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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.

www.ets.org/gre

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

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, see the *GRE Guide to the Use of Scores* at **www.ets.org/gre/stupubs**.

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 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 committee members and by other university faculty members who are subject-matter specialists. All questions proposed for the test are reviewed and revised by the committee and subject-matter specialists at ETS. The tests are assembled 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.

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 remains current. 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. 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 more 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. For Subject Tests that report subscores, the maximum possible range is 20 to 99; however, the actual range of subscores for any test or test edition may be smaller. Subject Test score interpretive information is provided in *Interpreting Your GRE Scores*, which you will receive with your GRE score report. This publication is also available at **www.ets.org/gre/stupubs**.

Content of the Chemistry Test

The test consists of about 130 multiple-choice questions. A periodic table is printed in the test booklet as well as a table of information (see pages 10 and 11) 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, taking note of the directions. If you 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 actual 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.
- Your score will be determined by subtracting one-fourth the number of incorrect answers from the number of correct answers. 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.
- 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 number of actual scaled score points, 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
800	96-97	95-97	94-95
700	73-74	72-73	70-72
600	50-51	48-50	47-48
500	26-28	24-25	23-24
Number of Questions Used to Compute Raw Score			
	129	130	130

*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 73 through 74 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
73	73	0	56	129
73	79	23	27	129
73	84	44	1	129
74	74	0	55	129
74	79	21	29	129
74	85	43	1	129

Practice Test

To become familiar with how the administration will be conducted at the test center, first remove the answer sheet (pages 57 and 58). Then go to the back cover of the test book (page 52) 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.

FORM GR0627

27

GRADUATE RECORD EXAMINATIONS®

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.

DO NOT DETACH FROM BOOK.

PERIODIC TABLE OF THE ELEMENTS

1																	18
1 **H** 1.008	2											13	14	15	16	17	2 **He** 4.00
3 **Li** 6.94	4 **Be** 9.01											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.30	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.95
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** 54.94	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** (266)	107 **Bh** (264)	108 **Hs** (277)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)							

*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)	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** (262)

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

TABLE OF INFORMATION

Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
Proton rest mass	$m_p = 1.672 \times 10^{-27}$ kg
Neutron rest mass	$m_n = 1.675 \times 10^{-27}$ kg
Magnitude of the electron charge	$e = 1.60 \times 10^{-19}$ C
Bohr radius	$a_0 = 5.29 \times 10^{-11}$ m
Avogadro number	$N_A = 6.02 \times 10^{23}$ per mol
Universal gas constant	$R = 8.314$ J mol^{-1} K^{-1} $= 0.0821$ L • atm mol^{-1} K^{-1} $= 0.08314$ L • bar mol^{-1} K^{-1}
Boltzmann constant	$k = 1.38 \times 10^{-23}$ J/K
Planck constant	$h = 6.63 \times 10^{-34}$ J • s $\hbar = h/2\pi = 1.05 \times 10^{-34}$ J • s
Speed of light	$c = 3.00 \times 10^{8}$ m/s $= 3.00 \times 10^{10}$ cm/s
1 bar pressure	1 bar $= 1.000$ N m^{-2} $= 1.000 \times 10^{5}$ Pa $= 0.987$ atm
1 atmosphere pressure	1 atm $= 1.013 \times 10^{5}$ N m^{-2} $= 1.013 \times 10^{5}$ Pa $= 1.013$ bar
Faraday constant	$\mathcal{F} = 9.65 \times 10^{4}$ C/mol
1 atomic mass unit (amu)	1 amu $= 1.66 \times 10^{-27}$ kg
1 electron volt (eV)	1 eV $= 1.602 \times 10^{-19}$ J
Angstrom	1 Å $= 10^{-10}$ m $= 10^{-1}$ nm
Volume of 1 mol of ideal gas at 0° C, 1 atmosphere	$= 22.4$ L

GO ON TO THE NEXT PAGE.

CHEMISTRY TEST

Time—170 minutes

130 Questions

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.

Note: 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	L	=	liter(s)
S	=	entropy	mL	=	milliliter(s)
H	=	enthalpy	g	=	gram(s)
U	=	internal energy	kg	=	kilogram(s)
G	=	Gibbs energy	m	=	meter(s)
A	=	Helmholtz energy	nm	=	nanometer(s)
R	=	gas constant	atm	=	atmosphere(s)
n	=	number of moles	J	=	joule(s)
s	=	seconds	kJ	=	kilojoule(s)
mol	=	mole(s)	ppm	=	parts per million
C	=	coulomb(s)	Pa	=	Pascal(s)
			V	=	volt(s)

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1. Of the following, which element has the highest first ionization energy?

   (A) As
   (B) Ge
   (C) Ga
   (D) Rb
   (E) Sr

2. Which of the following is the most acceptable Lewis electron dot structure for carbon monoxide?

   (A) $C{=}O$

   (B) $\dot{\underset{\cdot\cdot}{C}}{=}\dot{\underset{\cdot\cdot}{O}}$

   (C) $:C{\equiv}O:$

   (D) $C{\equiv}O$

   (E) $\dot{\underset{\cdot\cdot}{C}}{\equiv}\dot{\underset{\cdot\cdot}{O}}$

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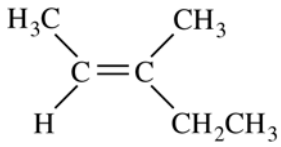
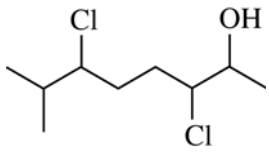


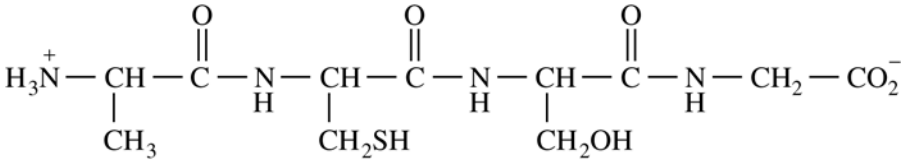
3. What is the correct IUPAC name for the compound shown above?

(A) *trans*-3-methyl-3-pentene
(B) *cis*-2-ethyl-2-butene
(C) (*E*)-3-methyl-2-pentene
(D) (*Z*)-3-methyl-2-pentene
(E) (*Z*)-2-ethyl-2-butene



4. What is the total number of stereoisomers possible for the compound shown above?

(A) 3
(B) 4
(C) 6
(D) 8
(E) 16



5. The total number of peptide bonds in the structure shown above is

(A) 1
(B) 2
(C) 3
(D) 4
(E) 5

6. A 0.10 L solution of $Cl^-(aq)$ is titrated with 1.0×10^{-3} M $Ag^+(aq)$. The end point is reached when 0.025 L of the Ag^+ solution has been added. What was the concentration of Cl^- in the original solution?

(A) 1.0×10^{-4} M
(B) 2.5×10^{-4} M
(C) 4.0×10^{-4} M
(D) 8.0×10^{-4} M
(E) 1.0×10^{-3} M

$$C(s) + CO_2(g) \rightleftharpoons 2\,CO(g)$$

7. ΔH for the reaction shown above is greater than zero. Assuming ΔH is independent of temperature, which of the following statements about the percent yield of $CO(g)$ is true?

(A) It increases as the amount of $C(s)$ increases.
(B) It increases as the temperature increases.
(C) It decreases as the temperature increases.
(D) It doubles when the initial partial pressure of CO_2 is doubled.
(E) It increases when the total pressure of the reaction system increases.

[A]	[B]	Initial Rate
0.50 M	0.50 M	10 M s^{-1}
0.50 M	1.00 M	20 M s^{-1}
0.25 M	0.50 M	5 M s^{-1}
1.00 M	1.00 M	40 M s^{-1}

8. The initial rates given above were determined for the reaction $A + 2\,B \rightarrow AB_2$. What is the overall rate law for this reaction?

(A) Rate $= k[A]^2[B]^2$
(B) Rate $= k[A]^2[B]$
(C) Rate $= k[A][B]^2$
(D) Rate $= k[A][B]$
(E) Rate $= k$

9. Assuming that air is approximately 80 percent nitrogen and 20 percent oxygen by volume, which of the following is closest to the density of air at 0°C and 1 atmosphere?

(A) 0.01 g/L
(B) 0.1 g/L
(C) 1 g/L
(D) 10 g/L
(E) 100 g/L

10. How many π bonds are there in acetylene, shown above?

(A) 1
(B) 2
(C) 3
(D) 4
(E) 5

1. $CHF_2CH_2CH_2CO_2H$
2. $CH_3CF_2CH_2CO_2H$
3. $CH_3CH_2CF_2CO_2H$
4. $CH_3CH_2CH_2CO_2H$

11. In which of the following are the carboxylic acids shown above listed in order of decreasing acidity, from most acidic to least acidic?

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

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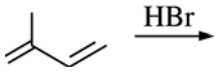
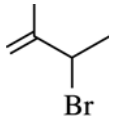
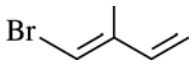
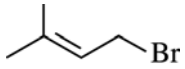
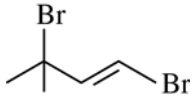


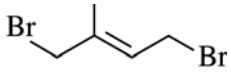
12. Which of the following is a 1,4-addition product of the reaction shown above?

(A) 

(B) 

(C) 

(D) 

(E) 

13. Which of the following is a weak Brønsted-Lowry acid?

(A) HCl
(B) HNO_3
(C) H_2SO_4
(D) H_2S
(E) $HClO_4$

14. Which of the following correctly lists the species in order of increasing radius from smallest to largest?

(A) $K^+ < Ar < Cl^-$
(B) $Ar < Cl^- < K^+$
(C) $K^+ < Cl^- < Ar$
(D) $Cl^- < Ar < K^+$
(E) $Ar < K^+ < Cl^-$

15. The half-life of ^{14}C is 5,730 years. All of the following are true for the method of carbon dating EXCEPT:

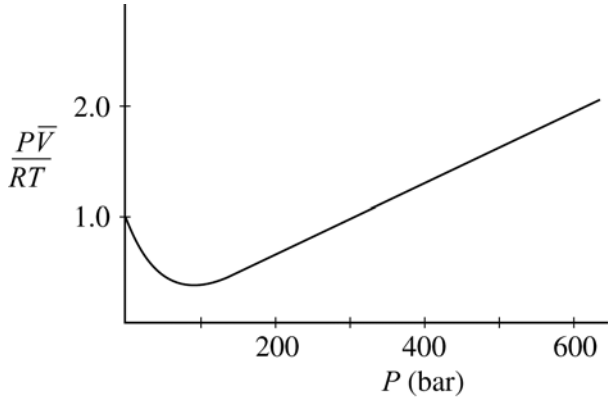
(A) ^{14}C undergoes β-decay to produce ^{14}N.

