1. What is the decay product resulting from the emission of an alpha particle from $^{210}_{85}$At?
   a) $^{207}_{82}$Pb  
   b) $^{210}_{86}$Rn  
   c) $^{206}_{85}$Bi  
   d) $^{206}_{81}$Tl  
   e) $^{206}_{85}$At

2. Which nuclide is needed to balance the following nuclear reaction?
   \[ ^{235}_{92}U + ^{1}_{0}n \rightarrow ? + ^{96}_{39}Y + 3^{1}_{0}n \]
   a) $^{139}_{53}$I  
   b) $^{138}_{53}$I  
   c) $^{137}_{53}$I  
   d) $^{136}_{53}$I  
   e) $^{135}_{53}$I

3. Only one of the following isotopes of strontium undergoes radioactive decay by $\beta^-$ emission. Which one is it?
   a) $^{83}_{38}$Sr  
   b) $^{86}_{38}$Sr  
   c) $^{87}_{38}$Sr  
   d) $^{88}_{38}$Sr  
   e) $^{90}_{38}$Sr

4. For which one of the following atoms or ions would the 2s and 2p orbitals have the same energy?
   a) O$^{2-}$  
   b) H  
   c) He  
   d) Li$^+$  
   e) F$^{6+}$

5. Which of the following electron excitations of the hydrogen atom requires light of the shortest wavelength?
   a) $n = 2$ to $n = 3$  
   b) $n = 3$ to $n = 4$  
   c) $n = 4$ to $n = 20$  
   d) $n = 5$ to $n = 100$  
   e) $n = 4$ to $n = 1000$
6. How many nodes does a 5s atomic orbital have?
   a) 0 planar nodes and 0 spherical nodes
   b) 3 planar nodes and 2 spherical nodes
   c) 1 planar node and 1 spherical node
   d) 0 planar nodes and 4 spherical nodes
   e) 2 planar nodes and 3 spherical nodes

7. The 1s 3p → 1s^2 transition of He is at 54 nm. Which of the following statements is correct?
   a) The 1s 2p → 1s^2 transition of He is at a longer wavelength than 54 nm.
   b) The 1s 2p → 1s^2 transition of He is at a shorter wavelength than 54 nm.
   c) The 1s 2p → 1s^2 transition of He is also at 54 nm.
   d) No deduction about the 1s 2p → 1s^2 transition of He can be made.

8. The half-life of ^14C is 5730 years. Which of the following can be usefully dated using ^14C dating methods?
   a) dinosaur bones (70 million years old)
   b) 15th century paintings
   c) rocks that are 2 billion years old
   d) early human ancestor remains (approximately 2 million years old)
   e) a corpse in a murder investigation (less than 2 years old)

9. Which one of the following sets of quantum numbers is valid?
    \[ \begin{array}{cccc}
    n & l & m_l & m_s \\
    \hline
    a) & 3 & 1 & 0 & 0 \\
    b) & 1 & 1 & 0 & -\frac{1}{2} \\
    c) & 3 & 3 & -2 & +\frac{1}{2} \\
    d) & 1 & 1 & 1 & 0 \\
    e) & 5 & 4 & 3 & +\frac{1}{2} \\
    \end{array} \]

    When computed on a calculator, the algebraic expression \( \frac{0.350 \text{ kg} \times 141 \text{ J}}{(0.921 \text{ m} + 68 \text{ m})} \) has a value of 0.716037202. Expressed to the appropriate number of significant figures, this is:
    a) 0.7 kg J m\(^{-1}\)
    b) 0.71 kg J m\(^{-1}\)
    c) 0.72 kg J m\(^{-1}\)
    d) 0.716 kg J m\(^{-1}\)
    e) 0.71604 kg J m\(^{-1}\)
    Correct answers: 1C, 2C, 3E, 4B, 5A, 6D, 7A, 8B, 9E, 10C
1. What is the decay product resulting from electron capture by the $^{144}_{61}$Pm nuclide?

a) $^{144}_{60}$Pm  

b) $^{144}_{62}$Pm  

c) $^{145}_{60}$Nd  

d) $^{144}_{60}$Nd  

e) $^{144}_{62}$Sm

2. Which nuclide is needed to balance the following nuclear reaction?

$$^{233}_{92}U + ^1_0n \rightarrow ? + ^{101}_{42}Mo + ^3_0n$$

a) $^{132}_{50}$Sn  

b) $^{133}_{50}$Sn  

c) $^{130}_{50}$Sn  

d) $^{129}_{50}$Sn  

e) $^{128}_{50}$Sn

3. Only one of the following isotopes of gallium does not undergo radioactive decay via electron capture. Which one is it?

a) $^{69}_{31}$Ga  

b) $^{68}_{31}$Ga  

c) $^{67}_{31}$Ga  

d) $^{66}_{31}$Ga  

e) $^{65}_{31}$Ga

4. For which one of the following atoms or ions would the 2s and 2p orbitals have the same energy?

a) O$^{2-}$  

b) H$^-$  

c) He  

d) Be$^{2+}$  

e) N$^{6+}$

5. Which of the following electron excitations of the hydrogen atom requires light of the longest wavelength?

a) $n = 2$ to $n = 3$  

b) $n = 3$ to $n = 4$  

c) $n = 4$ to $n = 20$  

d) $n = 5$ to $n = 100$  

e) $n = 4$ to $n = 1000$
6. How many nodes does a 2p atomic orbital have?
   a) 0 planar nodes and 0 spherical nodes
   b) 0 planar nodes and 1 spherical nodes
   c) 1 planar nodes and 0 spherical nodes
   d) 1 planar node and 1 spherical node
   e) 2 planar nodes and 2 spherical nodes

7. The 1s 3p → 1s² transition of He is at 54 nm. Which of the following statements is correct?
   a) The 1s 2p → 1s² transition of He is at a longer wavelength than 54 nm.
   b) The 1s 2p → 1s² transition of He is at a shorter wavelength than 54 nm.
   c) The 1s 2p → 1s² transition of He is also at 54 nm.
   d) No deduction about the 1s 2p → 1s² transition of He can be made.

8. The half-life of ¹⁴C is 5730 years. Which of the following can be usefully dated using ¹⁴C dating methods?
   a) dinosaur bones (70 million years old)
   b) 15th century paintings
   c) rocks that are 2 billion years old
   d) early human ancestor remains (approximately 2 million years old)
   e) a corpse in a murder investigation (less than 2 years old)

9. Which one of the following sets of quantum numbers is valid?

<table>
<thead>
<tr>
<th>n</th>
<th>l</th>
<th>m_l</th>
<th>m_s</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
<td>3</td>
<td>+1/2</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td>-1/2</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>-2</td>
<td>+1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>


    When computed on a calculator, the algebraic expression \( \frac{3.69 \text{ kg} \times 30. \text{ J}}{(87.1 \text{ m} + 98.5 \text{ m})} \) has a value of 0.596443966. Expressed to the appropriate number of significant figures, this is:

   a) 0.5 kg J m⁻¹
   b) 0.6 kg J m⁻¹
   c) 0.59 kg J m⁻¹
   d) 0.60 kg J m⁻¹
   e) 0.596 kg J m⁻¹

Correct answers:  1D, 2C, 3A, 4E, 5D, 6C, 7A, 8B, 9B, 10D