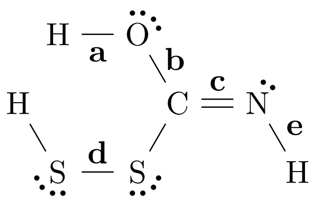
This print-out should have 30 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

LDE Identifying Bonds 005
001 10.0 points

Rank the labeled bonds in the molecule below from least to most polar.



1. c < e < b < a < c

2. c < d < e < a < b

3. d < c < e < b < a **correct**

4. c < d < e < b < a

5. d < c < b < e < a

Explanation:
Bonds a, b, c, d, and e have a ΔEN of 1.4, 1.0, 0.5, 0.0, and 0.9, respectively.

Brodbelt 013 322
002 10.0 points

Which of the following statements about polarity is false?

1. Linear molecules can be polar.

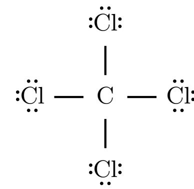
2. Polar molecules must have a net dipole moment.

3. Lone (unshared) pairs of electrons on the central atom play an important role in influencing polarity.

4. CCl_4 is a polar molecule. **correct**

5. Dipole moments can "cancel", giving a net non-polar molecule.

Explanation:
The Lewis Dot structure for CCl_4 is



The molecule has tetrahedral electronic and molecular geometry. The C−Cl bond is polar, but becuase of the symmetry of the molecule, the individual dipole moments cancel. The molecule is therefore nonpolar.

ChemPrin3e T03 39
003 10.0 points

Which of the following is NOT polar?

1. $COCl_2$

2. ClF_3

3. BrO_3^-

4. CH_3^+ **correct**

5. O_3

Explanation:
$COCl_2$ (the central atom is C) is polar because there are two different bonds: C=O and C-Cl which have different sized dipoles so their effects do not cancel. The other incorrect choices have either 3, 4 or 5 RHED: one or more of these are lone pairs on the central atom which causes the polar bonds to be placed in positions where the dipole of at least one bond is not opposing another, causing the species to be polar. In CH_3^+ there are no lone pairs; the C-H bonds are at 120° so their effects cancel and the ion is nonpolar.

ChemPrin3e T03 22
004 10.0 points

Which of the following has bond angles slightly less than 109°?

1. NH_4^+

2. BrO_3^- **correct**

3. ClO_4^-

4. BH_4^-

5. PO_4^{3-}

Explanation:

While all structures have four regions of electron density around the central atom, only BrO_3^- also has one of these regions as a lone pair. Since the lone pair requires more room, the other bonds are repelled away from it slightly, folding them up rather like an umbrella and resulting in angles slightly less than 109.5°.

Brodbelt 013 320

005 10.0 points

The sp^3 hybridization has what percent s character and what percent p character?

1. 50%; 50%

2. 33%; 67%

3. 67%; 33%

4. 75%; 25%

5. 25%; 75% **correct**

Explanation:

$$s = \frac{1}{4} = 25\%$$
$$p = \frac{3}{4} = 75\%$$

Brodbelt 013 308

006 10.0 points

NF_2^- has (2, 3, 4) regions of high electron density and (2, 4, 6) bonded electrons.

1. 2; 2

2. 4; 4 **correct**

3. 2; 4

4. 4; 6

5. 2; 6

6. 4; 2

7. 3; 4

8. 3; 6

9. 3; 2

Explanation:

$$N = 8 \times 3 = 25$$
$$A = 5 + (7 \times 2) + 1 = 20$$
$$S = 24 - 20 = 4$$

First, draw the molecule. The number of regions of HED equals the number of bonds and the number of lone pairs. There are 4 shared, or bonded electrons, giving 2 regions of HED. The 2 F atoms have an octet. This means that 16 of the 20 available electrons are accounted for, leaving 4 electrons to be placed on the N atom as 2 lone pairs. Since there are 2 lone pairs, 2 bonds, that gives a total of 4 regions of HED.

Brodbelt 08 02

007 10.0 points

Which molecular geometries can stem from tetrahedral electronic geometry?

