

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

001 2.0 points

How many moles are in 63.0 g of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$?

- 1.00 mol
- 4.00 mol
- 0.500 mol
- 0.250 mol **correct**

Explanation:

$$m = 63.0 \text{ g}$$

Calculate the formula weight of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$:

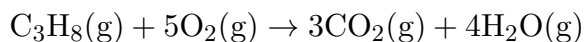
$$2 \left(14 \frac{\text{g N}}{\text{mol}} \right) + 8 \left(1 \frac{\text{g H}}{\text{mol}} \right) + 2 \left(52 \frac{\text{g Cr}}{\text{mol}} \right) + 7 \left(16 \frac{\text{g O}}{\text{mol}} \right) = 252 \text{ g/mol compd}$$

Given 63.0 g of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$, convert to moles by using the formula weight:

$$\begin{aligned} n_{\text{compd}} &= 63.0 \text{ g compd} \\ &\times \frac{1 \text{ mol compd}}{252 \text{ g compd}} \\ &= 0.250 \text{ mol compd} \end{aligned}$$

002 2.0 points

Consider the combustion of propane (C_3H_8) run at constant temperature and pressure:



If 5.00 L propane is reacted with 30.0 L oxygen, what is the final volume of all gases?

- 80.0 L
- 5.00 L
- 30.0 L
- 35.0 L

5. 40.0 L correct

Explanation:

Pentane is the limiting reactant with 5.00 L. You can use the amount of pentane to solve for the total volume of each product and the excess volume of oxygen.

Solve for the volume of carbon dioxide:

$$5.00 \text{ L C}_3\text{H}_8 \times \frac{3 \text{ L CO}_2}{1 \text{ L C}_3\text{H}_8} = 15.0 \text{ L}$$

Solve for the volume of water vapor:

$$5.00 \text{ L C}_3\text{H}_8 \times \frac{4 \text{ L H}_2\text{O}}{1 \text{ L C}_3\text{H}_8} = 20.0 \text{ L}$$

Solve for the volume of excess oxygen:

$$\begin{aligned} 30.0 \text{ L O}_2 - \left(5.00 \text{ L C}_3\text{H}_8 \times \frac{5 \text{ L O}_2}{1 \text{ L C}_3\text{H}_8} \right) \\ = 5.00 \text{ L} \end{aligned}$$

Solve for the total pressure:

$$15.0 + 20.0 + 5.00 = 40.0 \text{ L total}$$

003 2.0 points

A closed tube used to transport methane has a volume of 110 L at 300°C and 965 torr. How many moles of gas are in the tube?

- 2260
- 11300
- 7.78
- 2.97 **correct**
- 22.3
- 3390
- 4520
- 3.89

Explanation:

You can solve directly for moles (n) by rearranging the ideal gas law equation, such that:

$$n = PV/RT$$

$$= (965)(110)/(62.36)(300 + 273.15)$$

$$= 2.97$$

004 2.0 points

A 2.37 gram gas sample has a volume of 4.35 L, a pressure of 0.8 atm, and a temperature of 304 K. Which of the following gases is it?

1. SF₆
2. CO₂
3. O₂
4. Ne
5. NH₃ **correct**
6. SO₂

Explanation:

$$\text{MWt} = \text{mass } (m) / \text{moles } (n)$$

$$n = PV/RT$$

$$\text{MWt} = mRT/PV$$

$$= 2.37(0.08206)(304)/(0.8 \cdot 4.35)$$

$$= 17 \text{ g/mol which is NH}_3$$

005 2.0 points

The rate of effusion for carbon monoxide (CO) is _____ times the rate of effusion for chlorine (Cl₂) gas .

1. 1.59 **correct**
2. 2.53
3. 1.16
4. 1.13
5. 2.17

Explanation:

The rate of effusion can be interchanged with v_{rms} to give a ratio equal to:

$$\frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}}$$

Solving for the ratio of CO : Cl₂ gives

$$\frac{v_1}{v_2} = \sqrt{\frac{70.91}{28.01}} = 1.59$$

006 2.0 points

Based on the hard sphere model of gases, which of the following gases is best modeled by ideal behavior?

1. He **correct**
2. Ar
3. Kr
4. Xe
5. Ne

Explanation:

The hard sphere model adjusts the ideal gas law based on the volume of the particles. Therefore, ideal gas behavior is best modeled when the gas particles are smaller in volume, which correlates with lower molecular weight. Larger gas particles (high molecular weight) are expected to deviate from ideal behavior.

007 2.0 points

The compressibility factor (Z) for a gas at 400 atm is less than one. How can you make an accurate gas law calculation for this gas at 400 atm?

1. This gas can be modeled ideally at this pressure because $PV > nRT$
2. You must correct for attractive forces because $PV > nRT$
3. This gas can be modeled ideally at this pressure because $PV < nRT$
4. You must correct for repulsive forces because $PV < nRT$
5. This gas can be modeled ideally at this pressure because $PV = nRT$
6. You must correct for attractive forces because $PV < nRT$ **correct**

7. You must correct for repulsive forces because $PV > nRT$

Explanation:

The compressibility factor can have three conditions.

