① $\log_a N = x \Rightarrow a^x = N$

② Necessary rules $\Rightarrow a > 0, a \neq 1, N > 0$

③ $\log_a (x \cdot y) = \log_a x + \log_a y$

④ $\log_a (x/y) = \log_a x - \log_a y$

⑤ $\log_a a = 1$

⑥ $\log_a 1 = 0$

⑦ $\log_a x = \frac{1}{\log_x a}$

⑧ $a^{\log_a x} = x$

⑨ $\log_a b \cdot \log_b c \cdot \log_c d = \log_a d$

⑩ $\log_x a = \frac{\log_b a}{\log_b x}$

⑪ $\log_x a^m = \frac{m \log_b a}{\log x}$

⑫ $\log_x a^m = m \log_x a$

⑬ $\log_{a^p} x = \frac{1}{p} \log x$

⑭ $\log_{1/a} a = -1$

⑮ $\log_e e = 1$

⑯ $a^{\log_c b} = b^{\log_c a}$

$\ln x = \log_e x$

exponential logarithm of base $e = 2.78$