Harvard Undergraduate Science Olympiad India/Dubai 2025
Open Round
Chemistry Syllabus: 7th-8th 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!

Advanced Topics:
This syllabus contains topics which might be covered both in the open and the in person round, with **more emphasis being put on the black topics** and probably close to no emphasis being put on the red topics. The exam will have questions testing a subset and not all of these bullet points in this extensive list of topics in the syllabus. We wish you a lot of good luck studying! **Organic chemistry will not be tested.**

Inorganic Chemistry:
- Periodic Table:
    - Elements classification;
        - 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;
    - Trends:
      - Trends in electronegativity;
      - 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:
    - Unit Cells;
    - Metallic Bonding;
  - Oxides (acid and base properties);
- Chemical Reactions:
  - Reaction types;
  - Balancing reactions;
  - Empirical formulas;
  - Stoichiometric calculations:
    - Concentrations;
    - Mole concept via volume, mass and number of atoms;
  - Oxidizing and reducing agents, identifying and predicting;

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;
- ● Quantitative Analysis:
  - ○ Acid-base titrations;
  - ○ Oxidation-reduction titrations;
  - ○ Precipitation titrations;
  - ○ Combustion analysis;
- ● Qualitative Analysis:
  - ○ Flame tests;
  - ○ Specific identification reactions for common cations and anions;
  - ○ Solubility of Compounds:
    - ■ Soluble, slightly soluble, and insoluble salts;
    - ■ Working with solubility constants;
    - ■ Saturated, unsaturated, and supersaturated solutions;

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 expressed via concentrations, pressures, and mole fraction;
    - ■ Solubility product;
    - ■ Relevant calculations;
- ● Kinetics:
  - ○ Reaction rate:
    - ■ Order of reactions;
    - ■ Reaction rate constants;
    - ■ Rate Laws;
    - ■ Relation between half-life and rate constant;
    - ■ Relevant calculations;
  - ○ Factors influencing reaction rate:

- - - Catalyst effects;
  - - Concentration effects;
  - - Temperature effects;
- 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;
    - Gibbs' free energy and standard Gibbs' free energy changes;
      - Relationship between entropy, enthalpy and Gibbs' free energy;
      - Relationship between equilibrium constants and Gibbs' free energy.

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:
The following books which can be found online cover good fundamentals:
- General Chemistry Hardcover by Darrell Ebbing and Steven D. Gammon.

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) from old years (i.e. before 2015); IJSO chemistry exams (https://ijsoweb.org/downloads) again from old years (i.e before 2018), or mocking AP Chemistry exams are other ways recommended for preparation, but all of these are ABOVE the difficulty of this competition. Making sure you have a mastery of honors chemistry is the first priority.

There will be some difficult questions that will challenge even the brightest of students, so don't get discouraged while studying!

Formula Sheet Provided for both 7th-8th Grade and 9th-10th Grade Chemistry Exams:
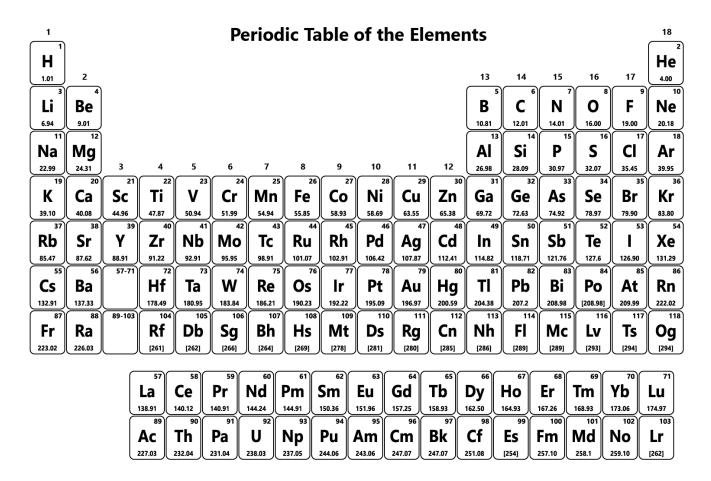
CONSTANTS:
h = 6.626 x 10^{-34} J·s
F = 96485 C/(mol e$^-$)
c = 2.998 x 10^8 m/s
R = 8.314 J/(K·mol) = 0.08206 L·atm/(mol·K)

Periodic Table of the Elements

1																	18
H 1.01	2											13	14	15	16	17	**He** 4.00
Li 6.94	**Be** 9.01											**B** 10.81	**C** 12.01	**N** 14.01	**O** 16.00	**F** 19.00	**Ne** 20.18
Na 22.99	**Mg** 24.31	3	4	5	6	7	8	9	10	11	12	**Al** 26.98	**Si** 28.09	**P** 30.97	**S** 32.07	**Cl** 35.45	**Ar** 39.95
K 39.10	**Ca** 40.08	**Sc** 44.96	**Ti** 47.87	**V** 50.94	**Cr** 51.99	**Mn** 54.94	**Fe** 55.85	**Co** 58.93	**Ni** 58.69	**Cu** 63.55	**Zn** 65.38	**Ga** 69.72	**Ge** 72.63	**As** 74.92	**Se** 78.97	**Br** 79.90	**Kr** 83.80
Rb 85.47	**Sr** 87.62	**Y** 88.91	**Zr** 91.22	**Nb** 92.91	**Mo** 95.95	**Tc** 98.91	**Ru** 101.07	**Rh** 102.91	**Pd** 106.42	**Ag** 107.87	**Cd** 112.41	**In** 114.82	**Sn** 118.71	**Sb** 121.76	**Te** 127.6	**I** 126.90	**Xe** 131.29
Cs 132.91	**Ba** 137.33	57-71	**Hf** 178.49	**Ta** 180.95	**W** 183.84	**Re** 186.21	**Os** 190.23	**Ir** 192.22	**Pt** 195.09	**Au** 196.97	**Hg** 200.59	**Tl** 204.38	**Pb** 207.2	**Bi** 208.98	**Po** [208.98]	**At** 209.99	**Rn** 222.02
Fr 223.02	**Ra** 226.03	89-103	**Rf** [261]	**Db** [262]	**Sg** [266]	**Bh** [264]	**Hs** [269]	**Mt** [278]	**Ds** [281]	**Rg** [280]	**Cn** [285]	**Nh** [286]	**Fl** [289]	**Mc** [289]	**Lv** [293]	**Ts** [294]	**Og** [294]

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La 138.91	**Ce** 140.12	**Pr** 140.91	**Nd** 144.24	**Pm** 144.91	**Sm** 150.36	**Eu** 151.96	**Gd** 157.25	**Tb** 158.93	**Dy** 162.50	**Ho** 164.93	**Er** 167.26	**Tm** 168.93	**Yb** 173.06	**Lu** 174.97
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac 227.03	**Th** 232.04	**Pa** 231.04	**U** 238.03	**Np** 237.05	**Pu** 244.06	**Am** 243.06	**Cm** 247.07	**Bk** 247.07	**Cf** 251.08	**Es** [254]	**Fm** 257.10	**Md** 258.1	**No** 259.10	**Lr** [262]