1. Which particle has approximately the same mass as a proton?
(A) alpha (C) electron
(B) beta (D) neutron

2. Experimental evidence indicates that the nucleus of an atom
(A) contains most of the mass of the atom
(B) contains a small percentage of the mass of the atom
(C) has no charge
(D) has a negative charge

3. The atomic number of an atom is always equal to the total number of
(A) neutrons in the nucleus
(B) protons in the nucleus
(C) neutrons plus protons in the atom
(D) protons plus electrons in the atom

4. An atom that contains 35 protons, 45 neutrons, and 35 electrons has an atomic number of
(A) 35 (C) 80
(B) 45 (D) 115

5. Which atom has a nucleus that contains 13 protons and 14 neutrons?
(A) Mg (C) Al
(B) Be (D) N

6. What is the total number of electrons in a neutral atom of fluorine?
(A) 9 (C) 19
(B) 10 (D) 28

7. What is the mass number of an atom which contains 21 electrons, 21 protons, and 24 neutrons?
(A) 21 (C) 45
(B) 42 (D) 66

8. Which of the following particles has the *least* mass?
(A) an electron (C) a hyrogen atom
(B) a proton (D) a neutron

9. Compared to an atom of $^{12}_{6}C$, an atom of $^{14}_{6}C$ has
(A) more protons (C) more neutrons
(B) fewer protons (D) fewer neutrons

10. Which two atoms are isotopes?
(A) $^{14}_{6}C$ and $^{14}_{7}N$
(B) $^{21}_{11}Na$ and $^{23}_{11}Na$
(C) $^{3}_{1}H$ and $^{3}_{2}He$
(D) $^{7}_{3}Li$ and $^{7}_{4}Be$

11. The number of protons in an atom of $^{3}_{1}H$ is
(A) 1 (C) 3
(B) 2 (D) 4

12. The nucleus of an atom of $^{127}_{53}I$ contains
(A) 53 neutrons and 127 protons
(B) 53 protons and 127 neutrons
(C) 53 protons and 74 neutrons
(D) 53 protons and 74 electrons

13. The nucleus of an atom of K-42 contains
(A) 19 protons and 23 neutrons
(B) 19 protons and 42 neutrons
(C) 20 protons and 19 neutrons
(D) 23 protons and 19 neutrons

14. An experiment in which alpha particles were used to bombard thin sheets of gold foil led to the conclusion that an atom is composed mostly of
(A) empty space and has a small, negatively charged nucleus
(B) empty space and has a small, positively charged nucleus
(C) a large, dense, positively charged nucleus
(D) a large, dense, negatively charged nucleus

15. Atoms of ^{16}O, ^{17}O, and ^{18}O have the same number of
(A) neutrons, but a different number of protons
(B) protons, but a different number of neutrons
(C) protons, but a different number of electrons
(D) electrons, but a different number of protons

16. All the isotopes of a given atom have
(A) the same mass number and the same atomic number
(B) the same mass number but different atomic numbers
(C) different mass numbers but the same atomic number
(D) different mass numbers and different atomic numbers

17. If the nucleus of an atom is represented as $^{24}_{11}X$, the atom is
(A) Na (C) Mg
(B) Al (D) Br

18. Which subatomic particles have a mass of approximately 1 atomic mass unit each?
(A) proton and electron
(B) proton and neutron
(C) neutron and positron
(D) electron and positron

19. 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.

20. The atomic mass of an element is defined as the weighted average mass of that element's
(A) most abundant isotope
(B) least abundant isotope
(C) naturally occurring isotopes
(D) radioactive isotopes

1. What is the total number of occupied principal energy levels in an atom of neon in the ground state?
(A) 1 (C) 3
(B) 2 (D) 4

2. Which element has atoms with only one completely filled principal energy level?
(A) N (C) As
(B) P (D) Sb

3. The principal quantum number of the outermost electron of an atom in the ground state is $n = 3$. What is the total number of occupied principal energy levels contained in this atom?
(A) 1 (C) 3
(B) 2 (D) 4

4. As an electron in a hydrogen atom moves from the second principal energy level to the first principal energy level, the energy of the atom
(A) decreases (C) remains the same
(B) increases

5. An atom contains a total of 25 electrons. When the atom is in the ground state, how many different principal energy levels will contain electrons?
(A) 1 (C) 3
(B) 2 (D) 4

6. What is the maximum number of electrons in the third shell of an atom?
(A) 6 (C) 3
(B) 9 (D) 18

7. Which electron configuration represents an atom in an excited state?
(A) $1s^2 2s^2 2p^6 3p^1$
(B) $1s^2 2s^2 2p^6 3s^2 3p^1$
(C) $1s^2 2s^2 2p^6 3s^2 3p^2$
(D) $1s^2 2s^2 2p^6 3s^2$

8. The total number of *d* orbitals in the third principal energy level is
(A) 1 (C) 3
(B) 5 (D) 7

9. Which atom in the ground state has three unpaired electrons in its outermost principal energy level?
(A) Li (C) N
(B) B (D) Ne

10. Which is the electron configuration of a neutral atom in the ground state with a total of six valence electrons?
(A) $1s^2 2s^2 2p^2$
(B) $1s^2 2s^2 2p^4$
(C) $1s^2 2s^2 2p^6$
(D) $1s^2 2s^2 2p^6 3s^2 3p^6$

11. Which principal energy level has a maximum of three sublevels?
(A) 1 (C) 3
(B) 2 (D) 4

12. What is the total number of valence electrons in an atom with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^3$?
(A) 6 (C) 3
(B) 2 (D) 5

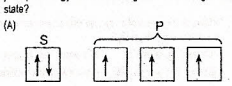
13. Which is an electron configuration of a fluorine atom in the excited state?
(A) $1s^2 2s^2 2p^4$
(B) $1s^2 2s^2 2p^5$
(C) $1s^2 2s^2 2p^4 3s^1$
(D) $1s^2 2s^2 2p^5 3s^1$

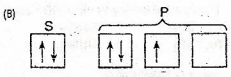
14. The maximum number of electrons that a single orbital of the 3*d* sublevel may contain is
(A) 5 (C) 3
(B) 2 (D) 4

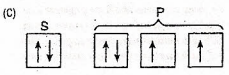
15. Which element has a completely filled third principal energy level?
(A) Ar (C) Fe
(B) N (D) Zn

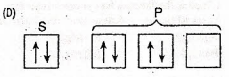
16. Which atom in the ground state contains a partially filled 3*p* orbital?
(A) argon (C) potassium
(B) calcium (D) aluminum

