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

Polar Bonds

10:07, general, multiple choice, < 1 min, fixed.

001

Consider the following compounds, each of which has 16 valence electrons:

NCF HSCN OCO HOCN NCCl

Assume the bonds form in the order the compounds are written. Which compound has the most polar bond?

1. NCF **correct**

2. HSCN

3. OCO

4. HOCN

5. NCCl

Explanation:

ChemPrin3e T03 37

12:08, basic, multiple choice, < 1 min, fixed.

002

Which of the following is NOT polar?

1. SF_4

2. ClO_2^-

3. IF_4^+

4. XeF_4 **correct**

5. ClF_3

Explanation:

All choices have either 4, 5 or 6 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 XeF_4 there are 6 RHED with two RHED being lone pairs situated opposite each other so their effects cancel – all of the polar bonds are placed opposite each other, and the molecule is nonpolar.

ChemPrin3e 03 20

12:08, basic, multiple choice, < 1 min, wording-variable.

003

Consider the molecules

I) CCl_4 (tetrachloromethane)

II) $CH_3CHOHCH_3$ (2-propanol; rubbing alcohol)

III) CH_3COCH_3 (2-propanone acetone; a common organic solvent used in nail polish remover)

Which would most likely be polar?

1. II and III only **correct**

2. I only

3. I and II only

4. I and III only

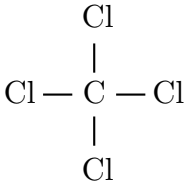
5. II only

6. III only

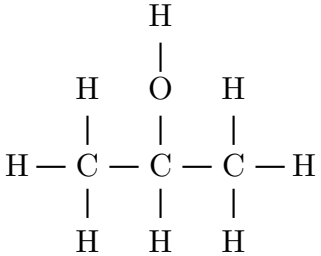
7. None of these

8. All of these

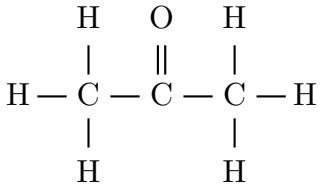
Explanation:



nonpolar



polar



polar

Bond Angles

10:99, general, multiple choice, < 1 min, fixed.

004

For which compound are all of the bond angles equal?

1. SF_6 **correct**

2. H_2O

3. NH_3

4. SCl_4

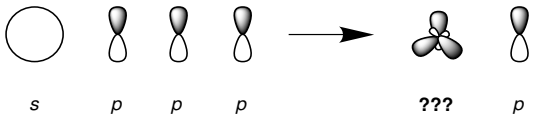
5. $CHCl_3$

Explanation:

Mccorde2sp2

13:01, general, multiple choice, < 1 min, fixed.

005



The hybridized orbital marked ??? is of what type?

1. sp

2. sp^2 **correct**

3. sp^3d

4. sp^3

Explanation:

To make the hybrid orbital, the s orbital and only 2 of the 3 available p orbitals were hybridized, as evidenced by the fact that one of the p orbitals appears not to have been hybridized. The hybrid orbital thus produced would be sp^2.

Pyramids in Electr Geom

12:50, general, multiple choice, < 1 min, fixed.

006

Which combination of electronic geometries

I) linear
II) trigonal planar
III) tetrahedral
IV) trigonal bipyramidal
V) octahedral

includes all of the molecular geometries with pyramidal structures?

1. III, IV, and V **correct**

2. III and IV

3. II, III, IV, and V

4. IV and V

5. IV

Explanation:

Mlib 03 2021

12:02, general, multiple choice, > 1 min, fixed.

007

OCS has what molecular geometry?

1. angular

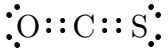
2. linear **correct**

3. trigonal

4. tetrahedral

5. T-shaped

Explanation:



For the central atom C, HED = 2, lone pairs = 0, the electronic geometry is linear and the molecular geometry linear.

Benzene Sigma Pi Bonds

13:02, general, multiple choice, < 1 min, fixed.