(B) The ^{14}C content of an organism decreases after it dies.

(C) The $^{14}C/^{12}C$ ratio is the same in living terrestrial organisms as in the atmosphere.

(D) The $^{14}C/^{12}C$ ratio can be used to date a sample from a dead organism.

(E) Carbon dating is equally useful for samples that are millions of years old as for samples that are about 10,000 years old.



16. The curve shown above illustrates the $P\overline{V}$ behavior of a real gas, where $\overline{V}$ is the molar volume. According to the van der Waals model for nonideal gas behavior, the values of $P\overline{V}/RT$ greater than 1.0 at high pressures are due to

(A) the effects of increased rate of collision of the molecules with the walls of the container
(B) the effects of dissociation of individual gas molecules
(C) the effects of the volume occupied by the molecules themselves
(D) the effects of forces of attraction between molecules
(E) ideal gas behavior in this pressure region

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$$O_3(g) \rightarrow \frac{3}{2}O_2(g)$$

17. For the reaction shown above at 298 K, $\Delta G^\circ = -163$ kJ/mol. What is the value of the equilibrium constant, K_P, for this reaction?

(A) $K_P > 1.0$
(B) $K_P = 1.0$
(C) $0.0 < K_P < 1.0$
(D) $K_P = 0.0$
(E) $K_P < 0.0$

18. In an isolated hydrogen atom, the $2p_x$ orbital has the same principal quantum number, n, as which of the following orbitals?

I. $2s$
II. $2p_z$
III. $3p_x$

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

19. Which of the following is NOT an allotrope of carbon?

(A) Diamond
(B) Graphite
(C) C_{60}
(D) C_{70}
(E) C_2^{2-}

20. Of the following covalent bonds, which has the greatest bond dissociation energy?

(A) C═C
(B) O═O
(C) C═Si
(D) Si≡Si
(E) C≡O

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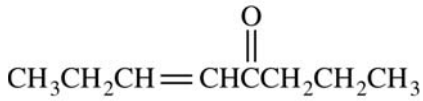
21. Assuming complete dissociation, which of the following is NOT true about a 1.00 M $Mg(NO_3)_2$ solution? (Molar masses: Mg = 24.30 g; NO_3^- = 62.01 g; $Mg(NO_3)_2$ = 148.31 g)

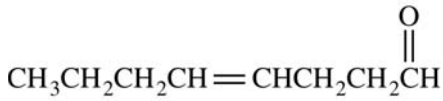
(A) The concentration of nitrate ions is 2.00 mol L^{-1}.
(B) The total concentration of ions is 3.00 mol L^{-1}.
(C) The total mass of solute in 1.00 L of this solution is 148 g.
(D) There are 2.43 g of Mg^{2+} in 100 mL of this solution.
(E) There are 6.20 g of NO_3^- in 100 mL of this solution.

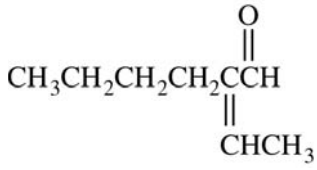
22. A 499 mg sample of $CuSO_4 \cdot nH_2O$ is heated to drive off the waters of hydration and then reweighed to give a final mass of 319 mg. Given that the sample contains 2.0 mmol of Cu, what is the average number of waters of hydration, n, in $CuSO_4 \cdot nH_2O$?

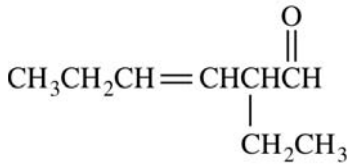
(A) 2.0
(B) 5.0
(C) 10.
(D) 18
(E) 20.

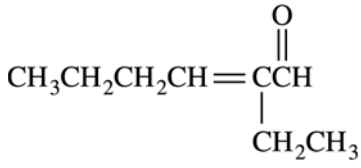
23. Which of the following is the aldol condensation product of butanal ($CH_3CH_2CH_2CHO$) ?

(A) 

(B) 

(C) 

(D) 

(E) 

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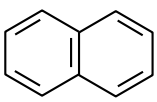
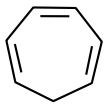
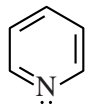
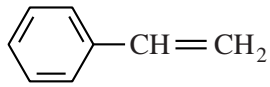

Naphthalene

Pyrrole


Cycloheptatriene



Pyridine



Styrene

24. Which of the following statements correctly applies Hückel's rule to the molecules shown above?

(A) Naphthalene is not monocyclic; therefore it cannot be aromatic.
(B) Pyrrole is not a hydrocarbon; therefore it cannot be aromatic.
(C) Cycloheptatriene is not completely conjugated; therefore it cannot be aromatic.
(D) Pyridine is weakly basic; therefore it cannot be aromatic.
(E) Styrene has $8\ \pi$ electrons; therefore it cannot be aromatic.

---

25. When 1.0 kJ of heat is added to 5.0 L of an ideal gas, the gas expands against a constant external pressure of 1.0 bar to a final volume of 8.0 L. What is the change in internal energy, ΔU, for the gas? (1.0 L·bar = 0.10 kJ)

(A) 0.30 kJ
(B) 0.70 kJ
(C) 1.0 kJ
(D) 1.3 kJ
(E) 1.8 kJ

26. Which of the following must be true for adiabatic processes?

(A) $C_V = C_P$
(B) $\Delta H = 0$
(C) $\Delta U = 0$
(D) $\Delta S = 0$
(E) $q = 0$

27. At 37°C, the dissociation constant, K_w, of water is 2.5×10^{-14} ($pK_w = 13.6$). What is the pH of a 1.0×10^{-5} M NaOH solution at 37°C ?

(A) 4.6
(B) 5.0
(C) 8.6
(D) 9.0
(E) 13.6

$$\_\_\ H^+ + \_\_\ IO_3^- + \_\_\ I^- \rightarrow \_\_\ I_2 + \_\_\ H_2O$$

28. The reaction shown above is not balanced. If the reaction is balanced using the smallest whole number coefficients possible, the coefficient for I^- will be

(A) 1
(B) 2
(C) 3
(D) 5
(E) 10

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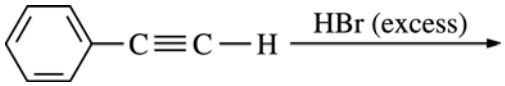
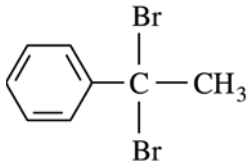
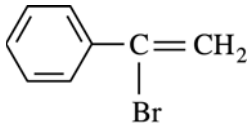
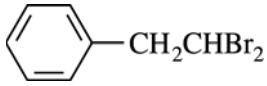
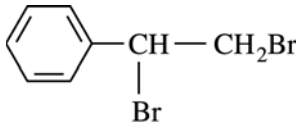


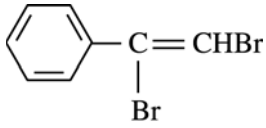
29. Which of the following is the major product of the reaction shown above?

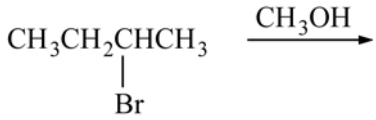
(A) 

(B) 

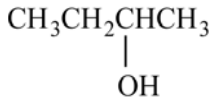
(C) 

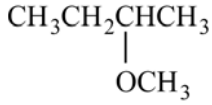
(D) 

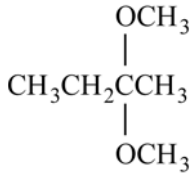
(E) 

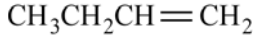


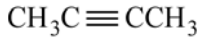
30. The reaction of 2-bromobutane with methanol, as shown above, yields which of the following as the major product?

(A) 

(B) 

(C) 

(D) 

(E) 

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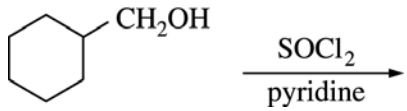
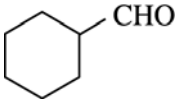
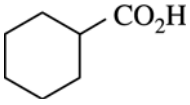
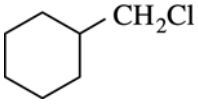
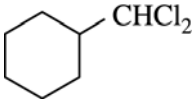


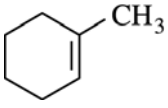
31. Which of the following is the major organic product of the reaction shown above?

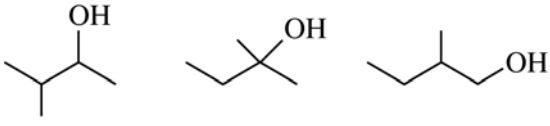
(A) 

(B) 

(C) 

(D) 

(E) 



32. In which of the following are the compounds shown above listed in order of increasing reactivity to acid-catalyzed dehydration?

(A) 1 < 2 < 3
(B) 1 < 3 < 2
(C) 2 < 3 < 1
(D) 3 < 1 < 2
(E) 3 < 2 < 1

33. Two cylinders, one containing 1 mole of C_4H_{10} gas at 1 atm and the other containing 1 mole of CH_4 gas at 1 atm, are at 288 K. If each gas absorbs 100 J of heat under conditions of constant volume, which of the following is true?

(A) The temperature of the CH_4 increases more than the temperature of the C_4H_{10}.
(B) The internal energy of both the CH_4 and the C_4H_{10} decreases.
(C) The heat capacity of the C_4H_{10} is less than the heat capacity of the CH_4.
(D) The entropy of both the CH_4 and the C_4H_{10} decreases.
(E) The heat transferred to the C_4H_{10} is greater than the heat transferred to the CH_4.

