1. According to the modern model of the atom, the nucleus of an atom is surrounded by one or more
   A) electrons  B) neutrons  C) positrons  D) protons

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

3. Compared to the charge of a proton, the charge of an electron has
   A) a greater magnitude and the same sign  B) a greater magnitude and the opposite sign
   C) the same magnitude and the same sign  D) the same magnitude and the opposite sign

4. 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+

5. Which phrase describes an atom?
   A) a negatively charged nucleus surrounded by positively charged protons
   B) a negatively charged nucleus surrounded by positively charged electrons
   C) a positively charged nucleus surrounded by negatively charged protons
   D) a positively charged nucleus surrounded by negatively charged electrons

6. An atom in the ground state has two electrons in its first shell and six electrons in its second shell. What is the total number of protons in the nucleus of this atom?
   A) 5  B) 2  C) 7  D) 8

7. What is the number of electrons in an atom that has 3 protons and 4 neutrons?
   A) 1  B) 7  C) 3  D) 4

8. The diagram below represents the nucleus of an atom.
   [Diagram of nucleus with protons and neutrons indicated]
   What are the atomic number and mass number of this atom?
   A) The atomic number is 9 and the mass number is 19.
   B) The atomic number is 9 and the mass number is 20.
   C) The atomic number is 11 and the mass number is 19.
   D) The atomic number is 11 and the mass number is 20.

9. A student constructs a model for comparing the masses of subatomic particles. The student selects a small, metal sphere with a mass of 1 gram to represent an electron. A sphere with which mass would be most appropriate to represent a proton?
   A) 1g  B) $\frac{1}{2}$g  C) $\frac{1}{2000}$g  D) 2000g

10. Which statement concerning elements is true?
    A) Different elements must have different numbers of isotopes.
    B) Different elements must have different numbers of neutrons.
    C) All atoms of a given element must have the same mass number.
    D) All atoms of a given element must have the same atomic number.

11. All atoms of a given element must contain the same number of
    A) protons
    B) neutrons
    C) electrons plus neutrons
    D) protons plus neutrons

12. What is the charge and mass of a proton?
    A) charge of +1 and mass of 1 amu
    B) charge of +1 and mass of $\frac{1}{1836}$ amu
    C) charge of –1 and mass of 1 amu
    D) charge of –1 and mass of $\frac{1}{1836}$ amu
13. What are the nucleons in an atom?
   A) protons and electrons
   B) protons and neutrons
   C) neutrons and electrons
   D) neutrons and positrons

14. As the number of neutrons in the nucleus of an atom increases, the nuclear charge of the atom
   A) decreases  B) increases
   C) remains the same

15. Which particle is electrically neutral?
   A) proton  B) positron
   C) neutron  D) electron

16. As a result of the gold foil experiment, it was concluded that an atom
   A) contains protons, neutrons, and electrons
   B) contains a small, dense nucleus
   C) has positrons and orbitals
   D) is a hard, indivisible sphere

17. Which statement describes the distribution of charge in an atom?
   A) A neutral nucleus is surrounded by one or more negatively charged electrons.
   B) A neutral nucleus is surrounded by one or more positively charged electrons.
   C) A positively charged nucleus is surrounded by one or more negatively charged electrons.
   D) A positively charged nucleus is surrounded by one or more positively charged electrons.

18. The gold foil experiment led to the conclusion that each atom in the foil was composed mostly of empty space because most alpha particles directed at the foil
   A) passed through the foil
   B) remained trapped in the foil
   C) were deflected by the nuclei in gold atoms
   D) were deflected by the electrons in gold atoms

19. Which sequence represents a correct order of historical developments leading to the modern model of the atom?
   A) the atom is a hard sphere → most of the atom is empty space → electrons exist in orbitals outside the nucleus
   B) the atom is a hard sphere → electrons exist in orbitals outside the nucleus → most of the atom is empty space
   C) most of the atom is empty space → electrons exist in orbitals outside the nucleus → the atom is a hard sphere
   D) most of the atom is empty space → the atom is a hard sphere → electrons exist in orbitals outside the nucleus

20. Which electron configuration represents the electrons in an atom of Ga in an excited state?
   A) 2-8-17-3  B) 2-8-17-4
   C) 2-8-18-3  D) 2-8-18-4

21. Every chlorine atom has
   A) equals the number of electrons
   B) equals the number of neutrons
   C) is less than the number of electrons
   D) is greater than the number of electrons

22. In an atom of argon-40, the number of protons
   A) 69  B) 79  C) 118  D) 197

23. What is the total number of protons in an atom with the electron configuration 2-8-18-32-18-1?
   A) 69  B) 79  C) 118  D) 197

24. What can be determined if only the atomic number of an atom is known?
   A) the total number of neutrons in the atom, only
   B) the total number of protons in the atom, only
   C) the total number of protons and the total number of neutrons in the atom
   D) the total number of protons and the total number of electrons in the atom

