This print-out should have 50 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

LDE Planck relation 001
001 10.0 points

What is the energy, in Joules, of a photon of wavelength 200 nm? What bond energy would this correspond to, in $\text{kJ} \cdot \text{mol}^{-1}$?

1. 1.32×10^{-40} J; 7.95×10^{-20} $\text{kJ} \cdot \text{mol}^{-1}$

2. 1.32×10^{-21} J; 795 $\text{kJ} \cdot \text{mol}^{-1}$

3. 9.94×10^{-21} J; 5.99 $\text{kJ} \cdot \text{mol}^{-1}$

4. 9.94×10^{-19} J; 599 $\text{kJ} \cdot \text{mol}^{-1}$ **correct**

5. 9.94×10^{-17} J; 1.65×10^{-43} $\text{kJ} \cdot \text{mol}^{-1}$

6. 1.32×10^{-31} J; 7.95×10^{-11} $\text{kJ} \cdot \text{mol}^{-1}$

Explanation:
$\lambda = 200$ nm $\qquad c = 3 \times 10^8$ m/s
$h = 6.626 \times 10^{-34}$ J · s.

For a photon $c = \lambda \nu$, so

$$E = h \nu = \frac{h c}{\lambda}$$

where c is the speed of light and h is Planck's constant.

$$\begin{aligned} E &= \frac{h c}{\lambda} \\ &= \left(6.63 \times 10^{-34} \text{ J} \cdot \text{s}\right) \left(3 \times 10^8 \text{ m/s}\right) \\ &\quad \cdot \frac{1}{200 \text{ nm}} \cdot \frac{10^9 \text{ nm}}{1 \text{ m}} \\ &= 9.94 \times 10^{-19} \text{ J} \end{aligned}$$

$$(9.94 \times 10^{-19} \text{ J})(6.022 \times 10^{23} \text{ mol}^{-1}) = 599 \text{ kJ} \cdot \text{mol}^{-1}$$

LDE Balmer Series 001
002 10.0 points

Which of the following electronic transitions for a hydrogen atom would correspond to the highest energy emission found in the Balmer series?

1. n=2 to n=4

2. n=2 to n=1

3. n=3 to n=1

4. n=1 to n=2

5. n=3 to n=2

6. n=4 to n=2 **correct**

Explanation:
The Balmer series is electronics transitions the involve n=2 and some higher principle energy level (n greater than 2) for the hydrogen atom. An emission occurs when an electron moves from some energy level to a lower energy level. Combining these constraints, n=4 to n=2 will be the highest energy emission in the Balmer series, of the available answer choices.

LDE Classical Failure 002
003 10.0 points

Which of the following statement(s) is/are true?

I) The failure of classical mechanics to predict the absorptions/emission spectra of gases is called the ultraviolet catastrophe.
II) Quantum mechanics accurately predicted the behavior of blackbody radiators.
III) The emission spectra of gases are discrete rather than continuous.
IV) Any frequency of light will eject an electron from a metal surface as long as the intensity is sufficient.

1. I and III

2. I, II and IV

3. II, III, and IV

4. II and III **correct**

5. III and IV

Explanation:

Classical mechanics predicted that the power radiated by a blackbody radiator would be proportional to the square of the frequency at which it emitted radiation, and thus approach infinity as the frequency increased. This was false, since at higher frequencies blackbody radiators emit less, not more power. This was termed the ultraviolet catastrophe. Classical mechanics also predicted that the energy (velocity) of electrons emitted from a metal surface is proportional to the intensity of light. In reality, the energy (velocity) is only dependent upon the frequency of light. Once the threshold frequency is reached, however, the number of emitted electrons is proportional to the intensity of light. Classical mechanics also fails in explaining the discrete lines in absorption/emission spectrum, which are due to discrete energy levels of electrons in atoms.

LDE Uncertainty Principle Theory 001
004 10.0 points

Which of the following are true consequences of the uncertainty principle?

I) The uncertainty in an electron's momentum can never be less than $\frac{\hbar}{2}$;

II) An electron can be measured in two places at once;

III) Electrons and other particles do not have a well-defined position or momentum like particles in classical mechanics do.

1. I only

2. II and III

3. I and II

4. II only

5. III only **correct**

6. I and III

Explanation:

I is false because Δp may be less than $\frac{\hbar}{2}$ provided that Δx is greater than unity (and vice versa).

II is false because an electron can only be observed in one place at one time, although there may be an equal probability of observing it at two different places.

III is true because quantum mechanics can only give probabilities of a particle having a certain position or momentum and not an exact value.

De Broglie Wavelength 01
005 10.0 points

Consider a flea of mass 4.5×10^{-4} g moving at 1.0 m/s midway through its jump. What is its de Broglie wavelength?

1. 1.4725×10^{-30} m

2. 2.9818×10^{-40} m

3. 2.9818×10^{-37} m

4. 1.47244×10^{-27} m **correct**

Explanation:

$$m = 0.00045 \text{ g} \times \frac{0.001 \text{ kg}}{1 \text{ g}} = 4.5 \times 10^{-7} \text{ kg}$$

$$\begin{aligned} \lambda &= \frac{h}{p} = \frac{h}{m \cdot v} \\ &= \frac{6.626 \times 10^{-34} \ \frac{\text{kg} \cdot \text{m}^2}{\text{s}}}{(4.5 \times 10^{-7} \text{ kg})(1 \text{ m/s})} \\ &= 1.47244 \times 10^{-27} \text{ m} \end{aligned}$$

Msci 01 0303
006 10.0 points

Which of the following is an intensive property?

