XIX. Chemistry, High School

High School Chemistry Test

The spring 2016 high school Chemistry test was based on learning standards in the Chemistry content strand of the *Massachusetts Science and Technology/Engineering Curriculum Framework* (2006). These learning standards appear on pages 69–73 of the *Framework*, which is available on the Department website at www.doe.mass.edu/frameworks/current.html.

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 2016 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 language learner students only. No other reference tools or materials were allowed.

Common Polyatomic Ions

Ion	Ionic Formula
Ammonium	NH_4^+
Carbonate	CO_3^{2-}
Hydroxide	OH^-
Nitrate	NO_3^-
Phosphate	PO_4^{3-}
Sulfate	SO_4^{2-}

Combined Gas Law: $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Ideal Gas Law: $PV = nRT$

Dilution Formula: $M_1V_1 = M_2V_2$

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

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

STP: 1 atm (101.3 kPa), 273 K (0°C)

Absolute Temperature Conversion: $K = °C + 273$

Definition of pH: $pH = -\log[H_3O^+] = -\log[H^+]$

Avogadro's Number: 6.02×10^{23} particles/mol

Nuclear Symbols

Name	Symbol
Alpha particle	α or ${}_2^4He$
Beta particle	β or ${}_{-1}^0e$
Gamma ray	γ
Neutron	${}_0^1n$

MASSACHUSETTS DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION

Massachusetts Comprehensive Assessment System

Periodic Table of the Elements

Period	1A 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	1.01 H 1 Hydrogen																	4.00 He 2 Helium
2	6.94 Li 3 Lithium	9.01 Be 4 Beryllium											10.81 B 5 Boron	12.01 C 6 Carbon	14.01 N 7 Nitrogen	16.00 O 8 Oxygen	19.00 F 9 Fluorine	20.18 Ne 10 Neon
3	22.99 Na 11 Sodium	24.31 Mg 12 Magnesium											26.98 Al 13 Aluminum	28.09 Si 14 Silicon	30.97 P 15 Phosphorus	32.06 S 16 Sulfur	35.45 Cl 17 Chlorine	39.95 Ar 18 Argon
4	39.10 K 19 Potassium	40.08 Ca 20 Calcium	44.96 Sc 21 Scandium	47.88 Ti 22 Titanium	50.94 V 23 Vanadium	52.00 Cr 24 Chromium	54.94 Mn 25 Manganese	55.85 Fe 26 Iron	58.93 Co 27 Cobalt	58.69 Ni 28 Nickel	63.55 Cu 29 Copper	65.39 Zn 30 Zinc	69.72 Ga 31 Gallium	72.59 Ge 32 Germanium	74.92 As 33 Arsenic	78.96 Se 34 Selenium	79.90 Br 35 Bromine	83.80 Kr 36 Krypton
5	85.47 Rb 37 Rubidium	87.62 Sr 38 Strontium	88.91 Y 39 Yttrium	91.22 Zr 40 Zirconium	92.91 Nb 41 Niobium	95.94 Mo 42 Molybdenum	(98) Tc 43 Technetium	101.07 Ru 44 Ruthenium	102.91 Rh 45 Rhodium	106.42 Pd 46 Palladium	107.87 Ag 47 Silver	112.41 Cd 48 Cadmium	114.82 In 49 Indium	118.71 Sn 50 Tin	121.75 Sb 51 Antimony	127.60 Te 52 Tellurium	126.91 I 53 Iodine	131.29 Xe 54 Xenon
6	132.91 Cs 55 Cesium	137.33 Ba 56 Barium		178.49 Hf 72 Hafnium	180.95 Ta 73 Tantalum	183.85 W 74 Tungsten	186.21 Re 75 Rhenium	190.23 Os 76 Osmium	192.22 Ir 77 Iridium	195.08 Pt 78 Platinum	196.97 Au 79 Gold	200.59 Hg 80 Mercury	204.38 Tl 81 Thallium	207.2 Pb 82 Lead	208.98 Bi 83 Bismuth	(209) Po 84 Polonium	(210) At 85 Astatine	(222) Rn 86 Radon
7	(223) Fr 87 Francium	(226) Ra 88 Radium		(267) Rf 104 Rutherfordium	(268) Db 105 Dubnium	(271) Sg 106 Seaborgium	(272) Bh 107 Bohrium	(277) Hs 108 Hassium	(276) Mt 109 Meitnerium	(281) Ds 110 Darmstadtium	(280) Rg 111 Roentgenium							

