

THE BUILDING

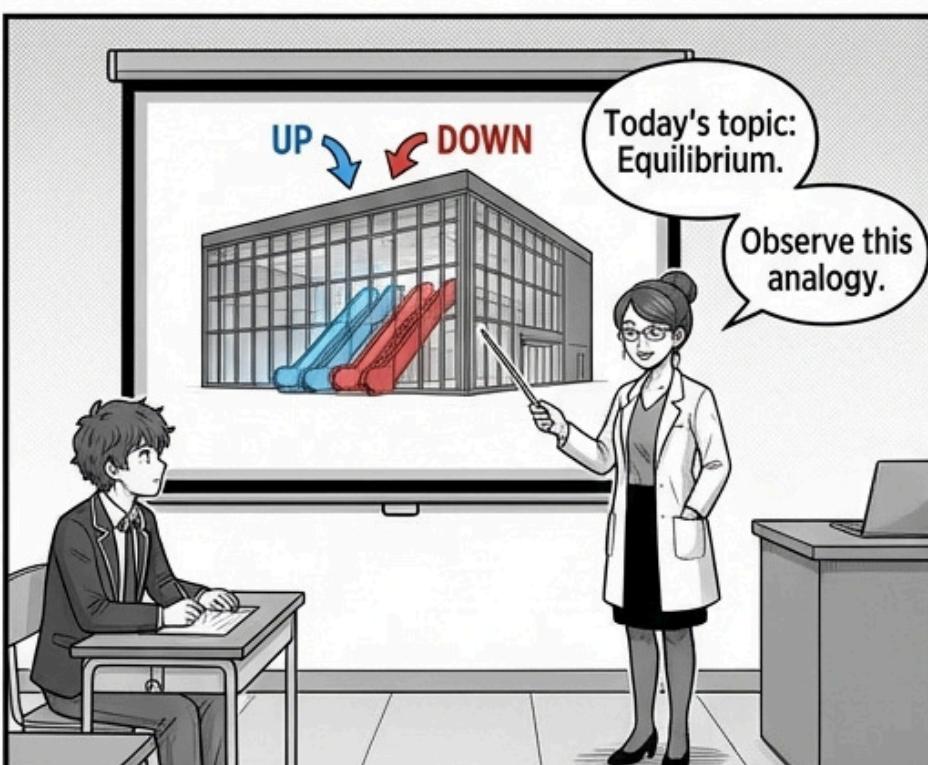
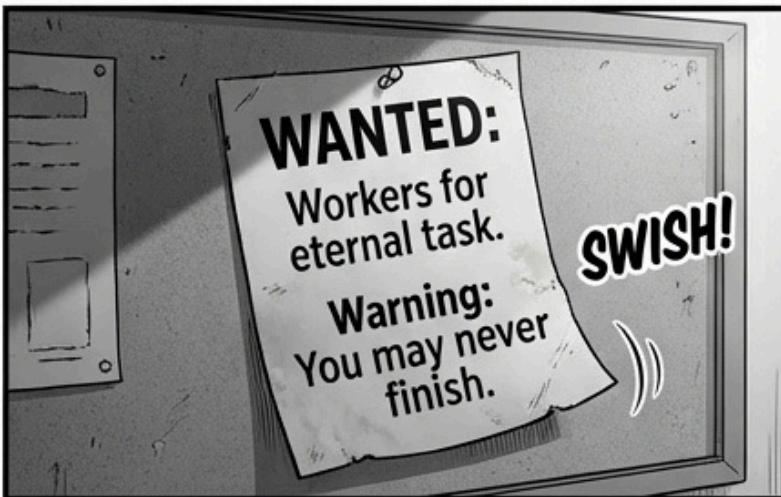