34. Which of the following statements is true about a pure substance above its critical point?

(A) One fluid phase is present.
(B) Solid, liquid, and gas are in equilibrium.
(C) Only liquid and gas are in equilibrium.
(D) A liquid forms.
(E) A solid forms.

$$\int_{-\infty}^{+\infty} \psi_1^*(x)\,\psi_2(x)\,dx = 0$$

35. If two wavefunctions $\psi_1(x)$ and $\psi_2(x)$ satisfy the condition given above, the two wavefunctions are

(A) orthogonal
(B) degenerate
(C) normalized
(D) continuous
(E) symmetrical

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$$\hat{A} = \frac{d^2}{dx^2} \qquad \psi = \sin kx$$

36. For the equation $\hat{A}\psi = a\psi$, where $\hat{A}$ and ψ are shown above, all of the following are true EXCEPT:

(A) ψ is an eigenfunction of $\hat{A}$.
(B) a is an eigenvalue.
(C) a is an observable.
(D) $\hat{A}$ is an operator corresponding to the observable.
(E) $\hat{A}$ is an eigenfunction of a.

37. At standard temperature and pressure, all of the following compounds exist in the gas state EXCEPT

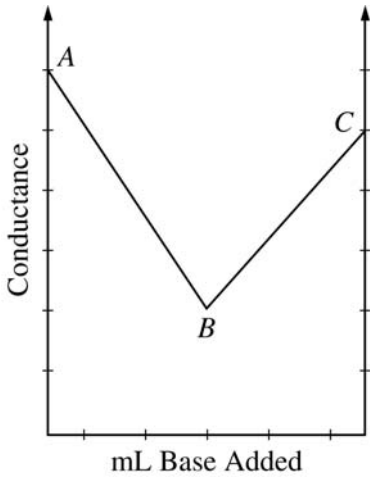
(A) HCl
(B) HBr
(C) NH_3
(D) BH_3
(E) LiH

38. The electron configuration of Co in $[Co(NH_3)_6]Cl_3$ is

(A) [Ar] $4s^2 3d^7$
(B) [Ar] $4s^2 3d^4$
(C) [Ar] $3d^9$
(D) [Ar] $3d^7$
(E) [Ar] $3d^6$

39. A 0.600 g sample of a pure, weak diprotic acid gives end points at 20.0 mL and 40.0 mL when it is titrated with 0.100 M NaOH. What is the molar mass of the weak acid?

(A) 120 g
(B) 150 g
(C) 180 g
(D) 300 g
(E) 450 g



40. The figure shown above is a plot of conductance data obtained during the titration of HCl with a standard solution of NaOH. Which of the following statements about the results is NOT true?

(A) Point B is the end point of the titration.
(B) $|\text{slope } AB| > |\text{slope } BC|$
(C) The measured conductance increases after point B because the overall concentration of ions increases.
(D) Na^+ must have a higher equivalent conductance than H_3O^+.
(E) Segment BC represents the conductance due to ions from NaCl and NaOH in solution.

41. The molecular geometry of IF_5 is

(A) square pyramidal
(B) trigonal planar
(C) bent
(D) linear
(E) octahedral

42. At a given temperature, the vapor pressure of SiF_4 is significantly higher than that of SF_4. The major physical basis for the difference in vapor pressure is that SiF_4 and SF_4 have different

(A) dipole moments
(B) molar masses
(C) ionization energies
(D) electron affinities
(E) magnetic susceptibilities

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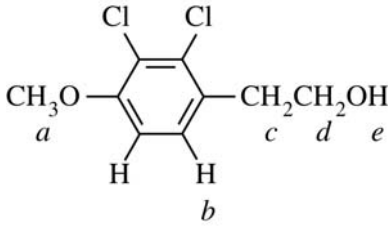


43. Which of the protons indicated will be observed as a doublet in the ^{1}H NMR spectrum of the molecule shown above?

(A) *a*
(B) *b*
(C) *c*
(D) *d*
(E) *e*

$$CH_3CH_2C{\equiv}CCH_2CH_3 \xrightarrow[\text{liquid } NH_3]{Na}$$

44. Which of the following is the major product of the reaction shown above?

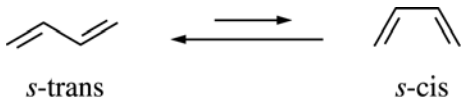
(A) $CH_3CH_2CH_2CH_2C{\equiv}CNa$

(B) $CH_3CH_2CH_2CH_2CH_2CH_3$

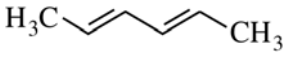
(C) *cis*-$CH_3CH_2CH{=}CHCH_2CH_3$

(D) *trans*-$CH_3CH_2CH{=}CHCH_2CH_3$

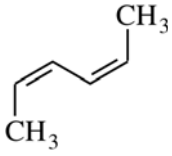
(E) $CH_3CH_2CH{=}\underset{\displaystyle NH_2}{\overset{\displaystyle |}{C}}CH_2CH_3$

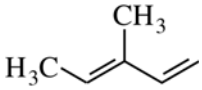


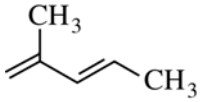
45. Acyclic conjugated dienes may exist in two conformations, as shown above. Based on differences in steric strain, which of the following dienes has the greatest preference for the *s*-trans conformation?

(A) 

(B) 

(C) 

(D) 

(E) 

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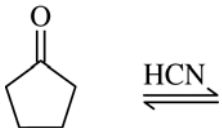
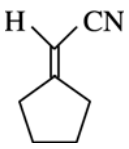
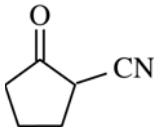
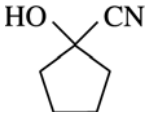


46. Which of the following substances is in equilibrium with cyclopentanone and HCN shown above?

(A) 

(B) 

(C) 

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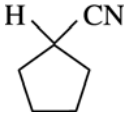
(E) 

47. All of the following elements have at least one isotope that is not radioactive EXCEPT

(A) O
(B) Pb
(C) Sn
(D) No
(E) He

48. Based on the molecular orbital model, which of the following is the number of unpaired electrons and the bond order for the superoxide ion, O_2^- ?

	Unpaired Electrons	Bond Order
(A)	1	0.5
(B)	1	1.5
(C)	1	2.5
(D)	2	1
(E)	2	2

49. For a system at thermal equilibrium, which of the following is the Boltzmann distribution expression for the probability, p_i, that a single molecule is in the ith energy state with energy ε_i ?

(A) $p_i = \varepsilon_i / kT$

(B) $p_i = 1 - e^{-\varepsilon_i / kT}$

(C) $p_i = \left(\sum_{i=0}^{\infty} e^{-\varepsilon_i / kT} \right) - e^{-\varepsilon_i / kT}$

(D) $p_i = \left(e^{-\varepsilon_i / kT} \right)^{N_i}$

(E) $p_i = \dfrac{e^{-\varepsilon_i / kT}}{\left(\sum_{i=0}^{\infty} e^{-\varepsilon_i / kT} \right)}$

50. Which of the following expressions involving fugacity, f, is correct as $P \rightarrow 0$?

(A) $f = P$

(B) $f = \dfrac{1}{P}$

(C) $f = 1$

(D) $f = \dfrac{1}{V}$

(E) $f = V$

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51. Sodium acetate spontaneously crystallizes out of a supersaturated solution on standing or on the addition of a seed crystal. Which of the following is true for the thermodynamic quantities of this system for this process?

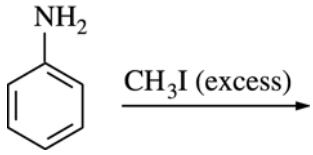
(A) $\Delta S < 0,\ \Delta H < 0$
(B) $\Delta S < 0,\ \Delta G > 0$
(C) $\Delta S > 0,\ \Delta H > 0$
(D) $\Delta S > 0,\ \Delta G < 0$
(E) $\Delta G < 0,\ \Delta H > 0$

52. If ideal gas behavior is assumed, for which of the following reactions does ΔH equal ΔU?

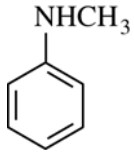
(A) $N_2O_4(g) \rightarrow 2\ NO_2(g)$
(B) $CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$
(C) $SO_2(g) + \frac{1}{2}\ O_2(g) \rightarrow SO_3(g)$
(D) $Br_2(l) + 3\ Cl_2(g) \rightarrow 2\ BrCl_3(g)$
(E) $Cl_2(g) + F_2(g) \rightarrow 2\ ClF(g)$

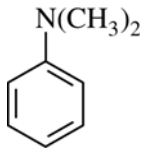
53. $PbF_2(s)$, which is slightly soluble in water, is dissolved in water to form a saturated solution in equilibrium with solid PbF_2. Which of the following will cause additional $PbF_2(s)$ to dissolve?

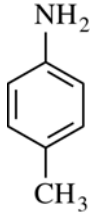
(A) Adding HNO_3
(B) Adding $Pb(NO_3)_2$
(C) Adding a seed crystal
(D) Adding solid PbF_2
(E) Evaporating some of the water to decrease the volume of solution

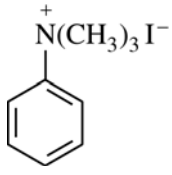


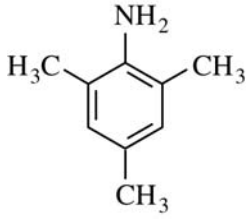
54. Which of the following is the major product of the reaction shown above?

(A) 

(B) 

(C) 

(D) 

(E) 

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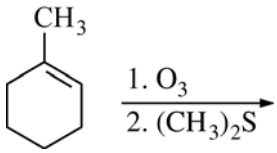
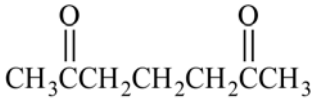
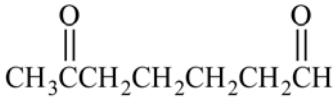
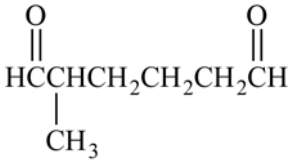
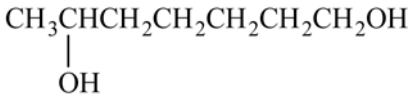


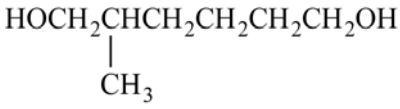
55. Which of the following is the product of the reaction shown above?

