GRADUATE RECORD EXAMINATIONS®

Chemistry Test
Practice Book

This practice book contains

- one actual full-length GRE Chemistry Test
- test-taking strategies

Become familiar with

- test structure and content
- test instructions and answering procedures

Compare your practice test results with the performance of those who took the test at a GRE administration.

Visit GRE Online at www.ets.org/gre

Listening.
Learning.
Leading.

This book is provided FREE with test registration by the Graduate Record Examinations Board.

Note to Test Takers: Keep this practice book until you receive your score report.
The book contains important information about content specifications and scoring.

CHEMISTRY TEST
PRACTICE BOOK

Table of Contents

Purpose of the GRE Subject Tests

The GRE Subject Tests are designed to help graduate school admission committees and fellowship sponsors assess the qualifications of applicants in specific fields of study. The tests also provide you with an assessment of your own qualifications.

Scores on the tests are intended to indicate knowledge of the subject matter emphasized in many undergraduate programs as preparation for graduate study. Because past achievement is usually a good indicator of future performance, the scores are helpful in predicting success in graduate study. Because the tests are standardized, the test scores permit comparison of students from different institutions with different undergraduate programs. For some Subject Tests, subscores are provided in addition to the total score; these subscores indicate the strengths and weaknesses of your preparation, and they may help you plan future studies.

The GRE Board recommends that scores on the Subject Tests be considered in conjunction with other relevant information about applicants. Because numerous factors influence success in graduate school, reliance on a single measure to predict success is not advisable. Other indicators of competence typically include undergraduate transcripts showing courses taken and grades earned, letters of recommendation, and GRE General Test scores. For information about the appropriate use of GRE scores, write to GRE Program, Educational Testing Service, Mail Stop 57-L, Princeton, NJ 08541, or visit our Web site at www.gre.org/codelst.html.

Development of the Subject Tests

Each new edition of a Subject Test is developed by a committee of examiners composed of professors in the subject who are on undergraduate and graduate faculties in different types of institutions and in different regions of the United States and Canada. In selecting members for each committee, the GRE Program seeks the advice of the appropriate professional associations in the subject.

The content and scope of each test are specified and reviewed periodically by the committee of examiners. Test questions are written by the committee and by other faculty who are also subject-matter specialists and by subject-matter specialists at ETS. All questions proposed for the test are reviewed by the committee and revised as necessary. The accepted questions are assembled into a test in accordance with the content specifications developed by the committee to ensure adequate coverage of the various aspects of the field and, at the same time, to prevent overemphasis on any single topic. The entire test is then reviewed and approved by the committee.

Subject-matter and measurement specialists on the ETS staff assist the committee, providing information and advice about methods of test construction and helping to prepare the questions and assemble the test. In addition, each test question is reviewed to eliminate language, symbols, or content considered potentially offensive, inappropriate for major subgroups of the test-taking population, or likely to perpetuate any negative attitude that may be conveyed to these subgroups. The test as a whole is also reviewed to ensure that the test questions, where applicable, include an appropriate balance of people in different groups and different roles.

Because of the diversity of undergraduate curricula, it is not possible for a single test to cover all the material you may have studied. The examiners, therefore, select questions that test the basic knowledge and skills most important for successful graduate study in the particular field. The committee keeps the test up-to-date by regularly developing new editions and revising existing editions. In this way, the test content changes steadily but gradually, much like most curricula. In addition, curriculum surveys are conducted periodically to ensure that the content of a test reflects what is currently being taught in the undergraduate curriculum.

After a new edition of a Subject Test is first administered, examinees' responses to each test question are analyzed in a variety of ways to determine whether each question functioned as expected. These analyses may reveal that a question is ambiguous, requires knowledge beyond the scope of the test, or is inappropriate for the total group or a particular subgroup of examinees taking the test. Answers to such questions are not used in computing scores.

Following this analysis, the new test edition is equated to an existing test edition. In the equating process, statistical methods are used to assess the difficulty of the new test. Then scores are adjusted so that examinees who took a difficult edition of the test are not penalized, and examinees who took an easier edition of the test do not have an advantage. Variations in the number of questions in the different editions of the test are also taken into account in this process.

Scores on the Subject Tests are reported as three-digit scaled scores with the third digit always zero. The maximum possible range for all Subject Test total scores is from 200 to 990. The actual range of scores for a particular Subject Test, however, may be smaller. The maximum possible range of Subject Test subscores is 20 to 99; however, the actual range of subscores for any test or test edition may be smaller than 20 to 99. Subject Test score interpretive information is provided in *Interpreting Your GRE Scores,* which you will receive with your GRE score report, and on the GRE Web site at www.gre.org/codelst.html.

Content of the Chemistry Test

The test consists of about 136 multiple-choice questions. A periodic table is printed in the test booklet as well as a table of information (see page 10) presenting various physical constants and a few conversion factors among SI units. Whenever necessary, additional values of physical constants are printed with the text of the question. Test questions are constructed to simplify mathematical manipulations. As a result, neither calculators nor tables of logarithms are needed. If the solution to a problem requires the use of logarithms, the necessary values are included with the question.

The content of the test emphasizes the four fields into which chemistry has been traditionally divided and some interrelationships among the fields. Because of these interrelationships, individual questions may test more than one field of chemistry. Some examinees may associate a particular question with one field, whereas other examinees may have encountered the same material in a different field. For example, the knowledge necessary to answer some questions classified as testing organic chemistry may well have been acquired in analytical chemistry courses by some examinees. Consequently, the emphases of the four fields indicated in the following outline of material covered by the test should not be considered definitive.

I. ANALYTICAL CHEMISTRY — 15%

   A. Data Acquisition and Use of Statistics — Errors, statistical considerations
   B. Solutions and Standardization — Concentration terms, primary standards
   C. Homogeneous Equilibria — Acid-base, oxidation-reduction, complexometry
   D. Heterogeneous Equilibria — Gravimetric analysis, solubility, precipitation titrations, chemical separations
   E. Instrumental Methods — Electrochemical methods, spectroscopic methods, chromatographic methods, thermal methods, calibration of instruments

F. Environmental Applications
G. Radiochemical Methods — Detectors, applications

II. INORGANIC CHEMISTRY — 25%

A. General Chemistry — Periodic trends, oxidation states, nuclear chemistry
B. Ionic Substances — Lattice geometries, lattice energies, ionic radii and radius/ratio effects
C. Covalent Molecular Substances — Lewis diagrams, molecular point groups, VSEPR concept, valence bond description and hybridization, molecular orbital description, bond energies, covalent and van der Waals radii of the elements, intermolecular forces
D. Metals and Semiconductors — Structure, band theory, physical and chemical consequences of band theory
E. Concepts of Acids and Bases — Brønsted-Lowry approaches, Lewis theory, solvent system approaches
F. Chemistry of the Main Group Elements — Electronic structures, occurrences and recovery, physical and chemical properties of the elements and their compounds
G. Chemistry of the Transition Elements — Electronic structures, occurrences and recovery, physical and chemical properties of the elements and their compounds, coordination chemistry
H. Special Topics — Organometallic chemistry, catalysis, bioinorganic chemistry, applied solid-state chemistry, environmental chemistry

III. ORGANIC CHEMISTRY — 30%

A. Structure, Bonding, and Nomenclature — Lewis structures, orbital hybridization, configuration and stereochemical notation, conformational analysis, systematic IUPAC nomenclature, spectroscopy (IR and ^{1}H and ^{13}C NMR)
B. Functional Groups — Preparation, reactions, and interconversions of alkanes, alkenes, alkynes, dienes, alkyl halides, alcohols, ethers, epoxides, sulfides, thiols, aromatic compounds, aldehydes, ketones, carboxylic acids and their derivatives, amines
C. Reaction Mechanisms — Nucleophilic displacements and addition, nucleophilic aromatic substitution, electrophilic additions, electrophilic aromatic substitutions, eliminations, Diels-Alder and other cycloadditions
D. Reactive Intermediates — Chemistry and nature of carbocations, carbanions, free radicals, carbenes, benzynes, enols
E. Organometallics — Preparation and reactions of Grignard and organolithium reagents, lithium organocuprates, and other modern main group and transition metal reagents and catalysts
F. Special Topics — Resonance, molecular orbital theory, catalysis, acid-base theory, carbon acidity, aromaticity, antiaromaticity, macromolecules, lipids, amino acids, peptides, carbohydrates, nucleic acids, terpenes, asymmetric synthesis, orbital symmetry, polymers

IV. PHYSICAL CHEMISTRY — 30%

A. Thermodynamics — First, second, and third laws, thermochemistry, ideal and real gases and solutions, Gibbs and Helmholtz energy, chemical potential, chemical equilibria, phase equilibria, colligative properties, statistical thermodynamics
B. Quantum Chemistry and Applications to Spectroscopy — Classical experiments, principles of quantum mechanics, atomic and molecular structure, molecular spectroscopy
C. Dynamics — Experimental and theoretical chemical kinetics, solution and liquid dynamics, photochemistry

Preparing for a Subject Test

GRE Subject Test questions are designed to measure skills and knowledge gained over a long period of time. Although you might increase your scores to some extent through preparation a few weeks or months before you take the test, last-minute cramming is unlikely to be of further help. The following information may be helpful.

- A general review of your college courses is probably the best preparation for the test. However, the test covers a broad range of subject matter, and no one is expected to be familiar with the content of every question.

- Use this practice book to become familiar with the types of questions in the GRE Chemistry Test, paying special attention to the directions. If you thoroughly understand the directions before you take the test, you will have more time during the test to focus on the questions themselves.

Test-Taking Strategies

The questions in the practice test in this book illustrate the types of multiple-choice questions in the test. When you take the test, you will mark your answers on a separate machine-scorable answer sheet. Total testing time is two hours and fifty minutes; there are no separately timed sections. Following are some general test-taking strategies you may want to consider.

- Read the test directions carefully, and work as rapidly as you can without being careless. For each question, choose the best answer from the available options.

- All questions are of equal value; do not waste time pondering individual questions you find extremely difficult or unfamiliar.

- You may want to work through the test quite rapidly, first answering only the questions about which you feel confident, then going back and answering questions that require more thought, and concluding with the most difficult questions if there is time.

- If you decide to change an answer, make sure you completely erase it and fill in the oval corresponding to your desired answer.

- Questions for which you mark no answer or more than one answer are not counted in scoring.

- As a correction for haphazard guessing, one-fourth of the number of questions you answer incorrectly is subtracted from the number of questions you answer correctly. It is improbable that mere guessing will improve your score significantly; it may even lower your score. If, however, you are not certain of the correct answer but have some knowledge of the question and are able to eliminate one or more of the answer choices, your chance of getting the right answer is improved, and it may be to your advantage to answer the question.

- Record all answers on your answer sheet. Answers recorded in your test book will not be counted.

- Do not wait until the last five minutes of a testing session to record answers on your answer sheet.

What Your Scores Mean

Your raw score—that is, the number of questions you answered correctly minus one-fourth of the number you answered incorrectly—is converted to the scaled score that is reported. This conversion ensures that a scaled score reported for any edition of a Subject Test is comparable to the same scaled score earned on any other edition of the same test. Thus, equal scaled scores on a particular Subject Test indicate essentially equal levels of performance regardless of the test edition taken. Test scores should be compared only with other scores on the same Subject Test. (For example, a 680 on the Computer Science Test is not equivalent to a 680 on the Mathematics Test.)

Before taking the test, you may find it useful to know approximately what raw scores would be required to obtain a certain scaled score. Several factors influence the conversion of your raw score to your scaled score, such as the difficulty of the test edition and the number of test questions included in the computation of your raw score. Based on recent editions of the Chemistry Test, the following table gives the range of raw scores associated with selected scaled scores for three different test editions. (Note that when the number of scored questions for a given test is greater than the range of possible scaled scores, it is likely that two or more raw scores will convert to the same scaled score.) The three test editions in the table that follows were selected to reflect varying degrees of difficulty. Examinees should note that future test editions may be somewhat more or less difficult than the test editions illustrated in the table.

Range of Raw Scores* Needed to Earn Selected Scaled Scores on Three Chemistry Test Editions That Differ in Difficulty

Scaled Score	Raw Scores		
	Form A	Form B	Form C
900	115-117	113-115	112-114
800	93-94	89-90	88-89
700	70-71	64-66	63-65
600	47-48	40-41	39-40
Number of Questions Used to Compute Raw Score			
	135	135	133

*Raw Score = Number of correct answers minus one-fourth the number of incorrect answers, rounded to the nearest integer.

For a particular test edition, there are many ways to earn the same raw score. For example, on the edition listed above as "Form A," a raw score of 70 through 71 would earn a scaled score of 700. Below are a few of the possible ways in which a scaled score of 700 could be earned on that edition.

Examples of Ways to Earn a Scaled Score of 700 on the Edition Labeled as "Form A"

Raw Score	Questions Answered Correctly	Questions Answered Incorrectly	Questions Not Answered	Number of Questions Used to Compute Raw Score
70	70	0	65	135
70	76	25	34	135
70	83	51	1	135
71	71	0	64	135
71	77	24	34	135
71	83	49	3	135

Practice Test

To become familiar with how the administration will be conducted at the test center, first remove the answer sheet (pages 55 and 56). Then go to the back cover of the test book (page 50) and follow the instructions for completing the identification areas of the answer sheet. When you are ready to begin the test, note the time and begin marking your answers on the answer sheet.

GRADUATE RECORD EXAMINATIONS®

GRE®

ETS
Educational
Testing Service

CHEMISTRY TEST

*Do not break the seal
until you are told to do so.*

*The contents of this test are confidential.
Disclosure or reproduction of any portion
of it is prohibited.*

THIS TEST BOOK MUST NOT BE TAKEN FROM THE ROOM.

Material in the tables on pages 10 and 11 may be useful in answering the questions in this examination.

DO NOT DETACH FROM BOOK.

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.179
11 **Na** 22.99	12 **Mg** 24.30											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.90	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.938	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.91	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 *****La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.21	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.02	89 †**Ac** 227.03	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 § (269)	111 § (272)	112 § (277)						

§Not yet named

*Lanthanide Series

58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97

†Actinide Series

90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

TABLE OF INFORMATION

Electron rest mass $\qquad$ $m_e = 9.11 \times 10^{-31}$ kilogram

Proton rest mass $\qquad$ $m_p = 1.672 \times 10^{-27}$ kilogram

Neutron rest mass $\qquad$ $m_n = 1.675 \times 10^{-27}$ kilogram

Magnitude of the electron charge $\qquad$ $e = 1.60 \times 10^{-19}$ coulomb

Bohr radius $\qquad$ $a_0 = 5.29 \times 10^{-11}$ meter

Avogadro number $\qquad$ $N_A = 6.02 \times 10^{23}$ per mole

Universal gas constant $\qquad$ $R = 8.314$ joules/(mol · K)
$\qquad$ $= 0.0821$ L · atm/(mol · K)
$\qquad$ $= 0.08314$ L · bar/(mol · K)

Boltzmann constant $\qquad$ $k = 1.38 \times 10^{-23}$ joule/K

Planck constant $\qquad$ $h = 6.63 \times 10^{-34}$ joule · second

Speed of light $\qquad$ $c = 3.00 \times 10^{8}$ m/s $= 3.00 \times 10^{10}$ cm/s

1 atmosphere pressure $\qquad$ 1 atm $= 1.0 \times 10^{5}$ newtons/meter^2
$\qquad$ $= 1.0 \times 10^{5}$ pascals (Pa)

Faraday constant $\qquad$ $\mathscr{F} = 9.65 \times 10^{4}$ coulombs/mol

1 atomic mass unit (amu) $\qquad$ 1 amu $= 1.66 \times 10^{-27}$ kilogram

1 electron volt (eV) $\qquad$ 1 eV $= 1.602 \times 10^{-19}$ joule

Volume of 1 mole of ideal
gas at 0° C, 1 atmosphere $\qquad$ $= 22.4$ liters

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 space on the answer sheet.

