AP Chemistry **Unit 5 Test**

Questions 1-3 refer to the atoms below.

(A) O
(B) Ba
(C) Rb
(D) Mg
(E) P

1. Is the most electronegative

2. Has the greatest first ionization energy

3. Has the largest radius

4. Which lists species are isoelectronic?
   a. Ba, Ra, Ca
   b. Cl^-, As^{-3}, S^{-2}
   c. Cr, Mn, Fe
   d. S^{-2}, Cl^-, K^+
   e. Ba^{+2}, Ca^{+2}, Be^{+2}

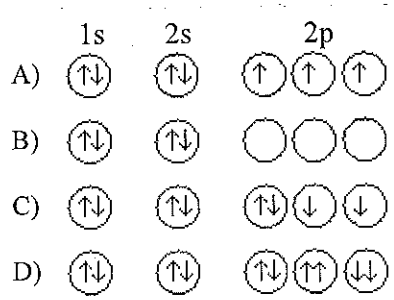
5. Based on the information in the table below, what is the most likely charge of element X?

Element	First Ionization Energy ($kJ\ mol^{-1}$)	First Ionization Energy ($kJ\ mol^{-1}$)	First Ionization Energy ($kJ\ mol^{-1}$)	First Ionization Energy ($kJ\ mol^{-1}$)
X	900	1757	14850	21000

   a. 1-
   b. 1+
   c. 2+
   d. 3+
   e. 4+

6. Which of the following techniques is utilized in the laboratory to determine the energies of core electrons within a pure sample of an element?
   a. Mass spectroscopy
   b. UV- visible spectroscopy
   c. infra-red (IR) spectroscopy
   d. photoelectron spectroscopy or PES

7. Which of the following orbital diagrams violates the Pauli exclusion principle?



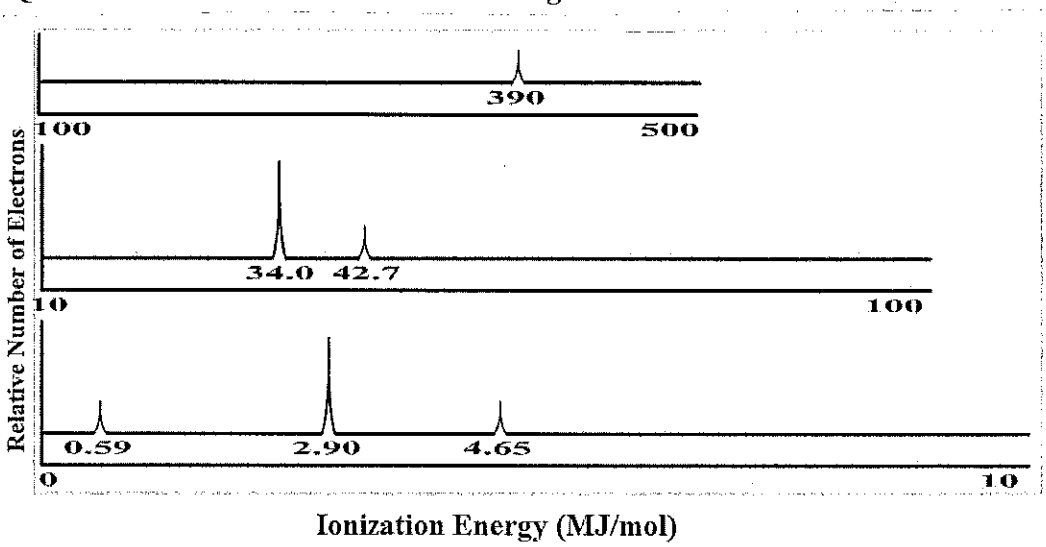
Questions 8 and 9 refer to the ionization energies for element X listed in the table below.

Ionization Energies of element X (kJ mol^{-1})				
First	**Second**	**Third**	**Fourth**	**Five**
580	**1,815**	**2,740**	**11,600**	**14,800**

8. On the basis of the data, element X is most likely to be
   a. Na
   b. Mg
   c. al
   d. Si

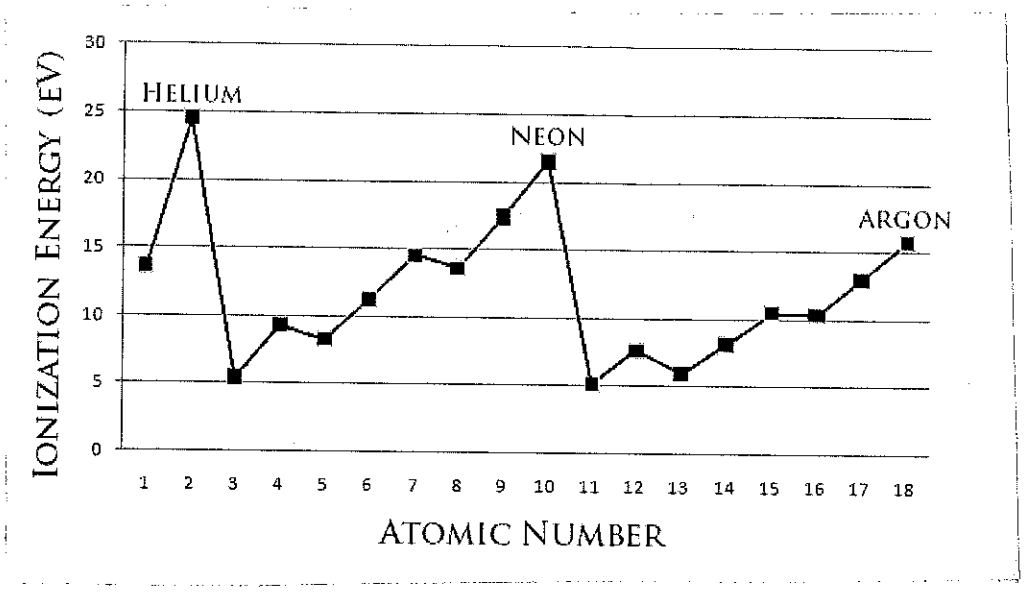
9. How many valence electrons are present in this atom?
   a. 1
   b. 2
   c. 3
   d. 4

Question 10 and 11 refer to the following PES data.