1. tetrahedral, trigonal pyramidal, angular **correct**

2. trigonal pyramidal, seesaw

3. tetrahedral, T-shaped, linear

4. only tetrahedral

5. tetrahedral, trigonal bipyramidal, linear, angular, seesaw

Explanation:

Tetrahedral, trigonal pyramidal and angular are three molecular geometries that can stem from tetrahedral electronic geometry.

Benzene Sigma Pi Bonds

008 10.0 points

How many σ and π bonds, respectively, are found in benzene (C_6H_6)?

1. 6; 6

2. 12; 6

3. 12; 12

4. 12; 3 **correct**

5. 3; 3

Explanation:

Bonds in C2H2

009 10.0 points

Which of the following bonds is not found in acetylene (C_2H_2)?

1. All of these bonds are found in C_2H_2. **correct**

2. π_{2p-2p}

3. σ_{sp-sp}

4. σ_{1s-sp}

Explanation:

Msci 02 1239

010 10.0 points

Which of the following is TRUE about antibonding orbitals of the molecular orbital theory?

1. Unshared electrons are placed in antibonding orbitals.

2. The strongest bonds between atoms have no electrons in antibonding orbitals.

3. Although antibonding orbitals may accept electrons, the electrons never remain for long.

4. Antibonding orbitals are higher in energy than their corresponding bonding orbitals. **correct**

5. Antibonding orbitals are made from the overlap of sigma and pi orbitals.

Explanation:

Antibonding orbitals are higher in energy than their corresponding bonding orbitals. Molecules can exist with electrons in antibonding orbitals, as long as the molecule does not place as many electrons in antibonding orbitals as there are in bonding orbitals.

Msci 02 1186

011 10.0 points

C_2 is calculated to have a bond order of two according to MO theory. Pick the true statement.

1. The molecule has exactly two pairs of bonding electrons and no more.

2. The molecule is held together by two pi bonds. **correct**

3. The molecule is held together by two sigma bonds.

4. The molecule is paramagnetic.

5. The molecule contains one sigma and one pi bond.

Explanation:

The MO energy diagram will fill with 8 total electrons (4 from each C). 4 electrons fill the σ_{2s} and $\sigma_{2s^\star}$ MO's. The order of the MO's made with the overlapping 2p's of the two C's is

$$\pi_{2p}, \pi_{2p} < \sigma_{2p} < \pi_{2p^\star}, \pi_{2p^\star} < \sigma_{2p^\star}$$

So the 2 π_{2p}'s fill first meaning C_2 is held together with 2 π bonds and no σ's.

LDE Bond Order 007

012 10.0 points

All of the species below have the same bond order except for one of them. Which is it?

1. H_2^-

2. B_2^- **correct**

3. Ne_2^+

4. F_2^-

5. H_2^+

Explanation:

All of the species have a bond order of 0.5 except for B_2^-, which has a bond order of 1.5.

LDE Paramagnetism 005

013 10.0 points

Which of the following species is paramagnetic?

1. He_2

2. N_2

3. Be_2^{2-} **correct**

4. C_2^{2-}

Explanation:

The species Be_2^{2-} will have two unpaired electrons in degenerate π bonding orbitals.

LDE Bond Order 008

014 10.0 points

Rank the following species in terms of increasing bond length: N_2, O_2^-, Ne_2^+, H_2, B_2^{2-}.

1. $Ne_2^+ < H_2 < O_2^- < N_2 < B_2^{2-}$

2. $N_2 < B_2^{2-} < O_2^- < H_2 < Ne_2^+$ **correct**

3. $N_2 < O_2^- < H_2 < Ne_2^+ < B_2^{2-}$

4. $Ne_2^+ < H_2 < B_2^{2-} < O_2^- < N_2$

5. $N_2 < O_2^- < B_2^{2-} < Ne_2^+ < H_2$

Explanation:

The species N_2, O_2^-, Ne_2^+, H_2 and B_2^{2-} have bond orders of 3, 1.5, 0.5, 1 and 2, respectively. Bond length is inversely proportional to bond strength.

