3 • Atomic Structure

3.0 Unite Test - Practice

- You may use a pencil, eraser, and scientific calculator to complete the test.
- You will be given a periodic table. No other resources are allowed.
- Please transfer your answers for Sections 1, 2, and 3 onto the Answer Document. Work for these questions will not be graded. However, sufficient and appropriate work must be shown for the Free Response questions in order to receive full credit.

SECTION 1: MATCHING. Use the choices below to answer the following questions. Answer choices may be used once, more than once, or not at all. (1 point each)

1. Has the smallest atomic radius. C
   (A) Aluminum
   (B) Beryllium
   (C) Carbon
   (D) Silicon

2. Has an electron configuration [Ne] 3s^2 3p^2. D

3. Has the largest ionization energy. C

4. Has two valence electrons. B

SECTION 2: TRUE/FALSE. (1 point each)
Evaluate the statement in column 1. If it’s TRUE, fill in bubble A. If it’s FALSE, fill in bubble B.
Evaluate the statement in column 2. If it’s TRUE, fill in bubble C. If it’s FALSE, fill in bubble D.
If column 2 is the correct explanation for column 1, then bubble E.

- If both columns are TRUE, and column 2 is the correct explanation, bubble ACE.
- If both columns are TRUE, but column 2 is not the correct explanation, bubble AC.
- If column 1 is TRUE and column 2 is FALSE, bubble AD.
- If column 1 is FALSE and column 2 is TRUE, bubble BC.
- If column 1 is FALSE and column 2 is FALSE, bubble BD.

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. In a cobalt atom, the electron furthest from the nucleus occupies the 3d orbital.</td>
<td>BECAUSE the valence electrons in cobalt occupy the 3d orbital.</td>
</tr>
<tr>
<td>6. There are four orbitals in the 4d subshell.</td>
<td>BECAUSE ten electrons can occupy the 4d subshell.</td>
</tr>
<tr>
<td>7. Fluorine has a higher ionization energy than oxygen.</td>
<td>BECAUSE fluorine has more valence electrons than oxygen.</td>
</tr>
</tbody>
</table>

SECTION 3: MULTIPLE CHOICE. Select the best answer choice for each question. (1 point each)

8. What is the energy in joules of a photon of light with frequency of 8.0 \( \times 10^{15} \) sec\(^{-1}\)?
   \( h = 6.626 \times 10^{-34} \) J s, \( c = 3.0 \times 10^8 \) m s\(^{-1}\)
   (A) \( 1 \times 10^9 \)
   (B) \( 5 \times 10^4 \)
   (C) \( 5 \times 10^{-18} \)
   (D) \( 2 \times 10^{-25} \)

9. Which of the following forms of light has the greatest energy?
   (A) Cell phone bands \( \nu = 8.0 \times 10^8 \) Hz
   (B) Microwave oven \( \nu = 2.4 \times 10^9 \) Hz
   (C) Blu-Ray laser \( \lambda = 4.0 \times 10^{-7} \) m
   (D) Satellite TV \( \lambda = 1.0 \times 10^{-1} \) m
10. What is the maximum number of electrons that can fill the 4f orbitals?
   (A) 7
   (B) 8
   (C) 10
   (D) 14

11. Which of the following is the correct electron configuration for the electrons in $^{34}\text{S}^{2-}$?
   (A) [Ne] $3s^2 3p^6$
   (B) [Ne] $3s^2 3p^6$
   (C) [Ne] $3s^2 3p^6$
   (D) [Ne] $3s^6$

12. Which of the following electron configurations is correct for a ground state neutral atom?
   (A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$
   (B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
   (C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
   (D) $1s^2 2s^2 3s^2 3p^6 4s^2$

13. Which electrons are being placed into orbitals correctly?
   (A) 
   (B) 
   (C) 
   (D) 

14. Which group of elements forms 1– ions?
   (A) Alkali metals
   (B) Alkaline earth metals
   (C) Halogens
   (D) Noble gases

15. When a neutral Cl atom becomes a Cl⁻ ion how and why does the size change?
   (A) bigger / more electron-electron repulsion
   (B) bigger / more electron-proton attraction
   (C) smaller / more electron-electron repulsion
   (D) smaller / more electron-proton attraction

16. The atomic orbital shown could be one in the
   (A) 1s subshell
   (B) 2p subshell
   (C) 3d subshell
   (D) 4f subshell