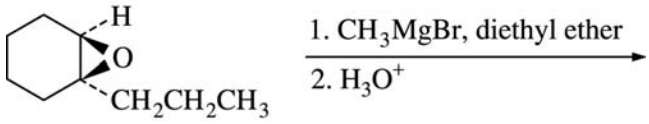
(A) 

(B) 

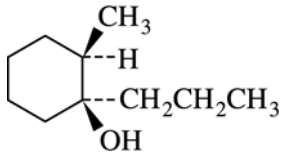
(C) 

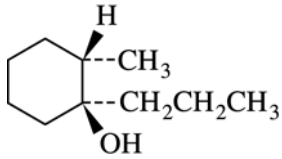
(D) 

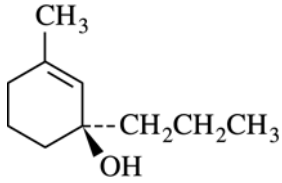
(E) 

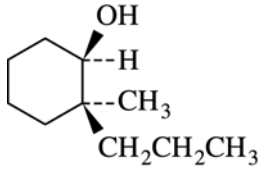


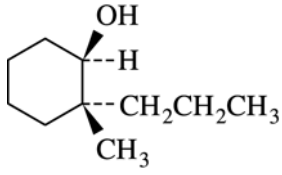
56. Which of the following is the major product of the reaction shown above?

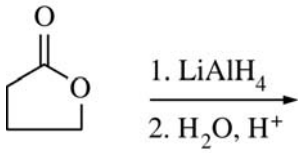
(A) 

(B) 

(C) 

(D) 

(E) 



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

(A) $CH_3CH_2CH_2COH$ (with O double-bonded)

(B) $HOCH_2CH_2COH$ (with O double-bonded)

(C) $HOCH_2CH_2CH_2CH_2OH$

(D) $CH_3CH_2CH_2CH_2OH$

(E) $HCOCH_2CH_2CH_3$ (with O double-bonded)

$$\left(\frac{\partial U}{\partial V}\right)_T = -P + T\left(\frac{\partial P}{\partial T}\right)_V$$

58. Given the expression above, what is the value of $\left(\frac{\partial U}{\partial V}\right)_T$ for an ideal gas undergoing isothermal expansion? ($PV = nRT$ for an ideal gas.)

(A) $-P + \frac{nR}{V}$

(B) nR

(C) $-P$

(D) 1

(E) 0

59. The heat of fusion of ice is 333.5 J/g. The entropy change for the water when freezing 5.0 g of water at 0°C and 1 atm pressure is

(A) 6.1 J/K
(B) 1.2 J/K
(C) 0
(D) −1.2 J/K
(E) −6.1 J/K

$$\text{rate} = \frac{V[\text{S}]}{K_m + [\text{S}]}$$

60. Many enzyme reactions follow the Michaelis-Menten rate law shown above, where V and K_m are constants and [S] is the concentration of substrate that is undergoing a catalyzed reaction. When $[\text{S}] >> K_m$, what is the apparent order of the reaction?

(A) Zero order
(B) One-half order
(C) First order
(D) Second order
(E) Third order

61. If for $Ni(OH)_2$ the K_{sp} is 8.0×10^{-18}, then the expression used to calculate the molar solubility S of $Ni(OH)_2$ is

(A) $S = \sqrt[3]{2.0 \times 10^{-18}}$

(B) $S = \sqrt[3]{4.0 \times 10^{-18}}$

(C) $S = \sqrt[3]{8.0 \times 10^{-18}}$

(D) $S = \sqrt[3]{5.0 \times 10^{-19}}$

(E) $S = \sqrt[3]{1.5 \times 10^{-19}}$

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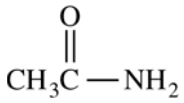
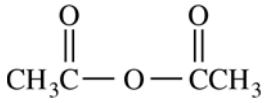
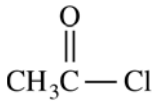
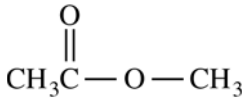
62. Of the following compounds, which reacts most rapidly with water?

(A) 

(B) 

(C) 

(D) 

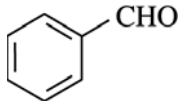
(E) $CH_3C{\equiv}N$

63. Which of the following compounds will react with $(CH_3)_2NH$ to form an enamine?

(A) CH_3CH_2CHO

(B) $CH_3CH_2CO_2H$

(C) $CH_3CH_2CH_2OH$

(D) 

(E) $H_2C{=}O$

64. All of the following reactions are examples of the Lewis definition of acid-base behavior EXCEPT

(A) $FeCl_3 + Cl^- \rightarrow [FeCl_4]^-$

(B) $I_2 + I^- \rightarrow I_3^-$

(C) $SO_3 + H_2O \rightarrow H^+ + HSO_4^-$

(D) $Zn(s) + I_3^- \rightarrow Zn^{2+} + 3I^-$

(E) $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

65. Of the following, which is the weakest oxidizing agent?

(A) $MnO_4^-(aq)$

(B) $H_2O_2(aq)$

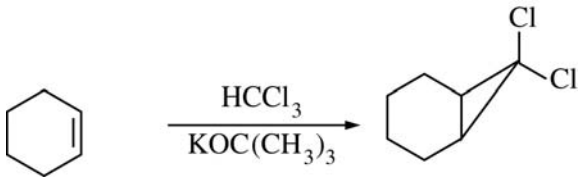
(C) $I_2(s)$

(D) $H^+(aq)$

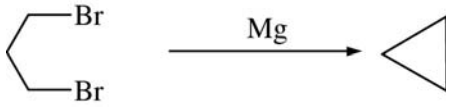
(E) $Mg(s)$

66. Which of the following reactions proceeds via a carbene (or carbenoid) intermediate?

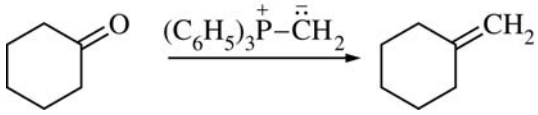
(A)



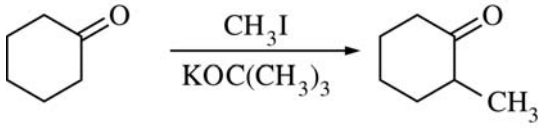
(B)



(C)



(D)



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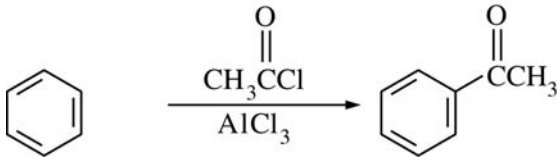

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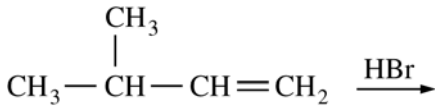
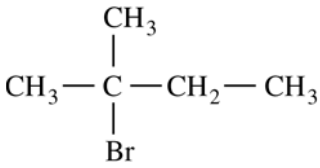
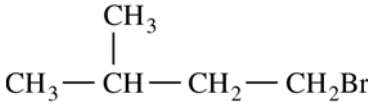


67. Which of the following is the major carbocation rearrangement product of the reaction shown above?

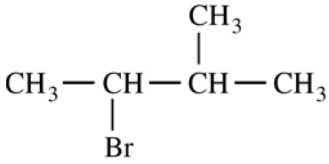
(A)



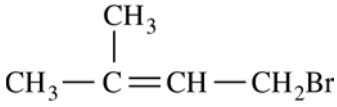
(B)



(C)



(D)



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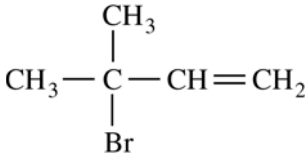

	Standard	Sample
[Benzene], μg/mL	50	-
[Ethylbenzene], μg/mL	10	10
Benzene peak area, mV·s	2,500	2,500
Ethylbenzene peak area, mV·s	1,000	500

68. The table above shows chromatographic data for the analysis of benzene using an ethylbenzene internal standard. What is the benzene concentration of the sample in μg/mL ?

(A) 10
(B) 25
(C) 80
(D) 100
(E) 250

69. A high-resolution infrared absorption spectrum of a heteronuclear diatomic molecule is shown above. Information about which of the following kinds of energy levels of the diatomic molecule can be obtained from this spectrum?

I. Electronic
II. Vibrational
III. Rotational

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

$$\Delta E = h c R_H \left(\frac{1}{n_1^{\,2}} - \frac{1}{n_2^{\,2}} \right)$$

70. The ionization energy of a ground state H atom is 13.6 eV. Given the equation shown above, how much energy is needed to excite an electron in an H atom from a state with quantum number $n = 1$ to a state with $n = 2$?

(A) (1/8) 13.6 eV
(B) (1/4) 13.6 eV
(C) (1/2) 13.6 eV
(D) (3/4) 13.6 eV
(E) 13.6 eV

71. All of the following are true about lasers EXCEPT:

(A) The light does not diverge significantly.
(B) The light is emitted only in pulses.
(C) The light waves are in phase.
(D) The light is essentially all the same wavelength.
(E) The light is essentially all the same frequency.

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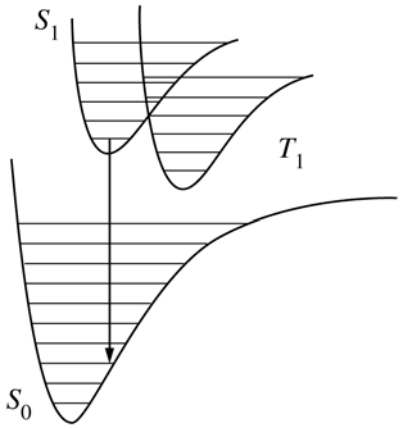


72. Consider the ground electronic state S_0, the excited singlet state S_1, and the triplet state T_1 of a molecule, shown above. The $S_1 \rightarrow S_0$ transition corresponds to

(A) a forbidden transition
(B) fluorescence
(C) phosphorescence
(D) photoionization
(E) vibrational relaxation

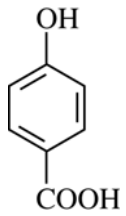
73. Graphite reacts with potassium to produce a compound with the empirical formula KC_8. Of the following, which is the best description of this compound's structure?