008

How many σ and π bonds, respectively, are

found in benzene (C_6H_6)?

1. 12; 3 **correct**

2. 6; 6

3. 12; 6

4. 12; 12

5. 3; 3

Explanation:

Bonds in C2H4

13:02, general, multiple choice, < 1 min, fixed.

009

Which bond is not found in ethylene (C_2H_4)?

1. σ_{sp^2-2p} **correct**

2. $\sigma_{sp^2-sp^2}$

3. σ_{1s-sp^2}

4. π_{2p-2p}

5. All of these bonds are found in C_2H_4.

Explanation:

Brodbelt 09 05

13:05, general, multiple choice, > 1 min, fixed.

010

Antibonding orbitals

1. lend instability to a molecule when populated with electrons. **correct**

2. are higher in energy than bonding orbitals and are therefore populated with electrons prior to bonding orbitals.

3. are lower in energy than bonding orbitals and are therefore populated with electrons prior to bonding orbitals.

4. are responsible for dipole moments in molecules.

5. are responsible for high ionization energies in atoms.

Explanation:

Antibonding orbitals have nothing to do with dipole moments or ionization energies. They form from the overlap of atomic orbitals, are higher in energy than bonding orbitals, are populated with electrons after the corresponding bonding orbitals are populated and lend instability to the molecule when populated with electrons.

Msci 09 0119

13:06, general, multiple choice, > 1 min, fixed.

011

Consider a homonuclear diatomic molecule built from atoms in the second row of the periodic table. When the p orbitals for the two atoms are combined to make molecular orbitals, how many molecular orbitals are made?

1. 3

2. 4

3. 6 **correct**

4. 5

5. 8

Explanation:

The three $2p$ orbitals of each atom combine to form six molecular orbitals, three bonding and three antibonding.

Msci 09 0309

13:07, general, multiple choice, > 1 min, fixed.

012

Which species has a bond order of zero?

1. He_2 **correct**

2. HeH

3. HeH^+

4. H_2^+

5. He_2^+

Explanation:
The corresponding bond orders are
$H_2^+ : \frac{1}{2}$; $HeH : \frac{1}{2}$; $He_2^+ : \frac{1}{2}$; $HeH^+ : 1$; $He_2 : 0$

MO Paramagnetism
13:10, general, multiple choice, < 1 min, fixed.
013
Which of the compounds
I) H_2^+ II) He_2 III) B_2 IV) Be_2^{2-} V) O_2
is/are paramagnetic?

1. all except II **correct**

2. all except III

3. I, III, and V

4. III, IV, and V

5. V

Explanation:

ChemPrin3e T03 61
13:10, general, multiple choice, < 1 min, fixed.
014
Which of the following has the longest bond?

1. N_2

2. NO^-

3. N_2^{2+}

4. N_2^{2-}

5. O_2^{2-} **correct**

Explanation:
The species with the lowest bond order is O_2^{2-}, so it has the longest bond.

Msci 09 0604
13:09, general, multiple choice, > 1 min, fixed.
015
Which of the following substances has a delocalized bond?

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

2. ClO_3^-

3. NH_3

4. CO_2

5. CO

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 1051
14:50, general, multiple choice, > 1 min, fixed.
016
At constant temperature, the volume occupied by a definite mass of a gas is inversely proportional to the applied pressure. This is a statement of which law?

1. Charles'

2. Boyle's **correct**

3. Graham's

4. Avogadros'

5. Dalton's

Explanation:
Boyle's Law relates the volume and pressure of a fixed (definite) mass of gas at constant temperature.

Msci 12 0914 alg
14:04, general, multiple choice, < 1 min, wording-variable.
017
An ideal gas occupies 40.0 L at 925 torr and 49.9°C.

What volume would it occupy at STP?