<u>Note:</u> Solutions are aqueous unless otherwise specified.

Throughout the test the following symbols have the specified definitions unless otherwise noted.

T	= temperature	M	= molar
P	= pressure	m	= molal
V	= volume	mL	= milliliter(s)
S	= entropy	g	= gram(s)
H	= enthalpy	nm	= nanometer(s)
U	= internal energy	L	= liter(s)
R	= molar gas constant	kg	= kilogram(s)
n	= number of moles	atm	= atmosphere(s)

1. THIS ITEM WAS NOT SCORED.

2. The third ionization energy of titanium is required to carry out which of the following processes?

(A) $Ti^{3+}(g) + e^- \rightarrow Ti^{2+}(g)$
(B) $Ti^{2+}(g) \rightarrow Ti^{3+}(g) + e^-$
(C) $3\ Ti(g) \rightarrow 3\ Ti^+(g) + 3e^-$
(D) $Ti(g) \rightarrow Ti^{3+}(g) + 3e^-$
(E) $Ti(s) \rightarrow Ti^+(g) + e^-$
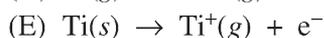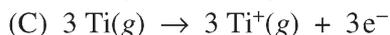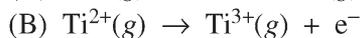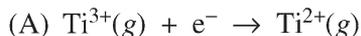
3. Which of the following has the largest radius?

(A) Ca^{2+}
(B) K^+
(C) Ar
(D) Cl^-
(E) S^{2-}
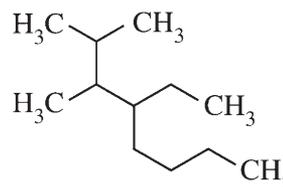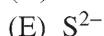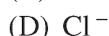
4. According to IUPAC nomenclature, which of the following is the name for the compound shown above?

(A) 3-butyl-2-(1-methylethyl)pentane
(B) 2-isopropyl-3-butylpentane
(C) 2-isopropyl-3-ethylheptane
(D) 4-ethyl-2,3-dimethyloctane
(E) 2-isododecane

GO ON TO THE NEXT PAGE.
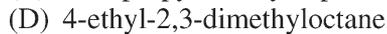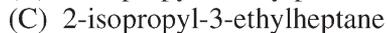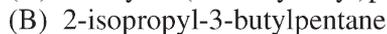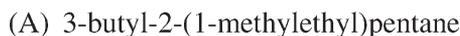
5. Of the following, which corresponds to a compound with exactly one ring or double bond?

   (A) $C_5H_{10}O$
   (B) $C_5H_{10}Cl_2O$
   (C) $C_5H_{11}Cl$
   (D) $C_5H_{11}ClO$
   (E) $C_5H_{12}O_2$

6. If 4.0 g of a gas occupies 11.2 L at 0.0°C and 0.25 atmosphere, then the molecular mass of the gas is

   (A)   8.0 g
   (B) 16 g
   (C) 32 g
   (D) 48 g
   (E) 64 g

7. Solutions of the following compounds, all at the same molality, were prepared. Which solution has the lowest freezing point?

   (A) KBr
   (B) $Al(NO_3)_3$
   (C) CH_3COONa
   (D) $NaNO_2$
   (E) $MgCl_2$

$$(P + n^2a/V^2)(V - nb) = nRT$$

8. Which of the following gases has the largest value of b in the van der Waals equation shown above?

   (A) CH_4
   (B) CCl_4
   (C) HCl
   (D) H_2O
   (E) N_2

9. The solubility product expression, K_{sp}, for the slightly soluble salt $Pb(IO_3)_2$ is equal to

   (A) $[Pb^{2+}][IO_3^-]$
   (B) $[Pb^{2+}]^2[IO_3^-]$
   (C) $[Pb^{2+}][IO_3^-]^2$
   (D) $[Pb^{2+}]^2[IO_3^-]^2$
   (E) $[Pb^{2+}][2\,IO_3^-]^2$

10. Which of the following is the pH of a solution obtained by mixing 50.0 mL of 0.100 M HA and 50.0 mL of 0.100 M NaOH ?

    I. Neutral if HA is a strong acid
    II. Basic if HA is a weak acid
    III. Neutral if HA is a weak acid

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

$$X^+ + e^- \rightarrow X(s) \qquad E° = -2.174 \text{ V}$$

11. For the half-reaction above, which of the following is a correct statement?

    (A) X^+ is readily reduced.
    (B) X^+ is a good oxidizing agent.
    (C) X is a poor reducing agent.
   (D) X is a good oxidizing agent.
    (E) X is readily oxidized.

$$
\begin{array}{cc}
CO_2H & CO_2H \\
\mid & \mid \\
H-C-OH & H-C-CH_3 \\
\mid & \mid \\
CH_3 & OH
\end{array}
$$
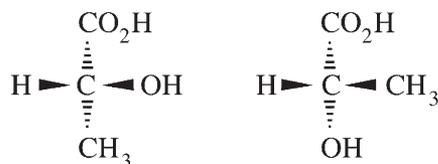
12. The structures shown above are

    (A) identical
    (B) different conformations of the same compound
    (C) enantiomers
    (D) diastereomers
    (E) constitutional isomers

GO ON TO THE NEXT PAGE.

13. Which of the following reactions yields the indicated compound as a major product?

(A)

(B)

(C)

(D)

(E)

$$\underset{\substack{| \\ CH_3}}{CH_3CHCH_2CH_2CH_3} + Br_2 \xrightarrow{\;hv\;}$$
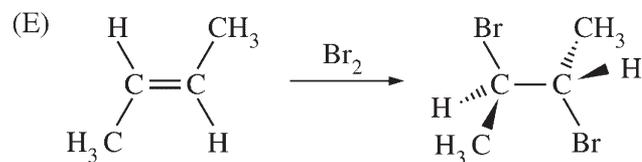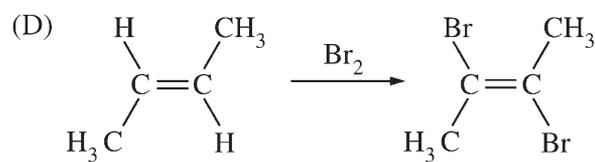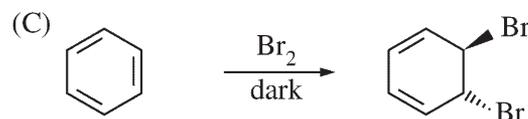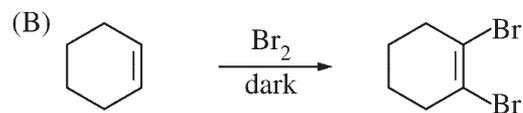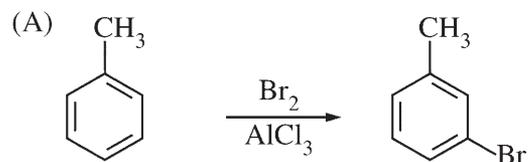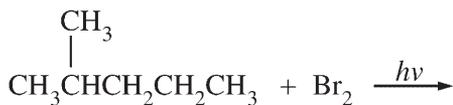
14. In the reaction shown above, the intermediate that is formed at the fastest rate is which of the following?

(A)
$$\overset{CH_3}{\underset{\cdot}{|}}$$
$$\overset{\cdot}{C}H_2CHCH_2CH_2CH_3$$

(B)
$$\overset{CH_3}{|}$$
$$CH_3\overset{\cdot}{C}CH_2CH_2CH_3$$

(C)
$$\overset{CH_3}{|}$$
$$CH_3CH\overset{\cdot}{C}HCH_2CH_3$$

(D)
$$\overset{CH_3}{|}$$
$$CH_3CHCH_2\overset{\cdot}{C}HCH_3$$

(E)
$$\overset{CH_3}{|}$$
$$CH_3CHCH_2CH_2\overset{\cdot}{C}H_2$$
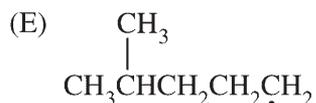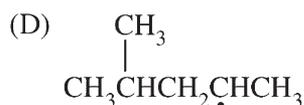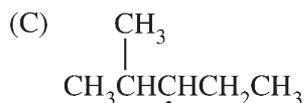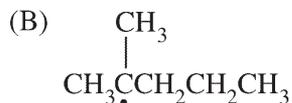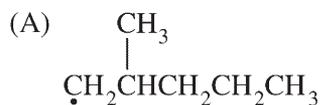
15. A high equivalent weight is desirable for compounds used as primary standards because

(A) such compounds are generally easier to purify
(B) such compounds are generally hygroscopic
(C) such compounds generally react with 1:1 stoichiometry
(D) larger compounds generally contain less surface water
(E) weighing errors are minimized

16. Given that a certain organic compound absorbs light in the visible region, it CANNOT be true that it

(A) is aromatic
(B) is an alkane
(C) is colored
(D) contains a nitro group
(E) contains a chlorine atom

17. What is the oxidation state of chromium in $(NH_4)_2Cr_2O_7$?

(A) +7
(B) +6
(C) +5
(D) +4
(E) +3

18. Which of the following transmutations entails an absorption of an alpha particle and release of a proton?

(A) $^{238}_{92}U \rightarrow\ ^{234}_{90}Th$

(B) $^{14}_{7}N \rightarrow\ ^{17}_{8}O$

(C) $^{238}_{92}U \rightarrow\ ^{234}_{91}Pa$

(D) $^{27}_{13}Al \rightarrow\ ^{30}_{15}P$

(E) $^{2}_{1}H \rightarrow\ ^{1}_{1}H$

19. The azide ion, N_3^-, is isoelectronic with which of the following?

(A) NO_2^-
(B) NO_2
(C) CO_2
(D) SO_2
(E) O_3

20. For which of the following sets of values of ΔH and ΔS will a reaction be spontaneous only at high temperature?

	ΔH(kJ)	ΔS(J/K)
(A)	+60	+19
(B)	+60	−19
(C)	−60	−19
(D)	−60	+19
(E)	0	−19

GO ON TO THE NEXT PAGE.

$$Cu_2O(s) + \frac{1}{2} O_2(g) \rightleftarrows 2\, CuO(s) \qquad \Delta H° = -11.3\ kJ$$

21. At 298 K and 1 atmosphere, the closed system shown above is at equilibrium. If the equilibrium is perturbed by isothermally decreasing the volume of the system, which of the following is NOT correct?

(A) More product will be present after equilibrium is reestablished.
(B) ΔG is less than zero for the process of reestablishing equilibrium.
(C) The equilibrium constant, K_{eq}, will decrease.
(D) The temperature will remain constant.
(E) $\Delta G°$ will remain unchanged.

22. Which of the following is NOT accompanied by an increase in the entropy of the system?

(A) Discharging a battery
(B) Boiling water at atmospheric pressure
(C) Very slow mixing of hot and cold water in a well-insulated container
(D) Very slow expansion of a gas into an evacuated flask
(E) Rapid expansion of a gas and recompression to its original temperature, pressure, and volume

23. Which of the following comparisons of the average kinetic energies and the average molecular speeds of H_2 and N_2 gases at 300 K is correct?

	Average Kinetic Energy	Average Molecular Speed
(A)	$H_2 = N_2$	$H_2 = N_2$
(B)	$H_2 = N_2$	$H_2 > N_2$
(C)	$H_2 = N_2$	$H_2 < N_2$
(D)	$H_2 > N_2$	$H_2 = N_2$
(E)	$H_2 < N_2$	$H_2 = N_2$

24. For a triprotic acid, H_3A, K_{a1} is 1.0×10^{-2}, K_{a2} is 1.0×10^{-6}, and K_{a3} is 1.0×10^{-10}. The pH range in which H_2A^- is the predominant form is a pH between

(A) 1 and 3
(B) 3 and 5
(C) 5 and 7
(D) 7 and 9
(E) 9 and 11

25. Which of the following is another way to express the concentration of a glucose solution that is 0.01 percent by weight?

(A)　　1.0 ppb
(B)　100 ppm
(C)　　10 ppt
(D)　　1.0 ppt
(E)　　1.0%

26. The molecular geometry of XeF_4O is

 (A) trigonal
 (B) octahedral
 (C) trigonal bipyramidal
 (D) square pyramidal
 (E) tetrahedral

27. The structure of cesium metal at 25°C and 1 atmosphere is body-centered cubic. At the same temperature but at high pressure, cesium undergoes a phase transition to yield a structure much more dense than body-centered cubic. Which of the following is the likely structure at high pressure?

 (A) Cubic close-packed
 (B) Amorphous
 (C) Primitive cubic
 (D) Primitive tetragonal
 (E) Primitive orthorhombic

28. Which of the following does NOT have a threefold rotational symmetry axis?

 (A) BCl_3
 (B) CH_4
 (C) NH_3
 (D) $CClF_3$
 (E) ClF_3
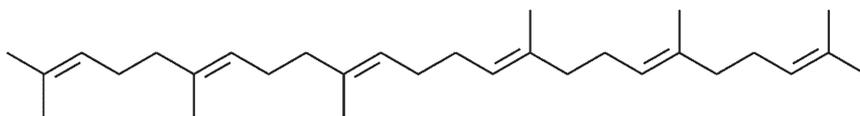

29. The compound shown above is a

 (A) triglyceride
 (B) trinucleotide
 (C) tripeptide
 (D) trisaccharide
 (E) triterpene

30. A pyranose form is a cyclic hemiacetal with a six-membered ring. Which of the following compounds CANNOT exist in a pyranose form?

(A)

```
      CH=O
  H ──┼── OH
  H ──┼── OH
  H ──┼── OH
      CH₂OH
```

(B)

```
      CH₂OH
      │
      C=O
  H ──┼── OH
  H ──┼── OH
      CH₂OH
```

(C)

```
      CH=O
  H ──┼── OH
  H ──┼── OH
  H ──┼── OH
  H ──┼── OH
      CH₂OH
```

(D)

```
      CH₂OH
      │
      C=O
  H ──┼── OH
  H ──┼── OH
  H ──┼── OH
      CH₂OH
```

(E)

```
      CH₃
      │
      C=O
  H ──┼── OH
  H ──┼── OH
  H ──┼── OH
      CH₂OH
```
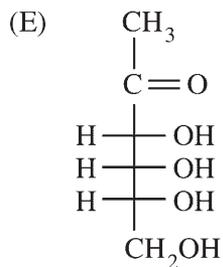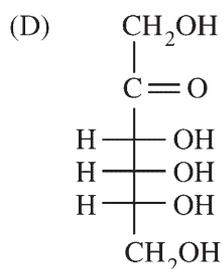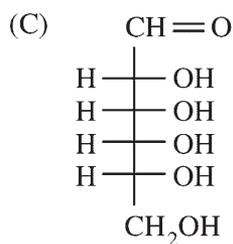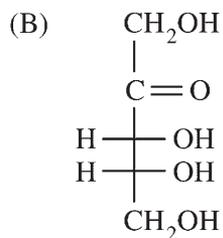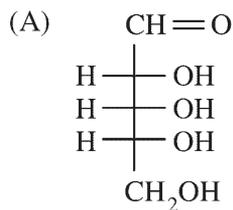
31. Which of the following substances is achiral?

(A)

H_3C····⫼ ⫼····CH_3, with Br, Br on top and H, H on bottom

(B) Br, H top; H_3C, Br bottom with CH_3

(C) Br, H top; H_3C, Cl bottom with CH_3

(D) H_3C····⫼ ⫼····CH_3, with Br, H top and H, Cl bottom

(E) Br, H top; H_3C, Br bottom with Br
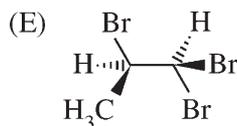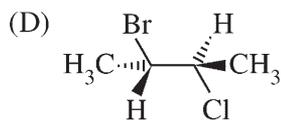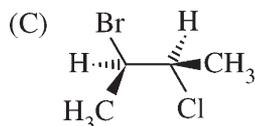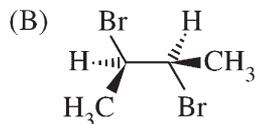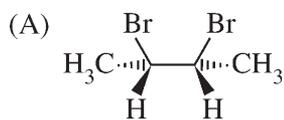
32. Which of the following structures is the most stable conformation of cis-1,3-dimethylcyclohexane?

