Version: A

---

1. Which correctly ranks the lattice energy for these ionic compounds?

   A. NaCl > MgO >CsI > ScN
   B. ScN > MgO > NaCl > CsI
   C. NaCl > CsI >ScN > CaO
   D. MgO > NaCl > ScN > CsI
   E. ScN > CsI > NaCl > MgO

2. Four atoms are labeled D, E, F, G. Their electronegativities are as follows:

   D=3.8, E=3.3, F = 2.8, and G = 1.3

   The atoms of these elements form the molecules DE, DG, EG, and DF. Arrange these molecules from most covalent to most ionic.

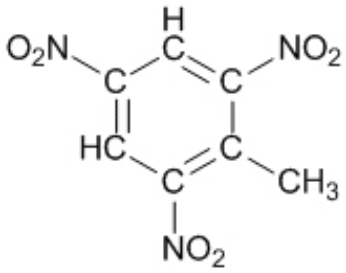
   A. Most covalent DE, DF, EG, DG Most ionic
   B. Most covalent DF, DE, EG, DG Most ionic
   C. Most covalent DG, EG, DF, DE Most ionic
   D. Most covalent DG, DF, EG, DE Most ionic
   E. Most covalent EG, DF, DE, DG Most ionic

3. Which of the following is/are exceptions to the octet rule?

   i) N_3^- ii) CH_2Cl_2 iii) AlH_3 iv) SCN^-

   A. i, iii, and iv
   B. ii and iii
   C. iii and iv
   D. iii
   E. iv

4. Trinitrotoluene (TNT), shown below, is an important explosive.



When TNT detonates the following reactions take place:
$2\ C_7H_5N_3O_6 \rightarrow 3\ N_2 + 5\ H_2O + 7\ CO + 7\ C$
$2\ C_7H_5N_3O_6 \rightarrow 3\ N_2 + 5\ H_2 + 12\ CO + 2\ C$

What **best explains** why these compounds release so much energy?

A. The breaking of the bonds in explosives (like TNT) releases energy.
B. Carbon-carbon double bonds in TNT have a large potential energy.
C. The bond enthalpy for a double bond is always endothermic.
D. Bond enthalpies are additive; the energy of two C-C single bonds equals the bond enthalpy of a C=C bond.
E. The products that form have very strong bonds.

5. Which of the following includes polar bonds, but has a zero dipole moment?

A. N_2
B. HCN
C. NF_3
D. BrF_5
E. XeF_4

6. Consider the following molecules and select those that are nonpolar.

1) XeF_2 2) XeF_4 3) XeF_6

A. 1 only
B. 2 only
C. 3 only
D. 1 and 2
E. 1 and 3

7. The shape of the reactant containing chlorine in the following reaction is _and that of the product is ___.

$$ClF_3 + F_2 \rightarrow ClF_5$$

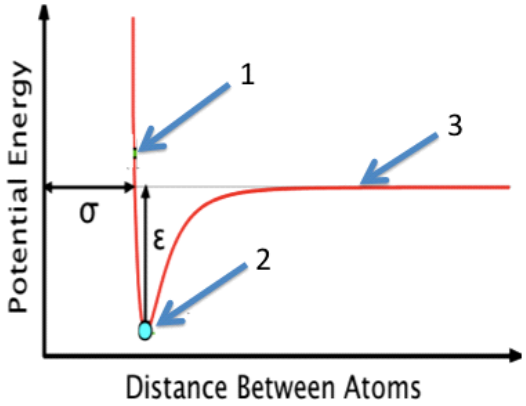
A. trigonal planar, trigonal pyramid
B. T-shaped, square pyramid
C. trigonal planar, square pyramid
D. T-shaped, trigonal bipyramid
E. trigonal pyramid, square pyramid

8. Which of the species in the following list is tetrahedral?

1) BF_4^- 2) SF_4 3) XeF_4 4) SiF_4 5) PCl_4^-

A. 1 only
B. 3 only
C. 1 and 3
D. 2 and 4
E. 1 and 4

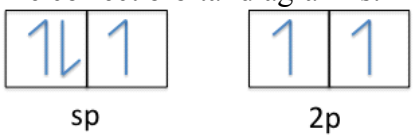
9. Consider the potential energy plot of two oxygen atoms. Which statement is true?