25. The total number of protons found in an H₂O molecule is
   A) 10  B) 8  C) 3  D) 4
26. An atom contains 22 neutrons and 40 nucleons. What is the total number of protons in the atom?
   A) 18   B) 22   C) 40   D) 62
27. Two atoms will always have the same atomic number if they have the same
   A) mass number   B) number of protons
   C) number of neutrons   D) number of nucleons
28. What is the atomic number of an element whose atoms each contain 47 protons, 60 neutrons, and 47 electrons?
   A) 13   B) 47   C) 60   D) 107
29. Which of the following atoms has the greatest nuclear charge?
   A) \(^{14}N\)   B) \(^{12}C\)   C) \(^{2}H\)   D) \(^{4}He\)
30. 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 u)(75.76) + (36.97 u)(24.24)   B) (34.97 u)(0.2424) + (36.97 u)(0.7576)
   C) (34.97 u)(0.7576) + (36.97 u)(0.2424)   D) (34.97 u)(24.24) + (36.97 u)(75.76)
31. Which quantity is equal to one mole of Au?
   A) the atomic mass in grams
   B) the atomic number in grams
   C) the mass of neutrons in grams
   D) the number of neutrons in grams
32. The atomic mass of magnesium is the weighted average of the atomic masses of
   A) all of the artificially produced isotopes of Mg
   B) all of the naturally occurring isotopes of Mg
   C) the two most abundant artificially produced isotopes of Mg
   D) the two most abundant naturally occurring isotopes of Mg
33. What is the mass number of a carbon atom that contains six protons, eight neutrons, and six electrons?
   A) 6   B) 8   C) 14   D) 20
34. What is the total number of neutrons in the nucleus of a neutral atom that has 19 electrons and a mass number of 39?
   A) 19   B) 20   C) 39   D) 58
35. In which list are the elements arranged in order of increasing atomic mass?
   A) Cl, K, Ar   B) Fe, Co, Ni
   C) Te, I, Xe   D) Ne, F, Na
36. The mass of a proton is approximately equal to the total mass of 1,836
A) electrons  B) neutrons  C) helium nuclei  D) alpha particles

37. Which atom has a mass of approximately two atomic mass units?
A) \( \frac{1}{1} \) H  B) \( \frac{2}{1} \) H  C) \( \frac{3}{2} \) H  D) \( \frac{4}{2} \) He

38. An atomic mass unit is defined as exactly
A) \( \frac{1}{12} \) the mass of a \( ^{12} \) C atom  B) \( \frac{1}{14} \) the mass of a \( ^{14} \) N atom  C) \( \frac{1}{16} \) the mass of a \( ^{16} \) O atom  D) \( \frac{1}{19} \) the mass of a \( ^{19} \) F atom

39. The table below shows the number of subatomic particles in atom X and in atom Z.

<table>
<thead>
<tr>
<th>Subatomic Particles in Two Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atom</td>
</tr>
<tr>
<td>X</td>
</tr>
<tr>
<td>Z</td>
</tr>
</tbody>
</table>

Atom X and atom Z are isotopes of the element
A) aluminum  B) carbon  C) magnesium  D) nitrogen

40. The table below indicates the stability of six nuclides.

<table>
<thead>
<tr>
<th>Stability of Six Nuclides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclide</td>
</tr>
<tr>
<td>C-12</td>
</tr>
<tr>
<td>C-14</td>
</tr>
<tr>
<td>N-14</td>
</tr>
<tr>
<td>N-16</td>
</tr>
<tr>
<td>O-16</td>
</tr>
<tr>
<td>O-19</td>
</tr>
</tbody>
</table>

All atoms of the unstable nuclides listed in this table have
A) an odd number of neutrons
B) an odd number of protons
C) more neutrons than protons
D) more protons than neutrons

41. Atoms of different isotopes of the same element differ in their total number of
A) electrons  B) neutrons  C) protons  D) valence electrons

42. What is the structure of a krypton-85 atom?
A) 49 electrons, 49 protons, and 85 neutrons  B) 49 electrons, 49 protons, and 49 neutrons  C) 36 electrons, 36 protons, and 85 neutrons  D) 36 electrons, 36 protons, and 49 neutrons

43. Each diagram below represents the nucleus of a different atom.

Which diagrams represent nuclei of the same element?
A) D and E, only  B) D, E, and Q  C) Q and R, only  D) Q, R, and E

44. What is the total number of neutrons in an atom of \( ^{57} \) Fe?
A) 26  B) 31  C) 57  D) 83

45. Which two notations represent atoms that are isotopes of the same element?
A) \( \frac{121}{50} \) Sn and \( \frac{119}{50} \) Sn  B) \( \frac{121}{50} \) Sn and \( \frac{121}{50} \) Sn  C) \( \frac{19}{8} \) O and \( \frac{19}{8} \) F  D) \( \frac{39}{17} \) Cl and \( \frac{39}{19} \) K

46. The atomic masses and the natural abundances of the two naturally occurring isotopes of lithium are shown in the table below.