Key:

atomic weight
Symbol
atomic number
Name

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

Lanthanide Series	138.91 La 57 Lanthanum	140.12 Ce 58 Cerium	140.91 Pr 59 Praseodymium	144.24 Nd 60 Neodymium	(145) Pm 61 Promethium	150.36 Sm 62 Samarium	151.96 Eu 63 Europium	157.25 Gd 64 Gadolinium	158.93 Tb 65 Terbium	162.50 Dy 66 Dysprosium	164.93 Ho 67 Holmium	167.26 Er 68 Erbium	168.93 Tm 69 Thulium	173.04 Yb 70 Ytterbium	174.97 Lu 71 Lutetium
Actinide Series	(227) Ac 89 Actinium	232.04 Th 90 Thorium	231.04 Pa 91 Protactinium	238.03 U 92 Uranium	(237) Np 93 Neptunium	(244) Pu 94 Plutonium	(243) Am 95 Americium	(247) Cm 96 Curium	(247) Bk 97 Berkelium	(251) Cf 98 Californium	(252) Es 99 Einsteinium	(257) Fm 100 Fermium	(258) Md 101 Mendelevium	(259) No 102 Nobelium	(262) Lr 103 Lawrencium

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

High School Chemistry
Spring 2016 Items:
Reporting Categories and Standards

Item No.	Reporting Category	Standard
1	*Atomic Structure and Periodicity*	2.4
2	*Atomic Structure and Periodicity*	3.3
3	*Atomic Structure and Periodicity*	2.5
4	*Properties of Matter and Thermochemistry*	6.4
5	*Bonding and Reactions*	4.4
6	*Bonding and Reactions*	5.5
7	*Atomic Structure and Periodicity*	2.6
8	*Solutions, Equilibrium, and Acid-Base Theory*	7.5
9	*Properties of Matter and Thermochemistry*	1.3
10	*Properties of Matter and Thermochemistry*	6.1
11	*Solutions, Equilibrium, and Acid-Base Theory*	8.3
12	*Bonding and Reactions*	4.1
13	*Solutions, Equilibrium, and Acid-Base Theory*	7.1
14	*Bonding and Reactions*	5.6
15	*Atomic Structure and Periodicity*	3.4
16	*Properties of Matter and Thermochemistry*	1.1
17	*Bonding and Reactions*	5.4
18	*Bonding and Reactions*	4.3
19	*Atomic Structure and Periodicity*	3.3
20	*Properties of Matter and Thermochemistry*	6.4
21	*Properties of Matter and Thermochemistry*	6.3
22	*Solutions, Equilibrium, and Acid-Base Theory*	7.4
23	*Properties of Matter and Thermochemistry*	1.2
24	*Atomic Structure and Periodicity*	2.7
25	*Properties of Matter and Thermochemistry*	6.2
26	*Solutions, Equilibrium, and Acid-Base Theory*	8.2
27	*Properties of Matter and Thermochemistry*	6.1
28	*Atomic Structure and Periodicity*	3.1
29	*Bonding and Reactions*	5.1
30	*Solutions, Equilibrium, and Acid-Base Theory*	8.1
31	*Atomic Structure and Periodicity*	2.2
32	*Solutions, Equilibrium, and Acid-Base Theory*	7.6
33	*Bonding and Reactions*	4.1
34	*Properties of Matter and Thermochemistry*	6.2
35	*Properties of Matter and Thermochemistry*	6.5
36	*Bonding and Reactions*	4.6
37	*Properties of Matter and Thermochemistry*	1.2
38	*Atomic Structure and Periodicity*	2.2
39	*Solutions, Equilibrium, and Acid-Base Theory*	7.2
40	*Atomic Structure and Periodicity*	2.3

Item No.	Reporting Category	Standard
41	*Bonding and Reactions*	4.2
42	*Solutions, Equilibrium, and Acid-Base Theory*	7.3
43	*Bonding and Reactions*	5.3
44	*Atomic Structure and Periodicity*	3.2
45	*Bonding and Reactions*	5.2