

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

Brodbelt 2008 photon1

001 10.0 points

Compared to a 280 nm photon, a 320 nm photon has:

1. longer wavelength, lower frequency, lower energy **correct**
2. longer wavelength, lower frequency, higher energy
3. shorter wavelength, lower frequency, higher energy
4. shorter wavelength, lower frequency, lower energy
5. longer wavelength, higher frequency, higher energy
6. shorter wavelength, higher frequency, lower energy

Explanation:

Work function 01

002 10.0 points

We conduct an experiment by shining 500 nm light on potassium metal. This causes electrons to be emitted from the surface via the photoelectric effect. Now we change our source light to 450 nm at the same intensity level. Which of the following is the result from the 450 nm light source compared to the 500 nm source?

1. No electrons would be emitted from the surface.
2. The same number of electrons would be emitted, but they would have a higher velocity **correct**
3. The same number of electrons would be emitted, but they would have a lower velocity

4. Fewer electrons would be emitted from the surface.

5. More electrons would be emitted from the surface.

Explanation:

500 nm light has more energy than the work function of potassium due to the fact that electrons were emitted. Therefore 450 nm light, which is higher in energy than the 500 nm light, will also emit electrons. The number of electrons emitted must be the same because the intensities (photons/s) are the same. However, the higher energy photons from the 450 nm light would yield electrons with a higher kinetic energy and therefore a higher velocity.

$$\frac{1}{2}mv^2 = h\nu - \Phi$$

ChemPrin3e T01 29

003 10.0 points

What is the shortest-wavelength line in the emission spectrum of the hydrogen atom?

1. 91.2 nm **correct**
2. 122 nm
3. 182 nm
4. 100 nm
5. 1.00 nm

Explanation:

The Rydberg formula gives the frequencies of the emission lines in the hydrogen atom:

$$\nu = R \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right).$$

The wavelengths would be given by

$$\lambda = \frac{c}{\nu} = \frac{c}{R \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)}$$

The smallest value of λ would have the largest value of ν and the largest value of $\frac{1}{n_1^2} - \frac{1}{n_2^2}$. This will happen when $n_1 = 1$ and $n_2 = \infty$, giving

$$\begin{aligned}\lambda &= \frac{3 \times 10^8 \text{ m/s}}{(3.29 \times 10^{15} \text{ Hz}) \left(1 - \frac{1}{\infty^2}\right)} \\ &= \frac{3 \times 10^8 \text{ m/s}}{(3.29 \times 10^{15} \text{ Hz})} (1) \\ &= 9.11854 \times 10^{-8} \text{ m}\end{aligned}$$

because $\frac{1}{\infty^2} = \frac{1}{\infty} = 0$.

JB Particle Box 07

004 10.0 points

An electron is in the first quantum level in a box of length L . If the box is stretched so that the length doubles, what happens to the resulting energy of the electron? How would this influence the wavelength of a photon needed to excite the electron to the second energy level?

1. energy of electron is increased by a factor of four; wavelength of photon is decreased by a factor of four.

2. energy of electron is increased by a factor of four; wavelength of photon is increased by a factor of four.

3. energy of electron is decreased by a factor of two; wavelength of photon is decreased by a factor of two.

4. energy of electron is decreased by a factor of four; wavelength of photon is increased by a factor of four. **correct**

5. energy of electron is decreased by a factor of four; wavelength of photon is decreased by a factor of four .

Explanation:

The energy of the electron in particle in a box is defined as: $E = \frac{n^2 \cdot h^2}{8 \cdot m \cdot L^2}$, where L

is the length of the box. Consequently, E is proportional to $\frac{1}{L^2}$, and the energy of the electron will decrease by a factor of 4 when the length is doubled. The energetic difference between $n = 1$ and $n = 2$ should also decrease by a factor of 4. A photon of 4 times the original wavelength would be needed, as energy and wavelength are inversely proportional.

LDE Uncertainty Principle Theory 001
005 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 $\hbar/2$
- 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. II only

2. II and III

3. I and III

4. I only

5. III only **correct**

6. I and II

Explanation:

I is false because Δp may be less than $\hbar/2$ 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.

ChemPrin3e T01 13
006 10.0 points

Calculate the velocity of an oxygen molecule if it has a de Broglie wavelength of 0.0140 nm.

