1. Which particles have approximately the same mass?

Ⓐ an electron and an alpha particle
Ⓑ an electron and a proton
Ⓒ a neutron and an alpha particle
Ⓓ a neutron and a proton

2. Which phrase describes an atom?

Ⓐ a negatively charged nucleus surrounded by positively charged protons
Ⓑ a negatively charged nucleus surrounded by positively charged electrons
Ⓒ a positively charged nucleus surrounded by negatively charged protons
Ⓓ a positively charged nucleus surrounded by negatively charged electrons

3. 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?

Ⓐ 5 Ⓑ 2 Ⓒ 7 **Ⓓ 8**

4. The mass of a proton is approximately equal to the mass of

Ⓐ an alpha particle Ⓑ a beta particle
Ⓒ a positron **Ⓓ a neutron**

5. What is the number of electrons in an atom that has 3 protons and 4 neutrons?

Ⓐ 1 Ⓑ 7 **Ⓒ 3** Ⓓ 4

6. Which statement concerning elements is true?

Ⓐ Different elements must have different numbers of isotopes.
Ⓑ Different elements must have different numbers of neutrons.
Ⓒ All atoms of a given element must have the same mass number.
Ⓓ All atoms of a given element must have the same atomic number.

7. Which statement is true about a proton and an electron?

Ⓐ They have the same masses and the same charges.
Ⓑ They have the same masses and different charges.
Ⓒ They have different masses and the same charges.
Ⓓ They have different masses and different charges.

8. What was concluded about the structure of the atom as the result of the gold foil experiment?

Ⓐ A positively charged nucleus is surrounded by positively charged particles.
Ⓑ A positively charged nucleus is surrounded by mostly empty space.
Ⓒ A negatively charged nucleus is surrounded by positively charged particles.
Ⓓ A negatively charged nucleus is surrounded by mostly empty space.

9. 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

10. In Rutherford's gold foil experiments, some alpha particles were deflected from their original paths but most passed through the foil with no deflection. Which statement about gold atoms is supported by these experimental observations?

(A) Gold atoms consist mostly of empty space.

(B) Gold atoms are similar to alpha particles.

(C) Alpha particles and gold nuclei have opposite charges.

(D) Alpha particles are more dense than gold atoms.

11. Every chlorine atom has

(A) 7 electrons

(B) 17 neutrons

(C) a mass number of 35

(D) an atomic number of 17

12. What is the charge of the nucleus of an oxygen atom?

(A) 0 (B) –2 **(C) +8** (D) +16

13. The notation for the nuclide $^{137}_{55}Cs$ gives information about

(A) mass number, only

(B) atomic number, only

(C) both mass number and atomic number

(D) neither mass number nor atomic number

14. An atom is electrically neutral because the

(A) number of protons equals the number of electrons

(B) number of protons equals the number of neutrons

(C) ratio of the number of neutrons to the number of electrons is 1:1

(D) ratio of the number of neutrons to the number of protons is 2:1

15. Compared to an atom of phosphorus-31, an atom of sulfur-32 contains

(A) one less neutron (B) one less proton

(C) one more neutron **(D) one more proton**

16. 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

17. The total mass of the protons in an atom of gold-198 is approximately

(A) 79 atomic mass units

(B) 119 atomic mass units

(C) 198 atomic mass units

(D) 277 atomic mass units

18. In which list are the elements arranged in order of increasing atomic mass?

Ⓐ Cl, K, Ar Ⓑ Fe, Co, Ni
Ⓒ Te, I, Xe Ⓓ Ne, F, Na

19. An atom that has 13 protons and 15 neutrons is an isotope of the element

Ⓐ nickel Ⓑ silicon
Ⓒ aluminum Ⓓ phosphorus

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

Subatomic Particles in Two Atoms

Atom	Number of Protons	Number of Neutrons	Number of Electrons
X	6	6	6
Z	6	7	6

Atom *X* and atom *Z* are isotopes of the element

Ⓐ aluminum **Ⓑ carbon**
Ⓒ magnesium Ⓓ nitrogen

21. The nucleus of an atom of cobalt-58 contains

Ⓐ 27 protons and 31 neutrons
Ⓑ 27 protons and 32 neutrons
Ⓒ 59 protons and 60 neutrons
Ⓓ 60 protons and 60 neutrons

22. All the isotopes of a given atom have

Ⓐ the same mass number and the same atomic number
Ⓑ the same mass number but different atomic numbers
Ⓒ different mass numbers but the same atomic number
Ⓓ different mass numbers and different atomic numbers

23. What is the structure of a krypton-85 atom?

Ⓐ 49 electrons, 49 protons, and 85 neutrons
Ⓑ 49 electrons, 49 protons, and 49 neutrons
Ⓒ 36 electrons, 36 protons, and 85 neutrons
Ⓓ 36 electrons, 36 protons, and 49 neutrons

