001 ___________ ___________ ___________________

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McCord CH301

unique: 49885

TTh 9:30 am - 11 am

Exam 2

Oct 15, 2018

Monday 7:30 - 9:00 PM

A - Mi in BUR 106

Mo - Z in JES A121A

Remember to refer to the Periodic Table handout that is separate from this exam copy.

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 22 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 3.0 points

Which of the following is the correct name for the chemical formula, $(NH_4)_2CO_3$?

1. Ammonium carbonate **correct**

2. Nitrohydrogen carbonic oxide

3. Nitrohydrogen carbamite

4. Nitrohydrogen carbonate

5. Ammonium carbamite

6. Diammonium carbonic oxide

Explanation:

Ammonium = NH_4^+

Carbonate = CO_3^{2-}

$(NH_4)_2CO_3$ = Ammonium carbonate

002 5.0 points

A mixture of argon and mercury vapor used in advertising signs emits light of wavelength of 580 nm. What is the energy for 1.00 mole of photons emitted at this wavelength?

1. 203 kJ/mol

2. 206 kJ/mol **correct**

3. 2.72×10^5 kJ/mol

4. 2.34×10^5 kJ/mol

5. 285 kJ/mol

6. 218 kJ/mol

7. 239 kJ/mol

8. 1.71×10^5 kJ/mol

Explanation:

$\lambda = 580 \text{ nm} = 5.8 \times 10^{-7}$ m

$c = \nu\,\lambda$, so $E = h\,\nu = \frac{h\,c}{\lambda}$.

$$\begin{aligned}\frac{E}{\text{atom}} &= \frac{6.626 \times 10^{-34}\ \text{J}\cdot\text{s}}{5.8 \times 10^{-7}\ \text{m}} \\ &\quad \times (3 \times 10^8\ \text{m}\cdot\text{s}^{-1}) \\ &= 3.42724 \times 10^{-19}\ \text{J/atom}\end{aligned}$$

$$\begin{aligned}\frac{E}{\text{mol}} &= (3.42724 \times 10^{-19}\ \text{J/atom}) \\ &\quad \times (6.022 \times 10^{23}\ \text{atoms/mol}) \\ &= 2.06388 \times 10^5\ \text{J/mol} \cdot \frac{1\ \text{kJ}}{1000\ \text{J}} \\ &= 206\,\text{kJ/mol}\end{aligned}$$

003 5.0 points

What is the wavelength corresponding to the smallest energy transition in the Balmer series?

1. 486 nm

2. 1875 nm

3. 657 nm **correct**

4. 122 nm

5. 182 nm

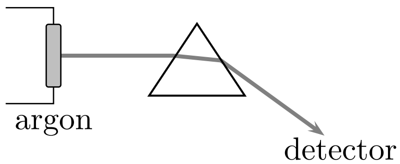
Explanation:

$$\begin{aligned}\nu &= \mathcal{R}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \\ &= (3.29 \times 10^{15}\ \text{Hz})\left(\frac{1}{2^2} - \frac{1}{3^2}\right) \\ &= 4.56944 \times 10^{14}\ \text{Hz}\end{aligned}$$

$$\begin{aligned}\lambda &= \frac{c}{\nu} \\ &= \frac{3.0 \times 10^8\ \text{m/s}}{4.56944 \times 10^{14}\ \text{Hz}} \\ &= 6.56535 \times 10^{-7}\ \text{m} \\ &= 656.535\ \text{nm}\end{aligned}$$

004 5.0 points

Argon gas absorbs light in the red, blue, and purple visible regions. To observe the emission spectra, a sample of argon gas is excited with electricity and the resulting electromagnetic radiation is passed through a prism (shown below).



Which of the following best describes the emission spectrum you should expect to see in this experiment?

1. A continuous spectrum broken by thin black lines in the green, orange, and yellow regions

2. Mostly black space with thin lines in the red, blue, and purple regions **correct**

3. Mostly black space with thin lines in the green, orange, and yellow regions

4. A continuous spectrum broken by thin black lines in the red, blue, and purple regions

5. A continuous spectrum

Explanation:
In this experiment, all light reaching the detector is being emitted by the argon atoms as electrons in these atoms fall from higher to lower energy levels. The energy of these emitted photons must correspond to the difference in energy between the two levels. Because energy levels are quantized – only specific energies are permitted – there will be only specific gaps between energy levels. Therefore we get only specific thin lines of color emitted, rather than a continuous spectrum.