If $PV > nRT$, $Z > 1$ and repulsions dominate.

If $PV < nRT$, $Z < 1$ and attractions dominate.

If $PV = nRT$, $Z = 1$ and the gas can be modeled ideally.

008 2.0 points

Consider three closed 10L containers at room temperature. Container 1 contains 0.5 moles neon gas. Container 2 contains 0.5 moles argon gas. Container 3 contains 0.5 moles hydrogen gas. Which of the following properties, if any, are the same between the containers?

- I. Mass density
- II. Number density
- III. Kinetic energy
- IV. Pressure

1. III only
2. I and III only
3. I, II, III and IV
4. None of the above
5. I only
6. II and IV only
7. I and IV only
8. II, III, and IV only **correct**

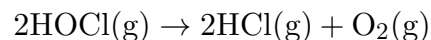
Explanation:

When comparing different ideal gases at the same temperature, pressure, and volume, the only key differences will be the mass density and the average velocity (both of these are

dependent on the molecular weight). The number of moles, number density, and kinetic energy will all be the same between the three containers.

009 2.0 points

Consider the following balanced chemical reaction:



At a certain temperature, 98.2 grams of hypochlorous acid (HOCl) fully decomposes to give a final pressure of 680 torr. What is the partial pressure of oxygen in the final reaction system?

1. 680 torr
2. 1223 torr
3. 1020 torr
4. 340 torr
5. 227 torr **correct**

Explanation:

This question can be easily reduced to a simple partial pressure problem by conceptually understanding that when HOCl reacts completely, it will be create a ratio of 2HCl : 1O₂ no matter what. Therefore, we don't need to solve for the exact quantities.

$$P_{\text{O}_2} = X_{\text{O}_2} P_{\text{tot}}$$

$$227 = (1/3)(680)$$

010 2.0 points

Consider the van der Waals equation for non ideal gases. Which of the following statements is true?

1. A gas with a low molecular weight will have a high a value
2. $(P + \frac{an^2}{V^2})$ represents the measured pressure
3. This equation can only be used to model

ideal gases

4. A large b value correlates with a low molecular weight

5. The b term correlates with the size of particles in a gaseous system **correct**

Explanation:

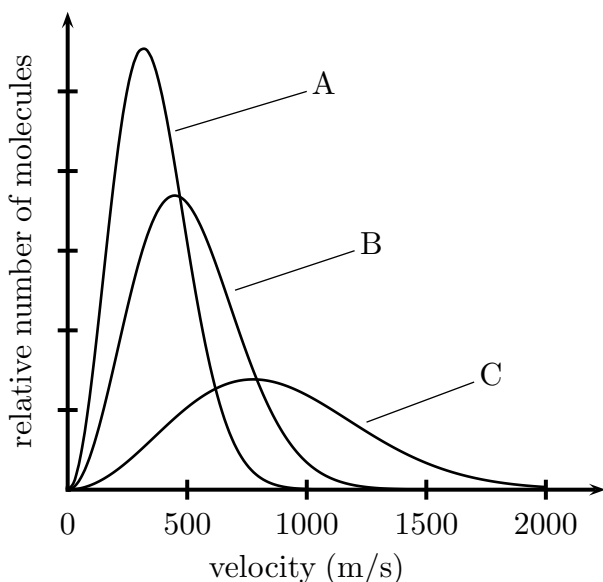
The van der Waals equation for non ideal gases is given below:

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

In this equation, $\left(P + \frac{an^2}{V^2}\right)$ represents the ideal pressure and $(V - nb)$ represents the available volume after making the corrections. The a term corrects for attractions and the b term corrects for the size of the particles (repulsions). Mathematically, the measured pressure is less than the ideal pressure. The available volume is less than the total volume.

011 2.0 points

The graph shows the approximate Maxwell-Boltzmann distribution plots for three different gases at the same temperature.



Which of the following statements is true?

1. The gas with the lowest molecular weight is Gas C **correct**

2. Gas B is heavier than Gas A

3. Gas C has the greatest kinetic energy

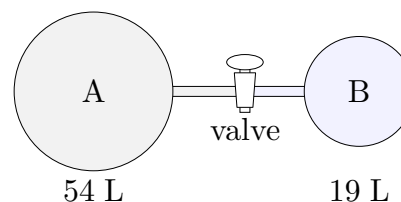
4. The v_{rms} for Gas A is 1500 m/s

Explanation:

The gas with the lowest molecular weight is Gas C

012 2.0 points

Consider the diagram shown below of two glass bulbs connected through a valve. The volume for each gas (A and B) is shown under the bulbs and the gases also happen to be at the same temperature (337K) and pressure (713 torr).



After the valve is opened, the two gases mix completely. What is the partial pressure of gas A in this new (opened valve) state?

1. 713 torr

2. 250.9 torr

3. 185.6 torr

4. 2026 torr

5. 527.4 torr **correct**

Explanation:

When the valve is opened the total available volume for both gases is now 73 liters, but the total pressure remains 420 torr. This means (Boyle's Law) that the gas A pressure will drop by a factor of 54/73.

$$(54/73)(713) = 527.4 \text{ torr for gas A.}$$

013 2.0 points

What is the wavelength of a 4.50×10^{14} Hz light ray?

