PRACTICE EXAM 24: PHYSICAL SETTING/CHEMISTRY SIMULATION (85 QUESTIONS) — CUMULATIVE CAPSTONE

1. An atom of an element has 17 protons, 18 neutrons, and 17 electrons. What is its mass number?

A. 17

B. 18

C. 34

D. 35

2. Which statement correctly describes isotopes of the same element?

A. They have different numbers of protons

B. They have the same number of protons but different numbers of neutrons

C. They have different numbers of electrons when neutral

D. They always have the same mass number

3. As the elements of Period 3 are considered in order from sodium to chlorine, the atomic radius generally

A. increases, then decreases

B. increases only

C. decreases

D. remains the same

4. What is the gram-formula mass of calcium carbonate, $CaCO_3$? (Ca = 40, C = 12, O = 16)

A. 68

B. 100

C. 56

D. 116

5. Which type of bond forms when electrons are transferred from one atom to another?

A. covalent bond

B. ionic bond

C. metallic bond

D. hydrogen bond

6. A gas occupies 4.0 liters at a pressure of 2.0 atmospheres. At constant temperature, what volume will it occupy at 1.0 atmosphere?

A. 8.0 L

B. 2.0 L

C. 4.0 L

D. 0.5 L

7. Adding a catalyst to a reaction increases the rate because the catalyst

A. raises the temperature of the reactants

B. increases the concentration of the reactants

C. is consumed to release energy

D. lowers the activation energy of the reaction

8. Which compound is a saturated hydrocarbon?

A. C_2H_4

B. C_2H_2

C. C_3H_6

D. C_3H_8

9. In the reaction $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$, which species is oxidized?

A. Zn

B. Cu^{2+}

C. Zn^{2+}

D. Cu

10. A solution in which the hydrogen ion concentration is greater than the hydroxide ion concentration is best classified as

A. neutral

B. a salt

C. basic

D. acidic

11. Which type of nuclear radiation has no charge and essentially no mass?

A. alpha particle

B. gamma radiation

C. beta particle

D. positron

12. The bright-line spectrum of an element is produced when electrons

A. fall from higher to lower energy levels, releasing energy as light

B. are removed from the atom entirely

C. move from the nucleus to the outer shell

D. are added to the nucleus

13. An element that is a poor conductor of electricity, brittle as a solid, and tends to gain electrons is best classified as a

A. metal

B. metalloid

C. nonmetal

D. noble gas

14. How many moles are present in 90. grams of water, H_2O? (gram-formula mass = 18)

A. 18

B. 1.0

C. 9.0

D. 5.0

15. The bond between the two atoms in a chlorine molecule, Cl_2, is

A. a nonpolar covalent bond

B. a polar covalent bond

C. an ionic bond

D. a metallic bond

16. Which sample of matter has its particles arranged in a regular, repeating geometric pattern?

A. water vapor

B. liquid water

C. molten iron

D. crystalline sodium chloride

17. At equilibrium in a closed system, the concentrations of the reactants and products

A. become equal to each other

B. continuously increase

C. remain constant

D. drop to zero

18. The compounds methane, ethane, and propane all belong to the same

A. homologous series

B. set of isomers

C. functional group of acids

D. group of noble gases

19. During electroplating, the object to be plated is connected as the

A. anode, where oxidation occurs

B. salt bridge

C. cathode, where reduction occurs

D. electrolyte solution

20. According to the Brønsted-Lowry theory, an acid is a substance that, in solution, acts as a

A. hydroxide ion donor

B. hydrogen ion (proton) donor

C. electron donor

D. neutron donor

21. The time required for half of a radioactive sample to decay is called its

A. decay constant

B. activation energy

C. half-life

D. binding energy

22. Which subatomic particles are found in the nucleus of a helium atom?

A. electrons and protons

B. only electrons

C. only neutrons

D. protons and neutrons

23. Which group of elements is characterized by a full outer electron shell and very low reactivity?

A. Group 1

B. Group 18

C. Group 17

D. Group 2

24. Given the balanced equation $2\ H_2 + O_2 \rightarrow 2\ H_2O$, how many moles of water form when 4 moles of hydrogen react completely?

A. 1 mole

B. 2 moles

C. 4 moles

D. 8 moles

25. A substance that conducts electricity in the liquid and dissolved states but not as a solid is most likely

A. a metal

B. a molecular covalent compound

C. a noble gas

D. an ionic compound

26. At STP, what volume is occupied by 2.0 moles of an ideal gas?

A. 22.4 L

B. 44.8 L

C. 11.2 L

D. 2.0 L

27. Increasing the surface area of a solid reactant increases the reaction rate because it

A. increases the area available for collisions

B. raises the activation energy

C. lowers the temperature

D. decreases the number of collisions

28. Which formula represents an organic acid?

A. CH_3OH

B. C_2H_6

C. CH_3COOH

D. C_2H_4

29. What is the oxidation number of sulfur in sulfuric acid, H_2SO_4?

A. −2

B. +2

C. +6

D. 0

30. When 25 mL of an acid exactly neutralizes 25 mL of a base of equal concentration, the resulting solution is

A. strongly acidic

B. strongly basic

C. a pure metal

D. neutral, containing a salt and water

31. In the nuclear equation $^{238}_{92}U \rightarrow {}^{234}_{90}Th + X$, particle X is

A. a beta particle

B. a gamma ray

C. an alpha particle

D. a neutron

32. A ground-state atom has the electron configuration 2-8-2. To which group and period does it belong?

A. Group 2, Period 2

B. Group 18, Period 3

C. Group 2, Period 3

D. Group 12, Period 2

33. Which property generally increases as one moves from left to right across a period?

A. atomic radius

B. electronegativity

C. metallic character

D. number of occupied shells

34. What is the percent by mass of oxygen in water, H_2O? (H = 1, O = 16; formula mass = 18)

A. 11%

B. 50%

C. 89%

D. 16%

35. Which molecule is polar?

A. CO_2

B. Cl_2

C. CH_4

D. H_2O

36. As the temperature of a gas sample increases at constant pressure, the average kinetic energy of its particles

A. decreases

B. increases

C. remains the same

D. becomes zero

37. Which change of state is exothermic?

A. melting

B. freezing

C. boiling

D. sublimation

38. According to Le Chatelier's principle, increasing the pressure on a gaseous equilibrium shifts it toward

A. the side with fewer gas molecules

B. the side with more gas molecules

C. neither side

D. the side that absorbs the most heat

39. Two compounds with the same molecular formula but different structural arrangements are called

A. isomers

B. isotopes

C. allotropes

D. polymers

40. In an operating voltaic cell, oxidation always occurs at the

A. cathode

B. salt bridge

C. anode

D. external wire

41. As an acidic solution is diluted with water, its pH

A. decreases

B. increases toward 7

C. remains exactly the same

D. drops to 1

42. Compared with an ordinary chemical reaction, a nuclear reaction generally releases

A. much greater amounts of energy

B. much less energy

C. exactly the same energy

D. no energy at all

43. The mass of an electron is approximately

A. equal to that of a proton

B. equal to that of a neutron

C. twice that of a proton

D. far smaller than that of a proton

44. Which element has the greatest tendency to lose one electron?

A. potassium

B. chlorine

C. argon

D. sulfur

45. What is the molarity of a solution containing 0.50 mole of solute dissolved in 2.0 liters of solution?

A. 1.0 M

B. 0.25 M

C. 2.0 M

D. 0.50 M

46. The forces of attraction between separate water molecules are best described as

A. covalent bonds

B. ionic bonds

C. metallic bonds

D. hydrogen bonds

47. Which sample contains particles with the lowest average kinetic energy?

A. water at 80 °C

B. water at 50 °C

C. water at 25 °C

D. water at 5 °C

48. The minimum energy required for reactant particles to form products is called the

A. bond energy

B. activation energy

C. heat of reaction

D. kinetic energy

49. The reaction in which a long molecule is built by joining many small identical units is called

A. combustion

B. substitution

C. fermentation

D. polymerization

50. A reaction in which one element replaces another in a compound is classified as

A. single replacement

B. double replacement

C. synthesis

D. decomposition

51. Which of the following is a property common to bases?

A. they turn blue litmus red

B. they taste sour

C. they react with metals to release hydrogen gas

D. they feel slippery and turn red litmus blue

52. Which process powers the Sun, releasing energy by combining light nuclei?

A. fission

B. radioactive decay

C. combustion

D. fusion

53. An ion has 11 protons, 10 electrons, and 12 neutrons. What is its net charge?

A. −1

B. +1

C. +2

D. 0

54. Which list of elements is arranged in order of increasing atomic number?

A. Li, Be, B, C

B. C, B, Be, Li

C. Be, Li, C, B

D. B, C, Li, Be

55. In the equation $N_2 + 3\ H_2 \rightarrow 2\ NH_3$, how many moles of hydrogen are needed to react completely with 1 mole of nitrogen?

A. 1

B. 2

C. 3

D. 6

56. Which statement best explains why metals are malleable?

A. layers of metal ions can slide past one another within a sea of mobile electrons

B. metals are held together by rigid covalent networks

C. metals contain weak ionic lattices that shatter easily

D. metals share their electrons in fixed pairs

57. Adding a nonvolatile solute to a solvent will

A. raise the freezing point and raise the boiling point

B. lower the freezing point and raise the boiling point

C. lower both the freezing point and the boiling point

D. have no effect on either point

58. For the reaction $A + B \rightleftharpoons C +$ heat, increasing the temperature shifts the equilibrium

A. toward the products

B. in neither direction

C. toward the reactants

D. to completion

59. Which functional group is characteristic of an alcohol?

A. —OH (hydroxyl)

B. —COOH (carboxyl)

C. —CHO (aldehyde)

D. —NH_2 (amino)

60. When a metal atom is oxidized, it

A. gains electrons and becomes more negative

B. gains protons

C. loses electrons and becomes a positive ion

D. gains neutrons

61. A neutralization reaction between hydrochloric acid and sodium hydroxide produces

A. hydrogen gas and a metal

B. only a gas

C. sodium chloride and water

D. an acid and a base

62. A radioactive isotope has a half-life of 8 days. What fraction of an original sample remains after 24 days?

A. 1/8

B. 1/4

C. 1/2

D. 1/16

63. The principal reason atoms form chemical bonds is to

A. increase their mass

B. achieve a more stable electron arrangement

C. gain neutrons

D. become radioactive

64. Which of these elements has the largest atomic radius?

A. fluorine

B. oxygen

C. nitrogen

D. lithium

65. How many atoms are present in exactly 1.0 mole of pure carbon?

A. 6.02×10^{23}

B. 12

C. 3.01×10^{23}

D. 1.0

66. The shape and polarity of a molecule are determined mainly by its

A. arrangement of bonded atoms and electron pairs

B. number of neutrons

C. atomic mass

D. nuclear charge only

67. Which statement about an ideal gas is correct according to kinetic molecular theory?

A. gas particles strongly attract one another

B. gas particles are in constant, random motion

C. gas particles themselves occupy most of the container's volume

D. gas particles lose energy in every collision

68. Which change would decrease the rate of a chemical reaction?

A. increasing the temperature

B. increasing the concentration of reactants

C. adding a catalyst

D. lowering the temperature

69. The complete combustion of a hydrocarbon always produces

A. hydrogen gas and carbon

B. carbon dioxide and water

C. carbon monoxide and hydrogen

D. an alcohol and water

70. In the half-reaction $Cu^{2+} + 2\ e^- \rightarrow Cu$, the copper ion is

A. oxidized

B. acting as an acid

C. reduced

D. losing electrons

71. Which pH value indicates the most basic solution?

A. pH 4

B. pH 12

C. pH 7

D. pH 1

72. During beta decay, a neutron in the nucleus is converted into

A. an alpha particle

B. a gamma ray

C. two protons

D. a proton and an emitted electron

73. The number that identifies an element and equals its number of protons is the

A. mass number

B. neutron number

C. atomic number

D. oxidation number

74. A solid changing directly into a gas without passing through the liquid state is undergoing

A. sublimation

B. condensation

C. melting

D. evaporation

75. What is the empirical formula of a compound whose molecular formula is C_4H_8?

A. CH_2

B. C_2H_4

C. C_4H_8

D. CH

76. As the difference in electronegativity between two bonded atoms increases, the bond becomes increasingly

A. metallic

B. nonpolar covalent

C. ionic in character

D. weaker, eventually breaking

77. Which sequence lists elements in order of decreasing first ionization energy?

A. Li, Na, K

B. Ne, F, O

C. O, F, Ne

D. K, Na, Li

78. Which of the following is a chemical property of a substance?

A. its density

B. its melting point

C. its ability to react with oxygen

D. its color

79. A reaction reaches equilibrium when the

A. reaction stops completely

B. reactants are entirely used up

C. products escape the system

D. forward and reverse reaction rates become equal

80. Which substance is an Arrhenius base when dissolved in water?

A. NaOH

B. HCl

C. CO_2

D. NaCl

81. In any redox reaction, the total number of electrons lost by the substance oxidized must

A. be greater than the number gained

B. equal the total number gained by the substance reduced

C. be less than the number gained

D. equal the number of protons present

82. Which statement distinguishes a chemical change from a nuclear change?

A. a chemical change rearranges atoms without changing their nuclei

B. a chemical change converts mass into large amounts of energy

C. a chemical change always forms a new element

D. a chemical change alters the number of protons in the nucleus

83. The total number of valence electrons in an atom of nitrogen (atomic number 7) is

A. 7

B. 2

C. 5

D. 3

84. Which separation technique relies on the different boiling points of the liquids in a mixture?

A. filtration

B. magnetic separation

C. using a centrifuge

D. distillation

85. A student must identify an unknown white solid that has a high melting point, dissolves readily in water, and whose solution conducts electricity. The solid is most likely

A. a molecular covalent compound such as sugar

B. a metallic element

C. a nonpolar liquid

D. an ionic compound such as a salt

Practice Exam 24 — Explained Answer Key (Cumulative Capstone)

1. D — The mass number is the sum of protons and neutrons, so 17 + 18 = 35. Electrons do not count toward mass number because their mass is negligible. The nucleons set the mass.
2. B — Isotopes share the same number of protons but differ in neutrons. The proton count keeps them the same element, while the neutron difference changes their mass. This is the defining feature of isotopes.
3. C — Across a period, increasing nuclear charge pulls the electrons in the same shell closer, so the radius decreases from sodium to chlorine. Greater positive charge means a tighter hold. The atoms shrink toward the right.
4. B — Adding the atomic masses gives 40 + 12 + (3 × 16) = 100. The gram-formula mass is the sum of all atoms in the formula. Calcium carbonate totals 100.
5. B — An ionic bond forms when electrons transfer from a metal to a nonmetal, creating oppositely charged ions. The transfer, not sharing, defines the ionic bond. The ions then attract.
6. A — By Boyle's law, $P_1V_1 = P_2V_2$, so $(2.0)(4.0) = (1.0)(V_2)$, giving $V_2 = 8.0$ L. Volume and pressure are inversely related at constant temperature. Halving the pressure doubles the volume.
7. D — A catalyst speeds a reaction by providing a pathway with a lower activation energy. More collisions then succeed. The catalyst is not used up in the process.

8. D — Propane, C_3H_8, is an alkane with only single bonds, making it saturated. The others contain double or triple bonds and are unsaturated. Single-bonded hydrocarbons are saturated.
9. A — Zinc loses electrons to become Zn^{2+}, so it is oxidized. Oxidation is the loss of electrons. The copper ion, gaining electrons, is reduced.
10. D — When hydrogen ions outnumber hydroxide ions, the solution is acidic. Excess hydrogen ions lower the pH below 7. This is the definition of an acidic solution.
11. B — Gamma radiation is high-energy electromagnetic radiation with no charge and no mass. It penetrates deeply because nothing about it is easily stopped. Alpha and beta particles, by contrast, have mass and charge.
12. A — A bright-line spectrum forms when excited electrons fall from higher to lower energy levels, releasing the energy difference as light. Each transition emits a specific wavelength. The lines are characteristic of the element.
13. C — A brittle, poorly conducting element that gains electrons is a nonmetal. Nonmetals lack metallic luster and conductivity. They tend to form negative ions.
14. D — Dividing the mass by the gram-formula mass gives $90 \div 18 = 5.0$ moles. The formula mass converts grams to moles. The sample contains 5 moles.
15. A — Two identical chlorine atoms share electrons equally, forming a nonpolar covalent bond. Equal electronegativity means no charge separation. Identical atoms always bond nonpolarly.
16. D — A crystalline solid such as sodium chloride has its particles in a regular, repeating lattice. The ordered arrangement defines a crystal. Liquids and gases lack this fixed pattern.
17. C — At equilibrium the forward and reverse rates are equal, so the concentrations of reactants and products stay constant. The reaction continues but the amounts do not change. Constant concentrations mark equilibrium.
18. A — Methane, ethane, and propane are successive members of the alkane homologous series, differing by a CH_2 unit. A homologous series shares a general formula and gradually changing properties. They are not isomers.
19. C — In electroplating, the object being plated is the cathode, where reduction deposits metal onto it. Metal ions gain electrons there. The cathode is the site of reduction.
20. B — Under the Brønsted-Lowry theory, an acid donates a hydrogen ion, or proton. Proton donation defines the acid. The substance accepting the proton is the base.
21. C — The half-life is the time for half of a radioactive sample to decay. It is a fixed property of each isotope. This constant rate underlies radioactive dating.
22. D — The nucleus of a helium atom contains protons and neutrons. Electrons orbit outside the nucleus. The two nucleons account for nearly all the atom's mass.
23. B — Group 18, the noble gases, have full outer shells and are very unreactive. A complete octet makes them stable. They rarely form compounds.
24. C — The ratio of H_2 to H_2O is 2 to 2, so 4 moles of hydrogen yield 4 moles of water. The coefficients set the mole ratio. The amounts match one to one here.
25. D — A substance that conducts when molten or dissolved but not as a solid is ionic. Its ions must be free to move to conduct. In the solid lattice they are locked in place.
26. B — At STP one mole of gas occupies 22.4 L, so 2.0 moles occupy 44.8 L. The molar volume scales with the number of moles. Doubling the moles doubles the volume.
27. A — Greater surface area exposes more particles for collisions, increasing the reaction rate. More contact points mean more frequent collisions. Powdered solids react faster than lumps.
28. C — CH_3COOH contains the carboxyl group, —COOH, which marks an organic acid. The carboxyl group donates a hydrogen ion. This is acetic acid.

29. C — In H_2SO_4, hydrogen is +1 (total +2) and oxygen is −2 (total −8), so sulfur must be +6 for a neutral molecule. The oxidation numbers must sum to zero. Sulfur balances the charges at +6.
30. D — Equal amounts of acid and base of equal concentration neutralize completely, leaving a neutral salt-and-water solution. The hydrogen and hydroxide ions combine into water. A salt remains from the other ions.
31. C — Losing four mass units and two atomic-number units corresponds to emitting an alpha particle, a helium nucleus. The alpha particle carries away two protons and two neutrons. This is alpha decay.
32. C — The configuration 2-8-2 has three occupied shells, placing it in Period 3, and two valence electrons, placing it in Group 2. The number of shells gives the period. The valence electrons give the group.
33. B — Electronegativity increases across a period as the nuclear pull on bonding electrons grows. The stronger attraction draws electrons more tightly. Atomic radius and metallic character decrease across a period.
34. C — Oxygen's mass is 16 out of a formula mass of 18, so $16 \div 18 \approx 89\%$. Percent composition is the element's mass over the total times 100. Oxygen makes up about 89% of water.
35. D — Water is a bent molecule with unequal charge distribution, making it polar. Its shape prevents the bond dipoles from canceling. The other molecules are symmetrical and nonpolar.
36. B — Raising the temperature increases the average kinetic energy of the gas particles. Temperature is a direct measure of average kinetic energy. Hotter particles move faster.
37. B — Freezing releases energy as a liquid becomes a solid, so it is exothermic. Energy leaves the substance as the particles settle into a lattice. Melting, boiling, and sublimation absorb energy.
38. A — By Le Chatelier's principle, higher pressure shifts a gaseous equilibrium toward the side with fewer gas molecules. The system relieves the pressure by reducing the molecule count. This favors the smaller-volume side.
39. A — Compounds with the same molecular formula but different structures are isomers. The atoms are arranged differently. This difference gives them distinct properties.
40. C — In a voltaic cell, oxidation always occurs at the anode. The anode loses electrons to the external circuit. Reduction occurs at the cathode.
41. B — Diluting an acid with water lowers the hydrogen ion concentration, raising the pH toward 7. Adding water moves it closer to neutral. The acid becomes weaker in effect.
42. A — Nuclear reactions release far greater energy than chemical reactions because they convert small amounts of mass into energy. The nuclear binding energy is enormous. This is why nuclear processes are so powerful.
43. D — An electron's mass is roughly 1/1836 that of a proton, so it is far smaller. The electron contributes almost no mass to the atom. Protons and neutrons carry essentially all of it.
44. A — Potassium, an alkali metal with a single, loosely held valence electron, loses one electron most readily. Its low ionization energy makes it highly reactive. It readily forms a +1 ion.
45. B — Molarity is moles divided by liters, so $0.50 \div 2.0 = 0.25$ M. The concentration is moles of solute per liter of solution. The solution is 0.25 molar.
46. D — Water molecules attract one another through hydrogen bonds. These bonds form between the partially positive hydrogen of one molecule and the partially negative oxygen of another. Hydrogen bonding explains water's high boiling point.
47. D — The coolest sample, water at 5 °C, has the lowest average kinetic energy. Lower temperature means slower particle motion. Kinetic energy falls with temperature.