1. 41.2 L **correct**

2. 57.6 L

3. 0.0243 L

4. 0.0174 L

5. 44.6 L

6. 53.1 L

7. 24.4 L

8. 97.2 L

9. 22.4 L

Explanation:
$P_1 = 925$ torr $\quad P_2 = 760$ torr
$V_1 = 40$ L $\quad T_2 = 323.05$ K
$T_1 = 49.9^\circ\text{C} + 273.15 = 323.05$ K

Using the Combined Gas Law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2},$$

and recalling that STP implies standard temperature (0°C or 273.15 K) and pressure (1 atm or 760 torr), we have

$$\begin{aligned} V_2 &= \frac{P_1 V_1 T_2}{T_1 P_2} \\ &= \frac{(925\text{ torr})(40\text{ L})(273.15\text{ K})}{(323.05\text{ K})(760\text{ torr})} \\ &= 41.1642\text{ L} \end{aligned}$$

ChemPrin3e 04 42

14:06, general, multiple choice, > 1 min, normal.

018

The analysis of a hydrocarbon revealed that it was 85.6281% C and 14.3719% H by mass. When 1.77 g of the gas was stored in a 1.5 L flask at 17.3256 °C, it exerted a pressure of 508 Torr. What is the molecular formula of the hydrocarbon?

1. C_3H_6 **correct**

2. C_8H_{16}

3. C_7H_{14}

4. C_4H_8

5. C_5H_{10}

6. C_3H_5

7. C_4H_{10}

8. C_3H_8

9. C_4H_6

Explanation:
$\text{m} = 1.77$ g $\quad V = 1.5$ L
$T = 290.476$ K $\quad P = 508$ Torr
$R = 0.08206\text{ L}\cdot\text{atm/K/mol}$

The empirical formula derived from the elemental analyses is $(CH_2)_n$.

Applying the ideal gas law,

$$\begin{aligned} PV = n\,RT &= \frac{\text{m}}{\text{MW}}\,RT \\ \text{MW} &= \frac{\text{m}\,T\,R}{P\,V} \\ &= \frac{(1.77\text{ g})(290.476\text{ K})}{(508\text{ Torr})(1.5\text{ L})}\left(\frac{760\text{ Torr}}{1\text{ atm}}\right) \\ &\quad \times 0.08206\text{ L}\cdot\text{atm/K/mol} \\ &= 42.0797\text{ g/mol}. \end{aligned}$$

The empirical formula mass is 14.0266 g/mol. The value of n in the formula $(CH_2)_n$ is, therefore, equal to 3.

Msci 02 1216

14:08, general, multiple choice, > 1 min, normal.

019

Calculate the volume of methane (CH_4) produced by the bacterial breakdown of 1.5 kg of sugar ($C_6H_{12}O_6$)

$$C_6H_{12}O_6 \rightarrow 3\,CH_4 + 3\,CO_2$$

at 300 K and 770 torr.

1. 607 L **correct**

2. 7403 L

3. 364 L

4. 615 L

5. 1110 L

Explanation:

$$n = 1.5 \text{ kg } C_6H_{12}O_6 \cdot \frac{1000 \text{ g}}{1 \text{ kg}} \cdot \frac{\text{mol } C_6H_{12}O_6}{180 \text{ g } C_6H_{12}O_6} \cdot \frac{3 \text{ mol } CH_4}{1 \text{ mol } C_6H_{12}O_6} = 25 \text{ mol } CH_4$$

$$T = 300 \text{ K}$$

$$P = 770 \text{ torr} \cdot \frac{1 \text{ atm}}{760 \text{ torr}} = 1.01316 \text{ atm}$$

Applying the ideal gas law equation,

$$PV = nRT$$

$$V = \frac{nRT}{P}$$

$$V = \frac{(25 \text{ mol})\left(0.08206 \frac{\text{L·atm}}{\text{mol·K}}\right)(300 \text{ K})}{1.01316 \text{ atm}} = 607.457 \text{ L}$$

DAL 0301 06

14:10, general, multiple choice, < 1 min, fixed.

