Directions (1–30): For *each* statement or question, record on your separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

1 The mass of a proton is approximately equal to the mass of
(1) an alpha particle   (3) a positron
(2) a beta particle   (4) a neutron

2 An orbital of an atom is defined as the most probable location of
(1) an electron   (3) a positron
(2) a neutron   (4) a proton

3 What must occur when an electron in an atom returns from a higher energy state to a lower energy state?
(1) A specific amount of energy is released.
(2) A random amount of energy is released.
(3) The atom undergoes transmutation.
(4) The atom spontaneously decays.

4 Which element is a liquid at 305 K and 1.0 atmosphere?
(1) magnesium   (3) gallium
(2) fluorine   (4) iodine

5 Which list of elements consists of a metal, a metalloid, and a nonmetal?
(1) Li, Na, Rb   (3) Sn, Si, C
(2) Cr, Mo, W   (4) O, S, Te

6 At STP, which physical property of aluminum always remains the same from sample to sample?
(1) mass   (3) length
(2) density   (4) volume

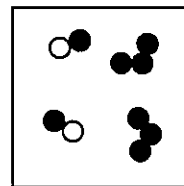7 Which statement describes a chemical property of silicon?
(1) Silicon has a blue-gray color.
(2) Silicon is a brittle solid at 20.°C.
(3) Silicon melts at 1414°C.
(4) Silicon reacts with fluorine.

8 Which diagram represents a mixture of two different molecular forms of the same element?
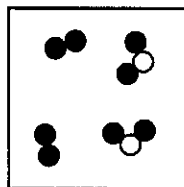
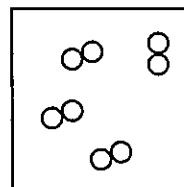| Key |
| --- |
| ● = atom of element X |
| O = atom of element Z |
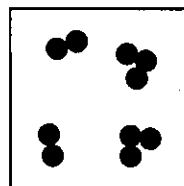
(1)   (3)

(2)   (4)

9 A compound is broken down by chemical means during
(1) chromatography   (3) electrolysis
(2) distillation   (4) filtration

10 Which quantities must be conserved in all chemical reactions?

(1) mass, charge, density
(2) mass, charge, energy
(3) charge, volume, density
(4) charge, volume, energy

11 Which phrase describes the distribution of charge and the polarity of a CH_4 molecule?

(1) symmetrical and polar
(2) symmetrical and nonpolar
(3) asymmetrical and polar
(4) asymmetrical and nonpolar

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

(1) 0
(2) −2
(3) +8
(4) +16

13 Which ion has *no* electrons?

(1) H^+
(2) Li^+
(3) Na^+
(4) Rb^+

14 To break a chemical bond, energy must be

(1) absorbed
(2) destroyed
(3) produced
(4) released

15 Which Lewis electron-dot diagram represents a nitrogen atom in the ground state?

(1)   (2)   (3)   (4)

16 What is the most likely electronegativity value for a metallic element?

(1) 1.3
(2) 2.7
(3) 3.4
(4) 4.0

17 Which polyatomic ion has a charge of 3−?

(1) chromate ion
(2) oxalate ion
(3) phosphate ion
(4) thiocyanate ion

18 Every chlorine atom has

(1) 7 electrons
(2) 17 neutrons
(3) a mass number of 35
(4) an atomic number of 17

19 Which substance can *not* be broken down by a chemical change?

(1) ammonia
(2) methanol
(3) propane
(4) phosphorus

20 At standard pressure, which substance becomes *less* soluble in water as temperature increases from 10.°C to 80.°C?

(1) HCl
(2) KCl
(3) NaCl
(4) NH_4Cl

21 Which type of concentration is calculated when the grams of solute is divided by the grams of the solution, and the result is multiplied by 1 000 000?