48. B — The minimum energy needed for particles to react is the activation energy. Collisions must meet or exceed it to form products. Catalysts work by lowering it.
49. D — Joining many small identical units into a long molecule is polymerization. The repeating units form a polymer chain. This builds plastics and many natural materials.
50. A — A reaction in which one element replaces another in a compound is single replacement. The more reactive element takes the place of the less reactive one. One element and one compound react.
51. D — Bases feel slippery and turn red litmus blue. The other listed properties belong to acids. Slipperiness and the litmus change are characteristic of bases.
52. D — Fusion combines light nuclei into heavier ones, releasing the energy that powers the Sun. Hydrogen nuclei fuse into helium. This is the Sun's energy source.
53. B — With 11 protons and 10 electrons, the ion has one more positive charge than negative, giving a net charge of +1. Neutrons do not affect charge. The proton excess sets the +1 charge.
54. A — Lithium (3), beryllium (4), boron (5), and carbon (6) increase by one proton each, so Li, Be, B, C is in increasing atomic number. Atomic number is the proton count. The list rises across Period 2.
55. C — The equation shows a 1-to-3 ratio of nitrogen to hydrogen, so 1 mole of N_2 needs 3 moles of H_2. The coefficients set the ratio. Three moles of hydrogen react with one of nitrogen.
56. A — Metals are malleable because layers of metal ions slide past one another within a sea of mobile electrons. The electrons keep the structure bonded as it deforms. This lets metals be hammered without shattering.
57. B — A nonvolatile solute lowers the freezing point and raises the boiling point of the solvent. These are colligative effects of dissolved particles. The liquid range widens.
58. C — In an exothermic reaction, heat is a product, so adding heat shifts the equilibrium toward the reactants. The system consumes the added heat by favoring the reverse reaction. The shift relieves the stress.
59. A — The hydroxyl group, —OH, is characteristic of an alcohol. This functional group defines the alcohol family. It gives alcohols their typical properties.
60. C — When a metal atom is oxidized, it loses electrons and becomes a positive ion. Oxidation is the loss of electrons. The resulting cation carries a positive charge.
61. C — Hydrochloric acid and sodium hydroxide neutralize to form sodium chloride and water. The hydrogen and hydroxide ions combine into water. The remaining ions form the salt.
62. A — In 24 days the isotope passes through three 8-day half-lives, leaving $(1/2)^3 = 1/8$ of the sample. Each half-life halves the amount. Three halvings give one-eighth.
63. B — Atoms bond to achieve a more stable, often full-shell, electron arrangement. Stability drives bonding. Reaching a noble-gas configuration lowers the atom's energy.
64. D — Lithium lies farthest left in Period 2, so it has the largest atomic radius among the choices. Radius decreases across a period as nuclear charge rises. Lithium's looser hold makes it the largest.
65. A — One mole of any substance contains Avogadro's number, 6.02×10^{23}, of particles. This count defines the mole. It applies to atoms, molecules, or ions alike.
66. A — A molecule's shape and polarity depend on how its bonded atoms and electron pairs are arranged. The geometry determines whether bond dipoles cancel. Arrangement, not mass, governs polarity.
67. B — Kinetic molecular theory describes gas particles as being in constant, random motion. They are assumed to have negligible volume and attraction. Their ceaseless motion produces gas pressure.

