This print-out should have 30 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 kJ·mole^{-1}?

1. 1.32×10^{-40} J; 7.95×10^{-20} kJ·mole^{-1}

2. 9.94×10^{-17} J; 1.65×10^{-43} kJ·mole^{-1}

3. 9.94×10^{-19} J; 599 kJ·mole^{-1}**correct**

4. 1.32×10^{-21} J; 795 kJ·mole^{-1}

5. 9.94×10^{-21} J; 5.99 kJ·mole^{-1}

6. 1.32×10^{-31} J; 7.95×10^{-11} kJ·mole^{-1}

Explanation:
$\lambda = 200$ nm $c = 3 \times 10^8$ 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.

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

9.94×10^{-19} J $\times\ 6.022 \times 10^{23}$ mol^{-1} = 599 kJ·mole^{-1}

LDE Classical Failure 001
002   10.0 points

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

I) Classical mechanics accurately predicted the behavior of blackbody radiators.

II) The failure of classical mechanics to predict the behavior of blackbody radiators is called the ultraviolet catastrophe.

III) A minimum frequency of light is required to eject an electron from a metal surface.

IV) The emission spectra of gases are continuous rather than discrete.

1. I, II and IV

2. II, III, and IV

3. II and III **correct**

4. III and IV

5. I and III

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 atoms.

LDE Rydberg Calc 001
003   10.0 points

For the Hydrogen atom, an electron moving between which two energy levels in the Balmer series would have to absorb light with a frequency (ν) of 6.19×10^{14} Hz?

1. $n = 2$ and $n = 3$

2. $n = 1$ and $n = 3$

3. $n = 3$ and $n = 5$

4. $n = 2$ and $n = 4$ **correct**

5. $n = 1$ and $n = 4$

6. $n = 1$ and $n = 2$

Explanation:
  A frequency of 6.19×10^{14} Hz corresponds to a transition from $n = 2$ to $n = 4$ using the Rydberg equation. The fact that the Balmer series is mentioned also indicates that n_1 must be 2.

LDE Particle in a Box Theory 001
004   10.0 points
Which of the following statements concerning particle in a box is/are true?
  I) The energy of the particle can be equal to zero.
  II) The wavelength (λ) is proportional to the length of the box (L).
  III) As the length of the box (L) increases, the energy levels become closer in value.

1. I and II

2. I only

3. I, II and III

4. III only

5. II and III **correct**

6. I and III

7. II only

Explanation:
  The energy of the particle in the box can never be zero; this is a consequence of the fact that it can never be stationary, and as a massive particle in motion, thus has to have some energy. The length of the box (L) and the principle energy level (n) determine the wavelength (λ) of the system, and because n can only have integer values, λ can only

have certain discrete values. The energy of the particle (E) is inversely proportional to L, and thus as L increases, the different energy levels are closer to total degeneracy.

LDE uncertainty calculation 003
005   10.0 points
An electron has a fairly well defined position with an uncertainty of only 10^{-10} m. What would the minimum uncertainty in the electron's velocity be? (A electron has a mass of 9.1×10^{-31} kg)

1. 5.3×10^5 m $\cdot$ s^{-1}

2. 3.5×10^5 m $\cdot$ s^{-1}

3. 5.8×10^5 m $\cdot$ s^{-1} **correct**

4. 4.6×10^5 m $\cdot$ s^{-1}

5. 6.1×10^5 m $\cdot$ s^{-1}

Explanation:

$$\Delta x (m \Delta v) \geq \frac{h}{4\pi}$$
$$\Delta v \geq \frac{h}{4\pi m \Delta x}$$
$$\geq \frac{6.626 \times 10^{-34} \text{ J} \cdot \text{s}}{4\pi \left(9.1 \times 10^{-31} \text{ kg}\right) \left(10^{-10} \text{ m}\right)}$$
$$\geq 5.8 \times 10^5 \text{ m} \cdot \text{s}^{-1}$$

LDE de Broglie 002
006   10.0 points

  What is the de Broglie wavelength of a bird being chased by Schrodinger's cat, Albert? The bird has a mass of 300 g and is flying at 50 km/h.

