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Before You Choose This UExcel Exam

Uses for the Examination

• Excelsior College, the test developer, recommends granting three (3) semester hours of lower-level undergraduate credit to students who receive a letter grade of C or higher on this examination. The examination may be used to help fulfill a science requirement or as a free elective for all Excelsior College Degree programs that allow for free electives.

• Other colleges and universities also recognize this exam as a basis for granting credit or advanced standing.

• Individual institutions set their own policies for the amount of credit awarded and the minimum acceptable score.

Exam-takers who have applied to Excelsior College should ask their academic advisor where this exam fits within their degree program.

Exam-takers not enrolled in an Excelsior College degree program should check with the institution from which they wish to receive credit to determine whether credit will be granted and/or to find out the minimum grade required for credit. Those who intend to enroll at Excelsior College should ask an admissions counselor where this exam fits within their intended degree program.

Examination Length and Scoring

The examination consists of approximately 70 questions, most of which are multiple choice; for samples of all the item types on this exam, see the sample items in the back of this guide. Some items are unscored, pretest items. The pretest items are embedded throughout the exam and are indistinguishable from the scored items. You will have two (2) hours to complete the examination. Your score will be reported as a letter grade.

UExcel Exam Resources

Excelsior College Bookstore

The Excelsior College Bookstore offers recommended textbooks and other resources to help you prepare for UExcel exams.

The bookstore is available online at (login required): www.excelsior.edu/bookstore

UExcel Practice Exams

The official UExcel practice exams are highly recommended as part of your study plan. Once you register for your UExcel exam, you are eligible to purchase the corresponding practice exam, which can be taken using any computer with a supported Web browser. Each practice exam includes two forms that you may take within a 180-day period.
Excelsior College Library

Enrolled Excelsior College students can access millions of authoritative resources online through the Excelsior College Library. Created through our partnership with the Sheridan Libraries of The Johns Hopkins University, the library provides access to journal articles, books, websites, databases, reference services, and many other resources. Special library pages relate to the nursing degree exams and other selected exams. To access it, visit www.excelsior.edu/library (login is required).

Our library provides:

- 24/7 availability
- The world’s most current authoritative resources
- Help and support from staff librarians

Online Tutoring

Excelsior College offers online tutoring through SMARTTHINKING™ to connect with tutors who have been trained in a variety of academic subjects. To access SMARTTHINKING, go to www.excelsior.edu/smarthinking. Once there, you may download a copy of the SMARTTHINKING Student Handbook as a PDF.

Preparing for UExcel Exams

Take Charge of Your Own Learning

At Excelsior College, independent, self-directed study supported by resources we help you find is not a new concept. We have always stressed to exam takers that they are acting as their own teacher, and that they should spend as much time studying for an exam as they would spend in a classroom and on homework for a corresponding college course in the same subject area.

Begin by studying the content outline contained in this content guide, at its most detailed level. You will see exactly which topics are covered, and where chapters on those topics can be found in the Recommended Resources. You will see exactly where you might need to augment your knowledge or change your approach.

The content outline, along with the Learning Outcomes for this exam and recommended textbooks, will serve as your primary resources.

How Long Will It Take Me to Study?

A UExcel exam enables you to show that you’ve learned material comparable to one or more 15-week college-level courses. As an independent learner, you should study and review as much as you would for a college course. For a 3-credit course in a subject they don’t know, most students would be expected to study nine hours per week for 15 weeks, for a total of 135 hours.

Study Tips

Become an active user of the resource materials. Aim for understanding rather than memorization. The more active you are when you study, the more likely you will be to retain, understand, and apply the information.

The following techniques are generally considered to be active learning:

- preview or survey each chapter
- highlight or underline text you believe is important
- write questions or comments in the margins
- practice re-stating content in your own words
- relate what you are reading to the chapter title, section headings, and other organizing elements of the textbook
- find ways to engage your eyes, your ears, and your muscles, as well as your brain, in your studies
- study with a partner or a small group (if you are an enrolled student, search for partners on MyExcelsior Community)
- prepare your review notes as flashcards or create recordings that you can use while commuting or exercising

When you feel confident that you understand a content area, review what you have learned. Take a second look at the material to evaluate your understanding. If you have a study partner, the two of you can review by explaining the content to each other or writing test questions for each other to answer. Review questions from textbook chapters may be helpful for partner or individual study, as well.

Using UExcel Practice Exams

We recommend taking the first form of the practice exam when you begin studying, to see how much you already know. After taking the first practice exam,
check your performance on each question and find out why your answer was right or wrong. This feedback will help you improve your knowledge of the subject and identify areas of weakness that you should address before taking the exam. Take the second form of the practice exam after you have finished studying. Analyze your results to identify the areas that you still need to review.

Although there is no guarantee, our research suggests that students who do well on the practice exams are more likely to pass the actual exam than those who do not do well (or do not take advantage of this opportunity).

About Test Preparation Services
Preparation for UExcel® exams and Excelsior College® Examinations, though based on independent study, is supported by Excelsior College with a comprehensive set of exam learning resources and services designed to help you succeed. These learning resources are prepared by Excelsior College so you can be assured that they are current and cover the content you are expected to master for the exams. These resources, and your desire to learn, are usually all that you will need to succeed.