24. What is the total number of neutrons in an atom of O-18?

Ⓐ 18 Ⓑ 16 **Ⓒ 10** Ⓓ 8

25. Which two notations represent different isotopes of the same element?

Ⓐ $^{6}_{4}\mathrm{Be}$ and $^{9}_{4}\mathrm{Be} Ⓑ $^{7}_{3}\mathrm{Li}$ and $^{7}_{3}\mathrm{Li}$ Ⓒ $^{14}_{7}\mathrm{N}$ and $^{14}_{6}\mathrm{C}$ Ⓓ $^{32}_{15}\mathrm{P}$ and $^{32}_{16}\mathrm{S}$

26. The atomic mass of titanium is 47.88 atomic mass units. This atomic mass represents the

Ⓐ total mass of all the protons and neutrons in an atom of Ti
Ⓑ total mass of all the protons, neutrons, and electrons in an atom of Ti
Ⓒ weighted average mass of the most abundant isotope of Ti
Ⓓ weighted average mass of all the naturally occurring isotopes of Ti

27. Hydrogen has three isotopes with mass numbers of 1, 2, and 3 and has an average atomic mass of 1.00794 amu. This information indicates that

Ⓐ equal numbers of each isotope are present
Ⓑ more isotopes have an atomic mass of 2 or 3 than of 1
Ⓒ more isotopes have an atomic mass of 1 than of 2 or 3
Ⓓ isotopes have only an atomic mass of 1

28. In the wave-mechanical model of the atom, an orbital is defined as

Ⓐ a region of the most probable proton location
Ⓑ a region of the most probable electron location
Ⓒ a circular path traveled by a proton around the nucleus
Ⓓ a circular path traveled by an electron around the nucleus

29. In the electron cloud model of the atom, an orbital is defined as the most probable

Ⓐ charge of an electron
Ⓑ conductivity of an electron
Ⓒ location of an electron
Ⓓ mass of an electron

30. Which phrase describes an atom?

Ⓐ a positively charged electron cloud surrounding a positively charged nucleus
Ⓑ a positively charged electron cloud surrounding a negatively charged nucleus
Ⓒ a negatively charged electron cloud surrounding a positively charged nucleus
Ⓓ a negatively charged electron cloud surrounding a negatively charged nucleus

31. What is the maximum number of electrons in an orbital of any atom?

Ⓐ 1 **Ⓑ 2** Ⓒ 6 Ⓓ 10

32. What is the total number of electrons needed to completely fill all of the orbitals in an atom's second principal energy level?

Ⓐ 16 Ⓑ 2 **Ⓒ 8** Ⓓ 4

33. 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

Ⓐ less energy and the same charge
Ⓑ less energy and a different charge
Ⓒ more energy and the same charge
Ⓓ more energy and a different charge

34. Which electron configuration represents the electrons of a sulfur atom in an excited state?

Ⓐ 2-6-6 **Ⓑ 2-7-7** Ⓒ 2-8-4 Ⓓ 2-8-6

35. Which element is paired with an excited-state electron configuration for an atom of the element?

Ⓐ Ca: 2-8-8-2
Ⓑ Na: 2-8-2
Ⓒ K: 2-6-8-3
Ⓓ F: 2-8

36. Which electron configuration represents a selenium atom in an excited state?

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

37. Explain, in terms of protons and neutrons, why U-235 and U-238 are different isotopes of uranium.

38. Copper has two naturally occurring isotopes. Information about the two isotopes is shown in the table below.

Naturally Occurring Isotopes of Copper

Isotope	**Atomic Mass** (atomic mass units, u)	**Percent Natural Abundance** (%)
Cu-63	62.93	69.17
Cu-65	64.93	30.83

In the space *in your answer booklet*, show a numerical setup for calculating the atomic mass of copper.

39. Describe the electrons in an atom of carbon in the ground state. Your response must include:

- the charge of an electron
- the location of electrons based on the wave-mechanical model
- the total number of electrons in a carbon atom

Base your answers to questions **40** and **41** on the information below.

In 1897, J. J. Thomson demonstrated in an experiment that cathode rays were deflected by an electric field. This suggested that cathode rays were composed of negatively charged particles found in all atoms. Thomson concluded that the atom was a positively charged sphere of almost uniform density in which negatively charged particles were embedded. The total negative charge in the atom was balanced by the positive charge, making the atom electrically neutral.

In the early 1900s, Ernest Rutherford bombarded a very thin sheet of gold foil with alpha particles. After interpreting the results of the gold foil experiment, Rutherford proposed a more sophisticated model of the atom.