10. The PES data above shows all of the electrons present in the atom. Which specific electrons are associated with the peak of 0.59 MJ/mol?
    a. 2p
    b. 3s
    c. 3p
    d. 4s

11. What is the significance of the relative height of the peaks at 34.0 MJ/mol and 42.7 MJ/mol?
    a. The height of the peaks represent the amount of energy associated with removing an electron from a specific energy level.
    b. the height peaks represent the amount of energy associated with removing an electron from a specific energy sublevel.
    c. the height peaks represent the amount of distance a given electron is from the nucleus.
    d. The height peaks represent the relative number of electrons in each sublevel.



12. Which of the following best describes *why* the first ionization energy for an oxygen atom is lower than the first ionization energy for a nitrogen atom?
    a. Less energy is required to remove an electron from an oxygen atom since the ionization energy increases across a period from left to right
    b. More energy is required to remove an electron from an oxygen atom since the ionization energy increase across a period from left to right.
    c. Less energy is required to remove an electron from an oxygen atom due to the fact that the oxygen atom has two doubly-occupied 2p orbitals and nitrogen has only one.
    d. less energy to required to remove an electron from an oxygen atom due to the fact that oxygen has one doubly-occupied 2p orbital and nitrogen does not.

Unit 5 Free Response Questions

1. Answer the following questions about nitrogen, oxygen, fluorine, and iodine using the principles of atomic and molecular structure

Element	First Ionization Energy ($kJ\ mol^{-1}$)
N	1402
O	1314
F	1681
I	???

   a. Explain why N has a smaller first ionization energy than F.
   b. Explain why O has a smaller first ionization energy then N.
   c. Would you predict the first ionization energy of atoms of iodine to be greater, less than, or equal to that of fluorine? Explain
   d. Which of the atoms listed in the table above would have the largest atomic radius? Explain.

2. Answer the following questions regarding light and its interactions with molecules, atoms, and ions.

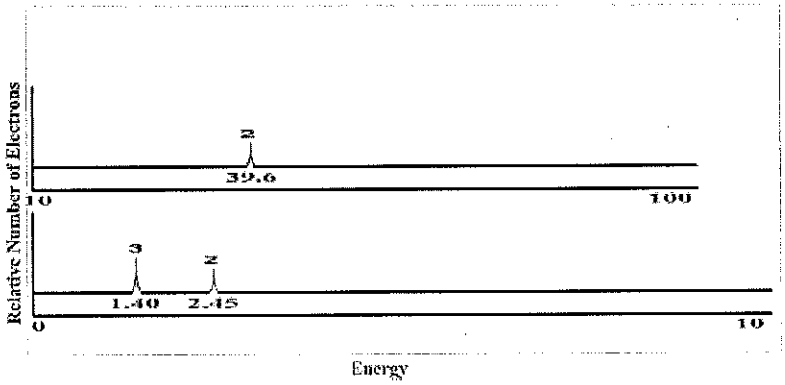
   a. The longest wavelength of light with enough energy to break the Cl-Cl bond in $Cl_2(g)$ is 495 nm.
      i. Calculate the frequency, in s^{-1}, of the light.

      ii. Calculate the energy, in J, of a photon of the light.

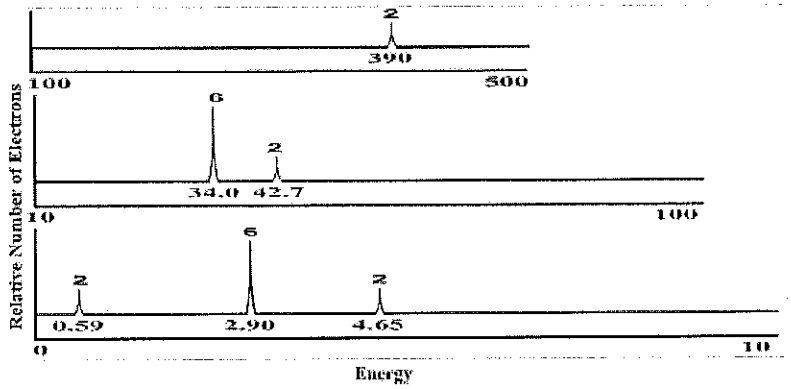
      iii. Calculate the minimum energy, in $kJ\ mol^{-1}$, of the Cl-Cl bond.

3. Use principles of atomic theory, along with the photoelectron spectroscopy data shown below, to answer the following questions about atoms of nitrogen and phosphorus.

Nitrogen



Calcium



P?

a. Examine the photoelectron spectrum for atoms of nitrogen.
   i. Circle the peak that contains the *first* electron that would be removed from a nitrogen atom.

   ii. How much energy is required to remove this first electron?

b. Once the first electron is removed from an atom of nitrogen would you expect the energy required to remove the second electron to be greater than, less than, or equal to the energy required to remove the first electron? Justify your answer.

c. Explain why atoms of phosphorus have a lower first ionization energy than those of nitrogen. Be sure to reference Coulomb's Law in your explanation.