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CLEP® Chemistry

… At a Glance

Description of the Examination

The Chemistry examination covers material that is usually taught in a one-year college course in general chemistry. Understanding of the structure and states of matter, reaction types, equations and stoichiometry, equilibrium, kinetics, thermodynamics, and descriptive and experimental chemistry is required, as is the ability to interpret and apply this material to new and unfamiliar problems. During this examination, an online scientific calculator function and a periodic table are available as part of the testing software.

The examination contains approximately 75 questions to be answered in 90 minutes. Some of these are pretest questions that will not be scored.

Knowledge and Skills Required

Questions on the Chemistry examination require candidates to demonstrate one or more of the following abilities.

- Recall — remember specific facts; demonstrate straightforward knowledge of information and familiarity with terminology
- Application — understand concepts and reformulate information into other equivalent terms; apply knowledge to unfamiliar and/or practical situations; use mathematics to solve chemistry problems
- Interpretation — infer and deduce from data available and integrate information to form conclusions; recognize unstated assumptions

The subject matter of the Chemistry examination is drawn from the following topics. The percentages next to the main topics indicate the approximate percentage of exam questions on that topic.

20% Structure of Matter

Atomic theory and atomic structure

- Evidence for the atomic theory
- Atomic masses; determination by chemical and physical means
- Atomic number and mass number; isotopes and mass spectroscopy
- Electron energy levels: atomic spectra, quantum numbers, atomic orbitals
- Periodic relationships, including, for example, atomic radii, ionization energies, electron affinities, oxidation states

Chemical bonding

- Binding forces
  - Types: covalent, ionic, metallic, macromolecular (or network), dispersion, hydrogen bonding
  - Relationships to structure and to properties
  - Polarity of bonds, electronegativities
- Geometry of molecules, ions and coordination complexes: structural isomerism, dipole moments of molecules, relation of properties to structure
- Molecular models
  - Valence bond theory; hybridization of orbitals, resonance, sigma and pi bonds
  - Other models, for example, molecular orbital

Nuclear chemistry: nuclear equations, half-lives and radioactivity; chemical applications

19% States of Matter

Gases

- Laws of ideal gases; equations of state for an ideal gas
- Kinetic-molecular theory
  - Interpretation of ideal gas laws on the basis of this theory
  - The mole concept; Avogadro's number
  - Dependence of kinetic energy of molecules on temperature: Boltzmann distribution
  - Deviations from ideal gas laws

Liquids and solids

- Liquids and solids from the kinetic molecular viewpoint
- Phase diagrams of one-component systems
- Changes of state, critical phenomena
- Crystal structure

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CLEP® Chemistry (Continued)

Solutions

- Types of solutions and factors affecting solubility
- Methods of expressing concentration
- Colligative properties; for example, Raoult's law
- Effect of interionic attraction on colligative properties and solubility

12% Reaction Types

Formation and cleavage of covalent bonds

- Acid-base reactions; concepts of Arrhenius, Brønsted-Lowry and Lewis; amphoterism
- Reactions involving coordination complexes

Precipitation reactions

Oxidation-reduction reactions

- Oxidation number
- The role of the electron in oxidation-reduction
- Electrochemistry; electrolytic cells, standard half-cell potentials, prediction of the direction of redox reactions, effect of concentration changes

10% Equations and Stoichiometry

Ionic and molecular species present in chemical systems; net-ionic equations

Stoichiometry: mass and volume relations with emphasis on the mole concept

Balancing of equations, including those for redox reactions

7% Equilibrium

Concept of dynamic equilibrium, physical and chemical; LeChâtelier's principle; equilibrium constants

Quantitative treatment

- Equilibrium constants for gaseous reactions in terms of both molar concentrations and partial pressure (K_c, K_p)
- Equilibrium constants for reactions in solutions
  - Constants for acids and bases; pK; pH
  - Solubility-product constants and their application to precipitation and the dissolution of slightly soluble compounds
  - Constants for complex ions
  - Common ion effect; buffers

4% Kinetics

Concept of rate of reaction

Order of reaction and rate constant: their determination from experimental data

Effect of temperature change on rates

Energy of activation; the role of catalysts

The relationship between the rate-determining step and a mechanism

5% Thermodynamics

State functions

First law: heat of formation; heat of reaction; change in enthalpy, Hess's law; heat capacity; heats of vaporization and fusion

Second law: free energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes

Relationship of change in free energy to equilibrium constants and electrode potentials

14% Descriptive Chemistry

The accumulation of certain specific facts of chemistry is essential to enable students to comprehend the development of principles and concepts, to demonstrate applications of principles, to relate fact to theory and properties to structure, and to develop an understanding of systematic nomenclature that facilitates communication. The following areas are normally included on the examination:

- Chemical reactivity and products of chemical reactions
- Relationships in the periodic table: horizontal, vertical and diagonal
- Chemistry of the main groups and transition elements, including typical examples of each
- Organic chemistry, including such topics as functional groups and isomerism (may be treated as a separate unit or as exemplary material in other areas, such as bonding)

CLEP® Chemistry (Continued)

9% Experimental Chemistry

Some experiments are based on laboratory experiments widely performed in general chemistry and ask about the equipment used, observations made, calculations performed and interpretation of the results. The questions are designed to provide a measure of understanding of the basic tools of chemistry and their applications to simple chemical systems.

