

4.11: Exercises

4.1: Cutting Aluminum Until You Get Atoms

1. Give the proper formula for each diatomic element.

Answer

H₂, N₂, O₂, F₂, Cl₂, Br₂, I₂

4.2: Early Atomic Theory

2. In the following drawing, the green spheres represent atoms of a certain element. The purple spheres represent atoms of another element. If the spheres of different elements touch, they are part of a single unit of a compound. The following chemical change represented by these spheres may violate one of the ideas of Dalton's atomic theory. Which one?



Answer

The starting materials consist of one green sphere and two purple spheres. The products consist of two green spheres and two purple spheres. This violates Dalton's postulate that atoms are not created during a chemical change, but are merely redistributed.

4.3: Discovery of the Nucleus

3. Explain how atoms are composed.

Answer

Atoms have a small nucleus containing protons and neutrons. The nucleus is surrounded by "empty" space in which the electrons travel.

4. Where is most of the mass of an atom located?

Answer

in the nucleus

4.4: Protons, Neutrons, and Electrons

5. Define *atomic mass unit*. What is its abbreviation?

Answer

An atomic mass unit is $\frac{1}{12}$ of the mass of a carbon-12 atom. Its abbreviation is amu.

6. Which is larger, a proton or an electron?

Answer

proton

7. Which is larger, a neutron or an electron?

Answer

neutron

8. What are the charges for each of the three subatomic particles?

Answer

proton = 1+
neutron = 0,
electron = 1–

9. How are electrons and protons similar? How are they different?

Answer

They are similar in that they are both charged particles. They are different in that the charges are different and they have different masses.

10. How are protons and neutrons similar? How are they different?

Answer

They are similar in that they both have a mass of approximately 1 amu. They are different in that protons have a 1+ charge and neutrons are neutral.

4.5: Chemical Symbols and the Atomic Number

11. Define *atomic number*.

Answer

The number of protons in the nucleus of one atom of an element.

12. What is the atomic number for a boron atom?

Answer

5

13. What is the atomic number of helium?

Answer

2

14. Give the chemical symbol for each element.

- a. sodium
- b. argon

- c. nitrogen
- d. radon

Answer

- a. Na
- b. Ar
- c. N
- d. Rn

15. Give the chemical symbol for each element.

- a. silver
- b. gold
- c. mercury
- d. iodine

Answer

- a. Ag
- b. Au
- c. Hg
- d. I

16. Give the name of the element.

- a. Si
- b. Mn
- c. Fe
- d. Cr

Answer

- a. silicon
- b. manganese
- c. iron
- d. chromium

17. Give the name of the element.

- a. F
- b. Cl
- c. Br
- d. I

Answer

- a. fluorine
- b. chlorine
- c. bromine
- d. iodine

4.6: The Periodic Table

18. Distinguish between a metal and a nonmetal.

Answer

Metals are typically shiny, conduct electricity and heat well, and are malleable and ductile; nonmetals are a variety of colors and phases, are brittle in the solid phase, and do not conduct heat or electricity well.

19. What properties do metalloids have?

Answer

Metalloids have properties that are intermediate between metals and nonmetals.

20. Why is iron considered a metal?

Answer

Iron is a metal because it is solid, is shiny, and conducts electricity and heat well.

21. Why is oxygen considered a nonmetal?

Answer

Oxygen is a gas. It is not a good conductor of heat or electricity.

22. Elemental carbon is a black, dull-looking solid that conducts heat and electricity well. It is very brittle and cannot be made into thin sheets or long wires. Of these properties, how does carbon behave as a metal? How does carbon behave as a nonmetal?

Answer

Carbon behaves as a metal because it conducts heat and electricity well. It is a nonmetal because it is black and brittle and cannot be made into sheets or wires.

23. Pure silicon is shiny and silvery but does not conduct electricity or heat well. Of these properties, how does silicon behave as a metal? How does silicon behave as a nonmetal?

Answer

Silicon behaves as a metal because it is silver and shiny. It behaves as a nonmetal because it does not conduct heat or electricity well.

