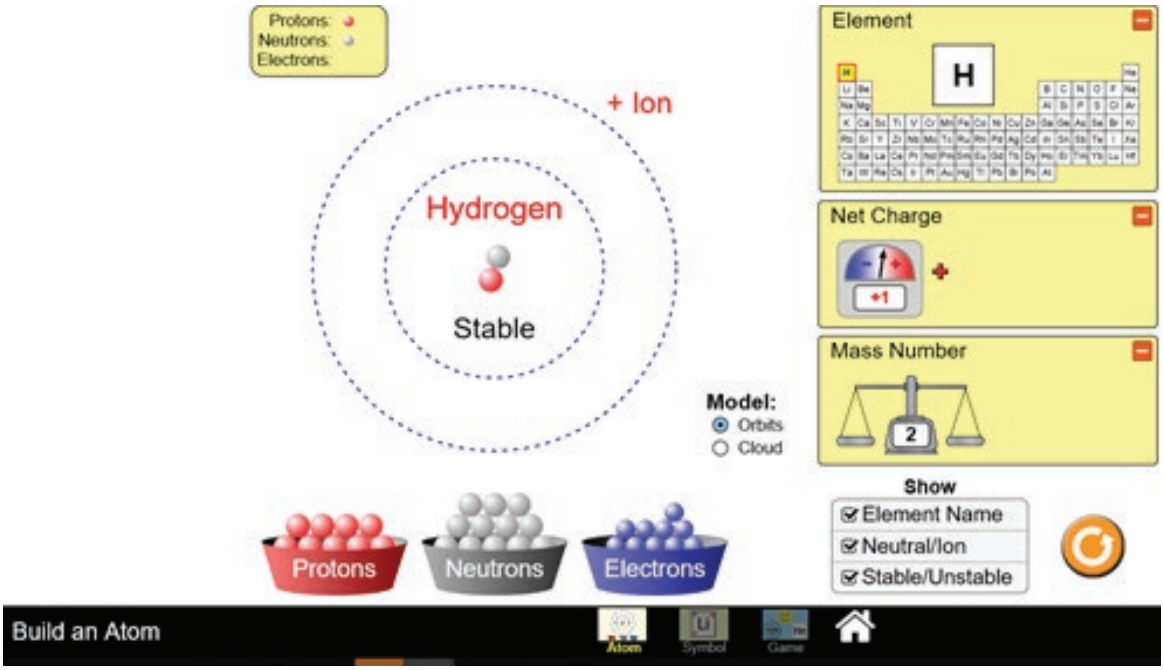
Learning outcome:

The pupils will discover why the naturally abundant element type occurs.

Student outcome:

The pupils will write their own rules for the occurrence of the most naturally abundant isotopes of the elements.

Adding neutrons: When adding a neutron, what will happen when a proton are added to the stability of the element?

