

# Periodic Table of the Elements

|                                  |                                       |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |
|----------------------------------|---------------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| 1A<br><b>1</b>                   | <b>Periodic Table of the Elements</b> |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  | 8A<br><b>18</b>                  |
| <b>1</b><br><b>H</b><br>1.008    |                                       |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  | <b>2</b><br><b>He</b><br>4.003   |                                  |                                  |                                  |                                  |                                  |                                  |
|                                  | 2A<br><b>2</b>                        |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  | 3A<br><b>13</b>                  | 4A<br><b>14</b>                  | 5A<br><b>15</b>                  | 6A<br><b>16</b>                  | 7A<br><b>17</b>                  |                                  |
| <b>3</b><br><b>Li</b><br>6.941   | <b>4</b><br><b>Be</b><br>9.012        |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  | <b>5</b><br><b>B</b><br>10.81    | <b>6</b><br><b>C</b><br>12.01    | <b>7</b><br><b>N</b><br>14.01    | <b>8</b><br><b>O</b><br>16.00    | <b>9</b><br><b>F</b><br>19.00    | <b>10</b><br><b>Ne</b><br>20.18  |
| <b>11</b><br><b>Na</b><br>22.99  | <b>12</b><br><b>Mg</b><br>24.31       | 3B<br><b>3</b>                   | 4B<br><b>4</b>                   | 5B<br><b>5</b>                   | 6B<br><b>6</b>                   | 7B<br><b>7</b>                   | 8B<br><b>8</b>                   | 8B<br><b>9</b>                   | 8B<br><b>10</b>                  | 1B<br><b>11</b>                  | 2B<br><b>12</b>                  | <b>13</b><br><b>Al</b><br>26.98  | <b>14</b><br><b>Si</b><br>28.09  | <b>15</b><br><b>P</b><br>30.97   | <b>16</b><br><b>S</b><br>32.07   | <b>17</b><br><b>Cl</b><br>35.45  | <b>18</b><br><b>Ar</b><br>39.95  |
| <b>19</b><br><b>K</b><br>39.10   | <b>20</b><br><b>Ca</b><br>40.08       | <b>21</b><br><b>Sc</b><br>44.96  | <b>22</b><br><b>Ti</b><br>47.87  | <b>23</b><br><b>V</b><br>50.94   | <b>24</b><br><b>Cr</b><br>52.00  | <b>25</b><br><b>Mn</b><br>54.94  | <b>26</b><br><b>Fe</b><br>55.85  | <b>27</b><br><b>Co</b><br>58.93  | <b>28</b><br><b>Ni</b><br>58.69  | <b>29</b><br><b>Cu</b><br>63.55  | <b>30</b><br><b>Zn</b><br>65.38  | <b>31</b><br><b>Ga</b><br>69.72  | <b>32</b><br><b>Ge</b><br>72.64  | <b>33</b><br><b>As</b><br>74.92  | <b>34</b><br><b>Se</b><br>78.96  | <b>35</b><br><b>Br</b><br>79.90  | <b>36</b><br><b>Kr</b><br>83.80  |
| <b>37</b><br><b>Rb</b><br>85.47  | <b>38</b><br><b>Sr</b><br>87.62       | <b>39</b><br><b>Y</b><br>88.91   | <b>40</b><br><b>Zr</b><br>91.22  | <b>41</b><br><b>Nb</b><br>92.91  | <b>42</b><br><b>Mo</b><br>95.94  | <b>43</b><br><b>Tc</b><br>(98)   | <b>44</b><br><b>Ru</b><br>101.07 | <b>45</b><br><b>Rh</b><br>102.91 | <b>46</b><br><b>Pd</b><br>106.42 | <b>47</b><br><b>Ag</b><br>107.87 | <b>48</b><br><b>Cd</b><br>112.41 | <b>49</b><br><b>In</b><br>114.82 | <b>50</b><br><b>Sn</b><br>118.71 | <b>51</b><br><b>Sb</b><br>121.76 | <b>52</b><br><b>Te</b><br>127.60 | <b>53</b><br><b>I</b><br>126.90  | <b>54</b><br><b>Xe</b><br>131.29 |
| <b>55</b><br><b>Cs</b><br>132.91 | <b>56</b><br><b>Ba</b><br>137.33      | <b>57</b><br><b>La</b><br>138.91 | <b>72</b><br><b>Hf</b><br>178.49 | <b>73</b><br><b>Ta</b><br>180.95 | <b>74</b><br><b>W</b><br>183.84  | <b>75</b><br><b>Re</b><br>186.21 | <b>76</b><br><b>Os</b><br>190.23 | <b>77</b><br><b>Ir</b><br>192.22 | <b>78</b><br><b>Pt</b><br>195.08 | <b>79</b><br><b>Au</b><br>196.97 | <b>80</b><br><b>Hg</b><br>200.59 | <b>81</b><br><b>Tl</b><br>204.38 | <b>82</b><br><b>Pb</b><br>207.20 | <b>83</b><br><b>Bi</b><br>208.98 | <b>84</b><br><b>Po</b><br>(209)  | <b>85</b><br><b>At</b><br>(210)  | <b>86</b><br><b>Rn</b><br>(222)  |
| <b>87</b><br><b>Fr</b><br>(223)  | <b>88</b><br><b>Ra</b><br>(226)       | <b>89</b><br><b>Ac</b><br>(227)  | <b>104</b><br><b>Rf</b><br>(261) | <b>105</b><br><b>Db</b><br>(262) | <b>106</b><br><b>Sg</b><br>(266) | <b>107</b><br><b>Bh</b><br>(264) | <b>108</b><br><b>Hs</b><br>(277) | <b>109</b><br><b>Mt</b><br>(268) | <b>110</b><br><b>Ds</b><br>(281) | <b>111</b><br><b>Rg</b><br>(281) | <b>112</b><br><b>Cn</b><br>(285) | <b>113</b><br><b>Nh</b><br>(286) | <b>114</b><br><b>Fl</b><br>(289) | <b>115</b><br><b>Mc</b><br>(289) | <b>116</b><br><b>Lv</b><br>(293) | <b>117</b><br><b>Ts</b><br>(293) | <b>118</b><br><b>Og</b><br>(294) |

|                                  |                                  |                                  |                                 |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |                                  |
|----------------------------------|----------------------------------|----------------------------------|---------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| <b>58</b><br><b>Ce</b><br>140.12 | <b>59</b><br><b>Pr</b><br>140.91 | <b>60</b><br><b>Nd</b><br>144.24 | <b>61</b><br><b>Pm</b><br>(145) | <b>62</b><br><b>Sm</b><br>150.36 | <b>63</b><br><b>Eu</b><br>151.96 | <b>64</b><br><b>Gd</b><br>157.25 | <b>65</b><br><b>Tb</b><br>158.93 | <b>66</b><br><b>Dy</b><br>162.50 | <b>67</b><br><b>Ho</b><br>164.93 | <b>68</b><br><b>Er</b><br>167.26 | <b>69</b><br><b>Tm</b><br>168.93 | <b>70</b><br><b>Yb</b><br>173.04 | <b>71</b><br><b>Lu</b><br>174.97 |
| <b>90</b><br><b>Th</b><br>232.04 | <b>91</b><br><b>Pa</b><br>231.04 | <b>92</b><br><b>U</b><br>238.03  | <b>93</b><br><b>Np</b><br>(237) | <b>94</b><br><b>Pu</b><br>(244)  | <b>95</b><br><b>Am</b><br>(243)  | <b>96</b><br><b>Cm</b><br>(247)  | <b>97</b><br><b>Bk</b><br>(247)  | <b>98</b><br><b>Cf</b><br>(251)  | <b>99</b><br><b>Es</b><br>(252)  | <b>100</b><br><b>Fm</b><br>(257) | <b>101</b><br><b>Md</b><br>(258) | <b>102</b><br><b>No</b><br>(259) | <b>103</b><br><b>Lr</b><br>(262) |