24. Use its place on the periodic table to determine if indium, In, atomic number 49, is a metal or a nonmetal.

Answer

metal

25. Only a few atoms of astatine, At, atomic number 85, have been detected. On the basis of its position on the periodic table, would you expect it to be a metal or a nonmetal?

Answer

It is a metalloid. However, between the two options, it would behave more like a nonmetal than a metal.

26. Using the periodic table, classify each of the following elements as a metal or a nonmetal, and then further classify each as a main-group (representative) element, transition metal, or inner transition metal:

- a. uranium
- b. bromine
- c. strontium
- d. neon
- e. gold
- f. americium
- g. rhodium
- h. sulfur
- i. carbon
- j. potassium

Answer

- a. metal, inner transition metal
- b. nonmetal, main-group element
- c. metal, main-group element
- d. nonmetal, main-group element
- e. metal, transition metal
- f. metal, inner transition metal
- g. metal, transition metal
- h. nonmetal, main-group element
- i. nonmetal, main-group element
- j. metal, main-group element

27. Using the periodic table, classify each of the following elements as a metal or a nonmetal, and then further classify each as a main-group (representative) element, transition metal, or inner transition metal:

- a. cobalt
- b. europium
- c. iodine
- d. indium
- e. lithium
- f. oxygen
- g. cadmium
- h. terbium
- i. rhenium

Answer

- a. metal, transition metal
- b. metal, inner transition metal
- c. nonmetal, main-group element
- d. metal, main-group element
- e. metal, main-group element
- f. nonmetal, main-group element
- g. metal, transition metal
- h. metal, inner transition metal
- i. metal, transition metal

28. Using the periodic table, identify the lightest member of each of the following groups:

- a. noble gases
- b. alkaline earth metals
- c. alkali metals

Answer

- a. He
- b. Be
- c. Li (as H is not technically an alkali metal)

29. Using the periodic table, identify the heaviest member of each of the following groups:

- a. alkali metals
- b. noble gases
- c. alkaline earth metals

Answer

- a. Fr
- b. Og
- c. Ra

30. Use the periodic table to give the name and symbol for each of the following elements:

- a. the noble gas in the same period as germanium
- b. the alkaline earth metal in the same period as selenium
- c. the halogen in the same period as lithium

Answer

- a. Kr, krypton
- b. Ca, calcium
- c. F, fluorine

31. Use the periodic table to give the name and symbol for each of the following elements:

- a. the halogen in the same period as the alkali metal with 11 protons
- b. the alkaline earth metal in the same period with the neutral noble gas with 18 electrons
- c. the noble gas in the same row as an isotope with 25 protons
- d. the noble gas in the same period as gold

Answer

- a. Cl, chlorine
- b. Mg, magnesium
- c. Kr, krypton
- d. Rn, radon

32. Write a symbol for each of the following neutral isotopes. Include the atomic number and mass number for each.

- a. the alkali metal with 11 protons and a mass number of 23
- b. the noble gas element with 75 neutrons in its nucleus and 54 electrons in the neutral atom
- c. the isotope with 33 protons and 40 neutrons in its nucleus

- d. the alkaline earth metal with 88 electrons and 138 neutrons
- e. the noble gas, used in lighting, with 10 electrons and 10 neutrons
- f. the lightest alkali metal with three neutrons

Answer

- a. $^{23}_{11}\text{Na}$
- b. $^{129}_{54}\text{Xe}$
- c. $^{73}_{33}\text{As}$
- d. $^{226}_{88}\text{Ra}$
- e. $^{20}_{10}\text{Ne}$
- f. ^6_3Li

4.7: Isotopes and Mass Numbers

33. Which pair represents isotopes?

- a. ^4_2He and ^3_2He
- b. $^{56}_{26}\text{Fe}$ and $^{56}_{25}\text{Mn}$
- c. $^{28}_{14}\text{Si}$ and $^{31}_{15}\text{P}$

Answer

pair a

34. Which pair represents isotopes?

- a. $^{40}_{20}\text{Ca}$ and $^{40}_{19}\text{K}$
- b. $^{56}_{26}\text{Fe}$ and $^{56}_{28}\text{Fe}$
- c. $^{238}_{92}\text{U}$ and $^{235}_{92}\text{U}$