17. Which electron transition represents the release of energy?
(A) 1*s* to 3*p* (C) 3*p* to 1*s*
(B) 2*s* to 2*p* (D) 2*p* to 3*s*

18. Which orbital notation correctly represents the outermost principal energy level of a nitrogen atom in the ground state?
(A) 

(B) 

(C) 

(D) 

19. During a flame test, ions of a specific metal are heated in the flame of a gas burner. A characteristic color of light is emitted by these ions in the flame when the electrons
(A) gain energy as they return to lower energy levels
(B) gain energy as they move to higher energy levels
(C) emit energy as they return to lower energy levels
(D) emit energy as they move to higher energy levels

20. In the ground state, atoms of the elements in Group 15 of the Periodic Table all have the same number of
(A) filled energy levels (shells)
(B) occupied energy levels (shells)
(C) neutrons in the nucleus
(D) electrons in the valence shell

1. The element in Period 2 with the largest atomic radius is
(A) a halogen (C) an alkali metal
(B) a noble gas (D) an alkaline earth metal

2. Which sequence of atomic numbers represents elements which have similar chemical properties?
(A) 19, 23, 30, 36 (C) 3, 12, 21, 40
(B) 9, 16, 33, 50 (D) 4, 20, 38, 88

3. All of the atoms of the elements in Period 2 have the same number of
(A) protons
(B) neutrons
(C) valence electrons
(D) occupied energy levels (shells)

4. In which classification is an element placed if the outermost 3 sublevels of its atoms have a ground state electron configuration of $3p^6 3d^{10} 4s^2$?
(A) alkaline earth metals (C) metalloids (semimetals)
(B) transition metals (D) nonmetals

5. Low ionization energies are most characteristic of atoms that are
(A) metals (C) metalloids
(B) nonmetals (D) noble gases

6. In a given period of the Periodic Table, the element with the lowest first ionization energy is always in
(A) Group 1 (C) Group 17
(B) Group 2 (D) Group 18

7. As the atoms of the elements in Group 1 are considered in order from top to bottom, compared to the ionization energy of the atom above it, the ionization energy of each successive atom
(A) decreases (C) remains the same
(B) increases

8. The table below shows some properties of elements *A*, *B*, *C*, and *D*.

Element	Ionization Energy	Electronegativity	Conductivity of Heat and Electricity
A	low	low	low
B	low	low	high
C	high	high	low
D	high	high	high

Which element is most likely a nonmetal?
(A) *A* (C) *C*
(B) *B* (D) *D*

9. Which of these metals loses electrons most readily?
(A) calcium (C) potassium
(B) magnesium (D) sodium

10. Which sequence correctly places the elements in order of increasing ionization energy?
(A) H → Li → Na → K (C) O → S → Se → Te
(B) I → Br → Cl → F (D) H → Be → Al → Ga

11. Which of the following particles has the smallest radius?
(A) Na^0
(B) K^0
(C) Na^+
(D) K^+

12. Which atom has the strongest attraction for electrons?
(A) Cl (C) Br
(B) F (D) I

13. As the elements in Group 1 are considered in order of increasing atomic number, the atomic radius of each successive element increases. This is primarily due to an increase in the number of
(A) neutrons in the nucleus
(B) electrons in the outermost shell
(C) unpaired electrons
(D) principal energy levels (shells)

14. When a sodium atom becomes an ion, the size of the atom
(A) decreases by gaining an electron
(B) decreases by losing an electron
(C) increases by gaining an electron
(D) increases by losing an electron

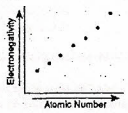
15. Which element has an atomic radius that is greater than its ionic radius?
(A) S (C) F
(B) K (D) O

16. Elements that readily gain electrons tend to have
(A) high ionization energy and high electronegativity
(B) high ionization energy and low electronegativity
(C) low ionization energy and low electronegativity
(D) low ionization energy and high electronegativity

17. Which element in Period 3 has the greatest tendency to gain electrons?
(A) Na (C) Cl
(B) Si (D) Ar

18. Which sequence of elements is arranged in order of decreasing atomic radii?
(A) Al, Si, P (C) Cl, Br, I
(B) Li, Na, K (D) N, C, B

19. Which diagram correctly shows the relationship between electronegativity and atomic number for the elements of Period 3?

(A)


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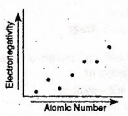

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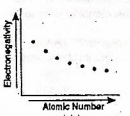

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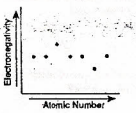


20. Within Period 2 of the Periodic Table, as the atomic number increases, the atomic radius generally
(A) decreases (C) remains the same
(B) increases

1. Which formula represents an ionic compound?
(A) NaCl (C) HCl
(B) N_2O (D) H_2O

2. Which formula correctly represents the compound calcium hydroxide?
(A) CaOH (C) $CaOH_2$
(B) Ca_2OH (D) $Ca(OH)_2$

3. Which metal will form a compound with the general formula M_2CO_3 when it combines with a carbonate ion?
(A) beryllium (C) calcium
(B) aluminum (D) lithium

4. Which is the formula for magnesium sulfide?
(A) MgS (C) MnS
(B) $MgSO_3$ (D) $MnSO_3$

5. The correct formula for calcium phosphate is
(A) $CaPO_4$ (C) Ca_3P_2
(B) $Ca_2(PO_4)_3$ (D) $Ca_3(PO_4)_2$

6. What is the correct name of Fe_2O_3?
(A) iron (I) oxide (C) iron (III) oxide
(B) iron (II) oxide (D) iron (V) oxide

7. Which formula represents sodium sulfate?
(A) $NaSO_4$ (C) Na_2SO_4
(B) $NaSO_3$ (D) Na_2SO_3

8. Which formula correctly represents the composition of iron (III) oxide?
(A) FeO_3 (C) Fe_2O
(B) Fe_2O_3 (D) Fe_3O_2

9. If *M* represents a Group 1 metal, what is the formula for the compound formed by *M* and oxygen?
(A) MO_2 (C) M_2O_3
(B) M_2O (D) M_3O_2

10. Element *M* is a metal and its chloride has the formula MCl_2. To which group of the Periodic Table does element *M* most likely belong?
(A) 1 (C) 15
(B) 2 (D) 17

11. What is the correct name of the compound with the formula NH_4NO_2?
(A) ammonia nitrite (C) ammonia nitrate
(B) ammonium nitrite (D) ammonium nitrate

12. The chemical formula for nickel (II) bromide is
(A) Ni_2Br (C) N_2Br
(B) $NiBr_2$ (D) NBr_2

13. Atoms of metals tend to
(A) lose electrons and form negative ions
(B) lose electrons and form positive ions
(C) gain electrons and form negative ions
(D) gain electrons and form positive ions