40. State *one* conclusion from Rutherford's experiment that contradicts one conclusion made by Thomson.

41. State *one* aspect of the modern model of the atom that agrees with a conclusion made by Thomson.

42. Base your answer to the following question on the information below and on your knowledge of chemistry.

Illuminated **EXIT** signs are used in public buildings such as schools. If the word **EXIT** is green, the sign may contain the radioisotope tritium, hydrogen-3. The tritium is a gas sealed in glass tubes. The emissions from the decay of the tritium gas cause a coating on the inside of the tubes to glow.

State, in terms of neutrons, how an atom of tritium *differs* from an atom of hydrogen-1.

Base your answers to questions **43** through **46** on the information below and on your knowledge of chemistry.

A student compares some models of the atom. These models are listed in the table below in order of development from top to bottom.

Models of the Atom

Model	Observation	Conclusion
Dalton model	Matter is conserved during a chemical reaction.	Atoms are hard, indivisible spheres of different sizes.
Thomson model	Cathode rays are deflected by magnetic/electric fields.	Atoms have small, negatively charged particles as part of their internal structure.
Rutherford model	Most alpha particles pass straight through gold foil but a few are deflected.	An atom is mostly empty space with a small,dense,positively as part of their nucleus.
Bohr model	Unique spectral lines are emitted by excited gaseous elements.	Packets of energy are absorbed or emitted by atoms when an electron changes shells.

43. State *one* way in which the Bohr model agrees with the Thomson model.

44. Using the conclusion from the Rutherford model, identify the charged subatomic particle that is located in the nucleus.

45. State *one* conclusion about the internal structure of the atom that resulted from the gold foil experiment.

46. State the model that first included electrons as subatomic particles.

Base your answers to questions **47** through **49** on the information below

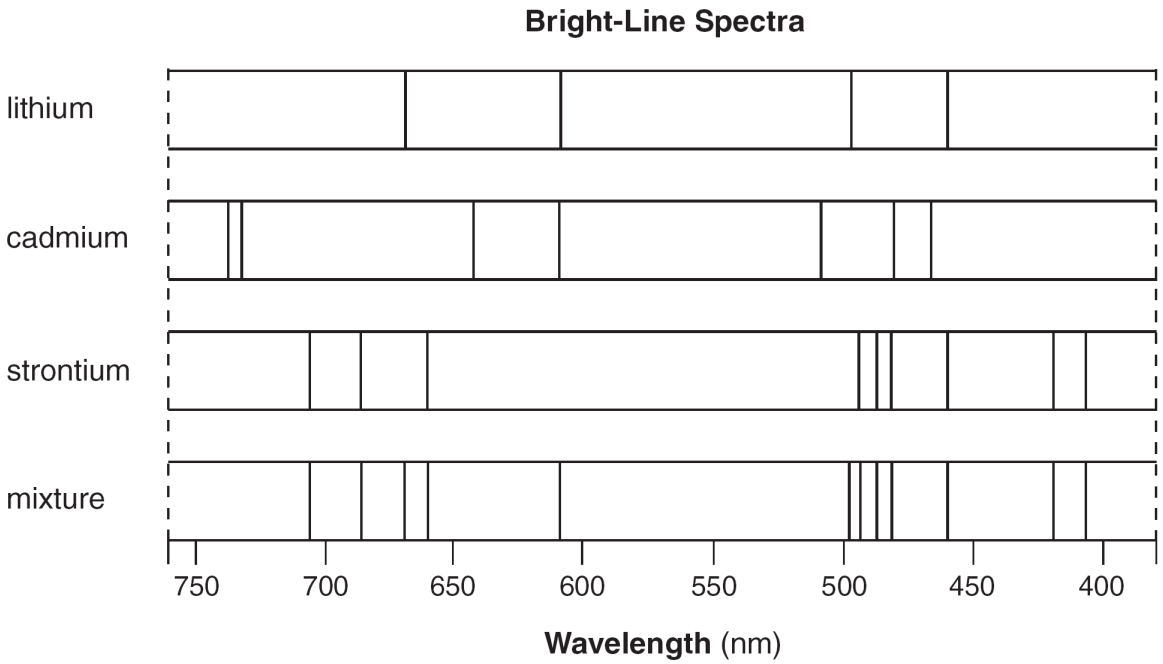
The element boron, a trace element in Earth's crust, is found in foods produced from plants. Boron has only two naturally occurring stable isotopes, boron-10 and boron-11.

47. State, in terms of subatomic particles, *one* difference between the nucleus of a carbon-11 atom and the nucleus of a boron-11 atom.

48. Write an isotopic notation of the heavier isotope of the element boron. Your response must include the atomic number, the mass number, and the symbol of this isotope.

49. Compare the abundance of the two naturally occurring isotopes of boron.

Base your answers to questions **50** through **52** on the information below.
The bright-line spectra for three elements and a mixture of elements are shown below.