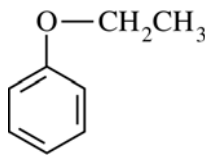
(A) K^+ ions close-packed with polyhedral C_8^- ions
(B) K^- ions close-packed with polyhedral C_8^+ ions
(C) K^+ ions packed with C_2^{2-} ions
(D) Negatively charged hexagonal carbon layers with intercalated K^+ ions between them
(E) An expanded diamond lattice with K^+ ions in the tetrahedral holes

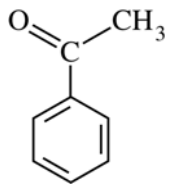
74. The experimental technique most suited for the determination of the three-dimensional structure of a crystalline solid is

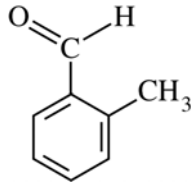
(A) UV-visible spectroscopy
(B) X-ray diffraction
(C) measurement of colligative properties
(D) polarimetry
(E) Fourier transform mass spectrometry

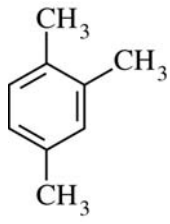
75. In a particular TLC separation, the stationary phase is a C2 plate (= $-CH_2CH_3$), and the mobile phase is 60% methanol:40% water (*v*:*v*). Of the following compounds, which will likely travel the greatest distance during the analysis?

(A) 

(B) 

(C) 

(D) 

(E) 

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76. Which of the following statements about sulfur dioxide is true?

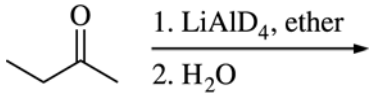
(A) It forms an S–S bonded dimer in condensed phases.
(B) It is the anhydride of sulfuric acid, H_2SO_4.
(C) It plays an important physiological role in the transmission of nerve impulses.
(D) Its O–S–O angle is 180°.
(E) It is a product of the combustion of fossil fuels that contain sulfur.

77. Which of the following statements about polonium, the heaviest Group 16 element, is NOT true?

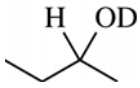
(A) Polonium is the least metallic of the Group 16 elements.
(B) Polonium has the lowest ionization energy of the Group 16 elements.
(C) Polonium atoms are the largest of the Group 16 elements.
(D) Polonium is expected to be a solid at room temperature and pressure.
(E) When ^{209}Po undergoes alpha decay, it forms ^{205}Pb.

78. In their metallic form, elements from which of the following groups are usually effective hydrogenation catalysts?

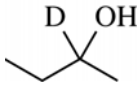
(A) Alkaline earth metals
(B) Platinum metals
(C) Halogens
(D) Actinides
(E) Group 12 metals

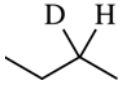


79. Which of the following is the product of the reaction shown above?

(A) 

(B) 

(C) 

(D) 

(E) 

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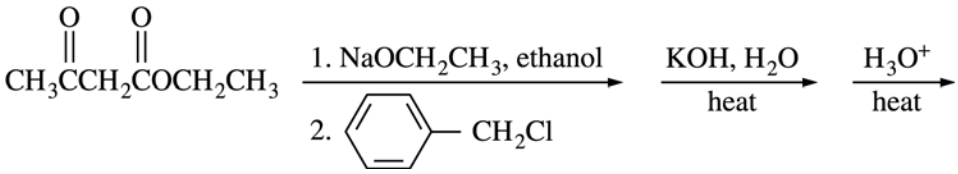
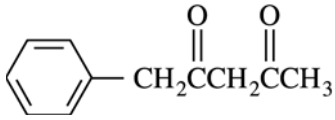
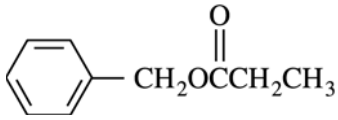
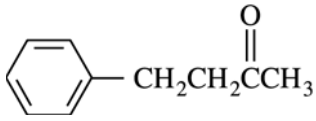
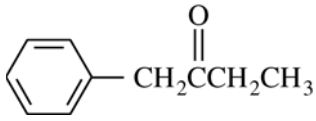


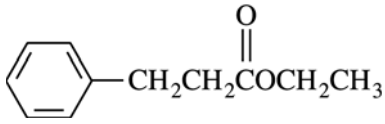
80. Which of the following is the product of the series of reactions shown above?

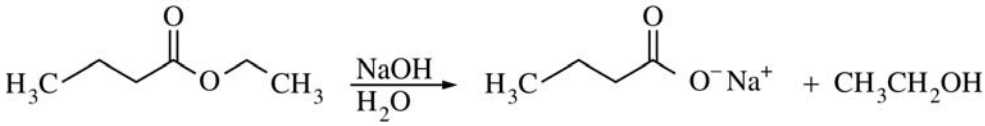
(A) 

(B) 

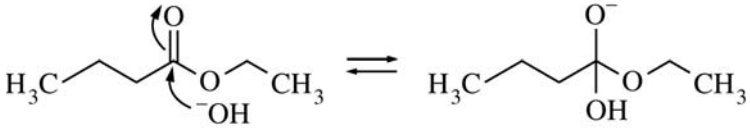
(C) 

(D) 

(E) 



81. Which of the following is a step in the mechanism of the hydrolysis of the ester shown above?

(A)


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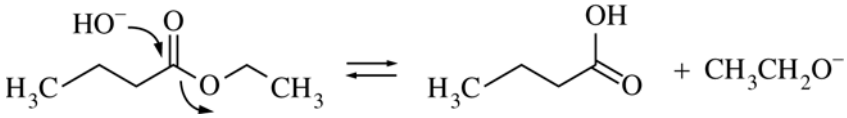
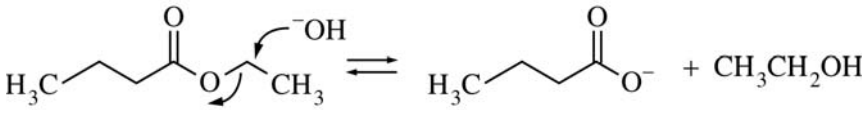
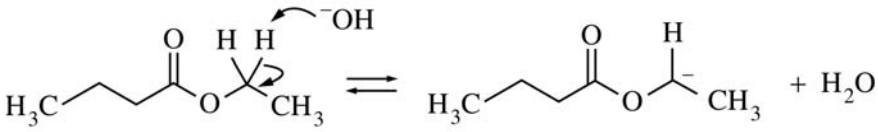
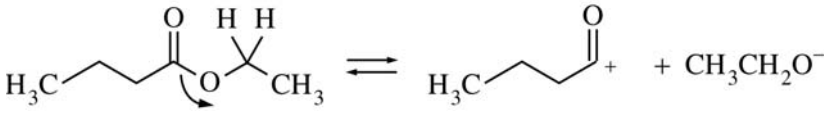


(C)


(D)


(E)


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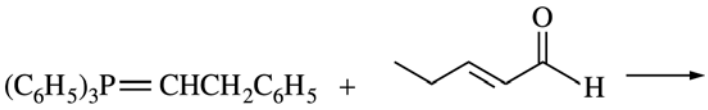
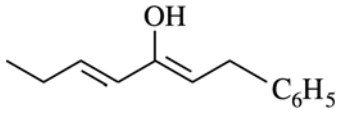
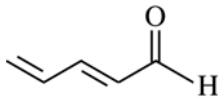
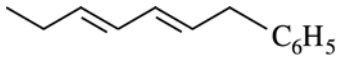
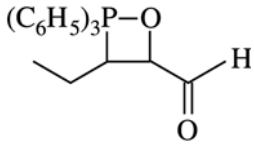


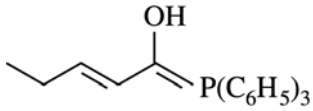
82. Which of the following is the major product of the reaction shown above?

(A) 

(B) 

(C) 

(D) 

(E) 

$$A \rightarrow \text{Products}$$

83. For the reaction shown above, the experimental rate law is rate $= k[A]^2$. Which of the following is the integrated rate law for this reaction?

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

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

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

(D) $[A]^2 - [A]_0^2 = kt$

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

$$NO + NO \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2$$

$$N_2O_2 + O_2 \xrightarrow{k_2} 2\,NO_2$$

84. Consider the mechanism shown above for oxidation of NO by O_2. Based on the steady state approximation, which of the following conditions is true for this mechanism?

(A) $\dfrac{d[NO_2]}{dt} = 2\dfrac{d[N_2O_2]}{dt}$

(B) $\dfrac{d[NO_2]}{dt} = 0$

(C) $\dfrac{d[N_2O_2]}{dt} = 0$

(D) $[N_2O_2] = 0$

(E) $k_2 = k_1 + k_{-1}$

$$A \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} B \qquad K_1 = \frac{[B]_{eq}}{[A]_{eq}} = 1$$

$$A \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} C \qquad K_2 = \frac{[C]_{eq}}{[A]_{eq}} = 2$$

$k_1 = 10\,k_2$

at $t = 0$: $[B] = [C] = 0$

85. Given the information above, the concentrations of B and C and the control (thermodynamic or kinetic) of the system at short and long times are described by which of the following?

	Short Time	Long Time
(A)	[B] > [C] kinetic	[C] > [B] thermodynamic
(B)	[C] > [B] kinetic	[B] > [C] thermodynamic
(C)	[B] > [C] thermodynamic	[C] > [B] kinetic
(D)	[C] > [B] thermodynamic	[B] > [C] kinetic
(E)	[B] > [C] kinetic	[B] > [C] kinetic

86. In $CrF_2(s)$, the coordination of the six F's around the Cr is a distorted octahedron with four short and two long Cr—F bonds. Which of the following best explains this observation?

(A) F has a -1 anionic charge.
(B) Cr^{2+} has a low cationic charge.
(C) The Jahn-Teller effect
(D) Spin-orbit coupling in Cr^{2+}
(E) The formation of Cr—Cr bonds in $CrF_2(s)$

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87. Each of the following molecules can act as a chelating ligand EXCEPT

(A) $H_2NCH_2CH_2NH_2$
(B) $CH_3NHCH_2CH_2NH_2$
(C) $HC(CH_2CH_2NH_2)_3$
(D) $CH_3NHCH_2CH_2CH_3$
(E) $N(CH_2CH_2NH_2)_3$

88. Which of the following is NOT a desirable property of an indicator to be used in a complexometric titration that involves EDTA?

(A) The indicator should be a Lewis base.
(B) The indicator should bind more tightly to the analyte metal than does EDTA.
(C) The complexation reaction between the indicator and the analyte metal should be reversible.
(D) The uncomplexed form of the indicator should be a different color than the indicator-metal complex.
(E) The indicator should be highly soluble in the sample.

89. Which of the following statements about complexes that form between metals, M^{n+}, and EDTA in aqueous solutions is true?