1. 8.9 m/s
2. 3×10^8 m/s
3. 445 m/s
4. 1780 m/s
5. 891 m/s **correct**

Explanation:

$$\lambda = 0.0140 \text{ nm} = 1.4 \times 10^{-11} \text{ m}$$

$$\begin{aligned} m &= \frac{32 \text{ g/mol}}{6.022 \times 10^{23}} \\ &= 5.31385 \times 10^{-23} \text{ g} \\ &= 5.31385 \times 10^{-26} \text{ kg} \end{aligned}$$

$$\begin{aligned} \lambda &= \frac{h}{m v} \\ v &= \frac{h}{m \lambda} \\ &= \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{5.31385 \times 10^{-26} \text{ kg}} \\ &\quad \times \frac{1}{1.4 \times 10^{-11} \text{ m}} \\ &= 890.665 \text{ m/s} \end{aligned}$$

LDE Count Potential Energy Terms 001
007 10.0 points

How many $V(r)$ terms are found in the solution to the Schrödinger equation for a Li^+ ion?

1. 4 $V(r)$ terms
2. 6 $V(r)$ terms
3. 5 $V(r)$ terms
4. 2 $V(r)$ terms
5. 1 $V(r)$ terms

6. 3 $V(r)$ terms correct

Explanation:

Each of the two electrons has an attractive potential energy term with the nucleus. And they mutually repel each other in a final potential energy term.

LDE quantum rules 006

008 10.0 points

Consider a filled $n = 3$ shell. For a given configuration within that shell, how many electrons will be assigned $m_\ell = 1$?

1. 18
2. 8
3. 16
4. 6
5. 4 **correct**

Explanation:

The quantum number $n = 3$ describes an s , p and d subshell ($\ell = 0, 1$ and 2). However, because $m_\ell = 1$, the s subshell is disallowed (ℓ must be ≥ 1 for $m_\ell = 1$), leaving only the p and d subshells. Within each of those subshells, each m_ℓ can be assigned to 2 electrons, giving a total of 4 electrons with $m_\ell = 1$.

Brodgelt 520054
009 10.0 points

How many electrons can possess this set of quantum numbers: principal quantum number $n = 4$, magnetic quantum number $m_\ell = 0$?

1. 4
2. 6
3. 18
4. 0
5. 2

6. 8 correct

7. 16

8. 14

9. 12

10. 10

Explanation:

$m_\ell = 0$ represents one orientation of each orbital with the principal quantum number 4. At the principle level 4, there exists the $4s$, $4p$, $4d$, and $4f$ orbitals. Each orbital will have one orientation with $m_\ell = 0$. Two electrons can exist in each of these orbitals, thus there can be a total of 8 electrons (4 orbitals with 2 electrons per orbital). Note that $4p$, $4d$, and $4f$ also have there orientations where m_ℓ is +1 and -1 for p , +2, +1, -1 and -2 for d , and +3, +2, +1, -1, -2, and -3 for f .

ChemPrin3e 01 62**010** 10.0 points

Which of the following *valence-shell configurations*

- | | | |
|---------------------------|----------------------|--------------|
| | $4s$ | $4p$ |
| I) $\uparrow\downarrow$ | \uparrow | \downarrow |
| II) \uparrow | \uparrow | \uparrow |
| III) $\uparrow\downarrow$ | \uparrow | \uparrow |
| IV) $\uparrow\downarrow$ | $\uparrow\downarrow$ | \uparrow |

is/are possible for a neutral atom for an element?

1. III only **correct**
2. None of the configurations
3. IV only
4. I only
5. More than one of the configurations
6. II only

Explanation:

The atom with a $4s^2 4p^2$ valence-shell configuration is germanium (Ge). The ground-state configuration is given by



The other configurations represent excited states.

Msci 05 1675**011** 10.0 points

Which response includes only species that have the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6$, and no other species?

1. Cl^- , Na^+
2. Cl^- , K^+ , Ar, Mg^{2+}
3. Na^+ , Ar, P^{3-}
4. Na^+ , K^+ , Ar
5. Cl^- , K^+ , Ar, P^{3-} **correct**

Explanation:**Brodbelt 05 07****012** 10.0 points

A comparison of the electron configurations of cobalt (Co) and chromium (Cr) indicates that

1. Cr has 2 fewer d electrons and the same number of s electrons as Co.
2. Cr has 3 fewer d electrons and the same number of s electrons as Co.
3. Cr has 3 fewer d electrons and one more s electron than Co.
4. Cr has 3 fewer d electrons and one less s electron than Co.
5. Cr has 2 fewer d electrons and one less s electron than Co. **correct**

Explanation:

Cr is an exception. It is more stable when it has a half filled d -orbital. One of its $4s$

electrons is elevated into the $3d$ orbital, giving it one $4s$ electron and five $3d$ electrons.