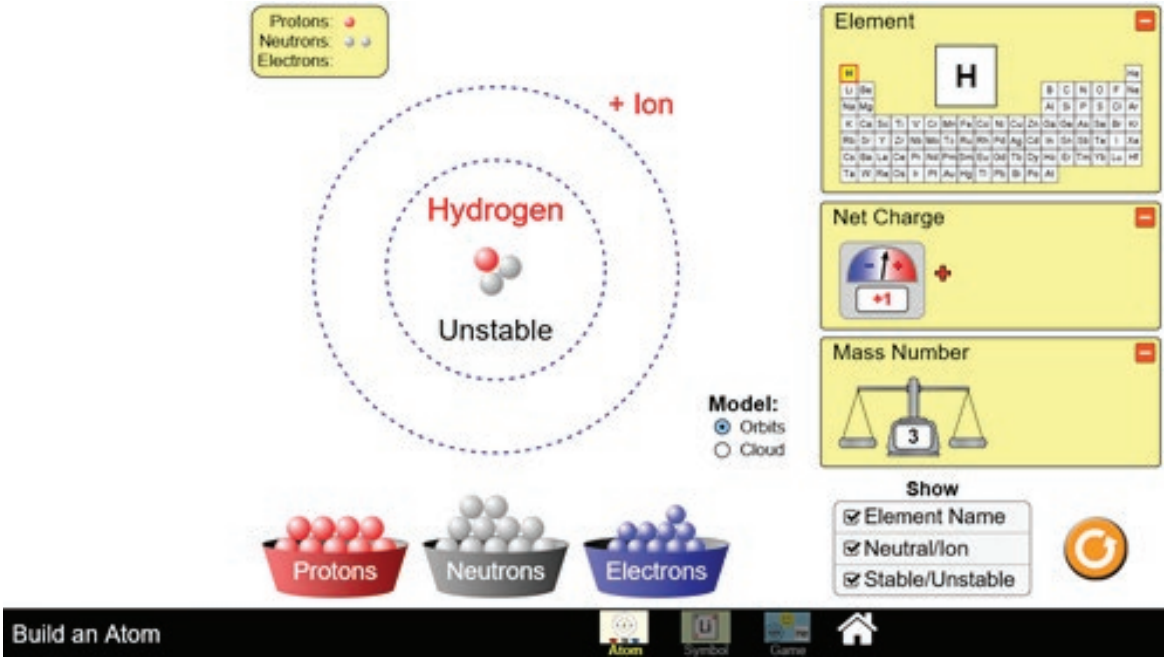


This atom has one proton (mass of one) and one neutron (mass of one). The atomic mass (mass number) is two. The arrangement of protons and neutrons make a stable atom.

This will be the most abundant of this type of element.

When another neutron is added the atomic mass (mass number) increases to 3. That is because there are two neutrons, each with a mass of one, and one proton with a mass of one. However this particular combination of protons and neutrons makes an unstable hydrogen atom. Since it is unstable its natural abundance is low.

When the number of neutrons change for a particular element then these are called isotopes.



Possible scaffolded questions for the pupils:

What are the most stable combinations of the first 10 elements? Look at the atomic number and the atomic mass (mass number).

Active Learning:
How adding electrons affects the atom

The pupils will discover how adding electrons to an atom can change its properties.

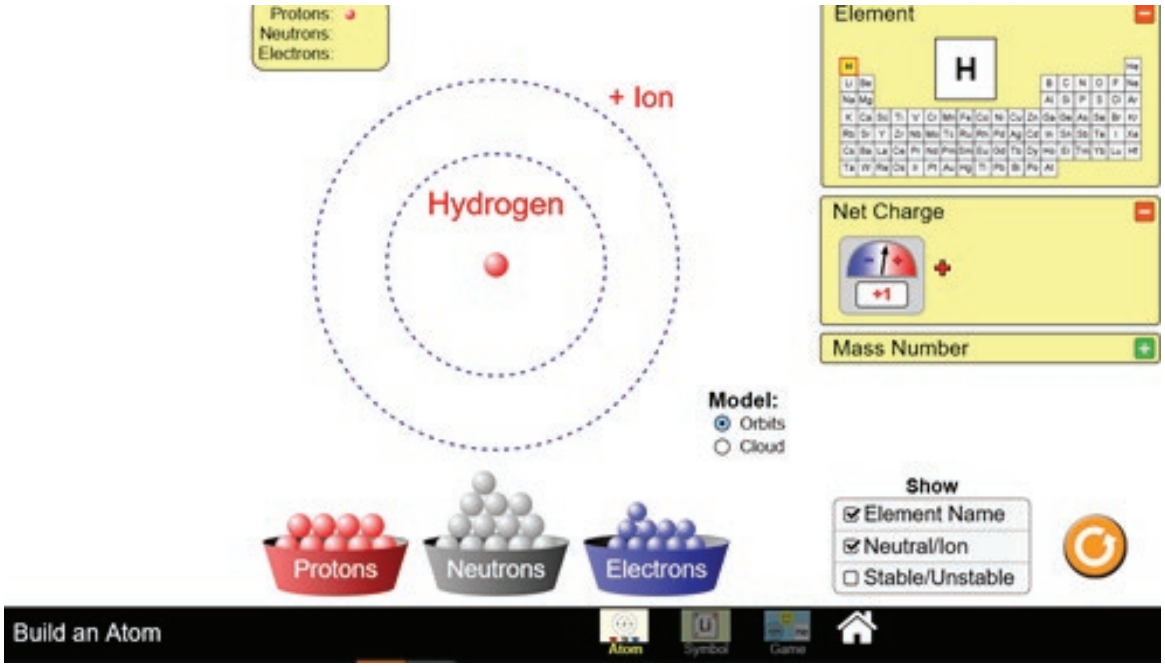
Learning outcome:

The pupils will discover that adding electrons on the overall charge of the atom.