(A) Metal-EDTA complexes have an equilibrium concentration that is independent of pH.
(B) Metal-EDTA complexes are usually highly colored.
(C) Metal-EDTA complexes are often 2:1 in stoichiometry.
(D) Metal-EDTA complexes are less stable than the corresponding metal-ammine complexes.
(E) The presence of other complexing ligands in solution affects the equilibrium concentrations of metal-EDTA complexes.

90. Which of the following compounds exists in stereoisomeric forms?

(A) $[Pt(NH_3)_4]^{2+}$
(B) $[Pt(NH_3)_3Cl]^{+}$
(C) $[Pt(NH_3)_2Cl_2]$
(D) $[Pt(NH_3)Cl_3]^{-}$
(E) $[PtCl_4]^{2-}$

91. All of the following are recognized as pathways that can reduce the CO_2 level in the atmosphere EXCEPT

(A) dissolution in the oceans
(B) photosynthesis
(C) respiration
(D) reduced burning of fossil fuels
(E) rainfall with dissolved CO_2

92. Which of the following is a wavefunction, $\psi(r,\theta,\phi)$, for an s electron?

(A) $N\left(2-\frac{Zr}{a}\right)e^{\frac{-Zr}{2a}}$
(B) $N\,re^{\frac{-Zr}{2a}}\cos\theta$
(C) $N\,re^{\frac{-Zr}{2a}}\sin\theta\cos\phi$
(D) $N\,re^{\frac{-Zr}{2a}}\sin\theta\sin\phi$
(E) $N\,r^2e^{\frac{-Zr}{3a}}\left(3\cos^2\theta-1\right)$

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93. Due to electron-electron interactions, it is not possible to obtain exact solutions to the Schrödinger equation for many-electron atoms. One approach that addresses this difficulty uses

(A) the rigid-rotor approximation
(B) the harmonic oscillator approximation
(C) the principle of corresponding states
(D) effective nuclear charges
(E) the Franck-Condon principle

94. Of the following linear combinations of atomic orbitals centered on two atoms, A and B, which best represents the ground-state molecular orbital for the hydrogen molecule, H_2 ?

(A) $\psi = N(1s_A + 1s_B)$
(B) $\psi = N(1s_A - 1s_B)$
(C) $\psi = N(1s_A + 2p_B)$
(D) $\psi = N(1s_A - 2p_B)$
(E) $\psi = N(2p_A + 2p_B)$

95. Acetic acid is extracted from ether into water. Which of the following actions will NOT increase the fraction of acetic acid removed from ether?

(A) Raising the pH of the water
(B) Increasing the volume of water
(C) Decreasing the volume of ether
(D) Adding benzoic acid to the water
(E) Adding ammonia to the water

96. The ionic strength of an aqueous 0.10 M $Pb(NO_3)_2$ solution is

(A) 0.10 M
(B) 0.25 M
(C) 0.30 M
(D) 0.50 M
(E) 0.60 M

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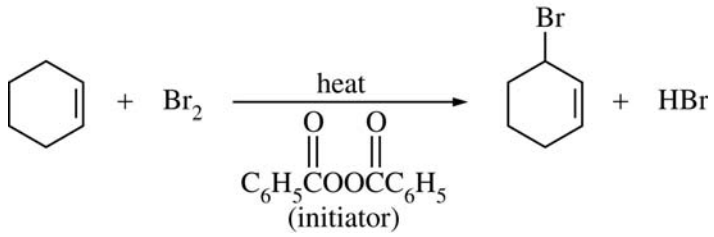
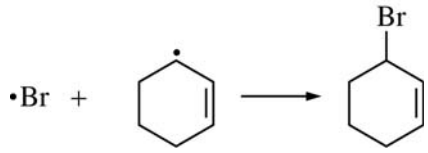
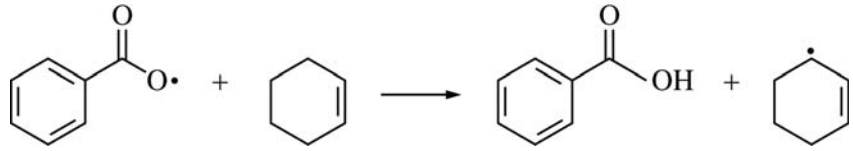
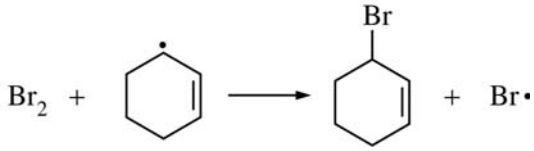


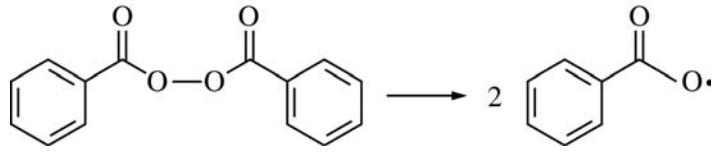
97. Which two of the following are the propagation steps in the allylic bromination of cyclohexene shown above?

I.


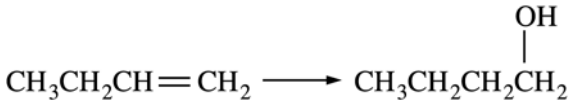
II.


III.


IV.


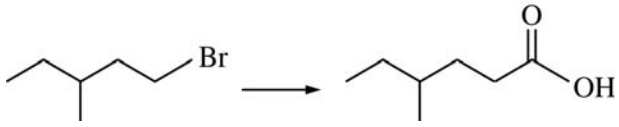
V.


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



98. The transformation shown above is carried out by which of the following reagents?

(A) KOH
(B) BH_3/THF then H_2O_2, NaOH
(C) $Hg(O_2CCH_3)_2/H_2O$ then $NaBH_4$
(D) H_2O, H_2SO_4
(E) H_2O, peroxides



99. Which of the following could carry out the conversion shown above?

(A) 1. Mg, ether
2. CO_2
3. H_3O^+

(B) 1. O_3
2. Zn, H_2O

(C) 1. $KMnO_4$, OH^-
2. H_3O^+

(D) 1. NaOH
2. CrO_3, H_2SO_4

(E) 1. Li
2. $H_2C{=}O$
3. H_3O^+

100. Vitamin B_{12}, an essential nutrient for humans, contains which of the following elements?

(A) Cobalt
(B) Chromium
(C) Copper
(D) Zinc
(E) Iron

101. Which of the following is a strong acid in pure liquid HF?

(A) H_2O
(B) SbF_5
(C) CH_3COOH
(D) NH_3
(E) NaF

102. What is the most common natural form in which fluorine is found on Earth?

(A) As a fluoride ion in various minerals
(B) As $XeF_2(s)$
(C) As the weak acid $HF(aq)$
(D) As the free element $F_2(g)$
(E) In various fluorocarbon compounds in the atmosphere

$$E_n = n^2h^2/8mL^2$$

103. For a particle of mass m in a one-dimensional box of length L, the energy of the particle is given by the equation shown above. How much energy is required to promote the particle from the state with quantum number $n = 2$ to the state with quantum number $n = 3$?

(A) $9h^2/8mL^2$
(B) $5h^2/8mL^2$
(C) $4h^2/8mL^2$
(D) $h^2/8mL^2$
(E) 0

104. A large activation energy implies which of the following about a reaction?

(A) It is spontaneous.
(B) It is highly endothermic.
(C) It is at equilibrium.
(D) It is very rapid.
(E) It has a highly temperature-dependent rate constant.

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105. Analysis of a bottle of 100 mg vitamin C tablets yields an average vitamin C content of 99.8 mg, with a standard deviation of ±0.3 mg. Assuming Gaussian statistics, which of the following is true?

(A) None of the tablets contains less than 99.5 mg of vitamin C.
(B) 68% of the tablets contain between 99.5 and 100.1 mg of vitamin C.
(C) 97% of the tablets contain between 99.5 and 100.1 mg of vitamin C.
(D) All of the tablets contain less than 100 mg of vitamin C.
(E) The average value is incorrect.

106. In an experiment to test the de Broglie hypothesis, a beam of high-energy electrons with momenta

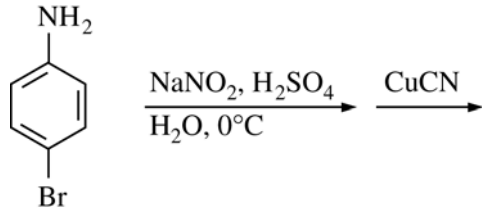
$$p = m_e v = 6 \times 10^{-24} \text{ kg·m/s}$$

would be scattered by a nickel crystal with a pattern similar to that of which of the following?

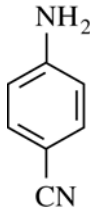
(A) X-rays of wavelength $\lambda = h/p$
(B) Electromagnetic radiation with wavelength $\lambda = p/h$
(C) A beam of protons with velocity v
(D) Billiard balls undergoing perfectly elastic collisions
(E) Visible light with a mixture of frequencies frequently characterized as "white"

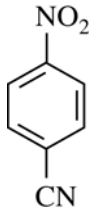
107. Which of the following is true about the quantum yield for photodecomposition of a chromophore?

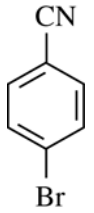
(A) It depends on the intensity of the light source used for the photolysis.
(B) It depends on the duration of the light source used for the photolysis.
(C) It is the reciprocal of the fluorescence lifetime.
(D) It has a value of either 0 or 1, reflecting the quantum nature of photons.
(E) It is the ratio of the number of chromophores decomposed to the number of photons absorbed.

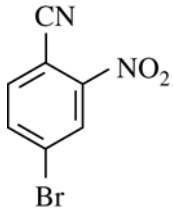


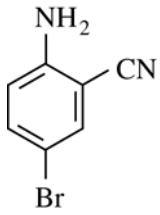
108. Which of the following is the major organic product of the reaction sequence shown above?