020

You have learned from kinetic molecular theory that for an ideal gas there is an inverse square root relationship between gas velocity and mass. Given this information, what is the ratio of gas velocities for H_2 to CO_2?

1. 4.69 to 1 **correct**

2. 22 to 1

3. 1 to 4.69

4. 1 to 22

5. 2 to 44

Explanation:

$\overline{u} \propto \frac{1}{\sqrt{m}}$, so

$$\frac{v_{H_2}}{v_{CO_2}} = \sqrt{\frac{\text{MW}_{CO_2}}{\text{MW}_{H_2}}} = \sqrt{\frac{44 \text{ g/mol}}{2 \text{ g/mol}}} = 4.69042$$

Ideal Gas Behavior

14:13, general, multiple choice, < 1 min, fixed.

021

List the gases H_2, CH_3F, N_2, CF_4, HF in order of DECREASING tendency to behave as ideal gases. (Consider only intermolecular forces in determining non-ideality.)

1. H_2, N_2, CF_4, CH_3F, HF **correct**

2. HF, CH_3F, CF_4, N_2, H_2

3. H_2, HF, N_2, CH_3F, CF_4

4. CF_4, CH_3F, N_2, HF, H_2

5. H_2, CH_3F, N_2, CF_4, HF

Explanation:

The stronger the intermolecular forces present, the greater the non-ideality:

Induced Dipole	H_2	smallest, most ideal
	N_2	↓
	CF_4	largest
Dipole−dipole	CH_3F	
H−Bonding	HF	least ideal

Sparks real gas 011

14:13, general, multiple choice, < 1 min, fixed.

022

A gas is least likely to behave ideally under what conditions?

1. low temperature and high pressure **correct**

2. high temperature and high pressure

3. low temperature and low pressure

4. high temperature and low pressure

Explanation:

Msci 13 0218

15:03, general, multiple choice, > 1 min, fixed.

023

Which of the following statements about dispersion forces is NOT correct? Dispersion forces

1. are also called London forces.

2. decrease in strength with increasing molecular size. **correct**

3. are temporary rather than permanent dipole-dipole interactions.

4. are the only forces between nonpolar molecules.

Explanation:
Polarizability increases with increasing sizes of molecules and therefore with increasing numbers of electrons. Therefore, London forces are generally stronger for molecules that are larger or have more electrons.

ChemPrin3e 05 01 02

15:03, general, multiple choice, < 1 min, wording-variable.

024

Identify the kinds of intermolecular forces that might arise between molecules of N_2H_4.

1. London forces, dipole-dipole, hydrogen bonding **correct**

2. London forces, dipole-dipole

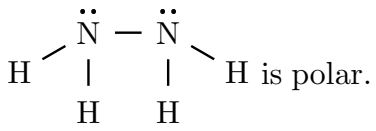
3. London forces

4. dipole-dipole

5. hydrogen bonding

6. None of these

Explanation:



ChemPrin3e 05 04

15:03, general, multiple choice, < 1 min, wording-variable.

025

For which of the molecules

A) SO_2 B) O_3 C) O_2 D) CO_2

will dipole-dipole interactions be important?

1. A and B only **correct**

2. A and C only

3. A and D only

4. B and D only

5. C and D only

6. B and C only

7. None has dipole-dipole interactions.

8. All have dipole-dipole interactions.

9. Another combination of compounds

Explanation:
O_2 and CO_2 do not have dipole moments.

Mlib 04 2045

15:04, general, multiple choice, > 1 min, fixed.

026

Surface tension describes

1. the resistance to flow of a liquid.

2. the inward forces that must be overcome in order to expand the surface area of a liquid. **correct**

3. adhesive forces between molecules.

4. capillary action.

5. the forces of attraction between the surface of a liquid and the air above it.

6. the forces of attraction between surface molecules of a solvent and the solute molecules.