<table>
<thead>
<tr>
<th>Lithium Isotopes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isotope</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Li-6</td>
</tr>
<tr>
<td>Li-7</td>
</tr>
</tbody>
</table>

Which numerical setup can be used to determine the atomic mass of lithium?
A) \( (0.075)(6.02 \text{ u}) + (0.925)(7.02 \text{ u}) \)  B) \( (0.925)(6.02 \text{ u}) + (0.075)(7.02 \text{ u}) \)  C) \( (7.5)(6.02 \text{ u}) + (92.5)(7.02 \text{ u}) \)  D) \( (92.5)(6.02 \text{ u}) + (7.5)(7.02 \text{ u}) \)
47. A 100.00-gram sample of naturally occurring boron contains 19.78 grams of boron-10 (atomic mass = 10.01 atomic mass units) and 80.22 grams of boron-11 (atomic mass = 11.01 atomic mass units). Which numerical setup can be used to determine the atomic mass of naturally occurring boron?

A) \((0.1978)(10.01) + (0.8022)(11.01)\)
B) \((0.8022)(10.01) + (0.1978)(11.01)\)
C) \((0.1978)(10.01)/(0.8022)(11.01)\)
D) \((0.8022)(10.01)/(0.1978)(11.01)\)

48. Element \(X\) has two isotopes. If 72.0% of the element has an isotopic mass of 84.9 atomic mass units, and 28.0% of the element has an isotopic mass of 87.0 atomic mass units, the average atomic mass of element \(X\) is numerically equal to

A) \((72.0 \times 84.9) \times (28.0 + 87.0)\)
B) \((72.0 - 84.9) \times (28.0 + 87.0)\)
C) \(\frac{(72.0 \times 84.9) + (28.0 \times 87.0)}{100}\)
D) \((72.0 \times 84.9) + (28.0 \times 87.0)\)

49. The average isotopic mass of chlorine is 35.5. Which mixture of isotopes (shown as percents) produces this average mass?

A) 50% \({}^{12}\text{C}\) and 50% \({}^{13}\text{C}\)
B) 50% \({}^{35}\text{Cl}\) and 50% \({}^{37}\text{Cl}\)
C) 75% \({}^{35}\text{Cl}\) and 25% \({}^{37}\text{Cl}\)
D) 75% \({}^{12}\text{C}\) and 25% \({}^{13}\text{C}\)

50. Which atom in the ground state has an outermost electron with the most energy?

A) Cs  B) K  C) Li  D) Na

51. How do the energy and the most probable location of an electron in the third shell of an atom compare to the energy and the most probable location of an electron in the first shell of the same atom?

A) In the third shell, an electron has more energy and is closer to the nucleus.
B) In the third shell, an electron has more energy and is farther from the nucleus.
C) In the third shell, an electron has less energy and is closer to the nucleus.
D) In the third shell, an electron has less energy and is farther from the nucleus.

52. 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

53. What is the highest principal energy level for an electron in an atom of sulfur in the ground state?

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

54. A bromine atom in an excited state could have an electron configuration of

A) 2-8-18-6  B) 2-8-18-7  C) 2-8-17-7  D) 2-8-17-8

55. Given the bright-line spectra of three elements and the spectrum of a mixture formed from at least two of these elements:

[Image of bright-line spectra]

Which elements are present in this mixture?

A) \(E\) and \(D\), only  B) \(E\) and \(G\), only  C) \(D\) and \(G\), only  D) \(D\), \(E\), and \(G\)

56. When compared with the energy of an electron in the first shell of a carbon atom, the energy of an electron in the second shell of a carbon atom is

A) less  B) greater  C) the same

57. The light emitted from a flame is produced when electrons in an excited state

A) absorb energy as they move to lower energy states  B) absorb energy as they move to higher energy states  C) release energy as they move to lower energy states  D) release energy as they move to higher energy states

58. As an electron in an atom moves from the ground state to the excited state, the electron

A) gains energy as it moves to a higher energy level  B) gains energy as it moves to a lower energy level  C) loses energy as it moves to a higher energy level  D) loses energy as it moves to a lower energy level
59. The characteristic bright-line spectrum of an element occurs when electrons
A) move from lower to higher energy levels
B) move from higher to lower energy levels
C) are lost by a neutral atom
D) are gained by a neutral atom

60. Which principal energy level change by the electron of a hydrogen atom will cause the greatest amount of energy to be absorbed?
A) \( n = 2 \) to \( n = 4 \)
B) \( n = 2 \) to \( n = 5 \)
C) \( n = 4 \) to \( n = 2 \)
D) \( n = 5 \) to \( n = 2 \)

61. Which change results in an increase in entropy?
A) \( \text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(l) \)
B) \( \text{H}_2\text{O}(l) \rightarrow \text{H}_2\text{O}(s) \)
C) \( \text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l) \)
D) \( \text{H}_2\text{O}(g) \rightarrow \text{H}_2\text{O}(s) \)