(A)

(B)

(C)

(D)

(E)

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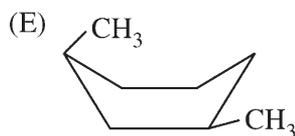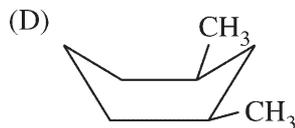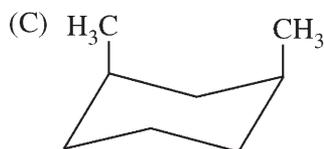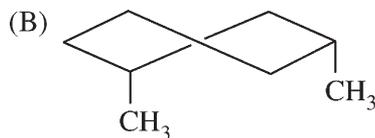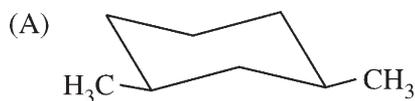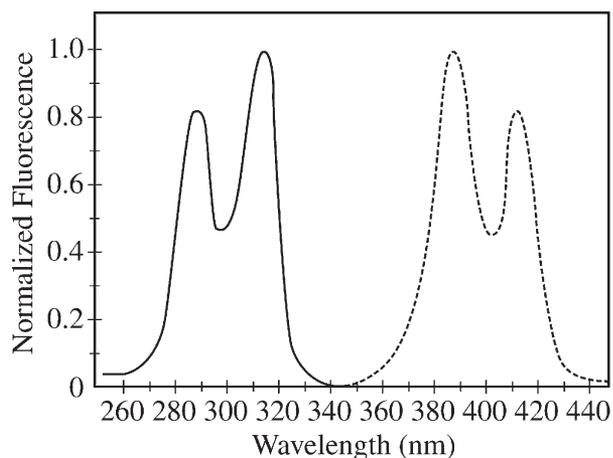
33. Based on the excitation and emission spectra for compound Y shown above, what excitation and emission wavelengths should be chosen to maximize the measured fluorescence intensity?

	Excitation λ (nm)	Emission λ (nm)
(A)	290	420
(B)	390	315
(C)	415	290
(D)	315	390
(E)	315	415
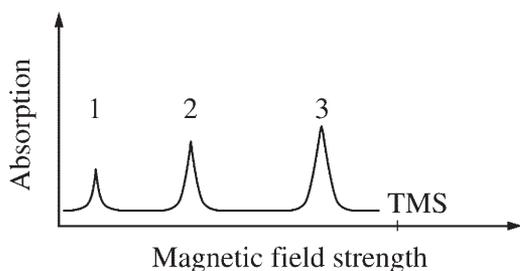
34. Based on the low-resolution proton NMR spectrum of a particular compound shown above, which of the following is(are) true?

   I. There are at least three different types of protons in this compound.

  II. There are more protons of the type corresponding to peak 3 than the type corresponding to peak 1.

  III. Protons of the type corresponding to peak 2 are more shielded than those corresponding to peak 1.

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

35. Which of the following is classified as an indeterminate (random) error in analytical measurements?

(A) A colorimetric reaction has not reached completion before the absorbance of the product is measured.
(B) An arithmetic mistake is made in computing the concentration of a measured substance.
(C) A balance is incorrect by a constant amount of 0.10 g.
(D) A blank used to correct for background interference is accidentally contaminated with the analyte.
(E) A pipet is not handled in quite the same way during the repetitions of a determination.

$$2\,NO(g) \ + \ 2\,H_2(g) \ \rightarrow \ N_2(g) \ + \ 2\,H_2O(g)$$
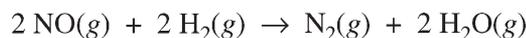
36. The method of initial rates is used to determine the rate law for the reaction shown above. The following initial rates were determined.

P_{NO}(torr)	P_{H_2}(torr)	Initial Rate (torr/s)
200	400	0.46
400	200	0.92
400	400	1.85

These data imply which of the following rate laws?

(A) Rate $= k\,P_{NO}$

(B) Rate $= k\,P_{NO}\,P_{H_2}$

(C) Rate $= k\,P_{NO}\,P^2_{H_2}$

(D) Rate $= k\,P^2_{NO}\,P_{H_2}$

(E) Rate $= k\,P^2_{NO}\,P^2_{H_2}$

$$^{64}Cu \ \rightarrow \ ^{64}Zn \ + \ \beta^-$$
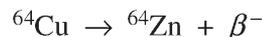
37. A radioactive isotope of copper, ^{64}Cu, decays via the reaction shown above. The half-life for the reaction is 12.8 hours. Starting with 100 g of ^{64}Cu, how much ^{64}Zn is produced in 25.6 hours?

(A) 12.5 g
(B) 20.0 g
(C) 50.0 g
(D) 75.0 g
(E) 100. g

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38. For the reaction $A \rightarrow B$, with A and B not participating in any other reactions, the rate of formation of B is directly proportional to the molar concentration of A, $[A]$. Which of the following is the integrated rate equation for this reaction?

(A) $[A] = kt$

(B) $\ln \dfrac{[A]_0}{[A]} = kt$

(C) $\dfrac{1}{[A]} - \dfrac{1}{[A]_0} = kt$

(D) $[A]_0 - [A] = kt$

(E) $\dfrac{[A]_0}{[A]} = kt$

39. If the elementary step $A \rightarrow B$ has a reaction enthalpy of -50 kJ and an activation energy of 10 kJ, the activation energy for the reverse step $B \rightarrow A$ is

(A) 0 kJ
(B) 10 kJ
(C) 40 kJ
(D) 50 kJ
(E) 60 kJ

40. The reaction of nitrogen dioxide with water yields

(A) HNO_3 only
(B) HNO_2 only
(C) HNO_3 and NO
(D) NH_3 and H_2O_2
(E) NH_3 and O_2

41. Which of the following compounds produces H_2 gas when added to water?

(A) LiH
(B) CH_4
(C) NH_3
(D) PH_3
(E) H_2S

42. Which of the following is NOT true about the electrolysis of concentrated aqueous sodium chloride?

(A) Sodium metal is a final product.
(B) H_2 is produced from H_2O.
(C) One mole of H_2 is produced for each mole of Cl_2 produced.
(D) It is a redox reaction.
(E) It yields products that are thermodynamically less stable than the reactants.

20

43. Which of the following reactions will produce a secondary amine?

(A)

1. LiAlH$_4$, diethyl ether

2. H$_2$O

(B)

1. LiAlH$_4$, diethyl ether

2. H$_2$O

(C)

1. LiAlH$_4$, diethyl ether

2. H$_2$O

(D)

1. LiAlH$_4$, diethyl ether

2. H$_2$O

(E)

1. LiAlH$_4$, diethyl ether

2. H$_2$O

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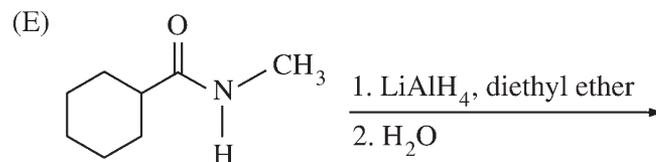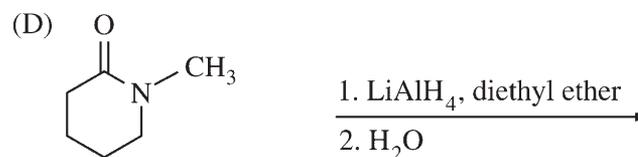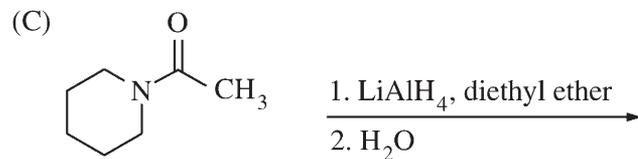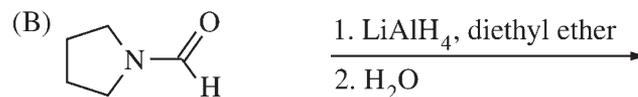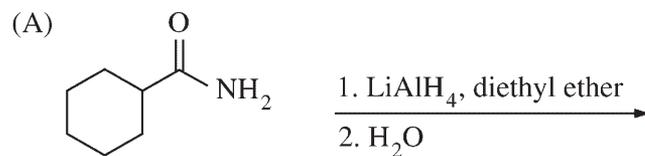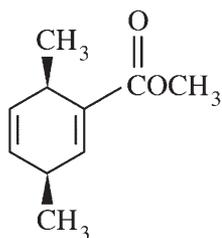
44. The best combination of reactants that will produce the product above via a Diels-Alder reaction is which of the following?
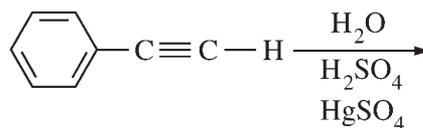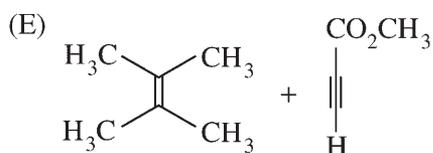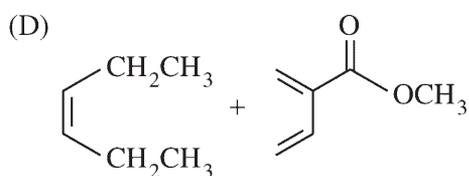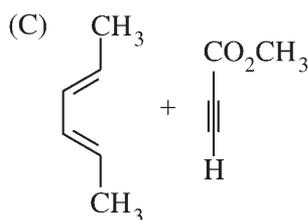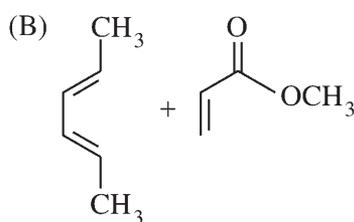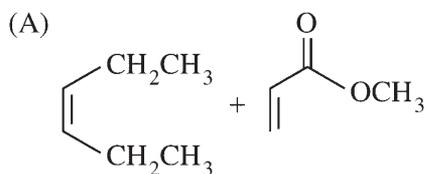
(A)

(B)

(C)

(D)

(E)

45. Which of the following is the major organic product of the reaction sequence shown above?
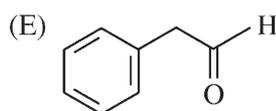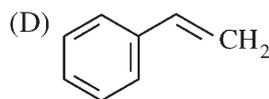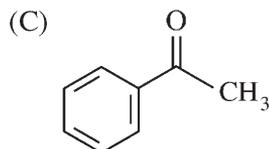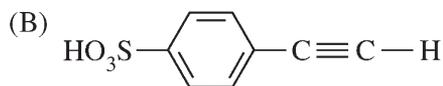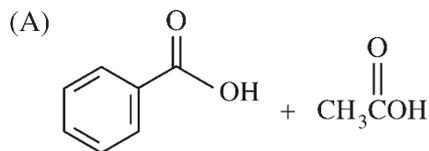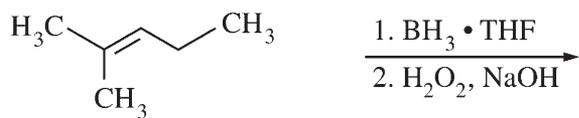
(A)

(B)

(C)

(D)

(E)

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$$H_3C \diagup\diagdown CH_3 \quad \xrightarrow[\text{2. } H_2O_2, \text{ NaOH}]{\text{1. } BH_3 \bullet \text{THF}}$$

$$CH_3$$

46. Which of the following is the major organic product of the reaction sequence shown above?

(A) H_3C — CH_3
   HO CH_3

(B) HO
   CH_3
   CH_3

(C) OH
   H_3C — CH_3
   CH_3

(D) H_3C — CH_3
   CH_3 OH

(E) H_3C — OH
   CH_3
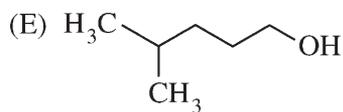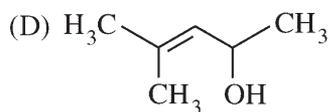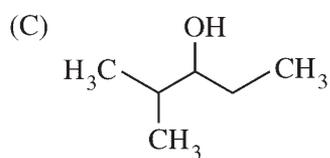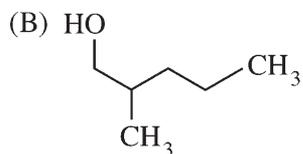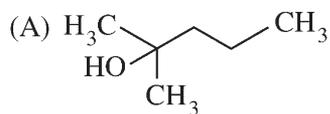
47. Which of the following is the correct order of reactivity, from fastest to slowest, toward acid-catalyzed dehydration?

I.   OH
   H_3C — CH_3

II. CH_3
   H_3C — OH

III. H_3C — CH_3
   H_3C OH
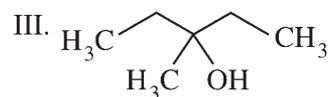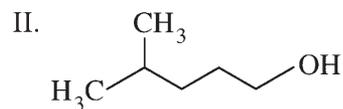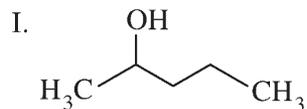
(A) I > II > III
(B) I > III > II
(C) II > III > I
(D) III > I > II
(E) III > II > I

48. Which of the following partial derivatives is zero for an ideal gas?

(A) $\left(\dfrac{\partial U}{\partial T}\right)_V$

(B) $\left(\dfrac{\partial H}{\partial T}\right)_P$

(C) $\left(\dfrac{\partial S}{\partial T}\right)_P$

(D) $\left(\dfrac{\partial U}{\partial V}\right)_T$

(E) $\left(\dfrac{\partial S}{\partial V}\right)_T$

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49. Given that $dU = TdS - PdV$ and that $H = U + PV$, which of the following is true?

(A) $dH = TdS + VdP$
(B) $dH = SdT - VdP$
(C) $dH = -SdT - PdV$
(D) $dH = dU + PdV$
(E) $dH = dU - TdS$

50. A reaction is at equilibrium in a closed rigid vessel at constant temperature when

(A) $\Delta S = 0$
(B) $\Delta H = 0$
(C) $\Delta U = 0$
(D) $\Delta G = 0$
(E) $\Delta A = 0$

GO ON TO THE NEXT PAGE.

$$\text{H}{-}\underset{\underset{\displaystyle \text{CH}_3}{\overset{\displaystyle |}{\underset{|}{\text{CH}_2}}}}{\overset{\displaystyle \text{CH}_3}{\overset{|}{\text{C}}}}{-}\text{O}{-}\overset{\displaystyle O}{\overset{\|}{\text{C}}}{-}\text{CH}_2{-}\text{CH}_2{-}\text{CH}_3 \quad \xrightarrow[\text{H}_2{}^{18}\text{O}]{\text{Na}^{18}\text{OH}}$$
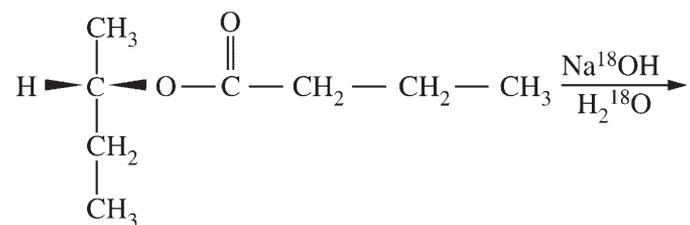
51. The saponification of the optically active ester using isotopically labeled oxygen as shown above would most likely produce which of the following products?

