$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$

	25°C 298 K	327°C 600 K	727°C 1000 K
$k\ (M^{-1}s^{-1})$	3.82×10^{-11}	0.3174	2.64×10^{3}
K (from $\Delta G°$)	4.65×10^{-13}	7.43×10^{-7}	2.1×10^{-4}
K_{rev}	2.15×10^{12}	1.346×10^{6}	4.76×10^{3}

(these are wrong!) (wrong!)

$A = 2\times10^{9}\ M^{-1}s^{-1}$

$E_a = 112.55\ kJ\ mol^{-1}$

at 25°C: $\Delta H° = 114.1\ kJ\ mol^{-1}$, $\Delta S° = 147\ J\ mol^{-1}K^{-1}$

$\Delta G° = 70.4\ kJ\ mol^{-1}$ (at 25°C)

$rate_f = k_1[NO_2]^2$

$rate_r = k_{-1}[NO]^2[O_2]$

equal @ equilibrium ∴ equal @ equilibrium

$k_1[NO_2]^2 = k_{-1}[NO]^2[O_2]$

$\frac{k_1}{k_{-1}} = \frac{[NO]^2[O_2]}{[NO_2]^2} = K$ (equilibrium constant; equilibrium expression) or $\frac{k_{-1}}{k_1} = \frac{[NO_2]^2}{[NO]^2[O_2]} = K_{rev}$

Find equilibrium concentrations at 25°C $[NO_2]_i = 1.0\ M$

①

	$2NO_2(g)$	$\rightleftharpoons 2NO(g)$	$+ O_2(g)$
I	1.0	0	0
C	$-2x$	$+2x$	$+x$
E	$1.0-2x$	$2x$	x

② $\frac{[NO]^2[O_2]}{[NO_2]^2} = K$

$\frac{(2x)^2(x)}{(1.0-2x)^2} = 4.65\times10^{-13}$

③b (small x approx) $\frac{(2x)^2(x)}{1.0} = 4.65\times10^{-13}$

$4x^3 = 4.65\times10^{-13}$

$x = \left(\frac{4.65\times10^{-13}}{4}\right)^{1/3}$

$x = 4.88\times10^{-5}$

Test x (<5%): $\frac{2(4.88\times10^{-5})}{1.0}\times100\% = 0.009\%$ ✓

③a $\frac{4x^3}{1.0-2x-2x+4x^2} = 4.65\times10^{-13}$

$4x^3 = 4.65\times10^{-13}(1.0-4x+4x^2)$

cubic! $4x^3 = 4.65\times10^{-13} - 1.86\times10^{-12}x + 1.86\times10^{-12}x^2$

$4x^3 - 1.86\times10^{-12}x^2 + 1.86\times10^{-12}x - 4.65\times10^{-13} = 0$

$x = 4.88\times10^{-5}$

$[NO_2]_{eq} = 1.0 - 2(4.88\times10^{-5})$
$= 0.99990\ M$

$[NO]_{eq} = 2(4.88\times10^{-5})$
$= 9.76\times10^{-5}\ M$

$[O_2]_{eq} = 4.88\times10^{-5}\ M$

Find equilibrium concentrations at 727°C $[NO_2]_i = 1.0\ M$

	$2NO_2(g)$	$\rightleftharpoons 2NO(g)$	$+ O_2(g)$
I	1.0	0	0
C	$-2x$	$+2x$	$+x$
E	$1.0-2x$	$2x$	x

$\frac{[NO]^2[O_2]}{[NO_2]^2} = K$

$\frac{(2x)^2(x)}{(1.0-2x)^2} = 2.1\times10^{-4}$

(small x approx.) $\frac{(2x)^2(x)}{1.0} = 2.1\times10^{-4}$

$4x^3 = 2.1\times10^{-4}$

$x = 3.74\times10^{-2}$

Test x (<5%): $\frac{2(3.74\times10^{-2})}{1.0}\times100\% = 7.5\%$ too big!

$4x^3 = 2.1\times10^{-4}(1.0-4x+4x^2)$

$4x^3 = 2.1\times10^{-4} - 8.4\times10^{-4}x + 8.4\times10^{-4}x^2$

$4x^3 - 8.4\times10^{-4}x^2 + 8.4\times10^{-4}x - 2.1\times10^{-4} = 0$

$x = 3.56\times10^{-2}$

$[NO_2]_{eq} = 1.0 - 2(3.56\times10^{-2})$
$= 0.9288\ M$

$[NO]_{eq} = 2(3.56\times10^{-2})$
$= 0.0712\ M$

$[O_2]_{eq} = 0.0356\ M$