14. Which is the formula for the compound that forms when magnesium bonds with phosphorus?
(A) Mg_2P (C) Mg_2P_3
(B) MgP_2 (D) Mg_3P_2

15. Which pair of atoms is held together by a covalent bond?
(A) HCl (C) NaCl
(B) LiCl (D) KCl

16. A correct name for N_2O_3 is
(A) nitrogen (I) oxide (C) nitrogen (III) oxide
(B) nitrogen (II) oxide (D) nitrogen (IV) oxide

17. Which of the following is the correct formula for nitric acid?
(A) HNO_3 (C) HF
(B) HNO_2 (D) H_2S

18. The name of the compound $KClO_2$ is potassium
(A) hypochlorite (C) chlorate
(B) chlorite (D) perchlorate

19. When a potassium atom reacts with bromine, the potassium atom will
(A) lose only 1 electron (C) gain only 1 electron
(B) lose 2 electrons (D) gain 2 electrons

20. What is the formula of nitrogen (II) oxide?
(A) NO (C) N_2O
(B) NO_2 (D) N_2O_4

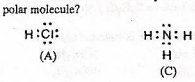
Unit 6 Molecular Geometry

1. The bonds between hydrogen and oxygen in a water molecule are classified as
(A) polar covalent (C) ionic
(B) nonpolar covalent (D) metallic

2. Which molecule is nonpolar?
(A) H_2O (C) CO
(B) NH_3 (D) CO_2

3. Which of these substances has the strongest intermolecular forces?
(A) H_2O (C) H_2Se
(B) H_2S (D) H_2Te

4. Which electron-dot structure represents a non-polar molecule?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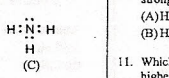
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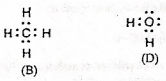
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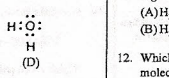

(D)

5. Which molecule contains a triple covalent bond between its atoms?
(A) N_2 (C) F_2
(B) O_2 (D) H_2

6. A diamond is an example of
(A) a supercooled liquid (C) a metallic substance
(B) an ionic compound (D) a network solid

7. In which liquid is hydrogen bonding strongest?
(A) $HF(\ell)$ (C) $CH_4(\ell)$
(B) $H_2(\ell)$ (D) $NH_3(\ell)$

8. Which type of molecule is CF_4?
(A) polar, with a symmetrical distribution of charge
(B) polar, with an asymmetrical distribution of charge
(C) nonpolar, with a symmetrical distribution of charge
(D) nonpolar, with an asymmetrical distribution of charge

9. The shape of a molecule of BF_3 is said to be:
(A) trigonal planar (C) big bent
(B) trigonal pyramidal (D) linear

10. Which compound has molecules that form the strongest hydrogen bonds?
(A) HI (C) HF
(B) HBr (D) HCl

11. Which of the following compounds has the highest boiling point?
(A) H_2O (C) H_2Se
(B) H_2S (D) H_2Te

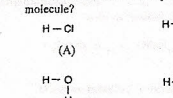
12. Which pair of characteristics describes the molecule illustrated below?

(A) symmetrical and polar
(B) symmetrical and nonpolar
(C) asymmetrical and polar
(D) asymmetrical and nonpolar

13. Which molecule has an asymmetrical shape?
(A) N_2 (C) Cl_2
(B) NH_3 (D) CCl_4

14. The shape of a molecule of BF_3 is said to be:
(A) trigonal planar (C) big bent
(B) trigonal pyramidal (D) linear

15. Which structural formula represents a nonpolar molecule?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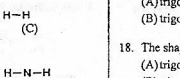
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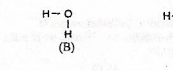
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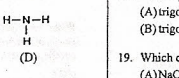
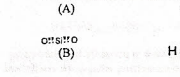

(D)

16. Which electron-dot structure is correct for SiO_2?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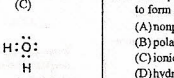
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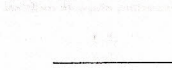
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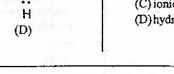

(D)

17. The shape of a molecule of oxygen is said to be:
(A) trigonal planar (C) big bent
(B) trigonal pyramidal (D) linear

18. The shape of a molecule of PF_3 is said to be:
(A) trigonal planar (C) big bent
(B) trigonal pyramidal (D) linear

19. Which compound contains only covalent bonds?
(A) NaOH (C) $Ca(OH)_2$
(B) $Ba(OH)_2$ (D) CH_3OH

20. When phosphorus and chlorine atoms combine to form a molecule of PCl_3, 6 electrons will form
(A) nonpolar covalent bonds
(B) polar covalent bonds
(C) ionic bonds
(D) hydrogen bonds

Unit 7 Mole

1. What is the total number of moles of atoms present in 1 gram formula mass of $Pb(C_2H_3O_2)_2$?
(A) 9 (C) 3
(B) 14 (D) 15

2. The gram formula mass of NH_4Cl is
(A) 22.4 g/mole (C) 53.5 g/mole
(B) 28.0 g/mole (D) 95.5 g/mole

3. The gram-formula mass of $(NH_4)_2CO_3$ is
(A) 46.0 g (C) 78.0 g
(B) 64.0 g (D) 96.0 g

4. Which substance has the greatest molecular mass?
(A) H_2O_2 (C) CF_4
(B) NO (D) I_2

5. The number of moles of molecules in a 12.0-gram sample of Cl_2 is
$\frac{12.0}{35.5}$ mole (A) 12.0 moles (C)
$\frac{12.0}{71.0}$ mole (B) 12.0×35.5 moles (D)

6. The total number of moles represented by 20 grams of $CaCO_3$ is
(A) 1 (C) 0.1
(B) 2 (D) 0.2

7. What is the total mass of 2.0 moles of $H_2(g)$?
(A) 1.0 g (C) 3.0 g
(B) 2.0 g (D) 4.0 g

8. A sample of an unknown gas at STP has a density of 1.25 grams per liter. What is the gram molecular mass of this gas?
(A) 28.0 g (C) 64.0 g
(B) 44.0 g (D) 80.0 g

9. The empirical formula of a compound is CH_3. The molecular formula of this compound could be
(A) CH_4 (C) C_2H_6
(B) C_2H_4 (D) C_3H_6

10. What is the empirical formula of a compound that contains 30.4% nitrogen and 69.6% oxygen by mass?
(A) NO (C) N_2O_3
(B) NO_2 (D) N_2O_5

