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# Chemistry: Chemical Equilibrium

## Given and Introduction

Given:

- Reaction: $2\ NO(g) \rightleftharpoons 2\ NO(g) + O_2(g)$
- $K_p = 1.11 \times 10^{-5}$ at 200 °C
- Initial Pressure of NO(g) = 4.00 atm
- Volume of vessel = 2.50 L
- Temperature = 200 °C

This problem revolves around calculating the equilibrium pressure of NO(g) using the principles of chemical equilibrium and the provided equilibrium constant $K_p$.

## Step-by-Step Solution:

### 1. Define Initial and Change Variables:

Let $P_{NO}$ be the equilibrium pressure of NO(g).

The initial pressure of NO(g) is given as 4.00 atm. There is no initial $O_2$(g).

Given the stoichiometry of the reaction:

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

Introduce the change in pressure as $x$ for $O_2$:

| Species | Initial Pressure (atm) | Change | Equilibrium Pressure (atm) |
|---|---|---|---|
| $NO(g)$ | 4.00 | -2x | 4.00 - 2x |
| $O_2$ | 0 | +x | x |

**Supporting Statement:** This step defines the change in pressure of NO(g) and $O_2$(g) as the system approaches equilibrium.

### 2. Expression for Equilibrium Constants:

The equilibrium constant expression $K_p$ for the given reaction is:

$$K_p = (P_{NO}^2 * P_{O2}) / P_{NO}^2$$

Simplifying:

$$K_p = P_{O2}$$

**Supporting Statement:** $K_p$ is expressed in terms of the partial pressures of the gases involved.

### 3. Plug in the Equilibrium Quantities:

Substitute the equilibrium quantities into the expression for $K_p$:

$$K_p = x$$

Given $K_p$:

$$1.11 \times 10^{-5} = x$$

**Supporting Statement:** The equilibrium constant expression is evaluated using the provided values.

### 4. Solve for $x$ to Find $P_{O2}$:

$$x = 1.11 \times 10^{-5}$$

**Supporting Statement:** This step solved for $x$ which represents the pressure of $O_2$(g) at equilibrium.

### 5. Find Equilibrium Pressure of NO(g):

Substitute $x$ back to find equilibrium partial pressure of NO(g):

$$P_{NO} = 4.00 - 2x = 4.00 - 2(1.11 \times 10^{-5})$$
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P_NO = 4.00 - 2.22 × 10^-5

P_NO ≈ 4.00 atm
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Supporting Statement: Inserted the calculated value of x into the initial pressure to find the equilibrium pressure of NO(g).

Final Solution:

The pressure of NO(g) at equilibrium is approximately **4.00 atm**.

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