Student outcome:

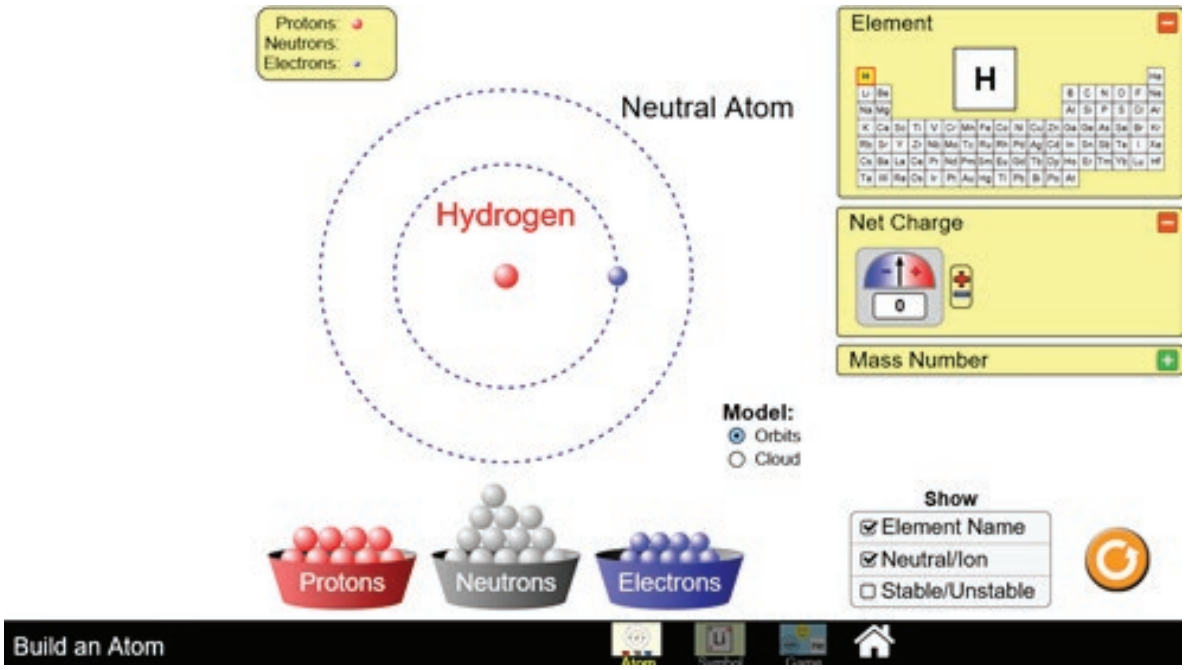
The pupils will write their own rules for electron and proton balance.

Adding electrons: When adding an electron, what will happen to the name of the element? What will happen to the atomic mass (mass number) of the element? What will happen to the overall charge (net charge) of the element?

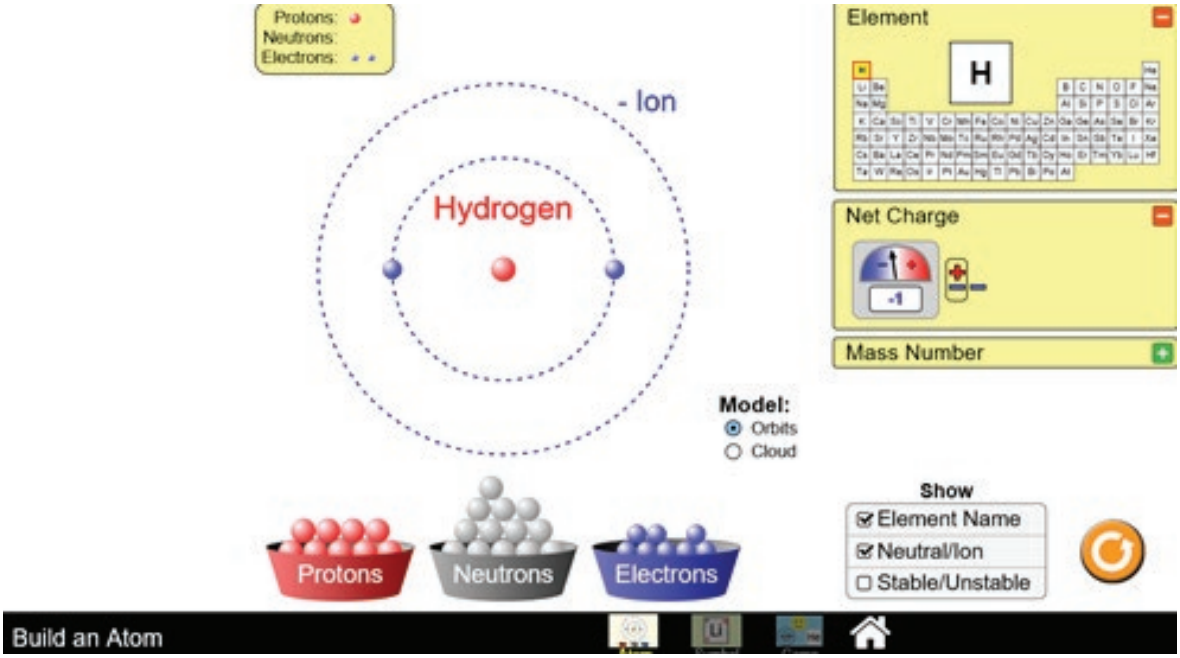


The hydrogen atom has only one proton. The pupils will notice that when there is no electrons in the hydrogen ion (hydrogen cation) then the overall net charge is +1.

