**Atomic Structure and Periodicity Practice Problems**

**Multiple Choice**

*Identify the letter of the choice that best completes the statement or answers the question.*

\_\_\_\_ 1. Which of the following shows the correct number of protons, neutrons and electrons in a neutral cesium-134 atom?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 55 p, 55 n, 55 e | c. | 55 p, 79 n, 79 e |
| b. | 55 p, 79 n, 55 e | d. | 79 p, 55 n, 79 e |

\_\_\_\_ 2. Which of the following correctly calculates the energy (in joules) of a single photon of light with a wavelength of 645 nm?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | $$\frac{(6.63 × 10^{-34})(3.00 × 10^{8})}{645 × 10^{-9}}$$ | c. | $$\frac{(6.63 × 10^{-34})}{(645) (3.00 × 10^{8})}$$ |
| b. | $$\frac{645 × 10^{-9}}{(6.63 × 10^{-34})(3.00 × 10^{8})}$$ | d. | $$\frac{(3.00 × 10^{8})}{(645 × 10^{-9})}$$ |

\_\_\_\_ 3. In which of the following groups are the three species isoelectronic; i.e., have the same number of electrons?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | S2ñ, K+, Ca2+ | c. | O2ñ, S2ñ, Clñ |
| b. | Sc, Ti, V2+ | d. | Mg2+, Ca2+, Sr2+ |

\_\_\_\_ 4. Which element has atoms containing only one electron in the highest occupied energy sublevel? (Assume that the atoms are in the ground state.)

|  |  |  |  |
| --- | --- | --- | --- |
| a. | S | c. | Ga |
| b. | Ca | d. | Sb |

\_\_\_\_ 5. Of the following electron configurations of neutral atoms, which represents an atom in an excited state?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 1s2 2s2 2p5 | c. | 1s2 2s2 2p6 3s1 |
| b. | 1s2 2s2 2p5 3s2 | d. | 1s2 2s2 2p6 3s2 3p2 |

\_\_\_\_ 6. 1*s*2 2*s*2 2*p*6 3*s*2 3*p*3

 Atoms of an element, X, have the electronic configuration shown above. The compound most likely formed with magnesium, Mg, is \_\_\_\_.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | MgX | c. | MgX2 |
| b. | Mg2X | d. | Mg3X2 |

The graph below shows the photoelectron spectrum of argon.



\_\_\_\_ 7. Which of the following statements correctly explains why peak C has a higher photoelectron intensity than peak B?

|  |  |
| --- | --- |
| a. | Argon atoms have eight valence electrons. |
| b. | The electrons in the 2s sublevel experience a greater coulombic attraction to the nucleus than electrons in the 2p sublevel. |
| c. | The electrons in the 2p sublevel have a larger average distance from the nucleus than electrons in the 2s sublevel. |
| d. | Six electrons occupy the 2p sublevel in argon, and two electrons occupy the 2s sublevel. |

\_\_\_\_ 8. Which of the following statements best why peak C has a lower ionization energy than peak B?

|  |  |
| --- | --- |
| a. | The electrons in the 2s sublevel experience a greater coulombic attraction to the nucleus than electrons in the 2p sublevel.  |
| b. | Six electrons occupy the 2p sublevel in argon, and two electrons occupy the 2s sublevel. |
| c. | The electrons in the 2s sublevel have a larger average distance from the nucleus than electrons in the 2p sublevel. |
| d. | The electrons in the 2s sublevel experience a greater shielding effect from the nuculear charge than the electrons in the 2p sublevel. |

\_\_\_\_ 9.

|  |
| --- |
| Ionization Energies for element *X* (kJ mol-1) |
| First | Second | Third | Fourth | Fifth |
| 580 | 1,815 | 2,740 | 11,600 | 14,800 |

The ionization energies for element *X* are listed in the table above. On the basis of the data, element *X* is most likely to be

|  |  |  |  |
| --- | --- | --- | --- |
| a. | Na | c. | Al |
| b. | Mg | d. | Si |

\_\_\_\_ 10. Which of the following is the best explanation for the fact that the F- ion is smaller than the O2- ion?

|  |  |
| --- | --- |
| a. | F- has a larger nuclear mass than O2- has. |
| b. | F-has a larger nuclear charge than O2- has. |
| c. | F-has more electrons than O2- has. |
| d. | F- is more electronegative than O2- is. |

\_\_\_\_ 11. In the periodic table, as the atomic number increases from 11 to 17, what happens to the atomic radius?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | It remains constant. | c. | It increases, then decreases. |
| b. | It increases only. | d. | It decreases only. |

\_\_\_\_ 12. Which of the following correctly identifies which has the smaller atomic radius, P or As, and supplies the correct justification?

|  |  |
| --- | --- |
| a. | P, because its electrons experience a high effective nuclear charge |
| b. | P, because its ionization energy is lower |
| c. | As, because its core electrons contribute a greater shielding effect |
| d. | As, because its nuclear mass is higher |

**Problem**

Answer the following questions about the element selenium, Se (atomic number 34). (2000)

 13. Samples of natural selenium contain six stable isotopes. In terms of atomic structure, explain what these isotopes have in common, and how they differ. (2 pts)

 14. Write the *complete* electron configuration (e.g., 1s2 2s2 etc.) for a selenium atom in the ground state. Indicate the number of unpaired electrons in the ground-state atom, and explain your reasoning. (2 pts)

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Answer the following questions regarding light and its interactions with molecules, atoms, and ions. (1999)

