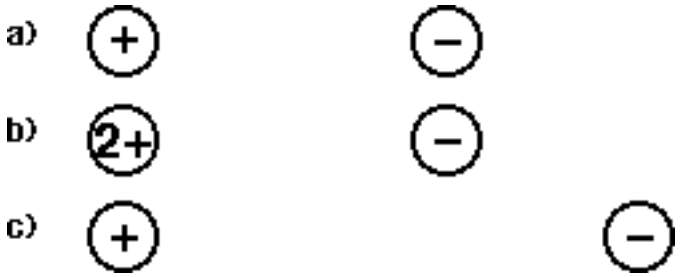
Question: How are electrons ‘arranged’ in an atom?

1. What is the nature of the interaction between protons and electrons in an atom? Consider using some or all of the following terms in your description: attraction, repulsion, neutral, positive, negative, charge, distance, nucleus, force, energy.

2. Compare the relative energy necessary to separate positive and negative electrical charges in the following situations? Compare a and b, then compare a and c.



The ionization energy is defined as the minimum energy necessary to remove an electron from an atom. This definition can be represented in the following chemical equation;

$$A(g) \rightarrow A^{+}(g) + 1e^{-}$$

3. The values for the first ionization energy for a hydrogen and helium atom are provided in the table below.

Atom	H	He	Li
Ionization Energy (kJ mol^{-1})	1312	2373	

Based on comparisons you made in Q2 how would you explain their relative values for the first ionization energy?

4. Predict a value for the first ionization energy for lithium. Justify your prediction based on Q2.

5. The value of the ionization energy of lithium is 520 kJ mol^{-1}. Based on comparisons you made in Q2 how would you explain the ionization energy for lithium compared to the ionization energy for helium? Compared to hydrogen?

6. Predict the relative value of the energy necessary to remove a second electron (called the second ionization energy) from lithium. Support your prediction with an explanation.

7. The first ionization energies for selected elements from the second period of the periodic table follows;

Atom	$_3$Li	$_4$Be	$_6$C	$_7$N	$_9$F	$_{10}$Ne
Ionization Energy (kJ mol^{-1})	520	899	1086	1302	1681	2081

Explain the trend in ionization energies in terms of the relative location of the electrons and the charge of the nucleus.

8. The first ionization energy for the element sodium is given in the following table. Predict the other values for the selected third period elements;

Atom	$_{11}$Na	$_{12}$Mg	$_{14}$Si	$_{15}$P	$_{17}$Cl	$_{18}$Ar
Ionization Energy (kJ mol^{-1})	495					

How did you arrive at your predictions?

9. Describe the electron structure (location of the electron) of the atom. Consider using some or all of the following terms in your description; nucleus, electron, energy, distance, level, proton, shell, arrangement, attraction, repulsion, positive, negative, charge, location.

Important conclusions:

The shell model has the shells getting further from the nucleus;
Larger size can accommodate more electrons;
As electrons get further from the nucleus less energy is required to remove the electron from the atom;
As electrons are closer to the nucleus it requires more energy to remove the electron;
Going across a period the general trend is for the first ionization energy to increase. For elements with outer electrons in the same shell the ionization energy increases with increasing atomic number (number of protons). However, note there are two exceptions to this explanation;
Going down a group the general trend is for the first ionization energy to decrease because the electron removed is coming from a shell that is further from the nucleus, and therefore requires less energy to remove.

Experimental determination of ionization energies are determined using mass spectrometers. The ionization of the neutral atom is brought about by an electron beam.

When discussing ionization energy: what electron are you removing.
Rule of thumb: the shell value is the most important factor, number of protons is next, and finally on the number of electrons.

We are not trying to invent Coulomb's law in this activity, we assume students have an idea of what Coulomb's law. In Q2 we are not expecting students to know that charge is more important (term in CL) than distance.

The data say that charge is more important when the electrons are in the same n value.

Comparisons of the type provided in Q2 are the only comparison we see when looking at first ionization energies of elements. We are always comparing the FIE of one atom to another and trying to explain in terms of charge arguments, or in terms of distance arguments why one element's FIE is higher or lower then the other element's FIE.