CHEMISTRY TEST

Part A

Directions: Each set of lettered choices below refers to the numbered questions or statements immediately following it. Select the one lettered choice that best answers each question or best fits each statement, and then fill in the corresponding oval on the answer sheet. A choice may be used once, more than once, or not at all in each set.

Questions 1-4

(A) $X_2Y$
(B) $XY$
(C) $XY_2$
(D) $XY_3$
(E) $XY_4$

Which of the above represents the formula for the most common compound of $X$ and $Y$, where $X$ and $Y$ represent given pairs of elements as indicated below?

1. $B$  Mg  S  
2. $C$  Ca  F  
3. $D$  N  H  
4. $C$  Si  O

$\text{Mg}_2\text{S}_2^-$  $\text{MgS}$
$\text{Ca}^{2+}\text{F}^-\text{H}^{+}$  $\text{CaF}_2$
$\text{N}^{3+}\text{H}_3$  $\text{NH}_3$
$\text{Si}^{4+}\text{O}_2^-$  $\text{SiO}_2$

Si$_2$O$_4$ $\rightarrow$ SiO$_2$
5. **HINTS**

(a) Cr$_2$O$_7^{2-}$
(b) H$^+$
(c) OH$^-$
(d) Cr$^{3+}$
(e) Ba$^{2+}$

Which of the above is the appropriate ion for each blank in the following series of reactions?

\[
\text{OH}^- + \text{Cr}_2\text{O}_7^{2-} \rightarrow \text{CrO}_4^{2-} + \text{H}^+ + \text{Ba}^{2+} \rightarrow \text{BaCrO}_4 \text{ ppt} = \text{Ba}^2+ + \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}
\]

GO ON TO THE NEXT PAGE
when considering hybridization use this general rule:
when only 2 atoms are bonded, no hybridization occurs.
Hybrids occur with 3 or more atoms in a central atom.

CHEMISTRY TEST—Continued

Questions 16-19

(A) Element with atomic number 2 He
(B) Element with atomic number 7 N
(C) Element with atomic number 19 K
(D) Element with atomic number 35 Br
(E) Element with atomic number 74 W

16. An element that reacts vigorously with water C

17. A transition element E

18. An element whose chemical properties are similar to those of chlorine D

19. An element that forms diatomic molecules that have triple bonds B N≡N

Questions 13-15 refer to the following elements.

(A) Lithium
(B) Sodium
(C) Potassium
(D) Rubidium
(E) Cesium

13. Which forms the smallest of the +1 ions? A

14. Which has the largest atomic radius? E

15. Which has the smallest first ionization energy? E

GO ON TO THE NEXT PAGE

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Questions 20-22 refer to the following processes.

(A) Precipitation
(B) Oxidation-reduction
(C) Distillation
(D) Hydration
(E) Condensation

20. Electrolysis of water to form hydrogen and oxygen gases

21. Reaction of silver ion with chloride ion in water $\text{AgCl}$

22. Reaction of iron filings with powdered sulfur

$$\text{Fe} + \text{S} \rightarrow \text{FeS}$$

Questions 23-25

(A)

(B)

(C)

(D)

(E)

23. Could be a plot of the pressure of a gas ($y$) against the volume ($x$) for one mole of an ideal gas at fixed temperature

24. Could be a plot of the pressure of a gas ($y$) against the absolute temperature ($x$) for one mole of an ideal gas in a fixed volume

25. Could be the plot of the average molecular kinetic energy of molecules ($y$) against the absolute temperature ($x$) for one mole of an ideal gas

$$\text{Direct} \quad \Delta\text{as } T\text{Increase}$$

$$\text{KE Increase}$$
Directions: Each question below consists of two statements, I in the left-hand column and II in the right-hand column. For each question, determine whether statement I is true or false and whether statement II is true or false and fill in the corresponding T or F ovals on your answer sheet. Fill in oval CE only if statement II is a correct explanation of statement I.

EXAMPLES:

EX 1. H₂SO₄ is a strong acid BECAUSE H₂SO₄ contains sulfur.
EX 2. An atom of oxygen is electrically neutral BECAUSE an oxygen atom contains an equal number of protons and electrons.

SAMPLE ANSWERS

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101. The shape of a water molecule is linear BECAUSE the bonds in a water molecule are nonpolar.
102. Some alpha particles shot at a thin metal foil are reflected back toward the source BECAUSE alpha particles shot at thin metal foil sometimes approach the nuclei of the metal atoms head-on and are thus repelled.
103. Potassium permanganate is a colored compound BECAUSE both potassium and manganese are metals.
104. A molecule of silicon tetrachloride, SiCl₄, is nonpolar BECAUSE the four bonds in SiCl₄ are identical and the molecule has a tetrahedral structure.
105. When solid KNO₃ dissolves in water, covalent bonds are broken BECAUSE solid KNO₃ dissociates into K⁺ and NO₃⁻ ions in water.
106. An element that has the electron configuration 1s²2s²2p⁶ 3s²3p⁶3d¹ 4s² is a transition element BECAUSE in atoms of transition elements, the 1s, 2s, 2p, 3s and 3p orbitals are completely filled in the ground state.
107. The reaction of hydrogen with oxygen to form water is an exothermic reaction BECAUSE water molecules have polar covalent bonds.
CHEMISTRY TEST—Continued

108. An element whose atoms have an outer electron configuration $3s^1$ shows metallic properties
- T BECAUSE metallic elements readily gain electrons.
- F

109. H$_2$O and H$_2$O$_2$ have the same empirical formula
- F BECAUSE in H$_2$O and H$_2$O$_2$, oxygen has the same oxidation state.
- F

110. A salt whose water solution has a pH of 5 is basic
- F BECAUSE a solution having a pH of 5 has a higher concentration of H$_3$O$^+$ ions than of OH$^-$ ions.
- T

111. A buret is normally used in volumetric titrations
- T BECAUSE a buret can accurately measure the volumes of a solution delivered.
- T CE

112. The combustion of fuels containing sulfur leads to the production of acid rain
- T BECAUSE sulfur oxides form acid solutions in water.
- T CE

113. After a system has reached chemical equilibrium, there is no change in the concentrations of reactants and products
- T BECAUSE reactions are not reversible at equilibrium.
- F

114. At the same temperature and pressure, 1 liter of hydrogen gas and 1 liter of neon gas have the same mass
- F BECAUSE equal volumes of ideal gases at the same temperature and pressure contain the same number of moles.
- T

A container of water is placed inside an insulated bell jar as shown above. A vacuum pump lowers the pressure.

115. When the pressure drops sufficiently, the water starts to boil
- T BECAUSE at the boiling point, the vapor pressure of the water equals the pressure inside the bell jar.
- CE

RETURN TO THE SECTION OF YOUR ANSWER SHEET YOU STARTED FOR CHEMISTRY AND ANSWER QUESTIONS 26-70.
CHEMISTRY TEST—Continued

Part C

Directions: Each of the questions or incomplete statements below is followed by five suggested answers or completions. Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.

28. A certain mass of carbon required 16 grams of oxygen to be converted into carbon monoxide, CO. If this same mass of carbon were to be converted into carbon dioxide, CO₂, the mass of oxygen required would be
   (A) 4.0 grams
   (B) 8.0 grams
   (C) 12 grams
   (D) 32 grams
   (E) indeterminable from the information given

29. As shown in the figure above, two compartments are separated by a porous membrane that is permeable to ionic salts. A sodium chloride solution is placed in one compartment while distilled water is placed in the other. Factors that influence the initial rate at which the water diffuses into the compartment containing the NaCl solution include which of the following?
   I. Concentration of the sodium chloride solution
   II. Area of the porous membrane
   III. Temperature of the system
   (A) I only
   (B) II only
   (C) I and III only
   (D) II and III only
   (E) I, II, and III

30. Given the reaction:
   \[ 2\text{BCl}_3 + 3\text{H}_2 \rightarrow 6\text{HCl} + 2\text{B}\]

   When the equation for the reaction represented above is balanced with coefficients reduced to the lowest whole-number terms, correct statements include which of the following?
   I. The coefficient for \(\text{Cl}^-\) is 4.
   II. The coefficient for \(\text{ClO}_3^-\) is 2.
   III. The coefficient for \(\text{ClO}^-\) is 3.
   (A) I only
   (B) II only
   (C) III only
   (D) I and II only
   (E) I, II, and III

TRY

\[ \frac{\text{ClO}}{1}\left(\text{-2}\right) = -1 \]
\[ \frac{\text{ClO}_3}{1}\left(\text{-2}\right) = -1 \]
\[ \frac{\text{ClO}_3^-}{1}\left(\text{-1}\right) + 2e^- \]
\[ \text{ClO}^- \rightarrow \text{ClO}_3^- \rightarrow 4\text{Cl}^- \]

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31. A student adds 0.1-molar HCl to 0.1-molar KOH until the resulting solution is neutral. When this solution is evaporated to dryness, the substance that remains can be correctly described as which of the following?
   (A) A white, crystalline solid
   (B) A covalent solid
   (C) A water-soluble salt
   (D) I and III only
   (E) I, II, and III

32. How many milliliters of 0.200-molar sodium hydroxide must be added to a 100-milliliter solution of 0.100-molar nitric acid to obtain a solution with a pH of 7?

   \[
   \text{pH} = \frac{\text{HNO}_3 + \text{NaOH}}{2} = \frac{10}{2} = \frac{\log 10}{2} = 5.0
   \]

   (A) 10.0 mL
   (B) 25.0 mL
   (C) 50.0 mL
   (D) 100 mL
   (E) 200 mL

33. Which of the following statements about catalysts is true?

   (A) They increase the value of the equilibrium constant.
   (B) They increase the amount of product present at equilibrium.
   (C) They increase the concentration of reactants.
   (D) They are permanently altered as the reaction proceeds.
   (E) They reduce the activation energy of the reaction.

34. Complete combustion of hydrocarbons produces
   (A) C_2H_6OH
   (B) HC_2H_3O_2
   (C) H_2 + CH_3COOH
   (D) CO_2 + H_2O
   (E) CH_3CH_2CH_3 + CH_4

35. The rate at which a solid dissolves in water is increased by which of the following?
   (I) Increasing the surface area of the solid
   (II) Raising the temperature of the water
   (III) Stirring the mixture

   (A) I only
   (B) II only
   (C) I and II only
   (D) II and III only
   (E) I, II, and III

GO ON TO THE NEXT PAGE
CHEMISTRY TEST—Continued

36. \( \text{C(s)} + \ldots \text{H}_2\text{SO}_4(\ell) \rightarrow \ldots \text{CO}_2(g) + \ldots \text{SO}_2(g) + \ldots \text{H}_2\text{O}(\ell) \)

When the equation for the reaction represented above is balanced and the coefficients are reduced to the lowest whole-number terms, the coefficient for \( \text{SO}_2(g) \) is

(A) 1  (B) 2  (C) 3  (D) 4  (E) 6

37. The ground state electron configuration of the silicon atom is characterized by which of the following?

I. Partially filled \( 3p \) orbitals
II. The presence of unpaired electrons
III. Six valence electrons

(A) I only  (B) II only  (C) I and II only  (D) I and III only  (E) I, II, and III

38. Which of the following gases is \textbf{least} dense when all are measured under the same conditions?

(A) \( \text{CO}_2 \)  (B) \( \text{Cl}_2 \)  (C) \( \text{SO}_2 \)  (D) \( \text{H}_2 \)  (E) \( \text{NO} \)

39. Which of the following best accounts for some of the nonideal behavior observed in real gases?

(A) Some gaseous molecules are not spherical.
(B) There are intermolecular attractive forces.
(C) The temperature is not kept constant.
(D) \( R \), the gas constant, is not a true constant.
(E) Experimental errors are made in the measurement of the pressure and the volume.

\[ \text{C}^0 + 2\text{H}_2\text{SO}_4 \rightarrow \text{CO}_2 + 2\text{SO}_2 + 2\text{H}_2\text{O} \]

\[ 2(\text{H}_2\text{SO}_4 + 2e^- \rightarrow \text{SO}_2) \]
CHEMISTRY TEST—Continued

Questions 40-43 refer to the experiment shown below in which the vapor pressure of isopropanol was determined. Throughout the experiment, the temperature was held constant at 25°C, and the atmospheric pressure remained at 760 millimeters of Hg.

Figure I

Isopropanol

Hg

Each Division = 1 mm

Before injection of isopropanol

40. According to Figure I, the initial pressure inside the flask is
   (A) near zero (vacuum)
   (B) 27 mm Hg
   (C) 760 mm Hg
   (D) (760 - 27) mm Hg
   (E) (760 + 27) mm Hg

41. According to Figure II, the vapor pressure of isopropanol at 25°C was determined to be
   (A) 20 mm Hg
   (B) 35 mm Hg
   (C) 45 mm Hg
   (D) 725 mm Hg
   (E) 795 mm Hg

42. Which of the following is a possible source of error in the results of this experiment?
   (A) Inaccurate weighing of the isopropanol
   (B) The presence of bits of broken glass in the flask
   (C) Failure to correct for humidity
   (D) Misreading of the atmospheric pressure
   (E) Leakage around the rubber stopper

43. Which of the following changes in the experiment would cause the Hg levels in the U-tube to vary from those shown in Figure II?
   (A) Replacing the flask with one that has a round bottom
   (B) Doubling the volume of liquid injected into the flask
   (C) Increasing the temperature of the system to 30°C
   (D) Replacing the air originally in the flask with helium gas at a pressure of 760 mm Hg
   (E) Increasing the diameter of the U-tube

Remember that there is air in the flask at 760 mm Hg pressure to begin with. When isoprop. is added, the pressure within the flask shown in Figure I is increased.
CHEMISTRY TEST—Continued

44. Filtration is a technique particularly suited to the separation of
   (A) two solids with different densities
   (B) two liquids with different molar masses
   (C) two liquids with different boiling points
   (D) a solid and a liquid
   (E) a gas and a liquid

45. In which of the following compounds does bromine have the highest positive oxidation state?
   (A) HBr
   (B) BrF₃
   (C) BrO₂
   (D) NaBrO
   (E) NaBrO₃

46. What is the empirical formula of a compound that contains 0.025 mole of Cd, 0.050 mole of C, and 0.100 mole of O?
   (A) CdCO
   (B) CdCO₂
   (C) CdCO₃
   (D) CdC₂O₂
   (E) CdC₃O₄

47. The mass of 6.02 × 10²³ molecules of a gas is 64.0 grams. What volume does 8.00 grams of the gas occupy at standard temperature and pressure?
   (A) 2.80 liters
   (B) 8.00 liters
   (C) 11.2 liters
   (D) 22.4 liters
   (E) 64.0 liters

48. Raising the temperature at which a chemical reaction proceeds may do all of the following EXCEPT
   (A) increase the molecular collision frequency
   (B) increase the number of molecules with energy greater than the activation energy
   (C) speed up the forward and reverse reactions
   (D) decrease the randomness of the system
   (E) change the relative concentrations of products to reactants that are present at equilibrium

49. To determine whether a water solution of Na₂S₂O₃ at room temperature is supersaturated, one can
   (A) heat the solution to its boiling point
   (B) add water to the solution
   (C) add a crystal of Na₂S₂O₃ to the solution
   (D) acidify the solution
   (E) cool the solution to its freezing point

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Questions 50-52

The following elements are listed in order of decreasing reactivity as they appear in the electrochemical series.

Ca, Na, Mg, Zn, Fe, H, Cu, Hg, Ag, Au

50. The element that is the best reducing agent is
(A) Ca  (B) Au  (C) H  (D) Fe  (E) Cu

51. Of the following, the element that does NOT react with hydrochloric acid to produce hydrogen gas is
(A) Zn  (B) Fe  (C) Hg  (D) Ca  (E) Mg

52. In the electrochemical cell shown above, which of the following half-reactions occurs at the anode?
(A) Cu^{2+} + e → Cu
(B) Zn(s) → Zn^{2+} + 2 e
(C) Zn^{2+} + 2 e → Zn(s)
(D) Cu(s) → Cu^{2+} + 2 e
(E) Cu^{2+} + 2 e → Cu(s)

53. An atom contains 15 protons, 15 electrons, and 16 neutrons. Which of the following combinations of particles is an isotope of that atom?

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<th>Protons</th>
<th>Electrons</th>
<th>Neutrons</th>
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<td>(E)</td>
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<td>15</td>
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54. What is the percent composition by mass of aluminum in a compound of aluminum and oxygen if the mole ratio of Al:O is 2:3?
(A) 37% Al
(B) 47% Al
(C) 53% Al
(D) 63% Al
(E) 74% Al

55. At constant temperature, the change of state of any substance from liquid to gas always includes which of the following?
   I. The breaking of covalent bonds
   II. An increase in the randomness of the system
   III. The absorption of energy
(A) I only
(B) II only
(C) I and II only
(D) II and III only
(E) I, II, and III only
CHEMISTRY TEST—Continued

Questions 56-57

N₂(g) + 3 H₂(g) → 2 NH₃(g) + 92 kilojoules

56. Ammonia is produced from nitrogen and hydrogen by the exothermic reaction represented above. When 4 moles of ammonia are produced by the reaction, which of the following occurs?
(A) 46 kilojoules are absorbed.
(B) 92 kilojoules are absorbed.
(C) 184 kilojoules are absorbed.
(D) 92 kilojoules are given off.
(E) 184 kilojoules are given off.

57. According to the equation above, what mass of nitrogen gas is required to produce 68 grams of ammonia?
(A) 112 grams
(B) 56 grams
(C) 44 grams
(D) 28 grams
(E) 14 grams

58. The electron dot structure for the hydronium ion is
(A) H⁺
(B) [H:Ö:]
(C) [H:Ö:H]⁺
(D) [H:H:Ö:H]
(E) [H:Ö:H]⁺

59. Which of the following does NOT react with a dilute H₂SO₄ solution?
(A) NaNO₃
(B) Na₂S
(C) Na₃PO₄
(D) Na₂CO₃
(E) NaOH

60. AlCl₃(aq) + NH₃(aq) + H₂O →

Which of the following is one of the products obtained from the reaction above?
(A) AlN
(B) AlH₃
(C) Al
(D) Al(NO₃)₃
(E) Al(OH)₃

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AlCl₃ + NH₃ + H₂O →

Al³⁺ + Cl⁻ → NH₄⁺ + OH⁻

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CHEMISTRY TEST—Continued

61. A 0.1-molar solution of which of the following compounds has the lowest hydrogen ion concentration?
   (A) HCl
   (B) AlCl₃
   (C) NaHCO₃
   (D) NaOH
   (E) HC₃H₂O₂ (acetic acid)

62. Milliliters of 0.1 \( M \) \( \text{Pb(NO₃)₂} \) Milliliters of 0.1 \( M \) \( \text{NaI} \)

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<th>( \text{NaI} )</th>
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<td>V</td>
<td>6</td>
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</table>

Which of the mixtures listed above yields the maximum amount of precipitated \( \text{PbI}_₂ \)?
   (A) I (B) II (C) III (D) IV (E) V

63. When \( \text{HS}⁻ \) acts as a Brönsted base, which of the following is formed?
   (A) \( \text{S}²⁻ \)
   (B) \( \text{H}⁻ \)
   (C) \( \text{H₂S} \)
   (D) \( \text{H}_₂\text{S}_₂ \)
   (E) \( \text{H}_₂\text{S}⁻ \)

64. \( 2 \text{NO}(g) + \text{H}_₂(g) \rightleftharpoons \text{N}_₂\text{O}(g) + \text{H}_₂\text{O}(g) + 351 \text{ kilojoules} \)

If the total pressure on the system is increased when the reaction represented above is at equilibrium, which of the following occurs?
   (A) The concentration of \( \text{H}_₂\text{O} \) increases.
   (B) The concentration of \( \text{N}_₂\text{O} \) decreases.
   (C) The rate of the reaction decreases.
   (D) The temperature of the system decreases.
   (E) The \( \text{H}_₂ \) gas condenses.
65. Neutralization of 500 milliliters of 2 molar NaOH requires the smallest volume of which of the following?

(A) 1 M $\text{H}_2\text{SO}_4$
(B) 1 M $\text{CH}_3\text{COOH}$
(C) 1 M $\text{HCl}$
(D) 1 M $\text{NH}_3$
(E) 0.1 M $\text{H}_2\text{SO}_4$

66. Boron trifluoride, $\text{BF}_3$, is a nonpolar molecule, whereas ammonia, $\text{NH}_3$, is a polar molecule. The difference in polarities is related to the fact that

(A) $\text{BF}_3$ has no hydrogen bonding and $\text{NH}_3$ does
(B) $\text{BF}_3$ is triangular planar and $\text{NH}_3$ is pyramidal
(C) $\text{BF}_3$ is a Lewis base and $\text{NH}_3$ is a Lewis acid
(D) the $\text{B-F}$ bond is less polar than the $\text{N-H}$ bond
(E) boron is more electronegative than nitrogen

I. $\text{A} + \text{B} = 2\text{C} + \text{D}$
II. $2\text{C} + \text{D} = \text{A} + \text{B}$

67. If the equilibrium constant for the reaction represented by equation I above is $4.0 \times 10^{-2}$, what is the value of the equilibrium constant for the reaction represented by equation II?

(A) $16 \times 10^{-4}$
(B) $4.0 \times 10^{-2}$
(C) $\frac{1}{4.0}$
(D) $\frac{1}{4.0} \times 10^{-2}$
(E) $4.0 \times 10^{2}$

68. A solution is made by adding 5.6 grams of KOH (molar mass 56 grams) to enough water to make 1.0 liter of solution. What is the approximate pH of the resulting solution?

(A) 1
(B) 3
(C) 7
(D) 9
(E) 13

69. $\text{H}_2(g) + \text{S(s)} = \text{H}_2\text{S(g)}$

What is the mass action expression (equilibrium constant expression) for the equilibrium mixture of solid sulfur, hydrogen gas, and hydrogen sulfide gas represented by the equation above?

(A) $K = \frac{1}{[\text{H}_2]}$
(B) $K = \frac{1}{[\text{H}_2\text{S}]}$
(C) $K = \frac{[\text{H}_2\text{S}]}{[\text{H}_2][\text{S}]}$
(D) $K = \frac{[\text{H}_2\text{S}]}{[\text{H}_2][\text{S}]}$
(E) $K = \frac{[\text{H}_2\text{S}]}{[\text{H}_2][\text{S}]}$

70. A 1.0-liter sample of a 0.01-molar solution of CaCl$_2$ contains a total of

(A) 0.04 mole of Ca$^{2+}$
(B) 0.02 mole of Ca$^{2+}$
(C) 0.01 mole of Cl$^-$
(D) 0.01 mole of Cl$^-$
(E) 0.02 mole of Cl$^-$

STOP

IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS TEST ONLY.
DO NOT TURN TO ANY OTHER TEST IN THIS BOOK.
### TABLE A

**Answers to the SAT II: Chemistry Subject Test, Form 3PAC7 reformatted, and Percentage of Students Answering Each Question Correctly**

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Correct Answer</th>
<th>Right</th>
<th>Wrong</th>
<th>Percentage of Students Answering the Question Correctly*</th>
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*These percentages are based on an analysis of the answer sheets for a random sample of 2,382 students who took this form of the test in May 1994 and whose mean score was 598. They may be used as an indication of the relative difficulty of a particular question. Each percentage may also be used to predict the likelihood that a typical SAT II: Chemistry Subject Test candidate will answer correctly that question on this edition of this test.

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