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## XIX. Chemistry, High School

# High School Chemistry Test

The spring 2019 high school Chemistry test was based on learning standards in the Chemistry content strand of the October 2006 version of the *Massachusetts Science and Technology/Engineering Curriculum Framework*. The 2006 framework is available on the Department website at [www.doe.mass.edu/frameworks/archive.html](http://www.doe.mass.edu/frameworks/archive.html). Massachusetts adopted a new curriculum framework in science and technology/engineering in 2016. A plan for transitioning the MCAS assessments to the new framework is available at [www.doe.mass.edu/mcas/tdd/sci.html?section=transition](http://www.doe.mass.edu/mcas/tdd/sci.html?section=transition).

Chemistry test results are reported under the following four MCAS reporting categories:

- Atomic Structure and Periodicity
- Bonding and Reactions
- Properties of Matter and Thermochemistry
- Solutions, Equilibrium, and Acid-Base Theory

The table at the conclusion of this chapter indicates each item's reporting category and the framework learning standard it assesses. In order to support future test development, items from the spring 2019 Chemistry test are not included in this publication. The omission of these items will have no impact on the reporting of results.

## Test Sessions

The high school Chemistry test included two separate test sessions, which were administered on consecutive days. Each session included multiple-choice and open-response questions.

## Reference Materials and Tools

Each student taking the high school Chemistry test was provided with a Chemistry Formula and Constants Sheet/Periodic Table of the Elements. Copies of both sides of this formula sheet appear on the following pages.

Each student also had sole access to a calculator with at least four functions and a square-root key.

During both Chemistry test sessions, the use of bilingual word-to-word dictionaries was allowed for current and former English learner students only. No other reference tools or materials were allowed.

**Common Polyatomic Ions**

Ion	Ionic Formula
Ammonium	$\text{NH}_4^+$
Carbonate	$\text{CO}_3^{2-}$
Hydroxide	$\text{OH}^-$
Nitrate	$\text{NO}_3^-$
Phosphate	$\text{PO}_4^{3-}$
Sulfate	$\text{SO}_4^{2-}$

**Combined Gas Law:**  $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

**Ideal Gas Law:**  $PV = nRT$

**Dilution Formula:**  $M_1 V_1 = M_2 V_2$

**Molar Volume of Ideal Gas at STP:** 22.4 L/mol

**Ideal Gas Constant:**  $R = 0.0821 \text{ L} \cdot \text{atm/mol} \cdot \text{K} = 8.31 \text{ L} \cdot \text{kPa/mol} \cdot \text{K}$

**STP:** 1 atm (101.3 kPa), 273 K (0°C)

**Absolute Temperature Conversion:**  $\text{K} = ^\circ\text{C} + 273$

**Definition of pH:**  $\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log[\text{H}^+]$

**Avogadro's Number:**  $6.02 \times 10^{23}$  particles/mol

**Nuclear Symbols**

Name	Symbol
Alpha particle	$\alpha$ or ${}^4_2\text{He}$
Beta particle	$\beta$ or ${}^0_{-1}e$
Gamma ray	$\gamma$
Neutron	${}^1_0n$

# Massachusetts Comprehensive Assessment System

## Periodic Table of the Elements

Group (Family)

1A  
1

8A  
18

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.01 H Hydrogen	6.94 Li Lithium	9.01 Be Beryllium	47.88 Ti Titanium	50.94 V Vanadium	52.00 Cr Chromium	54.94 Mn Manganese	55.85 Fe Iron	58.93 Co Cobalt	58.93 Ni Nickel	63.55 Cu Copper	65.39 Zn Zinc	10.81 B Boron	12.01 C Carbon	14.01 N Nitrogen	16.00 O Oxygen	19.00 F Fluorine	20.18 Ne Neon
22.99 Na Sodium	24.31 Mg Magnesium	44.96 Sc Scandium	87.62 K Potassium	92.91 Ca Calcium	95.94 Scandium	98 (98) Mn Manganese	101.07 Fe Iron	102.91 Co Cobalt	106.42 Ni Nickel	107.87 Cu Copper	112.41 Zn Zinc	26.98 Al Aluminum	28.09 Si Silicon	30.97 P Phosphorus	32.06 S Sulfur	35.45 Cl Chlorine	39.95 Ar Argon
85.47 Rb Rubidium	87.62 Sr Strontium	88.91 Y Yttrium	91.22 Zr Zirconium	92.91 Nb Niobium	95.94 Mo Molybdenum	98 (98) Tc Technetium	101.07 Ru Ruthenium	102.91 Rh Rhodium	106.42 Pd Palladium	107.87 Ag Silver	112.41 Cd Cadmium	114.82 In Indium	118.71 Sn Tin	121.75 Sb Antimony	127.60 Te Tellurium	126.91 I Iodine	131.29 Xe Xenon
132.91 Cs Cesium	137.33 Ba Barium	180.95 La Lanthanum	178.49 Hf Hafnium	180.95 Ta Tantalum	183.85 W Tungsten	186.21 Re Rhenium	190.23 Os Osmium	192.22 Ir Iridium	195.08 Pt Platinum	196.97 Au Gold	200.59 Hg Mercury	204.38 Tl Thallium	207.2 Pb Lead	208.98 Bi Bismuth	(209) Po Polonium	(222) At Astatine	(222) Rn Radon
223 (223) Fr Francium	(226) (226) Ra Radium	138.91 La Lanthanum	140.12 Ce Cerium	140.91 Pr Praseodymium	144.24 Nd Neodymium	145 (145) Pm Promethium	150.36 Sm Samarium	151.96 Eu Europium	157.25 Gd Gadolinium	158.93 Tb Terbium	162.50 Dy Dysprosium	164.93 Ho Holmium	167.26 Er Erbium	168.93 Tm Thulium	173.04 Yb Ytterbium	174.97 Lu Lutetium	
		232.04 (227) Ac Actinium	232.04 (227) Th Thorium	231.04 (231) Pa Protactinium	238.03 (238) U Uranium	237 (237) Np Neptunium	244 (244) Pu Plutonium	243 (243) Am Americium	247 (247) Cm Curium	251 (251) Bk Berkelium	257 (257) Cf Californium	252 (252) Es Einsteinium	257 (257) Fm Fermium	258 (258) Md Mendelevium	259 (259) No Nobelium	262 (262) Lr Lawrencium	