1. weight

2. volume

3. density **correct**

4. mass

5. number of moles of molecules

Explanation:
Intensive properties are independent of the amount of matter present. The density of a substance will be the same regardless of the size (large or small) of the sample.

LDE quantum rules 002
007 10.0 points

Which of the following sets of quantum numbers are **invalid**, i.e. violate one or more boundary conditions?

I) $n = 3, \ell = 2, m_\ell = -2, m_s = +\frac{1}{2}$
II) $n = 9, \ell = 5, m_\ell = 6, m_s = +\frac{1}{2}$
III) $n = 2, \ell = 1, m_\ell = 0, m_s = +1$
IV) $n = 2, \ell = 0, m_\ell = 0, m_s = +\frac{1}{2}$
V) $n = 1, \ell = 0, m_\ell = 0, m_s = -\frac{1}{2}$

1. III only

2. I, III, IV

3. IV only

4. I, IV

5. I, II, IV

6. II only

7. I only

8. II, III **correct**

Explanation:
Set II and III are invalid. For II, $m_l = 6$ is disallowed because $\ell = 5$. For III, $m_s = +1$ is disallowed because m_s may only be $+\frac{1}{2}$ or $-\frac{1}{2}$.

Msci 05 1648
008 10.0 points

Hund's rule states that

1. it is impossible to determine accurately both the momentum and position of an electron simultaneously.

2. electrons occupy all the orbitals of a given sublevel singly before pairing begins. **correct**

3. no two electrons in an atom may have identical sets of four quantum numbers.

Explanation:

Mlib 02 4077
009 10.0 points

Write the electron configuration for P.

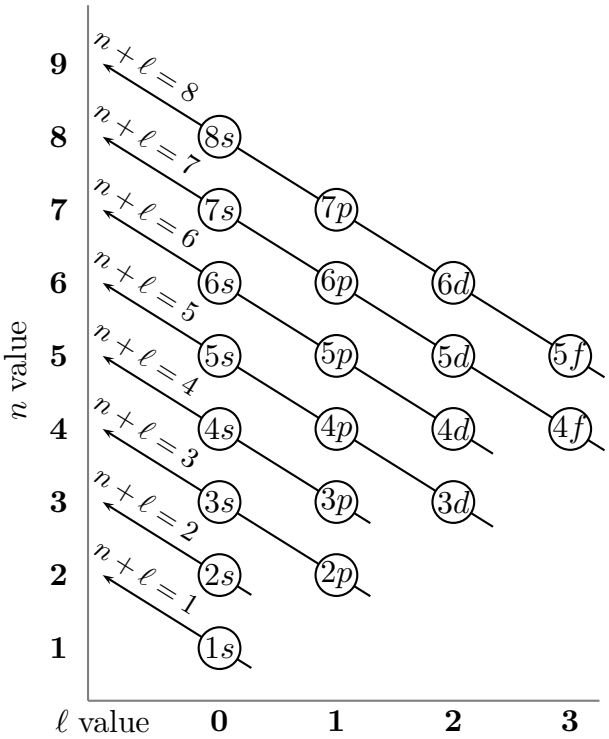
1. $1s^2\,2s^2\,2p^6\,3d^5$

2. $1s^2\,2s^2\,2p^6\,3s^2\,3p^3$ **correct**

3. $1s^2\,2s^2\,2p^6\,3p^5$

4. $1s^2\,2s^2\,2p^6\,3s^2\,3p^6$

Explanation:
P has atomic number 15. Follow the pyramid



until exponents sum to 15.

LDE periodic trend theory 001
010 10.0 points

Which of the following BEST describes the purpose of effective nuclear charge?

1. It is used to rationalize chemical bonding in covalently bonded molecules.

2. It is a method to evaluate how much attraction a given electron "feels" from the nucleus so that periodic trends can be predicted and rationalized. **correct**

3. It is used to determine the number of valence electrons of a given species.

4. It exists only to torture foolish CH 301 students who did not study.

5. It is a measure of the effect of filled and half-filled subshells on the stability of atoms and ions.

6. It is a measure of how many protons a given atom has which is useful because of variations from isotope to isotope.

Explanation:
Inner shell electrons "shield" the outer shell electrons from the full attraction of the nucleus. An electron in a higher shell, farther from the nucleus, feels much less attraction, for example; in other words the effective nuclear charge it experiences is smaller. This is used to rationalize the periodic trends.

LDE Ranking trends 002
011 10.0 points

Rank the following species in terms of increasing electron affinity: Sulfur (S), Rubidium (Rb), Germanium (Ge), Krypton (Kr), Floruine (F)

1. Kr < Ge < Rb < S < F

2. Ge < Rb < S < F < Kr

3. Kr < Rb < Ge < S < F **correct**

4. Not enough information

5. Rb < Ge < S < F < Kr

6. F < Ge < S < Rb < Kr

Explanation:
Elements' electron affinities increase across a given period and up and given group. Noble gases (*i.e.* Kr) have an electron affinity of essentially zero. Rb is greater than zero, Ge is greater than Rb, S is greater than Ge, and F is greater than P.

ChemPrin3e T02 07
012 10.0 points

Which of the following has the highest lattice energy?

1. MgO **correct**

2. BaO

3. KI

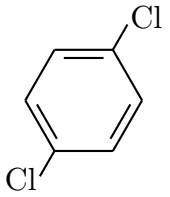
4. NaCl

5. CaO

Explanation:
Mg^{2+} and O^{2-} have the highest charge densities.

