Pressure Change During Two-Stage Reaction

https://gemini.google.com/app/38c125737c65c7f9

Response: To determine how the pressure of the system changes with time, let's analyze the change in the total number of moles of gas during both stages of the reaction.

Since the container is rigid (V is constant) and the reaction takes place at a constant temperature (T), total pressure P is directly proportional to the total moles of gas present in the container (n_{total}):

$$P \propto n_{\text{total}}$$

Step-by-Step Analysis

Stage 1: Fast Reaction

$$\mathrm{A(g)} + \mathrm{B(g)} \to \mathrm{C(g)} \quad \text{(fast)}$$

- **Change in moles:** $2 \text{ moles of gas Reactants} \to 1 \text{ mole of gas Product}$.
- **Effect on total moles:** The total number of gaseous moles decreases rapidly as $\mathrm{B(g)}$ quickly reacts with $\mathrm{A(g)}$.
- **Effect on pressure: Pressure decreases rapidly.**

Stage 2: Slow Reaction

$$\mathrm{A(g)} + \mathrm{C(g)} \to \mathrm{3D(g)} \quad \text{(slow)}$$

- **Change in moles:** $2 \text{ moles of gas Reactants} \to 3 \text{ moles of gas Products}$.
- **Effect on total moles:** As $\mathrm{C(g)}$ is consumed slowly by excess $\mathrm{A(g)}$, the total number of gaseous moles increases overall ($+1 \text{ mole net increase per mole of C}$ consumed).
- **Net Overall Change:**
  - Let the initial moles of $\mathrm{B(g)}$ introduced be x (small amount).
  - In Stage 1: x moles of A and x moles of B form x moles of C.
    - Moles lost = x moles.
  - In Stage 2: x moles of C react with x moles of A to form $3x$ moles of D.
    - Moles gained = $3x - 2x = x$ moles.
  - Therefore, the final total number of moles equals the initial total number of moles!

- **Effect on pressure: Pressure increases slowly back to its initial value.**

Conclusion

1. **Initially:** Pressure **decreases** (fast stage).
2. **Subsequently:** Pressure increases back and **returns to the initial value again** (slow stage).

Thus, the correct option is **(4) Pressure decreases and returns to the initial value again.**
