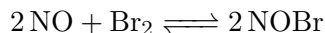# Zumdahl Challenge Problems Solutions

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Problem: Nitric oxide and bromine at initial pressures of 98.4 and 41.3 torr, respectively, were allowed to react at 300. K. At equilibrium the total pressure was 110.5 torr. The reaction is as follows.

$$2\,\mathrm{NO} + \mathrm{Br_2} \rightleftharpoons 2\,\mathrm{NOBr}$$

a) Calculate the value of K_p

b) What would be the partial pressures of all species if NO and $\mathrm{Br_2}$, both at an initial partial pressure of 0.30 atm, were allowed to come to equilibrium at this temperature?

Solution: We model the change in pressure of each substance through an ICE table and note the concentrations.

	$[2\,\mathrm{NO}]$	$+$	$[\mathrm{Br_2}]$	$\rightleftharpoons$	$[2\,\mathrm{NOBr}]$
I	98.4		41.3		
C	$-2x$		$-x$		$+2x$
E	$(98.4 - 2x)$		$(41.3 - x)$		$(+2x)$

We are told that $P_E = 110.5$ torr, meaning that we can solve for x

$$P_E = P_{\mathrm{NO}} + P_{\mathrm{Br_2}} + P_{\mathrm{NOBr}}$$
$$110.5 = (98.4 - 2x) + (41.3 - x) + (2x)$$
$$x = 29.2 \text{ torr}$$

Solving for each equilibrium concentration gives us a K_p value of

$$K_p = \frac{58.4^2}{40.0^2 \times 12.1} = 0.176 \text{ torr} = \boxed{137 \text{ atm}^{-1}}$$

Solving for the second part of the problem becomes a bit more convoluted. We are given that the initial concentrations of the reactants NO and $\mathrm{Br_2}$ are 0.3 atm each.

Writing an ICE table for the following reaction is trivial and is omitted. We end with a K_p of

$$134 = \frac{(2x)^2}{(0.3 - 3x)^2(0.3 - x)}$$

Solving for x is complicated to do algebraically, but graphically, we see that $x = 0.125$ atm. Knowing that the equilibrium concentrations of NO and Br_2 are $0.3 - 2x$ and $0.3 - x$, and NOBr is $2x$, we see that the partial pressures of each of the substances are

$$P_{NO} = 0.052 \text{atm}$$
$$P_{Br_2} = 0.18 \text{atm}$$
$$P_{NOBr} = 0.25 \text{atm}$$

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