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005 5.0 points

In a photoelectric effect experiment, a blue light forces the electrons of a metallic surface to eject at a velocity of about 380 m/s. The blue light is shut off and a dimmer (lower intensity) violet light is shined on the metal surface for the same amount of time. Which of the following best explains the results?

1. A fewer number of electrons are ejected, but the ejected electrons have a velocity greater than 380 m/s **correct**

2. The same number of electrons are ejected, but the ejected electrons have a velocity greater than 380 m/s

3. The same number of electrons are ejected and the ejected electrons have a velocity less than 380 m/s

4. The same number of electrons are ejected with the same velocity

5. A fewer number of electrons are ejected and the ejected electrons have a velocity less than 380 m/s

Explanation:
In this photoelectric effect experiment, decreasing the intensity results in a fewer number of ejected electrons. However, each photon has a higher energy. Therefore, the ejected electrons will have a higher kinetic energy and velocity. The overall conclusion is that a fewer number of electrons are ejected with a higher velocity.

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006 5.0 points

A 114 nm beam of light is shined on a palladium surface. What is the maximum velocity of the excited electrons? The work function of palladium is 5.60 eV.

1. No electrons are emitted

2. 964.0 km/s

3. -964.0 km/s

4. 1148 km/s

5. 1.859×10^9 km/s

6. 1363 km/s **correct**

7. 9.64×10^5 km/s

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.

$$E_{photon} = \frac{(6.626 \times 10^{-34} Js)(3.00 \times 10^8 \frac{m}{s})}{114 \times 10^{-9} m}$$

$$E_{photon} = 1.74 \times 10^{-18}\ J$$

$$\text{Work function} = 5.60\,\text{eV}\ (1.60 \times 10^{-19} \frac{J}{eV}) = 8.97 \times 10^{-19}\ J$$

The kinetic energy is the difference between the photon energy and the work function, which is 8.47×10^{-19} J.

Finally, the kinetic energy equation gives $E_k = \frac{1}{2}mv^2$, which can be used to solve for the velocity in m/s:

$$v = \sqrt{\frac{2 \times 8.47 \times 10^{-19}}{9.11 \times 10^{-31}}} \times \frac{1\,\text{km}}{1000\,\text{m}}$$

Answering in km/s gives us approximately 1363 km/s.

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007 3.0 points

Which of the following statement(s) is/are true regarding particle in a box and the radial distribution function?

I. When $n = 1$ for a particle in a box, the particle has the highest probability of being found in the center of the box

II. When $n = 3$ for a radial distribution function, there are three humps with the highest probability of finding an electron in the third hump (furthest from the nucleus)

III. The number of nodes is equal to the principal quantum number, n, for both radial distribution and particle in a box

IV. When $n = 1$ for a particle in a box, there is a zero percent chance that the particle will be found in the center of the box

1. I, II, and IV only

2. I and II only **correct**

3. II only

4. I, II, and III only

5. IV only

6. I only

Explanation:
For $n = 1$, the center of the box is the peak probability density. For the RDF, when $n = 3$, there are three humps with the highest probability in the furthest hump from the nucleus. Statements I and II are true. The number of the humps is equal to n and the number of nodes is equal to $n - 1$. Statement III is false. Statement IV is the opposite of Statement I.

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008 4.0 points

Which of the following is a possible quantum number set for a valence electron in calcium?