11. A compound consists of 25.9% nitrogen and 74.1% oxygen by mass. What is the empirical formula of the compound?
(A) NO (C) N_2O
(B) NO_2 (D) N_2O_5

12. What is the percent by mass of oxygen in propanal, CH_3CH_2CHO?
(A) 10.0% (C) 38.1%
(B) 27.6% (D) 62.1%

13. In which compound is the percent by mass of oxygen greatest?
(A) BeO (C) CaO
(B) MgO (D) SrO

14. An example of an empirical formula is
(A) CH_4 (C) $C_2H_4(OH)_2$
(B) C_2H_4 (D) $C_6H_{12}O_6$

15. Which molecular formula is correctly paired with its corresponding empirical formula?
(A) CO_2 and CO
(B) C_2H_2 and CH_2
(C) C_6H_6 and C_2H_2
(D) P_4O_{10} and P_2O_5

16. Which sample contains a total of 9.0×10^{23} atoms?
(A) 0.50 mole of HCl (C) 1.5 moles of Cu
(B) 0.75 mole of H_2O (D) 1.5 moles of H_2

17. What is the total number of atoms contained in a 1.00-mole sample of helium?
(A) 1.00 atom
(B) 2.00 atoms
(C) 1.20×10^{24} atoms
(D) 6.02×10^{23} atoms

18. What is the total number of nitrogen atoms in 0.25 mole of NO_2 gas?
(A) 1.5×10^{23}
(B) 6.0×10^{23}
(C) 3.0×10^{23}
(D) 1.2×10^{24}

19. The volume occupied by 9.03×10^{23} molecules of N_2 gas at STP is closest to
(A) 0.500 liter (C) 22.4 liters
(B) 1.50 liters (D) 33.6 liters

20. The total number of molecules in 34.0 grams of NH_3 is equal to
(A) 1.00×22.4
(B) 2.00×22.4
(C) $1.00 \times 6.02 \times 10^{23}$
(D) $2.00 \times 6.02 \times 10^{23}$

Unit 8 — Chemical Reactions

1. Which formula correctly represents antimony (V) oxide?
(A) SbO_5 (C) Sb_2O_5
(B) Sb_5O (D) Sb_5O_2

2. Given the reaction:

$Mg(s) + 2\ AgNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + 2\ Ag(s)$

Which type of reaction is represented?
(A) single replacement (C) synthesis
(B) double replacement (D) decomposition

3. Which equation represents a double replacement reaction?
(A) $2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$
(B) $CaCO_3 \rightarrow CaO + CO_2$
(C) $LiOH + HCl \rightarrow LiCl + H_2O$
(D) $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

4. $2\ NH_3(g) \leftrightarrow N_2(g) + 3\ H_2(g)$

What type of reaction is shown above?
(A) synthesis (C) single replacement
(B) decomposition (D) double replacement

5. $2\ SO_2(g) + O_2(g) \leftrightarrow 2\ SO_3(g)$

What type of reaction is shown above?
(A) synthesis (C) single replacement
(B) decomposition (D) double replacement

6. When hydrocarbons burn completely in an excess of oxygen, the products are
(A) carbon monoxide and water
(B) carbon dioxide and water
(C) carbon monoxide and carbon dioxide
(D) carbon dioxide and carbon

7. If an equation is balanced properly, both sides of the equation must have the same number of
(A) atoms (C) molecules
(B) coefficients (D) moles of molecules

8. Given the unbalanced equation:

$\_\_Al + \_\_CuSO_4 \rightarrow \_\_Al_2(SO_4)_3 + \_\_Cu$

When the equation is balanced using the *smallest* whole-number coefficients, what is the coefficient of Al?
(A) 1 (C) 3
(B) 2 (D) 4

9. Given the unbalanced equation:

$\_\_Al(s) + \_\_O_2(g) \rightarrow \_\_Al_2O_3(s)$

When this equation is correctly balanced using smallest whole numbers, what is the coefficient of $O_2(g)$?
(A) 6 (C) 3
(B) 2 (D) 4

10. Given the unbalanced equation:

$\_\_CaSO_4 + \_\_AlCl_3 \rightarrow Al_2(SO_4)_3 + \_\_CaCl_2$

What is the coefficient of $Al_2(SO_4)_3$ when the equation is completely balanced using the smallest whole-number coefficients?
(A) 1 (C) 3
(B) 2 (D) 4

11. When the equation

$\_\_C_2H_4 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$

is balanced using smallest whole numbers, what is the coefficient of the O_2?
(A) 1 (C) 3
(B) 2 (D) 4

12. Which equation is correctly balanced?
(A) $CaO + 2H_2O \rightarrow Ca(OH)_2$
(B) $NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$
(C) $Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 3H_2O$
(D) $Cu + H_2SO_4 \rightarrow CuSO_4 + H_2O + SO_2$

13. Given the unbalanced equation:

$\_\_Al_2(SO_4)_3 + \_\_Ca(OH)_2 \rightarrow \_\_Al(OH)_3 + \_\_CaSO_4$

When the equation is completely balanced using the smallest whole number coefficients the sum of the coefficients is
(A) 5 (C) 3
(B) 9 (D) 4

14. Given the unbalanced equation:

$Al(OH)_3 + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2O$

What is the coefficient in front of the H_2O when the equation is completely balanced using the smallest whole number coefficients?
(A) 6 (C) 3
(B) 2 (D) 4

15. Given the balanced equation:
$2Mg + O_2 \rightarrow 2X$
What is the correct formula for the product represented by the letter *X*?
(A) MgO (C) MgO_2
(B) Mg_2O (D) Mg_2OH

16. Given the balanced equation:
$K_2CO_3 + BaCl_2 \rightarrow 2X + BaCO_3$
What is the correct formula for the product represented by the letter *X*?
(A) K (C) KCO_3
(B) Cl (D) KCl

17. Given the incomplete equation:
$CaCl_2 \rightarrow$
Which set of products completes and balances the incomplete equation?
(A) Ca + Cl (C) $CaCl + O_2$
(B) $Ca + Cl_2$ (D) $CaCl + H_2O$

18. Given the balanced equation:

$X + Cl_2 \rightarrow C_2H_5Cl + HCl$

Which molecule is represented by *X*?
(A) C_2H_4 (C) C_3H_6
(B) C_2H_6 (D) C_3H_8

19. Given the incomplete equation:

$2\ N_2O_5(g) \rightarrow$

Which set of products completes and balances the incomplete equation?
(A) $2\ N_2(g) + 3\ H_2(g)$ (C) $4\ NO_2(g) + O_2(g)$
(B) $2\ N_2(g) + 2\ O_2(g)$ (D) $4\ NO(g) + SO_2(g)$

Unit 9 — Stoichiometry

1. Given the equation:

$6\ CO_2(g) + 6\ H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6\ O_2(g)$

What is the minimum number of liters of $CO_2(g)$, measured at STP, needed to produce 32.0 grams of oxygen?
A) 264 L C) 192 L
B) 32.0 L D) 22.4 L

2. Given the unbalanced equation:

$\_\_Mg(ClO_3)_2(s) \rightarrow \_\_MgCl_2(s) + \_\_O_2(g)$

What is the coefficient of O_2 when the equation is balanced correctly using the *smallest* whole number coefficients?
A) 1 C) 3
B) 2 D) 4

3. Given the reaction:

$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$

What is the total number of moles of water needed to make 2.5 moles of $C_6H_{12}O_6$?
A) 12 C) 2.5
B) 6.0 D) 15

4. Given the balanced equation:

$2\ C_4H_{10}(g) + 13\ O_2(g) \rightarrow 8\ CO_2(g) + 10\ H_2O(g)$

What is the total number of moles of $O_2(g)$ that must react completely with 5.00 moles of $C_4H_{10}(g)$?
A) 32.5 C) 26.5
B) 20.0 D) 10.0

5. Given the reaction:

$2\ C_2H_2(g) + 5\ O_2(g) \rightarrow 4\ CO_2(g) + 2\ H_2O(g)$

What is the total number of grams of $O_2(g)$ needed to react completely with 0.50 mole of $C_2H_2(g)$?
A) 160 g C) 40. g
B) 80. g D) 10. g

6. Given the reaction

$N_2(g) + 3\ H_2(g) \rightarrow 2\ NH_3(g)$

How many liters of ammonia, measured at STP, are produced when 28.0 grams of nitrogen is completely consumed?
A) 44.8 C) 11.2
B) 5.60 D) 22.4

7. Given the reaction:

$2\ C_8H_{16}(g) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$

What volume of $C_8H_{16}(g)$ will completely react to produce exactly 36 liters of $H_2O(g)$?
A) 27 L C) 36 L
B) 2.0 L D) 4.0 L

8. Given the equation:

$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

How many moles of carbon dioxide are produced for each mole of butane consumed?
A) 1 C) 8
B) 2 D) 4

9. Given the reaction:

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

What is the total number of liters of $O_2(g)$ at STP needed to produce 6.0×10^{23} molecules of $H_2O(l)$?
A) 33.6 L C) 44.8 L
B) 22.4 L D) 11.2 L

10. Given the reaction:

$2\ H_2 + O_2 \rightarrow 2\ H_2O$

The total number of grams of O_2 needed to produce 54 grams of water is
A) 61 C) 36
B) 48 D) 75

11. Given the reaction:

$2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$

What is the total number of CO_2 molecules produced when one mole of C_2H_6 is consumed?
A) 6.02×10^{23}
B) $2(6.02 \times 10^{23})$
C) $3(6.02 \times 10^{23})$
D) $4(6.02 \times 10^{23})$

12. Given the reaction:

$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

How many grams of H_2SO_4 are needed to produce exactly 11.2 liters of H_2, measured at STP?
A) 49.0 C) 24.5
B) 98.0 D) 196

13. Given the reaction:

$4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$

What is the total number of moles of NO produced when 1.0 mole of O_2 is completely consumed?
A) 1.0 mole C) 0.80 mole
B) 1.2 moles D) 4.0 moles

14. Given the reaction:

$2\ Na + 2\ H_2O \rightarrow 2\ NaOH + H_2$

What is the total number of moles of hydrogen produced when 4 moles of sodium react completely?
A) 1 C) 3
B) 2 D) 4

15. Given the reaction:

$N_2(g) + 3\ H_2(g) \leftrightarrow 2\ NH_3(g)$

What is the mole-to-mole ratio between nitrogen gas and hydrogen gas?
A) 1:3 C) 1:2
B) 2:3 D) 2:2

16. Given the balanced equation:
$K_2CO_3 + BaCl_2 \rightarrow 2X + BaCO_3$
What is the correct formula for the product represented by the letter *X*?
A) KCO_3
B) KCl
C) K
D) Cl

17. Given the equation:

$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$

How many moles of HCl would be required to produce a total of 2 moles of H_2?
A) 0.5 C) 3
B) 2 D) 4

18. Given the balanced equation:

$Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(sq) + Cu(s)$

What total mass of iron is necessary to produce 1.00 mole of copper?
A) 112 g C) 55.8 g
B) 26.0 g D) 192 g

19. Given the balanced equation:

$NaOH + HCl \rightarrow NaCl + H_2O$

What is the total number of grams of H_2O produced when 116 grams of the product, NaCl, is formed?
A) 9.0 g C) 54 g
B) 36 g D) 18 g

20. Given the reaction:

$C_8H_{16} + 12\ O_2 \rightarrow 8\ CO_2 + 8\ H_2O$

How many moles of H_2O are produced when 11.2 liters of C_8H_{16} gas, measured at STP, reacts completely?
A) 8.00 C) 30.0
B) 10.0 D) 4.00

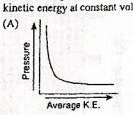
1. A gas occupies a volume of 444 mL at 273 K and 79.0 kPa. What is the final kelvin temperature when the volume of the gas is changed to 1880 mL and the pressure is changed to 38.7 kPa?
(A) 31.5 K (C) 566 K
(B) 292 K (D) 2360 K

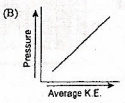
2. The volume of a gas is 4.00 liters at 293 K and constant pressure. For the volume of the gas to become 3.00 liters, the Kelvin temperature must be equal to
(A) $\frac{3.00 \times 293}{4.00}$
(B) $\frac{4.00 \times 293}{3.00}$
(C) $\frac{3.00 \times 4.00}{293}$
(D) $\frac{293}{3.00 \times 4.00}$

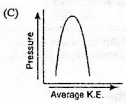
3. A gas occupies a volume of 40.0 milliliters at 20°C. If the volume is increased to 80.0 milliliters at constant pressure, the resulting temperature will be equal to
(A) $20°C \times \frac{80.0mL}{40.0mL}$ (C) $293K \times \frac{80.0mL}{40.0mL}$
(B) $20°C \times \frac{40.0mL}{80.0mL}$ (D) $293K \times \frac{40.0mL}{80.0mL}$

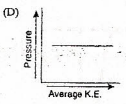
4. As the temperature of a gas increases at constant pressure, the volume of the gas
(A) decreases (C) remains the same
(B) increases

5. Standard temperature and a pressure of 0.5 atmosphere are equal to
(A) 0°C and 51.6 kPa (C) 0°C and 101.3 kPa
(B) 32°C and 51.6 kPa (D) 32°C and 101.3 kPa

6. Which graph best shows the relationship between the pressure of a gas and its average kinetic energy at constant volume?
(A) 

(B) 

(C) 

(D) 

7. The temperature of a 2.0-liter sample of helium gas at STP is increased to 27°C and the pressure is decreased to 80. kPa What is the new volume of the helium sample?
(A) 1.4 L (C) 2.8 L
(B) 2.0 L (D) 4.0 L

8. A gas has a volume of 1,400 milliliters at a temperature of 20. K and a pressure of 1.0 atm. What will be the new volume when the temperature is changed to 40. K and the pressure is changed to 0.50 atm?
(A) 350 mL (C) 1,400 mL
(B) 750 mL (D) 5,600 mL

9. A cylinder with a tightly fitted piston is shown in the diagram below.


As the piston moves downward, the number of molecules of air in the cylinder
(A) decreases (C) remains the same
(B) increases

10. Which graph best represents the pressure-volume relationship for an ideal gas at constant temperature?
(A) 

(C) 

(B) 

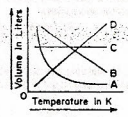
(D) 

11. A gas sample has a volume of 25.0 milliliters at a pressure of 1.00 atmosphere. If the volume increases to 50.0 milliliters and the temperature remains constant, the new pressure will be
(A) 1.00 atm (C) 0.250 atm
(B) 2.00 atm (D) 0.500 atm

12. The volume of a 1.00-mole sample of an ideal gas will decrease when the
(A) pressure decreases and the temperature decreases
(B) pressure decreases and the temperature increases
(C) pressure increases and the temperature decreases
(D) pressure increases and the temperature increases

13. As the pressure of a gas at 150 kPA is changed to 100 kPa at constant temperature, the volume of the gas
(A) decreases (C) remains the same
(B) increases

14. When 500. milliliters of hydrogen gas is heated from 30°C to 60°C at constant pressure, the volume of the gas at 60°C is equal to
(A) $500 ml \times \frac{213}{243}$ (C) $500 ml \times \frac{333}{303}$
(B) $500 ml \times \frac{243}{213}$ (D) $500 ml \times \frac{333}{333}$

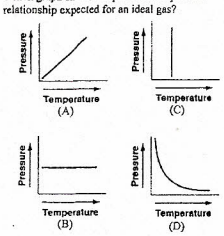
15. 

At constant pressure, which curve best shows the relationship between the volume of an ideal gas and its absolute temperature?
(A) *A* (C) *C*
(B) *B* (D) *D*

16. When the pressure exerted on a confined gas at constant temperature is doubled, the volume of the gas is
(A) halved (C) tripled
(B) doubled (D) quartered

17. If 4.00 moles of oxygen gas, 3.00 moles of hydrogen gas, and 1.00 mole of nitrogen gas are combined in a closed container at standard pressure, what is the partial pressure exerted by the hydrogen gas?
(A) 1.00 atm (C) 3.00 atm
(B) 0.125 atm (D) 0.375 atm

18. A gas sample consisting of 2.0 moles of hydrogen and 1.0 mole of oxygen is collected over water at 29°C and 75 kPa. What is the partial pressure of the hydrogen in the sample?
(A) 24 kPa (C) 72 kPa
(B) 48 kPa (D) 75 kPa

19. Which graph shows the pressure-temperature relationship expected for an ideal gas?


20. Real gas behavior deviates from ideal gas behavior because real gas particles have
(A) no volume and no attraction for each other
(B) no volume but some attraction for each other
(C) volume but no attraction for each other
(D) volume and some attraction for each other

1. The average kinetic energy of water molecules is greatest in which of these samples?
(A) 10 g of water at 35°C (C) 100 g of water at 25°C
(B) 10 g of water at 55°C (D) 100 g of water at 45°C

2. Given the balanced equation representing a reaction:

$$CH_4(g) + 2O_2(g) \rightarrow 2H_2O(g) + CO_2(g) + \text{heat}$$

Which statement is true about energy in this reaction?
(A) The reaction is exothermic because it releases heat.
(B) The reaction is exothermic because it absorbs heat.
(C) The reaction is endothermic because it releases heat.
(D) The reaction is endothermic because it absorbs heat.

3. When ammonium chloride crystals are dissolved in water, the temperature of the water decreases. What does this temperature change indicate about the dissolving of ammonium chloride in water?
(A) It is an endothermic reaction because it absorbs heat.
(B) It is an endothermic reaction because it releases heat.
(C) It is an exothermic reaction because it absorbs heat.
(D) It is an exothermic reaction because it releases heat.

4. As the temperature of a substance decreases, the average kinetic energy of its particles
(A) decreases (C) remains the same
(B) increases

5. When 200 grams of water cools from 50.°C to 25°C, the total amount of heat energy released by the water is
(A) 42 kJ (C) 34 J
(B) 21 kJ (D) 17 J

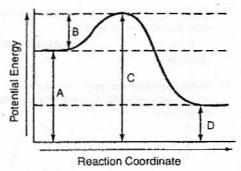
6. How many Joules of heat energy are released when 50. grams of water are cooled from 70.°C to 60.°C?
(A) 42 J (C) 2100 J
(B) 210 J (D) 4200 J

7. A sample of water is heated from 10.0°C to 15.0°C by the addition of 126 Joules of heat. What is the mass of the water?
(A) 5.00 g (C) 30.0 g
(B) 6.00 g (D) 150.0 g

8. When 420 Joules of heat energy is added to 10. grams of water at 20.°C, the final temperature of the water will be
(A) 10.°C (C) 40.°C
(B) 30.°C (D) 100°C

9. What is the total number of kiloJoules of heat energy absorbed when the temperature of 200 grams of water is raised from 10°C to 40°C?
(A) 0.126 kJ (C) 25.2 kJ
(B) 0.840 kJ (D) 33.6 kJ

10. The potential energy diagram below represents a reaction.



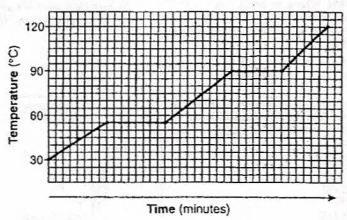
Which arrow represents the activation energy of the forward reaction?
(A) *A* (C) *C*
(B) *B* (D) *D*

11. How much energy is required to vaporize 10.00 grams of water at its boiling point?
(A) 2.26 kJ (C) 4.2 kJ
(B) 3.34 kJ (D) 22.6 kJ

12. Approximately how many Joules of heat are needed to completely change 10.0 grams of ice to water at the melting point temperature?
(A) 1.00 J (C) 334 J
(B) 33.4 J (D) 3,340 J

13. What is the total number of Joules lost when 10. grams of water at 80.°C is cooled to 60.°C?
(A) 42 (C) 420
(B) 84 (D) 840

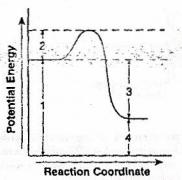
14. The graph below represents the heating curve of a substance that starts as a solid below its freezing point.



What is the melting point of this substance?
(A) 30°C (B) 55°C (C) 90°C (D) 120°C

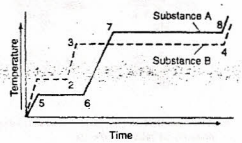
15. Base your answer to the following question on the potential energy diagram below, which represents the reaction:

$A + B \rightarrow C$ + energy.



Which statement correctly describes this reaction?
(A) It is endothermic and energy is absorbed.
(B) It is endothermic and energy is released.
(C) It is exothermic and energy is absorbed.
(D) It is exothermic and energy is released.

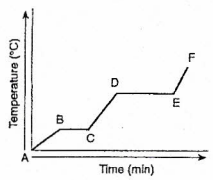
16. Base your answer to the following question on the graph below. The graph shows heat being added at a constant rate to substance *A* and to substance *B*, which begin as solids below their melting point temperatures.



Compared to substance *B*, substance *A* has a
(A) lower melting point and a lower boiling point
(B) lower melting point and a higher boiling point
(C) higher melting point and a lower boiling point
(D) higher melting point and a higher boiling point

17. A 32 gram sample of iron (initially at 500 °C) is placed in 125 grams of water at 25°C, the final temperature of the system is 375°C. What is the specific heat of iron?
(A) 42.2 (C) 45.7
(B) 84.3 (D) 840

18. The graph below represents the uniform heating of a substance, starting with the substance as a solid below its melting point.



Which segment of the graph represents a time when both the solid and liquid phases are present?
(A) *AB* (C) *DE*
(B) *BC* (D) *EF*

19. How many Joules of heat energy are absorbed in raising the temperature of 10. grams of water from 5.0°C to -20.°C?
(A) 3,959 J (C) 4,453 J
(B) 39,590 J (D) 44,530 J

20. How many Joules of heat energy are required in raising the temperature of 100 grams of water from -10.0°C to 0°C?
(A) -2,050 J (C) +2,050
(B) -3, 400 J (D) +3, 400 J

Unit 13 — Acids and Bases

1. Which compound is an electrolyte?
   (A) $C_6H_{12}O_6$ (C) CH_3OH
   (B) $CaCl_2$ (D) CCl_4

2. According to the Arrhenius theory, when a base dissolves in water it produces
   (A) CO_3^{2-} as the only negative ion in solution
   (B) OH^- as the only negative ion in solution
   (C) NH_4^+ as the only positive ion in solution
   (D) H^+ as the only positive ion in solution

3. Which substance is an Arrhenius acid?
   (A) NH_3 (C) $HC_2H_3O_2$
   (B) KOH (D) CH_3OH

4. The pH of a 0.1 M solution is 11. What is the concentration of H_3O^+ ions, in moles per liter?
   (A) 1×10^{-1}
   (B) 1×10^{-3}
   (C) 1×10^{-11}
   (D) 1×10^{-13}

5. What is the pH of a 0.01 M solution of HNO_3?
   (A) 1 (C) 13
   (B) 2 (D) 14

6. Which reaction represents the process of neutralization?
   (A) $Mg(s) + 2\,HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
   (B) $HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(\ell)$
   (C) $Pb(NO_3)_2(aq) + CaCl(aq) \rightarrow Ca(NO_3)_2(aq) + PbCl_2(s)$
   (D) $2\,KClO_3(s) \rightarrow KCl(s) + 3\,O_2(g)$

7. Which acid-base pair will always undergo a reaction that produces a neutral solution?
   (A) a weak acid and a weak base
   (B) a weak acid and a strong base
   (C) a strong acid and a weak base
   (D) a strong acid and a strong base

8. Given the neutralization reaction:

   $$H_2SO_4 + 2\,KOH \rightarrow K_2SO_4 + 2\,HOH$$

   Which compound is a salt?
   (A) KOH (C) K_2SO_4
   (B) H_2SO_4 (D) HOH

9. An aqueous solution of an ionic compound turns red litmus blue, conducts electricity, and reacts with an acid to form a salt and water This compound could be
   (A) HCl (C) KNO_3
   (B) NaI (D) LiOH

10. When hydrochloric acid is neutralized by sodium hydroxide, the salt formed is sodium
    (A) hydrochlorate (C) chloride
    (B) chlorate (D) perchloride

11. Which pH indicates a basic solution?
    (A) 1 (C) 7
    (B) 5 (D) 12

12. Which of these pH numbers indicates the highest level of acidity?
    (A) 5 (C) 10
    (B) 8 (D) 12

13. Which statement describes the characteristics of an Arrhenius base?
    (A) It changes blue litmus to red and has a pH less than 7.
    (B) It changes blue litmus to red and has a pH greater than 7.
    (C) It changes red litmus to blue and has a pH less than 7.
    (D) It changes red litmus to blue and has a pH greater than 7.

14. Red litmus will turn blue when placed in an aqueous solution of
    (A) KCl (C) CH_3OH
    (B) KOH (D) CH_3COOH

15. What is the H_3O^+ ion concentration of a solution that has an OH^- ion concentration of 1.0×10^{-3} M?
    (A) 1.0×10^{-3}M
    (B) 1.0×10^{-7}M
    (C) 1.0×10^{-11}M
    (D) 1.0×10^{-14}M

16. What is the H^+ ion concentration of an aqueous solution in which the OH^- ion concentration is 1×10^{-2} mole per liter?
    (A) 1×10^{-14} M
    (B) 1×10^{-12} M
    (C) 1×10^{-9} M
    (D) 1×10^{-2} M

17. If a solution has a hydronium ion concentration of 1×10^{-9} M, the solution is
    (A) basic and has a pH of 9
    (B) basic and has a pH of 5
    (C) acidic and has a pH of 9
    (D) acidic and has a pH of 5

18. Both $HNO_3(aq)$ and $CH_3COOH(aq)$ can be classified as
    (A) Arrhenius acids that turn blue litmus red
    (B) Arrhenius bases that turn blue litmus red
    (C) Arrhenius acids that turn red litmus blue
    (D) Arrhenius bases that turn red litmus blue

