$N_2O_4 \rightleftharpoons 2NO_2 \quad K_c^{273} = [NO_2]^2/[N_2O_4] = 0{,}00077$

- What are the concentrations at the equilibrium if the initial concentration of (N_2O_4) is 0.50 M? The Kc = 0.00077 at 273 K

From the ICE table we get:

$$\frac{(2x)^2}{0{,}50 - x} = \frac{4x^2}{0{,}5 - x} = 0{,}00077$$

$$4x^2 = 0{,}00077 \cdot 0{,}5 - 0{,}00077 \cdot x$$

$$4x^2 + 0{,}00077x - 0{,}000385 = 0$$

quadratic equation

$$ax^2 + bx + c = 0$$

$a = 4$

$b = 0{,}00077$

$c = -0{,}000385$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$x = \frac{-0{,}00077 \pm \sqrt{(0{,}00077)^2 - 4 \cdot 4 \cdot (-0{,}000385)}}{2 \cdot 4}$$

$$= -0{,}000096 \pm \frac{\sqrt{0{,}00000059 + 0{,}00616}}{8}$$

$$= -0{,}000096 \pm \frac{\sqrt{0{,}00616}}{8} = -0{,}000096 \pm \frac{0{,}078}{8}$$

$$x = -0{,}000096 + 0{,}00981 = 0{,}0097 \simeq 0{,}010$$

It cannot be negative $\Rightarrow \pm \rightarrow +$

$$0{,}50 - x = 0{,}50 - 0{,}010 = 0{,}49\ M$$

$$[NO_2] = 2x = 2 \cdot 0{,}010 = 0{,}02\ M$$

You can check if the result is correct by replacing the obtained values into the equation:

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{[0{,}02]^2}{0{,}49} = \frac{0{,}0004}{0{,}49} = 0{,}0008 \simeq 0{,}00077$$