There are test-preparation companies that will offer to help you study for our examinations. Some may imply a relationship with Excelsior College and/or make claims that their products and services are all that you need to prepare for our examinations.

Excelsior College is not affiliated with any test preparation firm and does not endorse the products or services of these companies. No test preparation vendor is authorized to provide admissions counseling or academic advising services, or to collect any payments, on behalf of Excelsior College. Excelsior College does not send authorized representatives to a student’s home nor does it review the materials provided by test preparation companies for content or compatibility with Excelsior College examinations.

To help you become a well-informed consumer, we suggest that before you make any purchase decision regarding study materials provided by organizations other than Excelsior College, you consider the points outlined on our website at www.excelsior.edu/testprep.

Preparing for This Exam

Prior Knowledge
A familiarity with college algebra or higher is assumed.

Using the Content Outline
Each content area in the outline includes (1) the recommended minimum hours of study to devote to that content area and (2) the most important sections of the recommended resources for that area. These annotations are not intended to be comprehensive. You may need to refer to other chapters in the recommended textbooks. Chapter numbers and titles may differ in other editions.

This content outline contains examples of the types of information you should study. Although these examples are numerous, do not assume that everything on the exam will come from these examples. Conversely, do not expect that every detail you study will appear on the exam. Any exam is only a broad sample of all the questions that could be asked about the subject matter.

Using the Sample Questions and Rationales
Each content guide provides sample questions to illustrate those typically found on the exam. These questions are intended to give you an idea of the level of knowledge expected and the way questions are typically phrased. The sample questions do not sample the entire content of the exam and are not intended to serve as an entire practice test.
Recommended Resources for the UExcel Exam in General Chemistry I

The resources and materials listed below were used by the examination development committee to verify all the questions on the exam. Excelsior College recommends you use these resources as the most appropriate information when ordering textbooks from the college’s bookstore (see page 1 of this content guide). You should allow ample time to obtain resources and to study sufficiently before taking the exam, so plan appropriately and systematically.

A word about textbook editions: Textbook editions listed in the UExcel content guides may not be the same as those listed in the bookstore. Textbook editions may not exactly match up in terms of table of contents and organization, depending upon the edition. However, our team of exam developers checks exam content against every new textbook edition to verify that all subject areas tested in the exam are still adequately available in the study materials. If needed, exam developers will list supplemental resources to ensure that all topics in the exam are still sufficiently covered. Public libraries may have the textbooks you need, or may be able to obtain them for you through interlibrary loan to reduce textbook costs. You may also consider financial aid, if you qualify, to further help defray the steep cost of textbooks. A section on OER has been included in this guide to help you locate additional resources to augment your study.

Textbooks

This textbook may be purchased from the Excelsior College Bookstore. A login is required.
www.excelsior.edu/bookstore


Reducing Textbook Costs

Many students know it is less expensive to buy a used textbook, and buying a previous edition is also an option. The Excelsior College bookstore includes a buyback feature and a used book marketplace, as well as the ability to rent digital versions of textbooks for as long as students need them. Students are encouraged to explore these and the many other opportunities available online to help defray textbook costs.

A Word About Open Educational Resources

Open educational resources (OER) are educational materials available for study at no cost on the Web. Some OER are available for anyone to access any time. Others, such as Massive Open Online Courses (MOOCs), require sign-up and are only available during certain windows. Please note that some MOOC providers offer certificates of completion or other products or services for a fee. No MOOC or other OER is a complete substitute for the content guide and officially Recommended Resources listed here in this content guide. However, by definition, MOOCs are essentially free of charge and include access to a main body of learning materials that may help you in your learning.

Being an independent learner preparing for credit by exam, you may not need any of the fee-based options that are offered elsewhere online. But if you are looking for a coherent academic course for self-study, lectures on specific topics, or audio or visual materials that fit your learning style better than print materials alone, a MOOC or other type of OER may be your answer. Keep in mind that none of these OER were designed by Excelsior, nor are they guaranteed to match the exam content outlines completely. They are simply another tool available in your study kit.

We highly encourage using the Recommended Resources. In the content outline, you will see that the topics in the exam are referenced to specific portions of recommended textbooks. Using OER alone will not ensure you’ve completely covered the content in the exam, or it may not cover some topics in sufficient-enough depth without the use of the formal, recommended textbooks.

If the OER course you choose does not include a textbook for reference and you do not have significant practical theory-based experience in the field of study, use a college textbook to ensure adequate preparation for the exam, and use the exam’s content outline as a guide.

Combined with comparable college textbooks, OER provides you with a variety of choices in knowledge sources and learning experiences, to enhance your understanding of the subject matter.
Choosing Open Educational Resources

Most sites for university-based OER can be searched through www.ocwconsortium.org and/or www.oercommons.org.

Sites that specialize in Web courses designed by college professors under contract with the website sponsor, rather than in Web versions of existing college courses, include:

www.education-portal.com

www.opencourselibrary.org (abbreviated as OCL)

We have included specific courses that cover material for one or more UExcel® exams from the sites in the listings above. It’s worth checking these sites frequently to see if new courses have been added that may be more appropriate or may cover an exam topic not currently listed.