ChemPrin3e T01 48

013 10.0 points

Write the ground-state electron configuration of In^+ .

1. $[\text{Kr}] 4d^8 5s^1 5p^3$
2. $[\text{Kr}] 4d^5 5s^1 5p^6$
3. $[\text{Kr}] 4d^{10} 5s^2$ **correct**
4. $[\text{Kr}] 4d^{10} 5s^1 5p^1$
5. $[\text{Kr}] 4d^7 5s^2 5p^3$

Explanation:

Write the electron configuration for the atom and then adjust for the charge of the ion. The Aufbau order of electron filling is $1s$, $2s$, $2p$, $3s$, $3p$, $4s$, $3d$, $4p$, $5s$, $4d$, $5p$, $6s$, $4f$, $5d$, $6p$, etc.

s orbitals can hold 2 electrons, p orbitals 6 electrons, and d orbitals 10 electrons. Note some exceptions do occur in the electron configuration of atoms because of the stability of either a full or half-full outermost d -orbital, so you may need to account for this by ‘shuffling’ an electron from the $(n - 1)$ s orbital. When electrons are removed from orbitals in a neutral atom to create a positive ion they are taken in this order: outermost (highest value of n) p , outermost s , then outermost d . Finally use noble gas shorthand to get the answer: $[\text{Kr}] 4d^{10} 5s^2$.

LDE Periodic Table 004

014 10.0 points

Fill in the blanks: chlorine is one of the most well-known elements in the halogen _____. It belongs to _____17 which makes it a _____ element. Its valence electrons belong to the $n = 3$ _____, and it has a nearly-filled $3p$ _____, making it very reactive. Cl^- is a very stable anion because it is isoelectronic to a _____.

1. family, group, main group, shell, subshell, noble gas **correct**

2. group, column, non-metal, shell, orbital, metal

3. family, column, common, row, shell, anion

4. series, family, reactive, row, subshell, noble gas

5. row, group, main group, shell, orbital, noble gas

Explanation:

Family refers to the common name of a group or groups of similar elements, e.g. rare earth, coinage metal, halogen. The number (1-18) of the column of an element is the group. All elements in rows 3-12 are called d-block elements, while the rest of the rows are called main group elements. Chlorine is on row 3, but the principal quantum number n always refers to an electron shell. The $3p$ orbitals of Cl form a subshell of the $n = 3$ shell, along with the $3s$ orbital. Cl^- is isoelectronic to group 18 which are called the noble gases.

Msci 07 1206

015 10.0 points

When dealing with electrons in atoms and molecules, the electrons that are not considered as valence electrons (can, cannot) effectively shield the nucleus and thereby (decrease, increase) the effective nuclear charge.

1. can; decrease **correct**

2. The non-valence electrons do nothing.

3. cannot; decrease

4. can; increase

5. cannot; increase

Explanation:

Msci 06 0509**016** 10.0 points

Which pair of atoms (ions) is listed in order of INCREASING radii?

1. Mg^{2+} , Na^+ **correct**
2. Br^- , Cl^-
3. Mg , Mg^{2+}
4. S^{2-} , Cl^-

Explanation:

Ionic radii become *larger* as you move *down* a column or as you move from *right to left* across a row.

ChemPrin3e T01 62**017** 10.0 points

Given the elements Cl, Ge, and K and the values 418, 1255, and 784 kJ/mol of possible first ionization energies, match the atoms with their first ionization energies.

1. Cl: 784 kJ/mol; Ge: 1255 kJ/mol; and K: 418 kJ/mol
2. Cl: 418 kJ/mol, Ge: 1255 kJ/mol; and K: 784 kJ/mol
3. Cl: 1255 kJ/mol; Ge: 784 kJ/mol; and K: 418 kJ/mol **correct**
4. Cl: 1255 kJ/mol; Ge: 418 kJ/mol; and K: 784 kJ/mol
5. Cl: 418 kJ/mol; Ge: 784 kJ/mol; and K: 1255 kJ/mol

Explanation:

Cl is a Group 7 non-metal and will tend to form a -1 ion, so it will be very reluctant to give up an electron and will have a very high first ionization energy. K is a group 1 metal and will readily lose an electron to form a $+1$ ion so the first ionization energy will be very low. Ge will form positive ions and be intermediate in its first ionization energy.