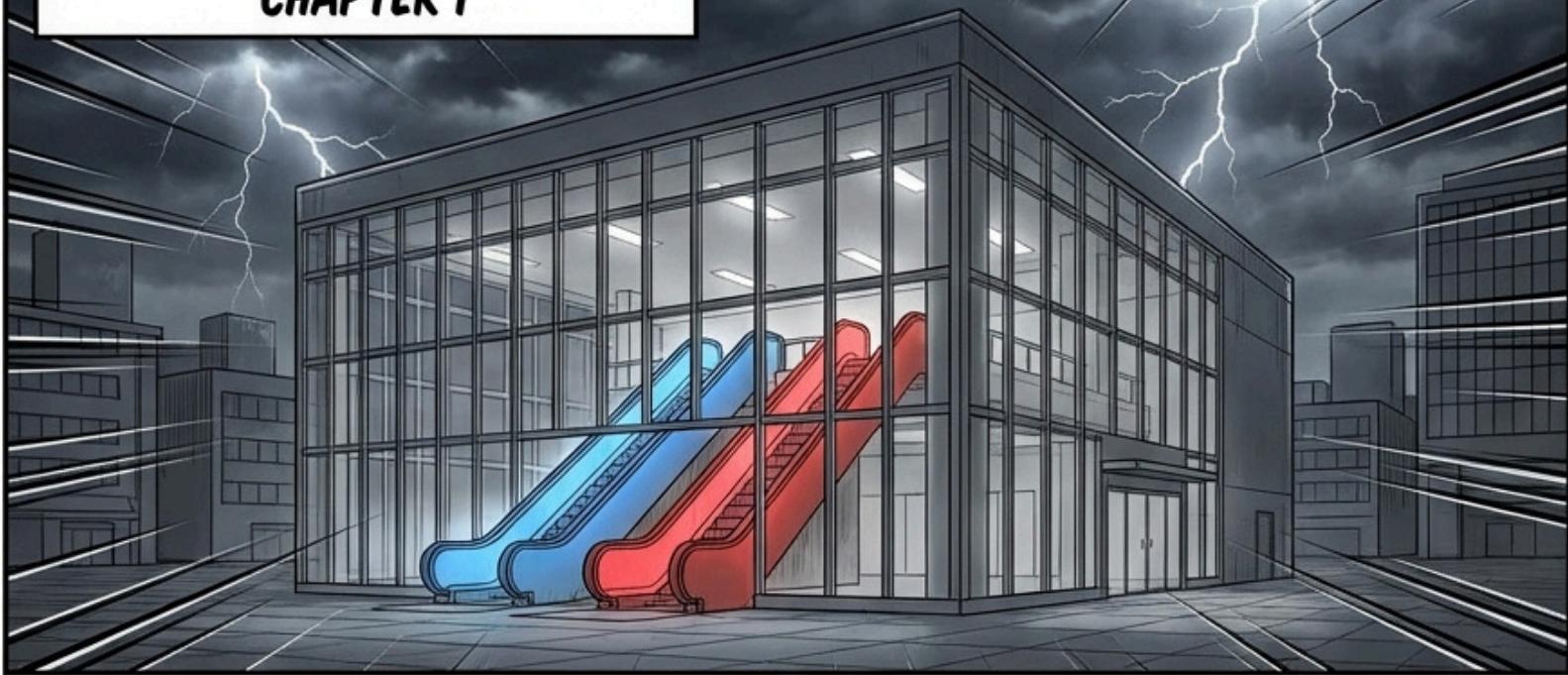
A Visual Manga Story of Chemical Equilibrium



