$$PV = nRT$$

$$R = 0.08206 \frac{L\ atm}{mol\ K}$$

$$1atm = 760torr = 760mmHg$$

$$q = n\Delta H$$

$$\pi V = nRT$$

$$\Delta T_F = \kappa_F C_{molal}$$

$$K_w = [OH^-]\,[H_3O^+] = 1.0 \times 10^{-14}$$

$$pH = -log\,[H_3O^+]$$

$$pH = pK_a + log\left(\frac{Base}{Acid}\right)$$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$q = mC\Delta T$$

$$q = m\Delta H$$

$$C_1V_1 = C_2V_2$$

$$\Delta T_B = \kappa_B C_{molal}$$

$$K_A = \frac{[H^+]\,[A^-]}{[HA]}$$

$$[H_3O^+] = 10^{-pH}$$

$$N_{acid}V_{acid} = N_{base}V_{base}$$

Table 8.5 Melting Points, Boiling Points, Heats of Fusion, and Heats of Vaporization of Some Common Substances

Substance	Melting Point (°C)	Boiling Point (°C)	Heat of Fusion cal/g (J/g)	Heat of Vaporization cal/g (J/g)
Ammonia	−77.7	−33.4	84.0 (351)	327 (1370)
Butane	−138.4	−0.5	19.2 (80.3)	92.5 (387)
Ether	−116	34.6	23.5 (98.3)	85.6 (358)
Ethyl alcohol	−117.3	78.5	26.1 (109)	200 (837)
Isopropyl alcohol	−89.5	82.4	21.4 (89.5)	159 (665)
Sodium	97.8	883	14.3 (59.8)	492 (2060)
Water	0.0	100.0	79.7 (333)	540 (2260)

Table 10.2 Relative Strengths of Acids and Conjugate Bases

	Acid		Conjugate base			
Increasing acid strength ↑	Strong acids: 100% dissociated — Perchloric acid	$HClO_4$	ClO_4^-	Perchlorate ion	Little or no reaction as bases	Increasing base strength ↓
	Sulfuric acid	H_2SO_4	HSO_4^-	Hydrogen sulfate ion		
	Hydriodic acid	HI	I^-	Iodide ion		
	Hydrobromic acid	HBr	Br^-	Bromide ion		
	Hydrochloric acid	HCl	Cl^-	Chloride ion		
	Nitric acid	HNO_3	NO_3^-	Nitrate ion		
	Hydronium ion	H_3O^+	H_2O	**Water**		
	Weak acids — Hydrogen sulfate ion	HSO_4^-	SO_4^{2-}	Sulfate ion		
	Phosphoric acid	H_3PO_4	$H_2PO_4^-$	Dihydrogen phosphate ion	Very weak bases	
	Nitrous acid	HNO_2	NO_2^-	Nitrite ion		
	Hydrofluoric acid	HF	F^-	Fluoride ion		
	Acetic acid	CH_3COOH	CH_3COO^-	Acetate ion		
	Very weak acids — Carbonic acid	H_2CO_3	HCO_3^-	Bicarbonate ion		
	Dihydrogen phosphate ion	$H_2PO_4^-$	HPO_4^{2-}	Hydrogen phosphate ion		
	Ammonium ion	NH_4^+	NH_3	Ammonia	Weak bases	
	Hydrocyanic acid	HCN	CN^-	Cyanide ion		
	Bicarbonate ion	HCO_3^-	CO_3^{2-}	Carbonate ion		
	Hydrogen phosphate ion	HPO_4^{2-}	PO_4^{3-}	Phosphate ion		
	Water	H_2O	OH^-	**Hydroxide ion**	Strong base	

Table 10.3 Some Acid Dissociation Constants, K_a, at 25 °C

Acid	K_a	Acid	K_a
Hydrofluoric acid (HF)	3.5×10^{-4}	*Polyprotic acids*	
Hydrocyanic acid (HCN)	4.9×10^{-10}	Sulfuric acid	
Ammonium ion (NH_4^+)	5.6×10^{-10}	H_2SO_4	Large
		HSO_4^-	1.2×10^{-2}
Organic acids		Phosphoric acid	
Formic acid (HCOOH)	1.8×10^{-4}	H_3PO_4	7.5×10^{-3}
Acetic acid (CH_3COOH)	1.8×10^{-5}	$H_2PO_4^-$	6.2×10^{-8}
Propanoic acid (CH_3CH_2COOH)	1.3×10^{-5}	HPO_4^{2-}	2.2×10^{-13}
Ascorbic acid (vitamin C)	7.9×10^{-5}	Carbonic acid	
		H_2CO_3	4.3×10^{-7}
		HCO_3^-	5.6×10^{-11}

