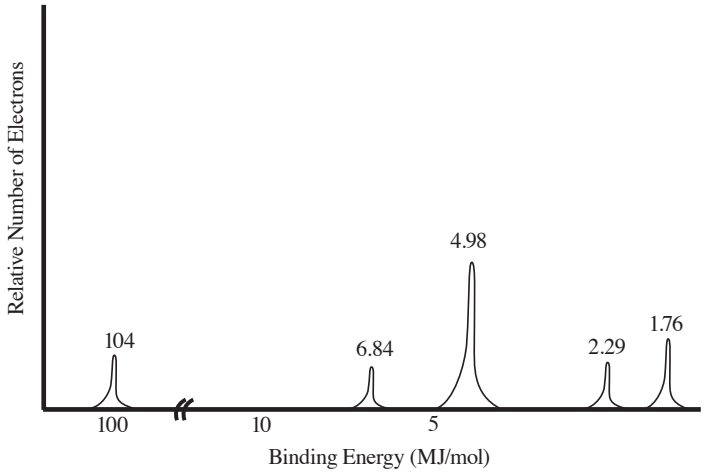
CHAPTER 3 QUESTIONS

Multiple-Choice Questions

Use the PES spectra below to answer questions 1-4.



1. What element does this spectra represent?

   (A) Boron
   (B) Nitrogen
   (C) Aluminum
   (D) Phosphorus

2. Which peak represents the 2*s* subshell?

   (A) The peak at 104 MJ/mol
   (B) The peak at 6.84 MJ/mol
   (C) The peak at 2.29 MJ/mol
   (D) The peak at 1.76 MJ/mol

3. An electron from which peak would have the greatest velocity after ejection?

   (A) The peak at 104 MJ/mol
   (B) The peak at 6.84 MJ/mol
   (C) The peak at 4.98 MJ/mol
   (D) The peak at 1.76 MJ/mol

4. How many valence electrons does this atom have?

   (A) 2
   (B) 3
   (C) 4
   (D) 5

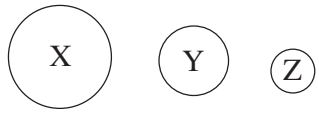
5. Why does an ion of phosphorus, P^{3-}, have a larger radius than a neutral atom of phosphorus?

   (A) There is a greater Coulombic attraction between the nucleus and the electrons in P^{3-}.
   (B) The core electrons in P^{3-} exert a weaker shielding force than those of a neutral atom.
   (C) The nuclear charge is weaker in P^{3-} than it is in P.
   (D) The electrons in P^{3-} have a greater Coulombic repulsion than those in the neutral atom.

6. A compound is entirely made up of silicon and oxygen atoms. If there are 14.0 g of silicon and 32.0 g of oxygen present, what is the empirical formula of the compound?

   (A) SiO_2
   (B) SiO_4
   (C) Si_2O
   (D) Si_2O_3

7. The diagram below shows the relative atomic sizes of three different elements from the same period. Which of the following statements must be true?



   (A) The effective nuclear charge will be the greatest in element X.
   (B) The first ionization energy will be greatest in element X.
   (C) The electron shielding effect will be greatest in element Z.
   (D) The electronegativity value will be greatest in element Z.

8. The first ionization energy for a neutral atom of chlorine is 1.25 MJ/mol and the first ionization energy for a neutral atom of argon is 1.52 MJ/mol. How would the first ionization energy value for a neutral atom of potassium compare to those values?

   (A) It would be greater than both because potassium carries a greater nuclear charge than either chlorine or argon.
   (B) It would be greater than both because the size of a potassium atom is smaller than an atom of either chlorine or argon.
   (C) It would be less than both because there are more electrons in potassium, meaning they repel each other more effectively and less energy is needed to remove one.
   (D) It would be less than both because a valence electron of potassium is farther from the nucleus than one of either chlorine or argon.

9. Neutral atoms of chlorine are bombarded by high-energy photons, causing the ejection of electrons from the various filled subshells. Electrons originally from which subshell would have the highest velocity after being ejected?

   (A) 1*s*
   (B) 2*p*
   (C) 3*p*
   (D) 3*d*

10. The average mass, in grams, of one mole of carbon atoms is equal to

    (A) the average mass of a single carbon atom, measured in amus
    (B) the ratio of the number of carbon atoms to the mass of a single carbon atom
    (C) the number of carbon atoms in one amu of carbon
    (D) the mass, in grams, of the most abundant isotope of carbon

11. Which of the following statements is true regarding sodium and chlorine?

    (A) Sodium has greater electronegativity and a larger first ionization energy.
    (B) Sodium has a larger first ionization energy and a larger atomic radius.
    (C) Chlorine has a larger atomic radius and a greater electronegativity.
    (D) Chlorine has greater electronegativity and a larger first ionization energy.

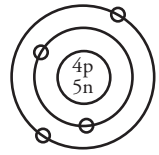
12. An atom of silicon in its ground state is subjected to a frequency of light that is high enough to cause electron ejection. An electron from which subshell of silicon would have the highest kinetic energy after ejection?

    (A) 1*s*
    (B) 2*p*
    (C) 3*p*
    (D) 4*s*

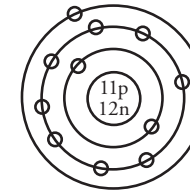
13. The wavelength range for infrared radiation is 10^{-5} m, while that of ultraviolet radiation is 10^{-8} m. Which type of radiation has more energy, and why?

    (A) Ultraviolet has more energy because it has a higher frequency.
    (B) Ultraviolet has more energy because it has a longer wavelength.
    (C) Infrared has more energy because it has a lower frequency.
    (D) Infrared has more energy because it has a shorter wavelength.

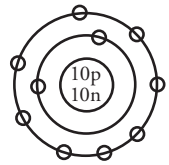
14. A photoelectron spectra for which of the following atoms would show peaks at exactly three different binding energies?



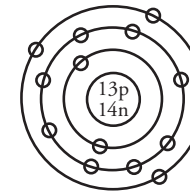
(A)



(C)



(B)



(D)

15. Examining data obtained from mass spectrometry supports which of the following?

    (A) The common oxidation states of elements
    (B) Atomic size trends within the periodic table
    (C) Ionization energy trends within the periodic table
    (D) The existence of isotopes

16. In general, do metals or nonmetals from the same period have higher ionization energies? Why?

    (A) Metals have higher ionization energies because they usually have more protons than nonmetals.
    (B) Nonmetals have higher ionization energies because they are larger than metals and harder to ionize.
    (C) Metals have higher ionization energies because there is less electron shielding than there is in nonmetals.
    (D) Nonmetals have higher ionization energies because they are closer to having filled a complete energy level.

17. The ionization energies for an element are listed in the table below.

First	Second	Third	Fourth	Fifth
8 eV	15 eV	80 eV	109 eV	141 eV

Based on the ionization energy table, the element is most likely to be

(A) sodium
(B) magnesium
(C) aluminum
(D) silicon

Use the following information to answer questions 18-20.

The outermost electron of an atom has a binding energy of 2.5 eV. The atom is exposed to light of a high enough frequency to cause exactly one electron to be ejected. The ejected electron is found to have a KE of 2.0 eV.

18. How much energy did photons of the incoming light contain?

(A) 0.50 eV
(B) 0.80 eV
(C) 4.5 eV
(D) 5.0 eV

19. If the wavelength of the light were to be shortened, how would that affect the kinetic energy of the ejected electron?

(A) A shorter wavelength would increase the kinetic energy.
(B) A shorter wavelength would decrease the kinetic energy.
(C) A shorter wavelength would stop all electron emissions completely.
(D) A shorter wavelength would have no effect on the kinetic energy of the ejected electrons.

20. If the intensity of the light were to be decreased (that is, if the light is made dimmer), how would that affect the kinetic energy of the ejected electron?

(A) The decreased intensity would increase the kinetic energy.
(B) The decreased intensity would decrease the kinetic energy.
(C) The decreased intensity would stop all electron emissions completely.
(D) The decreased intensity would have no effect.

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21. Nitrogen's electronegativity value is between those of phosphorus and oxygen. Which of the following correctly describes the relationship between the three values?

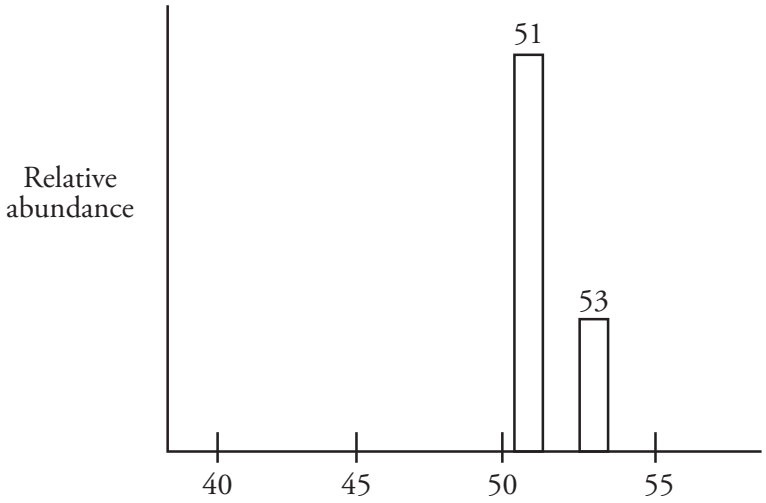
(A) The value for nitrogen is less than that of phosphorus because nitrogen is larger, but greater than that of oxygen because nitrogen has a greater effective nuclear charge.
(B) The value for nitrogen is less than that of phosphorus because nitrogen has fewer protons, but greater than that of oxygen because nitrogen has fewer valence electrons.
(C) The value for nitrogen is greater than that of phosphorus because nitrogen has fewer electrons, but less than that of oxygen because nitrogen is smaller.
(D) The value for nitrogen is greater than that of phosphorus because nitrogen is smaller, but less than that of oxygen because nitrogen has a smaller effective nuclear charge.