 15. The longest wavelength of light with enough energy to break the Cl-Cl bond in Cl2*(g)* is 495 nm.

a) Calculate the frequency, in s-1, of the light. (1 pt)

b) Calculate the energy, in J, of a photon of the light. (1 pt)

c) Calculate the minimum energy, in kJ mol-1, of the Cl-Cl bond. (1 pt)

16. A certain line in the spectrum of atomic hydrogen is associated with the electronic transition in the H atom from the sixth energy level (n = 6) to the second energy level (n = 2).

a) Indicate whether the H atom emits energy or whether it absorbs energy during the transition. Explain your answer. (3 pts)

b) Explain why the wavelength of light associated with the n = 5 to n = 2 transition in the H atom is greater than that associated with the n = 6 to n = 2 transition in the H atom. (2 pts)

The diagram shows the first ionization energies for the elements from Li to Ne. (1990 D)



 17. In terms of atomic structure, explain why there is an increase in the first ionization energy from Li to Ne.

 18. In terms of atomic structure, explain why the first ionization energy of O is lower than that of N.

 19. In terms of atomic structure, explain why the ionic radius of N3- is larger than that of O2-.

20. As shown in the table below, the first ionization energies of Si, P, and Cl show a trend.

|  |  |
| --- | --- |
| **Element** | **First Ionization Energy (kJ mol-1)** |
| Si | 786 |
| P | 1,012 |
| Cl | 1,251 |

a) For each of the three elements, identify the principle energy level (e.g, n = 1, n = 2, etc.) occupied by the valance electrons in the atom. (1 pt)

b) Explain the reasons for the trend in first ionization energies. (1 pt)

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 21. In terms of atomic structure, explain why the first ionization energy of selenium is

i) less than that of bromine (atomic number 35), and

ii) greater than that of tellurium (atomic number 52). (2 pts)

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 22. Using principles of atomic structure, explain why potassium has a lower first-ionization energy than lithium.

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**Atomic Structure and Periodicity Practice Problems**

**Answer Section**

**MULTIPLE CHOICE**

 1. ANS: B PTS: 1

 2. ANS: A PTS: 1

 3. ANS: A PTS: 1

 4. ANS: C PTS: 1

 5. ANS: B PTS: 1

 6. ANS: D PTS: 1

 7. ANS: D PTS: 1

 8. ANS: A PTS: 1

 9. ANS: C PTS: 1 DIF: 4

 10. ANS: B PTS: 1

 11. ANS: D PTS: 1

 12. ANS: A PTS: 1

**PROBLEM**

 13. ANS:

The isotopes have the same number of protons (34), but a different number of neutrons. No comment about the number of electrons is necessary.

PTS: 1

 14. ANS:

1s2 2s2 sp6 3s2 3p6 4s2 3d10 4p4

since there are three different 4p orbitals, there must be two unpaired electrons (some explanation of hund’s rule, may include a diagram!)

PTS: 1

 15. ANS:

a) 6.06 x 1014 sec-1

b) 4.02 x 10-19 J

c) answer from b x 1/avogadro’s number x 1000j/kJ = 242 kJ/mol

PTS: 1

 16. ANS:

a) Energy is emitted. The n = 6 state is at a higher energy than the n = 2 state. Going from a high energy state to a low energy state means that energy must be emitted.

c) deltaE for n = 6 to n = 2 is greater than deltaE for the n = 5 to n = 2 transition. Since deltaE is smaller for the n = 5 to n = 2 transition, the wavelength of light emitted is longer.

PTS: 1

 17. ANS:

Across the period from Li to Ne, the number of protons is increasing in the nucleus. Hence, the nuclear charge is increasing with a consequently stronger attraction for electrons and an increase in ionization energy.

PTS: 1

 18. ANS:

The electron ionized in O is paired with another electron in the same orbital, whereas in N the electron comes from a singly-occupied orbital. The ionization energy of the O electron is less because of the repulsion between the two electrons in the same orbital.

PTS: 1

 19. ANS:

The addition of electrons to a neutral atom produces an anion that is significantly larger than its parent atom. Even though both ions are isoelectronic, there is a greater nuclear positive charge in the oxide ion causing its electrons to be more tightly pulled toward the nucleus.

PTS: 1

 20. ANS:

period # = principle energy level 3

l to R: increasing nuclear charge, but the outermost electrons are in the same sublevel, so as you go from Si to Cl, the outermost electrons experience a stronger coulombie attraction to the nucleus. The outermost electrons of Cl have a stronger attraction to the nucleus than for Si, so more energy is required to remove an electron from Cl than from Si.

PTS: 1

 21. ANS:

i) the ionized electrons in both Se and Br are in the same energy level, but Br has more protons than Se (higher nuclear charge) , so the outermost electrons in Br experience a stronger coulombic attraction to the nucleus than the outermost electrons of Se. (good answer should have 2 parts)

ii) The electron removed from a Te atom is in a 5p orbital, while the electron removed from a Se atom is in a 4p orbital. The 5p orbital is in a higher energy level and is farther from the nucleus than an electron in a 4p sublevel. Therefore, the outermost electron of Te experiences a weaker coulombic attraction to the nucleus than the outermost electron of Se, and so less energy is required to remove the valence electron from Te than from Se.

(Make sure students directly compare the two elements in their response! Avoid pronouns and specify the chemical species in your response)

PTS: 1

 22. ANS:

potassium’s valence electron occupies the 4*s*sublevel, whhile lithium’s outermost electron occupies the 2*s*1 sublevel. Potassium’s electron is is a higher energy level which is farther from the nucleus than the valence electron of Li, so K’s valence electron experiences a weaker coulombic attraction to the nucleus than Li’s valence. Therefore less energy required to remove the valence electron from K than from Li.

PTS: 1