In addition, sites like Khan Academy (www.khanacademy.com) and iTunes U feature relatively brief lessons on very specific topics rather than full courses. Full courses are also available on iTunes U (http://www.apple.com/education/ipad/itunes-u/). We have chosen a few courses and collections for this listing.

Other Online Resources

This section of the OER Guide is provided to allow learners to independently search for resources. Send an e-mail to OER@excelsior.edu if you have questions about a resource’s credibility.

Open Online Textbooks

Boundless open textbooks

https://www.boundless.com/open-textbooks/

BookBoon

http://bookboon.com/en/textbooks-ebooks

Flatworld Knowledge

http://catalog.flatworldknowledge.com/#our-catalog

College Readiness

Khan Academy

http://www.khanacademy.org/

Hippocampus

http://www.hippocampus.org/

Open Course Library

http://opencourselibrary.org/college-110-college-success-course/

Study Aids

Education Portal

http://education-portal.com/

Khan Academy

http://www.khanacademy.org/

Annenberg Learner

http://www.learner.org/

OpenCourseWare

http://ocwconsortium.org/en/courses/search

OER Commons

http://www.oercommons.org/

Open Course Library

http://www.opencourselibrary.org/
Content Outline

**General Description of the Examination**

The UExcel General Chemistry I examination is based on material typically taught in a one-semester, three-credit, lower-level undergraduate course in chemistry.

The examination measures knowledge and understanding of theory and problem solving in chemical reactions, atomic structures and periodic trends, chemical bonding, states of matter, gases, and energy.

Those beginning to study for this exam should have an understanding of college-level algebra.

**Learning Outcomes**

After you have successfully worked your way through the recommended study materials, you should be able to demonstrate the following learning outcomes:

1. Identify and balance chemical reactions.
2. Classify types of matter and explain their related properties.
3. Solve problems in chemistry using SI measurements, scientific notation, and significant figures.
4. Explain the formation of covalent bonds using Lewis structure, valence bond, and molecular orbital theories.
5. Predict molecular geometry and polarity using valence shell electron pair repulsion (VSEPR) Theory.
6. Describe the arrangement and trends of the periodic table.
7. Distinguish the gas laws and use them to perform calculations.
8. Describe the law of conservation of energy and use it in heat and work problems.
Content Outline

The content outline describes the various areas of the test, similar to the way a syllabus outlines a course. To fully prepare requires self-direction and discipline. Study involves careful reading, reflection, and systematic review.

The major content areas on the General Chemistry I examination, the percent of the examination, and the hours to devote to each content area are listed below.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Percent of the Examination</th>
<th>Hours of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Chemical Reactions and Problem Solving</td>
<td>25%</td>
<td>34</td>
</tr>
<tr>
<td>II. Atomic Structures and Periodic Trends</td>
<td>25%</td>
<td>34</td>
</tr>
<tr>
<td>III. Chemical Bonding</td>
<td>20%</td>
<td>27</td>
</tr>
<tr>
<td>IV. Liquids, Solids, and Attractive Forces</td>
<td>10%</td>
<td>14</td>
</tr>
<tr>
<td>V. Gases</td>
<td>10%</td>
<td>14</td>
</tr>
<tr>
<td>VI. Energy Balance</td>
<td>10%</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Cognitive Activity

<table>
<thead>
<tr>
<th>Cognitive Activity</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Knowledge</td>
<td>30</td>
</tr>
<tr>
<td>II. Comprehension</td>
<td>35</td>
</tr>
<tr>
<td>III. Application and Higher-Level Abilities</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**NOTE**: Occasionally, examples will be listed for a content topic to help clarify that topic. However, the content of the examination is not limited to the specific examples given.

I. Chemical Reactions and Problem Solving

**25 PERCENT OF EXAM | 34 HOURS OF STUDY**

Tro (2013)

Ch. 1, Matter, Measurement, and Problem Solving

Ch. 3, Molecules, Compounds, and Chemical Equations (except organic compounds)

Ch. 4, Chemical Quantities and Aqueous Reactions

A. Scientific method (for example: observation, hypothesis formulation, data collection/analysis)

B. Measurements
1. System of measurements
2. Scientific notation
3. Significant digits

C. Matter
1. Classification
2. Physical and chemical properties

D. Chemical equations
1. Formulas and names
2. Balance and classify
3. Molar mass and the mole concept

E. Aqueous solutions and reaction calculations
1. Limiting reactant
2. Yield calculations
3. Concentration and dilution
4. Solubility and precipitation reactions
5. Ionic equations
6. Acid-base and redox reactions

II. Atomic Structures and Periodic Trends

25 PERCENT OF EXAM  |  34 HOURS OF STUDY

Tro

Ch. 2, Atoms and Elements
Ch. 7, The Quantum-Mechanical Model of the Atom
Ch. 8, Periodic Properties of the Elements

A. Composition of the atom
1. Subatomic particles
2. Isotopes
3. Average atomic mass

B. The Bohr model

C. Electromagnetic spectrum and atomic spectroscopy

D. Wave-particle duality and the uncertainty principle

E. Quantum numbers and atomic orbitals
1. Principle quantum number \( n \)
2. Angular momentum quantum number \( l \)
3. Magnetic quantum number \( m_l \)
4. Spin quantum number \( m_s \)
5. Shapes of atomic orbitals \( s, p, d, f \)