Line Drawing to Formula
013 10.0 points

Determine the molecular formula for the molecule:



1. C_6H_6

2. $C_4H_{12}Cl_2$

3. $C_6H_4Cl_2$ **correct**

4. $C_6H_6Cl_2$

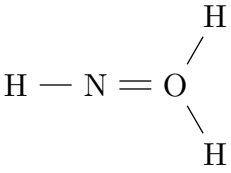
5. $C_4H_4Cl_2$

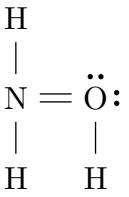
6. C_6H_4Cl

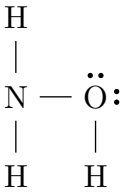
Explanation:

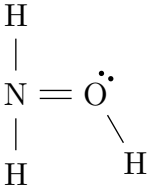
LDE Lewis Structures 005
014 10.0 points

Which of the following is the correct Lewis structure of hydroxylamine (NH_2OH)?

1.


2.


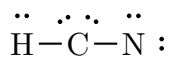
3.

correct

4.


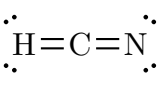
Explanation:

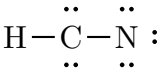
Lewis HCN dash
015 10.0 points

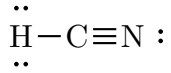
Which of the following is the correct Lewis formula for hydrogen cyanide (HCN)?

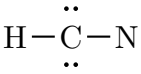
1.

correct

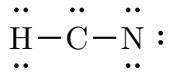
2.

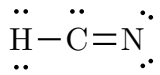
3.


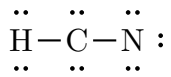
4.


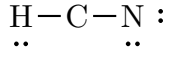
5.


6.


7.


8.


9.


10.


Explanation:
The Lewis formula for hydrogen cyanide (HCN) is

Mlib 03 1025
016 10.0 points

How many resonance structures are there for the NO_3^- polyatomic ion?

1. 3 **correct**

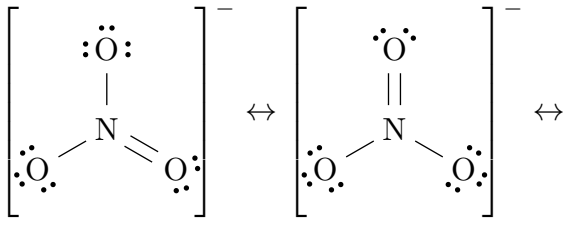
2. 2

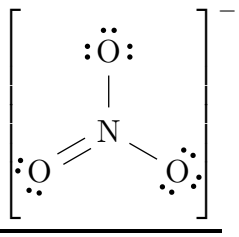
3. 1

4. This molecule does not exhibit resonance.

5. 5

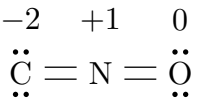
6. 4

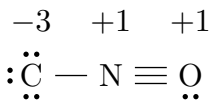
Explanation:


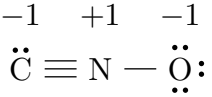


ChemPrin3e 02 76
017 10.0 points

Which of the three Lewis structures is the most important for the fulminate ion (CNO^-)?

I) 

II) 

III) 

1. None of these is important.

2. I only

3. I and II only

4. I and III only

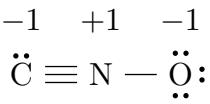
5. III only **correct**

6. II and III only

7. II only

8. All of these are important.

Explanation:

The Lewis structure  is probably the most important as it is the structure with the formal charges of the individual atoms closest to zero.

Brodbelt 08 04
018 10.0 points

ICl_3 is sp^3d hybridized. What is the electronic and molecular geometry?

1. octahedral; T-shaped

2. trigonal bipyramidal, seesaw

3. trigonal bipyramidal; T-shaped **correct**

4. tetrahedral; pyramidal

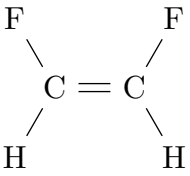
5. trigonal planar; trigonal planar

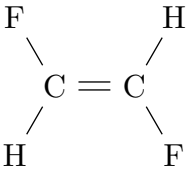
Explanation:

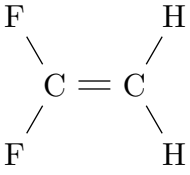
The hybridization tells us that there are 5 regions of high electron density. Three of those regions are the bonded Cl atoms. The other two regions must be lone pairs of electrons on the central I atom. This corresponds to trigonal bipyramidal electronic geometry and T-shaped molecular geometry.

LDE VSEPR Molecular Geometry 002
019 10.0 points

Which of the following molecules is/are polar?

I) 

II) 

III) 

1. I, II, III

2. I only

3. I, III **correct**

4. III only

5. I, II

6. II, III

7. II only

Explanation:
Molecule II is symmetrical and therefore its individual dipole moments cancel, making it non-polar. Molecules I and III are asymmetrical and therefore polar.

LDE VB Sigma Pi Bonds 004
020 10.0 points

How many sigma (σ) and pi (π) bonds are in the Lewis structure for $C(COOH)_4$?

1. 12 σ, 0 π

2. 8 σ, 4 π

3. 16 σ, 0 π

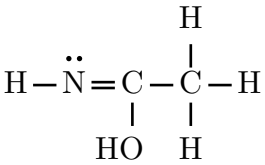
4. 12 σ, 4 π

5. 16 σ, 4 π **correct**

Explanation:

Brodbelt 8200504
021 10.0 points

Give the hybridization of each central atom: nitrogen, middle carbon, right carbon.