(A)

$$\text{H}{-}\overset{\displaystyle \text{CH}_3}{\underset{\displaystyle \text{CH}_2}{\underset{\displaystyle \text{CH}_3}{\text{C}}}}{-}\text{OH}$$

(B)

$$\text{H}{-}\overset{\displaystyle \text{CH}_3}{\underset{\displaystyle \text{CH}_2}{\underset{\displaystyle \text{CH}_3}{\text{C}}}}{-}{}^{18}\text{OH}$$

(C)

$$\text{H}^{18}\text{O}{-}\overset{\displaystyle \text{CH}_3}{\underset{\displaystyle \text{CH}_2}{\underset{\displaystyle \text{CH}_3}{\text{C}}}}{-}\text{H}$$

(D)

$$\text{HO}{-}\overset{\displaystyle \text{CH}_3}{\underset{\displaystyle \text{CH}_2}{\underset{\displaystyle \text{CH}_3}{\text{C}}}}{-}\text{H}$$

(E)

$$\text{H}{-}\overset{\displaystyle \text{H}}{\underset{\displaystyle \text{CH}_2}{\underset{\displaystyle \text{CH}_2}{\underset{\displaystyle \text{CH}_3}{\text{C}}}}}{-}\text{OH}$$

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52. Of the following, which is the strongest base?

(A)

(B)

(C)

(D)

(E)

$$CH_3CH_2CH_2CCH_2CH$$
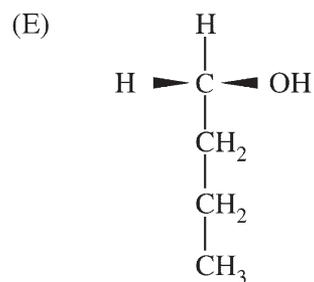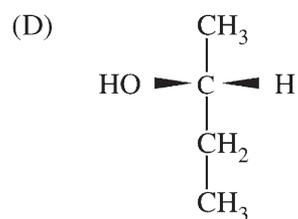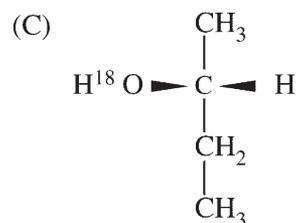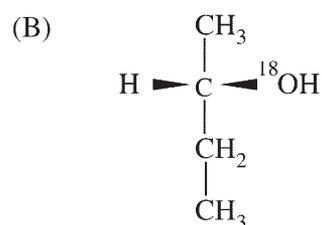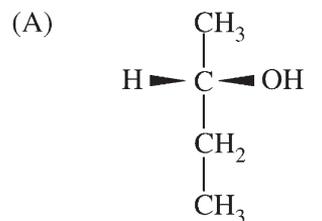
A   B   C   D   E
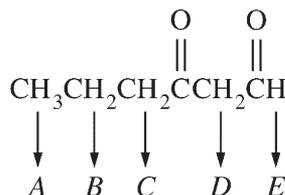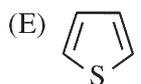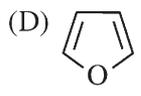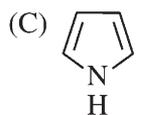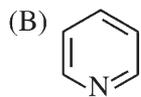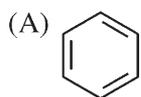
53. A hydrogen in which position in the structure shown above is most acidic?

(A) A
(B) B
(C) C
(D) D
(E) E

54. Of the following carboxylic acids, which is the most acidic?

(A) CH_3CO_2H

(B) HCO_2H

(C)

 CO_2H

(D) Cl_3CCO_2H

(E) $(CH_3)_3CCO_2H$
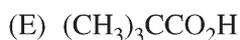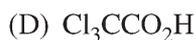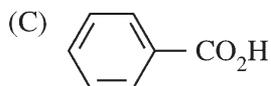
55. Of the following, which is the strongest Brønsted acid in aqueous solution?

(A) $HClO_3$
(B) $HClO_2$
(C) $HOCl$
(D) $HOBr$
(E) HOI

56. HF behaves as a base in which of the following solvents?

(A) $NH_3(l)$
(B) $H_2O(l)$
(C) $CH_3COOH(l)$
(D) $H_2SO_4(l)$
(E) Aqueous 0.10 M NaOH

57. Of the following materials, which contribute(s) most to the production of acid rain?

(A) Uranium hexafluoride
(B) Ozone
(C) Phosphate detergents
(D) Nitric oxide
(E) Chlorofluorocarbons

Bond	Bond Enthalpy (kJ/mol)
H–H	435
Cl–Cl	243
H–C	414
H–Cl	431
C–Cl	331

58. Based on the bond enthalpies listed above, what is the value of ΔH for the reaction $CH_4 + Cl \rightarrow CH_3Cl + H$?

(A)   275 kJ
(B)   109 kJ
(C)   83 kJ
(D)   −83 kJ
(E) −109 kJ

GO ON TO THE NEXT PAGE.

59. The quantity $T\Delta S$ may be expressed in units of

(A) J
(B) K
(C) J·K
(D) J·K^{-1}
(E) L·atm·K^{-1}

60. In which of the following processes is energy transferred into the substance by work ($w > 0$) ?

(A) Expansion of a gas against the surroundings
(B) Expansion of a gas into a vacuum
(C) Vaporization of one mole of water at 50°C in an open container
(D) Melting of 100 g of ice on a laboratory benchtop
(E) Combustion of methane in a constant-volume container

61. If helium gas trapped in a cylinder with a movable piston undergoes an adiabatic expansion, which of the following statements is true for the expansion? (q = heat; w = work; ΔU = internal energy change)

(A) $q = w$
(B) $w = 2q$
(C) $\Delta U = 0$
(D) $\Delta U = q$
(E) $\Delta U = w$

62. One mole of an ideal gas expands isothermally until its volume is doubled. What is the change in Gibbs energy, ΔG, for the process?

(A) $R \ln \frac{1}{2}$
(B) $R \ln 2$
(C) $RT \ln \frac{1}{2}$
(D) $RT \ln 2$
(E) $e^{-2/RT}$

63. In chromatography, the van Deemter equation relates the theoretical column-plate height (HETP) to which of the following?

I. Mobile-phase flow rate
II. Eddy diffusion
III. Longitudinal diffusion
IV. Mass transfer

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

64. The key components common to both a high-performance liquid and a gas chromatographic system include all of the following EXCEPT a

(A) detector
(B) mobile or eluent phase
(C) stationary phase
(D) device for temperature programming
(E) sample injector
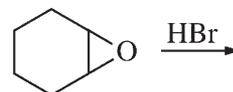
65. The *trans*-2-bromo-1-cyclohexanol product of the reaction shown above is

(A) a mixture of equal quantities of diastereomers
(B) optically active
(C) not optically active, because it is achiral
(D) not optically active, because it is a *meso* form
(E) not optically active, because it contains equal quantities of enantiomers

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$$\xrightarrow[\text{then neutralize with NaOH}]{\text{Fe, HCl, H}_2\text{O}}$$
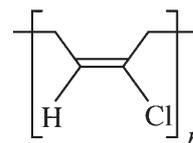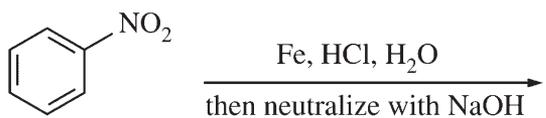
66. What is the major product of the reaction shown above?

(A)

(B)

(C)

(D)

(E)
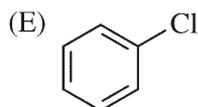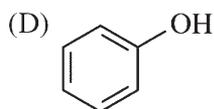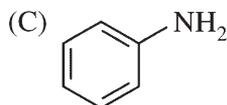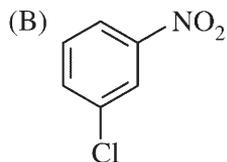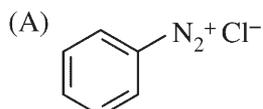
67. Which of the following monomers or pair of monomers is used to make the addition polymer neoprene shown above?

(A)

(B) $H_2C=C-C=CH_2$ with H and Cl substituents

(C) $H_2C=CH_2$ and $H_2C=CHCl$

(D)

(E) $H_2C=O$ and $HC\equiv CCl$

GO ON TO THE NEXT PAGE.

$$C_6H_5\overset{\displaystyle O}{\underset{}{\|}}\!\!\!-OCH_3 \xrightarrow[\text{(2) } H_3O^+]{\text{(1) } CH_3CH_2MgBr \ (2 \text{ moles})}$$
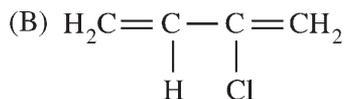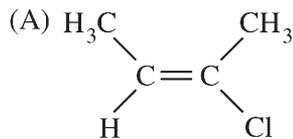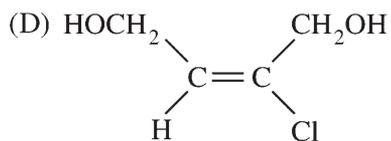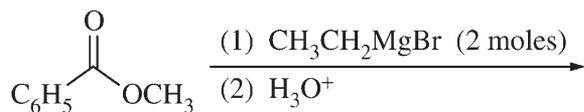
68. Which of the following is a product of the reaction shown above?

(A) $C_6H_5-CH_2OH$

(B)
$$C_6H_5-\underset{\underset{\displaystyle }{|}}{\overset{\overset{\displaystyle OH}{|}}{C}H}CH_2CH_3$$

(C)
$$C_6H_5-\underset{\underset{\displaystyle CH_2CH_3}{|}}{\overset{\overset{\displaystyle OH}{|}}{C}}CH_2CH_3$$

(D)
$$C_6H_5-\overset{\overset{\displaystyle O}{\|}}{C}OCH_2CH_3$$

(E)
$$C_6H_5-\underset{\underset{\displaystyle CH_2CH_3}{|}}{C}HCH_2CH_3$$
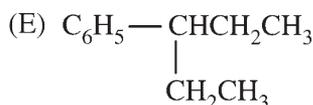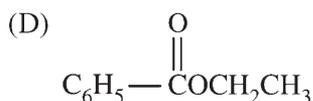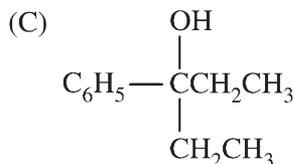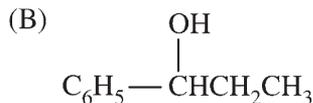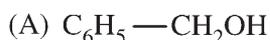
69. Which of the following molecules will exhibit a pure rotational absorption spectrum?

    I. Cl_2
    II. HCl
    III. CH_4
    IV. PF_3
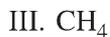
(A) II only
(B) I and II only
(C) I and III only
(D) II and IV only
(E) I, II, III, and IV

70. Which of the following hydrogen molecules has the highest vibrational frequency?
(D = deuterium; T = tritium)

(A) H_2
(B) HD
(C) D_2
(D) HT
(E) T_2

71. When gaseous HBr in the ground electronic state absorbs infrared radiation, which of the following changes in the vibrational quantum number, v, and the rotational quantum number, J, are allowed?

(A) $\Delta v = 0,\ \Delta J = 0$
(B) $\Delta v = 1,\ \Delta J = 0$
(C) $\Delta v = 1,\ \Delta J = \pm 1$
(D) $\Delta v = 1,\ \Delta J = \pm 2$
(E) $\Delta v = 2,\ \Delta J = 0$

72. Of the following metal ions, which has the largest magnetic moment in its low-spin octahedral complexes?

(A) Fe^{3+}
(B) Co^{3+}
(C) Co^{2+}
(D) Sc^{3+}
(E) Cr^{2+}
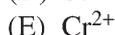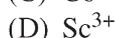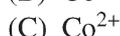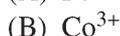
73. A Jahn-Teller distortion of $[Ti(H_2O)_6]^{3+}$ acts to

(A) raise its symmetry
(B) remove an electronic degeneracy
(C) cause loss of a H_2O ligand
(D) promote a d-electron to an antibonding molecular orbital
(E) cause reduction of the metal to Ti^0

GO ON TO THE NEXT PAGE.

74. Which of the following represents the correct distribution of electrons in the $3d$ orbitals of a ground-state $[CoCl_4]^{2-}$ ion?

(A)

E

⇅ — ↑ ↑ e_g

↑↓ ↑↓ ↑↓ t_{2g}

(B)

E

↑ — e_g

↑↓ ↑↓ ↑↓ t_{2g}

(C)

E

↑ ↑ ↑ t_2

↑↓ ↑↓ e

(D)

E

— ↑ ↑↓ t_2

↑↓ ↑↓ e

(E)

E

↑ ↑ ↑↓ t_2

↑ ↑↓ e
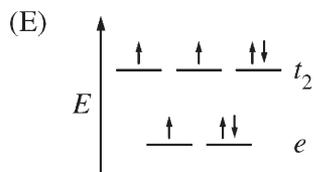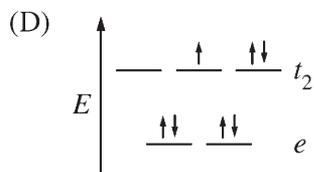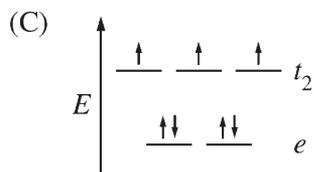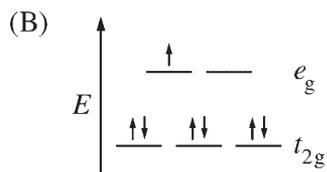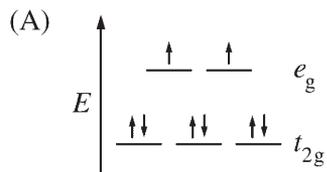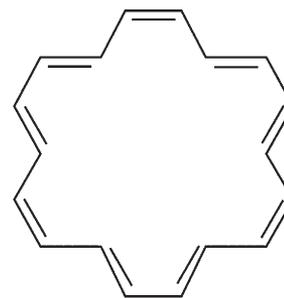
75. What value of n in Huckel's rule applies to the aromatic compound shown above?

(A) 3
(B) 4
(C) 5
(D) 9
(E) 18

$$CH_2{=}CHCH_2CH_3 \ + \ Br_2 \ \xrightarrow{\text{light}} \ CH_2{=}CHCHCH_3 \ + \ BrCH_2CH{=}CHCH_3 \ + \ HBr$$

$$\overset{|}{Br}$$
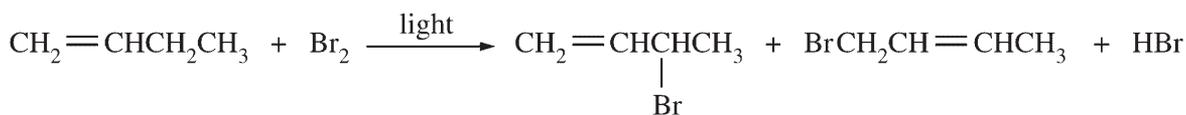
76. What kind of reactive intermediate is formed in the reaction shown above?

(A) Carbanion
(B) Carbocation
(C) Bromonium ion
(D) Bromide ion
(E) Free radical

$$\text{C}_6\text{H}_5-\text{CH}_2\text{CH}_3 + \text{Cl}_2 \xrightarrow{\text{FeCl}_3} \text{Cl}-\text{C}_6\text{H}_4-\text{CH}_2\text{CH}_3$$
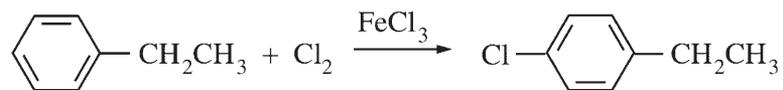
77. Which of the following is a key intermediate in the reaction shown above?