1. $n = 2, \ell = 0, m_\ell = -1, m_s = -1/2$

2. $n = 4, \ell = 4, m_\ell = -3, m_s = 1/2$

3. $n = 3, \ell = 0, m_\ell = 0, m_s = -1/2$

4. $n = 4, \ell = 0, m_\ell = 0, m_s = 1/2$ **correct**

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

6. $n = 4, \ell = 3, m_\ell = -1, m_s = -1/2$

Explanation:
There are only two possible quantum number sets total possible for a valence electron

in calcium because there are only two valence electrons in calcium. They are both $4s$ electrons, s-orbitals only have a single orientation ($\ell = 0$ and $m_\ell = 0$), and the spin in each orbital can be positive or negative. Therefore, the two possible quantum number sets are:

$$n = 4, \ell = 0, m_\ell = 0, m_s = 1/2$$

$$n = 4, \ell = 0, m_\ell = 0, m_s = -1/2$$

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009 5.0 points

What is the maximum number of quantum number sets possible for a $4d$ electron?

1. 10 **correct**

2. 5

3. 3

4. 14

5. 8

6. 6

Explanation:
According to Pauli's Exclusion Principle, each electron in a subshell will have a unique quantum number set. For a $4p$ electron, there are 3 orientations possible (m_ℓ = -1, 0, 1) and each orientation can have a negative and positive spin. This results in 6 quantum number sets. For a $4d$ electron, there are 5 orientations possible (m_ℓ = -2, -1, 0, 1, 2) and each orientation can have a negative and positive spin. This results in 10 quantum number sets.

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010 5.0 points

The third ionization of titanium is given by the equation:

$$Ti^{2+}(g) \longrightarrow Ti^{3+}(g) + e^-$$

This electron is removed from the...

1. 3p subshell

2. 2p subshell

3. 3d subshell **correct**

4. 3s subshell

5. 4d subshell

6. 4s subshell

Explanation:
Follow the energy order for removing from transition metals. The first two electrons (Ti to Ti^{2+}) are removed from the 4s. Finally the third electron, which is depicted by the equation in the question, is removed from the 3d.

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011 4.0 points

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

1. [Ar] $3d^6$

2. [Ar] $3d^5\,4s^1$ **correct**

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

4. [Ar] $4s^2\,4d^4$

5. [Ar] $4s^1\,4d^5$

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: [Ar] $3d^5\,4s^1$.

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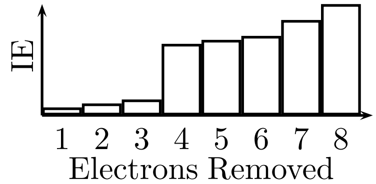
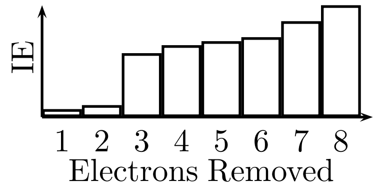
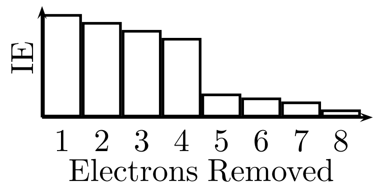
012 5.0 points

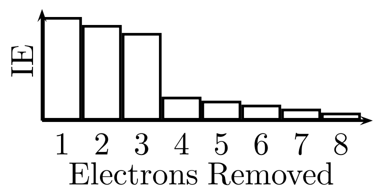
Which graph shows the correct trend for ionization energies, IE, of aluminum, Al?

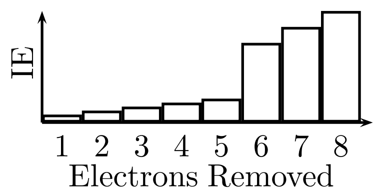
1. 

correct

2. 

3. 

4. 

5. 

Explanation:
Al has the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^1$. After three electrons are removed, the resulting ion, Al^{3+}, is isoelectric with neon and has a stable, full octet for its outer shell. This stable configuration makes it very hard to remove an electron and we see a large increase in the energy needed to remove a fourth electron.

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013 5.0 points

As you go from the top right to the bottom left of the periodic table, the atomic radius increases because Z_{eff} is getting (larger/smaller) and the shielding is (increasing/decreasing).

1. larger, increasing

2. larger, decreasing

3. smaller, decreasing

4. smaller, increasing **correct**

Explanation:
As you go down in the periodic table, shielding increases. Shielding will buffer the outer electrons from the positive charge on the nucleus, causing the atomic radius to increase. As you go from right to left on the periodic table, the Z_{eff} is getting smaller. Consequently, there is a smaller attractive force between the nucleus. Once again, this results in a larger radius.

