This print-out should have 25 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

ChemPrin3e 01 01
001 10.0 points

What is the correct order of increasing energy?

1. microwaves, ultraviolet light, visible light, x-rays, γ-rays

2. microwaves, x-rays, γ-rays, visible light, ultraviolet light

3. microwaves, visible light, ultraviolet light, x-rays, γ-rays **correct**

4. ultraviolet light, visible light, microwaves, x-rays, γ-rays

5. x-rays, γ-rays, microwaves, visible light, ultraviolet light

Explanation:

$$\text{microwaves} < \text{visible light} < \text{ultraviolet light} < \text{x-rays} < \gamma\text{-rays}$$

Mlib 50 2001
002 10.0 points

How much energy does a photon with a wavelength equal to 350 nm have?

1. 1.89×10^{-27} J

2. 2.32×10^{-31} J

3. 3.50×10^{-7} J

4. 5.68×10^{-19} J **correct**

5. 1.29×10^{-48} J

Explanation:

$\lambda = 350$ nm $\qquad c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ 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.

$$\begin{aligned} E &= \frac{h\,c}{\lambda} \\ &= \left(6.63 \times 10^{-34}\ \text{J} \cdot \text{s}\right)\left(3 \times 10^{8}\ \text{m/s}\right) \\ &\quad \cdot \frac{1}{350\ \text{nm}} \cdot \frac{10^9\ \text{nm}}{1\ \text{m}} \\ &= 5.68 \times 10^{-19}\ \text{J} \end{aligned}$$

Blackbody Radiators
003 10.0 points

The observation and characterization of black body radiation was key to the development of our quantum mechanical view of the atom. Which statement below is **correct** regarding blackbody radiation?

1. Theoreticians were unable to explain why blackbody radiators emitted so much UV light at room temperature, which became known as the "UV Catastrophe".

2. The peak intensity of the emission curve for a blackbody shifts to shorter wavelengths as the temperature of the blackbody increases. **correct**

3. The emission from a blackbody consists of a series of discrete spectral lines, the colors of which are unique to the type of blackbody used.

4. The emission of radiation from an incandescent lightbulb does not resemble the emission of radiation from a blackbody.

Explanation:

A blackbody's radiation emission curve is broad, lopsided and has a peak which shifts to shorter wavelengths as the temperature of the blackbody increases. Theoreticians tried to model this using classical mechanics and never could get their models to behave because they predicted vast amounts of UV, gamma, etc. being produced by a blackbody above absolute zero - the "UV Catastrophe".

A plain old incandescent lightbulb with a dimmer switch can be used to reproduce the emission curves of a blackbody - and even vary its temperature by changing the current with the dimmer switch.

Work function 01
004 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. Fewer electrons would be emitted from the surface.

3. More electrons would be emitted from the surface.

4. The same number of electrons would be emitted, but they would have a lower velocity

5. The same number of electrons would be emitted, but they would have a higher velocity **correct**

Explanation:

500 nm light has more energy than 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.

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

Mlib 02 0095
005 10.0 points

Which of the following experiments provided evidence that the electrons in atoms are arranged in distinct energy levels?

1. the results of the Millikan oil-drop experiment

2. the scattering of α particles by a metal foil

3. the existence of elements with noninteger values for atomic weights

4. the observation of line spectra from gas discharge tubes **correct**

5. the deflection of ions in a mass spectrometer

Explanation:

The fact that gases emitted only specific wavelengths of energy suggested that electron energy states are quantized.

LDE Q01 05
006 10.0 points

In the 20th century, quantum mechanics addressed the failures of classical mechanics by introducing the concept of wave-particle duality. Why did classical mechanics able to explain the world just fine up until then?

1. Only at very high velocity, rarely traveled by macroscopic objects, does the wavelength of particles become large enough to influence its behavior.