Periodic Table of the Elements

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.811	6 **C** Carbon 12.011	7 **N** Nitrogen 14.007	8 **O** Oxygen 15.999	9 **F** Fluorine 18.998	10 **Ne** Neon 20.180
11 **Na** Sodium 22.990	12 **Mg** Magnesium 24.305											13 **Al** Aluminum 26.982	14 **Si** Silicon 28.086	15 **P** Phosphorus 30.974	16 **S** Sulfur 32.066	17 **Cl** Chlorine 35.453	18 **Ar** Argon 39.948
19 **K** Potassium 39.098	20 **Ca** Calcium 40.078	21 **Sc** Scandium 44.956	22 **Ti** Titanium 47.867	23 **V** Vanadium 50.942	24 **Cr** Chromium 51.996	25 **Mn** Manganese 54.938	26 **Fe** Iron 55.845	27 **Co** Cobalt 58.933	28 **Ni** Nickel 58.693	29 **Cu** Copper 63.546	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.723	32 **Ge** Germanium 72.631	33 **As** Arsenic 74.922	34 **Se** Selenium 78.971	35 **Br** Bromine 79.904	36 **Kr** Krypton 83.798
37 **Rb** Rubidium 85.468	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.906	40 **Zr** Zirconium 91.224	41 **Nb** Niobium 92.906	42 **Mo** Molybdenum 95.95	43 **Tc** Technetium 98.907	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.906	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.868	48 **Cd** Cadmium 112.414	49 **In** Indium 114.818	50 **Sn** Tin 118.711	51 **Sb** Antimony 121.760	52 **Te** Tellurium 127.6	53 **I** Iodine 126.904	54 **Xe** Xenon 131.294
55 **Cs** Cesium 132.905	56 **Ba** Barium 137.328	57 **La** Lanthanum 138.905	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.948	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.207	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.217	78 **Pt** Platinum 195.085	79 **Au** Gold 196.967	80 **Hg** Mercury 200.592	81 **Tl** Thallium 204.383	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.980	84 **Po** Polonium [208.982]	85 **At** Astatine 209.987	86 **Rn** Radon 222.018
87 **Fr** Francium 223.020	88 **Ra** Radium 226.025	89 **Ac** Actinium 227.028	104 **Rf** Rutherfordium [261]	105 **Db** Dubnium [262]	106 **Sg** Seaborgium [266]	107 **Bh** Bohrium [264]	108 **Hs** Hassium [269]	109 **Mt** Meitnerium [278]	110 **Ds** Darmstadtium [281]	111 **Rg** Roentgenium [280]	112 **Cn** Copernicium [285]	113 **Nh** Nihonium [286]	114 **Fl** Flerovium [289]	115 **Mc** Moscovium [289]	116 **Lv** Livermorium [293]	117 **Ts** Tennessine [294]	118 **Og** Oganesson [294]

Lanthanide Series	58 **Ce** Cerium 140.116	59 **Pr** Praseodymium 140.908	60 **Nd** Neodymium 144.243	61 **Pm** Promethium 144.913	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.964	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.925	66 **Dy** Dysprosium 162.500	67 **Ho** Holmium 164.930	68 **Er** Erbium 167.259	69 **Tm** Thulium 168.934	70 **Yb** Ytterbium 173.055	71 **Lu** Lutetium 174.967
Actinide Series	90 **Th** Thorium 232.038	91 **Pa** Protactinium 231.036	92 **U** Uranium 238.029	93 **Np** Neptunium 237.048	94 **Pu** Plutonium 244.064	95 **Am** Americium 243.061	96 **Cm** Curium 247.070	97 **Bk** Berkelium 247.070	98 **Cf** Californium 251.080	99 **Es** Einsteinium [254]	100 **Fm** Fermium 257.095	101 **Md** Mendelevium 258.1	102 **No** Nobelium 259.101	103 **Lr** Lawrencium [262]