1. sp^3, sp^2, sp^3

2. sp^2, sp^3, sp^3

3. sp^2, sp^2, sp^2

4. sp^3, sp^3, sp^3

5. sp, sp^3, sp^3

6. sp^2, sp, sp^2

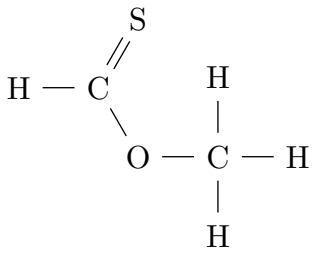
7. sp, sp, sp

8. sp^2, sp^2, sp^3 **correct**

Explanation:
Hybridization is chosen based on the electronic geometry around the central atom, which is based on the number of RHED around the central atom. The RHED are three, three, and four.

LDE VB Hybridization 002
022 10.0 points

Consider the thionoester molecule



What orbitals were used to form the π (pi) bond?

1. $sp^2, 3s$

2. $2s, 3p$

3. $sp^3, 3s$

4. $sp^3, 3p$

5. $2p, 3p$ **correct**

Explanation:

LDE Bond Order 009
023 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. F_2^-

3. B_2^- **correct**

4. H_2^-

5. Ne_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 004
024 10.0 points

Which of the following species is/are paramagnetic?
I) Li_2^-
II) O_2
III) H_2^+

1. I only

2. I and III

3. III only

4. II only

5. II and III

6. I and II

7. I, II and III **correct**

Explanation:
Li_2^- and H_2^+ both have an odd number of electrons and therefore must be paramagnetic. O_2 has 16 total electrons, the last two of which must go into separate degenerate π^* anti-bonding orbitals.

Msci 12 0911
025 10.0 points

2.0 g of H_2 and 8.0 g of He are put in a 22.4 liter container at 0°C. The total pressure is

1. 1.0 atm.

2. 10.0 atm.

3. 3.0 atm. **correct**

4. 5.0 atm.

Explanation:

$$n_{H_2} = \frac{2\text{ g}\cdot\text{mol}}{2\text{ g}} = 1\text{ mol} \qquad V = 22.4\text{ L}$$
$$n_{He} = \frac{8\text{ g}\cdot\text{mol}}{4\text{ g}} = 2\text{ mol} \qquad n_{total} = 3\text{ mol}$$
$$T = 0°\text{C} + 273 = 273\text{ K}$$

Applying the ideal gas law equation,

$$P\,V = n\,R\,T$$
$$P = \frac{n\,R\,T}{V}$$
$$P = \frac{(3\text{ mol})\left(0.08206\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)(273\text{ K})}{22.4\text{ L}}$$
$$= 3.00032\text{ atm}$$

Msci 12 0918a
026 10.0 points

What volume will 40.0 L of He at 50.00°C and 1201 torr occupy at STP?

1. 53.4 L **correct**

2. 26.7 L

3. 31.1 L

4. 12.8 L

5. 18.6 L

Explanation:
$P_1 = 1201\text{ torr} \qquad P_2 = 760\text{ torr}$
$V_1 = 40\text{ L} \qquad T_2 = 273.15\text{ K}$
$T_1 = 50° + 273.15 = 323.15\text{ K}$

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 (273.15 K) and pressure (1 atm or 760 torr), we have

$$V_2 = \frac{P_1\,V_1\,T_2}{T_1\,P_2}$$
$$= \frac{(1201\text{ torr})\,(40.0\text{ L})\,(273.15\text{ K})}{(323.15\text{ K})\,(760\text{ torr})}$$
$$= 53.4302\text{ L}$$

Mass Density and Pressure
027 10.0 points

A sample of nitrous oxide gas (NO) has a density of 12 g L^{-1}. What pressure does the sample exert at 27 °C?

1. 1.0 atm

2. 61.6 atm

3. not enough information

4. 997.9 atm

5. 9.9 atm **correct**

Explanation:

By thoughtful substitutions and rearrangement, the ideal gas law can be used to relate the mass density of a gas to its pressure.

$PV = nRT$

Recalling that a number of moles (n) is equal to a mass (m) divided by a molecular weight (M.W.), we can substitute into the ideal gas law.

$$n = \frac{m}{M.W.}$$

$$PV = \frac{m}{M.W.}RT$$

This can be rearranged to solve for P.

$$P = \frac{m}{V}\frac{RT}{M.W}$$

By substituting the definition of density (ρ), we can arrive at a readily usable equation.

$$\rho = \frac{m}{V}$$

$$P = \rho\frac{RT}{M.W} = 12\frac{0.0821 \times 300}{30} = 9.852\,\text{atm}$$

Brodbelt 12 04a
028 10.0 points

For the reaction

$$2\,HCl + Na_2CO_3 \rightarrow 2\,NaCl + H_2O + CO_2$$

179.2 liters of CO_2 is collected at STP. How many moles of NaCl are also formed?