Answer

pair c

35. Give complete symbols of each atom, including the atomic number and the mass number.

- a. an oxygen atom with 8 protons and 8 neutrons
- b. a potassium atom with 19 protons and 20 neutrons
- c. a lithium atom with 3 protons and 4 neutrons

Answer

- a. $^{16}_8\text{O}$
- b. $^{39}_{19}\text{K}$
- c. ^7_3Li

36. Give complete symbols of each atom, including the atomic number and the mass number.

- a. a magnesium atom with 12 protons and 12 neutrons
- b. a magnesium atom with 12 protons and 13 neutrons
- c. a xenon atom with 54 protons and 77 neutron

Answer

- a. $^{24}_{12}\text{Mg}$
- b. $^{25}_{12}\text{Mg}$
- c. $^{131}_{54}\text{Xe}$

37. Americium-241 is an isotope used in smoke detectors. What is the complete symbol for this isotope?

Answer



38. Carbon-14 is an isotope used to perform radioactive dating tests on previously living material. What is the complete symbol for this isotope?

Answer



39. A rare isotope of helium has a single neutron in its nucleus. Write the complete atomic symbol of this isotope.

Answer



40. Americium-241 is a crucial part of many smoke detectors. How many neutrons are present in its nucleus?

Answer

146

41. Potassium-40 is a radioactive isotope of potassium that is present in the human body. How many neutrons are present in its nucleus?

Answer

21

42. Give the number of protons, electrons, and neutrons in neutral atoms of each of the following isotopes:

- a. $^{10}_5\text{B}$
- b. $^{199}_{80}\text{Hg}$
- c. $^{63}_{29}\text{Cu}$
- d. $^{13}_6\text{C}$
- e. $^{77}_{34}\text{Se}$

Answer

- a. 5 protons, 5 electrons, 5 neutrons
- b. 80 protons, 80 electrons, 119 neutrons
- c. 29 protons, 29 electrons, 34 neutrons
- d. 6 protons, 6 electrons, 7 neutrons
- e. 34 protons, 34 electrons, 43 neutrons

43. Give the number of protons, electrons, and neutrons in neutral atoms of each of the following isotopes:

- a. ${}^7_3\text{Li}$
- b. ${}^{125}_{52}\text{Te}$
- c. ${}^{109}_{47}\text{Ag}$
- d. ${}^{15}_7\text{N}$
- e. ${}^{31}_{15}\text{P}$

Answer

- a. 3 protons, 3 electrons, 4 neutrons
- b. 52 protons, 52 electrons, 73 neutrons
- c. 47 protons, 47 electrons, 62 neutrons
- d. 7 protons, 7 electrons, 8 neutrons
- e. 15 protons, 15 electrons, 16 neutrons

4.8: Atomic Mass

44. Define *atomic mass*. What is its unit?

Answer

Atomic mass is the average mass of atoms of an element. Its unit is atomic mass units (amu).

45. Determine the atomic mass of each element, given the isotopic composition.

- a. lithium, which is 92.4% lithium-7 (mass 7.016 amu) and 7.60% lithium-6 (mass 6.015 amu)
- b. oxygen, which is 99.76% oxygen-16 (mass 15.995 amu), 0.038% oxygen-17 (mass 16.999 amu), and 0.205% oxygen-18 (mass 17.999 amu)

Answer

- a. 6.94 amu
- b. 16.00 amu

46. Determine the atomic mass of each element, given the isotopic composition.

- a. neon, which is 90.48% neon-20 (mass 19.992 amu), 0.27% neon-21 (mass 20.994 amu), and 9.25% neon-22 (mass 21.991 amu)
- b. uranium, which is 99.27% uranium-238 (mass 238.051 amu) and 0.720% uranium-235 (mass 235.044 amu)

Answer

- a. 20.18 amu
- b. 238.0 amu

47. An element has the following natural abundances and isotopic masses: 90.92% abundance with 19.99 amu, 0.26% abundance with 20.99 amu, and 8.82% abundance with 21.99 amu. Calculate the average atomic mass of this element.

