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McCord CH301
50070

Exam 2

Oct 10, 2017
Tuesday

Remember to refer to the Periodic Table handout that is separate from this exam copy. There are many conversion factors and physical constants available there.

NOTE: Please keep this exam copy intact (all pages still stapled - including this cover page). You must turn in ALL the materials that were distributed. This means that you turn in your exam copy (name and signature included), bubble sheet, periodic table handout, and all scratch paper. Please also have your UT ID card ready to show as well.

This print-out should have 20 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

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001 6.0 points

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

1. 0.288 nm

2. 666 nm **correct**

3. 882 nm

4. 0.441 nm

5. 456 nm

6. 0.664 nm

7. 0.882 nm

8. 992 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:

$(2.998 \times 10^8 / \ 4.50 \times 10^{14}) \times 10^9$

$= 666$ nm

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002 5.0 points

Which of the following best describes the effect of blue light on matter?

1. Electron excitation **correct**

2. Repulsion

3. No effect

4. Rotation

5. Ionization

6. Vibration

Explanation:

The visible spectrum can have sufficient energy to excite electrons in molecules.

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003 5.0 points

A particle confined to a one-dimensional box of length 480 nm for Ψ_3 has zero probability of being found:

1. Only 240 nm

2. 160 nm and 320 nm **correct**

3. 80 nm, 240 nm, and 160 nm

4. 160 nm and 240 nm

5. 80 nm, 240 nm, and 400 nm

Explanation:

For a particle in a box, the particle is most likely to be found at the peaks and never found at the nodes. For Ψ_3 at length 480 , the peaks are: 80 nm, 240 nm, and 400 nm. The nodes are 160 nm and 320 nm.

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004 3.0 points

Effective nuclear charge represents the attraction between the nucleus and the outer (valence) electrons.

1. False

2. True **correct**

Explanation:

Effective nuclear charge represents the attraction between the nucleus and the outer electrons.

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005 5.0 points

Rank the following species by ionic radius, from largest to smallest: $Cl^-, K^+, Ca^{2+}, S^{2-}$.

1. $K^+, Ca^{2+}, S^{2-}, Cl^-$

2. $S^{2-}, Cl^-, K^+, Ca^{2+}$ **correct**

3. $Ca^{2+}, K^{+}, Cl^{-}, S^{2-}$

4. $Ca^{2+}, S^{2-}, Cl^{-}, K^{+}$

5. $S^{2-}, Cl^{-}, Ca^{2+}, K^{+}$

6. $K^{+}, Cl^{-}, Ca^{2+}, S^{2-}$

Explanation:
All of the species are isoelectronic with Argon. With the same electronic configuration, the only thing different between species is the nuclear charge. So the species with the largest nuclear charge will have the smallest radius.

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006 5.0 points
The second ionization of Fe is given by the reaction:

$$Fe^{+}(g) \longrightarrow Fe^{2+}(g) + e^{-}$$

This electron is removed from the:

1. 3s subshell

2. 4p subshell

3. 3d subshell

4. 3p subshell

5. 4s subshell **correct**

6. 4d subshell

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.

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007 5.0 points
Which of the following atoms has an electronic structure that will weakly attract a magnetic field?

1. Ne

2. Li **correct**

3. Be

4. Zn

Explanation:
Paramagnetic substances have unpaired electrons that weakly attract a magnetic field. Out of the choices present, lithium (Li) is the only paramagnetic substance.

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008 6.0 points
The following table shows the first six ionization energies for an unknown element:

#	I.E. (kJ/mol)
1	7.89×10^2
2	1.58×10^3
3	3.23×10^3
4	4.36×10^3
5	1.61×10^4
6	1.98×10^4

The unknown element is:

1. N

2. Si **correct**

3. B

4. Ne

5. O

Explanation:
The table shows a drastic increase between ionization energy 4 and 5. This means that it takes removing four electrons to reach the noble gas configuration for the unknown element. The only answer choice in Group 4 is Si.

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009 6.0 points
Which of the following statement(s) is/are true regarding the Schrödinger equation and particle in a box?