Study Resources

Most textbooks used in chemistry courses cover the topics in the outline above, but the approaches to certain topics and the emphases given to them may differ. To prepare for the Chemistry exam, it is advisable to study one or more college textbooks, which can be found in most college bookstores.

A recent survey conducted by CLEP® found that the following textbooks are among those used by college faculty who teach the equivalent course. Most of these have companion websites with practice test questions and other study resources. HINT: When selecting a textbook, check the table of contents against the Knowledge and Skills required for this test.

Chang and Overby, *General Chemistry: The Essential Concepts* (McGraw-Hill)
Cracolice and Peters, *Introductory Chemistry: An Active Learning Approach* (Brooks/Cole)
Gilbert et al., *Chemistry: The Science in Context* (W.W. Norton)
Goldberg, *Fundamentals of Chemistry* (McGraw-Hill)
Hill, Kolb and McCreary, *Chemistry for Changing Times* (Prentice-Hall)
Joesten et al., *The World of Chemistry: Essentials* (Brooks/Cole)
Kelter et al., *Chemistry: A World of Choices* (McGraw-Hill)
Moog and Farrell, *Chemistry: A Guided Inquiry* (Wiley)
Snyder, *The Extraordinary Chemistry of Ordinary Things* (Wiley)
Zumdahl and DeCoste, *Introductory Chemistry: A Foundation* (Brooks/Cole)

In addition, the following resource, compiled by CLEP test development committee and staff members, may help you study for your exam. However, none of these sources are designed specifically to provide preparation for a CLEP exam. The College Board has no control over their content and cannot vouch for accuracy:

Frostburg State University: General Chemistry Online
http://antoine.frostburg.edu/chem/senese/101/index.shtml

Visit **www.collegeboard.com/clepprep** for additional Chemistry resources. You can also find suggestions for exam preparation in Chapter IV of the *CLEP Official Study Guide*. In addition, many college faculty members post their course materials on their schools' websites.

Sample Test Questions

The following sample questions do not appear on an actual CLEP examination. They are intended to give potential test-takers an indication of the format and difficulty level of the examination and to provide content for practice and review. For more sample questions and info about the test, see the *CLEP Official Study Guide*.

Note: For all questions involving solutions and/or chemical equations, assume that the system is in pure water and at room temperature unless otherwise stated.

Questions 1–3 refer to reactions represented by the following chemical equations.

A. $2\ KClO_3(s) \rightarrow 2\ KCl(s) + 3\ O_2(g)$

B. $Zn(s) + Cu^2{+}(aq) \rightarrow Zn^2{+}(aq) + Cu(s)$

C. $Co^3{+}(aq) + 6\ NH^3(aq) \rightarrow [Co(NH^3)_6{}^3{+}](aq)$

D. $H_3O{+}(aq) + NH_3(aq) \rightarrow H_2O(l) + NH_4{+}(aq)$

E. $2\ C_8H_{18}(l) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$

1. A Brønsted-Lowry acid-base reaction
2. A decomposition reaction
3. A combustion reaction
4. The attractions between atoms within a molecule of NH_3 are best characterized as
   A. hydrogen bonds
   B. ionic bonds
   C. polar covalent bonds
   D. London (dispersion) forces
   E. ion-dipole forces

CLEP® Chemistry (Continued)

F. Which of the following is the ground-state electron configuration of a halide ion?

G. $1s^2\ 2s^2 2p5$

H. $1s^2\ 2s^2 2p^6$

I. $1s^2\ 2s^2 2p^6\ 3s^1$

J. $1s^2\ 2s^2 2p^6\ 3s^2$

K. $1s^2\ 2s^2 2p^6\ 3s^2 3p^1$

5. Which of the following represents the number of moles of an ideal gas in a 2.0 L container at 3.0 atm and 450 K ?

A. $\frac{(3.0)(450)}{(0.0821)(2.0)}$ mol

B. $\frac{(3.0)(2.0)}{(0.0821)(450)}$ mol

C. $\frac{(450)(2.0)}{(0.0821)(3.0)}$ mol

D. $\frac{(0.0821)(450)}{(3.0)(2.0)}$ mol

E. $\frac{(0.0821)(2.0)}{(3.0)(450)}$ mol

6. $R(g) + 2\ T(g) \rightleftarrows 2\ X(g) + Z(g)$

The reaction mixture represented above is at equilibrium at 298 K. The value of the equilibrium constant for the reaction is 16 at 298 K. If R(*g*), X(*g*) and Z(*g*) each have an equilibrium concentration of 2.0 M, what is the equilibrium concentration of T(*g*)?

A. 0.25

B. 0.50

C. 2.0

D. 4.0

E. 8.0

7. What is the pH of a solution made by diluting 1.00 mL of 0.10 *M* HCl with enough distilled water to make 1.00 L of solution?

A. 1.0

B. 2.0

C. 3.0

D. 4.0

E. 7.0

Credit Recommendations

The American Council on Education has recommended that colleges grant 6 credits for a score of 50, which is equivalent to a course grade of C, on the CLEP Chemistry exam. Each college, however, is responsible for setting its own policy. For candidates with satisfactory scores on the CLEP Chemistry examination, colleges may grant credit toward fulfillment of a distribution requirement, or for a particular course that matches the exam in content. Check with your school to find out the score it requires for granting credit, the number of credit hours granted and the course that can be bypassed with a passing score.

Answers to Sample Questions: **1-D; 2-A; 3-E; 4-C; 5- B; 6-B; 7-B; 8-D**