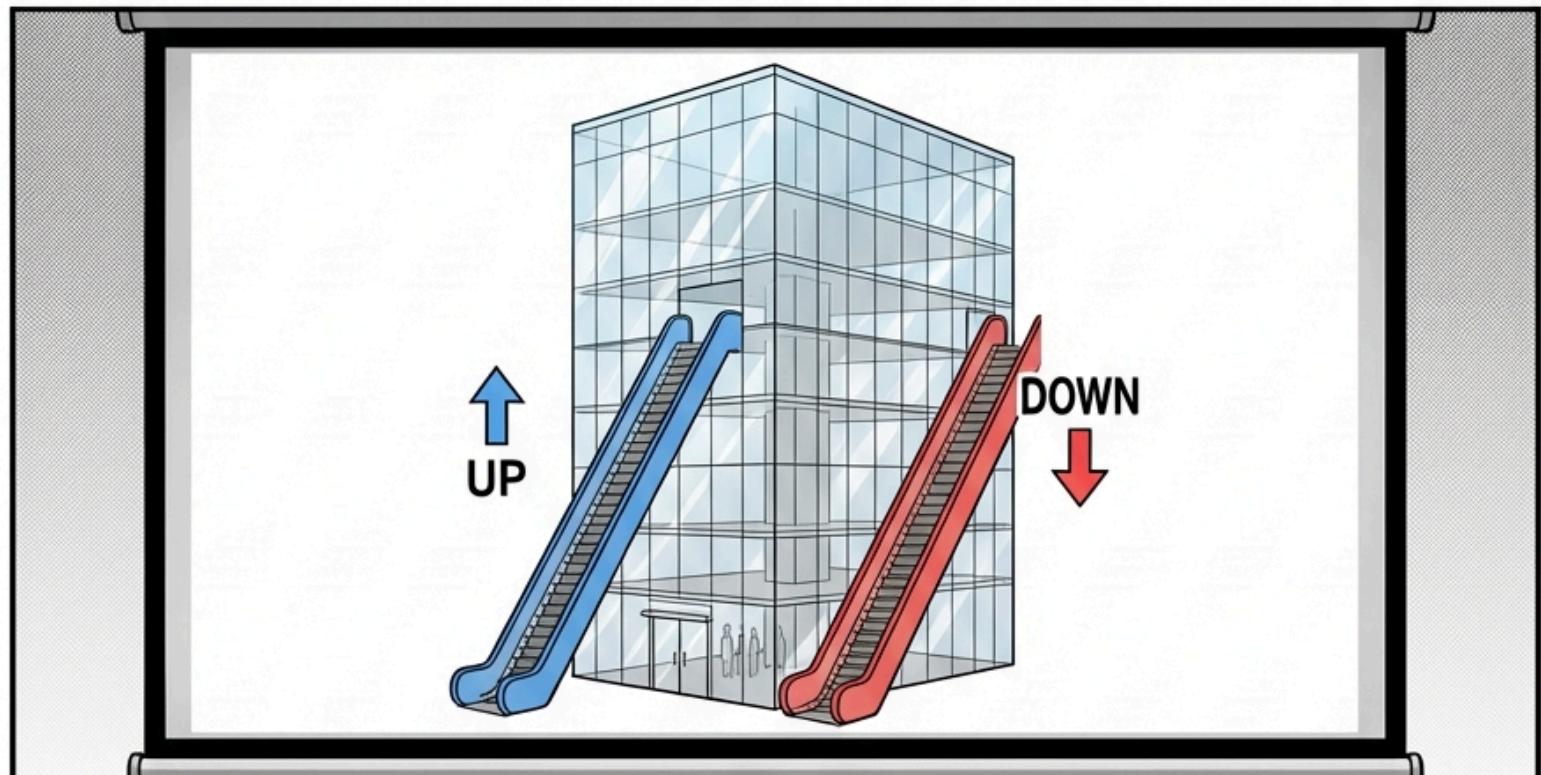
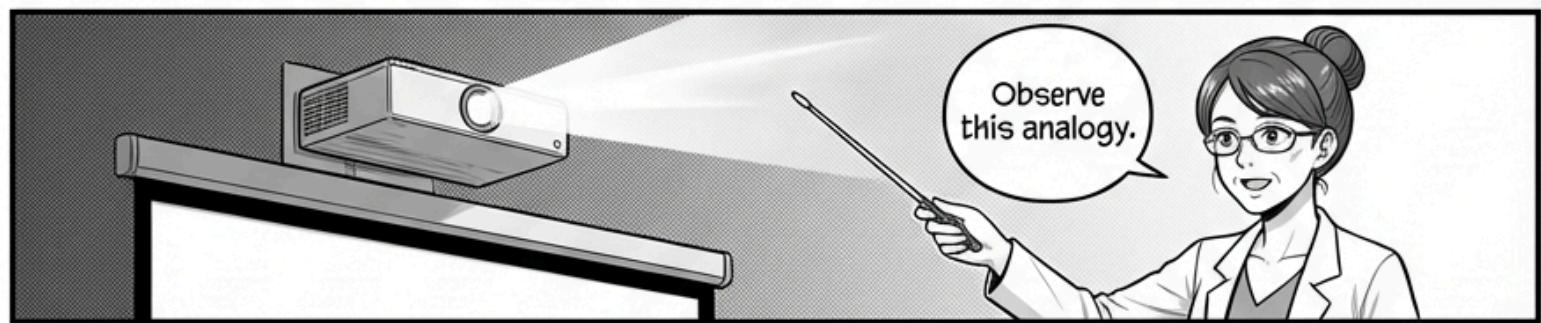