1. Not enough information is given.

2. 1.59024×10^{-37}

3. 4.41733×10^{-39}

4. 1.59024×10^{-34} m **correct**

5. 4.41733×10^{-35}

Explanation:
$m = 300 \text{ g} = 0.3 \text{ kg}$
$v = 50 \text{ km/h} \cdot \dfrac{1000 \text{ m}}{1 \text{ km}} \cdot \dfrac{1 \text{ h}}{3600 \text{ s}}$
$\quad = 13.8889 \text{ m/s}$

$$\lambda = \frac{h}{p} = \frac{h}{m \cdot v}$$
$$= \frac{6.626 \times 10^{-34} \frac{\text{kg} \cdot \text{m}^2}{\text{s}}}{(0.3 \text{ kg})(13.8889 \text{ m/s})}$$
$$= 1.59024 \times 10^{-34} \text{ m}$$

LDE Schrodinger and wave theory
007   10.0 points
Which of the following statements concerning the Schrodinger equation and its solution for the hydrogen atom is/are true?

I) An electron's exact location cannot be determined using the Schrodinger equation.

II) The use of polar coordinates simplifies the solution to the Schrodinger equation for the hydrogen atom.

III) The solution to the Schrodinger for the hydrogen atom contains a single potential energy term.

1. I only

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

3. II and III

4. II only

5. I and II

6. I and III

7. III only

Explanation:
Solutions to the Schrodinger equation are wave functions, which when squared express the probable location of electrons; but, the exact location cannot be known. Attractive potential energy terms are found in all solutions for all atoms. Repulsive potential energy terms are found only in atoms that have more than one electron, i.e. everything beyond hydrogen. Polar coordinates are preferred for 3-D solutions because they simplify the math.

LDE quantum rules 003
008   10.0 points
Which of the following is not a permitted combination of quantum numbers?

1. $n = 4,\ \ell = 0,\ m_\ell = -2,\ m_s = -\dfrac{1}{2}$ **correct**

2. $n = 3,\ \ell = 2,\ m_\ell = -2,\ m_s = \dfrac{1}{2}$

3. $n = 6,\ \ell = 5,\ m_\ell = -5,\ m_s = -\dfrac{1}{2}$

4. $n = 8,\ \ell = 0,\ m_\ell = 0,\ m_s = \dfrac{1}{2}$

5. $n = 5,\ \ell = 3,\ m_\ell = -2,\ m_s = \dfrac{1}{2}$

Explanation:
For $\ell = 0$, m_ℓ can only have a value of 0.

LDE quantum rules 004
009   10.0 points
How many electrons are in principle energy level 7 $(n = 7)$?

1. 196

2. 14

3. 98 **correct**

4. 28

5. 49

Explanation:
the number of electrons in a given principle energy level is equal to $2n^2$.

LDE orbital filling 001
010   10.0 points
Consider the electron filling diagram below:
3p ↑↓   ↑↓
3s ↑↓

2p ↑↓ ↑↓ ↑↓
2s ↑
1s ↑↓
Which of the following does it violate?
I) The aufbau principle
II) The Pauli exclusion principle
III) Hund's rule

1. II and III

2. I only

3. I and II

4. I, II and III

5. I and III **correct**

6. II only

7. III only

Explanation:
The half-filled $2s$

LDE Electronic configuration 003
011   10.0 points

What is the correct electronic configuration for a ground-state divalent Barium cation (Ba^{2+})?

1. [Rn] $6s^1$

2. [Xe] **correct**

3. [Xe] $6s^2\,4f^2$

4. [Rn]

5. [Xe] $6s^1$

6. [Rn] $6s^2\,5d^2$

Explanation:
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 con-

figuration 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. Finally use noble gas shorthand to get the answer: Ba^{2+} has 54 electrons all of which are accounted for by the shorthand notation, [Xe].

LDE Electronic configuration 004
012   10.0 points

What is the correct electronic configuration for a ground-state Gold atom (Au)?

1. [Rn] $6s^2\,4f^{14}\,5d^9$

2. [Rn] $6s^1\,4f^{14}\,5d^{10}$

3. [Rn] $6s^1\,5d^{10}$

4. [Xe] $6s^2\,4f^{14}\,5d^9$

5. [Xe] $6s^1\,5d^{10}$

6. [Xe] $6s^1\,4f^{14}\,5d^{10}$ **correct**

Explanation:
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 in the case of gold you need to account for this by 'shuffling' an electron from the $6s$ orbital into the $5d$ orbital. Finally use noble gas shorthand to get the answer: [Xe] $6s^1\,4f^{14}\,5d^{10}$.

LDE Electronic configuration 005
013   10.0 points

What is the correct electronic configuration for a ground-state Antimony(V) ion (Sb^{5+})?