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014 5.0 points

WITHDRAWN

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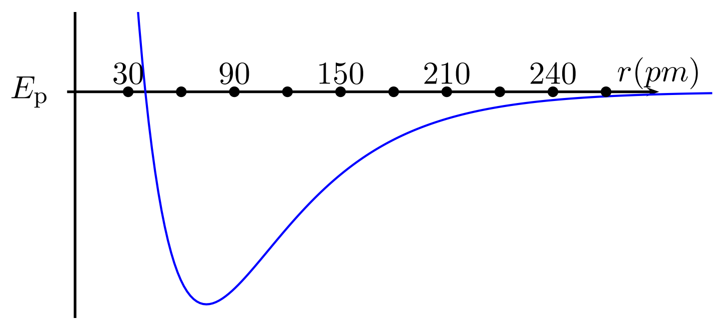
015 4.0 points

Consider the following potential energy (E_p) vs internuclear distance (r) plot for the interaction between two hydrogen atoms.



What will happen if you place two hydrogen atoms at an internuclear distance of 120 pm?

1. Attractions will dominate until the internuclear distance is approximately 75 pm **correct**

2. Attractions will dominate until the internuclear distance is approximately 90 pm

3. There will be no attractions or repulsions at this distance

4. Repulsions will dominate until the internuclear distance is infinite

5. Repulsions will dominate until the internuclear distance is approximately 75 pm

6. Attractions will dominate until the internuclear distance is equal to 0 pm

Explanation:

The bond length (minimum potential energy) is equal to about 75 pm. At any distance greater than 75 pm, attractions will dominate to reach minimum potential energy. At any distance less than 75 pm, repulsions will dominate to reach minimum potential energy.

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016 4.0 points

Which of the following fully describes the Lewis structure of CH_3OH?

1. 5 single bonds and 2 lone pairs **correct**

2. 3 single bonds and 1 double bond

3. 3 single bonds, 1 double bond, and 1 lone pair

4. 4 single bonds and 2 lone pairs

5. 5 single bonds and 0 lone pairs

Explanation:

Use S = N - A.

The Lewis structure for this molecule has 24 needed electrons and 14 available electrons. This results in 10 shared electrons or 5 bonds total. When you use all 5 bonds, you have 4 electrons left over, which will go into the lone pairs of oxygen. This molecule has 5 bonds total and 2 lone pairs.

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017 5.0 points

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

MgO, NaF, $CaCO_3$, Na_2O, NH_4ClO

1. $NH_4ClO < NaF < MgO < CaCO_3 < Na_2O$

2. $NH_4ClO < NaF < Na_2O < CaCO_3 < MgO$ **correct**

3. $Na_2O < NaF < CaCO_3 < MgO < NH_4ClO$

4. $MgO < CaCO_3 < NH_4ClO < NaF < Na_2O$

5. $Na_2O < MgO < NaF < NH_4ClO < CaCO_3$

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 NH_4ClO 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:

$$NH_4ClO < NaF < Na_2O < CaCO_3 < MgO$$

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018 5.0 points

What is the approximate bond order of the carbon-nitrogen bonds in the resonance hybrid of $C(NH_2)_3^+$?

1. 1.33 **correct**

2. 4

3. 1 and 2

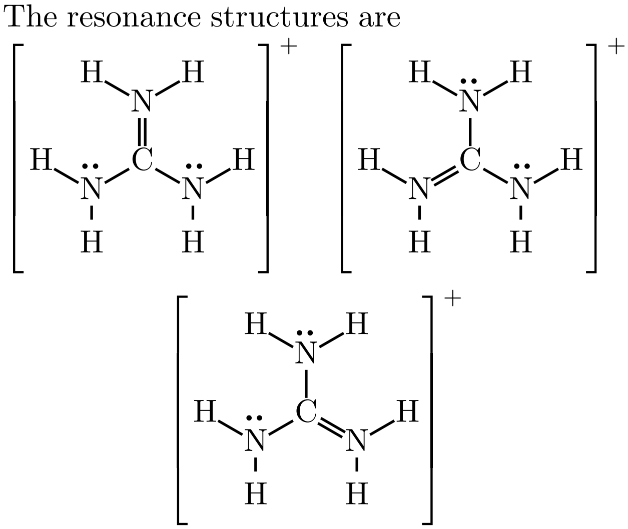
4. 4 and 3

5. 1, 2, and 3

6. 3

Explanation:

The resonance structures are



There are 4 total bonds averaged around 3 bonding regions. This results in an average bond order equal to about 1.33.

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019 4.0 points

Identify the type of compound for each of the following:

CaI_2 HCl $Ca_3(PO_4)_2$

1. CaI_2: Ionic

HCl: Covalent

$Ca_3(PO_4)_2$: Ionic **correct**

2. CaI_2: Ionic

HCl: Covalent

$Ca_3(PO_4)_2$: Covalent

3. CaI_2: Ionic

HCl: Ionic

$Ca_3(PO_4)_2$: Ionic

4. CaI_2: Covalent

HCl: Ionic

$Ca_3(PO_4)_2$: Covalent

5. CaI_2: Covalent

HCl: Covalent

$Ca_3(PO_4)_2$: Ionic

Explanation:

CaI_2: Ionic (metal-nonmetal)

HCl: Covalent (nonmetal-nonmetal)

$Ca_3(PO_4)_2$: Ionic (metal-polyatomic nonmetal)

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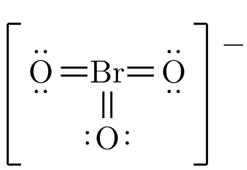
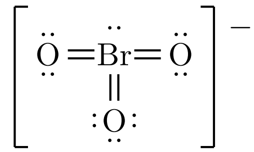
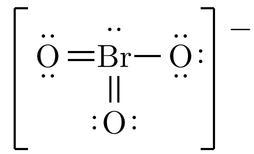
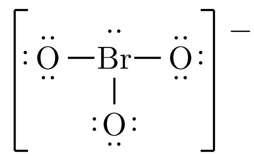
020 5.0 points

Which of the following is an acceptable Lewis structure for the bromate anion (BrO_3^-)?

1. 

2. 

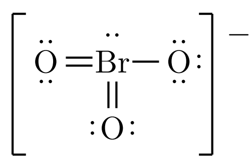
3.  **correct**

4. 

5. None of these structures contribute to the resonance of BrO_3^-

Explanation:

You must account for the number of available electrons, which is equal to 7 + 6(3) + 1 = 26 electrons. The structure:



has minimized formal charges, and the formal charges of all atoms add up to -1.

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021 5.0 points

Consider the Lewis structures for HCN and CH_3NH_2. Compared to HCN, the carbon-nitrogen bond in CH_3NH_2 is (longer/shorter) and (stronger/weaker).

1. longer, weaker **correct**

2. shorter, weaker

3. The carbon-nitrogen bond is the same length and strength in each molecule

4. shorter, stronger

5. longer, stronger

Explanation:

When comparing covalent bonds between the same elements, a stronger bond is expected to be shorter and a weaker bond is expected to be longer. The C-N bond in HCN is a triple bond. The C-N bond in CH_3NH_2 is a single bond. The single bond in CH_3NH_2 is expected to be longer and weaker.

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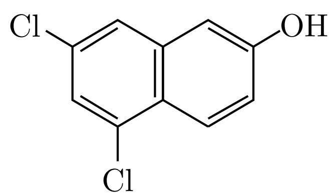
022 4.0 points

Consider the substituted naphthalene molecule below:



What is the correct empirical formula for this compound?

1. $C_{12}H_6Cl_2O$

2. $C_{10}H_6Cl_2O$ **correct**

3. $C_{10}H_5Cl_2O$

4. $C_{10}H_{11}Cl_2O$

5. $C_{13}H_5Cl_2O$

6. $C_{12}H_8Cl_2O$

Explanation:
The empirical formula is $C_{10}H_6Cl_2O$.