Chapter 8
Basic Concepts of the Chemical Bonding

1. There are ________ paired and ________ unpaired electrons in the Lewis symbol for a phosphorus atom.
   (a). 4, 2  
   (b). 2, 4  
   (c). 4, 3  
   (d). 2, 3

**Explanation:** Read the question carefully here, you are being asked for how many valence electrons are paired and how many are unpaired. The abbreviated electron configuration of the P atom is given by [Ne] 3s²3p³. The outermost electrons would be arranged as 2 electrons paired and 3 electrons unpaired as shown below:

\[
\begin{align*}
\text{P} & \quad \text{2} \\
\text{P} & \quad \text{3} \\
\end{align*}
\]

2. Based on the octet rule, magnesium most likely forms a ________ ion.
   (a). Mg²⁻  
   (b). Mg²⁺  
   (c). Mg⁶⁻  
   (d). Mg⁶⁺

**Explanation:** According to the octet rule the Mg atom will achieve an octet by losing its 2 outermost electrons and thus gaining 2+ charges. Since Mg is located in the alkali metal group it will lose electrons rather than gaining them.

3. Based on the octet rule, phosphorus most likely forms a ________ ion.
   (a). P³⁺  
   (b). P⁵⁻  
   (c). P⁵⁺  
   (d). P³⁻

**Explanation:** According to the octet rule the phosphorus atom should gain 3 electrons, thus gaining 3 negative charges and forming the phosphide ion.
4. How many unpaired electrons are there in the Lewis structures of a N$^{3-}$ ion?

   (a). 0
   (b). 1
   (c). 2
   (d). 3

Explanation: In forming the N3- ion, the N atom gains 3 electrons and as a result has the same electron configuration as the Ne atom. The nitride ion will have 8 electrons in it’s outer shell and thus have zero unpaired electrons.

5. The halogens, alkali metals, and alkaline earth metals have __________ valence electrons, respectively.

   (a). 7, 4, and 6
   (b). 1, 5, and 7
   (c). 8, 2, and 3
   (d). 7, 1, and 2

Explanation: The valence electrons are the ones in the outermost shell of an atom. Based on the location of these elements in the periodic table (their group number) one can decide on the number of valence electrons the atoms have.

6. The only noble gas without eight valence electrons is __________.

   (a). Ar
   (b). Ne
   (c). He
   (d). Kr

Explanation: The noble gases are characterized by the presence of eight electrons in their outermost shell with one notable exception of Helium. Since He has only 2 electrons it can never have 8 in its outermost shell.

7. Which of the following would have to lose two electrons in order to achieve a noble gas electron configuration __________?

   O  Sr  Na  Se  Br

   (a). O, Se
   (b). Na
   (c). Sr
   (d). As

Explanation: The only element that will lose 2 electrons from this group is Strontium (Sr). Sr is located in the group 2A of the periodic table and thus will lose 2 electrons.
to form the Sr$^{2+}$ ion and achieve the noble gas electron configuration same as Krypton.

8. For a given arrangement of ions, the lattice energy increases as ionic radius ______ and as ionic charge ______.

(a). increases, decreases  
(b). decreases, increases  
(c). increases, increases  
(d). decreases, decreases  

**Explanation:** The lattice energy is the amount of energy required to completely separate a mole of the solid ionic compound into its gaseous ions. Thus if the ionic radius decreases and the ionic charges increase, the ions will be held closer and tighter. As a result of this more energy will be needed to separate the ions apart.

9. The principal quantum number of the electrons that are lost when tungsten forms a cation is ______.

(a). 6  
(b). 5  
(c). 4  
(d). 3  

**Explanation:** Tungsten (W) is in group 8B which is a group of transition metals. It is in row six and its valence electrons would reside in a shell with n = 6.

10. Elements from opposite sides of the periodic table tend to form ______.

(a) covalent compounds  
(b) **ionic compounds**  
(c) ionic compounds that are gaseous at room temperature  
(d) homonuclear diatomic compounds  

**Explanation:** The 2 sides of the periodic table are the metals on the left and the non-metals on the right. When they come together they will form ionic compounds. These compounds will not necessarily be in the gaseous state hence (c) is not the correct choice.

11. A _______ covalent bond between the same two atoms is the longest.

(a). They are all the same length.  
(b). double  
(c). triple  
(d). single
Explanation: As the number of bonds between atoms increases the atoms are also drawn closer to each other. Thus a single bond would be the longest possible bond.

12. A double bond consists of ________ pairs of electrons shared between two atoms.

(a). 1  
(b). 2  
(c). 3  
(d). 4

Explanation: Each covalent bond is considered to be due to a pair of electrons being shared by the 2 atoms. Thus a double bond would involve the sharing of 2 pairs of electrons.

13. What is the maximum number of double bonds that a hydrogen atom can form?

(a). 0  
(b). 1  
(c). 2  
(d). 3

Explanation: Each hydrogen atom has a single electron in its valence shell and as a result can form only one bond. It cannot form a double bond as it does not have the necessary electrons to share.

14. What is the maximum number of double bonds that a carbon atom can form?

(a). 4  
(b). 1  
(c). 2  
(d). 0

Explanation: Each carbon atom has 4 valence electrons that it can share with other atoms. Since each double bond corresponds to a pair of electrons, the carbon atom can form only 2 double bonds.

15. The ability of an atom in a molecule to attract electrons is best quantified by the ________.

(a). paramagnetism  
(b). diamagnetism  
(c). electronegativity  
(d). electron affinity
Explanation: By definition, the electronegativity of an atom measures the ability of the atom to attract electrons towards itself in a molecule. It is not be confused with the electron affinity of the atom which has to do with a free atom.

16. Given the electronegativities below, which covalent single bond is most polar?

<table>
<thead>
<tr>
<th>Atom</th>
<th>H</th>
<th>C</th>
<th>N</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronegativity</td>
<td>2.1</td>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
</tr>
</tbody>
</table>

(a). C-H  
(b). N-H  
(c). O-H  
(d). O-N  

Explanation: Bond polarity can be judged based on the differences between the electronegativities of the atoms involved. Of the available choices, the bond between O and H will have the largest electronegativity difference making it the most polar bond in this group.

17. Electronegativity _________ from left to right within a period and _________ from top to bottom within a group.

(a). decreases, increases  
(b). increases, increases  
(c). stays the same, increases  
(d). increases, decreases  

Explanation: Atomic size decreases from the left to the right in a period thus making it easier for the nuclei to attract electrons towards themselves resulting in an increase in the electronegativity. On the other hand atomic size increases down a group making it harder for the nuclei to attract the valence electrons towards themselves resulting in a decrease in electronegativity.

18. The ion ICl₄⁻ has _________ valence electrons.

(a). 34  
(b). 36  
(c). 35  
(d). 28  

Explanation: Here each of the atoms present contribute 7 valence electrons (= 35 electrons) but since the ion has a negative charge, the total number of electrons = 35 + 1 = 36.
19. The Lewis structure of PF$_3$ shows that the central phosphorus atom has __________ nonbonding and __________ bonding electron pairs.

(a). 2, 2  
(b). 1, 3  
(c). 3, 1  
(d). 1, 2

**Explanation:** In PF$_3$ each P atom contributes 5 valence electrons while each F contributes 7 valence electrons making a total of 26 valence electrons. The central P atom forms single bonds with each of the F atoms. Phosphorus ends up with a non-bonding pair since the F atoms already have 8 electrons around them.

20. The Lewis structure of HCN (H bonded to C) shows that __________ has __________ nonbonding electron pairs.

(a). C, 1  
(b). N, 2  
(c). H, 1  
(d). N, 1

**Explanation:** In the structure for HCN, the C atom forms a single bond with the hydrogen atom, a triple bond with the N atom and the N atom gets the left over nonbonding pair. By doing this all the atoms (with the exception of H) can satisfy the octet rule.

21. Lattice energy is __________.

(a). the energy required to convert a mole of ionic solid into its constituent ions in the gas phase.  
(b). the energy given off when gaseous ions combine to form one mole of an ionic solid.  
(c). the energy required to produce one mole of an ionic compound from its constituent elements in their standard states  
(d). the sum of ionization energies of the components in an ionic solid

**Explanation:** By definition.
22. The type of compound that is most likely to contain a covalent bond is _________.

(a). one that is composed of a metal from the far left of the periodic table and a nonmetal from the far right of the periodic table
(b). a solid metal
(c). one that is composed of only nonmetals
(d). held together by the electrostatic forces between oppositely charged ions

**Explanation:** A covalent bond is formed by the sharing of a pair of electrons by 2 atoms. The only type of elements that will share electrons are non-metals and thus a compound composed of non-metals only will have covalent bonds.

23. Of the atoms below, ________ is the most electronegative.

(a). Si
(b). Br
(c). Rb
(d). Ca

**Explanation:** The electronegativity of elements increases across the periodic table from the left to the right and decreases from top to bottom. Of the elements involved here Br is a halogen making it the most electronegative element of this group.

24. Of the atoms below, ________ is the least electronegative.

(a). Cs
(b). F
(c). Si
(d). Cl

**Explanation:** The electronegativity of elements increases across the periodic table from the left to the right and decreases from top to bottom. Here Cs is an alkali metal and is close to the bottom of its group, making it the least electronegative element.

25. Resonance structures differ by ________.

(a). number and placement of electrons
(b). number of electrons only
(c). placement of atoms only
(d). placement of electrons only

**Explanation:** Resonance structures of a compound contain the same atoms joined to each other in the same order with the major difference being the type of bonds between the atoms. In other words the numbers of electrons placed in between the atoms are different.
26. To convert from one resonance structure to another, __________.

(a). only electrons can be moved
(b). electrons and atoms can both be moved
(c). only atoms can be moved
(d). electrons must be added

**Explanation:** Resonance structures are different from each other only by the placement of electrons between the atoms. Thus to convert from one resonance structure to another only electrons can be moved. Moving atoms would change the structure completely.

27. For resonance forms of a molecule or ion, __________.

(a). one always corresponds to the observed structure
(b). all the resonance structures are observed in various proportions
(c). the observed structure is an average of the resonance forms
(d). the same atoms need not be bonded to each other in all resonance forms

**Explanation:** Since no single resonance structure can explain the behavior of a particular molecule or ion the observed structure is considered to be an average of the resonance forms.

28. As the number of covalent bonds between two atoms increases, the distance between the atoms _________ and the strength of the bond between them _________.

(a). increases, increases
(b). decreases, decreases
(c). increases, decreases
(d). decreases, increases

**Explanation:** As the number of bonds between atoms increases the distance between the atoms will decrease and the amount of energy needed to break these bonds will increase making them stronger bonds.

29. Of the possible bonds between carbon atoms (single, double, and triple), _________.

(a). a triple bond is longer than a single bond
(b). a double bond is stronger than a triple bond
(c). a single bond is stronger than a triple bond
(d). a double bond is longer than a triple bond

**Explanation:** The bond length decreases as the number of bonds increases. The bond strength increases as the number of bonds increases. Considering these facts the only statement above that is correct is (d).