1. [Kr] $5s^2\,4d^{10}$

2. [Kr] $5s^0\,4d^{10}$ **correct**

3. $[Kr] 5s^1 4d^{10}$

4. $[Kr] 5s^0 3f^{14} 4d^{10}$

5. $[Kr] 5s^2 4d^8$

Explanation:

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 ions of main group metals (such as Antimoy). When forming an ion from a main group metal, electrons are removed first from the highest energy p orbital followed by the highest energy s orbital. Finally use noble gas shorthand to get the answer: $[Kr] 5s^0 4d^{10}$.

LDE periodic table 001
014   10.0 points

Which of the following elements is not correctly paired with its group (family) name?

1. Lithium (Li), Alkali metals

2. Radon (Rn), Noble gases

3. Bismuth (Bi), Halogens **correct**

4. Strontium (Sr), Alkaline earth metals

Explanation:

The pnictogens are the family containing nitrogen through bismuth. The halogens are fluorine through astatine.

LDE periodic trend theory 001
015   10.0 points

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

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

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

3. It a method to evaluate how much attrac-

tion a given electron feels from the nucleus so that periodic trends can be predicted and rationalized. **correct**

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

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

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

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 smller. This is used to rationalize the periodic trends.

LDE Ranking trends 003
016   10.0 points

Rank the following isoelectronic species from smallest to largest ionic radius: Ca^{2+}, S^{2-}, Cl^-, Ga^{3+}.

1. $S^{2-} < Cl^- < Ca^{2+} < Ga^{3+}$

2. $Cl^- < S^{2-} < Ca^{2+} < Ga^{3+}$

3. $Ga^{3+} < Ca^{2+} < Cl^- < S^{2-}$ **correct**

4. $Ca^{2+} < Ga^{3+} < < S^{2-} Cl^-$

5. $Ga^{3+} < S^{2-} < Ca^{2+} < Cl^-$

Explanation:

The ionic radius trend is very smooth. For a given set of isoelectronic species, the one with most protons is the smallest and the one with the least protons is the largest.

LDE rank trend exceptions 001
017   10.0 points

Rank the following from least to greatest ionization energy: silicon (Si), phosphorous (P),

sulfur (S).

1. S < P < Si

2. P < S < Si

3. Si < S < P **correct**

4. P < Si < S

5. S < Si < P

6. Si < P < S

Explanation:
Ionization energy increases increases across a given row, but because of the added stability of a half-filled p subshell, sulfur has a lower ionization energy than would be simply predicted based on effective nuclear charge arguments.

LDE Lewis Structures 003
018   10.0 points
Which of the following is the correct Lewis structure of Sodium Fluoride (NaF)?

1. $Na^+, \left[:\overset{..}{\underset{..}{F}}: \right]^-$ **correct**

2. $:\overset{..}{N}a\!-\!\overset{..}{\underset{..}{F}}:$

3. $\left[:\overset{..}{\underset{..}{N}a}: \right]^+, F^-$

4. $Na\!-\!\overset{..}{\underset{..}{F}}:$

Explanation:

LDE rank lattice energy 001
019   10.0 points
Rank the following salts from least to greatest lattice energy: Lithium Fluoride (LiF), Lithium Bromide (LiBr), Beryllium Fluoride (BeF_2), Beryllium Bromide ($BeBr_2$).

1. $BeBr_2 < BeF_2 < LiBr < LiF$

2. $LiBr < LiF < BeBr_2 < BeF_2$ **correct**

3. $LiF < LiBr < BeF_2 < BeBr_2$

4. $LiF < BeF_2 < LiBr < BeBr_2$

5. $BeF_2 < BeBr_2 < Lif < LiBr$

Explanation:
Charge density is the ratio of the charge of a species to its size, in this case ionic radius is an excellent proxy for the actual volume. Thus the smaller and more highly charged the cation and anion of salt are, the greater their attraction and thus lattice energy will be.

LDE Lewis Structures 004
020   10.0 points
Which of the following is the correct Lewis structure of ozone (O_3)?

1.

2.

3.

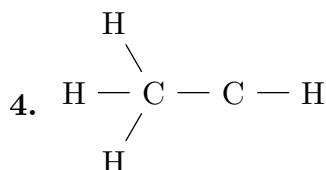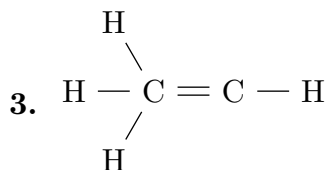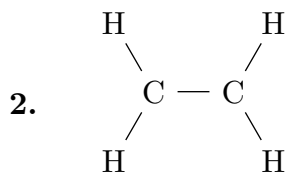**4.**

correct

5.