1. 882 nm

2. 666 nm **correct**

3. 0.288 nm

4. 456 nm

5. 0.882 nm

6. 992 nm

7. 0.441 nm

8. 0.664 nm

Explanation:

Using the relationship between light, wavelength, and frequency:

$$c = \lambda\nu$$

$$\lambda = c/\nu$$

You must calculate for wavelength and convert from meters to nanometers:

$$\begin{aligned} & (2.998 \times 10^8 / 4.50 \times 10^{14}) \times 10^9 \\ & = 666 \text{ nm} \end{aligned}$$

014 2.0 points

A 200 nm beam of light is shined on a gold surface. What is the maximum velocity of the excited electrons? The work function of gold is 5.10 eV.

1. 4.406×10^5 km/s

2. 3.883×10^8 km/s

3. -440.6 km/s

4. 440.6 km/s

5. 408.2 km/s

6. No electrons are emitted

7. 623.2 km/s **correct**

Explanation:

Using the photoelectric equation:

$$E_k = h\nu - \phi$$

The KE of any photoelectron produced is the remainder after the work function has been subtracted from the energy of the photon.

$$E_{\text{photon}} = \frac{(6.626 \times 10^{-34} \text{ Js})(3.00 \times 10^8 \frac{\text{m}}{\text{s}})}{200 \times 10^{-9} \text{ m}}$$

$$E_{\text{photon}} = 9.94 \times 10^{-19} \text{ J}$$

$$\begin{aligned} \text{Work function} &= 5.10 \text{ eV} (1.60 \times 10^{-19} \frac{\text{J}}{\text{eV}}) \\ &= 8.17 \times 10^{-19} \text{ J} \end{aligned}$$

The kinetic energy is the difference between the photon energy and the work function, which is 1.77×10^{-19} J. Finally, the kinetic energy equation gives $E_k = 1/2mv^2$, which can be used to solve for the velocity in m/s. Answering in km/s gives us 623.2 km/s.

015 2.0 points

When a cold gas absorbs white light, you see a continuous absorption spectrum broken by thin black lines in the blue and purple region. Which of the following best describes the emission spectrum of this gas when it is excited with electricity?

1. A continuous spectrum broken by black lines shifted to slightly longer wavelengths

2. Mostly black with thin lines in the blue and purple region **correct**

3. Mostly black with thin lines in the yellow and orange region

4. A continuous spectrum broken by black lines in the yellow and orange region

Explanation:

The emission spectrum will be opposite of the absorption spectrum. Therefore, you will see a mostly black spectrum with thin lines in the blue and purple region. Both spectra depict the discrete energy levels of electrons, so

you will not see patterns at other wavelengths (such as yellow or orange).

016 2.0 points

An excited hydrogen electron emits a photon in the Balmer series when it falls from $n = 5$. What is the energy of the photon emitted?

1. 4.58×10^{-19} J correct
2. 2.3×10^6 J
3. 4.58×10^{-17} J
4. -2.3×10^{-17} J
5. -4.58×10^{-17} J
6. 2.3×10^{-17} J

Explanation:

$$\Delta E = R \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$$

$$\Delta E = (2.18 \times 10^{-18} \text{ J}) \left(\frac{1}{2^2} - \frac{1}{5^2} \right)$$

$$\Delta E = 4.58 \times 10^{-19} \text{ J}$$

017 2.0 points

Which set of quantum numbers is possible for an electron in the s subshell found in the ground state of Se?

1. $n = 3, \ell = 2, m_\ell = +2, m_s = +\frac{1}{2}$
2. $n = 4, \ell = 4, m_\ell = +2, m_s = +\frac{1}{2}$
3. $n = 4, \ell = 2, m_\ell = +1, m_s = -\frac{1}{2}$
4. $n = 4, \ell = 1, m_\ell = +1, m_s = -\frac{1}{2}$
5. $n = 4, \ell = 0, m_\ell = 0, m_s = +\frac{1}{2}$ correct
6. $n = 1, \ell = 1, m_\ell = +2, m_s = -\frac{1}{2}$

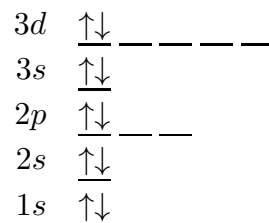
Explanation:

The subshell of an electron indicates the angular momentum quantum number, ℓ . The s subshell has an ℓ number equal to 0. The

value of n for Se can be any integer up to 4 for the s and p orbitals, and up to 3 for the d orbitals. The value of m_ℓ is -0 to $+0$. Lastly, m_s can be $+\frac{1}{2}$ or $-\frac{1}{2}$. Only one answer choices matches these rules for the s subshell of Se.

018 2.0 points

A fellow student completes an electron filling diagram for a ground state atom as shown below:



Understanding that your fellow student's electron filling diagram is not necessarily correct (i.e., the electrons have not necessarily been placed in the correct orbitals), what is the electron configuration for this atom?