(1) molarity
(2) parts per million
(3) percent by mass
(4) percent by volume

22 Which type of energy is associated with the random motion of atoms and molecules in a sample of air?

(1) chemical energy
(2) electrical energy
(3) nuclear energy
(4) thermal energy

23 The temperature of a sample of matter is a measure of the

(1) total kinetic energy of the particles in the sample
(2) total potential energy of the particles in the sample
(3) average potential energy of the particles in the sample
(4) average kinetic energy of the particles in the sample

24 Which unit is used to express the pressure of a gas?

(1) mole
(2) joule
(3) kelvin
(4) pascal

Part B–1

Answer all questions in this part.

Directions (31–50): For *each* statement or question, record on your separate answer sheet the *number* of the word or expression that, of those given, best completes the statement or answers the question. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry*.

31 An atom in the ground state has two electrons in its first shell and six electrons in its second shell. What is the total number of protons in the nucleus of this atom?

(1) 5   (3) 7

(2) 2   (4) 8

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

(1) 2-8-18-6   (3) 2-8-17-7

(2) 2-8-18-7   (4) 2-8-17-8

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

Lithium Isotopes

Isotope	Atomic Mass (u)	Natural Abundance (%)
Li-6	6.02	7.5
Li-7	7.02	92.5

Which numerical setup can be used to determine the atomic mass of lithium?

(1) $(0.075)(6.02 \text{ u}) + (0.925)(7.02 \text{ u})$

(2) $(0.925)(6.02 \text{ u}) + (0.075)(7.02 \text{ u})$

(3) $(7.5)(6.02 \text{ u}) + (92.5)(7.02 \text{ u})$

(4) $(92.5)(6.02 \text{ u}) + (7.5)(7.02 \text{ u})$

34 Element X reacts with chlorine to form an ionic compound that has the formula XCl_2. To which group on the Periodic Table could element X belong?

(1) Group 1   (3) Group 13

(2) Group 2   (4) Group 15

35 Which general trend is found in Period 3 as the elements are considered in order of increasing atomic number?

(1) increasing atomic radius

(2) increasing electronegativity

(3) decreasing atomic mass

(4) decreasing first ionization energy

36 Given the formula for a compound:
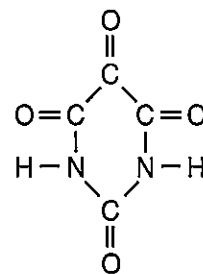
Which molecular formula and empirical formula represent this compound?

(1) C_2HNO_2 and CHNO

(2) C_2HNO_2 and C_2HNO_2

(3) $C_4H_2N_2O_4$ and CHNO

(4) $C_4H_2N_2O_4$ and C_2HNO_2
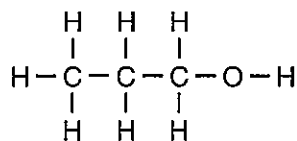
37 What is the gram-formula mass of $(NH_4)_3PO_4$?

(1) 112 g/mol   (3) 149 g/mol

(2) 121 g/mol   (4) 242 g/mol

38 In the ground state, which atom has a completely filled valence electron shell?
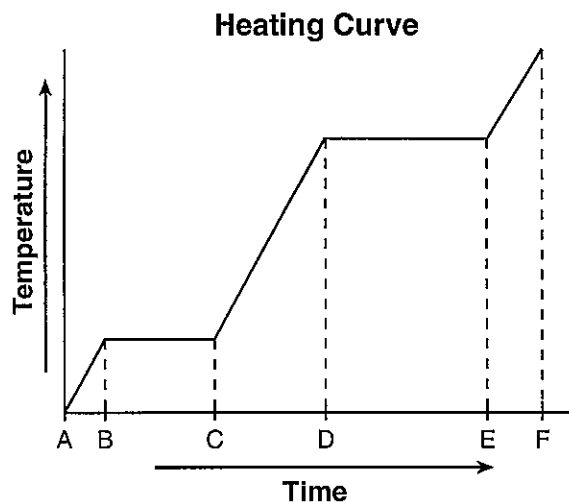
(1) C   (3) Ne

(2) V   (4) Sb

39 Given the formula:

$$H-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}-O-H$$

The bond between which two atoms has the greatest degree of polarity?