Explanation:

LDE Lewis Structures 001
021   10.0 points
Which of the following is the correct Lewis structure for ethene (C_2H_4)?

1.   **correct**

2.

$$
\begin{array}{ccc}
\text{H} & & \text{H} \\
\diagdown & & \diagup \\
& \text{C} - \text{C} & \\
\diagup & & \diagdown \\
\text{H} & & \text{H}
\end{array}
$$

3.

$$
\begin{array}{c}
\text{H} \\
\diagdown \\
\text{H} - \text{C} = \text{C} - \text{H} \\
\diagup \\
\text{H}
\end{array}
$$

4.

$$
\begin{array}{c}
\text{H} \\
\diagdown \\
\text{H} - \text{C} - \text{C} - \text{H} \\
\diagup \\
\text{H}
\end{array}
$$

Explanation:

LDE Lewis Structures Exceptions 001
022   10.0 points
   Which of the following is the correct Lewis structure of Nitric Oxide (NO)?

1. $:N \equiv \overset{\bullet}{O}:$

2. $:\overset{\bullet}{N} \equiv O:$

3. $:\overset{\bullet\bullet}{N} = \overset{\bullet}{O}:$

4. $:\overset{\bullet}{N} = \overset{\bullet\bullet}{O}:$ **correct**

Explanation:

LDE Lewis Structures Exceptions 002
023   10.0 points
Which group on the periodic table contains at least one element likely to form stable covalent compounds that have fewer than 8 valence electrons on their central atom?
   1. Group 2

2. Group 3 **correct**

3. Group 7

4. Group 4

5. Group 5

Explanation:

LDE Lewis Structures 002
024   10.0 points
Which of the following compounds has only single bonds?
  I) N_2
 II) O_2
III) H_2
IV) CH_4

1. II only

2. I, II

3. III, IV **correct**

4. I, IV

5. I only

6. III only

Explanation:

LDE Lewis Structures Exceptions 003
025   10.0 points
How many bonding and non-bonding electrons does the sulfur atom in SCl_4 have?

1. 10 bonding, 0 non-bonding

2. 4 bonding, 1 non-bonding

3. 4 bonding, 2 non-bonding

4. 8 bonding, 0 non-bonding

5. 8 bonding, 2 non-bonding **correct**

Explanation:
   The correct Lewis structure for SCl_4 has a total of 34 valence electrons, two of which

have to be present as non-bonding electrons on the sulfur atom, as it is the only atom that can be hypervalent.

LDE Lewis Structures Exceptions 004
026   10.0 points
Which of the following compounds have a hypervalent central atom?
  I) SCl_6
  II) BF_3
  III) Br_3^-
  IV) CH_3Cl

1. I, IV

2. III only

3. II, III

4. I, III **correct**

5. II, IV

6. I, II, III

Explanation:

LDE Assigning Formal Charge 001
027   10.0 points
What is the formal charge on the Xenon atom (Xe) in XeF_2?

1. 6
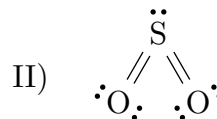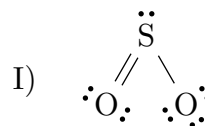
2. 2

3. 0 **correct**

4. -2

5. -4

Explanation:

LDE Formal Charge and Lewis 001
028   10.0 points
  Based on formal charge considerations alone, which of the following is a better Lewis structure for sulfur dioxide (SO_2)?

I)

II)

1. Both are correct

2. II **correct**

3. I

4. Neither is correct

Explanation:
  In structure II, all of the atoms have a formal charge of zero.

LDE Ranking Bonding Trends 001
029   10.0 points
Rank the following diatomic molecules in terms of increasing bond length: HI, HF, HBr, HCl

1. HI < HF < HCl < HBr

2. Not enough information.

3. HI < HBr < HCl < HF

4. HF < HCl < HBr < HI **correct**

5. HCl < HBr < HI < HF

Explanation:
  As the difference in electronegativity decreases for a given bond, the bond tends to become longer and weaker.

LDE EN Difference Calc
030   10.0 points
Approximate the electronegativity difference (ΔEN) of the C—H bonds in methane (CH_4).

1. 0.3 **correct**

2. 0

3. 0.8

4. 1.3

5. 0.7

Explanation: