MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) Electrons in the 1s subshell are much closer to the nucleus in Ar than in He due to the larger _________ in Ar.
   A) diamagnetism
   B) Hund's rule
   C) paramagnetism
   D) azimuthal quantum number
   **E) nuclear charge**

2) Of the following, which gives the correct order for atomic radius for Mg, Na, P, Si and Ar?
   A) Si > P > Ar > Na > Mg
   B) Ar > P > Si > Mg > Na
   C) Ar > Si > P > Na > Mg
   **D) Na > Mg > Si > P > Ar**
   E) Mg > Na > P > Si > Ar

3) The atomic radius of main-group elements generally increases down a group because _________.
   A) effective nuclear charge decreases down a group
   B) effective nuclear charge increases down a group
   C) effective nuclear charge zigzags down a group
   **D) the principal quantum number of the valence orbitals increases**
   E) both effective nuclear charge increases down a group and the principal quantum number of the valence orbitals increases

4) Which one of the following has the smallest radius?
   A) P
   B) Br
   **C) Cl**
   D) Na
   E) Fe

5) In which of the following atoms is the 2s orbital closest to the nucleus?
   A) S
   B) P
   **C) Cl**
   D) Si
   E) The 2s orbitals are the same distance from the nucleus in all of these atoms.

6) Which of the following correctly lists the five atoms in order of increasing size (smallest to largest)?
   A) F < K < Ge < Br < Rb
   **B) F < Br < Ge < K < Rb**
   C) F < Ge < Br < K < Rb
   D) F < Br < Ge < Rb < K
   E) F < K < Br < Ge < Rb
Consider the following electron configurations to answer the questions that follow:

(i) [Kr] 5s\(^1\)
(ii) [Ne] 3s\(^2\) 3p\(^5\)
(iii) [Ar] 4s\(^2\) 3d\(^{10}\) 4p\(^4\)
(iv) [Ne] 3s\(^2\) 3p\(^6\)
(v) [Ar] 4s\(^1\)

7) The electron configuration of the atom with the largest atomic radius is ________.
   - A) (i)  
   - B) (ii)  
   - C) (iii)  
   - D) (iv)  
   - E) (v)

8) The electron configuration of the atom that is expected to form a stable -2 ion is ________.
   - A) (i)  
   - B) (ii)  
   - C) (iii)  
   - D) (iv)  
   - E) (v)

9) The electron configuration of the atom that is expected to have the lowest first ionization energy is ________.
   - A) (i)  
   - B) (ii)  
   - C) (iii)  
   - D) (iv)  
   - E) (v)

10) Of the choices below, which gives the order for first ionization energies?
    - A) Al > Si > S > Cl > Ar
    - B) Cl > S > Al > Si > Ar
    - C) S > Si > Cl > Al > Ar
    - D) Cl > S > Al > Ar > Si
    - E) Ar > Cl > S > Si > Al

11) ________ have the lowest first ionization energies of the groups listed.
    - A) Noble gases
    - B) Alkali metals
    - C) Halogens
    - D) Alkaline earth metals
    - E) Transition elements

12) Which of the following correctly lists the six elements in order of increasing first ionization energy?
    - A) Li < Be < B < C < O < N
    - B) Li < B < Be < C < O < N
    - C) Li < Be < B < O < C < N
    - D) Li < Be < B < C < N < O
    - E) Li < B < Be < C < N < O

13) Which of the following has the largest second ionization energy?
    - A) P
    - B) Mg
    - C) Al
    - D) Na
    - E) Si
14) Which equation correctly represents the first ionization of aluminum?
   A) $\text{Al}^+ (g) + e^- \rightarrow \text{Al} (g)$
   B) $\text{Al}^- (g) \rightarrow \text{Al} (g) + e^-$
   C) $\text{Al} (g) \rightarrow \text{Al}^+(g) + e^-$
   D) $\text{Al} (g) + e^- \rightarrow \text{Al}^- (g)$
   E) $\text{Al} (g) \rightarrow \text{Al}^- (g) + e^-$

15) Which of the following correctly represents the second ionization of aluminum?
   A) $\text{Al}^- (g) + e^- \rightarrow \text{Al}^{2-} (g)$
   B) $\text{Al} (g) \rightarrow \text{Al}^+ (g) + e^-$
   C) $\text{Al}^+ (g) + e^- \rightarrow \text{Al} (g)$
   D) $\text{Al}^+ (g) \rightarrow \text{Al}^{2+} (g) + e^-$
   E) $\text{Al}^+ (g) + e^- \rightarrow \text{Al}^{2+} (g)$

16) Which of the following sets contains species that are isoelectronic?
   A) Cl, Ar, K
   B) F, Ne, Na
   C) F$^-$, S$^2-$, Ar$^-$
   D) Al$^{3+}$, S$^2-$, Ar
   E) F$^-$, Ne, Na$^+$$^*