F. Electronic configuration
1. Pauli exclusion principle
2. Aufbau principle
3. Hund’s rule
4. Orbital diagram

G. Periodic table and trends
1. Effective and nuclear charge
2. Atomic and ionic radii
3. Ionization energy
4. Electron affinity
5. Electronegativity
6. Magnetic properties

III. Chemical Bonding

20 PERCENT OF EXAM  |  27 HOURS OF STUDY

Tro

Ch. 9, Chemical Bonding I: The Lewis Model
Ch. 10, Chemical Bonding II: Molecular Shapes, Valence Bond Theory, and Molecular Orbital Theory

A. Types of bonds (for example: covalent, ionic, and metallic)

B. Ionic bonding and lattice energy (for example: Born-Haber cycle)

C. Covalent bonding and Lewis theory
1. Valence electrons
2. Writing Lewis structures
3. Octet rule and exceptions
4. Resonance and formal charge
5. Bond polarity and dipole moment

D. Valence shell electron pair repulsion (VSEPR) theory
1. Basic electron group geometry
2. Lone pairs, molecular shape, and molecular polarity

E. Valence bond theory
1. Hybridization
2. Sigma (\( \sigma \)) and pi (\( \pi \)) bonding

F. Molecular orbital theory
1. Bonding and antibonding
2. Linear combination of atomic orbitals (LCAO)
3. Lowest unoccupied molecular orbital (LUMO) and highest occupied molecular orbital (HOMO)

IV. Liquids, Solids, and Attractive Forces

A. Three states of matter
B. Intermolecular interactions
   1. London dispersion force
   2. Dipole-dipole force
   3. Hydrogen bonding
C. Properties of liquids
   1. Surface tension
   2. Viscosity
   3. Vapor pressure and heat of vaporization ($\Delta H_{\text{vap}}$)
   4. Boiling point
D. Properties of Solids
   1. Crystal structures and unit cells
   2. Types of crystals (for example: ionic, molecular, and metallic)
   3. X-ray diffraction and Bragg's Law
   4. Other types of solids (for example: glass, network, and polymers)
   5. Melting point and sublimation
E. Phase changes
   1. Relationship between three states of matter (for example: heating and cooling curves)
   2. Phase diagram (for example: critical point and triple point)

V. Gases

A. Properties of gases
B. Simple gas laws (for example: Boyle's, Charles's, and Avogadro's)
C. Ideal gas law and related calculations
D. Mole fraction and Dalton's law of partial pressures
E. Kinetic Molecular Theory
   1. Root mean square velocity
   2. Graham's law of effusion
F. Real gases

VI. Energy Balance

A. Types of energy (for example: kinetic, potential, chemical)
B. First Law of Thermodynamics
   1. Internal energy (E)
   2. Work (w)
   3. Heat (q)
C. Enthalpy (H)
   1. Endothermic processes
   2. Exothermic processes
   3. Stoichiometry problems
D. Hess's Law and standard heat of formation ($\Delta H_{\text{f}}$)
E. Calorimetry, heat capacity and specific heat
Sample Questions

The sample questions give you an idea of the level of knowledge expected in the exam and how questions are typically phrased. They are not representative of the entire content of the exam and are not intended to serve as a practice test.

Rationales for the questions can be found on pages 13–16 of this guide. In that section, the correct answer is identified and each answer is explained. The number in parentheses at the beginning of each rationale refers to the corresponding section of the content outline. For any questions you answer incorrectly, return to that section of the content outline for further study.

You will be provided with an erasable white board to use during your exam. During your exam, tables of essential formulas, values, and constants will be available for your reference, and you will have access to a scientific calculator. The calculator button is in the top left hand corner of the page as each question is presented and the tables and formulas are in the Help button located in the lower left hand corner as each question is presented. Copies of the tables and a picture of a typical scientific (nongraphing) calculator are provided at the back of this content guide.

1. What is the order of the steps of the scientific method?
   A. conclusion
   B. data collection
   C. experiment
   D. hypothesis
   E. data analysis

   1) DCBEA
   2) BCEDA
   3) DBCEA
   4) EDBCA

2. Which substance is a molecular compound?
   1) ammonium chloride (NH₄Cl)
   2) calcium oxide (CaO)
   3) methanol (CH₃OH)
   4) potassium iodide (KI)

3. What is the estimated molar mass of carbon dioxide (CO₂) that you would find using the periodic table?
   1) 12 g/mol
   2) 16 g/mol
   3) 28 g/mol
   4) 44 g/mol

4. How many grams of iron (Fe) are produced if 159.7 g of ferric oxide (Fe₂O₃) reacts with 100 g of carbon (C) and the percent yield of Fe produced in this reaction is 45%? (Hint: the reaction is not balanced.)
   \[ \text{Fe}_2\text{O}_3(s) + \text{C}(s) \rightarrow \text{Fe}(s) + \text{CO}(g) \]
   1) 25.1 g
   2) 50.2 g
   3) 55.85 g
   4) 111.70 g

5. Which type of reaction is shown by the equation below?
   \[ \text{NH}_3(l) + \text{H}_2\text{O}(l) \rightarrow \text{NH}_4^+(aq) + \text{OH}^-(aq) \]
   1) acid-base
   2) combustion
   3) oxidation-reduction
   4) precipitation
6. Which atom is represented by the symbol “X”?