2. The wave nature of particles does not affect any macroscopic phenomena and is only important at the atomic scale.

3. Macroscopic objects can be modeled purely as particles because their wavelength is so small compared to their scale that it can be neglected for most purposes and still give a good description of their behavior. **correct**

4. Planck's constant is proportional to the size of the object it describes, so that the wavelength of that particle is only significant for small objects.

5. Macroscopic objects have no wave-like properties

Explanation:

When Newton was laying the foundation for classical mechanics, the implicit assumption throughout was that macroscopic objects do not have a wavelength. Although de Broglie later demonstrated that they do, he also demonstrated that de Broglie wavelengths for macroscopic objects are so small that they can be neglected without impacting our calculations and predictions about behavior. So, although Newton and his successors had no idea that everything has a wavelength, the framework they developed (classical mechanics) still worked quite well.

ChemPrin3e T01 13
007 10.0 points

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

1. 3×10^8 m/s

2. 891 m/s **correct**

3. 1780 m/s

4. 445 m/s

5. 8.9 m/s

Explanation:

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

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

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

ChemPrin3e T01 10a
008 10.0 points

You are caught in a radar trap and hope to show that the speed measured by the radar gun is in error due to the uncertainty principle. If you assume that the uncertainty in your position is large, say about 10 m, and that the car has a mass of 2150 kg, what is the uncertainty in the velocity?

1. 4×10^{38} m/s

2. 1×10^{-34} m/s

3. 5.0×10^{-42} m/s

4. 2.5×10^{-39} m/s **correct**

5. 1×10^{33} m

Explanation:

$\Delta x = 10$ m $\qquad m = 2150$ kg

$$\begin{aligned} \Delta v &= \frac{\hbar}{2\, m\, \Delta x} \\ &= \frac{1.055 \times 10^{-34} \text{ J} \cdot \text{s}}{2\,(2150 \text{ kg})\,(10 \text{ m})} \\ &= 2.45349 \times 10^{-39} \text{ m/s} \end{aligned}$$

Msci 05 1103R
009 10.0 points

An electron in a hydrogen atom could undergo any of the transitions listed below, by emitting light. Which transition would give light of the shortest wavelength?

1. $n = 4$ to $n = 2$

2. $n = 2$ to $n = 1$

3. $n = 4$ to $n = 1$ **correct**

4. $n = 4$ to $n = 3$

5. $n = 3$ to $n = 1$

Explanation:

Shorter wavelengths have more energy than longer wavelengths. $n = 4$ is a very excited energy level, shorter than $n = 3$, 2 or 1. A transition from $n = 4$ to $n = 1$ will release more energy than any other option given.

Mlib 02 0063alt
010 10.0 points

The following three statements refer to the Bohr theory of the atom.

Z1) An electron can remain in a particular orbit as long as it continually absorbs radiation of a definite frequency.
Z2) The lowest energy orbits are those closest to the nucleus.
Z3) An electron can jump from an inner orbit to an outer orbit by emitting radiation of a definite frequency.

Which response contains all the statements that are consistent with the Bohr theory of the atom and no others?

1. Z1, Z2 and Z3

2. Z2 and Z3 only

3. Z1 and Z2 only

4. Z2 only **correct**

5. Z3 only

Explanation:

LDE Schrodinger Theory 002
011 10.0 points

Which of the following statements concerning the Schrödinger equation and its solutions is true?

I) Its solutions are wave functions.
II) It can be used to determine an electron's exact position.
III) Both attractive and repulsive $V(r)$ terms are used when solving the Schrödinger equation for the hydrogen atom.

1. II only

2. II, III

3. I only **correct**

4. I, II

5. I, III

6. I, II, 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.

ChemPrin3e T01 24
012 10.0 points

If a particle is confined to a one-dimensional box of length 300 pm, for Ψ_3 the particle is most likely to be found at

1. 300 pm.

2. 50, 150, and 250 pm, respectively. **correct**

3. 17.3 pm.

4. 100 and 200 pm, respectively.

5. 0 pm.

Explanation:

Msci 05 1404
013 10.0 points

The size of an atomic orbital is determined by which quantum number?

