Covalent Bonding

1) (a) What are valence electrons?

   (b) What is the kernel of an atom?

2) What is covalent bonding?

3) (a) As independent particles, atoms are at a relatively (high or low) potential energy?

   (b) As atoms covalently bond with each other, they (increase or decrease) their potential energy which produces a (more stable or less stable) electron configuration.

4) What is the neutral particle that results from covalent bonding?

5) Draw the Lewis Diagram for the following molecules.

   (a) H_2

   (b) O_2

   (c) N_2

   (d) F_2

6) When the octet rule is satisfied as illustrated in Question 5, the outermost _____ is/are filled.

7) What group or family of elements satisfy the octet rule without forming compounds?

8) If two covalently bonded atoms are identical (homonuclear), the chemical bond is said to be _____.

9) (a) When atoms share electrons, the force of attraction of an atom for the bonding pair of electrons is called the atom's _____.

   (b) The smaller the difference in electronegativities between two bonded atoms, the greater the percentage of _____.

10) When atoms that share electrons have an unequal attraction for the bonding pair of electrons, the bond is said to be _____.

11) **(a) When all the bonds in a molecule are nonpolar, the molecule is _____.**

(b) When the polar bonds in a molecule are the same, the polarity of the molecule is dependent upon the _____.

12) **Why is a hydrogen fluoride molecule polar?**

13) **A charged group of covalently bonded atoms are called _____.**

14) **Draw Lewis Structures for the following:**

(a) H_2O

(b) CH_4

(c) CS_2

(d) NH_3

(e) NH_4^+

(f) OH^-

(g) CO_3^{2-}

15) **A formula that shows the types and numbers of atoms combined as a single molecule is called a(n) _____.**

16) **Which of the following is not an example of a molecular formula?**

(a) CO_2	**(c)** C
(b) H_2O_2	**(d)** Cl_2

Solutions

1) (a) Valence electrons are the electrons found in the highest numbered principal energy level (n) that determine the chemical properties of an element.

(b) The kernel of an atom is the nucleus of an atom and its inner (core) electrons.

2) Covalent bonding results when valence electrons are shared between two atoms. When two atoms share a pair of electrons (one electron from each atom), a single bond is formed. Covalent bonding can also result from the sharing of two pairs of electrons (a double bond) or three pairs of electrons (a triple bond).

3) (a) As independent particles, atoms are at a relatively high potential energy.

(b) As atoms covalently bond with each other, they decrease their potential potential energy which produces a more stable electron configuration.

4) A molecule.

5) (a) H_2

2H atoms → 2 valence e^-

H : H	Because the electrons are being shared, they are counted for both atoms.

(b) O_2

2O atoms → 12 valence e^-

O : O	Assume single bonds between atoms.
¨ ¨ : O : O : ¨	Use remaining 10 e^- trying to form a complete octet. Fails because the O on the right has only 6 valence e^-.
¨ ¨ : O :: O :	Form a double bond giving each O 8 valence e^-.

(c) N_2

2N atoms → 10 valence e^-

N : N	Assume single bonds between atoms.
. . . .	
: N : N	Use remaining 8 e^- trying to form a complete octet.
. .	Fails because the N on the right has only 4 valence e^-.
: N ::: N :	Form a triple bond giving each N 8 valence e^-.

(d) F_2

2F atoms → 14 valence e^-

F : F	Assume single bonds between atoms.
. . . .	
: F : F :	Use remaining 12 e^- trying to form a complete octet.
. . . .	Each F atom has a complete octet, therefore only a single bond is needed.

6) Principal energy level or s and p orbitals.

7) Group or family VIII (the inert or noble gases).

8) Nonpolar covalent.

9) (a) Electronegativity.

(b) Covalent character.

10) Polar.

11) (a) Nonpolar.

(b) Molecular geometry or the shape of the molecule.

12) The HF molecule is polar because fluorine (the most electronegative element) attracts the bonding pair of electrons more strongly than the hydrogen.

13) A polyatomic ion.

14) (a) H_2O

2H atoms → 2 valence e^-
1O atom → 6 valence e^-

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8 valence e^-

H : O : H   Assume single bonds between atoms.

```
    . .
H : O : H
    . .
```

Use remaining 4 e^- trying to form a complete octet.

(b) CH_4

1C atoms → 4 valence e^-
4H atom → 4 valence e^-

---

8 valence e^-

H : C : H   Assume single bonds between atoms.

```
    . .
H : C : H
    . .
```

Use remaining 4 e^- trying to form a complete octet.

(c) CS_2

1C atoms → 4 valence e^-
2S atom → 12 valence e^-

16 valence e^-

S : C : S — Assume single bonds between atoms.

```
 . .      . .
: S : C : S :
 . .      . .
```

Use remaining 12 e^- trying to form a complete octet. Always start distributing electrons around the terminal atoms, saving the central atom for last. Fails because the central atom C has only 4 valence e^-.

```
 . .         . .
: S :: C :: S :
```

Use remaining 12 e^- trying to form a complete octet. Form two double bonds giving each atom 8 valence e^-.

(d) NH_3

1N atoms → 5 valence e^-
3H atoms → 3 valence e^-

8 valence e^-

```
H : N : H
    . .
     H
```

Assume single bonds between atoms.

```
    . .
H : N : H
    . .
     H
```

Use remaining 2 e^- trying to form a complete octet. Note the pair of electrons above the N called a nonbonding pair of electrons.

(e) NH_4^+

1N atoms → 5 valence e^-
4H atoms → 4 valence e^-

---

9 valence e^-
- 1 **Subtract 1 e^- because of the + charge.**

---

8 valence e^-

```
  H
  . .
H : N : H        Assume single bonds between atoms.
  . .
  H
```

```
   H
   . .
[H : N : H]+     Both atoms have the maximum number of electrons.
   . .
   H
```

(f) OH^-

1O atoms → 6 valence e^-
1H atoms → 1 valence e^-

---

7 valence e^-
+ 1 **Add 1 e^- because of the - charge.**

---

8 valence e^-

```
H : O            Assume single bonds between atoms.
```

```
       . .
[H : O :]-       Use remaining 6 e- trying to form a complete octet.
       . .
```

(g) CO_3^{2-}

1C atoms → 4 valence e^-
3O atom → 18 valence e^-

---

22 valence e^-
+ 2 **Add 2 e^- because of the -2 charge.**

---

24 valence e^-

```
O : C : O
   . .
    O
```

Assume single bonds between atoms.

```
 . .      . .
: O : C : O :
 . .  . .  . .
    : O :
     . .
```

Use remaining 18 e^- trying to form an octet.
Fails because the central atom C has only 6 valence e^-.

```
 . .       . .
: O : C :: O :
. .   . .
    : O :
     . .
```

Form a double bond giving each atom 8 valence e^-.

Because CO_3^{2-} has three equally correct Lewis Diagrams, it is an example of resonance. Note that a double arrow is used indicating that the molecule is a composite of the three structures with the three bonds being identical.

```
 . .      . .        . .      . .         . .      . .
: O : C :: O :  ↔  : O :: C : O :  ↔  : O : C : O :
. .   . .                 . .  . .        . .   . .  . .
    : O :                : O :                 . .
     . .                  . .                 : O :
```

15) Molecular formula.

16) C is the symbol for the element carbon and not a molecular formula.