Answer

20.17 amu

48. Average atomic masses listed by IUPAC are based on a study of experimental results. Bromine has two isotopes ^{79}Br and ^{81}Br , whose masses (78.9183 and 80.9163 amu) and abundances (50.69% and 49.31%) were determined in earlier experiments. Calculate the average atomic mass of bromine based on these experiments.

Answer

79.90 amu

49. Variations in average atomic mass may be observed for elements obtained from different sources. Lithium provides an example of this. The isotopic composition of lithium from naturally occurring minerals is 7.5% ^6Li and 92.5% ^7Li , which have masses of 6.01512 amu and 7.01600 amu, respectively. A commercial source of lithium, recycled from a military source, was 3.75% ^6Li (and the rest ^7Li). Calculate the average atomic mass values for each of these two sources.

Answer

mineral = 6.94 amu; commercial = 6.978 amu

50. The ^{18}O : ^{16}O abundance ratio in some meteorites is greater than that used to calculate the average atomic mass of oxygen on earth. Is the average mass of an oxygen atom in these meteorites greater than, less than, or equal to that of a terrestrial oxygen atom?

Answer

The average mass of an oxygen atom in the meteorites will be greater than the average mass of a terrestrial oxygen atom due to the extra ^{18}O .

4.9: Ion Formation

51. Explain how cations form.

Answer

Cations are formed when an atom loses electrons.

52. Explain how anions form.

Answer

Anions are formed when an atom gains electrons.

53. Give the charge each atom takes when it forms an ion.

- a. K
- b. O

Answer

- a. K^+
- b. O^{2-}

54. Give the charge each atom takes when it forms an ion.

- a. Ca
- b. I

Answer

- a. Ca^{2+}
- b. I^{-}

55. Give the charge each atom takes when it forms an ion.

- a. Al
- b. Br

Answer

- a. Al^{3+}
- b. Br^{-}

56. Give the charge each atom takes when it forms an ion.

- a. S
- b. Na

Answer

- a. S^{2-}
- b. Na^{+}

57. Write the symbol for each of the following ions:

- a. the ion with a 1+ charge, atomic number 55, and mass number 133
- b. the ion with 54 electrons, 53 protons, and 74 neutrons
- c. the ion with atomic number 15, mass number 31, and a 3- charge
- d. the ion with 24 electrons, 30 neutrons, and a 3+ charge

Answer

- a. $^{133}\text{Cs}^{+}$
- b. $^{127}\text{I}^{-}$
- c. $^{31}\text{P}^{3-}$
- d. $^{57}\text{Co}^{3+}$

58. Write the symbol for each of the following ions:

- a. the ion with a 3+ charge, 28 electrons, and a mass number of 71
- b. the ion with 36 electrons, 35 protons, and 45 neutrons
- c. the ion with 86 electrons, 142 neutrons, and a 4+ charge
- d. the ion with a 2+ charge, atomic number 38, and mass number 87

Answer

- $^{71}\text{Ga}^{3+}$
- $^{80}\text{Br}^{-}$
- $^{232}\text{Th}^{4+}$
- $^{87}\text{Sr}^{2+}$

59. Determine the number of protons, electrons, and neutrons in the following isotopes that are used in medical diagnoses:

- a. atomic number 9, mass number 18, charge of 1⁻
- b. atomic number 43, mass number 99, charge of 7⁺
- c. atomic number 53, atomic mass number 131, charge of 1⁻
- d. atomic number 81, atomic mass number 201, charge of 1⁺

Answer

- a. 9 protons, 10 electrons, 9 neutrons
- b. 43 protons, 36 electrons, 56 neutrons
- c. 53 protons, 54 electrons, 78 neutrons
- d. 81 protons, 80 electrons, 120 neutrons

60. The following are properties of isotopes of two elements that are essential in our diet. Determine the number of protons, electrons and neutrons in each and name them.

- a. atomic number 26, mass number 58, charge of 2⁺
- b. atomic number 53, mass number 127, charge of 1⁻

Answer

- a. 26 protons, 24 electrons, 32 neutrons
- b. 53 protons, 54 electrons, 74 neutrons

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