1. n **correct**

2. ℓ

3. m_s

4. m_ℓ

Explanation:

n is the principle quantum number. It is the main energy level or shell and determines the size of the orbitals.

Msci 05 1432
014 10.0 points

Which set of quantum numbers does NOT provide a satisfactory solution to the wave equation?

1. $n = 2$, $\ell = 0$, $m_\ell = -1$ **correct**

2. $n = 1$, $\ell = 0$, $m_\ell = 0$

3. $n = 4$, $\ell = 2$, $m_\ell = +2$

4. $n = 5$, $\ell = 3$, $m_\ell = -3$

5. $n = 3$, $\ell = 2$, $m_\ell = -1$

Explanation:

Msci 05 1427
015 10.0 points

In an atom, what would be the maximum number of electrons having the quantum numbers $n = 6$ and $\ell = 2$?

1. 10. **correct**

2. 5.

3. 6.

4. 8.

5. 72.

Explanation:

Ten electrons can have this set of quantum numbers. Where $\ell = 2$, five values of m_ℓ are possible, namely, 2, 1, 0, -1, and -2. Each one of these m_ℓ values represents a single orbital, so there are 5 orbitals. Since each orbital can accomodate 2 electrons, 10 electrons can have this set of n and ℓ values.

LDE Aufbau, Hund, Pauli 002
016 10.0 points

Consider the electron filling diagram

$3p$	↑↓	↑	__
$3s$	↑		
$2p$	↑↓	↑↓	↑↓
$2s$	↑↓		
$1s$	↑↓		

for a ground state atom. Which of the following does it violate?

I) The Aufbau principle
II) Hund's rule
III) The Pauli exclusion principle

1. III only

2. I, II, III

3. I, II **correct**

4. I only

5. II only

6. II, III

7. I, III

Explanation:

Aufbau's principle says you must fill the orbitals in order from lowest energy to highest. Putting electrons in the $3p$ orbitals before filling the $3s$ orbital violates that.

Hund's rule says that orbitals in the same subshell must each have an unpaired electron before any of them can have a pair. This is violated in the $3p$ subshell.

The Pauli exclusion principle says that no two electrons can have the same four quantum numbers, which the given configuration does not violate.

LDE Periodic Table 005
017 10.0 points

Fill in the blanks: potassium is one of the most well-known elements in the alkali metal ______. It is in the ______which makes it a ______element. Its single valence electron is in the ______subshell of the ______shell, making it very reactive. It reacts readily with non-metals to form ______.

1. row; d block; main group; $\ell = 1$; $n = 4$; salts

2. row; d block; non-metal; $\ell = 1$; $n = 3$; alloys

3. series; s block; common; $\ell = 2$; $n = 4$; networks

4. family; s block; reactive; $\ell = 0$; $n = 3$; alloys

5. family; s block; main group; $\ell = 0$; $n = 4$; salts **correct**

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. Potassium is on row 4, but the principal quantum number n always refers to an electron shell. The $4s$ electron of K is its entire valence. K^+ is isoelectronic to group 18 which are called the noble gases. The reaction of a metal and non-metal usually produces a salt.

ChemPrin3e T01 42
018 10.0 points

Write the ground-state electron configuration of a europium atom.

1. [Xe] $4f^5\,5d^2\,6s^2$

2. [Xe] $4f^9$

3. [Xe] $5d^7\,6s^2$

4. [Xe] $4f^2\,5d^5\,6s^2$

5. [Xe] $4f^7\,6s^2$ **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 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: [Xe] $4f^7\,6s^2$.

Msci 05 1675
019 10.0 points

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

1. Na^+, K^+, Ar

2. Cl^-, K^+, Ar, P^{3-} **correct**

3. Cl^-, Na^+

4. Na^+, Ar, P^{3-}

5. Cl^-, K^+, Ar, Mg^{2+}

Explanation:
For a set of species to have the same electron configuration, they must be isoelectronic. Only one answer choice satisfies this criterion.