$$R = 8.314 \text{ J/mol K}$$

$$R = 0.08206 \text{ L}\cdot\text{atm/mol}\cdot\text{K}$$

$$N_A = 6.022 \times 10^{23} / \text{mol}$$

$$1 \text{ atm} = 760 \text{ torr}$$

$$1 \text{ atm} = 14.7 \text{ psi}$$

$$1 \text{ bar} = 10^5 \text{ Pa}$$

$$1 \text{ L}\cdot\text{atm} = 101.325 \text{ J}$$

$$1 \text{ in} = 2.54 \text{ cm}$$

$$1 \text{ mi} = 5280 \text{ ft}$$

$$1 \text{ lb} = 453.6 \text{ g}$$

$$1 \text{ gal} = 3.785 \text{ L}$$

$$K_w = 1.0 \times 10^{-14} \text{ @ } 25^\circ\text{C}$$

## Ionization Constants of some common acids

| name                 | formula                            | $K_a$                 | $pK_a$ |
|----------------------|------------------------------------|-----------------------|--------|
| acetic acid          | CH <sub>3</sub> COOH               | $1.8 \times 10^{-5}$  | 4.74   |
| acrylic acid         | CH <sub>2</sub> CHCOOH             | $5.6 \times 10^{-5}$  | 4.25   |
| butanoic acid        | C <sub>3</sub> H <sub>7</sub> COOH | $1.5 \times 10^{-5}$  | 4.82   |
| formic acid          | HCOOH                              | $1.8 \times 10^{-4}$  | 3.74   |
| hydrofluoric acid    | HF                                 | $6.3 \times 10^{-4}$  | 3.20   |
| hypoiodous acid      | HIO                                | $2.0 \times 10^{-11}$ | 10.70  |
| nitrous acid         | HNO <sub>2</sub>                   | $4.0 \times 10^{-4}$  | 3.40   |
| trichloroacetic acid | CCl <sub>3</sub> COOH              | $2.2 \times 10^{-1}$  | 0.66   |

### Ionization Constants of some common **bases**

| <b>name</b>    | <b>formula</b> | <b><math>K_b</math></b> | <b><math>pK_b</math></b> |
|----------------|----------------|-------------------------|--------------------------|
| ammonia        | $NH_3$         | $1.8 \times 10^{-5}$    | 4.74                     |
| aniline        | $C_6H_5NH_2$   | $4.3 \times 10^{-10}$   | 9.37                     |
| hydroxylamine  | $NH_2OH$       | $1.1 \times 10^{-8}$    | 7.96                     |
| methylamine    | $CH_3NH_2$     | $4.38 \times 10^{-4}$   | 3.36                     |
| pyridine       | $C_5H_5N$      | $1.8 \times 10^{-9}$    | 8.74                     |
| trimethylamine | $(CH_3)_3N$    | $6.5 \times 10^{-5}$    | 4.19                     |

### Ionization Constants of some common acid/base **indicators**

| <b>name</b>        | <b>colors : acid to base</b> | <b>pH range</b> |
|--------------------|------------------------------|-----------------|
| malachite green    | yellow to blue/green         | 0.2 - 1.8       |
| methyl orange      | red to yellow                | 3.2 - 4.4       |
| bromocresol green  | yellow to blue               | 3.8 - 5.4       |
| methyl red         | red to yellow                | 4.8 - 6.0       |
| bromocresol purple | yellow to purple             | 5.2 - 6.8       |
| bromothymol blue   | yellow to blue               | 6.0 - 7.6       |
| phenol red         | yellow to red                | 6.6 - 8.0       |
| phenolphthalein    | colorless to pink            | 8.2 - 10.0      |
| thymolphthalein    | colorless to blue            | 9.4 - 10.6      |
| alizarin yellow R  | yellow to red                | 10.1 - 12.0     |

### Ionization Constants of some common **salts**

| <b>name</b>             | <b>formula</b> | <b><math>K_{sp}</math></b> |
|-------------------------|----------------|----------------------------|
| barium nitrate          | $Ba(NO_3)_2$   | $4.6 \times 10^{-3}$       |
| barium chromate         | $BaCrO_4$      | $1.2 \times 10^{-10}$      |
| copper(I) oxide         | $Cu_2O$        | $2.0 \times 10^{-15}$      |
| calcium fluoride        | $CaF_2$        | $3.5 \times 10^{-11}$      |
| magnesium carbonate     | $MgCO_3$       | $6.8 \times 10^{-6}$       |
| manganese(II) hydroxide | $Mn(OH)_2$     | $2.0 \times 10^{-13}$      |
| mercury(I) bromide      | $Hg_2Br_2$     | $6.4 \times 10^{-23}$      |
| silver chloride         | $AgCl$         | $1.8 \times 10^{-10}$      |