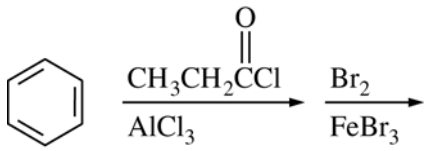
(A) 

(B) 

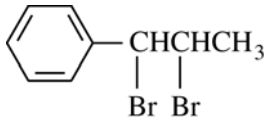
(C) 

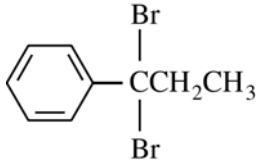
(D) 

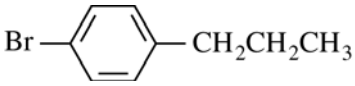
(E) 



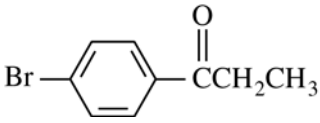
109. Which of the following is the major organic product of the sequence of reactions shown above?

(A) 

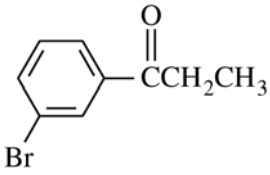
(B) 

(C) 

and ortho isomer

(D) 

and ortho isomer

(E) 

110. A characteristic common to polymers that can be made to conduct electricity, such as polyacetylene and polypyrrole, is

(A) the presence of stereogenic centers of the same configuration
(B) a monodisperse distribution in molecular weight
(C) a very low glass transition temperature
(D) conjugation throughout the polymer chain
(E) a high degree of cross-linking

111. Which of the following complexes does NOT contain a significant π component in the metal-ligand bonding?

(A) $[Co(NH_3)_6]^{3+}$
(B) $[Fe(CO)_5]$
(C) $[CrO_4]^{2-}$
(D) $[Co(CN)_6]^{3-}$
(E) $[Cr(\eta\text{-}C_6H_6)_2]$

112. In an experiment to determine riboflavin by fluorescence spectrometry, a series of riboflavin standards was analyzed and gave a calibration line with a slope of $1000\ ppm^{-1}$ and a *y*-intercept of 25. If a sample gave a fluorescence reading of 750, the riboflavin concentration (in ppm) of the sample is

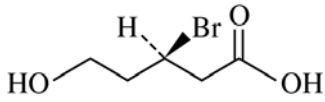
(A) 0.0750
(B) 0.0775
(C) 0.725
(D) 0.775
(E) 7.50

113. The rate constant for a first-order reaction $R \rightarrow P$ is $0.010\ s^{-1}$. The concentration of R decreases to one-half of its initial value after

(A) $\frac{2}{0.010}$ s
(B) $\frac{\ln 2}{0.010}$ s
(C) $\frac{1}{2(0.010)}$ s
(D) $\frac{1}{4(0.010)}$ s
(E) $5(0.010)$ s

114. The activated-complex theory (or transition state theory) assumes that an equilibrium exists between the

(A) activated complex and reactants only
(B) activated complex and products only
(C) products and reactants only
(D) reactants, activated complex, and products
(E) system (reaction) and surroundings



115. Oxidation of (*R*)-3-bromo-5-hydroxypentanoic acid, shown above, yields the corresponding 3-bromopentanedicarboxylic acid product that is

(A) a mixture of two diastereomers in unequal amounts
(B) a racemic mixture
(C) a single pure enantiomer
(D) a meso compound
(E) an achiral compound

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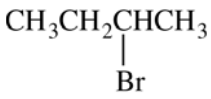
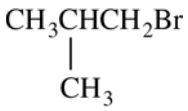
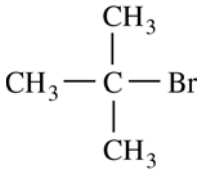
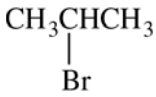
116. Of the following molecules, which most readily undergoes a unimolecular elimination (E1) reaction?

(A) 

(B) 

(C) 

(D) 

(E) $CH_3CH_2CH_2CH_2Br$

117. Compounds have been prepared from which of the following noble gas elements?

(A) He only
(B) He and Ne only
(C) Ne and Ar only
(D) He, Ne, and Ar
(E) Kr, Xe, and Rn

118. AgCl is insoluble in water at room temperature. The dissolution of $AgCl(s)$ into aqueous ammonia can best be explained as the

(A) coprecipitation of $NH_4Cl(s)$
(B) formation of $AgNO_3$
(C) oxidation of Ag^+ in aqueous base
(D) reduction of Ag^+ by NH_3
(E) formation of the complex cation $Ag(NH_3)_2^+$

$$\frac{d[HBr]}{dt} = k[H_2][Br_2]^{\frac{1}{2}}$$

119. The rate law shown above is for the reaction $H_2 + Br_2 \rightarrow 2\ HBr$ at the early stages of the reaction, when [HBr] is low and holds over a wide range of concentrations of H_2 and Br_2. An explanation that is consistent with the half-integer order in Br_2 is given by which of the following?

(A) The mechanism is an elementary reaction involving one Br_2 and two H_2 molecules.
(B) The overall reaction is not accomplished by a single elementary step.
(C) The rate-limiting step involves one Br_2 and two H_2 molecules.
(D) The rate-limiting step involves one H_2 and two Br_2 molecules.
(E) Quantum mechanical tunneling affects the rate.

GO ON TO THE NEXT PAGE.

120. In a mixture of He and Ar atoms in thermal equilibrium, what is the average speed of the He atoms, v_{He}, compared with the average speed of the Ar atoms, v_{Ar} ? (m_{He} is the mass of He atoms, and m_{Ar} is the mass of Ar atoms.)

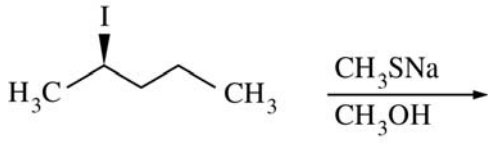
(A) $v_{He} = v_{Ar}$

(B) $\frac{v_{He}}{v_{Ar}} = \frac{m_{He}}{m_{Ar}}$

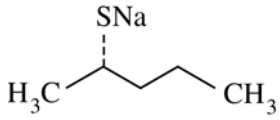
(C) $\frac{v_{He}}{v_{Ar}} = \frac{m_{Ar}}{m_{He}}$

(D) $\frac{v_{He}}{v_{Ar}} = \sqrt{\frac{m_{He}}{m_{Ar}}}$

(E) $\frac{v_{He}}{v_{Ar}} = \sqrt{\frac{m_{Ar}}{m_{He}}}$



121. Which of the following is the major nucleophilic substitution product of the reaction shown above?

(A)


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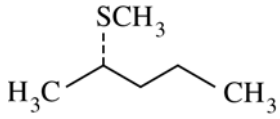

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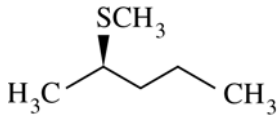
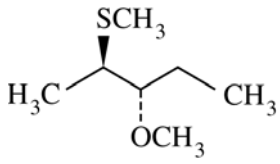


(D)


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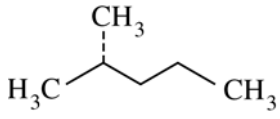
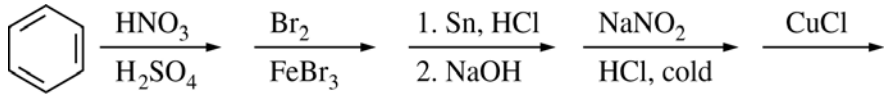
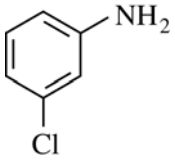
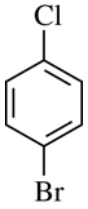
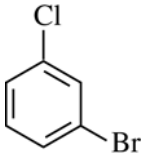


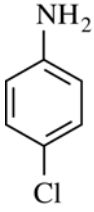


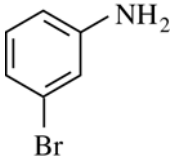
122. What is the major organic product from the sequence of reactions shown above?

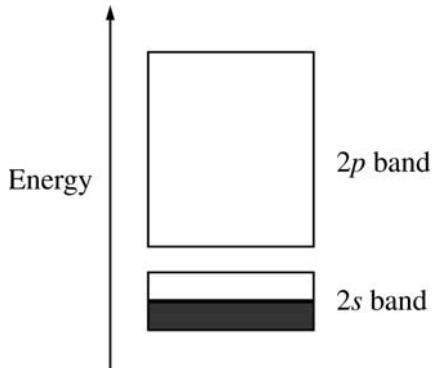
(A) 

(B) 

(C) 

(D) 

(E) 



123. A simple electronic band structure for lithium metal is shown above. Based on this band structure, which of the following is correct?

(A) Electrons occupy one of two distinct energy states in the $2s$ band.
(B) If the number of lithium atoms in a piece of lithium metal is represented by N, then the number of $2s$ orbitals that make up the $2s$ band is $2N$.
(C) The electrons in the $2s$ band are each localized on a particular lithium atom.
(D) Electrons must be promoted to the $2p$ band in order to conduct.
(E) The partial filling of the $2s$ band is responsible for the metallic character of lithium.

$$H_3C—O—C(CH_3)_3$$

124. Methyl *t*-butyl ether (MTBE), shown above, is a controversial gasoline additive. Of the following analytical techniques, which would be the best method to measure quantitatively trace amounts of MTBE in contaminated groundwater?

(A) Capillary electrophoresis
(B) Gas chromatography
(C) Atomic absorption spectroscopy
(D) Fluorescence spectroscopy
(E) EPR spectroscopy

125. For the species H_2, HD, HT, and D_2, all of the bond strengths (and force constants) are the same. Which of the following will have the lowest fundamental vibration frequency? (D = deuterium; T = tritium)

(A) H_2
(B) HD
(C) HT
(D) D_2
(E) All will have the same fundamental vibration frequency.

126. Which of the following is NOT true about Raman scattering?

(A) Raman scattering requires a change in dipole moment.
(B) Raman frequency shifts are independent of the frequency of excitation.
(C) Raman scattering results in equal shifts in frequency above and below the incident frequency.
(D) Some Raman-active transitions are not infrared active.
(E) Raman scattering requires a change in polarizability.