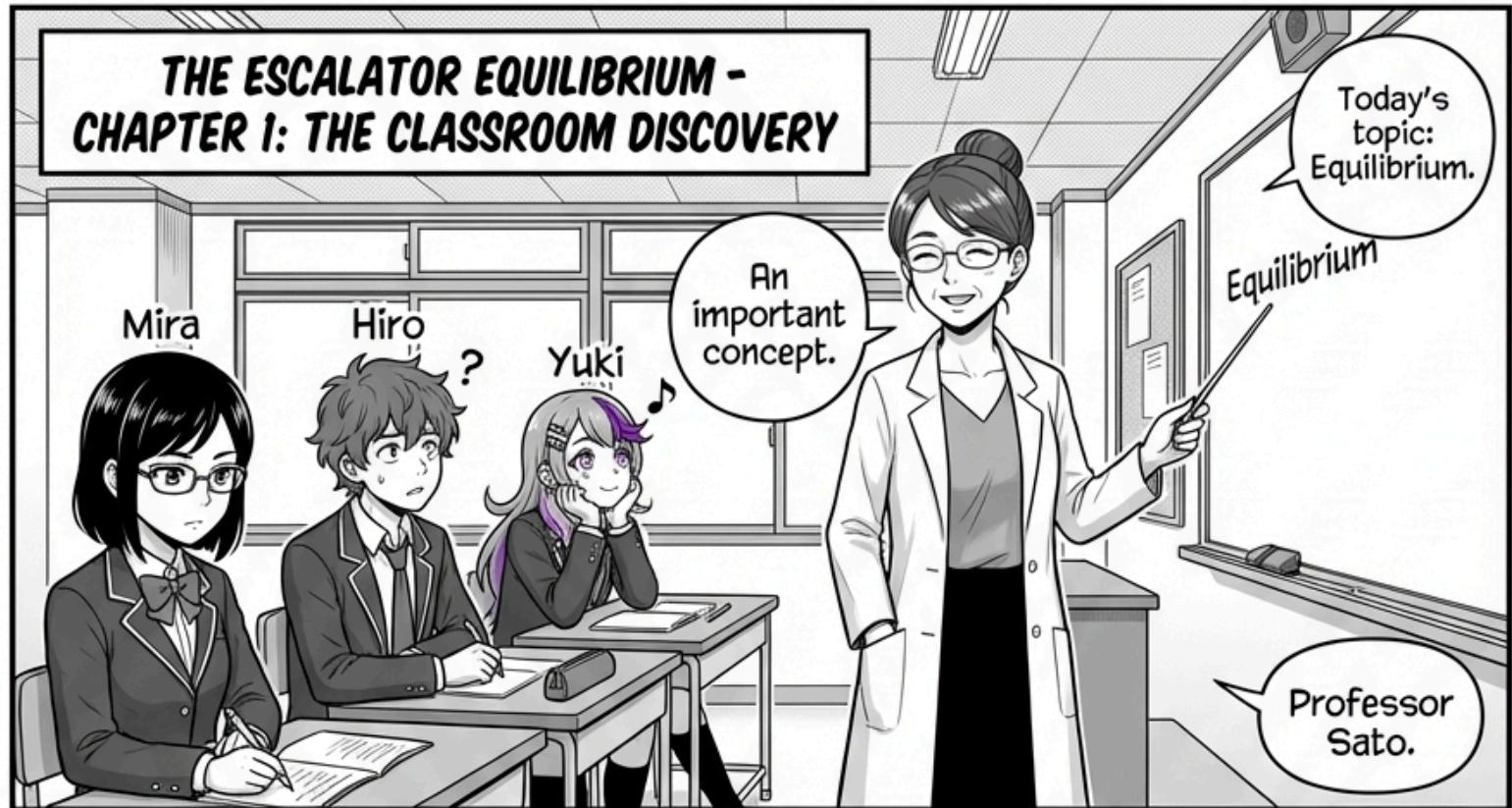
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By Mr. Hisham Mahmoud