22. Which of the following ions would have the most unpaired electrons?

(A) Mn^{2+}
(B) Ni^{3+}
(C) Ti^{2+}
(D) Cr^{6+}

Free-Response Questions

1. Explain each of the following in terms of atomic and molecular structures and/or forces.
   (a) The first ionization energy for magnesium is greater than the first ionization energy for calcium.
   (b) The first and second ionization energies for calcium are comparable, but the third ionization energy is much greater.
   (c) There are three peaks of equal height in the PES of carbon, but on the PES of oxygen the last peak has a height twice as high as all the others.
   (d) The first ionization energy for aluminum is lower than the first ionization energy for magnesium.



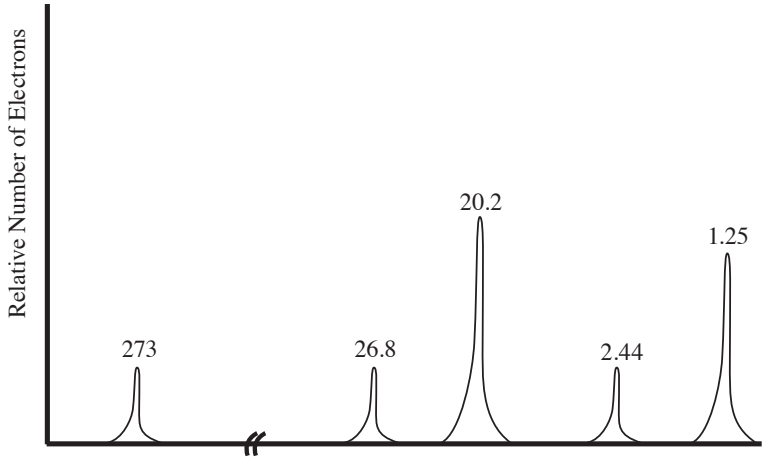
2. The above mass spectra is for the hypochlorite ion, ClO^-. Oxygen has only one stable isotope, which has a mass of 16 amu.
   (a) How many neutrons does the most common isotope of chlorine have?
   (b) Using the spectra, calculate the average mass of a hypochlorite ion.
   (c) Does the negative charge on the ion affect the spectra? Justify your answer.
   (d) The negative charge in the ion is located around the oxygen atom. Speculate as to why.

3. The table below gives data on four different elements, in no particular order:

Carbon, Oxygen, Phosphorus, and Chlorine

	Atomic radius (pm)	First Ionization Energy (kJ/mol^{-1})
Element 1	170	1086.5
Element 2	180	1011.8
Element 3	175	1251.2
Element 4	152	1313.9

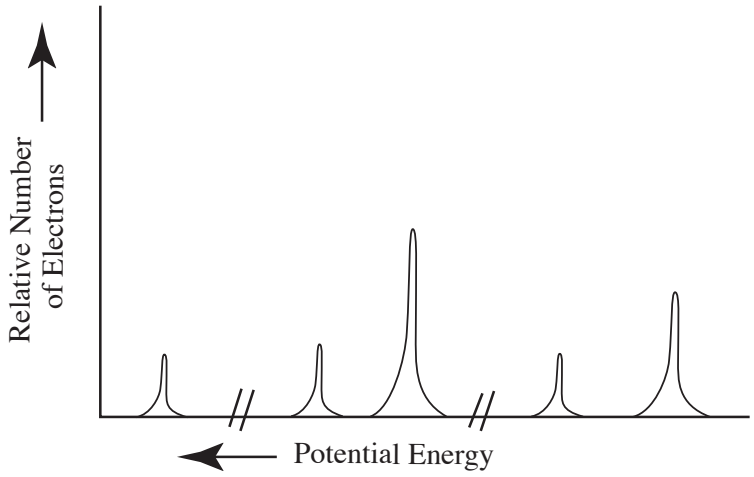
(a) Which element is number 3? Justify your answer using both properties.
(b) What is the outermost energy level that has electrons in element 2? How many valence electrons does element 2 have?
(c) Which element would you expect to have the highest electronegativity? Why?
(d) How many peaks would the PES for element 4 have and what would the relative heights of those peaks be to each other?



4. The above PES belongs to a neutral chlorine atom.

(a) What wavelength of light would be required to eject a 3*s* electron from chlorine?
(b) For the PES of a chloride ion, how would the following variables compare to the peaks on the PES above? Justify your answers.
  (i) Number of peaks
  (ii) Height of the peaks

5. The photoelectron spectrum of an element is given below:



(a) Identify the element this spectra most likely belongs to and write out its full electron configuration.

(b) Using your knowledge of atomic structure, explain the following:
   (i) The reason for the three discrete areas of ionization energies
   (ii) The justification for there being a total of five peaks
   (iii) The relative heights of the peaks when compared to one another