\[ ^{A}X \]

“A” is 235 and the atom contains 143 neutrons.
1) nobelium
2) thorium
3) uranium
4) zirconium

7. Which set of quantum numbers describes an electron in a 3d atomic orbital?
1) \( n = 2, l = 0, m_l = 0, m_s = \frac{1}{2} \)
2) \( n = 3, l = 1, m_l = 1, m_s = -\frac{1}{2} \)
3) \( n = 3, l = 2, m_l = -2, m_s = \frac{1}{2} \)
4) \( n = 4, l = 3, m_l = +3, m_s = -\frac{1}{2} \)

8. Which element has the following ground state electron configuration?

\( 1s^22s^22p^63s^23p^3 \)
1) Ar
2) He
3) N
4) P

9. Which orbital diagram represents the ground state electron configuration for a carbon atom?
1) ![Orbital Diagram 1]
2) ![Orbital Diagram 2]
3) ![Orbital Diagram 3]
4) ![Orbital Diagram 4]

10. Which number is the best estimation of the ionization energy of a hydrogen atom using the Bohr model?
1) \( 5.45 \times 10^{-19} \) J
2) \( 1.63 \times 10^{-18} \) J
3) \( 1.94 \times 10^{-18} \) J
4) \( 2.18 \times 10^{-18} \) J

11. Which equation describes the lattice energy of cesium bromide (CsBr)?
1) \( \text{CsBr}(l) \rightarrow \text{CsBr}(s) \)
2) \( \text{CsBr}(g) \rightarrow \text{CsBr}(s) \)
3) \( \text{Cs}(s) + \text{Br}_2(g) \rightarrow \text{CsBr}(s) \)
4) \( \text{Cs}^+(g) + \text{Br}^-(g) \rightarrow \text{CsBr}(s) \)

12. What is the Lewis structure of the chlorine (Cl) atom?
1) \( :\text{Cl}: \)
2) \( :\text{Cl}: \)
3) \( \cdot\text{Cl}. \)
4) \( \cdot\text{Cl}. \)

13. What is the electron group geometry if there are three electron groups around a central atom?
1) linear
2) tetrahedral
3) trigonal planar
4) trigonal bipyramidal

14. What is the hybridization of the two carbon atoms in the acetonitrile molecule shown below?

\[
\text{CH}_3\text{CN}
\]
1) \( C_1 = sp^3, C_2 = sp^2 \)
2) \( C_1 = sp^3, C_2 = sp \)
3) \( C_1 = sp^2, C_2 = sp \)
4) \( C_1 = sp, C_2 = sp^3 \)

15. Which compound is expected to have the highest boiling point?
1) \( \text{CH}_3\text{CH}_2\text{CH}_3 \)
2) \( \text{CH}_3\text{OCH}_3 \)
3) \( \text{CH}_3\text{CHO} \)
4) \( \text{CH}_3\text{CN} \)
16. The figure below shows a cooling curve of a typical molecular compound:

Which phase(s) of matter is (are) present in region II?
1) gas, only
2) liquid, only
3) gas and liquid, only
4) liquid and solid, only

17. A sample of gas has initial volume of 3.26 L and a pressure of 1.3 atm at 27 °C. The gas is reduced to a final volume of 1.40 L at a pressure of 4000 mm of Hg. What is the final temperature?
1) 46.9 °C
2) 172 °C
3) 248 °C
4) 521 °C

18. Under which condition does a gas behave in the least ideal manner?
1) \( T = 100 \text{ K}; P = 1.0 \text{ atm} \)
2) \( T = 100 \text{ K}; P = 20 \text{ atm} \)
3) \( T = 500 \text{ K}; P = 1.0 \text{ atm} \)
4) \( T = 500 \text{ K}; P = 20 \text{ atm} \)

19. What amount of heat would be released if 310 g of \( \text{NH}_3 \) is completely reacted according to the chemical reaction below?
\[
\Delta H_{rxn} = -906 \text{kJ}
\]
\[
4\text{NH}_3(g) + 5\text{O}_2(g) \rightarrow 4\text{NO}(g) + 6\text{H}_2\text{O}(g)
\]
1) \(-4.13 \times 10^3 \text{kJ}\)
2) \(-1.65 \times 10^4 \text{kJ}\)
3) \(-6.61 \times 10^4 \text{kJ}\)
4) \(-2.81 \times 10^5 \text{kJ}\)

20. What is the change in enthalpy for the reaction below?
\[
\text{C}_3\text{H}_8(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(g)
\]

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<td>\text{CO}_2(g)</td>
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<tr>
<td>\text{H}_2\text{O}(g)</td>
<td>-241</td>
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</table>

1) \(-2043\)
2) \(-531\)
3) \(+531\)
4) \(+2043\)

21. What is the change in enthalpy for the reaction below?
\[
\text{C}_3\text{H}_8(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(g)
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<td>-241</td>
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</tbody>
</table>

1) \(-2043\)
2) \(-531\)
3) \(+531\)
4) \(+2043\)
1. (IA)
   *1) DCBEA

   The first step of the scientific method is to formulate a hypothesis. This is a potential explanation for a phenomenon. The second step is experimentation when controlled testing procedures are implemented. The third step is data collection whereby observations are generated and the fourth step, data analysis, serves to support or disprove a hypothesis. The final step is the conclusion, whereby the hypothesis is confirmed or revised based on the data analysis.