Msci 09 0604

015 10.0 points

Which of the following substances has a delocalized bond?

1. CO

2. CO_3^{2-} **correct**

3. CO_2

4. ClO_3^-

5. NH_3

Explanation:

Delocalized bonds occur whenever resonance occurs. In a molecule that exhibits resonance, the bond has partial double and partial single bond character. This means that electrons are delocalized around the resonance bond. CO_3^{2-} is the only compound that exhibits resonance and therefore delocalization.

Mlib 04 1137

016 10.0 points

The volume of a gas varies directly with its Kelvin temperature, at constant pressure. This is a statement of

1. Boyle's Law.

2. Dalton's Law of partial pressure.

3. Henry's Law.

4. Charles' Law. **correct**

Explanation:

Charles' Law relates the volume and temperature of a fixed (definite) mass of gas at constant pressure. The direct proportionality applies *only* if the temperature is expressed on the absolute (Kelvin) scale.

LDE Ideal Gas Calculation 006

017 10.0 points

If a gaseous system initially at 789 torr and 215 °C occupies a volume of 22.80 cm^3, what volume will it occupy if the pressure is reduced to 456 torr and the temperature is increased to 430 °C?

1. 9.14 cm^3

2. Not enough information.

3. 5.86 cm^3

4. 88.73 cm^3

5. 56.83 cm^3 **correct**

Explanation:

It is not necessary to use L and atm for this problem because the relationship can be written so that the units cancel (°C must be converted to K, though, because it is not an absolute measure):

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$
$$\frac{P_1V_1T_2}{T_1P_2} = V_2$$
$$\frac{(789\,\text{torr})(22.80\,\text{cm}^3)(703\,°\text{C})}{(488\,°\text{C})(456\,\text{torr})} = 56.83\,\text{cm}^3$$

ChemPrin3e T04 25

018 10.0 points

If 250 mL of a gas at STP weighs 2 g, what is the molar mass of the gas?

1. 44.8 g $\cdot$ mol^{-1}

2. 28.0 g $\cdot$ mol^{-1}

3. 56.0 g $\cdot$ mol^{-1}

4. 179 g $\cdot$ mol^{-1} **correct**

5. 8.00 g $\cdot$ mol^{-1}

Explanation:

$V = 250$ mL $\qquad P = 1$ atm

$T = 0°\text{C} = 273.15$ K $\qquad m = 2$ g

The density of the sample is

$$\rho = \frac{m}{V} = \frac{2\text{ g}}{0.25\text{ L}} = 8\text{ g/L}$$

The ideal gas law is

$$P\,V = n\,R\,T$$
$$\frac{n}{V} = \frac{P}{R\,T}$$

with unit of measure mol/L on each side. Multiplying each by molar mass (MM) gives

$$\frac{n}{V}\cdot\text{MM} = \frac{P}{R\,T}\cdot\text{MM} = \rho\,,$$

with units of g/L.

$$\begin{aligned}\text{MM} &= \frac{\rho\,R\,T}{P}\\ &= \frac{(8\text{ g/L})(0.08206\text{ L}\cdot\text{atm/mol/K})}{1\text{ atm}}\\ &\quad\times(273.15\text{ K})\\ &= 179.318\text{ g/mol}\end{aligned}$$

Brad C12 006

019 10.0 points

If sufficient acid is used to react completely with 21.0 grams of Mg

$$\text{Mg(s)} + 2\,\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$$

what volume of hydrogen at STP would be produced?

1. 22.40 liters

2. 9.68 liters

3. 10.60 liters

4. 4.84 liters

5. 19.37 liters **correct**

Explanation:

$\text{mass}_{\text{ini}} = 21$ g Mg

Four quantities are required to describe the behavior of gases: P (pressure), V (volume), T (temperature in Kelvin), and n (quantity in moles). Thus to know the volume of H_2 produced, we need to know P, T, and n.

Fortunately, we know that the hydrogen is produced at STP. STP implies standard temperature (1 atm or 760 torr) and temperature

(0°C or 273.15 K). Thus, to know the volume of gas produced, we need to find n, the number of moles of gas produced.