19. A student records the following observations about an unknown solution:

    • conducts electricity
    • turns blue litmus red

    The student should conclude that the unknown solution is most likely
    (A) an acid (C) an ester
    (B) a base (D) an alcohol

20. Which acid is almost completely ionized in a dilute solution at 298K?
    (A) CH_3COOH (C) H_3PO_4
    (B) H_2S (D) HNO_3

Unit 14 — Nuclear Chemistry

1. Which of these types of nuclear radiation has the greatest penetrating power?
   (A) alpha (C) neutron
   (B) beta (D) gamma

2. Which type of radioactive emission has a positive charge and weak penetrating power?
   (A) alpha particle (C) gamma ray
   (B) beta particle (D) neutron

3. Which list of particles is in order of increasing mass?
   (A) proton → electron → alpha particle
   (B) proton → alpha particle → electron
   (C) electron → proton → alpha particle
   (D) alpha particle → electron → proton

4. Which type of radiation is identical in mass and charge to a helium nucleus?
   (A) alpha (C) positron
   (B) beta (D) proton

5. Given the reaction:

   $$^{226}_{88}Ra \rightarrow ^{222}_{86}Rn + X$$

   Which type of emanation is represented by X?
   (A) alpha particle (C) proton
   (B) beta particle (D) positron

6. Which equation represents alpha decay?
   (A) $^{116}_{49}In \rightarrow ^{116}_{50}Sn + X$
   (B) $^{234}_{90}Th \rightarrow ^{234}_{91}Pa + X$
   (C) $^{38}_{19}K \rightarrow ^{38}_{18}Ar + X$
   (D) $^{222}_{86}Rn \rightarrow ^{218}_{84}Po + X$

7. In the reaction $^{239}_{93}Np \rightarrow ^{239}_{94}Pu + X$, what does X represent?
   (A) a neutron (C) an alpha particle
   (B) a proton (D) a beta particle

8. Given the reaction:

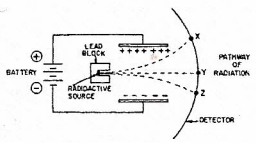
   $$^{24}_{11}Na \rightarrow ^{24}_{12}Mg + ^{0}_{-1}e$$

   This reaction is best described as
   (A) alpha decay (C) fission
   (B) beta decay (D) fusion

9. Which of these types of radiation has the greatest penetrating power?
   (A) alpha (C) gamma
   (B) beta (D) positron

10. Which type of radiation has *neither* mass nor charge?
    (A) gamma (C) alpha
    (B) neutron (D) beta

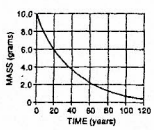
11. In the diagram below, the radiation from a radioactive source is being separated as it passes between electrically charged plates. What are the three types of radiation observed on the detector?



    (A) X = alpha, Y = beta, Z = gamma
    (B) X = gamma, Y = beta, Z = alpha
    (C) X = beta, Y = gamma, Z = alpha
    (D) X = gamma, Y = alpha, Z = beta

12. After 30 days, 5.0 grams of a radioactive isotope remains from an original 40.-gram sample. What is the half-life of this element?
    (A) 5 days (C) 15 days
    (B) 10 days (D) 20 days

13. The graph below represents the decay curve of a radioactive isotope. The half-life of this isotope is



    (A) 8 years (C) 45 years
    (B) 30 years (D) 60 years

14. The half-life of a radioactive isotope is 20.0 minutes. What is the total amount of a 1.00-gram sample of this isotope remaining after 1.00 hour?
    (A) 0.500 g (C) 0.250 g
    (B) 0.333 g (D) 0.125 g

15. An original sample of a radioisotope had a mass of 10 grams. After 2 days, 5 grams of the radioisotope remains unchanged. What is the half-life of this radioisotope?
    (A) 1 day (C) 5 days
    (B) 2 days (D) 4 days

16. In the equation:

    $$^{234}_{91}Pa \rightarrow ^{234}_{92}U + X$$

    The X represents a
    (A) helium nucleus (C) proton
    (B) beta particle (D) neutron

17. Given the nuclear reaction:

    $$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{138}_{56}Ba + ^{95}_{36}Kr + 3^{1}_{0}n + \text{energy}$$

    This equation can best be described as
    (A) fission (C) natural decay
    (B) fusion (D) endothermic

18. According to the equation:

    $$X \rightarrow ^{208}_{82}Pb + ^{4}_{2}He$$

    The nucleus correctly represented by X is
    (A) $^{204}_{80}Hg$
    (B) $^{212}_{84}Po$
    (C) $^{204}_{80}Bi$
    (D) $^{212}_{84}Pb$

19. Given the reaction:

    $$^{234}_{91}Pa \rightarrow X + ^{0}_{-1}e$$

    When the equation is correctly balanced the nucleus represented by X is
    (A) $^{234}_{92}U$
    (B) $^{235}_{92}U$
    (C) $^{230}_{90}Th$
    (D) $^{232}_{90}Th$

20. In the equation:

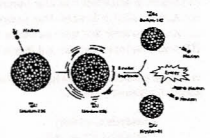
    $$X \rightarrow ^{226}_{88}Ra + ^{4}_{2}He$$

    The symbol X represents
    (A) $^{222}_{86}Th$
    (B) $^{230}_{90}Th$
    (C) $^{222}_{86}Rn$
    (D) $^{230}_{90}Rn$

21. Which equation represents a fusion reaction?
    (A) $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He$
    (B) $^{14}_{6}C \rightarrow ^{0}_{-1}e + ^{14}_{7}N$
    (C) $^{238}_{92}U + ^{4}_{2}He \rightarrow ^{241}_{94}Pu + ^{1}_{0}n$
    (D) $^{1}_{0}n + ^{27}_{13}Al \rightarrow ^{24}_{11}Na + ^{4}_{2}He$

22. Which type of reaction produces energy and intensely radioactive waste products?
    (A) fusion of tritium and deuterium
    (B) fission of uranium
    (C) burning of heating oil
    (D) burning of wood

23. The diagram below represents a nuclear reaction in which a neutron bombards a heavy nucleus.



Which type of reaction does the diagram illustrate?

(A) fission
(B) fusion
(C) alpha decay
(D) beta decay

24. The radioactive isotope carbon-14 can be used for

(A) determining the age of a sample
(B) determining medical disorders
(C) controlling fission reactions
(D) controlling speeds of neutrons

25. Radiation used in the processing of food is intended to

(A) increase the rate of nutrient decomposition
(B) kill microorganisms that are found in the food
(C) convert ordinary nutrients to more stable forms
(D) replace chemical energy with nuclear energy