1. 16.0 moles **correct**

2. 6.0 moles

3. 12.5 moles

4. 4.0 moles

5. 32.0 moles

6. 8.0 moles

Explanation:

$V_{CO_2} = 179.2$ L

At STP we can use the standard molar volume, 22.4 L/mol.

$$\frac{179.2\text{ L}}{22.4\text{ L/mol}} = 8.00\text{ mol } CO_2$$

$$8.00\text{ mol } CO_2 \times \frac{2\text{ mol NaCl}}{1\text{ mol } CO_2} = 16.0\text{ mol NaCl}$$

---

rms velocity of He 01
029 10.0 points

Helium has a rms velocity (v_{rms}) that is 4.21 times faster than which of the following gases?

1. neon, Ne

2. chlorine, Cl_2 **correct**

3. xenon, Xe

4. oxygen, O_2

5. argon, Ar

Explanation:

The relationship of rms velocities between different molecules is:

$$\frac{\text{rateA}}{\text{rateB}} = \sqrt{\frac{\text{massB}}{\text{massA}}}$$

Let massA be helium's mass of 4.0 and 4.21 be heliums rate so that:

$$\frac{4.21}{1} = \sqrt{\frac{\text{massB}}{4.0}}$$

$$(4.21)^2 = \frac{\text{massB}}{4.0}$$

$$70.9 = \text{massB}$$

This only matches the chlorine gas, Cl_2.

LDE Gas Non-ideality 002
030 10.0 points

Which of the following does **not** affect the ideality of gases?

I) the temperature of the gas
II) the density of the gas
III) the size of the gas molecules

1. III only

2. I only

3. II only

4. I, II, and III

5. II and III

6. none of the above **correct**

7. I and III

8. I and II

Explanation:
All of the listed factors influence gas ideality.

LDE Intermolecular Forces 001
031 10.0 points

Which of the following statements regarding intermolecular forces (IMF) is/are true?

I) Intermolecular forces result from attractive forces between regions of positive and negative charge density in neighboring molecules.
II) The stronger the bonds within a molecule are, the stronger the intermolecular forces will be.
III) Only non-polar molecules have instantaneous dipoles.

1. II and III

2. I only **correct**

3. III only

4. I and II

5. II only

6. I, II, and III

7. I and III

Explanation:
Statement I is true - all IMF result from Coulombic attraction. Statements II and III are both false; the strength of the bonds within a molecule have no bearing on the strength of the bonds between molecules; all molecules have London forces.

LDE Intermolecular Forces 002
032 10.0 points

Which of the following is not correctly paired with its dominant type of intermolecular forces?

1. NH_3, hydrogen bonding

2. SiH_4, instantaneous dipoles

3. C_6H_6 (benzene), instantaneous dipoles

4. CaO, ionic forces

5. HBr, hydrogen bonding **correct**

Explanation:
London forces, dispersion forces, van der Waals' forces, instantaneous or induced dipoles all describe the same intermolecular force. London forces are induced, short-lived, and very weak. Molecules and atoms can experience London forces because they have electron clouds. London forces result from the distortion of the electron cloud of an atom or molecule by the presence of nearby atoms or molecules.

Permanent dipole-dipole interactions are stronger than London forces and occur between polar covalent molecules due to charge separation.

H-bonds are a special case of very strong dipole-dipole interactions. They only occur when H is bonded to small, highly electronegative atoms – F, O or N only.

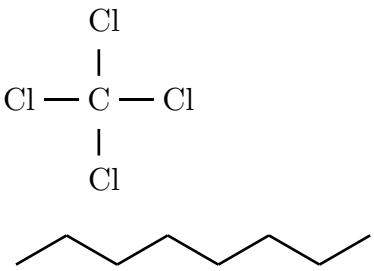
Ion-ion interactions are the strongest due to extreme charge separation and occur between ions (including polyatomic ions). They can be

thought of as both inter- and intramolecular bonding.

HBr is a polar molecule that does not contain H bonds; therefore, dipole-dipole forces will be the most significant type of intermolecular forces present.

Explaining Dispersion Forces
033 10.0 points

Carbon tetrachloride (CCl_4) and *n*-octane (C_8H_{18}) are both non-polar molecules. At standard pressure, they boil at 345 K and 399 K, respectively. Which answer choice below correctly explains their boiling points?



1. C_8H_{18} has a higher boiling point because its electron cloud is larger and allows it to form more instantaneous dipoles. **correct**

2. C_8H_{18} has a higher boiling point because its greater molecular weight enables it to form stronger instantaneous dipoles.

3. C_8H_{18} has a higher boiling point because its smaller surface area allows it to form stronger instantaneous dipoles.

4. CCl_4 has a lower boiling point because its smaller surface area allows it to form stronger instantaneous dipoles.

5. CCl_4 has a lower boiling point because its greater molecular weight enables it to form stronger instantaneous dipoles.

Explanation:
Carbon tetrachloride (CCl_4) and *n*-octane (C_8H_{18}) both have only instantaneous dipoles. Despite the fact that (CCl_4) has a greater molecular weight (153.81 g mol^{-1}) compared to C_8H_{18} (114.23 g mol^{-1}), the latter boils at a substantially higher temperature. In general, dispersion forces are greater in molecules with greater molecular weight, more total electrons and a larger surface area (i.e. the shape of the molecule). Since *n*-octane is a long skinny molecule, more of its electrons are accessible and ready to form instantaneous dipoles.

LDE Physical Properties 001
034 10.0 points

Which of the following statements about boiling is false?

1. As intermolecular forces increase, boiling point increases as well.

2. The boiling point of a liquid is independent of atmospheric pressure. **correct**

3. Boiling occurs when vapor pressure exceeds atmospheric pressure.

4. For a given pressure, the boiling point is always at a higher temperature than melting point.

Explanation:
Boiling point is directly proportional to atmospheric pressure.