2. (IC1)
   1) Ammonium chloride is an ionic compound because it is formed from ammonium cations (NH₄⁺) and chloride anions (Cl⁻).
   2) Calcium oxide is an ionic compound because it is formed from calcium cations (Ca²⁺) and oxide anions (O²⁻).
   *3) Methanol is made up of covalent bonds among carbon, hydrogen, and oxygen atoms. There are no ions in the methanol molecule.
   4) Potassium iodide is an ionic compound because it is formed from potassium cations (K⁺) and iodide anions (I⁻).

3. (ID3)
   1) This answer results from using only the atomic mass of one carbon (C) atom.
   2) This answer results from using only the atomic masses of two oxygen (O) atoms.
   3) This answer results from using only the atomic masses of one carbon atom and one oxygen atom.
   *4) Molar mass of all the atomic masses (rounded to nearest whole number) of all the atoms in a chemical formula.

   The calculation formula is:
   \[(1\times12)+(2\times16)=44\text{ g/mol}\]

4. (IE2)
   1) The equation must be balanced and then calculated, so the amount of Fe must be doubled due to the balanced coefficient of 2 for Fe.
   *2) There are 100 g of carbon and only one mole of ferric oxide; therefore, ferric oxide must be the limiting reactant. Since the balanced equation produces two moles or 111.7 g of Fe and percent yield is only 45%, that should give 50.2 g of Fe.

   The equation is balanced as:
   \[
   \text{Fe}_2\text{O}_3 + 3\text{C} \rightarrow 2\text{Fe} + 3\text{CO}
   \]

   \[
   m_{\text{Fe}} = \frac{159.7 \text{ g Fe}_2\text{O}_3}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{2 \text{ mol Fe}}{1 \text{ mol Fe}_2\text{O}_3} \times \frac{55.8 \text{ g Fe}}{1 \text{ mol Fe}} \times 45\% = 50.2 \text{ g Fe}
   \]

   3) The equation must be balanced first, then the limiting reactant determined. If percent yield is 100% it will produce 111.7 g.

   4) This reaction produces only 45% yield of Fe. Therefore, further calculation of 45% of 111.70 g is required.

   *correct answer
5. (IE6)
   1) Ammonia (NH₃), a base, gains a proton to form its conjugate acid, the ammonium ion (NH₄⁺). In addition, water (H₂O), an acid, loses a proton to form its conjugate base, the hydroxide ion (OH⁻).
   2) A combustion reaction requires oxygen to be a reactant.
   3) The oxidation state for nitrogen and oxygen did not change after the reaction.
   4) The reaction did not produce a solid as a reactant.

6. (IIA1)
   1) The number of protons in nobelium is 102.
   2) The number of protons in thorium is 90.
   *3) The number of protons (Z) is equal to the atomic mass (A) minus the number of neutrons. Therefore, Z = 235 – 143 = 92 and element “X” is uranium.
   4) The number of protons in zirconium is 40.

7. (IIE)
   1) This set of quantum numbers describes an electron in a 2s orbital. n = 2 describes the energy level of the orbital; l = 0 describes the shape of the s orbital.
   2) This set of quantum numbers describes an electron in a 3p orbital. n = 3 describes the energy level of the orbital; l = 1 describes the shapes of the p orbitals.
   *3) This set of quantum numbers describes an electron in a 3d orbital. n = 3 describes the energy level of the orbital; l = 2 describes the shapes of the d orbitals.
   4) This set of quantum numbers describes an electron in a 4f orbital. n = 4 describes the energy level of the orbital; l = 3 describes the shapes of the f orbitals.

8. (IIF)
   1) Argon has a ground state electron configuration of 1s²2s²2p⁶3s²3p⁶.
   2) Helium has a ground state electron configuration of 1s².
   3) Nitrogen has a ground state electron configuration of 1s²2s²2p³.
   *4) This is the electron configuration for phosphorus.

9. (2F4)
   1) According to Hund’s rule, both 2p electrons need to occupy separate orbitals to maximize their spin.
   *2) Hund’s rule states that the two electrons in the p orbitals should occupy two individual orbitals.
   3) The 1s orbital should be filled in the ground state before placing electrons in higher energy states.
   4) The 2s orbital should be filled in the ground state before filling the 2p orbitals.