(A) $\overset{\bullet}{\text{C}}\text{H}\text{CH}_3$ (attached to benzene ring)

(B) $\overset{+}{\text{C}}\text{H}\text{CH}_3$ (attached to benzene ring)

(C) Cl, H on ring carbon bearing negative charge; CH_2CH_3 substituent

(D) Cl, H on ring carbon bearing positive charge; CH_2CH_3 substituent

(E) Cl, H on ring carbon bearing radical; CH_2CH_3 substituent
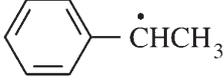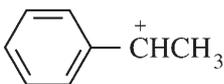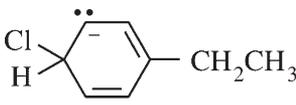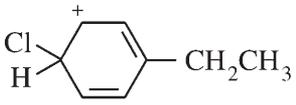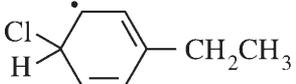
78. In which of the following reactions is an enol an important intermediate?

(A)

$$H_3C \overset{O}{\underset{}{\parallel}}CH_3 \xrightarrow{NaBH_4} H_3C \overset{OH}{\underset{}{|}} CH_3$$

(B)

$$H_3C \diagdown CH_3 \xrightarrow[H_2O]{Br_2} H_3C \overset{OH}{\underset{Br}{|}} CH_3$$

(C)

$$H_3C \overset{O}{\underset{}{\parallel}} CH_3 \xrightarrow{Br_2 \atop CH_3CO_2H} H_3C \overset{O}{\underset{Br}{\parallel}} CH_3$$

(D)

$$H_3C \overset{O}{\underset{}{\parallel}} CH_3 \xrightarrow[\text{2) } H_3O^+]{\text{1) } CH_3MgBr, \text{ diethyl ether}} H_3C \overset{HO \quad CH_3}{\underset{}{|}} CH_3$$

(E)

$$H_3C \overset{OH}{\underset{}{|}} CH_3 \xrightarrow[\text{pyridine}]{CrO_3} H_3C \overset{O}{\underset{}{\parallel}} CH_3$$
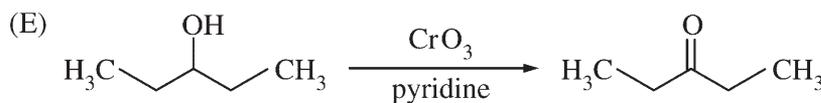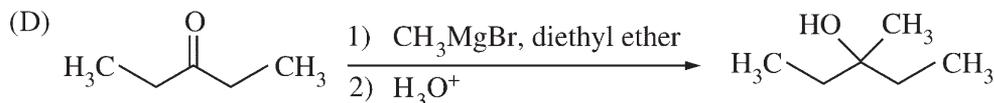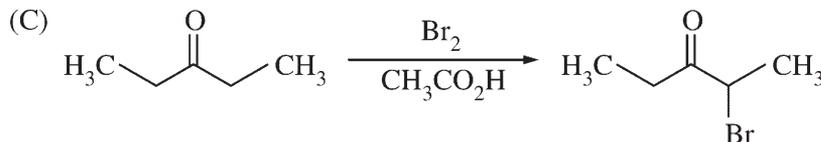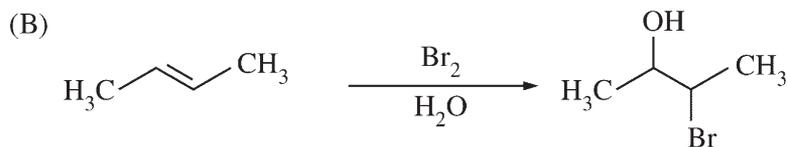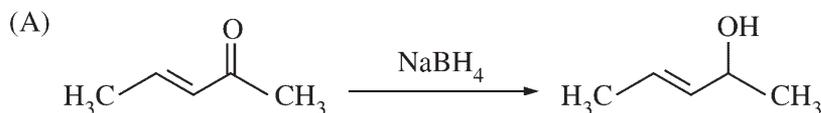
79. Which of the following ligands forms complexes that are examples of linkage isomers?

(A) NH_3

(B) NO_2^-

(C) PF_3

(D) $H_2NCH_2CH_2NH_2$

(E) SO_4^{2-}

80. A Ziegler-Natta catalyst for the polymerization of ethylene or propene consists of $TiCl_3$ and

(A) an aluminum alkyl

(B) titanium acetylacetonate

(C) a gold cluster

(D) ferrocene, $[Fe(\eta-C_5H_5)_2]$

(E) an amino acid

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81. In plotting data from the potentiometric titration of a strong acid with a strong base, a plot of the change in pH per change in volume of titrant ($\Delta pH/\Delta V$) *versus* volume of titrant will have which of the following shapes?

(A)

$\dfrac{\Delta pH}{\Delta V}$

Volume of Titrant

(B)

$\dfrac{\Delta pH}{\Delta V}$

Volume of Titrant

(C)

$\dfrac{\Delta pH}{\Delta V}$

Volume of Titrant

(D)

$\dfrac{\Delta pH}{\Delta V}$

Volume of Titrant

(E)

$\dfrac{\Delta pH}{\Delta V}$

Volume of Titrant
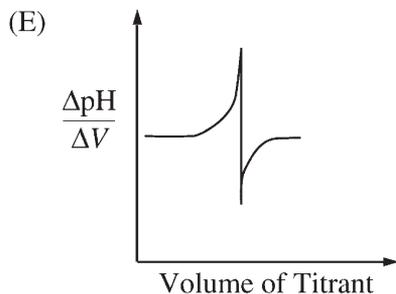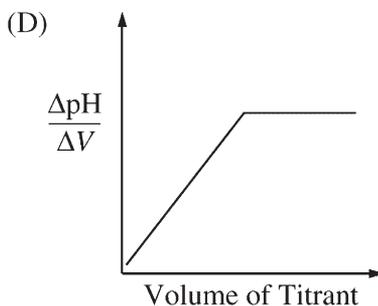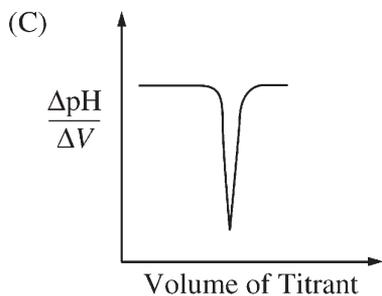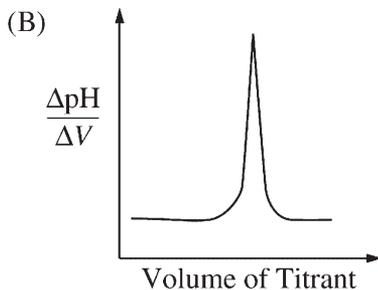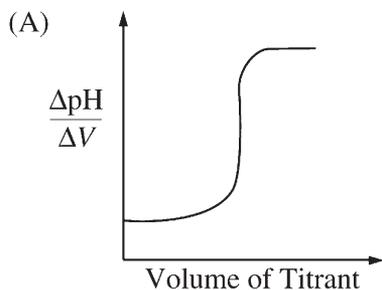
82. A weak acid, HA, has a K_a of 1.00×10^{-5}. If 0.100 mole of this acid is dissolved in one liter of water, the percentage of acid dissociated at equilibrium is closest to

(A) 0.100%
(B) 1.00%
(C) 99.0 %
(D) 99.9 %
(E) 100. %

83. If 99.1% of a substance dissolved in 25.0 mL of water is extracted into 25.0 mL of organic solvent, then the distribution coefficient for the substance between the organic solvent and the water is

(A) 1.01×10^{-4}
(B) 1.10×10^{-2}
(C) 1.00
(D) 1.10×10^2
(E) 1.10×10^4

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84. Which of the following electronic transitions is forbidden for a hydrogen-like atom?

(A) $2p \rightarrow 3p$
(B) $2p \rightarrow 1s$
(C) $2p \rightarrow 3s$
(D) $2p \rightarrow 4s$
(E) $2p \rightarrow 3d$

$$E_2 - E_1 = hcR\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

85. The Rydberg formula is given above. In the hydrogen atom emission spectrum, the Lyman series results from transitions in which the electron relaxes to the ground state ($n = 1$) from higher excited states. If the highest-energy transition in the series is 13.6 eV, the lowest transition is

(A) 0 eV
(B) 3.4 eV
(C) 6.8 eV
(D) 10.2 eV
(E) 13.6 eV

$v_1(1{,}388 \text{ cm}^{-1})$

I

$v_2(667 \text{ cm}^{-1})$

II
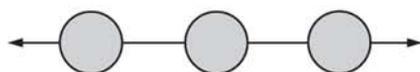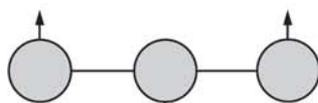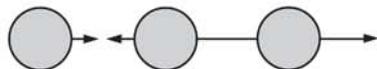
$v_3(2{,}349 \text{ cm}^{-1})$

III

86. Of the vibrational normal modes of CO_2 depicted above, which are infrared active?

(A) None
(B) I and II only
(C) I and III only
(D) II and III only
(E) I, II, and III
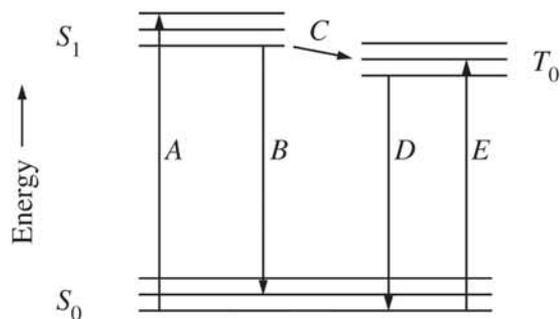
87. Fluorescence is best represented by which of the processes indicated in the diagram above?

(A) A
(B) B
(C) C
(D) D
(E) E

δ9.5 ppm, singlet, 1 H
δ6.5 ppm, quartet, 1 H
δ2.0 ppm, doublet, 3 H
δ1.8 ppm, singlet, 3 H

88. Which of the structures below is consistent with the ^{1}H NMR data above?

(A)
$$CH_2\!=\!CHCH_2CH_2CH\overset{O}{\overset{\|}{}}$$

(B)
$$CH_3CH_2CH\!=\!CHCH\overset{O}{\overset{\|}{}}$$

(C)
$$CH_3CH\!=\!CHCCH_3\overset{O}{\overset{\|}{}}$$

(D)
$$CH_2\!=\!\underset{CH_3}{\overset{O}{\overset{\|}{C}}}CCH_3$$

(E)
$$CH_3CH\!=\!\underset{CH_3}{\overset{O}{\overset{\|}{C}}}CH$$

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I   II
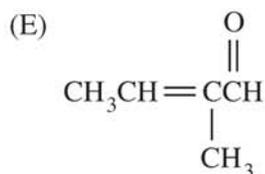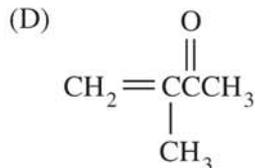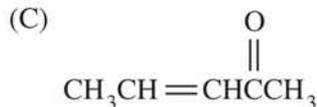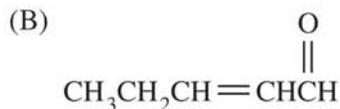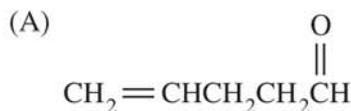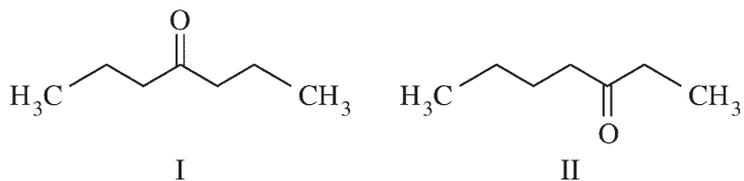
89. The isomeric ketones shown above can be distinguished from each other by the number of signals that they would show in their ^{13}C NMR spectra. These ketones should show which of the following numbers of signals?

	I	II
(A)	3	5
(B)	3	7
(C)	4	7
(D)	4	3
(E)	5	7

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$$\underset{\overset{\|}{CH_3\overset{O}{C}N(CH_3)_2}}{} + H_2O + HCl \longrightarrow \underset{\overset{\|}{CH_3\overset{O}{C}OH}}{} + (CH_3)_2\overset{+}{N}H_2\ Cl^-$$
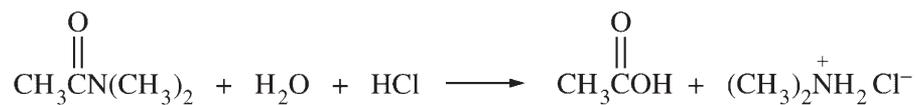
90. Which of the following structures is an intermediate formed in the amide hydrolysis shown above?

(A)

$$H_3C-\underset{OH}{\overset{OCl}{\underset{|}{\overset{|}{C}}}}-N\underset{CH_3}{\overset{CH_3}{<}}$$

(B)

$$H_3C-\underset{\underset{\underset{H\ \ \ H}{\diagup\overset{+}{\ }\diagdown}}{O}}{\overset{OH}{\underset{|}{\overset{|}{C}}}}-N\underset{CH_3}{\overset{CH_3}{<}}$$

(C)

$$H_3C-\underset{OH}{\overset{OH}{\underset{|}{\overset{|}{C}}}}-Cl$$

(D)

$$H_3C-\underset{Cl}{\overset{OH}{\underset{|}{\overset{|}{C}}}}-\underset{H}{\overset{|}{\overset{+}{N}}}\underset{CH_3}{\overset{CH_3}{<}}$$

(E)

$$H_3C-\underset{\underset{\underset{H\ \ \ H}{\diagup\overset{+}{\ }\diagdown}}{O}}{\overset{OH}{\underset{|}{\overset{|}{C}}}}-Cl$$

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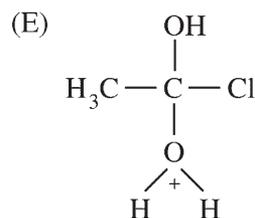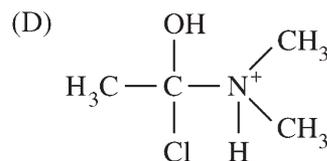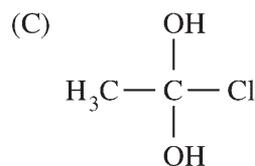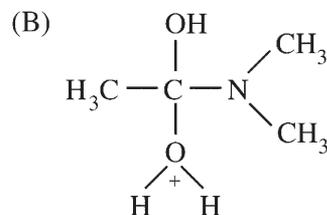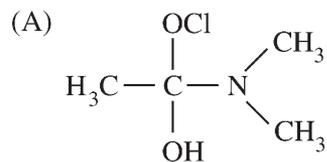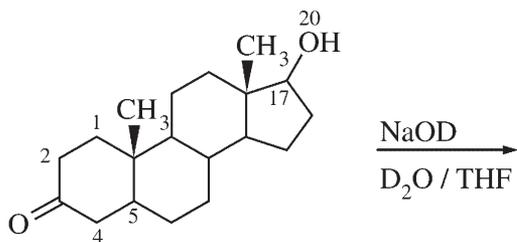
91. When the steroid shown above is treated with NaOD in D_2O/THF, several hydrogens are readily exchanged. The readily exchangeable hydrogens are on atoms numbered

(A) 2 and 20 only
(B) 2, 4, and 17 only
(C) 2, 4, and 20 only
(D) 1, 2, 17, and 20
(E) 2, 5, 17, and 20

	°C
F_2	−187.9
Cl_2	−34.0
Br_2	+58.8
I_2	+184.5

92. The increase in boiling points shown above is the result of an increase in which of the following from F_2 to I_2?

(A) Ionic bonding
(B) Covalent bond strength
(C) Electron affinity
(D) Van der Waals forces
(E) Nuclear quadrupole moment

93. Which of the following compounds forms the strongest hydrogen bonds with itself?

(A) HF
(B) $HCCl_3$
(C) PH_3
(D) H_2S
(E) CH_4

94. Of the following, which is the strongest oxidizing agent?

(A) O_2^+
(B) O_2
(C) O_2^-
(D) O_2^{2-}
(E) OH^-

95. Which of the following reactions does NOT represent the formation of a Lewis acid-base adduct?

(A) $(CH_3)_3N + BF_3 \rightarrow (CH_3)_3NBF_3$
(B) $Al(OH)_3 + OH^- \rightarrow Al(OH)_4^-$
(C) $H_2O + H^+ \rightarrow H_3O^+$
(D) $SnCl_2 + Cl^- \rightarrow SnCl_3^-$
(E) $PF_3 + F_2 \rightarrow PF_5$

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96. Although graphite is thermodynamically more stable than diamond at 25°C and 1 atmosphere, a diamond will not transform into graphite, even over a period of thousands of years. Which of the following correctly explains this observation?