Msci 05 1660
020 10.0 points

What is the ground state electron configuration for chromium?

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

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

3. $1s^2\ 2s^2\ 2p^8\ 3s^2\ 3p^8\ 3d^2$

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

Explanation:

Chromium is an exception to the rule in filling the subshells. There is extra stability afforded to the configuration by having half filled sub-shell. So instead of the $4s$ subshell filling up completely, the electrons are evenly distributed between the $4s$ and $3d$ levels.

LDE ENC Calculation 001
021 10.0 points

What is the effective nuclear charge experienced by the $2p$ and $3p$ electrons of an Chlorine atom (Cl), respectively?

1. 7, 2

2. 17, 7

3. 17, 10

4. 11, 7

5. 15, 7 **correct**

Explanation:

Electrons within the same energy level do not shield one another. Therefore the $2s$ electrons are not shielding the $2p$ electrons. To calculate effective nuclear charge the number of shielding electrons (all electrons in lower energy levels) are subtracted from the actual nuclear charge (number of protons in the nucleus). Chlorine, atomic number 17, has 17 protons. All of its electrons in principal energy level 2 are shielded only by the electrons in principal energy level 1, i.e. the 2 $1s$ electrons. 17 - 2 = 15 and for 3p 17 - 10 = 7.

LDE Rank Atomic Radius 001
022 10.0 points

Arrange the following atoms in order of increasing radius: Li, Au, C, Cs.

1. Li $<$ C $<$ Cs $<$ Au

2. Cs $<$ Au $<$ Li $<$ C

3. C $<$ Li $<$ Au $<$ Cs **correct**

4. Au $<$ Cs $<$ C $<$ Li

Explanation:

Atomic radius decreases across a period due to increasing effective nuclear charge (ENC) and increases down a group due to decreasing ENC and the increase in total electrons.

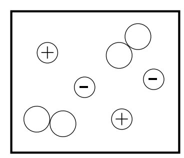
---

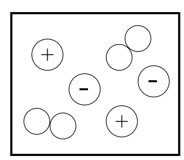
ion sizes 01
023 10.0 points

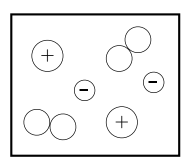
A diatomic molecule decomposes by the following reaction:

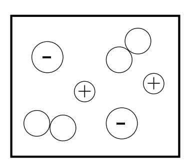
$$X_2 \rightarrow X^+ + X^-$$

Look carefully at the following pictures. Which one accurately depicts this reaction as it is proceeding?

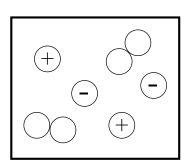
1. 

2. 

3. 

4. 

correct

5. 

Explanation:

Cations are smaller than their parent neutral atoms while anions are large than the parent neutral atom.

Msci 06 0315
024 10.0 points

Which elements are correctly listed in order of INCREASING ionization energy?

1. C < N < O

2. N < O < F

3. N < P < As

4. O < F < Ne **correct**

5. O < S < Se

Explanation:

Ionization enegy corresponds to how much energy it takes to ionize an element. Elements with high ionization energies do not want to give up their electrons, low ionization energies mean they do not want to receive an electron, but would rather give one up. In general, ionization energies increase as you move right along a period and up a group. Some atoms (like B, O, Al and S) can achieve more stable electronic configuration in filled or half-filled shells.

LDE Rank Electron Affinity 001
025 10.0 points

Rank the following species from least to greatest electron affinity: F, Ge, S, As, Se.

1. As < Ge < Se < S < F **correct**

2. Ge < As < Se < S < F

3. F < Se < S < Ge < As

4. F < S < Se < Ge < As

5. As < Ge < S < Se < F

Explanation:

The electron affinity trend increase as one moves from the lower left corner of the periodic table to the upper right corner of the periodic table, with exceptions occurring at filled and half-filled subshells, wich are inherently stable and this have a lower-than-expected electron affinity.