THE ESCALATOR EQUILIBRIUM - CHAPTER 1

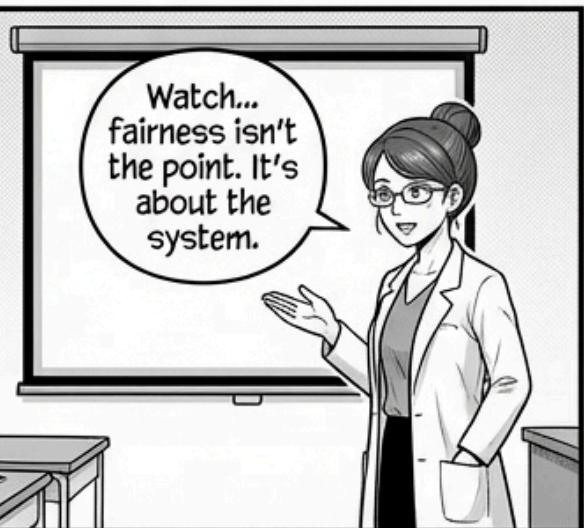


THE ESCALATOR EQUILIBRIUM - CHAPTER 1: THE CLASSROOM DISCOVERY



THE ESCALATOR EQUILIBRIUM

THE ESCALATOR EQUILIBRIUM - CHAPTER 2: THE RULES

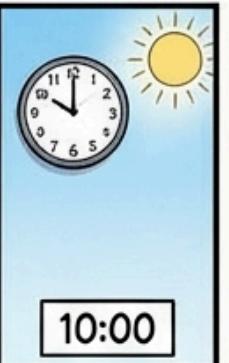
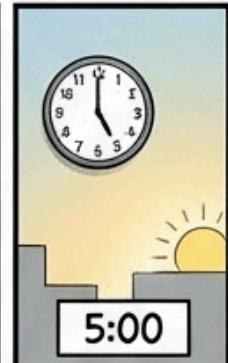


THE ESCALATOR EQUILIBRIUM - CHAPTER 3: THE WAITING GAME

Everyone sees
him working...
I look lazy.



I know
that
feeling...

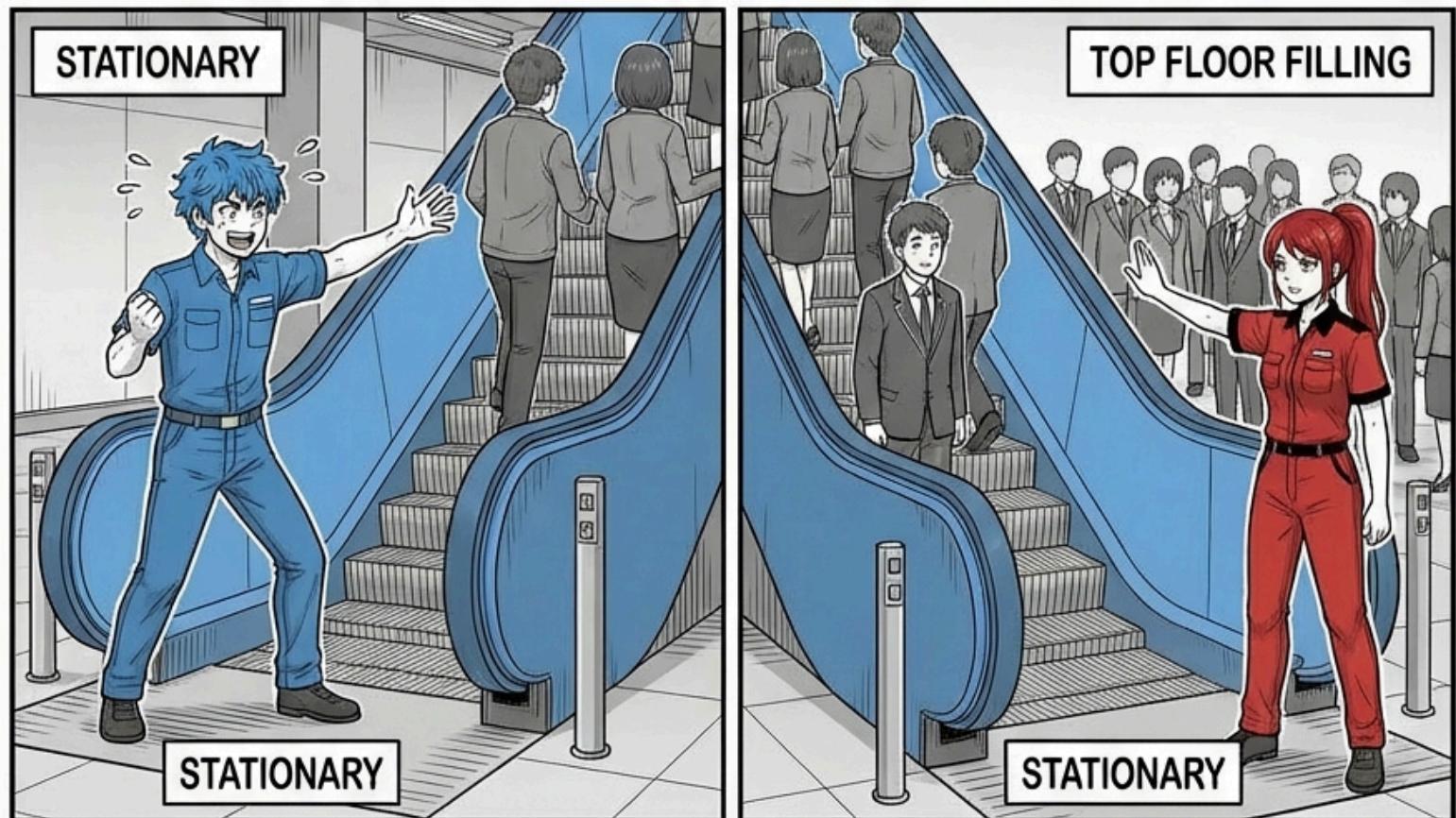
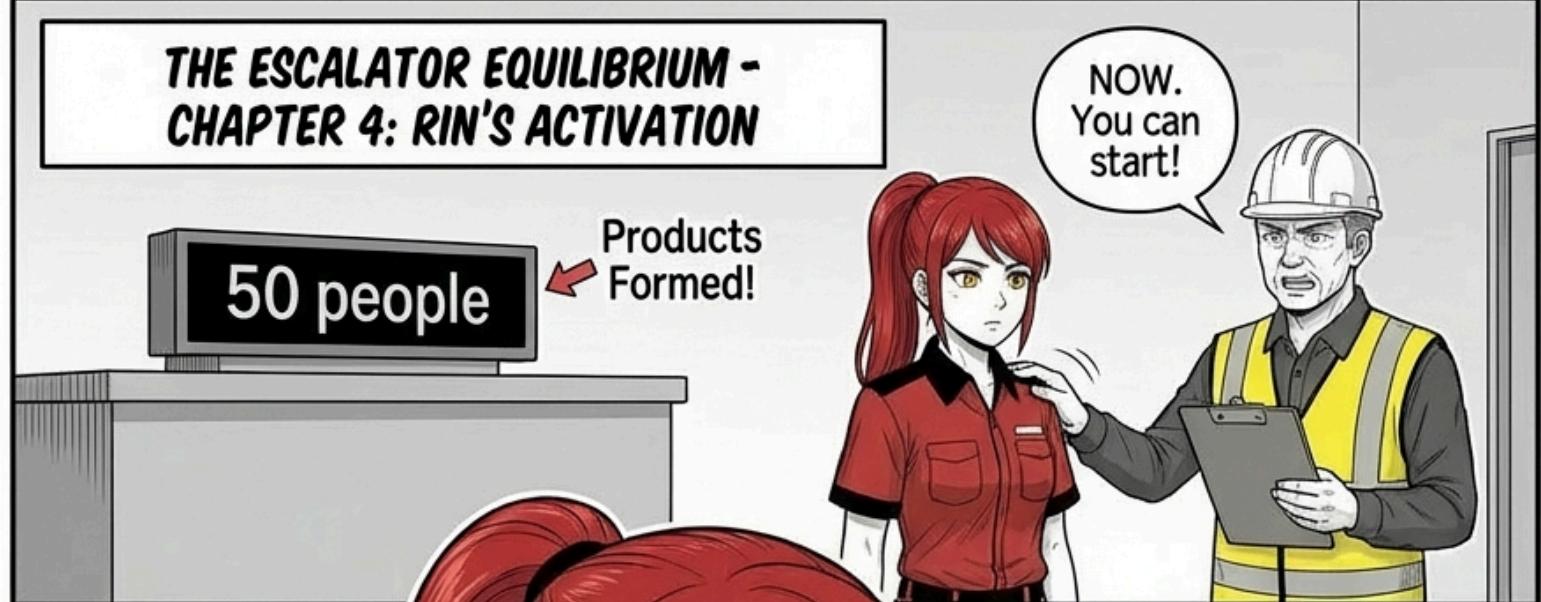


TOP FLOOR FILLING...

0 - 50 - 120



THE ESCALATOR EQUILIBRIUM - CHAPTER 4: RIN'S ACTIVATION



THE ESCALATOR EQUILIBRIUM - CHAPTER 5: THE COMPETITION

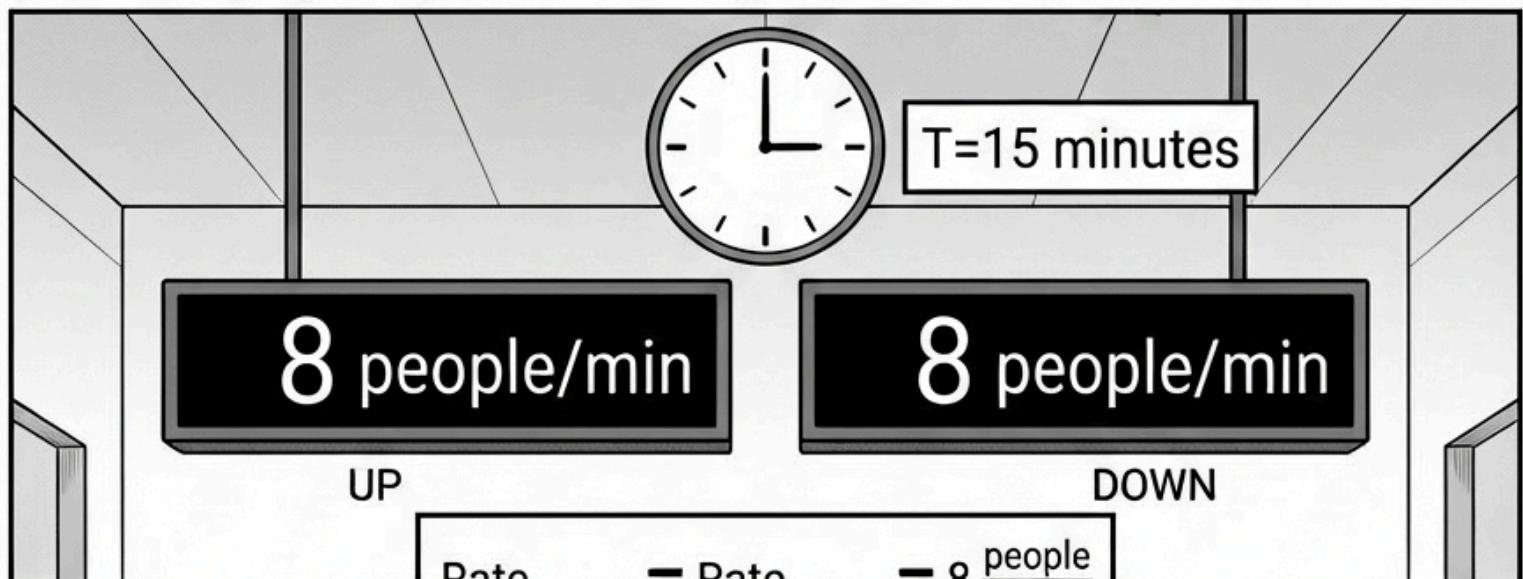


UP: 10 → 12 → 9 → 10
people/min

DOWN: 5 → 8 → 9 → 10
people/min



THE ESCALATOR EQUILIBRIUM - CHAPTER 6: THE CONVERGENCE



$$\text{Rate}_{\text{forward}} = \text{Rate}_{\text{reverse}} = 8 \frac{\text{people}}{\text{min}}$$



TOP FLOOR

GROUND FLOOR

60 people

40 people

NO CHANGE

NO CHANGE

Finally! The rates are equal. The system has reached dynamic equilibrium. The overall numbers on each floor are constant, but individuals are still moving!



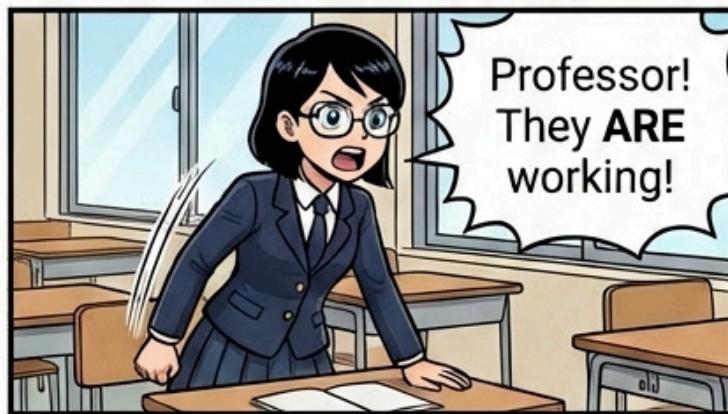
Exactly, Mira. This is what we call 'dynamic equilibrium'.