10. (IIG3)
    1) This is the energy required to promote the electron from n = 2 to n = ∞. \( \Delta E = E_3 - E_1 \) where \( E_n = -2.18 \times 10^{-18} \text{ J} \left(1/n^2\right)\).
    2) This is the energy required to promote the electron from n = 1 to n = 2. \( \Delta E = E_3 - E_1 \) where \( E_n = -2.18 \times 10^{-18} \text{ J} \left(1/n^2\right)\).
    3) This is the energy required to promote the electron from n = 1 to n = 3. \( \Delta E = E_3 - E_1 \) where \( E_n = -2.18 \times 10^{-18} \text{ J} \left(1/n^2\right)\).
    *4) The ionization of a hydrogen atom is equal to the energy that is required to promote the electron from a hydrogen atom from n = 1 to n = ∞. Therefore,

\[
\Delta E_{\text{ionization}} = E_\infty - E_1 = -2.18 \times 10^{-18} \text{ J}
\]

11. (IIIB)
    1) This is the heat of fusion for cesium bromide.
    2) This is the heat of sublimation for cesium bromide.
    3) This is the enthalpy of formation for cesium bromide.
    *4) The lattice energy of cesium bromide is defined as the amount of energy gained when gaseous Cs⁺ and Br⁻ ions combined to form the crystal lattice of the ionic solid of cesium bromide.
12. (IIIC2)  
*1) Chlorine has 7 valence electrons in its outer shell.
2) In period 3, argon has 8 valence electrons in its outer shell.
3) In period 3, phosphorus has 5 valence electrons in its outer shell.
4) In period 3, sulfur has 6 valence electrons in its outer shell.

13. (IIID1)  
1) Linear is the geometry for two electron groups around a central atom.
2) Tetrahedral is the geometry for four electron groups around a central atom.
*3) The geometry for three electron groups is trigonal planar.
4) Trigonal bipyramidal is the geometry for five electron groups around a central atom.

14. (IIIE2)  
1) The second carbon has a triple bond with nitrogen; therefore, it should be sp hybridized.
*2) The first carbon has four sigma bonds and it is sp\(^3\) hybridized. The second carbon has a triple bond and it is sp hybridized.
3) The first carbon has four sigma bonds and it is sp\(^3\) hybridized, not sp\(^2\).
4) This answer results from reversing the two carbons.

15. (IVC4)  
1) Propane is non-polar; therefore, it should have a low boiling point.
2) Dimethyl ether is slightly polar; therefore, it should have a higher boiling point than propane.
3) Acetaldehyde is more polar than dimethyl ether; therefore, it should have a higher boiling point than dimethyl ether.
*4) The dipole moment of acetonitrile is strongest among the four substances and is the most polar molecule; therefore, it should have the highest boiling point.

16. (IVE1)  
1) Region I has only gas phase, as the gas is being cooled to its boiling point.
2) Region III has only liquid phase as the liquid is being cooled to its melting point.
*3) In region II, the gas is being condensed at the boiling temperature. In this region, the gas and the liquid are in dynamic equilibrium. Both phases are present.
4) Region IV has both liquid and solid phases present. The liquid and solid are in dynamic equilibrium at the melting temperature.

17. (VB)  
1) This results when the absolute temperature for the calculation is not used.
2) This results when the initial and final pressures and volumes are reversed.
*3) Solution:
\[
T_2 = T_1 \left( \frac{P_2V_2}{P_1V_1} \right) \left( \frac{4000\text{mmHg}}{760\text{mmHg}} \right) \left( \frac{1\text{atm}}{1.3\text{atm}} \right) \left( \frac{3.26\text{L}}{1.4\text{L}} \right)
\]
\[T_2 = (27+273.15)K \times \left( \frac{1\text{atm}}{760\text{mmHg}} \right) \left( \frac{3.26\text{L}}{1.4\text{L}} \right) = 521K\]
\[T_2 = (512 - 273.15)K = 248°C\]
4) This results when the temperature is not converted from Kelvin to Celsius.

18. (VF)  
1) Gas particles at high temperatures have high kinetic energy; therefore, they tend to behave like an ideal gas. Gas particle volume does not affect the overall volume of the gas at low pressures.
*2) At low temperatures, attractive forces among the gas particles cause the gas pressure to be lower than ideal. At higher pressures, the gas particle volume causes the gas pressure to be higher than ideal.
3) Gas particle volume does not affect the overall volume of the gas at low pressures.
4) Gas particles at high temperatures have high kinetic energy; therefore, they tend to behave like an ideal gas.

*correct answer
19. (VIC3)

1) Solution:

\[ \Delta H_{\text{rxn}} = 310 \text{g} \text{NH}_3 \left( \frac{1 \text{ mol}}{17 \text{ g}} \right) \left( \frac{-906 \text{ kJ}}{4 \text{ mol NH}_3} \right) = -4130.3 \text{ kJ} \]

2) This results from forgetting to divide by 4 moles of \text{NH}_3 from the chemical reaction.

3) This results from forgetting to convert the mass of \text{NH}_3 to numbers of moles of \text{NH}_3.

4) This results from forgetting to convert from mass to moles and not dividing by 4 moles \text{NH}_3.

20. (VID)

1) Solution:

\[ \Delta H^2_{\text{rxn}} = \Sigma n_p \Delta H^0_{\text{products}} - \Sigma n_r \Delta H^0_{\text{reactants}} \]

\[ \Delta H^2_{\text{rxn}} = [3(-393 \text{ kJ/mol}) + 4(-241 \text{ kJ/mol})] - (-103 \text{ kJ}) \]

\[ \Delta H^2_{\text{rxn}} = 2043 \text{ kJ} \]

2) This results from forgetting to include the coefficients in the calculations.

3) This results from forgetting to include the coefficients and switching the products and reactants.

