1. During a flame test, a lithium salt produces a characteristic red flame. This red color is produced when electrons in excited lithium atoms

   **A) return to lower energy states within the atoms**
   B) are lost by the atoms
   C) are gained by the atoms
   D) move to higher energy states within the atoms

2. The mass of a calcium atom is due primarily to the mass of its

   A) protons, only
   B) neutrons, only
   C) **protons and neutrons**
   D) protons and electrons

3. The table below gives the atomic mass and the abundance of the two naturally occurring isotopes of chlorine.

<table>
<thead>
<tr>
<th>Isotopes</th>
<th>Atomic Mass of the Isotopes (u)</th>
<th>Natural Abundance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{35}\text{Cl}$</td>
<td>34.97</td>
<td>75.76</td>
</tr>
<tr>
<td>$^{37}\text{Cl}$</td>
<td>36.97</td>
<td>24.24</td>
</tr>
</tbody>
</table>

Which numerical setup can be used to calculate the atomic mass of the element chlorine?

   A) $(34.97 \text{ u})(0.7576) + (36.97 \text{ u})(0.2424)$
   B) $(34.97 \text{ u})(24.24) + (36.97 \text{ u})(75.76)$
   C) $(34.97 \text{ u})(0.2424) + (36.97 \text{ u})(0.7576)$
   D) $(34.97 \text{ u})(75.76) + (36.97 \text{ u})(24.24)$

4. Each diagram below represents the nucleus of an atom.

   ![Diagrams](image)

   How many different elements are represented by the diagrams?

   A) 1    B) 4    C) 2    D) 3

5. What is the approximate mass of a proton?

   A) 0.0005 g    C) 1 g
   B) 0.0005 amu  D) **1 amu**

6. When an excited electron in an atom moves to the ground state, the electron

   **A) emits energy as it moves to a lower energy state**
   B) absorbs energy as it moves to a higher energy state
   C) absorbs energy as it moves to a lower energy state
   D) emits energy as it moves to a higher energy state

7. What is the mass number of a carbon atom that contains six protons, eight neutrons, and six electrons?

   A) 8    B) 20    C) 6    D) **14**

8. What is the overall charge of an ion that has 12 protons, 10 electrons, and 14 neutrons?

   A) 2−    B) **2+**    C) 4−    D) 4+
9. What is the charge of the nucleus of an oxygen atom?
   A) 0    B) –2    C) +8    D) +16

10. In the late 1800s, experiments using cathode ray tubes led to the discovery of the
    A) neutron    C) electron
    B) positron    D) proton

11. Which diagram represents the nucleus of an atom of $^{27}_{13}$Al?
    A)
    
    B)

    C)

    D)

12. Which subatomic particles are paired with their charges?
    A) electron-positive, neutron-negative, proton-neutral
    B) electron-neutral, neutron-positive, proton-negative
    C) electron-negative, neutron-positive, proton-neutral
    D) electron-negative, neutron-neutral, proton-positive

13. The atomic mass of magnesium is the weighted average of the atomic masses of
    A) the two most abundant naturally occurring isotopes of Mg
    B) the two most abundant artificially produced isotopes of Mg
    C) all of the naturally occurring isotopes of Mg
    D) all of the artificially produced isotopes of Mg

14. Which conclusion was drawn from the results of the gold foil experiment?
    A) An atom is mostly empty space.
    B) The electrons in an atom are located in specific shells.
    C) The nucleus of an atom is negatively charged.
    D) An atom is electrically neutral.

15. Which particle has the least mass?
    A) $\frac{1}{2}$He    B) $^0$He    C) $^1$He    D) $^1$He

16. Compared to the energy and charge of the electrons in the first shell of a Be atom, the electrons in the second shell of this atom have
    A) less energy and the same charge
    B) more energy and the same charge
    C) more energy and a different charge
    D) less energy and a different charge

17. A sample of matter must be copper if
    A) the sample can conduct electricity
    B) atoms in the sample react with oxygen
    C) the sample melts at 1768 K
    D) each atom in the sample has 29 protons
18. Given the table below that shows student's examples of proposed models of the atom:

<table>
<thead>
<tr>
<th>Model</th>
<th>Location of Protons</th>
<th>Location of Electrons</th>
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<tbody>
<tr>
<td>A</td>
<td>in the nucleus</td>
<td>specific shells</td>
</tr>
<tr>
<td>B</td>
<td>in the nucleus</td>
<td>#174 ions of most probable location</td>
</tr>
<tr>
<td>C</td>
<td>dispersed throughout the atom</td>
<td>specific shells</td>
</tr>
<tr>
<td>D</td>
<td>dispersed throughout the atom</td>
<td>#174 ions of most probable location</td>
</tr>
</tbody>
</table>

Which model correctly describes the locations of protons and electrons in the wave-mechanical model of the atom?

A) A  
B) B  
C) C  
D) D

19. The atomic number of an atom is always equal to the number of its
   A) protons plus neutrons
   B) neutrons, only
   C) protons, only
   D) protons plus electrons

20. How many electrons are in the outermost principal energy level (shell) of an atom of carbon in the ground state?
   A) 6   B) 2   C) 3   D) 4

21. Which element is paired with an excited-state electron configuration for an atom of the element?
   A) K: 2-6-8-3  
   B) F: 2-8  
   C) Na: 2-8-2  
   D) Ca: 2-8-8-2

22. Which substance can not be broken down by a chemical change?
   A) propanal  
   B) ammonia  
   C) ethanol  
   D) zirconium

23. Which atom in the ground state has the same electron configuration as a calcium ion, Ca\(^{2+}\), in the ground state?
   A) Ar  
   B) Ne  
   C) Mg  
   D) K

24. What is the total number of protons in an atom with the electron configuration 2-8-18-32-18-1?
   A) 79  
   B) 197  
   C) 69  
   D) 118
25. In the space below, write an electron configuration for a sulfur atom in an excited state.

Base your answers to questions 26 through 28 on the information below.
The bright-line spectra for three elements and a mixture of elements are shown below.

26. State the total number of valence electrons in a lithium atom in the ground state.

27. Identify all the elements in the mixture.

28. Explain, in terms of both electrons and energy, how the bright-line spectrum of an element is produced.
<table>
<thead>
<tr>
<th>29. Explain, in terms of protons and neutrons, why Pt-193 and Pt-195 are different isotopes of platinum.</th>
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<tbody>
<tr>
<td>30. Base your answer to the following question on the information below.</td>
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<tr>
<td>In the gold foil experiment, a thin sheet of gold was bombarded with alpha particles. Almost all the alpha particles passed straight through the foil. Only a few alpha particles were deflected from their original paths. State one conclusion about atomic structure based on the observation that almost all alpha particles passed straight through the foil.</td>
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<tr>
<td>Question</td>
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