I. When $n = 2$ for a particle in a box, the particle has zero probability of being found in the center of the box

II. There are an infinite numbers of solutions to the Schrödinger equation

III. The Schrödinger equation gives only positive solutions for the wavefunction (ψ)

IV. The angular momentum quantum number is one of the Schrödinger equation solutions for the hydrogen atom.

1. I and II

2. II only

3. I, III, and IV

4. I, II, and III

5. IV only

6. I and IV

7. I only

8. I, II, and IV **correct**

Explanation:
For $n = 2$, the center of the box is a node, meaning there is zero probability of finding an electron there. The Schrödinger equation gives negative and positive values for ψ but only . When solved for an atom, the Schrödinger equation gives you the four principal quantum numbers: n, ℓ, m_ℓ, and m_s.

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010 5.0 points
Which of the following is the best description for a $4p$ orbital of hydrogen?

1. A dumbell shape with three spherical nodes and one angular node

2. Four concentric spheres with two angular nodes

3. Four concentric spheres with three radial nodes

4. A dumbell shape with two spherical nodes and one angular node **correct**

5. A dumbell shape with one spherical node and three angular nodes

6. Four concentric spheres with one angular node

7. A dumbell shape with four spherical nodes and one angular node

8. A dumbell shape with one spherical node and two angular nodes

Explanation:
Angular nodes = value of quantum number ℓ which is one for $4p$. Spherical nodes = n - l - 1 = *spherical*

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011 5.0 points
Which of the following statements is correct?

1. Ionization energy consistently increases as you approach the bottom left of the periodic table

2. Ionization energy consistently increases as you approach the top right of the periodic table

3. Phosphorus has a higher ionization energy than Sulfur because there are more electrons in the p subshell in Phosphorus

4. Magnesium has a higher ionization energy than Aluminum because the full s subshell of Magnesium is more stable than the partially filled p subshell of Aluminum **correct**

5. Sulfur has a higher ionization energy than Phosphorus because there are more electrons in the p subshell in Sulfur

6. None of the above

Explanation:
Ionization energy generally trends toward the top right of the periodic table. However, there are exceptions based on the fact that half-filled and fully-filled subshells are especially stable. In this case, the higher ioniza-

tion energy of Magnesium is explained by the fact that the full s subshell of Magnesium is more stable than the partially filled p subshell of Aluminum.

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012 3.0 points

Which of the following is the correct name for the chemical formula: $(NH_4)_2SO_4$?

1. Ammonium sulfite

2. Nitrohydrogen sulfurous oxide

3. Nitrohydrogen sulfuric oxide

4. Ammonium sulfate **correct**

5. Ammonium sulfurous oxide

Explanation:

The correct name for $(NH_4)_2SO_4$ is Ammonium sulfate.

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013 3.0 points

Which orbital corresponds to the following quantum number set:

$$m_s = -1/2,\ \ m_l = -2,\ \ n = 6\,,\ \ l = 3$$

1. 6f **correct**

2. 6d

3. 6p

4. 6f and 6d are both possible

5. All choices are possible

6. 3s

Explanation:

The quantum number n dictates the shell and l dictates the shape. Therefore, the only possibility with the n and l values given is 6f.

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014 5.0 points

What is the correct shorthand electron configuration for copper?

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

2. [Ar]$3d^9 4s^2$

3. [Ar]$3d^4 4s^2$

4. [Ar]$3d^{10} 4s^1$ **correct**

5. [Kr]$4d^5 5s^1$

6. [Ar]$3d^5 4s^1$

Explanation:

A half-filled or fully filled d subshell is more stable than a fully filled s subshell. Therefore, for copper will "borrow" an electron from the s subshell to stabilize the d subshell.

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015 6.0 points

What is the change in energy for an excited hydrogen electron falling from the $n = 4$ to the $n = 2$ energy level? Is light absorbed or emitted through this process?

1. 4.09×10^{-17} J, absorbed

2. -4.09×10^{-17} J, emitted

3. -2.06×10^{-17} J, absorbed

4. -2.06×10^{6} J, absorbed

5. -4.09×10^{-19} J, emitted **correct**

6. 2.06×10^{-17} J, absorbed

Explanation:

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

$\Delta E = (2.18 \times 10^{-18}\text{ J})(\frac{1}{2^2} - \frac{1}{4^2})$

$\Delta E = 4.09 \times 10^{-19}$ J

This energy is the energy of the electron that is lost through this process. Therefore, for the electron:

$\Delta E = -4.09 \times 10^{-19}$ J

In this process, a photon is emitted.