17. Where are the largest atoms located on the periodic table?
   (A) lower left
   (B) lower right
   (C) upper left
   (D) upper right

18. Atomic number increases →
Which sets of atoms represent the alkali metals?
   (A) W
   (B) X
   (C) Y
   (D) Z

19. Which of the following elements has the same number of valence electrons as carbon?
   (A) Calcium
   (B) Lead
   (C) Oxygen
   (D) Titanium

Questions 20-21: Consider the following elements on the Periodic Table:

<table>
<thead>
<tr>
<th>Se</th>
<th>Br</th>
</tr>
</thead>
<tbody>
<tr>
<td>Te</td>
<td>I</td>
</tr>
</tbody>
</table>

20. Which element has the largest atomic radius?
   (A) Br
   (B) I
   (C) Se
   (D) Te

21. Which element has the largest ionization energy?
   (A) Br
   (B) I
   (C) Se
   (D) Te
Questions 22-25: Consider the element iron.

22. The electrons in iron that are farthest from the nucleus occupy a ____ orbital.
   (A) 3p
   (B) 3d
   (C) 4s
   (D) 4p

23. The electrons in iron that have the highest energy occupy a ____ orbital.
   (A) 3p
   (B) 3d
   (C) 4s
   (D) 4p

24. How many orbitals in iron are half-filled, that is, have only one electron?
   (A) 1
   (B) 2
   (C) 3
   (D) 4

25. How many valence electrons does iron have?
   (A) 2
   (B) 6
   (C) 8
   (D) 4

26. Consider the following data for element X:
   First ionization energy: 738 kJ/mol
   Second ionization energy: 1451 kJ/mol
   Third ionization energy: 7733 kJ/mol
   Fourth ionization energy: 10540 kJ/mol
Which element could be X?
   (A) Ne
   (B) Na
   (C) Mg
   (D) Al

SECTION 4: FREE RESPONSE. Show all your work to receive full credit.

27. Consider the element tungsten, W (Z = 74).
   (a) One of the lines in the emission spectrum of tungsten (corresponding to the n = 4 to n = 1 transition) is in the x-ray frequencies and has a wavelength of 2.14 x 10^-11 m. What is the frequency of this light?
   Use c = 3.0 x 10^8 m/s and h = 6.626 x 10^-34 J s
   \[ f = \frac{c}{\lambda} = \frac{3.0 \times 10^8 \text{ m/s}}{2.14 \times 10^{-11} \text{ m}} = 1.4 \times 10^{19} \text{ Hz} \]

   (b) What is the energy of this light? (3 points)
   \[ E = hf = (6.626 \times 10^{-34} \text{ J s}) \times (1.4 \times 10^{19} \text{ Hz}) = 9.3 \times 10^{-15} \text{ J} \]

   (c) Write the long form electron configuration for the neutral atom, W. (4 points)
   Long Form: 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{14}
   Short Form: [Xe]6s^2 4f^{14} 5d^{14}
   Number of valence electrons: 2

   (d) Write the short form electron configuration for the tungsten(VI) ion, W^{6+}. (2 points)
   \[ [\text{Xe}]4f^{14} \]
(e) Which is expected to have a larger radius, W or W⁺? Explain briefly. (3 points)

\[
\text{W is expected to have a larger radius because ...}
\]

\[
\text{W has more e⁻ than W⁺, so it has more e⁻-e⁻ repulsion and larger radius.}
\]

28. Make a prediction for each of the following and explain. (4 points each)

(a) Which has a larger atomic radius: rubidium (Rb) or strontium (Sr)?

The outer e⁻ of Rb and Sr are both in the 5s, however Rb has 37p and Sr has 38p. The outer e⁻ of an atom with fewer p⁰ is less attracted to the nucleus than farther from the nucleus. Rb has fewer p⁰ so it is larger.

(b) Which has a higher ionization energy: selenium (Se) or tellurium (Te)?

The outer e⁻ of Se is in 4p and Te is 5p. An e⁻ in a lower shell is more attracted to the nucleus and therefore harder to remove. Because the outer e⁻ of Se is in a lower shell, it is harder to remove so Se has higher ionization energy.

(c) Which has a smaller radius: chloride ion (Cl⁻) or potassium ion (K⁺)?

Both Cl and K⁺ have 18 e⁻. But because K has more p⁰ the outer e⁻ are more attracted to the nucleus. So K is smaller.

This blank Periodic Table may be helpful to you.