Mlib 07 0227**018** 10.0 points

Which of the following is the best representation of the compound magnesium nitride?

1. Mg^{2+} , $2 \left[\begin{array}{c} \cdot\cdot \\ \text{N} \\ \cdot\cdot \end{array} \right]^-$
2. Mg^+ , $\left[\begin{array}{c} \cdot\cdot \\ \text{N} \\ \cdot\cdot \end{array} \right]^-$
3. Mg^{2+} , $\left[\begin{array}{c} \cdot\cdot \\ \text{N} \\ \cdot\cdot \end{array} \right]^{2-}$
4. 3Mg^{2+} , $2 \left[\begin{array}{c} \cdot\cdot \\ \text{N} \\ \cdot\cdot \end{array} \right]^{3-}$ **correct**

5. None is appropriate because magnesium nitride is a covalent compound.

6. 2Mg^+ , $\left[\begin{array}{c} \cdot\cdot \\ \text{N} \\ \cdot\cdot \end{array} \right]^{2-}$

Explanation:

The best drawing will show the valence electrons, the charges, and the appropriate ratio of ions for Mg_3N_2 .

Msci 07 1202**019** 10.0 points

Resonance structures would NOT apply to

1. ammonia. **correct**
2. carbonate ion.
3. ozone.
4. benzene.

Explanation:**Mlib 03 1057****020** 10.0 points

The carbon-nitrogen bond in a molecule of hydrogen cyanide (HCN) is what kind of bond?

1. double
2. triple **correct**

3. single

4. ionic

Explanation:

To draw the dot structure for HCN we must first calculate the number of valence electrons available from the atoms:

$$\begin{aligned} A &= 4 \times 1 \text{ (C atom)} + 1 \times 1 \text{ (H atoms)} \\ &\quad + 5 \times 1 \text{ (N atoms)} \\ &= 10 e^- \end{aligned}$$

We choose the least electronegative element as the central atom (carbon in this case). Remember that hydrogen can form only one bond and will never be a central atom. The other atoms are placed symmetrically around the carbon atom.

The correct dot structure for the molecule should show a complete octet (8 electrons) around each atom except hydrogen, 2 atoms around each hydrogen, and a total of 10 valence electrons for the entire structure. The correct structure is



As can be seen, there is a triple bond between the carbon and nitrogen.

(If using the $S = N - A$ rule to determine the dot structure,

$$\begin{aligned} N &= 8 \times 1 + 2 \times 1 + 8 \times 1 = 18 e^- \quad \text{and} \\ S &= 18 - 10 = 8 e^- . \end{aligned}$$

This would indicate 4 bonds and correspond to the structure shown above.)

ChemPrin3e T02 22

021 10.0 points

How many lone pairs of electrons are found in the Lewis structure of hydrazine (H_2NNH_2)?

1. 8

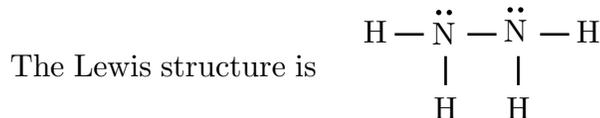
2. 1

3. 4

4. 2 correct

5. 0

Explanation:



Sparks LD large 002

022 10.0 points

How many double bonds are in the compound $\text{CH}_2\text{CHCH}_2\text{CHCH}_3$?

1. 1

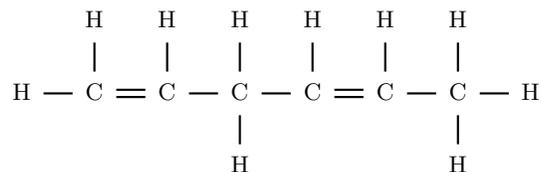
2. 2 correct

3. 4

4. 0

5. 3

Explanation:



ChemPrin3e 02 58

023 10.0 points

How many lone pairs are on the central atom of AsF_5 ?