(A) ΔG for the reaction $C(diamond) \rightarrow C(graphite)$ is greater than zero.
(B) ΔH for the reaction $C(diamond) \rightarrow C(graphite)$ is greater than zero.
(C) ΔS for the reaction $C(diamond) \rightarrow C(graphite)$ is less than zero.
(D) The reverse reaction $C(graphite) \rightarrow C(diamond)$ would proceed relatively quickly.
(E) The reaction $C(diamond) \rightarrow C(graphite)$ is not observed because it has a large activation energy.

97. Which of the following statements is generally true concerning the relationship between the rate constant, k, the Arrhenius activation energy, E_a, and the temperature?

(A) A plot of $\ln k$ vs. T is a straight line with slope E_a/R
(B) A plot of $\ln k$ vs. $\ln T$ is a straight line with slope E_a/R
(C) A plot of $\ln k$ vs. $\ln T$ is a straight line with slope $-E_a/R$
(D) A plot of $\ln k$ vs. $1/T$ is a straight line with slope $-E_a/R$
(E) A plot of $\ln k$ vs. $1/T$ is a straight line with slope E_a/R

$$A + M \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} A^* + M$$

$$A^* \xrightarrow{k_2} P$$
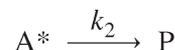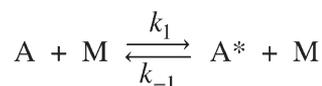
98. Based on the Lindemann mechanism shown above and the steady-state approximation for the intermediate A^*, the rate of formation of product P is given by

(A) $\dfrac{d[P]}{dt} = \dfrac{k_1 k_2 [A][M]}{(k_{-1}[M] + k_2)}$

(B) $\dfrac{d[P]}{dt} = \dfrac{k_1 [A][M]}{(k_{-1}[M] + k_1)}$

(C) $\dfrac{d[P]}{dt} = \dfrac{-k_1 k_2 [A][M]}{k_{-1}[M]}$

(D) $\dfrac{d[P]}{dt} = \dfrac{k_1 k_2 [A]}{[M]}$

(E) $\dfrac{d[P]}{dt} = k_1 [A][M]$

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$$2\ CH_3CH_2\overset{\displaystyle O}{\overset{\|}{C}}H \xrightarrow{\text{NaOH}} CH_3CH_2\overset{\displaystyle OH}{\underset{\underset{\displaystyle CH_3}{|}}{\overset{|}{C}}H}\overset{\displaystyle O}{\overset{\|}{C}}H$$
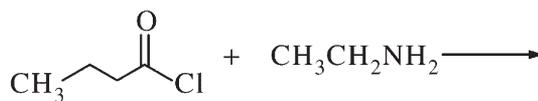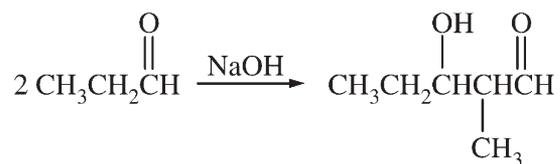
99. Which of the following species is an intermediate in the reaction shown above?

(A)

$$\overset{+}{C}H_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}H$$

(B)

$$\overset{-}{C}H_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}H$$

(C)

$$CH_3\overset{+}{C}H\overset{\displaystyle O}{\overset{\|}{C}}H$$

(D)

$$CH_3\overset{-}{C}H\overset{\displaystyle O}{\overset{\|}{C}}H$$

(E) $CH_3CH_2\overset{+}{C}{=}O$

$$\underset{CH_3}{\overset{\displaystyle O}{\overset{\|}{C}}}\diagup{Cl} \quad + \quad CH_3CH_2NH_2 \longrightarrow$$

100. What is the major product of the reaction shown above?

(A)

$$CH_3\diagup\overset{\displaystyle O}{\overset{\|}{C}}\diagup CH_2CH_3$$

(B)

$$CH_3\diagup\overset{\displaystyle O}{\overset{\|}{C}}\diagup NHCH_2CH_3$$

(C)

$$CH_3\diagup\overset{\displaystyle O}{\overset{\|}{C}}\diagup NH_2$$

(D)

$$CH_3\diagup\overset{NHCH_2CH_3}{\overset{\|}{C}}\diagdown Cl$$

(E)

$$CH_3\diagup\underset{NHCH_2CH_3}{\overset{\displaystyle O}{\overset{\|}{C}}}\diagup Cl$$

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$$\text{(spiro cyclopentane dioxolane)} \longrightarrow \text{cyclopentanone} = O + HOCH_2CH_2OH$$
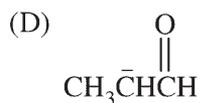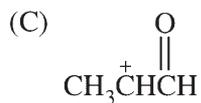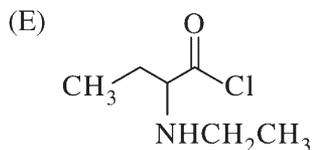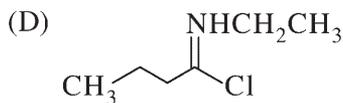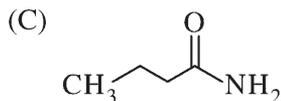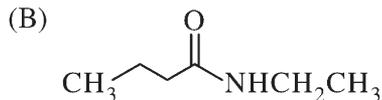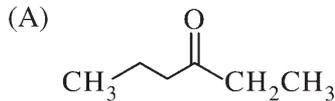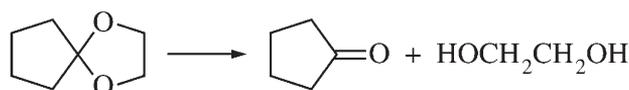
101. The conversion above can be accomplished with which of the following reagents?

(A) $LiAlH_4$

(B) HCl, H_2O, heat

(C) H_2NNH_2, heat

(D) $NaOH$, H_2O, heat

(E) H_2, Pt catalyst

$$CH_3CH_2CH_2CH = NCH_3$$

102. Of the following, which reacts with methylamine (CH_3NH_2) to form the imine shown above?

(A)
$$CH_3CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}H$$

(B)
$$CH_3CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}OH$$

(C)
$$CH_3CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}OCH_3$$

(D)
$$CH_3CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}NH_2$$

(E) $CH_3CH_2CH_2C \equiv N$

103. Which of the following is the best method for preparing $(CH_3)_3COCH_3$?

(A) $NaOCH_3 + (CH_3)_3CCl \longrightarrow$

(B) $(CH_3)_3COH + CH_3I \xrightarrow{H_2SO_4}$

(C) $(CH_3)_3CH + CH_3OH \xrightarrow{H_2SO_4}$

(D) $(CH_3)_3COK + CH_3OH \longrightarrow$

(E) $(CH_3)_3COK + CH_3I \longrightarrow$

$$\begin{array}{c} NH_3 \\ | \\ Cl-Pt-NH_3 \\ | \\ Cl \end{array}$$
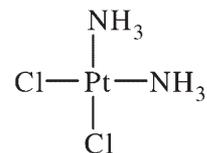
104. The systematic name of the compound shown above is

(A) platinum *cis*-ammoniumchloride
(B) *cis*-diammoniaplatinumdichloride
(C) *cis*-diamminedichloroplatinum(II)
(D) *cis*-dichlorodiammineplatinum(IV)
(E) platinum *cis*-dichloride *cis*-diammonia

105. Which of the following complexes exists as a pair of enantiomers?

(A) *trans*-$[Co(H_2NCH_2CH_2NH_2)_2Cl_2]^+$
(B) $[Co(NH_3)_4Cl_2]^+$
(C) $[Co\{P(C_2H_5)_3\}_2ClBr]$
(D) $[Pt\{P(C_2H_5)_3\}_2Cl_2]$
(E) $[Cr(H_2NCH_2CH_2NH_2)_3]^{3+}$

106. Which of the following is true for the element xenon?

(A) It does not form chemical compounds.
(B) It exists as the diatomic molecule Xe_2.
(C) It has a lower first ionization energy than Na.
(D) It has an extensive organometallic chemistry.
(E) It forms compounds with some electronegative elements.

107. Boron-rich deposits on Earth appear to have formed by precipitation from an aqueous solution. In what form does boron exist in the deposits?

(A) Its elemental form
(B) A sulfide
(C) An oxide or hydroxide
(D) Diborane
(E) Boron nitride

108. According to the second law of thermodynamics, which of the following quantities represents the change in a state function?

(A) q_{rev}
(B) q_{rev}/T
(C) Tq_{rev}
(D) w_{rev}
(E) Tw_{rev}

109. The function $F(x) = c\sin(ax)$ is an eigenfunction of d^2/dx^2. The eigenvalue is

(A) c
(B) a
(C) -1
(D) a^2c
(E) $-a^2$

110. In quantum mechanics, the measurements of two different physical properties are represented by the operators $\hat{A}$ and $\hat{B}$. It is possible to know, exactly and simultaneously, the values for both of these measured quantities only if the

(A) eigenfunctions of operator $\hat{A}$ form an orthonormal set and the eigenfunctions of operator $\hat{B}$ form an orthonormal set
(B) eigenfunctions for both operators $\hat{A}$ and $\hat{B}$ can be normalized
(C) eigenvalues for both operators $\hat{A}$ and $\hat{B}$ are real numbers
(D) operators $\hat{A}$ and $\hat{B}$ are both Hermitian
(E) operators $\hat{A}$ and $\hat{B}$ commute

$$E_{n_x,n_y,n_z} = \frac{h^2}{8ma^2}(n_x^2 + n_y^2 + n_z^2)$$

111. The energy levels of a particle in a cubic box are given by the expression above, in which n_x, n_y, $n_z = 1, 2, \ldots$. The degeneracy of the $E = 14\, h^2/8ma^2$ level is

(A) 2
(B) 3
(C) 4
(D) 5
(E) 6

112. Which of the following processes could be the termination step in a chain reaction?

(A) $C_2H_6 \rightarrow 2\,CH_3\cdot$
(B) $C_2H_6 + H\cdot \rightarrow H_2 + C_2H_5\cdot$
(C) $C_2H_6 + CH_3\cdot \rightarrow CH_4 + C_2H_5\cdot$
(D) $CH_3\cdot + CH_3\cdot \rightarrow C_2H_6$
(E) $C_2H_5\cdot \rightarrow C_2H_4 + H\cdot$

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113. The half-life of ^{14}C is 5,730 years. The ^{14}C activity of living material is approximately 920 decays/hr per gram of carbon. A fragment of wool fabric from an archaeological site has an activity of 680 decays/hr per gram of carbon. The approximate date of the sample is

(A) A.D. 1950
(B) 500 B.C.
(C) 3700 B.C.
(D) 5700 B.C.
(E) 10,000 B.C.

$$H_2PO_4^- \rightleftarrows HPO_4^{2-} + H^+ \qquad K_a = 5.0 \times 10^{-8}$$
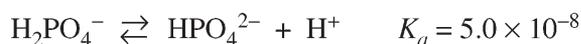
114. Given the information shown above, how many millimoles of K_2HPO_4 must be added to 100. mL of a $0.100\ M\ KH_2PO_4$ solution to obtain a solution with a pH of 7.0 ?

(A) 1.0 mmol
(B) 5.0 mmol
(C) 10. mmol
(D) 20. mmol
(E) 25. mmol

$$Hg^{2+} + 2e^- \rightarrow Hg \qquad E° = \ \ 0.85\ V$$
$$Zn^{2+} + 2e^- \rightarrow Zn \qquad E° = -0.76\ V$$
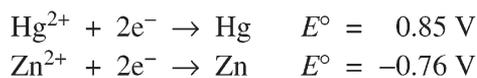
115. Given the cell potentials shown above, the equilibrium constant at 298 K for the reaction

$$Zn + Hg^{2+} \rightleftarrows Zn^{2+} + Hg$$
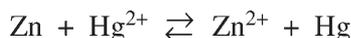
is closest to which of the following?

(A) 2.5×10^{54}
(B) 54
(C) 1.6
(D) 1.8×10^{-2}
(E) 4.1×10^{-55}

116. Which of the following isomers of C_6H_{12} has the highest heat of combustion?

(A) Cyclohexane
(B) Methylcyclopentane
(C) *trans*-1,2-dimethylcyclobutane
(D) Ethylcyclobutane
(E) 1,1,2-trimethylcyclopropane
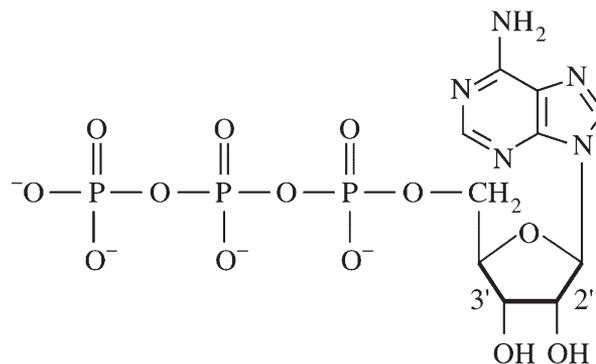
117. Energy is released when adenosine triphosphate (ATP), shown above, undergoes an enzyme-catalyzed reaction involving

(A) conversion of ATP to adenosine diphosphate (ADP) by hydrolysis of the terminal P—O—P linkage

(B) conversion of C-2′ from CHOH to CH_2 by reduction in the presence of the coenzyme NADH

(C) conversion of C-3′ from CHOH to C=O by oxidation in the presence of the coenzyme NAD^+

(D) dehydration by loss of a proton at C-2′ and of the hydroxyl group at C-3′

(E) inversion of configuration at C-3′
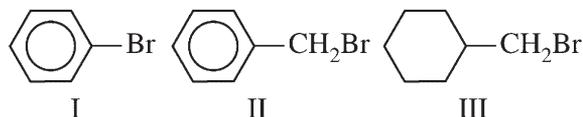
118. Which of the following correctly indicates the order of reactivity of the halides above with sodium iodide in acetone?

(A) I > II > III
(B) II > I > III
(C) II > III > I
(D) III > I > II
(E) III > II > I

GO ON TO THE NEXT PAGE.

119. Of the following experimental observations, which best demonstrates the wavelike character of electrons?

(A) The photoelectric effect
(B) The ionization of an atom
(C) The flow of electrons in a metal wire
(D) The deflection of an electron beam by electrical plates
(E) The diffraction pattern of electrons scattered from a crystalline solid

120. Light of frequency v is found to eject electrons of velocity v_e from a clean potassium surface in vacuum. Which of the following is true concerning this phenomenon?

(A) The frequency v is most likely in the infrared region.
(B) This phenomenon is best explained theoretically by using the wave model of light.
(C) The minimum energy required to remove an electron from the metal is $hv - \frac{1}{2}mv_e^2$.
(D) Light of frequency $2v$ will eject electrons of velocity $2v_e$.
(E) A more intense light source of frequency v will eject electrons with a velocity greater than v_e.

