Multiple Ionization Energies

The energy required to remove an electron completely from an atom is called the ionization energy, I.E. Write an equation to represent I.E.

I.E.$_1$ is the energy necessary to remove the first electron. The equation for I.E.$_1$ is:

I.E.$_2$ is the energy necessary to remove the second electron. The equation for I.E.$_2$ is:

I.E.$_3$ is the energy necessary to remove the first electron. The equation for I.E.$_3$ is:

We have previously seen some trends in first ionization energies, let us now examine what happens when successive electrons are removed from atoms.

Examine the following Table of ionization energies to help you to answer the following questions:

Table of Ionization Energies (kJ mol^{-1})

Element	I.E.$_1$	I.E.$_2$	I.E.$_3$	I.E.$_4$	I.E.$_5$	I.E.$_6$	I.E.$_7$
H	1311						
He	2370	5246					
Li	520	7288	11812				
Be	898	1759	14817	21007			
B	799	2421	3656	24995	32825		
C	1085	2349	4614	6142	37824		
N	1403	2855	4613	7468	9456	53300	
O	1312	3385	5318	7469	10962	13300	71300
F	1680	3373	6023	8432	11022	15200	
Ne	2077	3952	6122	9370	12178	15239	
Na	495	4563	6913	9544	13353	16611	20115
Mg	732	1446	7709	10541	13630	17995	
Al	576	1813	2747	11564	14800		
Si	785	1578	3228	4349	16021		
P	1010	1891	2909	4951	6083		
S	998	2253	3379	4559	6987	8432	
Cl	1255	2295	3849	5252	6505	9336	10961
Ar	1518	2700	3900	5800	7200	8800	
K	418	3066	4400	5900	8000	9600	
Ca	590	1144	4933	6500	8100	10500	

Answer the following questions using the Table of Ionisation Energies:
Write down the ionisation energies for the following families of the periodic table from the above Table of Ionisation Energies:

Group I	I.E.$_1$	I.E.$_2$	I.E.$_3$	I.E.$_4$	I.E.$_5$
Li					
Na					
K					

Group II
Be
Mg
Ca

Group VIII
He
Ne
Ar

1. What is the general trend for I.E.$_2$ as the atomic number increases in a family on the periodic table?

2. Which family has the lowest value for I.E.$_2$? Explain.

3. Which family has the highest value for I.E.$_2$? Explain.

4. Why is the I.E.$_2$ for lithium higher than the I.E.$_2$ for sodium? Explain.

5. Explain the dramatic jump between I.E.$_2$ and I.E.$_3$ for magnesium.

6. Look at the values for I.E.$_2$ and I.E.$_3$ for Be and B. why is there a dramatic difference in the value of I.E.$_3$ for B? Explain.

7. What generalization may be deduced from all your observations regarding the amount of energy required to remove successive electrons from an element and the Group number of the element.

8. Is there a connection between the charge carried by an ion of the element, its position in the periodic table and the successive ionisation energies of the element ?

9. Which group of elements are stable in their atomic form, and which group of elements have the least stability? Explain.

10. An element X has the following ionisation energies, (kJ/mol):

Element	I.E.$_1$	I.E.$_2$	I.E.$_3$	I.E.$_4$	I.E.$_5$
X	580	1828	2665	12545	14866

Predict which group of the periodic table the element X may belong to, predict if it is a metal or non-metal, and the charge on an ion of element X.