Mg is the limiting reactant in the equation described, and so we can determine the number of moles of H_2 produced in the reaction:

$$\text{mol } H_2 = 21.0 \text{ g Mg} \left(\frac{1 \text{ mol Mg}}{24.305 \text{ g Mg}}\right) \times \left(\frac{1 \text{ mol } H_2}{1 \text{ mol Mg}}\right) = 0.804 \text{ mol } H_2$$

We can then use the ideal gas law

$$P\,V = n\,R\,T$$

to determine the volume of H_2 gas produced:

$$V = \frac{n\,R\,T}{P} = \frac{(0.864 \text{ mol}) \left(\frac{0.08206 \text{ L}\cdot\text{atm}}{\text{K}\cdot\text{mol}}\right)}{1 \text{ atm}} \cdot (273.15 \text{ K}) = 19.367 \text{ L}$$

Mlib 04 1049

020 10.0 points

At constant temperature, the rate of effusion of H_2 is

1. one-half that of helium gas.

2. twice that of helium gas.

3. one-fourth that of oxygen gas.

4. None of these

5. four times that of oxygen gas. **correct**

Explanation:

$$\frac{\text{Rate of effusion of } O_2}{\text{Rate of effusion of } H_2} = \frac{\sqrt{\text{MW}_{H_2}}}{\sqrt{\text{MW}_{O_2}}}$$

$$\frac{\text{Eff}_{O_2}}{\text{Eff}_{H_2}} = \sqrt{\frac{2}{32}} = 0.25 = \frac{1}{4}$$

$$\text{Eff}_{O_2} = \frac{1}{4}\,\text{Eff}_{H_2}$$

LDE Ranking Gases 003

021 10.0 points

Which of the following molecules would have the smallest a and b term, respectively, in the van der Waals' equation: $O_3, CHF_3, SF_5Cl, SiHCl_3$, Xe.

1. Xe and O_3, respectively **correct**

2. CHF_3 and CHF_3, respectively

3. Xe and Xe, respectively

4. Xe and SF_5Cl, respectively

5. $SiHCl_3$ and O_3, respectively

Explanation:

Xenon is the only non-polar species and thus would have the smallest a term. Ozone is the smallest in terms of molecular weight and would thus have the smallest b term.

Msci 12 1406

022 10.0 points

In an improved version of the gas law, P is replaced by $\left(P + \frac{n^2\,a}{V^2}\right)$. In this expression, the second term, $\frac{n^2\,a}{V^2}$, accounts for

1. the forces of attraction between molecules. **correct**

2. the excluded volume of the molecules.

3. the size of the container.

4. the forces of repulsion between molecules.

5. the size of the molecules.

Explanation:

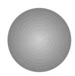
At high pressures, gas molecules are closer together than they would be at lower pressures. The attractive forces between gas molecules then become important.

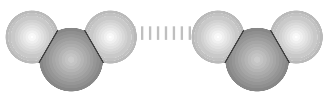
When more molecules are present (greater n) and when the molecules are close together (smaller V^2 in the denominator), the correction term becomes larger.

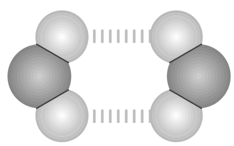
In this correction term, large values of a indicate strong attractive forces, and the correction term as a whole is added to compensate for attractive forces between gas molecules.

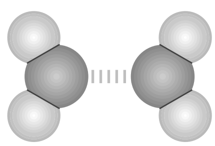
CIC T05 19
023 10.0 points

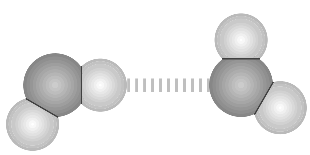
Which best describes the hydrogen bonding between two water molecules?

 hydrogen  oxygen

1. 

2. 

3. 

4.  **correct**

Explanation:
Note the water molecules line up so the δ^- on the O of one molecule is aligned with a δ^+ on a H of another molecule.