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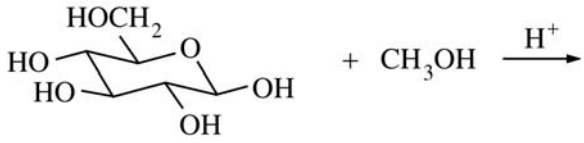
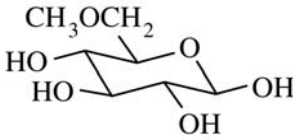
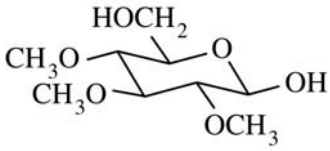
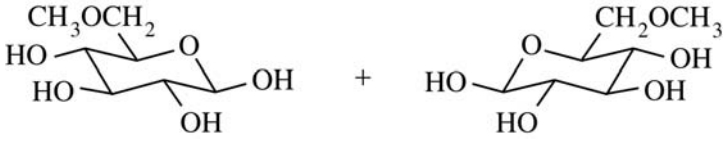
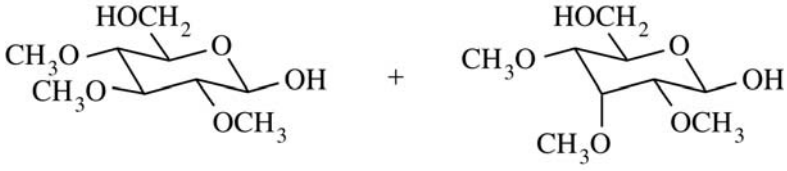


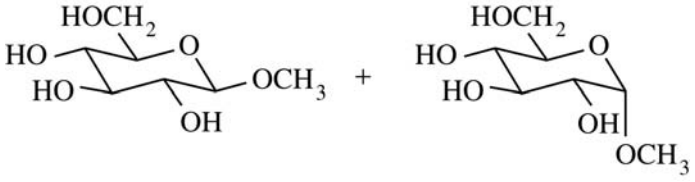
127. Which of the following is formed when a solution of β-D-glucopyranose is allowed to stand in methanol that contains a small amount of an acid catalyst, as indicated in the equation shown above?

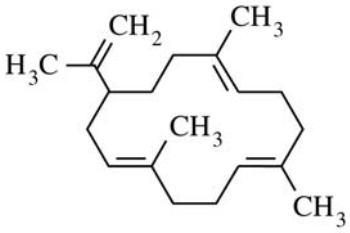
(A) 

(B) 

(C) 

(D) 

(E) 



128. The species shown above is

(A) a nucleotide
(B) a peptide
(C) a diterpene
(D) a disaccharide
(E) an alkaloid

129. Which of the following is NOT a known, relatively stable compound of uranium?

(A) UF_6
(B) UO_2
(C) UO_3
(D) $U(CH_3)_2$
(E) $U(C_8H_8)_2$

pK_{a1}	2.15
pK_{a2}	7.20
pK_{a3}	12.15

130. The pK_{a1}, pK_{a2}, and pK_{a3} values for H_3PO_4 are given above. When 50.0 mL of 0.10 M Na_2HPO_4 are mixed with 50.0 mL of 0.10 M Na_3PO_4, the pH of the resulting solution will be closest to

(A) 2.15
(B) 4.68
(C) 7.20
(D) 9.68
(E) 12.15

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

NO TEST MATERIAL ON THIS PAGE

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I

NOTE: To ensure prompt processing of test results, it is important that you fill in the blanks exactly 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	0	1	4
0	0	●	0	0
1	1	1	●	1
●	2	2	2	2
3	3	3	3	3
4	4	4	4	●
5	5	5	5	5
6	6	6	6	6
7	●	7	7	7
8	8	8	8	8
9	9	9	9	9

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

TEST NAME Chemistry

FORM CODE GR0627

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.

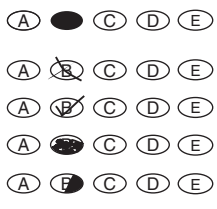
YOU MUST INDICATE ALL YOUR ANSWERS ON THE SEPARATE ANSWER SHEET. No credit will be given for anything written in this examination book, but you may write in the book as much as you wish to work out your answers. After you have decided on your response to a question, fill in the corresponding oval on the answer sheet. BE SURE THAT EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL. Mark only one 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.

Example:

What city is the capital of France?

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

Sample Answer



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Scoring Your Subject Test

The Chemistry Test scores are reported on a 200 to 990 score scale in ten-point increments. The actual range of scores is smaller, and it varies from edition to edition because different editions are not of precisely the same difficulty. However, this variation in score range is usually small and should be taken into account mainly when comparing two very high scores. In general, differences between scores at the 99th percentile should be ignored. **The score conversion table on page 55 shows the score range for this edition of the test only.**

The worksheet on page 54 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. 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 GR0627
Answer Key and Percentages* of Examinees Answering Each Question Correctly

QUESTION		P+	RESPONSE	
Number	Answer		C	I
1	A	83		
2	C	83		
3	C	64		
4	D	63		
5	C	90		
6	B	91		
7	B	47		
8	D	72		
9	C	48		
10	B	92		
11	C	85		
12	C	59		
13	D	87		
14	A	70		
15	E	50		
16	C	42		
17	A	71		
18	D	86		
19	E	78		
20	E	50		
21	E	82		
22	B	60		
23	E	45		
24	C	68		
25	B	48		
26	E	71		
27	C	60		
28	D	23		
29	A	67		
30	B	85		
31	C	60		
32	D	86		
33	A	62		
34	A	50		
35	A	73		
36	E	66		
37	E	61		
38	E	53		
39	D	55		
40	D	60		
41	A	82		
42	A	52		
43	B	83		
44	D	40		
45	C	62		

QUESTION		P+	RESPONSE	
Number	Answer		C	I
46	C	89		
47	D	69		
48	B	57		
49	E	50		
50	A	15		
51	A	44		
52	E	69		
53	A	72		
54	D	27		
55	B	69		
56	B	51		
57	C	64		
58	E	39		
59	E	50		
60	A	76		
61	A	34		
62	C	58		
63	A	32		
64	D	48		
65	E	53		
66	A	45		
67	A	74		
68	D	51		
69	D	59		
70	D	79		
71	B	65		
72	B	76		
73	D	37		
74	B	97		
75	A	75		
76	E	62		
77	A	77		
78	B	80		
79	C	62		
80	C	38		
81	A	78		
82	C	56		
83	E	62		
84	C	60		
85	A	63		
86	C	72		
87	D	68		
88	B	53		
89	E	54		
90	C	71		

QUESTION		P+	RESPONSE	
Number	Answer		C	I
91	C	89		
92	A	32		
93	D	23		
94	A	75		
95	D	62		
96	C	68		
97	E	67		
98	B	66		
99	A	73		
100	A	30		
101	B	27		
102	A	72		
103	B	87		
104	E	65		
105	B	58		
106	A	47		
107	E	51		
108	C	27		
109	E	48		
110	D	77		
111	A	51		
112	C	76		
113	B	69		
114	A	29		
115	E	36		
116	C	78		
117	E	78		
118	E	55		
119	B	51		
120	E	63		
121	B	79		
122	C	31		
123	E	36		
124	B	66		
125	D	47		
126	A	40		
127	E	43		
128	C	66		
129	D	27		
130	E	42		

Total Correct (**C**) _____

Total 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 2006 examinees selected to represent all CHEMISTRY Test examinees tested between July 1, 2005, and June 30, 2008.

Score Conversions and Percents Below* for GRE Chemistry Test, Form GR0627

TOTAL SCORE					
Raw Score	Scaled Score	%	Raw Score	Scaled Score	%
130	970	99	68-69	690	49
128-129	960	99	65-67	680	46
126-127	950	99	63-64	670	43
125	940	99	61-62	660	40
123-124	930	99	58-60	650	36
121-122	920	98	56-57	640	33
119-120	910	97	54-55	630	31
117-118	900	96	51-53	620	28
114-116	890	95	49-50	610	25
112-113	880	94	47-48	600	23
110-111	870	92	44-46	590	20
108-109	860	90	42-43	580	17
105-107	850	88	40-41	570	15
103-104	840	86	37-39	560	13
101-102	830	85	35-36	550	11
98-100	820	82	32-34	540	9
96-97	810	80	30-31	530	7
94-95	800	78	28-29	520	6
91-93	790	75	25-27	510	4
89-90	780	73	23-24	500	3
87-88	770	71	21-22	490	2
84-86	760	68	18-20	480	2
82-83	750	65	16-17	470	1
80-81	740	63	14-15	460	1
77-79	730	60	11-13	450	1
75-76	720	57	9-10	440	1
73-74	710	55	6-8	430	1
70-72	700	52	4-5	420	1
			2-3	410	1
			0-1	400	1

*Percent scoring below the scaled score is based on the performance of 8,549 examinees who took the CHEMISTRY Test between July 1, 2005, and June 30, 2008. This percent-below information was used for score reports during the 2009-10 testing year.

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 54 and the table on page 55 use performance data from GRE Chemistry Test examinees.

The data in the worksheet on page 54 are based on the performance of a sample of the examinees who took this test in November 2006. This sample was selected to represent the total population of GRE Chemistry Test examinees tested between July 2005 and June 2008. 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 55 contains, for each scaled score, the percentage of examinees tested between July 2005 and June 2008 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 2009-10 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 49. This means that 49 percent of the GRE Chemistry Test examinees tested between July 2005 and June 2008 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.

GRADUATE RECORD EXAMINATIONS® - ETS® GRE® - SUBJECT TEST SIDE 1

1. NAME **Enter your last name, first name initial (given name), and middle initial if you have one. Omit spaces, apostrophes, Jr., II., etc.**

Last Name only (Family Name or Surname) - First 15 Letters | First Name Initial | Middle Initial

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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: ______

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.

3. DATE OF BIRTH

Month: Jan. Feb. Mar. April May June July Aug. Sept. Oct. Nov. Dec.
Day: 0 1 2 3 | 0–9
Year: 0–9 | 0–9

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

0 1 2 3 4 5 6 7 8 9

5. REGISTRATION NUMBER (from your admission ticket)

0 1 2 3 4 5 6 7 8 9

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

0 1 2 3 4 5 6 7 8 9

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

FORM CODE (on back cover of your test book)

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

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1 2 3 4

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SIDE 2

SUBJECT TEST

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.

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 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

TR	TW	TFS	TCS	1R	1W	1FS	1CS	2R	2W	2FS	2CS
FOR ETS USE ONLY				3R	3W	3FS	3CS	4R	4W	4FS	4CS
				5R	5W	5FS	5CS	6R	6W	6FS	6CS

IF YOU DO NOT WANT THIS ANSWER SHEET TO BE SCORED

If you want to cancel your scores from this test administration, complete A and B below. You will not receive scores for this test. 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.

To cancel your scores from this test administration, you must:

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

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