Explanation:
Molecules in the interior of a liquid interact with molecules all around them, whereas molecules at the *surface* of a liquid can only be affected by those beneath the surface layer. This phenomenon leads to a net inward force of attraction on the surface molecules, contracting the surface and making the liquid behave as though it had a skin. Surface tension is a measure of the inward forces that must be overcome to expand the surface area of a liquid.

Sparks intermol 005
15:08, general, multiple choice, < 1 min, fixed.
027
Based on the types and strengths of intermolecular forces present, place the compounds

$C_6H_{14}, C_3H_8, C_5H_{11}OH, C_5H_{11}Cl, CaBr_2$

in order from lowest to highest boiling point (lowest on the left, highest on the right).

1.
$C_6H_{14}, C_3H_8, C_5H_{11}OH, C_5H_{11}Cl, CaBr_2$

2.
$C_3H_8, C_6H_{14}, C_5H_{11}OH, C_5H_{11}Cl, CaBr_2$

3. $C_3H_8, C_6H_{14}, C_5H_{11}Cl, C_5H_{11}OH, CaBr_2$ **correct**

4.
$CaBr_2, C_5H_{11}OH, C_5H_{11}Cl, C_6H_{14}, C_3H_8$

5.
$C_3H_8, C_5H_{11}OH, C_6H_{14}, C_5H_{11}Cl, CaBr_2$

6.
$CaBr_2, C_5H_{11}Cl, C_6H_{14}, C_5H_{11}OH, C_3H_8$

Explanation:
C_3H_8 and C_6H_{14} have only dispersion forces, the weakest type of intermolecular forces. C_6H_{14} has a higher molecular weight and will therefore have stronger dispersion forces.

$C_4H_{11}Cl$ and $C_5H_{11}OH$ are both approximately the same size as C_6H_{14} and would therefore have about the same strength of dispersion forces. $C_4H_{11}Cl$ also has dipole-dipole interactions, stronger than dispersion forces. $C_5H_{11}OH$ also has H - bonding, stronger than dipole-dipole interactions.

$CaBr_2$ is ionic and has interionic forces, the strongest type of intermolecular forces.

The stronger the intermolecular forces, the higher the boiling point.

MP IMF Ranking
15:08, general, multiple choice, > 1 min, fixed.
028
Rank the compounds

CH_4 LiF C_3H_8 NaF

in terms of increasing melting point.

1. $CH_4 < C_3H_8 < NaF < LiF$ **correct**

2. $LiF < NaF < C_3H_8 < CH_4$

3. $NaF < LiF < C_3H_8 < CH_4$

4. $C_3H_8 < CH_4 < LiF < NaF$

5. $C_3H_8 < CH_4 < NaF < LiF$

Explanation:

VP IMF Ranking
15:07, general, multiple choice, > 1 min, fixed.
029
Rank the compounds

CH_3CH_2OH CH_3NH_2 CH_3OH NaOH

in terms of increasing vapor pressure.

1. $NaOH < CH_3CH_2OH < CH_3OH < CH_3NH_2$ **correct**

2. $CH_3NH_2 < CH_3OH < CH_3CH_2OH < NaOH$

3. $NaOH < CH_3OH < CH_3NH_2 < CH_3CH_2OH$

4. $NaOH < CH_3NH_2 < CH_3OH < CH_3CH_2OH$

5. $CH_3CH_2OH < CH_3OH < CH_3NH_2 < NaOH$

Explanation:

Msci 01 0104

15:19, general, multiple choice, > 1 min, fixed.

030

Consider the solids

CO_2 (solid), CsCl (solid), and Ge (solid).

Which of the following correctly identifies the type of solid for CO_2, CsCl, Ge, respectively?

1. molecular, ionic, covalent **correct**

2. molecular, ionic, molecular

3. molecular, covalent, ionic

4. ionic, ionic, covalent

5. molecular, ionic, ionic

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. Metallic solids are composed only of metals held together by metallic bonds. Covalent solids are like huge molecules held together by covalent bonds. Carbon in diamond is the most known example. Group IV B elements can form tetrahedral electronic geometries.