121. A system consists of N particles and behaves according to Boltzmann statistics. At temperature T, the number of particles that are found in a state having energy ε and a degeneracy g is directly proportional to

(A) $g\varepsilon$
(B) ε/kT
(C) $g\varepsilon/kT$
(D) $ge^{-\varepsilon/kT}$
(E) $ge^{\varepsilon/kT}$
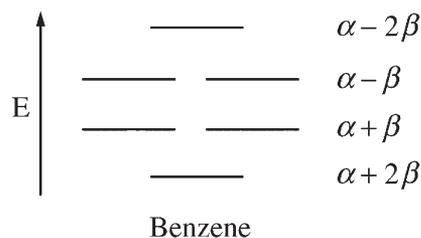
Benzene

122. Shown above is the energy-level diagram for the π orbitals of benzene, calculated on the basis of Hückel molecular orbital theory. According to this theory, the total energy of the six π electrons of ground-state benzene is given by

(A) $6\alpha + 8\beta$
(B) $4\alpha + 6\beta$
(C) $4\alpha + 4\beta$
(D) $2\alpha + 3\beta$
(E) $\alpha + 2\beta$

$$2\,CN^-(aq) + Ag^+(aq) \rightleftarrows Ag(CN)_2^-(aq)$$
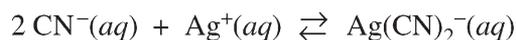
123. Cyanide ion may be determined by a complexometric titration with silver nitrate that uses a color indicator to detect the endpoint. If 20.00 mL of a 0.100 M solution of silver nitrate is required to titrate a 5.00 mL aliquot of a CN^- solution, the concentration of the original CN^- solution is

(A) 0.100 M
(B) 0.200 M
(C) 0.400 M
(D) 0.800 M
(E) 1.60 M

124. Which of the following statements is NOT true regarding glass-membrane pH electrodes?

(A) The electrodes are subject to both alkaline and acid errors.
(B) The electrodes are selective but not specific for measuring the activity of the hydrogen ion.
(C) The Nernst equation can usually be used to relate the activity of the hydrogen ion to the measured EMF in solution.
(D) The selectivity of glass-membrane electrodes is a function of their chemical composition.
(E) Hydrogen ions must migrate through the glass membrane to produce an EMF.

GO ON TO THE NEXT PAGE.

SOLID-LIQUID PHASE DIAGRAM FOR A AND B

Mole fraction of B, X_B
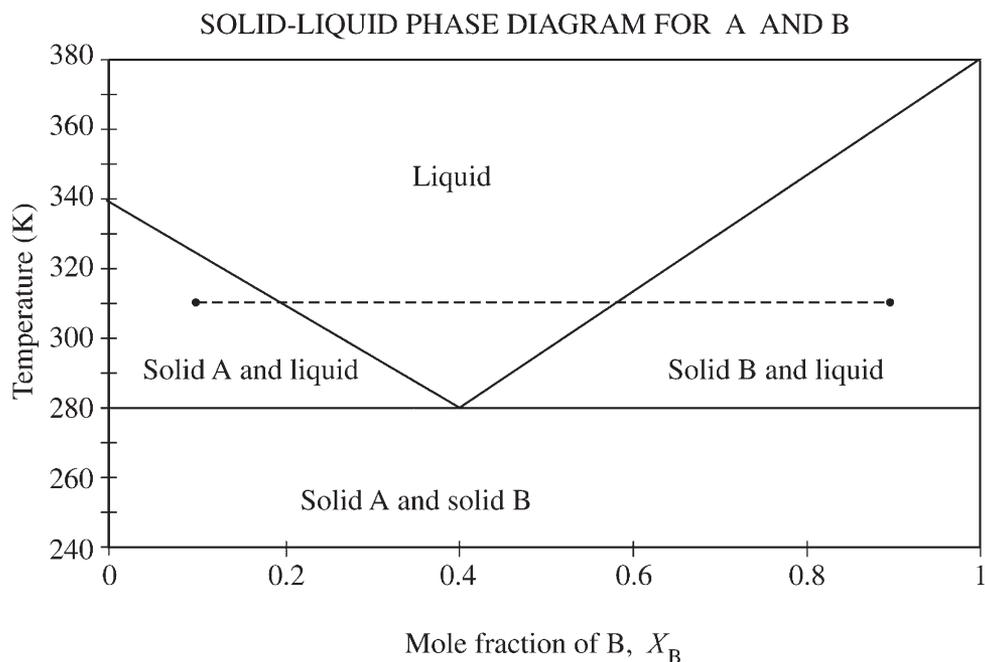
125. The phase diagram above shows the composition of mixtures of compounds A and B at different temperatures. A mixture at 310 K originally has $X_B = 0.10$. Pure B is added to the mixture until $X_B = 0.90$. A constant temperature is maintained throughout the process. Based on this information, which of the following is NOT true?

(A) As B is initially added, it melts into the liquid phase.
(B) When $X_B = 0.10$, about half of the A is in the solid phase and half is in the liquid mixture.
(C) When $X_B = 0.40$, no solid exists.
(D) When $X_B > 0.55$, the liquid solution is nearly all A.
(E) When $X_B = 0.90$, most of the B is in the pure solid state.

GO ON TO THE NEXT PAGE.

126. When a 0.001 M aqueous solution of each of the following compounds is prepared, which solution will have the greatest electrical conductivity?

(A) CH_3COOH
(B) CH_3OH
(C) NH_3
(D) SO_2
(E) HCl

$$H_2(g) + Cl_2(g) \xrightarrow{hv} 2\,HCl(g)$$
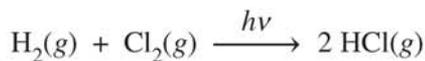
127. The yield of HCl from the photochemical reaction shown above is found to be 3.0×10^{-3} mol when 7.5×10^{16} photons are absorbed. Which of the following statements explains this observation?

(A) The process requires multiphoton absorption.
(B) The process violates the Franck-Condon principle.
(C) The fluorescence quantum yield is 1.00.
(D) The reaction is an oscillating reaction.
(E) The reaction is a chain reaction.

128. According to molecular-orbital theory, which of the following species has the highest bond order?

(A) NO^{2-}
(B) NO^-
(C) NO
(D) NO^+
(E) NO^{2+}

129. According to the 18-electron rule, which of the following is NOT a correct formula for a stable metal carbonyl? (Atomic numbers: $V = 23$, $Mn = 25$, $Fe = 26$, $Co = 27$, $Ni = 28$)

(A) $[V(CO)_6]^-$
(B) $[Mn(CO)_5]^-$
(C) $[Fe(CO)_4]^{2-}$
(D) $[Co(CO)_4]^+$
(E) $[Ni(CO)_4]$
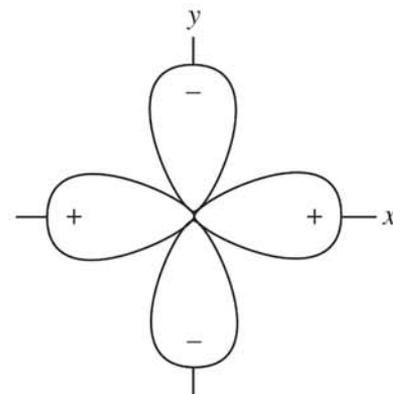
130. What type of orbital is shown above?

(A) $3\,p_x$
(B) $3\,p_y$
(C) $3\,d_{xy}$
(D) $3\,d_{x^2-y^2}$
(E) $3\,d_{z^2}$
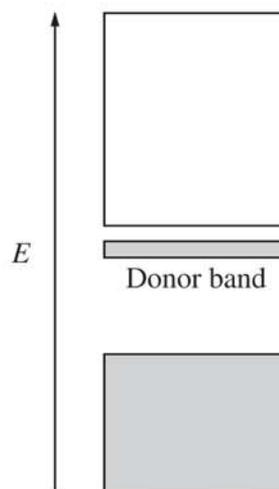
131. Which type of semiconductor is represented by the band structure shown above?

(A) An intrinsic semiconductor as in pure Si
(B) An n-type semiconductor as in Ga-doped Si
(C) An n-type semiconductor as in P-doped Si
(D) A p-type semiconductor as in Ga-doped Si
(E) A p-type semiconductor as in P-doped Si

132. Which of the following reactions would NOT be an acceptable method for the preparation of methyl benzoate?

(A)

$$\text{Ph-C(=O)-Cl} \xrightarrow{\text{CH}_3\text{OH}} \text{Ph-C(=O)-OCH}_3$$

(B)

$$\text{Ph-C(=O)-OH} \xrightarrow{\text{CH}_3\text{OH and trace H}_2\text{SO}_4} \text{Ph-C(=O)-OCH}_3$$

(C)

$$\text{Ph-C(=O)-O}^-\text{Na}^+ \xrightarrow{\text{CH}_3\text{I}} \text{Ph-C(=O)-OCH}_3$$

(D)

$$\text{Ph-C(=O)-O}^-\text{Na}^+ \xrightarrow{\text{CH}_3\text{OH}} \text{Ph-C(=O)-OCH}_3$$

(E)

$$\text{Ph-C(=O)-O-C(=O)-Ph} \xrightarrow{\text{CH}_3\text{OH}} \text{Ph-C(=O)-OCH}_3$$

GO ON TO THE NEXT PAGE.

$C(CH_3)_3$

[benzene ring]

NO_2
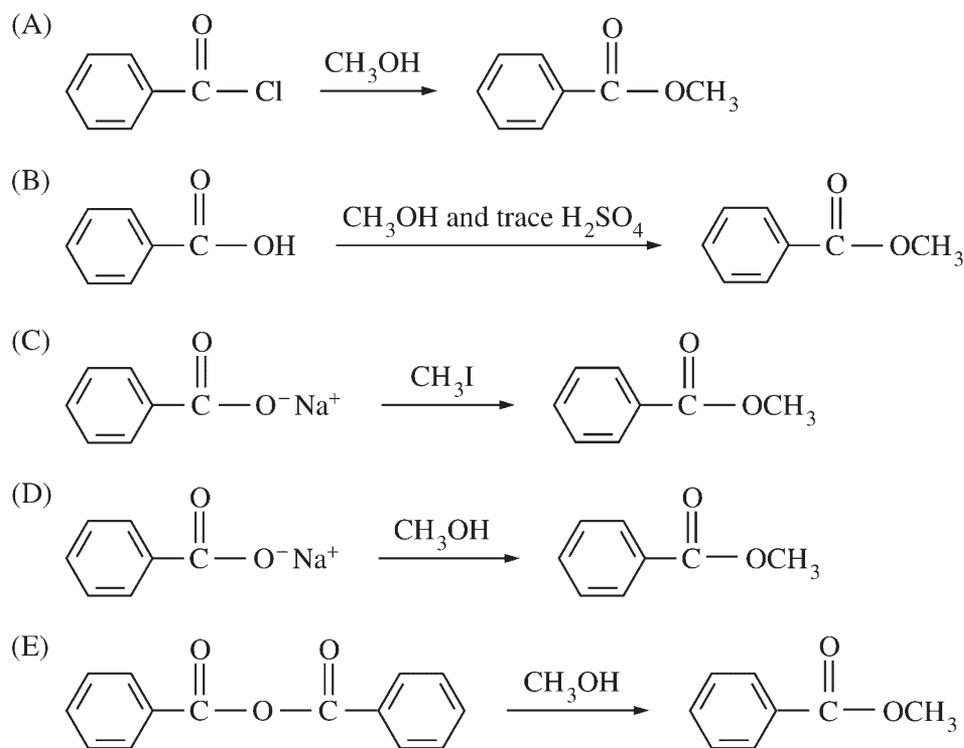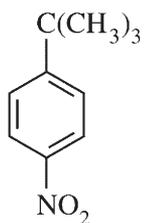
133. Of the following, which is the best synthesis of the compound shown above?

(A) [benzene ring] $\xrightarrow[\text{AlCl}_3]{(CH_3)_3CCl}$ $\xrightarrow[\text{H}_2\text{SO}_4]{\text{HNO}_3}$

(B) [benzene ring] $\xrightarrow[\text{H}_2\text{SO}_4]{\text{HNO}_3}$ $\xrightarrow[\text{AlCl}_3]{(CH_3)_3CCl}$

(C) [benzene ring] $\xrightarrow[\text{H}_2\text{SO}_4]{\text{HNO}_3}$ $\xrightarrow[\text{H}_2\text{SO}_4]{(CH_3)_3COH}$
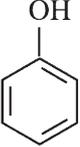
(D) [benzene ring with OH] $\xrightarrow[\text{H}_2\text{SO}_4]{(CH_3)_2C=CH_2}$ $\xrightarrow[\text{H}_2\text{SO}_4]{\text{HNO}_3}$
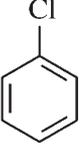
(E) [benzene ring with Cl] $\xrightarrow[\text{AlCl}_3]{(CH_3)_3CH}$ $\xrightarrow[\text{H}_2\text{SO}_4]{\text{HNO}_3}$

GO ON TO THE NEXT PAGE.

134. Which of the following is a suitable synthesis of *o*-methylphenol?

(A)

2-chlorotoluene $\xrightarrow{\text{KOH, 25°C}}$ 2-methylphenol

(B)

2-methylaniline $\xrightarrow[\text{2) H}_2\text{O, heat}]{\text{1) NaNO}_2\text{, H}_2\text{SO}_4\text{, H}_2\text{O}}$ 2-methylphenol

(C)

toluene $\xrightarrow[\text{H}_2\text{O, H}_2\text{SO}_4]{\text{heat}}$ 2-methylphenol

(D)

2-bromotoluene $\xrightarrow[\text{2) NaOH, H}_2\text{O, heat}]{\text{1) CH}_3\text{CONa, 25°C}}$ 2-methylphenol

(E)

toluene $\xrightarrow[\text{2) NaOH, H}_2\text{O}_2]{\text{1) BH}_3 \cdot \text{THF}}$ 2-methylphenol

GO ON TO THE NEXT PAGE.
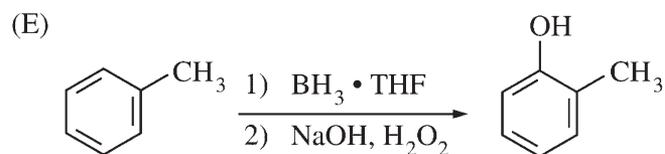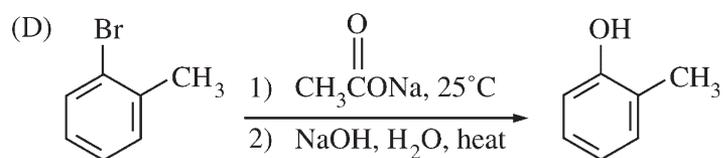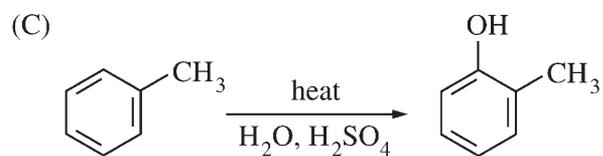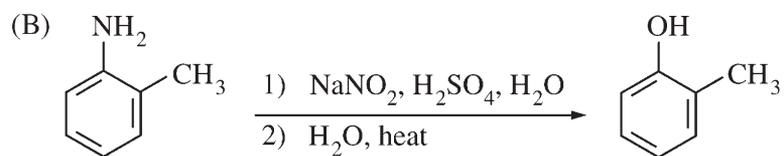
135. What is the <u>primary</u> advantage of a hollow-cathode lamp used in atomic absorption spectroscopy?

(A) It has high intensity.
(B) It emits a complete ultraviolet spectrum.
(C) It has a narrow line width.
(D) It allows direct application to nonmetal analysis.
(E) It eliminates the need for an ionization suppressor.
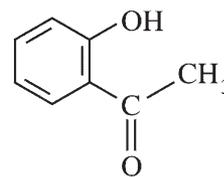
136. What infrared absorptions are most affected by intramolecular hydrogen bonding in the compound shown above?