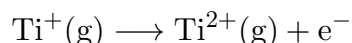
1. $1s^1 2s^1 2p^3 3s^1 3d^4$
2. $1s^2 2s^2 2p^3 3s^2 3d^1$
3. $1s^2 2s^2 2p^6 3s^2$
4. $1s^2 2s^2 2p^2 3s^2 3d^2$
5. $1s^2 2s^2 2p^6$ correct

Explanation:

The electron filling diagram is not properly filling the electrons in accordance with The Aufbau Principle and Hund's Rule. Properly filling the diagram gives you the electron configuration for neon, which is $1s^2 2s^2 2p^6$.

019 2.0 points

The second ionization energy of Ti is given by the reaction:



This electron is removed from the:

1. 4d subshell
2. 4p subshell
3. 3d subshell
4. 3p subshell
5. 3s subshell
6. 4s subshell **correct**

Explanation:

When removing electrons from transition metals, you must acknowledge that the filled d orbitals are lower in energy than the filled s orbitals. Therefore, the electrons removed will be the higher energy s subshell electrons.

020 2.0 points

Rank the following ionic compounds from least to greatest lattice energy:



1. $\text{KCl} < \text{K}_2\text{O} < \text{MgO} < \text{CaCO}_3$
2. $\text{CaCO}_3 < \text{K}_2\text{O} < \text{MgO} < \text{KCl}$
3. $\text{KCl} < \text{K}_2\text{O} < \text{CaCO}_3 < \text{MgO}$ **correct**
4. $\text{CaCO}_3 < \text{K}_2\text{O} < \text{KCl} < \text{MgO}$
5. $\text{MgO} < \text{KCl} < \text{K}_2\text{O} < \text{CaCO}_3$

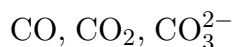
Explanation:

Lattice energy depends on charge and ionic radius. Rank first based on a charge so that the largest charges have the highest lattice energy. The smallest lattice energy in the list is KCl and the highest lattice energy is MgO. If two compounds have the same charges, the highest lattice energy will be the smaller ionic compound. This gives a final answer of:



021 2.0 points

Consider the following molecules:



Which molecule has the strongest covalent bonds?

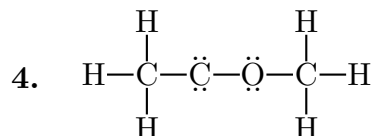
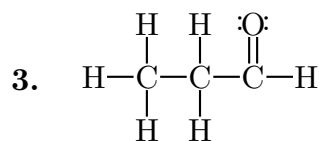
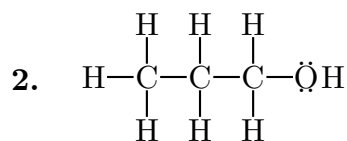
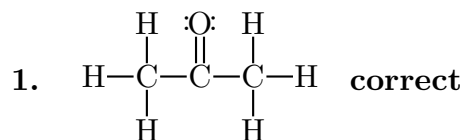
1. Both CO_3^{2-} and CO_2 have the strongest bonds
2. CO_2
3. All carbon-oxygen bonds have the same strength bonds
4. **CO correct**
5. CO_3^{2-}

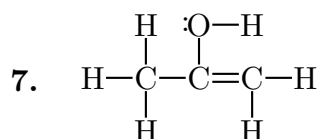
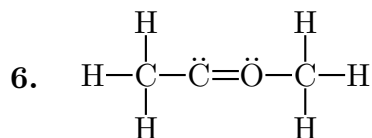
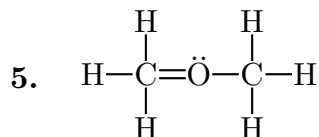
Explanation:

Carbon monoxide contains a triple bond between carbon and oxygen. Carbon dioxide contains a double bond between the carbon and oxygen atoms. Carbonate is a resonance structure that contains a double bond and two single bonds. Averaged, this results in approximate 1.33 bonds between the carbon and oxygen atoms. Therefore, carbon monoxide has the strongest and shortest bonds. Carbonate has the weakest and longest bonds.

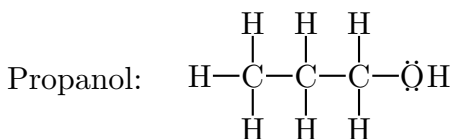
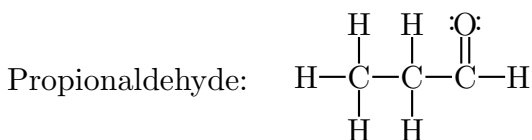
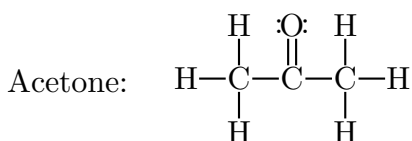
022 2.0 points

Which of the following choices is the correct line structure for acetone, CH_3COCH_3 ?





Explanation:



023 2.0 points

In an acceptable Lewis structure for NO_2^- , what is the formal charge on the central atom?