ChemPrin3e 05 52
024 10.0 points

Chloromethane (CH_3Cl) forms a molecular solid. What type of forces hold it in a solid configuration?

I) London forces
II) dipole-dipole forces
III) hydrogen bonding

1. I and II only **correct**

2. III only

3. II only

4. II and III only

5. I, II, and III

6. I only

Explanation:
Chloromethane is held in solid form by both London forces and dipole-dipole forces.

Dispersion Forces
025 10.0 points

In which of these compounds would you find ONLY dispersion forces existing between the molecules?

I. HBr;
II. NH_3;
III. CO_2;
IV. CH_2Cl_2.

1. I and IV only

2. III and IV only

3. II and IV only

4. I only

5. III only **correct**

6. II only

7. II and III only

8. I and II only

9. I and III only

10. IV only

Explanation:
A nonpolar covalent molecule would have only dispersion forces with another nonpolar covalent molecule.

Msci 13 0302
026 10.0 points

The term used to describe resistance to flow of a liquid is

1. vaporization.

2. capillary action.

3. viscosity. **correct**

4. surface tension.

5. vapor pressure.

Explanation:
Viscosity is used to describe the resistance to flow of a liquid.

ChemPrin3e 05 26
027 10.0 points
Rank the liquids
I) C_6H_6
II) CH_3CH_2OH
III) $CH_2OHCHOHCH_2OH$
IV) CH_2OHCH_2OH
V) H_2O
in order of increasing viscosity at 25°C.

1. I < V < II < IV < III **correct**

2. II < IV < I < V < III

3. I < V < III < IV < II

4. I < IV < II < V < III

5. IV < V < II < I < III

Explanation:
We need to consider both the strength of intermolecular forces and the tendency of molecules to get tangled like spaghetti.

Since glycerol ($CH_2OHCHOHCH_2OH$) can form several hydrogen bonds per molecule and it has a long chain structure, it has both strong intermolecular forces and the tendency to get tangled. Ethylene glycol (CH_2OHCH_2OH) is just one −CH−OH− unit smaller than glycerol, so we would expect it to be less viscous than glycerol but more viscous than water. Ethanol (CH_3CH_2OH) is slightly more viscous than water, which is more viscous than benzene (C_6H_6).

$C_6H_6 < H_2O < CH_3CH_2OH$
$CH_2OHCH_2OH < CH_2OHCHOHCH_2OH$

Evaporation and IMF Ranking
028 10.0 points
Rank the following compounds
H_2O NH_3 HF CH_3F
in terms of increasing vapor pressure.

1. $CH_3F < HF < H_2O < NH_3$

2. $H_2O < HF < NH_3 < CH_3F$ **correct**

3. $CH_3F < NH_3 < HF < H_2O$

4. $NH_3 < HF < H_2O < CH_3F$

5. $CH_3F < H_2O < HF < NH_3$

Explanation:

LDE Intermolecular Forces 007
029 10.0 points
Rank the following molecules in order of increasing intermolecular forces: C_2H_2, H_2, $C(CH_3)_4$, N_2.

1. $N_2 < H_2 < C_2H_2 < C(CH_3)_4$

2. $H_2 < N_2 < C(CH_3)_4 < C_2H_2$

3. $N_2 < N_2 < C(CH_3)_4 < C_2H_2$

4. $H_2 < C_2H_2 < N_2 < C(CH_3)_4$

5. $H_2 < N_2 < C_2H_2 < C(CH_3)_4$ **correct**

Explanation:
All of the molecules are nonpolar and have only instantaneous dipole forces. Instantaneous dipole forces increase with molecular weight.

ChemPrin3e 05 20
030 10.0 points
Classify the solid dry ice (CO_2).

1. network

2. None of these

3. ionic

4. molecular **correct**

Explanation:

Molecular solids consist of molecules held together by weak intermolecular forces.

Ionic solids are held together by electrostatic attraction between metal cations and non-metal anions.

Covalent (or network) solids are like huge molecules held together by covalent bonds. Carbon in diamond is the most well-known example. Group IV B elements can form tetrahedral electronic geometries.