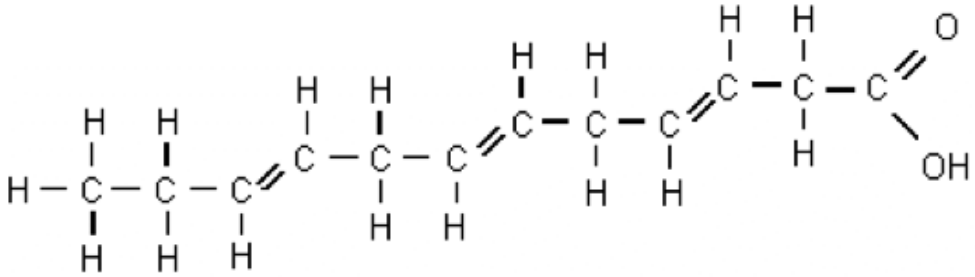
A. The decrease in potential energy (moving from region 3 to region 2) occurs because the electrons are attracted to each other.
B. The bottom of the potential energy well (region 2) corresponds to the optimal O=O bonding distance.
C. The potential energy increases rapidly at small distances (region 1) because the double bond is being converted into a single bond.
D. At very large distances (region 3) the bond enthalpy is the greatest.

10. Which statement is TRUE when hybridization is used to describe the bonding in water?

A. The molecule includes one σ and one π bond.
B. The oxygen atom is sp^3 hybridized.
C. An oxygen-hydrogen bond is formed from an unhybridized p-orbital.
D. The correct orbital diagram is:



11. Closely examine the unsaturated fatty acids.



How many σ and π bond are present in the molecule?

A. 31 σ bonds and 4 π bonds
B. 27 σ bonds and 4 π bonds
C. 30 σ bonds and 3 π bonds
D. 18 σ bonds and 5 π bonds
E. 35 σ bonds and zero π bonds

12. Which of the following does NOT have delocalized bonding?

A. C_6H_6 (benzene)
B. $H_2C{=}CH{-}CH{=}CH_2$
C. NO_3^- (nitrate ion)
D. O_3 (ozone)
E. $COOH^-$ (carbon is the central atom, bonded to all three atoms)

13. Which of the following ions would you expect to be paramagnetic?

A. N_2^{2-}
B. O_2^{2-}
C. C_2^{2-}
D. B_2^{2-}

14. Removal of an electron from O_2 ___ the bond, removal of an electron from N_2 ___ the bond.

A. weakens, weakens
B. strengthens, strengthens
C. weakens, strengthens
D. strengthens, weakens

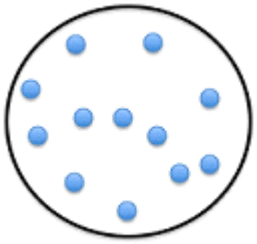
15. A chemist attempted to synthesize a compound containing only krypton and fluorine. An experiment was designed to have krypton serve as the central atom, where it was reacted with an excess of fluorine. After various reactions under extreme conditions, a product did indeed form, but it's identity was uncertain. The following data was collected:

- The molecule formed was non-polar
- They hybridization around the central atom was sp^3d
- There were no 90 degree angles formed between the central atom and the fluorine ligands

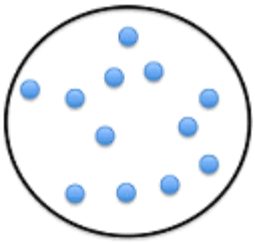
Based on this experimental data, which is the most likely identity of the product molecule which formed?

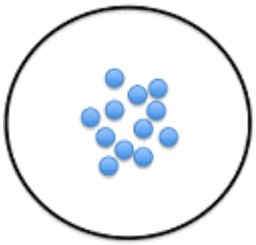
A. KrF_2
B. KrF_3
C. KrF_4
D. KrF_5
E. The fluorine must have reacted with oxygen in the air to form OF_2 since Kr is a noble gas and will not react since it has a stable octet.

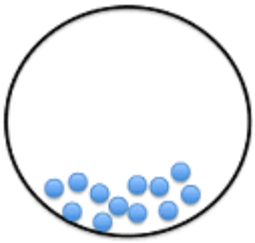
16. The circle below represents a steel tank holding hydrogen gas at 20°C and 3 atm pressure. The dots represent hydrogen molecules.

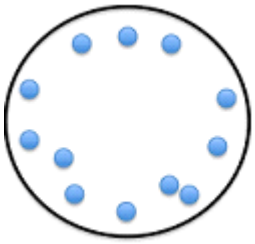


Which best represents the distribution of hydrogen molecules if the temperature is lowered to -15°C?

A. 

B. 

C. 

D. 

17. What volume of oxygen (L) at STP can be produced by the decomposition of 0.200 moles of Ag_2O?

$$2\ Ag_2O(s) \rightarrow 4\ Ag(s) + O_2(g)$$

A. 1.12
B. 2.24
C. 0.112
D. 0.224
E. 22.4

18. A 1.00 g sample of SF_x has a volume of 199 mL at 745 mm Hg and 75°C. What is the value of x?

A. 1
B. 2
C. 3
D. 4
E. 6

19. A hot air balloon containing 31,000 L of H_2 (g) was filled by reacting iron with hydrochloric acid:

$$Fe\ (s) + 2\ HCl\ (aq) \rightarrow FeCl_2\ (aq) + H_2\ (g)$$

How many kilograms of iron were needed to produce this volume of H_2 if the temperature was 22 °C?

A. 71 kg
B. 953 kg
C. 76.8 kg
D. 0.041 kg
E. 13.5 kg

20. A mixture of 3.65 g of CH_2Cl_2 and 1.50 g of CH_4 is contained in a 50.0 mL container at 400.°C. What is the partial pressure (atm) of CH_2Cl_2?

A. 47.5
B. 151
C. 103
D. 55.0
E. 125

21. Rank the following gases in order of increasing average molecular speed at 25°C: He, Ne, NF_3, SO_2

A. Slowest He, Ne, NF_3, SO_2 Fastest
B. Slowest NF_3, SO_2, Ne, He Fastest
C. Slowest SO_2, NF_3, He, Ne Fastest
D. Slowest NF_3, Ne, He, SO_2 Fastest
E. All of the gases have the same average molecular speed.

22. The Ne atom has 10 times the mass of H_2. Which of the following statements is true?

I. Since H_2 is lighter, all H_2 molecules move faster than all Ne atoms.
II. One mole of Ne exerts the same pressure as one mole of H_2 at STP.
III. Ne has a higher effusion rate than H_2.

A. I
B. II
C. III
D. I & II
E. II & III

23. When the pressure of a gas is increased from 2.0 to 50 atm at constant temperature, its volume changes from 1.0 L to 35 mL. What could cause this deviation from the expected ideal value?

A. The average molecular speed has decreased.
B. The volume of the gas molecules is now a significant fraction of the volume of t he container.
C. The molecules experience higher net attraction to each other at the higher pressure.
D. The collision of the molecules with the walls of the container are no longer elastic.
E. The molecules have decomposed to form more molecules.

24. An unknown gas diffuses at the rate of 83.3 mL/s in a diffusion apparatus in which a second gas whose molecular weight is 44.0, diffuses at a rate of 102 mL/s. Calculate the molecular weight of the first gas.

A. 29.3
B. 49.2
C. 53.9
D. 66.0
E. 71.5

25. When 0.72 g of a liquid is vaporized at 110°C and 0.967 atm, the gas occupies a volume of 0.559 L. The empirical formula of the gas is CH_2. What is the molecular formular of the gas?

A. CH_2
B. C_2H_4
C. C_3H_6
D. C_4H_8
E. C_5H_{10}

Version: B

---

1. Which correctly ranks the lattice energy for these ionic compounds?

A. ScN > MgO > NaCl > CsI
B. NaCl > CsI >ScN > CaO
C. NaCl > MgO >CsI > ScN
D. MgO > NaCl > ScN > CsI
E. ScN > CsI > NaCl > MgO

2. Four atoms are labeled D, E, F, G. Their electronegativities are as follows:

D=3.8, E=3.3, F = 2.8, and G = 1.3

The atoms of these elements form the molecules DE, DG, EG, and DF. Arrange these molecules from most covalent to most ionic.

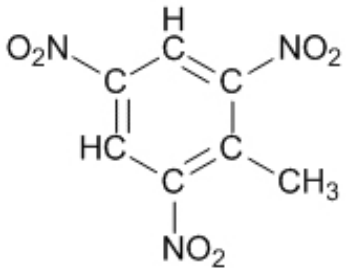
A. Most covalent DG, EG, DF, DE Most ionic
B. Most covalent DF, DE, EG, DG Most ionic
C. Most covalent DE, DF, EG, DG Most ionic
D. Most covalent DG, DF, EG, DE Most ionic
E. Most covalent EG, DF, DE, DG Most ionic

3. Which of the following is/are exceptions to the octet rule?

i) N_3^- ii) CH_2Cl_2 iii) AlH_3 iv) SCN^-

A. iii and iv
B. i, iii, and iv
C. iv
D. iii
E. ii and iii

4. Trinitrotoluene (TNT), shown below, is an important explosive.



When TNT detonates the following reactions take place:
$2\ C_7H_5N_3O_6 \rightarrow 3\ N_2 + 5\ H_2O + 7\ CO + 7\ C$
$2\ C_7H_5N_3O_6 \rightarrow 3\ N_2 + 5\ H_2 + 12\ CO + 2\ C$

What **best explains** why these compounds release so much energy?

A. The bond enthalpy for a double bond is always endothermic.
B. The products that form have very strong bonds.
C. The breaking of the bonds in explosives (like TNT) releases energy.
D. Bond enthalpies are additive; the energy of two C-C single bonds equals the bond enthalpy of a C=C bond.
E. Carbon-carbon double bonds in TNT have a large potential energy.

5. Which of the following includes polar bonds, but has a zero dipole moment?

A. NF_3
B. N_2
C. HCN
D. BrF_5
E. XeF_4

6. Consider the following molecules and select those that are nonpolar.

1) XeF_2 2) XeF_4 3) XeF_6

A. 3 only
B. 2 only
C. 1 only
D. 1 and 2
E. 1 and 3

7. The shape of the reactant containing chlorine in the following reaction is _and that of the product is ___.

$$ClF_3 + F_2 \rightarrow ClF_5$$

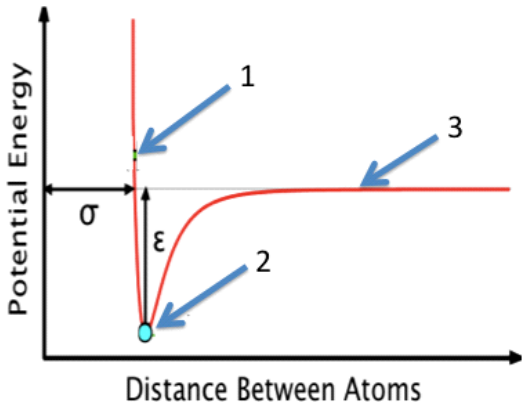
A. T-shaped, trigonal bipyramid
B. trigonal planar, square pyramid
C. T-shaped, square pyramid
D. trigonal planar, trigonal pyramid
E. trigonal pyramid, square pyramid

8. Which of the species in the following list is tetrahedral?

1) BF_4^- 2) SF_4 3) XeF_4 4) SiF_4 5) PCl_4^-

A. 2 and 4
B. 3 only
C. 1 only
D. 1 and 3
E. 1 and 4

9. Consider the potential energy plot of two oxygen atoms. Which statement is true?

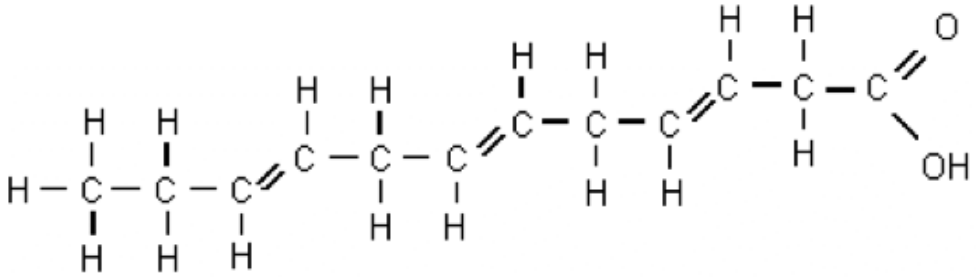


A. The potential energy increases rapidly at small distances (region 1) because the double bond is being converted into a single bond.
B. The bottom of the potential energy well (region 2) corresponds to the optimal O=O bonding distance.
C. At very large distances (region 3) the bond enthalpy is the greatest.
D. The decrease in potential energy (moving from region 3 to region 2) occurs because the electrons are attracted to each other.

10. Which statement is TRUE when hybridization is used to describe the bonding in water?

A. The molecule includes one σ and one π bond.
B. The oxygen atom is sp^3 hybridized.
C. An oxygen-hydrogen bond is formed from an unhybridized p-orbital.
D. The correct orbital diagram is:

11. Closely examine the unsaturated fatty acids.



How many σ and π bond are present in the molecule?

A. 18 σ bonds and 5 π bonds
B. 30 σ bonds and 3 π bonds
C. 35 σ bonds and zero π bonds
D. 31 σ bonds and 4 π bonds
E. 27 σ bonds and 4 π bonds

12. Which of the following does NOT have delocalized bonding?

A. NO_3^- (nitrate ion)
B. C_6H_6 (benzene)
C. $COOH^-$ (carbon is the central atom, bonded to all three atoms)
D. O_3 (ozone)
E. $H_2C{=}CH{-}CH{=}CH_2$

13. Which of the following ions would you expect to be paramagnetic?

A. O_2^{2-}
B. B_2^{2-}
C. C_2^{2-}
D. N_2^{2-}

14. Removal of an electron from O_2 ___ the bond, removal of an electron from N_2 ___ the bond.

A. strengthens, weakens
B. strengthens, strengthens
C. weakens, strengthens
D. weakens, weakens

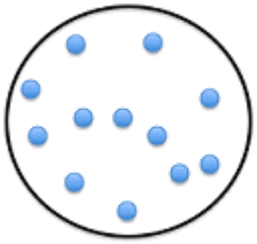
15. A chemist attempted to synthesize a compound containing only krypton and fluorine. An experiment was designed to have krypton serve as the central atom, where it was reacted with an excess of fluorine. After various reactions under extreme conditions, a product did indeed form, but it's identity was uncertain. The following data was collected:

- The molecule formed was non-polar
- They hybridization around the central atom was sp^3d
- There were no 90 degree angles formed between the central atom and the fluorine ligands

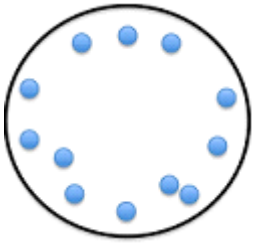
Based on this experimental data, which is the most likely identity of the product molecule which formed?

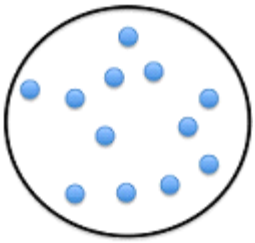
A. KrF_3
B. KrF_4
C. KrF_2
D. KrF_5
E. The fluorine must have reacted with oxygen in the air to form OF_2 since Kr is a noble gas and will not react since it has a stable octet.