Key:

atomic weight
Symbol
atomic number
Name

Mass numbers in parentheses are those of the most stable or most common isotope.

Lanthanide Series

Actinide Series

\* Revised based on IUPAC Commission on Atomic Weights and Isotopic Abundances, "Atomic Weights of the Elements 2007."

**High School Chemistry**  
**Spring 2019 Unreleased Operational Items**

<b>Item No.</b>	<b>Reporting Category</b>	<b>2006 Standard</b>
1	<i>Bonding and Reactions</i>	STE.CH.Reac5.1
2	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Sol7.1
3	<i>Bonding and Reactions</i>	STE.CH.Bond4.3
4	<i>Properties of Matter and Thermochemistry</i>	STE.CH.SM6.4
5	<i>Bonding and Reactions</i>	STE.CH.Reac5.2
6	<i>Properties of Matter and Thermochemistry</i>	STE.CH.SM6.3
7	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Sol7.5
8	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.2
9	<i>Bonding and Reactions</i>	STE.CH.Acid8.4
10	<i>Properties of Matter and Thermochemistry</i>	STE.CH.PM1.1
11	<i>Bonding and Reactions</i>	STE.CH.Bond4.2
12	<i>Bonding and Reactions</i>	STE.CH.Reac5.6
13	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.1
14	<i>Properties of Matter and Thermochemistry</i>	STE.CH.PM1.2
15	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Acid8.2
16	<i>Properties of Matter and Thermochemistry</i>	STE.CH.PM1.3
17	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.6
18	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Sol7.2
19	<i>Bonding and Reactions</i>	STE.CH.Bond4.5
20	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.5
21	<i>Properties of Matter and Thermochemistry</i>	STE.CH.SM6.5
22	<i>Properties of Matter and Thermochemistry</i>	STE.CH.SM6.1
23	<i>Bonding and Reactions</i>	STE.CH.Reac5.5
24	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Acid8.3
25	<i>Properties of Matter and Thermochemistry</i>	STE.CH.PM1.3
26	<i>Bonding and Reactions</i>	STE.CH.Bond4.6
27	<i>Bonding and Reactions</i>	STE.CH.Reac5.4
28	<i>Bonding and Reactions</i>	STE.CH.Bond4.1
29	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Sol7.3
30	<i>Atomic Structure and Periodicity</i>	STE.CH.Per3.4
31	<i>Properties of Matter and Thermochemistry</i>	STE.CH.SM6.2
32	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.3
33	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.1
34	<i>Atomic Structure and Periodicity</i>	STE.CH.Per3.2

<b>Item No.</b>	<b>Reporting Category</b>	<b>2006 Standard</b>
35	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.7
36	<i>Bonding and Reactions</i>	STE.CH.Reac5.3
37	<i>Properties of Matter and Thermochemistry</i>	STE.CH.PM1.2
38	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Acid8.1
39	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Sol7.4
40	<i>Atomic Structure and Periodicity</i>	STE.CH.Per3.3
41	<i>Atomic Structure and Periodicity</i>	STE.CH.Per3.1
42	<i>Atomic Structure and Periodicity</i>	STE.CH.AS2.4
43	<i>Properties of Matter and Thermochemistry</i>	STE.CH.SM6.1
44	<i>Properties of Matter and Thermochemistry</i>	STE.CH.SM6.3
45	<i>Solutions, Equilibrium, and Acid-Base Theory</i>	STE.CH.Sol7.6