1. -2
2. +2
3. -1
4. +1
5. None of the above
6. 0 correct

Explanation:

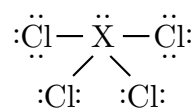
Formal charge can be expressed with the following basic formula:

$$\text{F.C.} = \text{V.E.} - (\text{Bonds} + \text{L.E.})$$

The nitrogen has one lone pair and is connected to three bonds total, resulting in a formal charge of 0.

024 2.0 points

Consider the following molecule:



What is the identify of the central atom, X?

1. Nitrogen
2. Carbon
3. Oxygen
4. Chlorine
5. Phosphorus
6. Selenium correct

Explanation:

The molecule shown has a central atom with a formal charge equal to 0. You can solve for the valence using the formula:

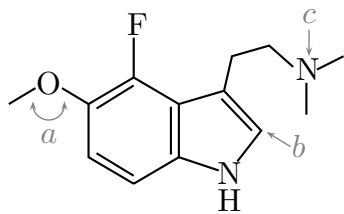
$$\text{F.C.} = \text{V.E.} - (\text{Bonds} + \text{L.E.})$$

$$0 = \text{V.E.} - 6$$

Therefore, your central atom must be in group 6. It is also exhibiting expanded valence, meaning it must be at least a 3rd period element. X = Selenium.

025 (part 1 of 3) 2.0 points

The molecule shown below is a rare alkaloid found in plants native to South America with profound cultural significance.



What is the correct empirical formula for this compound?

1. $C_{13}H_{12}FN_2O$
2. $C_{15}H_{17}FN_2O$
3. $C_{13}H_{17}FN_2O$ **correct**
4. $C_{13}H_{19}FN_2O$
5. $C_{13}H_{19}N_2O$
6. $C_{12}H_{15}FN_2O$

Explanation:

The empirical formula is $C_{13}H_{17}FN_2O$.

026 (part 2 of 3) 2.0 points

Which of the following best represents the bond angle labeled *a*?

1. 178°
2. 118°
3. 109.5°
4. 120°
5. 180°
6. 90°
7. 104.5° **correct**

Explanation:

There are two (not shown) lone pairs on the O there which means there are 4 electron regions and therefore a tetrahedral electronic geometry which has a bond angle of 109.5° . The lone pairs are more repulsive than the bonding pairs and therefore pushes the angles

down to about 104.5° .

027 (part 3 of 3) 2.0 points

What is the electronic geometry around the central atom labeled *b*?

1. Tetrahedral
2. Trigonal planar **correct**
3. Bent
4. Trigonal pyramid
5. Seesaw

Explanation:

In the line drawing, *b* has an understood hydrogen atom attached, giving the carbon a trigonal planar structure. The nitrogen labeled *c* has an understood lone pair, which gives it a tetrahedral electronic geometry.

028 2.0 points

VSEPR theory can estimate imperfect bond angles based on the fact that

1. bonding regions attract each other while lone pair regions repel each other
2. molecular orbitals hybridize
3. bonding regions are more repulsive than lone pair regions
4. lone pair regions are more repulsive than bonding regions **correct**

Explanation:

Lone pair regions on the central atom are pulled closer toward the nucleus. Therefore, the repulsive forces are stronger than in a bonding region. This causes bond angles to be slightly less than predicted by the electronic geometry. Molecular orbitals do hybridize, but this is not an explanation for why a molecule will form imperfect bond angles.

029 2.0 points

Which of the following molecules is non-

polar?

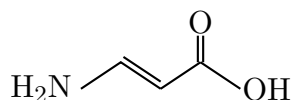
1. BeCl_2 **correct**
2. H_2O
3. PCl_3
4. HBr
5. NH_3

Explanation:

BeCl_2 has polar bonds, but they are canceled out by its symmetric molecular and electronic structure.

030 (part 1 of 2) 2.0 points

Use the following structure to answer the next two questions:



How many sigma and pi bonds are in the organic structure above?

1. 12 σ only
2. 10 σ and 2 π **correct**
3. 8 σ and 2 π
4. 12 σ and 2 π
5. 10 σ and 4 π

Explanation:

Accounting for the "understood" hydrogen atoms, there are a total of 8 single bonds and 2 double bonds. This is a total of 10 σ and 2 π .

031 (part 2 of 2) 2.0 points

For the structure shown above, what is the hybridization around the nitrogen?

1. sp^2

2. sp

3. sp^3 **correct**

4. sp^3d

5. sp^3d^2

Explanation:

The nitrogen has four regions of electron density, corresponding to a sp^3 hybridization.

032 2.0 points

Consider the MO diagram for F_2^+ . What is the bond order? Is F_2^+ paramagnetic or diamagnetic?

1. 1, diamagnetic
2. 2, diamagnetic
3. 2, paramagnetic
4. 1.5, diamagnetic
5. 1.5, paramagnetic **correct**
6. 2.5, diamagnetic
7. 2.5, paramagnetic

Explanation:

F_2^+ has 8 bonding electrons and 5 antibonding electrons.

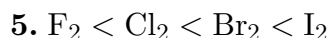
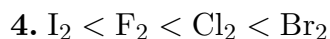
$$\begin{aligned} \text{BO} &= \frac{1}{2}[(\text{bonding } e^-) - (\text{antibonding } e^-)] \\ &= \frac{1}{2}(8 - 5) = 1.5 \end{aligned}$$

F_2^+ has unpaired electrons and is therefore paramagnetic.