VP IMF Ranking
035 10.0 points

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. $NaOH < CH_3NH_2 < CH_3OH < CH_3CH_2OH$

4. $CH_3CH_2OH < CH_3OH < CH_3NH_2 < NaOH$

5. $NaOH < CH_3OH < CH_3NH_2$

$< CH_3CH_2OH$

Explanation:

LaBrake CIC CH5 02
036 10.0 points

Which of the following substances would you predict might evaporate the fastest?

1. C_8H_{18}

2. $C_{10}H_{22}$

3. $C_{12}H_{24}$

4. C_6H_{14} **correct**

Explanation:
All the listed molecules are nonpolar hydrocarbons; therefore the dominant intermolecular force that exists in the condensed phase of all listed molecules is dispersion forces. Therefore, the molecule with the least number of atoms and the lowest molecular weight would have the lowest dispersion forces, and therefore would evaporate the easiest.

LDE Thermodynamic Theory 012 U not E
037 10.0 points

Which of the following statements concerning the laws of thermodynamics is not true?

1. S = 0 for a perfect crystal at absolute zero.

2. $\Delta U_{univ} = 0$

3. Entropy always increases in an isolated system.

4. $\Delta S_{univ} > 0$

5. Free energy is conserved in a closed system. **correct**

Explanation:
Free energy is conserved in an isolated system, but not in a closed system.

LDE Thermodynamic Work 0034
038 10.0 points

For which of the following reactions at room temperature (25°C) would there be 5.0 kJ of work done on the system?

1. $2\,H_2O(\ell) + O_2(g) \rightarrow 2\,H_2O_2(\ell)$

2. $CO_2(g) + 2\,H_2O(g) \rightarrow CH_4(g) + 2\,O_2(g)$

3. $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$

4. $N_2H_2(g) + CH_3OH(g) \rightarrow CH_2O(g) + N_2(g) + 2\,H_2(g)$

5. $CH_2O(g) + N_2(g) + 2\,H_2(g) \rightarrow N_2H_2(g) + CH_3OH(g)$ **correct**

6. $2\,H_2O_2(\ell) \rightarrow 2\,H_2O(\ell) + O_2(g)$

Explanation:
At room temperature (298 K), the product of the gas constant ($R = 8.314\ J \cdot mol^{-1} \cdot K^{-1}$) and T is very close to $2.5\ kJ \cdot mol^{-1}$. Based on $5.0\ kJ = -\Delta n_{gas}\left(2.5\ kJ \cdot mol^{-1}\right)$, the reaction for which $\Delta n_{gas} = -2$ will be the correct answer.

LDE Bomb Calorimeter 002
039 10.0 points

If we set up a bomb calorimetry experiment to determine the molar internal energy of combustion of ethene (C_2H_4) using 1 L of water as our heat sink, 2.805 g of ethene, and measure an initial and final temperature of 25.20°C and 58.92°C, respectively, what will be the experimentally determined molar internal energy of combustion of ethene? Assume the density of water is $1.00\ g \cdot mL^{-1}$ and the calorimeter itself absorbs no heat. The specific heat capacity of water is $4.184\ J \cdot g^{-1} \cdot K^{-1}$.

1. $-14.11\ kJ \cdot mol^{-1}$

2. $-141.1\ kJ \cdot mol^{-1}$

3. $-14,110\ kJ \cdot mol^{-1}$

4. $-141,100\ kJ \cdot mol^{-1}$

5. $-1,411\ \text{kJ} \cdot \text{mol}^{-1}$ **correct**

Explanation:

$$\Delta T = T_f - T_i = 58.92^\circ\text{C} - 25.20^\circ\text{C} = 33.72^\circ\text{C} = 33.72\ \text{K}$$

$$m = (1\ \text{L}) \cdot \frac{1000\ \text{mL}}{\text{L}} \cdot \frac{1.00\ \text{g}}{\text{mL}} = 1000\ \text{g}$$

$$n = 2.805\ \text{g ethene} \cdot \frac{28.05\ \text{g}}{\text{mol}} = 0.1\ \text{mol}$$

$$\frac{\Delta U rxn}{n} = \frac{-\Delta U cal}{n} = \frac{-m\,c\,\Delta T}{n} = -\frac{1000\ \text{g} \cdot \frac{4.184\ \text{J}}{\text{g·K}} \cdot 33.72\ \text{K}}{0.1\ \text{mol}} = -1,411\ \text{kJ} \cdot \text{mol}^{-1}$$

LDE Bond Enthalpy 002
040 10.0 points

Using the provided bond enthalpy data, calculate the change in enthalpy for the following reaction:

$$CH_4(g) + O_2(g) \longleftrightarrow CH_2O(g) + H_2O(g)$$

1. $-577\ \text{kJ} \cdot \text{mol}^{-1}$

2. $710\ \text{kJ} \cdot \text{mol}^{-1}$

3. $577\ \text{kJ} \cdot \text{mol}^{-1}$

4. $-710\ \text{kJ} \cdot \text{mol}^{-1}$

5. $349\ \text{kJ} \cdot \text{mol}^{-1}$

6. $-349\ \text{kJ} \cdot \text{mol}^{-1}$ **correct**

Explanation:

$$\begin{aligned}\Delta H_{rxn} &= \sum \text{BE}_{\text{reactants}} - \sum \text{BE}_{\text{products}} \\ &= \left[4(412\ \text{kJ} \cdot \text{mol}^{-1}) + 496\ \text{kJ} \cdot \text{mol}^{-1}\right] \\ &\quad - \left[2(412\ \text{kJ} \cdot \text{mol}^{-1}) + 743\ \text{kJ} \cdot \text{mol}^{-1} \right. \\ &\quad \left. + 2(463\ \text{kJ} \cdot \text{mol}^{-1})\right] \\ &= -349\ \ \text{kJ} \cdot \text{mol}^{-1}\end{aligned}$$

ChemPrin3e T06 48
041 10.0 points

Calculate the standard enthalpy of combustion of butane ($C_4H_{10}(g)$) at 298 K from standard enthalpy of formation data.