4) This results from switching the products and reactants heats of formation.
Diatomic Molecular Orbital Energy Level Diagrams

B₂, C₂, N₂, O₂, F₂, Ne₂

Energy

Atomic orbitals | Molecular orbitals | Atomic orbitals

σ² | π² | σ²

2p | 2p | 2p

σ² | π² | σ²

2s | 2s | 2s

σ² | π² | σ²

2s | 2s | 2s

σ² | σ² | σ²

σ² | σ² | σ²

σ² | σ² | σ²
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### Electronegativity Chart

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**Note:** The chart shows the electronegativity values for various elements, with higher values indicating greater electronegativity. Elements in the periodic table are arranged in order of increasing electronegativity. The periodic table and electronegativity chart are based on standardized values used in chemistry to compare the tendency of an atom to attract electrons in a chemical bond.
Equations and Constants

\( N_a = 6.022 \times 10^{23} \quad R = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \) or \( R = 0.08206 \text{ L} \cdot \text{atm} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} \)

1 atm = 760 torr = 1.01325 bar = 1.01325 \( \times 10^5 \) Pa = 14.7 psi

\[ PV = nRT \quad P_A = \chi_A \rho \cdot \rho \cdot \rho = \frac{PM}{RT} \quad u_{\text{rms}} = \sqrt{\frac{3RT}{M}} \]

\[
\text{effusion rate (A)} \quad \text{effusion rate (B)} = \sqrt{\frac{d_B}{d_A}} = \sqrt{\frac{M_B}{M_A}} \quad \left( P_{\text{meas}} + \frac{n^2 a}{V^2} \right) \left( V_{\text{meas}} - nb \right) = nRT
\]

Boltzmann Constant: \( k_B = \frac{R}{N_a} \quad 1 \text{D} = 3.34 \times 10^{-30} \text{ C} \cdot \text{m} \)

\( m_e = 9.10939 \times 10^{-31} \text{ kg} \quad c = 2.998 \times 10^8 \text{ m/s} \quad h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s} \)

\[
\frac{1}{\lambda} = R_H \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad R_H = 1.096776 \times 10^7 \text{ m}^{-1}
\]

\( E = h\nu \quad c = \nu \lambda \quad \nu_n = -(2.18 \times 10^{-18} \text{ J} \cdot \text{s})^2 \quad \text{(Hydrogen Atom)} \)

Momentum: \( p = mu \quad KE = \frac{mv^2}{2} = \frac{p^2}{2m} \) (note \( u = \) velocity, \( v = \) frequency)

\[
\lambda = \frac{h}{p} = \frac{h}{mu} \quad \mu = q(r) \quad q (\text{electron}) = 1.6 \times 10^{-19} \text{ C}
\]

\( KE_{\text{electron}} = hv - \Phi \)

\( q = C \Delta T = m \times C_s \times \Delta T = nC_m \) where \( m = \text{mass}; \ n = \text{moles}; \ C = \text{heat capacity}; \ C_s = \text{specific heat}; \ C_m = \text{molar heat capacity} \)

\( \Delta E = q + w \quad w = -P \Delta V \quad H = \Delta E + P \Delta V \)

\( \Delta H^{\text{rxn}} = \sum m \Delta H_f^{\text{products}} - \sum n \Delta H_f^{\text{reactants}} \)
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On the day of your exam, remember to:

- dress comfortably: the computer will not mind that you’re wearing your favorite relaxation outfit
- arrive at the test site rested and prepared to concentrate for an extended period
- allow sufficient time to travel, park, and locate the test center
• be prepared for possible variations in temperature at the test center due to weather changes or energy conservation measures

• bring your ID, but otherwise, don’t weigh yourself down with belongings that will have to be kept in a locker during the test.

**Academic Honesty Nondisclosure Statement**

• All test takers must agree to the terms of the Excelsior College Academic Honesty Policy before taking an examination. The agreement will be presented on screen at the Pearson VUE Testing Center before the start of your exam.

• Once the test taker agrees to the terms of the Academic Honesty Nondisclosure Statement, the exam will begin.

If you choose not to accept the terms of the agreement

• your exam will be terminated

• you will be required to leave the testing center

• you will not be eligible for a refund. For more information, review the Student Policy Handbook at [www.excelsior.edu/studentpolicyhandbook](http://www.excelsior.edu/studentpolicyhandbook).

Student behavior is monitored during and after the exam. Electronic measures are used to monitor the security of test items and scan for illegal use of intellectual property. This monitoring includes surveillance of Internet chat rooms, websites, and other public forums.

**Information About UExcel Exams for Colleges and Universities**

A committee of teaching faculty and practicing professionals determines the learning outcomes to be tested on each exam. Excelsior College Center for Educational Measurement staff oversee the technical aspects of test construction in accordance with current professional standards. To promote fairness in testing, we take special care to ensure that the language used in the exams and related materials is consistent, professional, and user friendly. Editorial staff perform systematic quantitative and qualitative reviews to ensure accuracy, clarity, and compliance with conventions of bias-free language usage.

Excelsior College, the test developer, recommends granting three (3) semester hours of lower-level undergraduate credit to students who receive a letter grade of C or higher on this examination. The examination may be used to help fulfill a science requirement or as a free elective for all Excelsior College Degree programs that allow for free electives. Other colleges and universities also recognize this exam as a basis for granting credit or advanced standing. Individual institutions set their own policies for the amount of credit awarded and the minimum acceptable score.

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