

# STAAR CHEMISTRY REFERENCE MATERIALS



## ATOMIC STRUCTURE

$$\text{Speed of light} = (\text{frequency})(\text{wavelength}) \quad c = f\lambda$$

$$\text{Energy} = (\text{Planck's constant})(\text{frequency}) \quad E_{\text{photon}} = hf$$

$$\text{Energy} = \frac{(\text{Planck's constant})(\text{speed of light})}{(\text{wavelength})} \quad E_{\text{photon}} = \frac{hc}{\lambda}$$

## BEHAVIOR OF GASES

$$\text{Total pressure of a gas} = \left( \begin{array}{l} \text{sum of the partial pressures} \\ \text{of the component gases} \end{array} \right) \quad P_T = P_1 + P_2 + P_3 + \dots$$

$$(\text{Pressure})(\text{volume}) = (\text{moles})(\text{ideal gas constant})(\text{temperature}) \quad PV = nRT$$

$$\frac{(\text{Initial pressure})(\text{initial volume})}{(\text{Initial moles})(\text{initial temperature})} = \frac{(\text{final pressure})(\text{final volume})}{(\text{final moles})(\text{final temperature})} \quad \frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$$

$$(\text{Initial pressure})(\text{initial volume}) = (\text{final pressure})(\text{final volume}) \quad P_1V_1 = P_2V_2$$

$$\frac{(\text{Initial volume})}{(\text{Initial temperature})} = \frac{(\text{final volume})}{(\text{final temperature})} \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{(\text{Initial volume})}{(\text{Initial moles})} = \frac{(\text{final volume})}{(\text{final moles})} \quad \frac{V_1}{n_1} = \frac{V_2}{n_2}$$

## SOLUTIONS

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liter of solution}} \quad M = \frac{\text{mol}}{\text{L}}$$

$$\text{Ionization constant of water} = \left( \begin{array}{l} \text{hydrogen ion} \\ \text{concentration} \end{array} \right) \left( \begin{array}{l} \text{hydroxide ion} \\ \text{concentration} \end{array} \right) \quad K_w = [\text{H}^+][\text{OH}^-]$$

$$\left( \begin{array}{l} \text{Volume of} \\ \text{solution 1} \end{array} \right) \left( \begin{array}{l} \text{molarity of} \\ \text{solution 1} \end{array} \right) = \left( \begin{array}{l} \text{volume of} \\ \text{solution 2} \end{array} \right) \left( \begin{array}{l} \text{molarity of} \\ \text{solution 2} \end{array} \right) \quad V_1M_1 = V_2M_2$$

$$\text{pH} = -\log(\text{hydrogen ion concentration}) \quad \text{pH} = -\log[\text{H}^+]$$

## THERMOCHEMISTRY

$$\text{Heat gained or lost} = (\text{mass}) \left( \begin{array}{l} \text{specific} \\ \text{heat} \end{array} \right) \left( \begin{array}{l} \text{change in} \\ \text{temperature} \end{array} \right) \quad Q = mc_p\Delta T$$

$$\text{Enthalpy of reaction} = \left( \begin{array}{l} \text{enthalpy} \\ \text{of products} \end{array} \right) - \left( \begin{array}{l} \text{enthalpy} \\ \text{of reactants} \end{array} \right) \quad \Delta H = \Delta H_f^\circ(\text{products}) - \Delta H_f^\circ(\text{reactants})$$

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## OTHER FORMULAS

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$D = \frac{m}{V}$$

$$\text{Percent error} = \left( \frac{\text{accepted value} - \text{experimental value}}{\text{accepted value}} \right) (100)$$

$$\text{Percent yield} = \left( \frac{\text{actual yield}}{\text{theoretical yield}} \right) (100)$$

## CONSTANTS AND CONVERSIONS

$$\text{Avogadro's number} = 6.02 \times 10^{23} \text{ particles per mole}$$

$$h = \text{Planck's constant} = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$$

$$c = \text{speed of light} = 3.00 \times 10^8 \frac{\text{m}}{\text{s}}$$

$$K_w = \text{ionization constant of water} = 1.00 \times 10^{-14} \left( \frac{\text{mol}}{\text{L}} \right)^2$$

$$\text{alpha particle } (\alpha) = {}_2^4\text{He} \quad \text{beta particle } (\beta) = {}_{-1}^0\text{e} \quad \text{neutron} = {}_0^1\text{n}$$

$$\text{standard temperature and pressure (STP)} = 0^\circ\text{C and } 1 \text{ atm}$$

$$0^\circ\text{C} = 273 \text{ K}$$

$$\text{volume of ideal gas at STP} = 22.4 \frac{\text{L}}{\text{mol}}$$

$$1 \text{ cm}^3 = 1 \text{ mL} = 1 \text{ cc}$$

$$1 \text{ atm} = 760 \text{ mm Hg} = 101.3 \text{ kPa}$$

$$R = \text{ideal gas constant} = 0.0821 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} = 8.31 \frac{\text{L} \cdot \text{kPa}}{\text{mol} \cdot \text{K}} = 62.4 \frac{\text{L} \cdot \text{mm Hg}}{\text{mol} \cdot \text{K}}$$

$$1 \text{ calorie (cal)} = 4.18 \text{ joules (J)}$$


$$1000 \text{ calories (cal)} = 1 \text{ Calorie (Cal)} = 1 \text{ kilocalorie (kcal)}$$