1. 1

2. 4

3. 0 correct

4. 2

5. 3

Explanation:

The Lewis dot structure for AsF_5 is

026 10.0 points

Rank the crystal lattice energy of the following salts from greatest to least: MgBr₂, KNO₃, SrS, LiF, CaI₂.

1. SrS > MgBr₂ > CaI₂ > LiF > KNO₃
correct

2. KNO₃ > SrS > MgBr₂ > CaI₂ > LiF

3. SrS > CaI₂ > MgBr₂ > LiF > KNO₃

4. SrS > MgBr₂ > CaI₂ > KNO₃ > LiF

5. SrS > CaI₂ > MgBr₂ > KNO₃ > LiF

Explanation:

Strontium sulfide has the greatest lattice energy because it has the largest charges on its constituent ions, +2 and -2. Magnesium bromide and calcium iodide have charges of +2 and -1, but calcium iodide has larger interion distance and thus less lattice energy. Likewise, lithium fluoride and potassium nitrate have identical charges, but both potassium ion and the nitrate polyatomic ion are significantly larger than their counterparts and therefore have less lattice energy.

LDE Rank Electronegativity 001**027** 10.0 points

Rank the following bonds from greatest to least difference in electronegativity (ΔEN): C-C, C-F, C-N, Li-H, B-H.

1. C-C > C-N > B-H > Li-H > C-F

2. Li-H > B-H > C-C > C-N > C-F

3. C-N > C-F > Li-H > B-H > C-C

4. Li-H > C-F > C-N > B-H > C-C

5. C-F > Li-H > C-N > B-H > C-C **correct**

Explanation:

The polarity of a bond is given by the difference in electronegativity of the atoms, ΔEN .

H has electronegativity 2.2, and the electronegativity for 2nd row atoms starts with 1.0 at Li and increases by 0.5 until 4.0 at F.

Sparks form chg 002**028** 10.0 points

Calculate the formal charge on N in the molecule NH₃.

1. 4

2. 2

3. 0 **correct**

4. 3

5. 1

Explanation:

The Lewis structure is

$$\begin{array}{c} \overset{0}{\text{H}} - \overset{\cdot\cdot}{\underset{0}{\text{N}}} - \overset{0}{\text{H}} \\ | \\ \text{H}^0 \end{array}$$
ChemPrin3e 02 48**029** 10.0 points

Consider the following pairs A and B

A₁) $\overset{\cdot\cdot}{\text{N}} = \text{N} = \overset{\cdot\cdot}{\text{O}}$ A₂) $:\text{N} \equiv \text{N} - \overset{\cdot\cdot}{\text{O}}:$

B₁) $\left[\begin{array}{c} :\ddot{\text{O}}: \\ | \\ \ddot{\text{O}} = \text{P} - \ddot{\text{O}}: \\ | \\ :\ddot{\text{O}}: \end{array} \right]^{3-}$ B₂) $\left[\begin{array}{c} :\ddot{\text{O}}: \\ | \\ \ddot{\text{O}} = \text{P} = \ddot{\text{O}} \\ | \\ :\ddot{\text{O}}: \end{array} \right]^{3-}$

of Lewis structures.

Select the one from each pair that is likely to make the dominant contribution to a resonance hybrid.

1. A₁ and B₁

2. A₁ and B₂

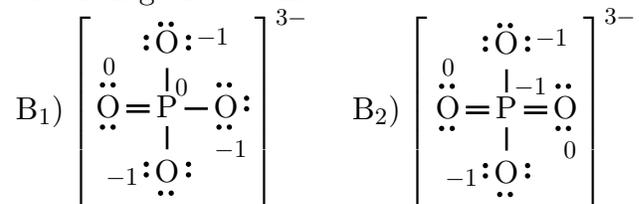
3. A₂ and B₂

4. A₂ and B₁ **correct**

Explanation:



The second structure is preferred because it places the negative formal charge on the most electronegative atom.



The first structure is preferred for the same reason.

LDE Ranking Bonding Trends 008

030 10.0 points

Rank the following bonds from highest energy to lowest energy: C-F, C-O, C-I, C-H.

1. C-N > C-H > C-F > C-O
2. C-F > C-H > C-O > C-N
3. C-O > C-F > C-H > C-N
4. C-F > C-O > C-N > C-H **correct**
5. C-H > C-F > C-O > C-N

Explanation:

The bond energies of carbon with other 2nd row atoms tend to increase with increasing ΔEN . Hydrogen has an electronegativity of 2.1