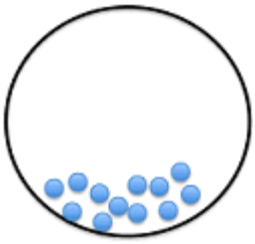
16. The circle below represents a steel tank holding hydrogen gas at 20°C and 3 atm pressure. The dots represent hydrogen molecules.

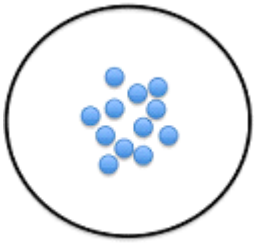


Which best represents the distribution of hydrogen molecules if the temperature is lowered to -15°C?

A. 

B. 

C. 

D. 

17. What volume of oxygen (L) at STP can be produced by the decomposition of 0.200 moles of Ag_2O?

$$2\ Ag_2O(s) \rightarrow 4\ Ag(s) + O_2(g)$$

A. 2.24
B. 0.112
C. 0.224
D. 1.12
E. 22.4

18. A 1.00 g sample of SF_x has a volume of 199 mL at 745 mm Hg and 75°C. What is the value of x?

A. 2
B. 4
C. 3
D. 1
E. 6

19. A hot air balloon containing 31,000 L of H_2 (g) was filled by reacting iron with hydrochloric acid:

$$Fe\ (s) + 2\ HCl\ (aq) \rightarrow FeCl_2\ (aq) + H_2\ (g)$$

How many kilograms of iron were needed to produce this volume of H_2 if the temperature was 22 °C?

A. 953 kg
B. 13.5 kg
C. 0.041 kg
D. 76.8 kg
E. 71 kg

20. A mixture of 3.65 g of CH_2Cl_2 and 1.50 g of CH_4 is contained in a 50.0 mL container at 400.°C. What is the partial pressure (atm) of CH_2Cl_2?

A. 103
B. 151
C. 47.5
D. 55.0
E. 125

21. Rank the following gases in order of increasing average molecular speed at 25°C: He, Ne, NF_3, SO_2

A. Slowest SO_2, NF_3, He, Ne Fastest
B. Slowest He, Ne, NF_3, SO_2 Fastest
C. Slowest NF_3, SO_2, Ne, He Fastest
D. Slowest NF_3, Ne, He, SO_2 Fastest
E. All of the gases have the same average molecular speed.

22. The Ne atom has 10 times the mass of H_2. Which of the following statements is true?

I. Since H_2 is lighter, all H_2 molecules move faster than all Ne atoms.
II. One mole of Ne exerts the same pressure as one mole of H_2 at STP.
III. Ne has a higher effusion rate than H_2.

A. II
B. I
C. I & II
D. III
E. II & III

23. When the pressure of a gas is increased from 2.0 to 50 atm at constant temperature, its volume changes from 1.0 L to 35 mL. What could cause this deviation from the expected ideal value?

A. The volume of the gas molecules is now a significant fraction of the volume of the container.
B. The average molecular speed has decreased.
C. The molecules experience higher net attraction to each other at the higher pressure.
D. The collision of the molecules with the walls of the container are no longer elastic.
E. The molecules have decomposed to form more molecules.

24. An unknown gas diffuses at the rate of 83.3 mL/s in a diffusion apparatus in which a second gas whose molecular weight is 44.0, diffuses at a rate of 102 mL/s. Calculate the molecular weight of the first gas.

A. 53.9
B. 66.0
C. 29.3
D. 49.2
E. 71.5

25. When 0.72 g of a liquid is vaporized at 110°C and 0.967 atm, the gas occupies a volume of 0.559 L. The empirical formula of the gas is CH_2. What is the molecular formular of the gas?

A. C_4H_8
B. C_2H_4
C. CH_2
D. C_5H_{10}
E. C_3H_6