68. D — Lowering the temperature slows particle motion, reducing the rate of reaction. Fewer and weaker collisions occur. The other options would speed the reaction up.
69. B — Complete combustion of a hydrocarbon always yields carbon dioxide and water. The carbon and hydrogen react fully with oxygen. These are the standard combustion products.
70. C — In $Cu^{2+} + 2\ e^- \rightarrow Cu$, the copper ion gains electrons, so it is reduced. Reduction is the gain of electrons. The gain lowers its oxidation number to zero.
71. B — The highest pH listed, 12, indicates the most basic solution. pH rises with basicity. A value well above 7 means a strong base.
72. D — In beta decay, a neutron converts into a proton and an emitted electron, the beta particle. The new proton raises the atomic number by one. The electron carries away the negative charge.
73. C — The atomic number identifies an element and equals its number of protons. It defines which element an atom is. Changing it would change the element.
74. A — A solid passing directly to a gas without melting is undergoing sublimation. No liquid stage occurs. Dry ice is a familiar example.
75. A — Dividing the subscripts of C_4H_8 by 4 gives the empirical formula CH_2. The empirical formula is the simplest whole-number ratio. C_4H_8 reduces to CH_2.
76. C — As the electronegativity difference grows, the bond becomes increasingly ionic in character. A large difference means electrons are pulled almost entirely to one atom. The sharing gives way to transfer.
77. B — Ionization energy increases across a period, so from highest to lowest the order is Ne, F, O. Neon, on the right, holds its electrons most tightly. The energy decreases toward the left.
78. C — The ability to react with oxygen is a chemical property, observed only during a reaction. The others are physical properties measured without changing the substance. Reactivity reveals chemical behavior.
79. D — Equilibrium is reached when the forward and reverse reaction rates become equal. The reaction continues in both directions at the same speed. Concentrations then stay constant.
80. A — Sodium hydroxide, NaOH, releases hydroxide ions in water, making it an Arrhenius base. Hydroxide ion production defines the Arrhenius base. The other substances are an acid, an oxide, and a salt.
81. B — In a redox reaction, electrons lost by the oxidized species equal those gained by the reduced species. Electrons are conserved in the transfer. This balance underlies all redox equations.
82. A — A chemical change rearranges atoms without altering their nuclei, unlike a nuclear change. The atoms keep their identity. Only the bonds, not the nuclei, change.
83. C — Nitrogen has the configuration 2-5, giving it 5 valence electrons in its outer shell. The valence electrons are those in the highest energy level. Five outer electrons drive its bonding.
84. D — Distillation separates liquids by their differing boiling points. The lower-boiling liquid vaporizes first and is condensed and collected. Boiling point is the basis of the separation.
85. D — A high-melting white solid that dissolves and conducts in solution is an ionic compound such as a salt. Its mobile ions in solution carry charge. The high melting point reflects the strong ionic lattice.