This is indicated in the *Net Charge* box in the simulation.



The pupils will discover that when an electron (which is negatively charged) is added to the hydrogen cation then the atom becomes a neutral atom (no overall charge). The pupils will discover that adding electrons have an effect on the overall charge (net charge of the atom). If the number of numbers of electrons (negative charged) and the number of protons (positively charged) are equal, then atom is neutral (no overall net charge).



The pupils will discover that when an addi-tional electron is added, to the neutral hydrogen atom, it produces an overall net charge of -1. There are two negative charges compared to one positive charge. When an atom has an overall negative net charge it is called an anion.

Active Learning:
How adding electrons affects the atom

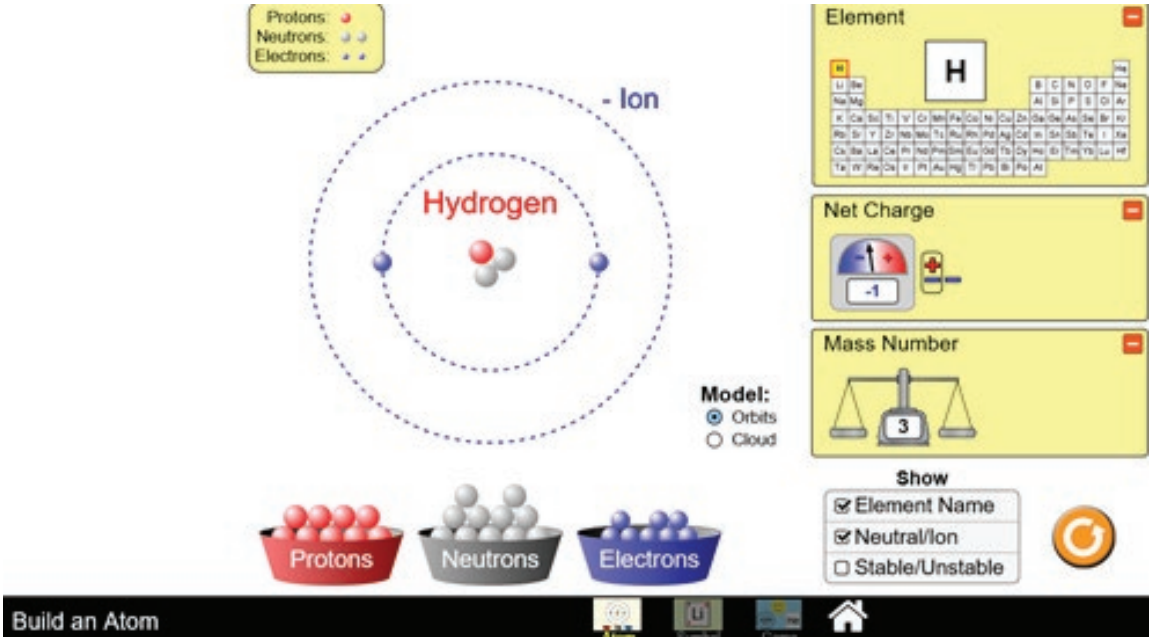
The pupils will discover how adding electrons to the atom can change its properties.

Learning outcome:

The pupils will discover the effect of adding electrons on the overall charge of the atom.

Student outcome:

The pupils will write their own rules for electron and proton balance.



What will happen when you add an extra electron to the shells (orbits) of the atom?

There are now two electrons with a combined negative charge of -2. There is only one proton with a charge of +1. When the negative and positive charges are related to each other, there is an excessive of negative charge. The excess negative charge is -1. When a charged particle (ion) has an overall negative charge then it is an anion.

NOTES FROM YOUR INVESTIGATIONS

Sub-atomic particle	Position in the atom?	Does it change the mass?	What effect does adding this have on the atom and element name?
Proton			
Neutron			
Electron			

The rules that your group discovered (top 4)

a.

b.

c.

d.

The rules the class have agreed upon.