033 2.0 points

Rank the following substances in order of vapor pressure: Cl_2 , I_2 , Br_2 , F_2

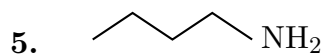
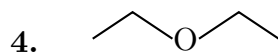
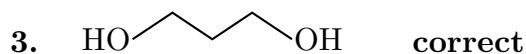
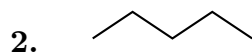
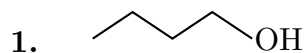
1. $\text{Br}_2 < \text{Cl}_2 < \text{I}_2 < \text{F}_2$
2. $\text{I}_2 < \text{Br}_2 < \text{Cl}_2 < \text{F}_2$ **correct**
3. $\text{F}_2 < \text{Cl}_2 < \text{I}_2 < \text{Br}_2$

**Explanation:**

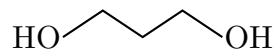
When determining the relative IMFs within a group, you should rank based on polarizability (molecular weight). Therefore, the ranking is: $F_2 < Cl_2 < Br_2 < I_2$. Vapor pressure goes opposite of IMF strength, giving the answer: $I_2 < Br_2 < Cl_2 < F_2$.

034 2.0 points

Which of the following has the lowest vapor pressure?

**Explanation:**

The molecule that has the lowest vapor pressure will have the strongest IMF's. Of the molecules shown, the molecule with the strongest IMF's will exhibit the most hydrogen bonding.



035 2.0 points

Which of the following can form hydrogen bonds with another molecule of itself?

- I. Ammonia
- II. Ethanol
- III. CH_3OCH_3
- IV. H_2CO

1. I, II only **correct**

2. I only

3. I, II, III, IV

4. I, III, IV only

Explanation:

The only molecules listed capable of making a hydrogen bond are ammonia and ethanol.

036 2.0 points

Select the option that correctly lists the substances in order of INCREASING boiling points.

1. $O_2, C_2H_6, C_3H_8, NH_3, H_2O, NaCl, CaO$ **correct**2. $O_2, C_3H_8, C_2H_6, NH_3, H_2O, NaCl, CaO$

3. None of these places the substances in correct order of increasing boiling points

4. $O_2, NH_3, C_2H_6, C_3H_8, H_2O, CaO, NaCl$ 5. $O_2, NH_3, C_3H_8, C_2H_6, NaCl, CaO, H_2O$ **Explanation:**

Consider the following IMF's in increasing order: dispersion forces, dipole-dipole, hydrogen-bonding, ionic. Therefore, the boiling points of the substances listed will follow this same trend: $O_2, C_2H_6, C_3H_8, NH_3, H_2O, NaCl, CaO$

037 2.0 points

Name the bond in oxygen (O_2) that forms as a result of head-on overlap on the internuclear axis.

1. σ_{2p-2p}
2. $\pi_{sp^2-sp^2}$
3. σ_{sp-sp^2}
4. π_{2p-2p}
5. σ_{sp-sp}
6. $\sigma_{sp^2-sp^2}$ **correct**
7. $\pi_{sp^3-sp^3}$
8. σ_{sp^2-2p}

Explanation:

A sigma bond forms from head-on overlap. For oxygen, this is $\sigma_{sp^2-sp^2}$. For nitrogen, this is σ_{sp-sp} . For carbon dioxide, this is σ_{sp-sp^2} .

038 2.0 points

Arrange the following substances in order from highest to lowest melting point:

C(s, diamond), NH_3 , LiF, $CaSO_4$

1. C(s, diamond) > $CaSO_4$ > NH_3 > LiF
2. C(s, diamond) > $CaSO_4$ > LiF > NH_3 **correct**
3. NH_3 > LiF > $CaSO_4$ > C(s, diamond)
4. C(s, diamond) > LiF > $CaSO_4$ > NH_3
5. NH_3 > $CaSO_4$ > LiF > C(s, diamond)

Explanation:

C(s, diamond) is a network covalent solid. Both $CaSO_4$ and LiF are ionic solids, but $CaSO_4$ has a greater charge density. NH_3 is a molecular solid. Thus, arranging the compounds in order from highest to lowest melting point, we get:

C(s, diamond) > $CaSO_4$ > LiF > NH_3 .

039 2.0 points

Which of the following terms is path-dependent?

1. Work **correct**
2. Heat Capacity
3. Free Energy
4. Enthalpy
5. All of the above

Explanation:

The only path function of the choices is Work.

040 2.0 points

A chemical reaction releases 86.9 kJ heat while 16.7 kJ work is done on the system via compression. What is the change in the internal energy (ΔU) for the system?