(A) Methyl group C—H stretching
(B) Hydroxyl group O—H stretching
(C) Aromatic ring C—H bending
(D) Aromatic ring C—H stretching
(E) Aromatic ring C—C stretching

If you finish before time is called, you may check your work on this test.

I

NOTE: To ensure prompt processing of test results, it is important that you fill in the blanks <u>exactly</u> as directed.

SUBJECT TEST

A. Print and sign your full name in this box:

PRINT: _____

(LAST)   (FIRST)   (MIDDLE)

SIGN: _____

Copy this code in box 6 on your answer sheet. Then fill in the corresponding ovals exactly as shown.

6. TITLE CODE

2 7 9 1 0

Copy the Test Name and Form Code in box 7 on your answer sheet.

TEST NAME ___*Chemistry*___

FORM CODE ___*GR0027*___

GRADUATE RECORD EXAMINATIONS SUBJECT TEST

B. The Subject Tests are intended to measure your achievement in a specialized field of study. Most of the questions are concerned with subject matter that is probably familiar to you, but some of the questions may refer to areas that you have not studied.

Your score will be determined by subtracting one-fourth the number of incorrect answers from the number of correct answers. Questions for which you mark no answer or more than one answer are not counted in scoring. If you have some knowledge of a question and are able to rule out one or more of the answer choices as incorrect, your chances of selecting the correct answer are improved, and answering such questions will likely improve your score. It is unlikely that pure guessing will raise your score; it may lower your score.

You are advised to use your time effectively and to work as rapidly as you can without losing accuracy. Do not spend too much time on questions that are too difficult for you. Go on to the other questions and come back to the difficult ones later if you can.

YOU MUST INDICATE ALL YOUR ANSWERS ON THE SEPARATE ANSWER SHEET. No credit will be given for anything written in this examination book, but you may write in the book as much as you wish to work out your answers. After you have decided on your response to a question, fill in the corresponding oval on the answer sheet. BE SURE THAT EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL. Mark <u>only one</u> answer to each question. No credit will be given for multiple answers. Erase all stray marks. If you change an answer, be sure that all previous marks are erased completely. Incomplete erasures may be read as intended answers. Do not be concerned that the answer sheet provides spaces for more answers than there are questions in the test.

<u>Example:</u>

What city is the capital of France?

(A) Rome
(B) Paris
(C) London
(D) Cairo
(E) Oslo

<u>Sample Answer</u>

Ⓐ ● Ⓒ Ⓓ Ⓔ   CORRECT ANSWER PROPERLY MARKED

Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ   IMPROPER MARKS
Ⓐ ● Ⓒ Ⓓ Ⓔ
Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

DO NOT OPEN YOUR TEST BOOK UNTIL YOU ARE TOLD TO DO SO.

ETS Educational Testing Service

Educational Testing Service
Princeton, New Jersey 08541

Scoring Your Subject Test

Chemistry Test scores typically range from 490 to 910. The range for different editions of a given test may vary because different editions are not of precisely the same difficulty. The differences in ranges among different editions of a given test, however, usually are small. This should be taken into account, especially when comparing two very high scores. **The score conversion table on page 53 shows the score range for this edition of the test only.**

The worksheet on page 52 lists the correct answers to the questions. Columns are provided for you to mark whether you chose the correct (C) answer or an incorrect (I) answer to each question. Draw a line across any question you omitted, because it is not counted in the scoring. At the bottom of the page, enter the total number correct and the total number incorrect. Divide the total incorrect by 4 and subtract the resulting number from the total correct. This is the adjustment made for guessing. Then round the result to the nearest whole number. This will give you your raw total score. Use the total score conversion table to find the scaled total score that corresponds to your raw total score.

Example: Suppose you chose the correct answers to 80 questions and incorrect answers to 46. Dividing 46 by 4 yields 11.5. Subtracting 11.5 from 80 equals 68.5, which is rounded to 69. The raw score of 69 corresponds to a scaled score of 690.

Worksheet for the Chemistry Test, Form GR0027 Only
Answer Key and Percentages* of Examinees Answering Each Question Correctly

Question Number	Answer	P +	TOTAL C	I	Question Number	Answer	P +	TOTAL C	I	Question Number	Answer	P +	TOTAL C	I
1	**	**			51	A	53			101	B	56		
2	B	80			52	B	52			102	A	59		
3	E	55			53	D	83			103	E	48		
4	D	95			54	D	56			104	C	60		
5	A	86			55	A	70			105	E	33		
6	C	58			56	D	75			106	E	76		
7	B	53			57	D	77			107	C	48		
8	B	57			58	C	47			108	B	55		
9	C	84			59	A	74			109	E	47		
10	D	85			60	D	18			110	E	33		
11	E	47			61	E	68			111	E	36		
12	C	56			62	C	34			112	D	94		
13	E	75			63	E	15			113	B	50		
14	B	81			64	D	64			114	B	30		
15	E	63			65	E	53			115	A	19		
16	B	63			66	C	41			116	E	48		
17	B	82			67	B	47			117	A	77		
18	B	63			68	C	70			118	C	41		
19	C	52			69	D	22			119	E	69		
20	A	72			70	A	50			120	C	56		
21	C	53			71	C	44			121	D	57		
22	E	63			72	E	33			122	A	58		
23	B	68			73	B	42			123	D	39		
24	B	56			74	C	47			124	E	31		
25	B	66			75	B	58			125	D	26		
26	D	63			76	E	82			126	E	78		
27	A	52			77	D	62			127	E	35		
28	E	49			78	C	53			128	D	40		
29	E	75			79	B	15			129	D	46		
30	B	57			80	A	24			130	D	57		
31	A	67			81	B	61			131	C	30		
32	A	90			82	B	45			132	D	53		
33	D	68			83	D	39			133	A	60		
34	E	63			84	A	33			134	B	42		
35	E	73			85	D	27			135	C	35		
36	D	73			86	D	51			136	B	85		
37	D	81			87	B	54							
38	B	57			88	E	77							
39	E	77			89	C	79							
40	C	30			90	B	63							
41	A	81			91	C	69							
42	A	30			92	D	63							
43	E	57			93	A	68							
44	C	67			94	A	70							
45	C	41			95	E	55							
46	C	66			96	E	62							
47	D	80			97	D	68							
48	D	38			98	A	33							
49	A	70			99	D	60							
50	E	12			100	B	79							

Correct (C) _____

Incorrect (I) _____

Total Score:

C − I/4 = _____

Scaled Score (SS) = _____

  * The P+ column indicates the percent of CHEMISTRY Test examinees who answered each question correctly; it is based on a sample of November 2000 examinees selected to represent all CHEMISTRY Test examinees tested between October 1, 1998 and September 30, 2001.

** Item 1 was not scored when this form of the test was originally administered.

Score Conversions and Percents Below*
for GRE Chemistry Test, Form GR0027 Only

TOTAL SCORE					
Raw Score	Scaled Score	%	Raw Score	Scaled Score	%
133-135	980	99	68-69	690	52
131-132	970	99	65-67	680	50
129-130	960	99	63-64	670	48
126-128	950	99	61-62	660	45
124-125	940	98	59-60	650	43
122-123	930	97	56-58	640	40
120-121	920	96	54-55	630	37
118-119	910	95	52-53	620	34
115-117	900	94	49-51	610	31
113-114	890	92	47-48	600	29
111-112	880	90	45-46	590	26
109-110	870	88	42-44	580	24
106-108	860	87	40-41	570	21
104-105	850	85	38-39	560	19
102-103	840	83	35-37	550	16
100-101	830	81	33-34	540	14
97-99	820	79	31-32	530	11
95-96	810	77	28-30	520	10
93-94	800	76	26-27	510	8
91-92	790	74	24-25	500	6
88-90	780	72	21-23	490	5
86-87	770	70	19-20	480	3
84-85	760	68	17-18	470	2
82-83	750	66	14-16	460	2
79-81	740	64	12-13	450	1
77-78	730	61	10-11	440	1
75-76	720	59	7-9	430	1
72-74	710	57	5-6	420	1
70-71	700	55	3-4	410	1
			0-2	400	1

*Percentage scoring below the scaled score is based on the performance of
9,359 examinees who took the CHEMISTRY Test between October 1, 1998
and September 30, 2001.

Evaluating Your Performance

Now that you have scored your test, you may wish to compare your performance with the performance of others who took this test. Both the worksheet on page 52 and the table on page 53 use performance data from GRE Chemistry Test examinees.

The data in the worksheet on page 52 are based on the performance of a sample of the examinees who took this test in November 2000. This sample was selected to represent the total population of GRE Chemistry Test examinees tested between October 1998 and September 2001. The numbers in the column labeled "P+" on the worksheet indicate the percentages of examinees in this sample who answered each question correctly. You may use these numbers as a guide for evaluating your performance on each test question.

The table on page 53 contains, for each scaled score, the percentage of examinees tested between October 1998 and September 2001 who received lower scores. Interpretive data based on the scores earned by examinees tested in this three-year period will be used by admissions officers in the 2002–03 testing year.

These percentages appear in the score conversion table in a column to the right of the scaled scores. For example, in the percentage column opposite the scaled score of 690 is the number 52. This means that 52 percent of the GRE Chemistry Test examinees tested between October 1998 and September 2001 scored lower than 690. To compare yourself with this population, look at the percentage next to the scaled score you earned on the practice test.

It is important to realize that the conditions under which you tested yourself were not exactly the same as those you will encounter at a test center. It is impossible to predict how different test-taking conditions will affect test performance, and this is only one factor that may account for differences between your practice test scores and your actual test scores. By comparing your performance on this practice test with the performance of other GRE Chemistry Test examinees, however, you will be able to determine your strengths and weaknesses and can then plan a program of study to prepare yourself for taking the GRE Chemistry Test under standard conditions.

DO NOT USE INK

Use only a pencil with soft, black lead (No. 2 or HB) to complete this answer sheet.

Be sure to fill in completely the space that corresponds to your answer choice.

Completely erase any errors or stray marks.

1. NAME

Last Name only (Family or Surname) - first 15 letters

Enter your last name, first name initial (given name), and middle initial if you have one.

Omit spaces, apostrophes, Jr., II, etc.

First Name Initial

Middle Initial

2.

YOUR NAME:
(Print)

Last Name (Family or Surname)   First Name (Given)   M.I.

MAILING ADDRESS:
(Print)

P.O. Box or Street Address

City   State or Province

Country   Zip or Postal Code

CENTER:

City   State or Province

Country   Center Number   Room Number

SIGNATURE:

---

3. DATE OF BIRTH

Month	Day	Year
Jan.		
Feb.		
Mar.		
April		
May		
June		
July		
Aug.		
Sept.		
Oct.		
Nov.		
Dec.		

4. SOCIAL SECURITY NUMBER
(U.S.A. only)

5. REGISTRATION NUMBER
(from your admission ticket)

6. TITLE CODE
(on back cover of your test book)

7. TEST NAME (on back cover of your test book)

FORM CODE (on back cover of your test book)

8. TEST BOOK SERIAL NUMBER
(red number in upper right corner of front cover of your test book)

SHADED AREA FOR ETS USE ONLY

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE INTENDED SPACE AS ILLUSTRATED HERE: ●

YOU MAY FIND MORE RESPONSE SPACES THAN YOU NEED. IF SO, PLEASE LEAVE THEM BLANK.

1	A B C D E	39	A B C D E	77	A B C D E
2	A B C D E	40	A B C D E	78	A B C D E
3	A B C D E	41	A B C D E	79	A B C D E
4	A B C D E	42	A B C D E	80	A B C D E
5	A B C D E	43	A B C D E	81	A B C D E
6	A B C D E	44	A B C D E	82	A B C D E
7	A B C D E	45	A B C D E	83	A B C D E
8	A B C D E	46	A B C D E	84	A B C D E
9	A B C D E	47	A B C D E	85	A B C D E
10	A B C D E	48	A B C D E	86	A B C D E
11	A B C D E	49	A B C D E	87	A B C D E
12	A B C D E	50	A B C D E	88	A B C D E
13	A B C D E	51	A B C D E	89	A B C D E
14	A B C D E	52	A B C D E	90	A B C D E
15	A B C D E	53	A B C D E	91	A B C D E
16	A B C D E	54	A B C D E	92	A B C D E
17	A B C D E	55	A B C D E	93	A B C D E
18	A B C D E	56	A B C D E	94	A B C D E
19	A B C D E	57	A B C D E	95	A B C D E
20	A B C D E	58	A B C D E	96	A B C D E
21	A B C D E	59	A B C D E	97	A B C D E
22	A B C D E	60	A B C D E	98	A B C D E
23	A B C D E	61	A B C D E	99	A B C D E
24	A B C D E	62	A B C D E	100	A B C D E
25	A B C D E	63	A B C D E	101	A B C D E
26	A B C D E	64	A B C D E	102	A B C D E
27	A B C D E	65	A B C D E	103	A B C D E
28	A B C D E	66	A B C D E	104	A B C D E
29	A B C D E	67	A B C D E	105	A B C D E
30	A B C D E	68	A B C D E	106	A B C D E
31	A B C D E	69	A B C D E	107	A B C D E
32	A B C D E	70	A B C D E	108	A B C D E
33	A B C D E	71	A B C D E	109	A B C D E
34	A B C D E	72	A B C D E	110	A B C D E
35	A B C D E	73	A B C D E	111	A B C D E
36	A B C D E	74	A B C D E	112	A B C D E
37	A B C D E	75	A B C D E	113	A B C D E
38	A B C D E	76	A B C D E	114	A B C D E

Item responses continued on reverse side.

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**COMPLETE THE
CERTIFICATION STATEMENT,
THEN TURN ANSWER SHEET
OVER TO SIDE 1.**

CERTIFICATION STATEMENT

Please write the following statement below, DO NOT PRINT.
"I certify that I am the person whose name appears on this answer sheet. I also agree not to disclose the contents of the test I am taking today to anyone."
Sign and date where indicated.

_____

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SIGNATURE: _____   DATE: ___/___/___
                                                   Month Day Year

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE INTENDED SPACE AS ILLUSTRATED HERE: ●.
YOU MAY FIND MORE RESPONSE SPACES THAN YOU NEED. IF SO, PLEASE LEAVE THEM BLANK.

115 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	147 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	179 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	211 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
116 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	148 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	180 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	212 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
117 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	149 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	181 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	213 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
118 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	150 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	182 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	214 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
119 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	151 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	183 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	215 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
120 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	152 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	184 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	216 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
121 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	153 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	185 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	217 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
122 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	154 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	186 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	218 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
123 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	155 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	187 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	219 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
124 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	156 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	188 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	220 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
125 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	157 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	189 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	221 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
126 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	158 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	190 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	222 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
127 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	159 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	191 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	223 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
128 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	160 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	192 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	224 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
129 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	161 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	193 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	225 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
130 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	162 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	194 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	226 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
131 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	163 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	195 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	227 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
132 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	164 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	196 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	228 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
133 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	165 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	197 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	229 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
134 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	166 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	198 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	230 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
135 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	167 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	199 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	231 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
136 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	168 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	200 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	232 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
137 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	169 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	201 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	233 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
138 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	170 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	202 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	234 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
139 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	171 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	203 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	235 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
140 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	172 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	204 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	236 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
141 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	173 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	205 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	237 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
142 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	174 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	206 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	238 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
143 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	175 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	207 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	239 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
144 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	176 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	208 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	240 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
145 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	177 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	209 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	241 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
146 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	178 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	210 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	242 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

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If you want to cancel your scores from this administration, complete A and B below. You will not receive scores for this test; however, you will receive confirmation of this cancellation. No record of this test or the cancellation will be sent to the recipients you indicated, and there will be no scores for this test on your GRE file. Once a score is canceled, it cannot be reinstated.

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A. fill in both ovals here . . . ◯ – ◯   B. sign your full name here: _____

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				5R	5W	5FS	5CS	6R	6W	6FS	6CS