50. State the total number of valence electrons in a cadmium atom in the ground state.

51. Identify *all the elements in the mixture.*

52. Explain, in terms of *both electrons and energy, how the bright-line spectrum of an element is produced.*

Base your answers to questions **53** and **54** on the information below

An atom in an excited state has an electron configuration of 2-7-2.

53. Write the electron configuration of this atom in the ground state.

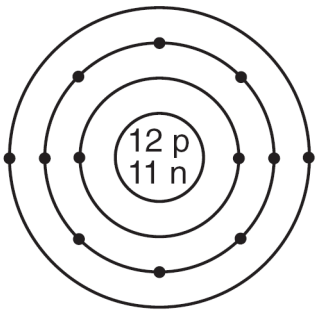
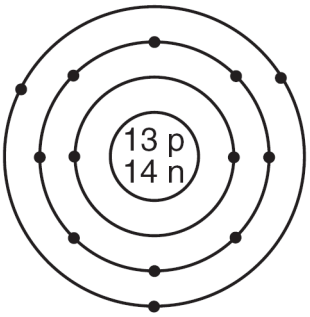
54. Explain, in terms of subatomic particles, why this excited atom is electrically neutral.

55. In the box below, draw a Lewis electron-dot diagram for an atom of boron.

56. Base your answer to the following question on the information below.

Atomic Diagrams of Magnesium and Aluminum

Key
• = electron

Element	Lewis Electron-Dot Diagram	Electron-Shell Diagram
magnesium	Mg:	
aluminum	Al:	

Determine the mass number of the magnesium atom represented by the electron-shell diagram.

57. Write *one* electron configuration for an atom of silicon in an excited state.

Base your answers to questions **58** through **60** on the information below.

Two isotopes of potassium are K-37 and K-42.

58. Explain, in terms of subatomic particles, why K-37 and K-42 are isotopes of potassium.

59. How many valence electrons are in an atom of K-42 in the ground state?

60. What is the total number of neutrons in the nucleus of a K-37 atom?

Answer Key
Atomic Concepts Review

1. D
2. D
3. D
4. D
5. C
6. D
7. D
8. B
9. A
10. A
11. D
12. C
13. C
14. A
15. D
16. C
17. A
18. A
19. C
20. B
21. A
22. C
23. D
24. C
25. A
26. D
27. C
28. B
29. C
30. C
31. B
32. C
33. C
34. B
35. C
36. B

37. – A U-235 atom has 92 protons and 143 neutrons, and a U-238 atom has 92 protons and 146 neutrons. – A U-235 atom and a U-238 atom have the same number of protons but a different number of neutrons.

38. Acceptable responses include, but are not limited to: • (62.93 u)(0.6917) + (64.93 u)(0.3083) or $\frac{(62.93)(69.17)+(64.93)(30.83)}{100}$

39. Answer: • an electron has a negative charge. • electrons are located in orbitals or regions of most probable location. • a carbon atom has six electrons.

40. An atom has a nucleus that is positively charged; An atom is mostly empty space; Negatively charged particles are located outside the positive nucleus.

41. An atom has equal amounts of negative and positive charge; An atom has an equal number of protons and electrons; All atoms contain electrons; Electrons are negatively charged.

42. –A tritium atom has two neutrons and an H-1 atom has no neutrons. –Only the tritium atom has neutrons. –H-1 has no neutrons.

43. –Atoms have electrons. –Atoms have small, negatively charged particles. –Both models show an internal structure. –Atoms are neutral.

44. –proton –p –p^+ –$_1$1p –$_1^1$H –H^+

45. –An atom is mainly empty space. –It has a nucleus. –The small, dense nucleus is positively charged.

46. –Thomson model –Thomson –plum pudding model

47. –The carbon-11 nucleus has one more proton than the nucleus of boron-11. –A B-11 atom has a different number of neutrons than a C-11 atom.

48. $^{11}_{5}\mathrm{B}$

49. –Boron-11 is about four times more abundant than boron-10. –The B-10 is less abundant.

50. – 2

51. – lithium and strontium

52. – When electrons in an excited state return to a lower energy state, specific amounts of energy are emitted. These energies are associated with specific wavelengths of light that are characteristic of the bright-line spectrum of an element. – Energy is emitted when excited electrons fall back to lower shells.

53. 2-8-1

54. The number of protons equals the number of electrons. *or* The atom has 11 protons and 11 electrons.

55. 

56. 23

57. *Examples*: - 2–7–4–1 ; 2–7–5 ; 2–8–3–1 ;1–8–5

58. Acceptable responses include, but are not limited to:
same number of protons, different number of neutrons
K-37 has fewer neutrons than K-42.
same element; different number of neutrons

59. 1 or one.

60. 18.