## RULES FOR SIGNIFICANT FIGURES

1. Non-zero digits and zeros between non-zero digits are always significant.
2. Leading zeros are not significant.
3. Zeros to the right of all non-zero digits are only significant if a decimal point is shown.
4. For values written in scientific notation, the digits in the coefficient are significant.
5. In a common logarithm, there are as many digits after the decimal point as there are significant figures in the original number.

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POLYATOMIC IONS	SOLUBILITY OF COMMON IONIC COMPOUNDS IN WATER		ACTIVITY SERIES
Acetate	<u>Soluble</u> compounds contain	<u>Common exceptions</u>	<div style="text-align: center;">  <p>Increasing Activity</p> </div>
Ammonium	C <sub>2</sub> H <sub>3</sub> O <sub>2</sub> <sup>-</sup> , CH <sub>3</sub> COO <sup>-</sup>	None	
Carbonate	NH <sub>4</sub> <sup>+</sup>	None	
Chlorate	CO <sub>3</sub> <sup>2-</sup>	None	
Chlorite	ClO <sub>3</sub> <sup>-</sup>	None	
Chromate	ClO <sub>2</sub> <sup>-</sup>	None	
Cyanide	CrO <sub>4</sub> <sup>2-</sup>	None	
Dichromate	CN <sup>-</sup>	None	
Hydrogen carbonate	Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup>	Compounds of Ag <sup>+</sup> , Pb <sup>2+</sup> , and Hg <sub>2</sub> <sup>+</sup>	
Hydroxide	HCO <sub>3</sub> <sup>-</sup>	Compounds of Ag <sup>+</sup> , Pb <sup>2+</sup> , and Hg <sub>2</sub> <sup>+</sup>	
Hypochlorite	OH <sup>-</sup>	Compounds of Sr <sup>2+</sup> , Ba <sup>2+</sup> , Pb <sup>2+</sup> , and Hg <sub>2</sub> <sup>+</sup>	
Nitrate	SO <sub>4</sub> <sup>2-</sup>	Compounds of Sr <sup>2+</sup> , Ba <sup>2+</sup> , Pb <sup>2+</sup> , and Hg <sub>2</sub> <sup>+</sup>	
Nitrite	<u>Insoluble</u> compounds contain	<u>Common exceptions</u>	
Perchlorate	CO <sub>3</sub> <sup>2-</sup>	Compounds of NH <sub>4</sub> <sup>+</sup> and the alkali metal cations	
Permanganate	PO <sub>4</sub> <sup>3-</sup>	Compounds of NH <sub>4</sub> <sup>+</sup> and the alkali metal cations	
Phosphate	NO <sub>2</sub> <sup>-</sup>	Compounds of NH <sub>4</sub> <sup>+</sup> and the alkali metal cations	
Sulfate	ClO <sub>4</sub> <sup>-</sup>	Compounds of NH <sub>4</sub> <sup>+</sup> and the alkali metal cations	
Sulfite	MnO <sub>4</sub> <sup>-</sup>	Compounds of NH <sub>4</sub> <sup>+</sup> and the alkali metal cations, Ca <sup>2+</sup> , Sr <sup>2+</sup> , and Ba <sup>2+</sup>	
	PO <sub>4</sub> <sup>3-</sup>	Compounds of NH <sub>4</sub> <sup>+</sup> , the alkali metal cations, Ca <sup>2+</sup> , Sr <sup>2+</sup> , and Ba <sup>2+</sup>	
	SO <sub>4</sub> <sup>2-</sup>	Compounds of NH <sub>4</sub> <sup>+</sup> , the alkali metal cations, Ca <sup>2+</sup> , Sr <sup>2+</sup> , and Ba <sup>2+</sup>	
	SO <sub>3</sub> <sup>2-</sup>		