1. $-2056.49\ \text{kJ} \cdot \text{mol}^{-1}$

2. $-2877.04\ \text{kJ} \cdot \text{mol}^{-1}$ **correct**

3. $-895.49\ \text{kJ} \cdot \text{mol}^{-1}$

4. $-2843.5\ \text{kJ} \cdot \text{mol}^{-1}$

5. $-2342.32\ \text{kJ} \cdot \text{mol}^{-1}$

Explanation:
The balanced equation is

$$C_4H_{10}(g) + \frac{13}{2}\,O_2 \rightarrow 4\,CO_2(g) + 5\,H_2O(\ell)$$

$$\begin{aligned}\Delta H_{\text{comb}} &= \sum \Delta H^\circ_{\text{f prod}} - \sum \Delta H^\circ_{\text{f react}} \\ &= \left[5\,\Delta H^\circ_{\text{f } H_2O(\ell)} + 4\,\Delta H^\circ_{\text{f } CO_2(g)}\right] \\ &\quad - \Delta H^\circ_{\text{f } C_4H_{10}(g)} \\ &= [5\,(-285.83\ \text{kJ/mol}) \\ &\qquad +4\,(-393.51\ \text{kJ/mol})] \\ &\quad - (-126.15\ \text{kJ/mol}) \\ &= -2877.04\ \text{kJ/mol}\end{aligned}$$

LDE Thermodynamic Signs 001
042 10.0 points

When wood is burning (i.e. a combustion process is occurring), which of the following quantities is positive?

1. Change in enthalpy.

2. Work.

3. Change in Gibbs' free energy.

4. Change in entropy. **correct**

Explanation:
A burning piece of wood produces a lot of gas and thus does expansion work on the surroundings so work is negative, not positive. It is an exothermic reaction (producing heat) so enthalpy change is negative, not positive. It happens spontaneously so change in free energy is negative, not positive. Finally, all the gas produced yields an increase in entropy so the change is indeed positive.

ChemPrin3e 07 25 26
043 10.0 points

Which one shows the substances in the decreasing order of their molar entropy?

1. C(s), H_2O(g), $H_2O(\ell)$, H_2O(s)

2. C(s), $H_2O(\ell)$, H_2O(g), H_2O(s)

3. None of these

4. H_2O(s), $H_2O(\ell)$, H_2O(g), C(s)

5. C(s), H_2O(s), $H_2O(\ell)$, H_2O(g)

6. H_2O(g), $H_2O(\ell)$, H_2O(s), C(s) **correct**

Explanation:
Gases will have a higher entropy than liquids so we expect $H_2O(\ell)$ to have the lowest molar entropy. The gases will increase in entropy in the order Ne(g) < Ar(g) < CO_2(g). Ne and Ar are both atoms so they should have less entropy than a molecular substance, which has more complexity. Ar will have a higher entropy than Ne because it has a larger mass and more fundamental particles.
The correct order is
$H_2O(\ell)$ < Ne(g) < Ar(g) < CO_2(g).

LDE Entropy 002
044 10.0 points
Which of the reactions below will likely have the largest increase in entropy (ΔS_{rxn})?

1. $2\,CH_4(g) + 2O_3(g) \rightarrow 4\,H_2O(g) + 2\,CO(g)$

2. $N_2H_4(g) + H_2(g) \rightarrow 2\,NH_3(g)$

3. $C_5H_{12}(\ell) + 8\,O_2(g) \rightarrow 6\,H_2O(g) + 5\,CO_2(g)$ **correct**

4. $Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$

5. $S_3(g) + 9\,F_2(g) \rightarrow 3\,SF_6(g)$

Explanation:
The reaction with the greatest positive value for Δn_{gas} will have the greatest value of ΔS_{rxn}.

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entropy change for metal heating 1
045 10.0 points
150 grams of iron is heated from 25°C to 150°C. What is ΔS for this change? The specific heat capacity of iron is 0.450 J/g K.

1. −8438 J/K

2. 0 J/K

3. +121 J/K

4. −23.6 J/K

5. −121 J/K

6. +8438 J/K

7. +23.6 J/K **correct**

Explanation:
$\Delta S = mC \ln(T_2/T_1)$
$\Delta S = 150(0.45) \ln\left(\dfrac{423.15}{298.15}\right)$
$\Delta S = 150(0.45) \ln(1.42)$
$\Delta S = +23.6$ J/K

ChemPrin3e T07 40
046 10.0 points
Calculate $\Delta S^\circ_{\text{surr}}$ at 298 K for the reaction

$$6\,C(s) + 3\,H_2(g) \rightarrow C_6H_6(\ell)$$

$\Delta H^\circ_r = +49.0$ kJ·mol^{-1} and $\Delta S^\circ_r = -253$ J·K^{-1}·mol^{-1}.