(1) C and C   (3) H and C
(2) C and O   (4) H and O

40 Given the diagram representing a heating curve for a substance:

Heating Curve

Time

During which time interval is the average kinetic energy of the particles of the substance constant while the potential energy of the particles increases?

(1) *AC*   (3) *CD*
(2) *BC*   (4) *DF*

41 At 50.°C and standard pressure, intermolecular forces of attraction are strongest in a sample of

(1) ethanoic acid   (3) propanone
(2) ethanol   (4) water

42 At 101.3 kPa and 298 K, what is the total amount of heat released when one mole of aluminum oxide, $Al_2O_3(s)$, is formed from its elements?

(1) 393.5 kJ   (3) 1676 kJ
(2) 837.8 kJ   (4) 3351 kJ

43 Given the balanced equation representing a reaction:

$$2H_2O(\ell) + 571.6 \text{ kJ} \rightarrow 2H_2(g) + O_2(g)$$
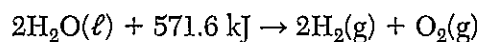
What occurred as a result of this reaction?

(1) Energy was absorbed, and entropy increased.
(2) Energy was absorbed, and entropy decreased.
(3) Energy was released, and entropy increased.
(4) Energy was released, and entropy decreased.

44 Given the potential energy diagram representing a reversible reaction:

Reaction Coordinate
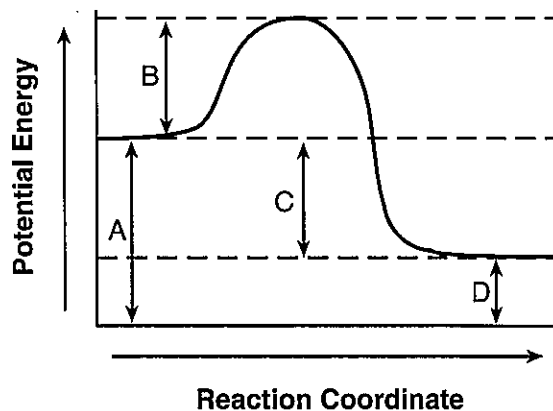
The activation energy for the reverse reaction is represented by

(1) *A + B*   (3) *B + D*
(2) *B + C*   (4) *C + D*

Part B–2

Answer all questions in this part.

Directions (51–65): Record your answers in the spaces provided in your answer booklet. Some questions may require the use of the *2011 Edition Reference Tables for Physical Setting/Chemistry.*

51 What is the mass of $KNO_3(s)$ that must dissolve in 100. grams of water to form a saturated solution at 50.°C? [1]

Base your answers to questions 52 through 55 on the information below.

The reaction between aluminum and an aqueous solution of copper(II) sulfate is represented by the unbalanced equation below.

$$Al(s) + CuSO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + Cu(s)$$
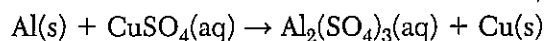
52 Identify the type of chemical reaction represented by the equation. [1]

53 Balance the equation ~~in your answer booklet~~, using the smallest whole-number coefficients. [1]

54 Explain why the equation represents a chemical change. [1]

55 Determine the total mass of Cu produced when 1.08 grams of Al reacts completely with 9.58 grams of $CuSO_4$ to produce 6.85 grams of $Al_2(SO_4)_3$. [1]

Base your answers to questions 56 through 59 on the information below.

A total of 1.4 moles of sodium nitrate is dissolved in enough water to make 2.0 liters of an aqueous solution. The gram-formula mass of sodium nitrate is 85 grams per mole.

56 Write the chemical formula for the solute in the solution. [1]

57 Show a numerical setup for calculating the mass of the solute used to make the solution. [1]

58 Compare the boiling point of the solution at standard pressure to the boiling point of H_2O at standard pressure. [1]

59 Determine the molarity of the solution. [1]