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## PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1A	2A	3B	4B	5B	6B	7B	8B	9B	10B	11B	12B	3A	4A	5A	6A	7A	8A
1 <b>H</b> 1.008 Hydrogen	2 <b>He</b> 4.003 Helium	3 <b>Li</b> 6.941 Lithium	4 <b>Be</b> 9.012 Beryllium	5 <b>B</b> 10.812 Boron	6 <b>C</b> 12.011 Carbon	7 <b>N</b> 14.007 Nitrogen	8 <b>O</b> 15.999 Oxygen	9 <b>F</b> 18.998 Fluorine	10 <b>Ne</b> 20.180 Neon	11 <b>Na</b> 22.990 Sodium	12 <b>Mg</b> 24.305 Magnesium	13 <b>Al</b> 26.982 Aluminum	14 <b>Si</b> 28.086 Silicon	15 <b>P</b> 30.974 Phosphorus	16 <b>S</b> 32.066 Sulfur	17 <b>Cl</b> 35.453 Chlorine	18 <b>Ar</b> 39.948 Argon
19 <b>K</b> 39.098 Potassium	20 <b>Ca</b> 40.078 Calcium	21 <b>Sc</b> 44.956 Scandium	22 <b>Ti</b> 47.867 Titanium	23 <b>V</b> 50.942 Vanadium	24 <b>Cr</b> 51.996 Chromium	25 <b>Mn</b> 54.938 Manganese	26 <b>Fe</b> 55.845 Iron	27 <b>Co</b> 58.933 Cobalt	28 <b>Ni</b> 58.693 Nickel	29 <b>Cu</b> 63.546 Copper	30 <b>Zn</b> 65.38 Zinc	31 <b>Ga</b> 69.723 Gallium	32 <b>Ge</b> 72.64 Germanium	33 <b>As</b> 74.922 Arsenic	34 <b>Se</b> 78.96 Selenium	35 <b>Br</b> 79.904 Bromine	36 <b>Kr</b> 83.798 Krypton
37 <b>Rb</b> 85.468 Rubidium	38 <b>Sr</b> 87.62 Strontium	39 <b>Y</b> 88.906 Yttrium	40 <b>Zr</b> 91.224 Zirconium	41 <b>Nb</b> 92.906 Niobium	42 <b>Mo</b> 95.96 Molybdenum	43 <b>Tc</b> (98) Technetium	44 <b>Ru</b> 101.07 Ruthenium	45 <b>Rh</b> 102.906 Rhodium	46 <b>Pd</b> 106.42 Palladium	47 <b>Ag</b> 107.868 Silver	48 <b>Cd</b> 112.412 Cadmium	49 <b>In</b> 114.818 Indium	50 <b>Sn</b> 118.711 Tin	51 <b>Sb</b> 121.760 Antimony	52 <b>Te</b> 127.60 Tellurium	53 <b>I</b> 126.904 Iodine	54 <b>Xe</b> 131.294 Xenon
55 <b>Cs</b> 132.905 Cesium	56 <b>Ba</b> 137.328 Barium	57 <b>La</b> 138.905 Lanthanum	58 <b>Ce</b> 140.116 Cerium	59 <b>Pr</b> 140.908 Praseodymium	60 <b>Nd</b> 144.242 Neodymium	61 <b>Pm</b> (145) Promethium	62 <b>Sm</b> 150.36 Samarium	63 <b>Eu</b> 151.964 Europium	64 <b>Gd</b> 157.25 Gadolinium	65 <b>Tb</b> 158.925 Terbium	66 <b>Dy</b> 162.500 Dysprosium	67 <b>Ho</b> 164.930 Holmium	68 <b>Er</b> 167.259 Erbium	69 <b>Tm</b> 168.934 Thulium	70 <b>Yb</b> 173.055 Ytterbium	71 <b>Lu</b> 174.967 Lutetium	72 <b>Hf</b> 178.49 Hafnium
87 <b>Fr</b> (223) Francium	88 <b>Ra</b> (226) Radium	89 <b>Ac</b> (227) Actinium	90 <b>Th</b> 232.038 Thorium	91 <b>Pa</b> 231.036 Protactinium	92 <b>U</b> 238.029 Uranium	93 <b>Np</b> (237) Neptunium	94 <b>Pu</b> (244) Plutonium	95 <b>Am</b> (243) Americium	96 <b>Cm</b> (247) Curium	97 <b>Bk</b> (247) Berkelium	98 <b>Cf</b> (251) Californium	99 <b>Es</b> (252) Einsteinium	100 <b>Fm</b> (257) Fermium	101 <b>Md</b> (258) Mendelevium	102 <b>No</b> (259) Nobelium	103 <b>Lr</b> (262) Lawrencium	104 <b>Rf</b> (267) Rutherfordium
105 <b>Db</b> (268) Dubnium	106 <b>Sg</b> (271) Seaborgium	107 <b>Bh</b> (272) Bohrium	108 <b>Hs</b> (270) Hassium	109 <b>Mt</b> (276) Meitnerium	110 <b>Ds</b> (281) Darmstadtium	111 <b>Rg</b> (280) Roentgenium	112 <b>Cn</b> (285) Copernicium	113 <b>Nh</b> (286) Nihonium	114 <b>Fl</b> (289) Flerovium	115 <b>Mc</b> (288) Moscovium	116 <b>Lv</b> (293) Livermorium	117 <b>Ts</b> (294) Tennessine	118 <b>Og</b> (294) Oganesson	119 <b>Uu</b> (295) Ununennium	120 <b>Uub</b> (293) Unbibium	121 <b>Uut</b> (293) Untrium	122 <b>Uuq</b> (293) Unquadium

Atomic number — 14  
Symbol — **Si**  
Atomic mass — 28.086  
Name — Silicon

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

Lanthanide Series

Actinide Series