1. 104 kJ
2. -70.2 kJ **correct**
3. -109 kJ
4. -75.2 kJ
5. -53.5 kJ
6. -104 kJ

Explanation:

$$\Delta U_{\text{sys}} = q + w$$

$$-70.2\text{kJ} = (-86.9\text{kJ}) + (16.7\text{kJ})$$

041 2.0 points

When an endothermic reaction has a positive internal energy change for the system,

- I. the internal energy change of the system is equal to the heat plus the work

- II. $\Delta H_{\text{rxn}} > 0$
- III. there is an overall energy change in the universe
- IV. heat enters the system from the surroundings
- I only
 - I and IV only
 - I, II, III and IV
 - I, II, and IV only **correct**
 - I and II only
 - II only
 - III and IV only

Explanation:

The first law of thermodynamics can be summed up with the idea that energy is always conserved in the universe. Mathematically, this means that:

$$\Delta U_{\text{sys}} = -\Delta U_{\text{surr}}$$

$$\Delta U_{\text{universe}} = \Delta U_{\text{sys}} + \Delta U_{\text{surr}}$$

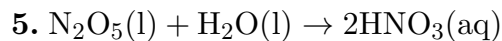
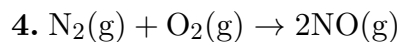
$$\Delta U_{\text{universe}} = 0$$

Internal energy is defined as the total energy content of a system. This can be represented as the sum of heat and work or as the sum of potential and kinetic energy. For an endothermic reaction, the heat flows from the surroundings to the system.

042 2.0 points

For which of the following reactions is $\Delta U_{\text{sys}} < \Delta H_{\text{sys}}$ at constant external pressure?

- $2\text{NH}_3(\text{g}) \rightarrow 3\text{H}_2(\text{g}) + \text{N}_2(\text{g})$ **correct**
- $\text{C}_2\text{H}_4(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
- $\text{SnO}_2(\text{g}) + \text{C}(\text{s}) \rightarrow \text{Sn}(\text{s}) + \text{CO}_2(\text{g})$

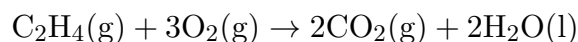
**Explanation:**

Based on the first law equation:

$$\Delta U = \Delta H - \Delta nRT,$$

it can be seen that this question is essentially asking to either identify the compression reaction ($\Delta U_{\text{sys}} > \Delta H_{\text{sys}}$) or the expansion reaction ($\Delta U_{\text{sys}} < \Delta H_{\text{sys}}$).

The compression reaction:



The expansion reaction:



043 2.0 points

A 21 mL sample of liquid water at 39°C is frozen and cooled to a final temperature of -18°C. Calculate the heat of this process.

- 11230 J **correct**
- 10440 J
- 7804 J
- 534.8 J
- 11230 J

Explanation:

You will need to make three different calculations for this problem:

- 1) Cool liquid water from 39°C to 0°C:

$$q = mC\Delta T = (21 \text{ g})(4.184 \frac{\text{J}}{\text{g}^\circ\text{C}})[0^\circ\text{C} - (39^\circ\text{C})] = -3427 \text{ J}$$

- 2) Freeze the ice at constant temperature:

$$q = (m)(-\Delta H_{\text{fus}}) = (21 \text{ g})(334 \frac{\text{J}}{\text{g}}) = -7014 \text{ J}$$

3) Cool the ice from 0°C to -18°C :

$$q = mC\Delta T = (21\text{ g})(2.09\frac{\text{J}}{\text{g}^{\circ}\text{C}})[-18^{\circ}\text{C} - 0^{\circ}\text{C}] \\ = -790.0\text{ J}$$

Total heat required:

$$(-3427\text{ J}) + (-7014\text{ J}) + (-790.0\text{ J}) = -11230\text{ J}$$

044 2.0 points

When a 0.401 g sample of a clean-burning hydrocarbon (molecular weight = 42.05 g/mol) is combusted in a rigid container, the temperature increases from 24.987°C to 28.623°C . The total volume of water is 0.746 L. The sum of all hardware components of the calorimeter have a heat capacity of $2.24\text{ kJ}/^{\circ}\text{C}$. Calculate the internal energy of combustion for one mole of this hydrocarbon.

1. -19.4936 kJ/mol
2. +8150.74 kJ/mol
3. +48.6124 kJ/mol
4. -2044.15 kJ/mol **correct**
5. +2044.15 kJ/mol
6. -3.26600 kJ/mol
7. +19.4936 kJ/mol
8. +3.26600 kJ/mol

Explanation:

Heat released by the combustion reaction:

$$q = mC\Delta T + C\Delta T$$

$$q_{\text{cal}} = (746)(4.184)(3.636) + (2.24 \times 1000)(3.636)$$

$$q_{\text{cal}} = 19493.6\text{ J}$$

For the system, $q_v = -q_{\text{cal}}$:

$$q_v = -19.4936\text{ kJ}$$

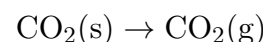
This is how much heat was released when 0.401 g of hydrocarbon was combusted (we

consider it to be negative). Convert to this to how much heat would be released per mole of ethylene combusted.

$$\frac{-19.4936\text{ kJ}}{0.401\text{ g}} \times \frac{42.05\text{ g}}{1\text{ mol}} = -2044.15\text{ kJ/mol}$$

045 2.0 points

Carbon dioxide is a unique substance that sublimates at atmospheric pressure. Assuming no excess heat is supplied to the system at constant pressure, what are the signs of ΔH , ΔS , and w for the following phase change reaction at -78.5°C ?



