# Harvard Undergraduate Science Olympiad 2026
# Open Round
# Chemistry Syllabus: 9th-10th Grade

**Reference Material:**
You should memorize common formulas and reactions, but you need not memorize any constants as a periodic table and all needed constants will be provided **(see the provided formula sheet at the end of this document).**

**Potential Topics Covered on the Exam:**
Please note that not necessarily every topic on this list will be on the exam, don't get overwhelmed! The syllabus is meant to be exhaustive of all ***potential*** topics that could be on the exam. A great place to start is with making sure you're comfortable with the high school chemistry curriculum (see Khan academy). It will be a difficult exam, but remember you don't need to (nor do we expect you to) get a 100%! Just do your best and show us all that you've learned! Good luck and happy studying!

This syllabus contains topics which might be covered both in the open and the in person round. The exam will have questions testing a subset and not all of these bullet points in this extensive list of topics in the syllabus. Organic chemistry will be tested on the exam, but no more than ~15-20% of the points on the open exam will be from organic chemistry.

## Inorganic Chemistry:

- Periodic Table:
    - Elements classification and properties;
        - Main group elements;
        - Transition group elements;
    - Isotopes:
        - Atomic number;

        - Mass number;
        - Relative atomic mass;
        - Radioactive decay and nuclear reactions (alpha, beta, gamma);
    - Electronic configuration of atoms and their ions:
        - Quantum numbers (n,l,m);
        - Orbital types (s,p,d);
        - Hund's rule,
        - Pauli principle;
        - Para vs diamagnetism;
    - Trends:
        - Trends in electronegativity;
        - Trends in ionization energy;
        - Trends in electronaffinity;
        - Trends in reactivity;
        - Trends in metallic and nonmetallic character;
        - Trends in atomic and ionic size;
- Chemical Bonds:
    - Bond Types;
    - Hybridization;
    - VSEPR theory;
        - Shapes;
        - Polarity;
        - Bond Angles;
    - Intermolecular Forces
    - Solid State Chemistry:
        - Metallic Bonding;
    - Oxides (their acid base properties);
- Chemical Reactions:
    - Reaction types;
    - Balancing reactions;
    - Empirical formulas;
    - Stoichiometric calculations:
        - Concentrations;
        - Mole concept via volume, mass and number of atoms;

**Analytical Chemistry:**

- Solutions:
    - Different concentration measurements (molarity, molality, etc.)
    - Self ionization of water;
    - Hydrolysis of salts;
    - Acidity and Basicity:

        - Arrhenius acid-base theory;
        - Bronsted acid-base theory;
        - Lewis acids and bases theory;
        - pH and pOH definitions;
        - $K_a$ and $K_b$ as a measure of acid and base strength;
        - Buffer solutions;
    - Solubility of Compounds:
        - Soluble, slightly soluble, and insoluble salts;
        - Working with solubility constants;
        - Saturated, unsaturated, and supersaturated solutions;
- Quantitative Analysis:
    - Titration indicators;
    - Titration curves;
    - Acid-base titrations;
- Qualitative Analysis:
    - Flame tests;
    - Specific identification reactions for common cations and anions;

**Physical Chemistry:**

- Equilibrium:
    - Le Chatelier's principle;
    - Phases:
        - Ideal gas law;
        - Phase diagrams;
        - Boiling point elevation and freezing point depression;
    - Equilibrium concept:
        - Equilibria expressed in terms of relative concentrations;
        - Equilibria expressed in terms of partial pressures;
        - Relationship between equilibrium constants and Gibbs' free energy;
        - Relationship between equilibrium constants expressed via concentrations, pressures, and mole fraction;
        - Solubility product;
        - Relevant calculations;
- Thermodynamics:
    - First law of thermodynamics:
        - Energy, heat and work;
        - Systems and its surroundings;
    - Second law of thermodynamics:
        - Entropy and standard entropy changes;
        - Enthalpy and standard enthalpy changes;
            - Standard enthalpy of formation;

- Standard enthalpy of phase transitions;
- Enthalpy changes for bond dissociation;
- Hess's Law;
- Lattice Energy;

**Organic Chemistry:**

- General Concepts:
  - Nomenclature;
  - Structures;
  - Arrow Pushing Mechanisms;
  - Conformational Analysis;
  - Stereochemistry and Chirality;
- General Reactions:
  - Electrophilic Addition (to carbonyl and alkene)
  - Nucleophilic Substitution;
  - Elimination Reactions;
- Functional Groups:
  - Acidity and Basicity of common functional groups;
  - Alkanes, Alkene and Alkyne chemistry;
  - Carbonyl compounds chemistry;

**Laboratory Skills:**

- Choosing appropriate materials for common lab task;
- Identifying correct procedures for common lab tasks;
- Error analysis.

* There will not be a hands-on lab exam, but students will be asked about laboratory skills or planning on the online exam.

**Preparation for Exam:**

In general, reading a university-level **general** chemistry textbook (eg. Zumdahl Chemistry) and supplementing it with relevant chapters from a university-level organic chemistry book (eg. Klein Organic Chemistry) will aid students in preparation.

Note that none of these books are required to prepare for the exam, nor are they the only way possible to prepare. Reviewing past US National chemistry olympiad **local** exams (acs.org/olympiad); IJSO chemistry exams (https://ijsoweb.org/downloads) are other ways recommended for preparation. The hardest questions on the exam will resemble USNCO National Chemistry Olympiad National Part I questions.

**Formula Sheet Provided for both 8th-9th Grade and 10th-12th Grade Chemistry Exams:**

**CONSTANTS:**

$h = 6.626 \times 10^{-34}$ J · s

F = 96485 C/(mol $e^-$)

$c = 2.998 \times 10^8$ m/s

R = 8.314 J/(K · mol) = 0.08206 L · atm/(mol · K)