1. -417 J·K^{-1}·mol^{-1}

2. $+253$ J·K^{-1}·mol^{-1}

3. -164 J·K^{-1}·mol^{-1} **correct**

4. $+164$ J·K^{-1}·mol^{-1}

5. -253 J·K^{-1}·mol^{-1}

Explanation:
$\Delta H^\circ_r = 49000$ J · mol^{-1} $T = 298$ K

$$\begin{aligned}\Delta S^\circ_{surr} &= \frac{q_{surr}}{T} = \frac{-q}{T} = \frac{-\Delta H^\circ_r}{298\text{ K}} \\ &= \frac{-(+49000\text{ J}\cdot\text{mol}^{-1})}{298\text{ K}} \\ &= -164.43\text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}.\end{aligned}$$

LDE Temperature and Phase Changes 003

047 10.0 points

Based on the enthalpy of sublimation ($\Delta H_{sub} = 393.5\text{ kJ}\cdot\text{mol}^{-1}$) and entropy of sublimation ($\Delta S_{sub} = 2.023\text{ kJ}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}$) of carbon dioxide, at what temperature does this phase transition occur?

1. 78.5 °C

2. -78.5 K

3. 0.2 °C

4. -78.5 °C **correct**

5. 0.2 K

Explanation:
$T_{sub} = \dfrac{\Delta H_{sub}}{\Delta S_{sub}} = \dfrac{393.5\text{ kJ}\cdot\text{mol}^{-1}}{2.023\text{ kJ}\cdot\text{mol}^{-1}\cdot\text{K}^{-1}} = 194.5\text{ K} = -78.5\text{ °C}$

ChemPrin3e T07 59

048 10.0 points

For the reaction

$$2\,C(s) + 2\,H_2(g) \rightarrow C_2H_4(g)$$

$\Delta H^\circ_r = +52.3$ kJ · mol^{-1} and $\Delta S^\circ_r = -53.07$ J · K^{-1} · mol^{-1} at 298 K. The reverse reaction will be spontaneous at

1. no temperatures.

2. temperatures below 1015 K.

3. temperatures above 985 K.

4. all temperatures. **correct**

5. temperatures below 985 K.

Explanation:
$\Delta G = \Delta H - T\Delta S$ is used to predict spontaneity. (ΔG is negative for a spontaneous reaction.) T is always positive; for the reverse reaction, we reverse the sign of ΔH and ΔS. We thus have $\Delta G = (-) - T(+)$ for the reverse reaction, so ΔG will be negative for any physically possible value of T.

ChemPrin3e T07 52

049 10.0 points

Calculate ΔG°_r for the decomposition of mercury(II) oxide

	$2\,HgO(s)$	$\rightarrow 2\,Hg(\ell)$	$+\,O_2(g)$
ΔH°_f (kJ · mol^{-1})	-90.83	–	–
ΔS°_m (J · K^{-1} · mol^{-1})	70.29	76.02	205.14

at 298 K.

1. -117.1 kJ · mol^{-1}

2. -246.2 kJ · mol^{-1}

3. $+117.1$ kJ · mol^{-1} **correct**

4. $+246.2$ kJ · mol^{-1}

5. -64.5 kJ · mol^{-1}

Explanation:

In order to find ΔG°_r at 298 K, we must first calculate ΔH°_r and ΔS°_r.

$$\begin{aligned}\Delta S^\circ_r &= 2 \cdot S^\circ_{Hg(\ell)} + S^\circ_{O_2(g)} - 2 \cdot S^\circ_{HgO(s)} \\ &= 2 \left(76.02 \frac{J}{K \cdot mol}\right) + 205.14 \frac{J}{K \cdot mol} \\ &\quad - 2 \left(70.20 \frac{J}{K \cdot mol}\right) \\ &= 216.6 \frac{J}{K \cdot mol}\end{aligned}$$

$$\begin{aligned}\Delta H^\circ_r &= 2 \cdot H^\circ_{Hg(\ell)} + H^\circ_{O_2(g)} - 2 \cdot H^\circ_{HgO(s)} \\ &= 0 - 2\,(-90.83\ kJ/mol) \\ &= 181.64\ kJ/mol\end{aligned}$$

$$\begin{aligned}\Delta G^\circ_r &= \Delta H^\circ_r - T\,\Delta S^\circ_r \\ &= 181.64\ kJ/mol - (298\ K) \\ &\quad \times \left(216.6 \frac{J}{K \cdot mol}\right) \left(\frac{1\ kJ}{1000\ J}\right) \\ &= 117.093\ kJ/mol\end{aligned}$$

LDE Gibbs Stability Ranking 002
050 10.0 points

Use the table data

	ΔG°_{rxn} [kg/(mol · K)]
$AgCl(s) \rightarrow Ag(s) + \frac{1}{2} Cl_2(g)$	109.7
$2\,Ag(s) + \frac{1}{2} O_2(g) \rightarrow Ag_2O(s)$	−10.8
$\frac{1}{2} N_2(g) + O_2(g) \rightarrow NO_2(g)$	51.8
$HI(g) \rightarrow \frac{1}{2} H_2(g) + \frac{1}{2} I_2(g)$	−1.3

to pick the thermodynamically most stable species.

1. HI(g)

2. $Ag_2O(s)$

3. $NO_2(g)$

4. AgCl(s) **correct**

Explanation:

Because the decomposition of solid silver chloride is highly non-spontaneous, its formation is highly spontaneous and it is quite stable.