1. $\Delta H > 0, \Delta S > 0, w > 0$
2. $\Delta H > 0, \Delta S > 0, w = 0$
3. $\Delta H > 0, \Delta S > 0, w < 0$ **correct**
4. $\Delta H > 0, \Delta S < 0, w < 0$
5. $\Delta H < 0, \Delta S < 0, w = 0$

Explanation:

The phase change from (s) to (g) requires energy, which is a positive change in enthalpy. Creating a gas from a solid is a positive change in entropy and a negative change in work (work is done on the system via compression).

046 2.0 points

For which of the following chemical equations would $\Delta H_{\text{rxn}}^{\circ} = \Delta H_{\text{f}}^{\circ}$?

1. $\frac{1}{2}\text{N}_2(\text{g}) + \frac{3}{2}\text{H}_2(\text{g}) \rightarrow \text{NH}_3(\text{g})$ **correct**
2. $\text{CH}_4(\text{g}) + 2\text{Cl}_2(\text{g}) \rightarrow \text{CCl}_4(\ell) + 2\text{H}_2(\text{g})$
3. $\text{N}_2(\ell) + 3\text{Cl}_2(\text{g}) \rightarrow 2\text{NCl}_3(\ell)$
4. $2\text{C}(\text{s, graphite}) + \text{O}_2(\ell) \rightarrow 2\text{CO}(\text{g})$
5. $\text{CH}_4(\text{g}) \rightarrow \text{C}(\text{s, graphite}) + 2\text{H}_2(\text{g})$

Explanation:

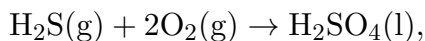
If $\Delta H_{\text{rxn}}^{\circ} = \Delta H_{\text{f}}^{\circ}$, the reaction written must be a formation reaction. A formation reaction is a single mole of products formed from its constituent elements in their standard states.

047 2.0 points

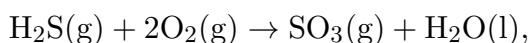
Consider the following balanced chemical reaction:



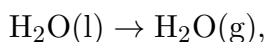
To solve for the $\Delta H_{\text{rxn}}^{\circ}$ for this reaction, you collect the following data in the lab:



$$\Delta H_{\text{rxn}}^{\circ} = -232.3 \text{ kJ/mol}$$



$$\Delta H_{\text{rxn}}^{\circ} = -201.1 \text{ kJ/mol}$$



$$\Delta H_{\text{rxn}}^{\circ} = 51.9 \text{ kJ/mol}$$

What is the $\Delta H_{\text{rxn}}^{\circ}$ of the overall balanced reaction?

1. 485 kJ/mol
2. -614 kJ/mol
3. 315 kJ/mol
4. -382 kJ/mol
5. 83.1 kJ/mol **correct**

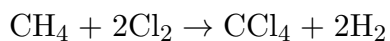
Explanation:

The objective is to arrange the three reactions so that the sum of the reactions gives you the overall balanced chemical reaction. This is accomplished simply by reversing the first reaction and flipping the sign of that enthalpy of reaction. From there:

$$\Delta H_{\text{rxn}}^{\circ} = -(-232.3) + (-201.1) + (51.9) = 83.1 \text{ kJ/mol}$$

048 2.0 points

Use bond energy data to determine ΔH_{rxn} for the following reaction:



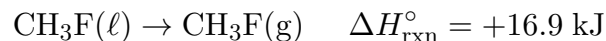
1. -45 kJ/mol
2. 45 kJ/mol
3. -90 kJ/mol **correct**
4. 90 kJ/mol
5. -180 kJ/mol

Explanation:

Drawing a Lewis Structure for each product and reactant will show the number of each type of bond in the reaction. Subtracting the enthalpy of bonds on the reactant side (bonds broken) by the enthalpy of bonds on the products side (bonds formed) gives -90 kJ/mol.

049 2.0 points

Calculate the ΔS_{surr} for the following reaction at 9.0°C and 1 atm.



1. 1.88 J/K
2. -939 J/K
3. 59.9 J/K
4. -59.9 J/K **correct**
5. 1880 J/K
6. -1.88 J/K

Explanation:

In general for any process:

$$\Delta S_{\text{surr}} = \frac{-\Delta H_{\text{sys}}}{T_{\text{surr}}}$$

This is because the heat flow in the surroundings is just the opposite of the heat flow for the system ($q_{\text{surr}} = -q_{\text{sys}}$) and at constant pressure the heat is equal to ΔH .

$$\begin{aligned} \text{therefore } \Delta S_{\text{surr}} &= -16900 / (9.0 + 273.15) \\ &= -59.9 \text{ J/K} \end{aligned}$$

050 2.0 points

Consider a reaction that has a negative change in entropy and a positive change in enthalpy. Which of the following conditions will favor spontaneity?

1. This reaction is spontaneous at all temperatures
2. Low Temperatures
3. High Temperatures
4. This reaction is non-spontaneous at all temperatures **correct**

Explanation:

For this reaction, both the entropy and enthalpy terms are unfavorable. This reaction will never be spontaneous