17) Of the following species, _________ has the largest radius.
   A) Kr
   B) Sr$^{2+}$
   C) Rb$^+$
   D) Br$^-$
   E) Ar

18) Of the compounds below, _________ has the smallest ionic separation.
   A) RbF
   B) KF
   C) SrBr$_2$
   D) K$_2$S
   E) RbCl

19) Which isoelectronic series is correctly arranged in order of increasing radius?
   A) Ca$^{2+}$ < K$^+$ < Cl$^-$ < Ar
   B) K$^+$ < Ca$^{2+}$ < Ar < Cl$^-$
   C) Ca$^{2+}$ < Ar < K$^+$ < Cl$^-$
   D) Cl$^-$ < Ar < K$^+$ < Ca$^{2+}$
   E) Ca$^{2+}$ < K$^+$ < Ar < Cl$^-$

20) Of the following elements, _________ has the most negative electron affinity.
    A) I
    B) Br
    C) Cl
    D) Se
    E) S

21) In general, as you go across a period in the periodic table from left to right:
    (1) the atomic radius _________;
    (2) the electron affinity becomes _________ negative; and
    (3) the first ionization energy _________
    A) decreases, increasingly, increases
    B) decreases, decreasingly, increases
    C) increases, increasingly, decreases
    D) increases, increasingly, increases
    E) decreases, decreasingly, decreases
22) Sodium is much more apt to exist as a cation than is chlorine. This is because ________.
   A) chlorine is more metallic than sodium
   B) chlorine has a greater electron affinity than sodium does
   C) chlorine is a gas and sodium is a solid
   D) chlorine has a greater ionization energy than sodium does
   E) chlorine is bigger than sodium

23) Which equation correctly represents the electron affinity of calcium?
   A) Ca (g) → Ca⁺ (g) + e⁻
   B) Ca⁺ (g) + e⁻ → Ca (g)
   C) Ca (g) → Ca⁻ (g) + e⁻
   D) Ca⁻ (g) → Ca (g) + e⁻
   E) Ca (g) + e⁻ → Ca⁻ (g)

Consider the following electron configurations to answer the questions that follow:

(i) 1s² 2s² 2p⁶ 3s¹
(ii) 1s² 2s² 2p⁶ 3s²
(iii) 1s² 2s² 2p⁶ 3s² 3p¹
(iv) 1s² 2s² 2p⁶ 3s² 3p⁴
(v) 1s² 2s² 2p⁶ 3s² 3p⁵

24) The electron configuration of the atom forming the smallest cation is ________.
   A) (i) B) (ii) C) (iii) D) (iv) E) (v)

25) The electron configuration belonging to the atom with the highest second ionization energy is ________.
   A) (i) B) (ii) C) (iii) D) (iv) E) (v)

26) The electron configuration of the atom with the most negative electron affinity is ________.
   A) (i) B) (ii) C) (iii) D) (iv) E) (v)

27) The electron configuration of the atom that is expected to have a positive electron affinity is ________.
   A) (i) B) (ii) C) (iii) D) (iv) E) (v)

28) Of the elements below, ________ is the most metallic.
   A) sodium B) barium C) cesium D) magnesium E) calcium

29) Element M reacts with chlorine to form a compound with the formula MCl₂. Element M is more reactive than magnesium and has a smaller radius than barium. This element is ________.
   A) Na B) Sr C) Be D) Ra E) K
30) Consider the general valence electron configuration of ns^2np^5 and the following statements:
   (i) Elements with this electron configuration are expected to form -1 anions. ✓
   (ii) Elements with this electron configuration are expected to have large positive electron affinities.
   (iii) Elements with this electron configuration are nonmetals. ✓
   (iv) Elements with this electron configuration form acidic oxides. ✓

Which statements are true?
A) (i) and (ii)
B) (ii) and (iii)
C) (i), (iii), and (iv)
D) (i), (ii), and (iii)
E) All statements are true.

31) Consider the general valence electron configuration of ns^2 and the following statements:
   (i) Elements with this electron configuration have low second ionization energies.
   (ii) Elements with this electron configuration have high third ionization energies.
   (iii) Elements with this electron configuration have positive electron affinities.
   (iv) Elements with this electron configuration form basic oxides.

Which statements are true?
A) (ii) and (iii)
B) (i), (iii), and (iv)
C) (ii) and (iv)
D) (i) and (iii)
E) All statements are true.

32) The wavelength of light that has a frequency of 1.20 x 10^{13} s^{-1} is ________ m.
   A) 12.0  B) 2.50 x 10^{-5}  C) 25.0  D) 2.5  E) 0.0400

33) Ham radio operators often broadcast on the 6-meter band. The frequency of this electromagnetic radiation is ________ MHz.
   A) 200  B) 20  C) 50  D) 500  E) 2.0

34) Of the following, ________ radiation has the shortest wavelength.
   A) microwave  B) ultraviolet  C) radio  D) infrared  E) X-ray

35) The wavelength of a photon that has an energy of 5.25 x 10^{19} J is ________ m.
   A) 4.21 x 10^{-24}  B) 3.79 x 10^{-7}  C) 2.38 x 10^{-23}  D) 3.79 x 10^{7}  E) 2.64 x 10^{6}

36) It takes 254 kJ/mol to eject electrons from a certain metal surface. What is the longest wavelength of light (nm) that can be used to eject electrons from the surface of this metal via the photoelectric effect?
   A) 725  B) 165  C) 233  D) 472  E) 552

\[ \frac{291 \text{ kJ/mol} \times \frac{1 \text{ mol}}{1 \text{ kJ}} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ photons}}}{4.22 \times 10^{-19} \text{ J/photon}} = 4.22 \times 10^{-19} \text{ J/photon} \]

\[ 4.22 \times 10^{-19} \text{ J} = h \nu \]

\[ \nu = \frac{4.22 \times 10^{-19} \text{ J}}{h} \]

\[ n = 4.72 \times 10^{7} \text{ m} \times \frac{10^{9} \text{ nm}}{1 \text{ m}} = 472 \]
37) Of the following transitions in the Bohr hydrogen atom, the _________ transition results in the emission of the highest-energy photon.
   A) n = 6 → n = 1    B) n = 1 → n = 4    C) n = 3 → n = 6    D) n = 1 → n = 6    E) n = 6 → n = 3

38) Which one of the following is not a valid value for the magnetic quantum number of an electron in a 5d subshell?
   A) -1    B) 2    C) 3    D) 1    E) 0

39) An electron cannot have the quantum numbers n = ________, l = ________, m_l = ________.
   A) 1, 1, 1    B) 2, 1, -1    C) 3, 2, 1    D) 2, 0, 0    E) 3, 1, -1

40) Electrons that are in degenerate orbitals have the same ________.
   A) spatial orientation    B) value of n    C) size    D) energy    E) shape

41) Which set of three quantum numbers (n, l, m_l) corresponds to a 3d orbital?
   A) 3, 3, 2    B) 3, 3, 3    C) 3, 2, 2    D) 2, 3, 3    E) 2, 1, 0

42) Which one of the following represents an acceptable possible set of quantum numbers (in the order n, l, m_l, m_s) for an electron in an atom?
   A) 2, 1, 0, 0    B) 2, 0, 2, +1/2    C) 2, 2, 0, 1/2    D) 2, 1, -1, 1/2    E) 2, 0, 1, -1/2
43) Which electron configuration represents a violation of the Pauli exclusion principle?

A) [Diagram A]

B) [Diagram B]

C) [Diagram C]

D) [Diagram D]

E) [Diagram E]

44) Which one of the following configurations depicts an excited oxygen atom?

A) 1s\(^2\)2s\(^2\)2p\(^1\)
B) 1s\(^2\)2s\(^2\)2p\(^4\)
C) 1s\(^2\)2s\(^2\)2p\(^2\)3s\(^2\)
D) [He]2s\(^2\)2p\(^4\)
E) 1s\(^2\)2s\(^2\)2p\(^2\)

45) There are _______ unpaired electrons in a ground state phosphorus atom.

A) 0
B) 1
C) 2
D) 3
E) 4
46) Which electron configuration represents a violation of Hund’s rule for an atom in its ground state?

A)
\[
\begin{array}{ccc}
1s & 2s & 2p \\
\updownarrow & \updownarrow & \upupdownupdownarrow \\
\end{array}
\]

B)
\[
\begin{array}{ccc}
1s & 2s & 2p \\
\updownarrow & \upuparrow & \upuparrow \\
\end{array}
\]

C)
\[
\begin{array}{ccc}
1s & 2s & 2p \\
\updownarrow & \upuparrow & \upuparrow \\
\end{array}
\]

D)
\[
\begin{array}{ccc}
1s & 2s & 2p \\
\updownarrow & \upuparrow & \updownarrow \updownarrow \\
\end{array}
\]

E)
\[
\begin{array}{ccc}
1s & 2s & 2p \\
\up & \up & \up \up \\
\end{array}
\]

47) The valence shell of the element X contains 2 electrons in a 5s subshell. Below that shell, element X has a partially filled 4d subshell. What type of element is X?

A) chalcogen  
B) main group element  
C) halogen  
D) alkali metal  
E) transition metal

48) Elements in group ________ have a np⁶ electron configuration in the outer shell.

A) 6A  B) 4A  C) 7A  D) 5A  E) 8A