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016 5.0 points

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

1. $n = 3, \ell = 2, m_\ell = +2, m_s = +\frac{1}{2}$

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

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

4. $n = 4, \ell = 2, m_\ell = +1, m_s = -\frac{1}{2}$

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

6. $n = 4, \ell = 4, m_\ell = +2, m_s = +\frac{1}{2}$

Explanation:

The subshell of an electron indicates the angular momentum quantum number, ℓ. The p subshell has an ℓ number equal to 1. The value of n for As 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 -1 to $+1$. Lastly, m_s can be $+\frac{1}{2}$ or $-\frac{1}{2}$. Only one answer choices matches these rules for the p subshell of As.

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017 5.0 points

Consider the following two gaseous samples at STP:

Sample A: 10L Hydrogen

Sample B: 3L Hydrogen

Each sample is excited with electricity and the light emitted is refracted through a dispersive prism. Which of the following best describes the difference between the two samples?

1. The emission spectrum for Sample A will show continuous lines in lower wavelengths

2. Both emission spectra will be identical

3. The emission spectrum for Sample A will show more discrete lines in higher wavelengths

4. The emission spectrum for Sample A will be brighter than Sample B **correct**

5. The emission spectrum for Sample A will show more discrete lines in lower wavelengths

Explanation:

The emission spectrum for a gas will show discrete wavelengths. The colors of the emission spectrum are independent of the amount of gas. However, Sample A will have more excited electrons which means more photons released. Sample A will be brighter.

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018 6.0 points

Which of the following best matches the quantum mechanical evidence to its conclusion?

1. Particle in a box: an electron can be found at any distance between 0 and L, with the highest probability being at L/n

2. Rydberg Energy Levels: the energy difference between consecutive n values decreases linearly as n increases

3. Absorption spectrum: the line spectra of any gas will show the same characteristic wavelengths

4. Emission spectrum: an excited sample of hydrogen gas releases characteristic wavelengths of light when its electrons fall from a high discrete energy level to a low discrete energy level **correct**

Explanation:

The emission spectrum demonstrated that an electrically excited sample of hydrogen emits characteristic wavelengths of light when the electrons fall from high quantized energy levels down to low energy levels.

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019 5.0 points

Which of the following is the correct shorthand electron configuration for Sb?

1. $[Ar]4s^2 3d^{10} 4p^2$

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

3. $[Kr]5s^2 5p^1$

4. $[Kr]5s^2 5p^2$

5. $[Ar]4s^2 4d^{10} 4p^1$

6. [Kr]$5s^2 4d^{10} 5p^3$ **correct**

7. [Ar]$4s^2 3d^{10} 4p^1$

8. [Kr]$5s^2 4d^{10} 5p^2$

Explanation:
The shorthand electron configuration includes only the valence electrons and the noble gas configuration representing the core electrons.

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020 6.0 points

A 37.0 nm beam of light is shined on a chromium surface. What is the maximum kinetic energy of the excited electrons? The work function of chromium is 4.50 eV.

1. No electrons are emitted

2. 1×10^{-17} J

3. 2.08×10^{-17} J

4. -7.16×10^{-19} J

5. 5.37×10^{-12} J

6. 4.65×10^{-18} J **correct**

7. -4.50 J

8. 5.37×10^{-15} J

Explanation:
Using the photoelectric equation:

$$\mathrm{E_k} = \mathrm{h}\nu - \phi$$

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

$$\mathrm{E_{photon}} = \frac{(6.626 \times 10^{-34}\mathrm{Js})(3.00 \times 10^{8}\frac{\mathrm{m}}{\mathrm{s}})}{37.0 \times 10^{-9}\mathrm{m}}$$

$$\mathrm{E_{photon}} = 5.37 \times 10^{-18}\ \mathrm{J}$$

$$\begin{aligned}\text{Work function} &= 4.50\,\mathrm{eV}\ (1.60 \times 10^{-19}\frac{\mathrm{J}}{\mathrm{eV}}) \\ &= 7.21 \times 10^{-19}\ \mathrm{J}\end{aligned}$$

The final answer is the difference between the photon energy and the work function, which is 4.65×10^{-18} J.