THE ESCALATOR EQUILIBRIUM - CHAPTER 7: THE ACCUSATION



THE ESCALATOR EQUILIBRIUM - CHAPTER 8: THE MICROSCOPIC TRUTH



MACROSCOPIC VIEW: No Observable Change

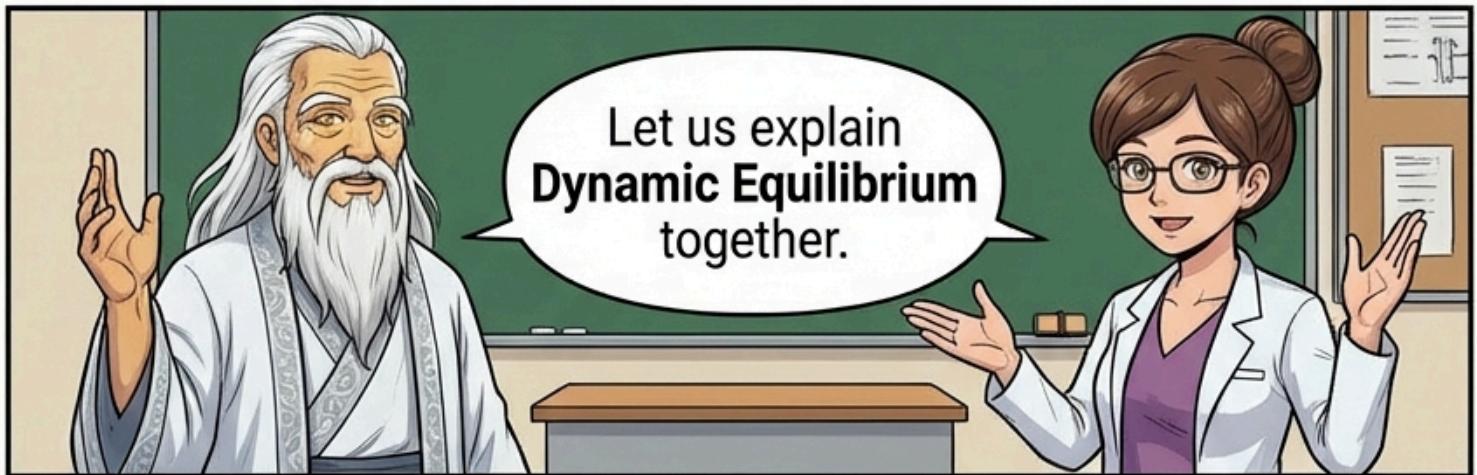
Top Floor: 60

Ground Floor: 40

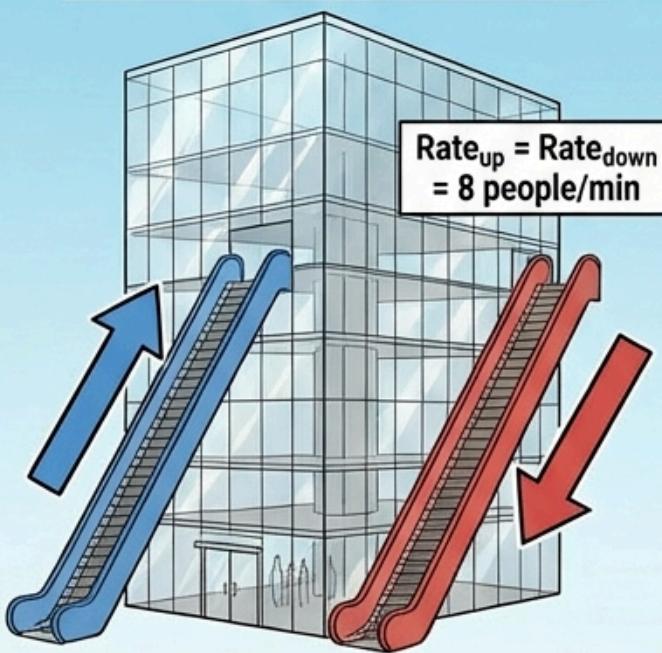
MICROSCOPIC VIEW: Continuous Dynamic Movement

Dynamic Equilibrium is only static from afar!
Up close, the reaction is always active!



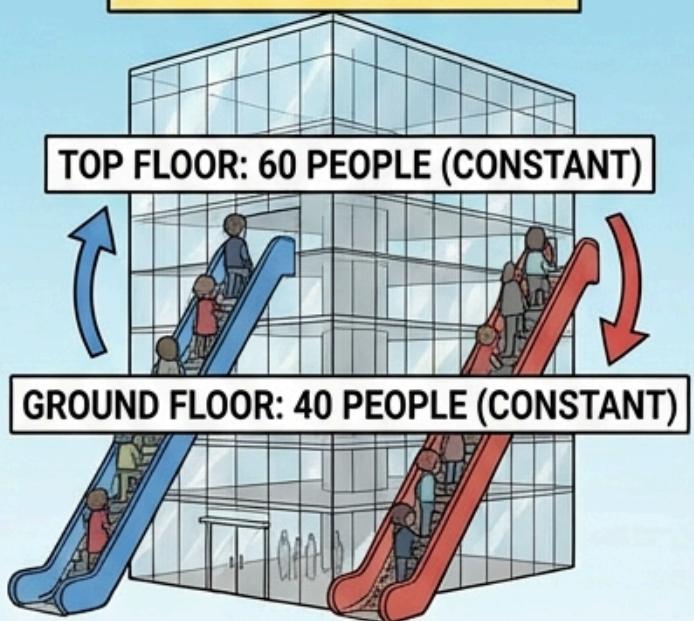


EQUAL OPPOSITE RATES



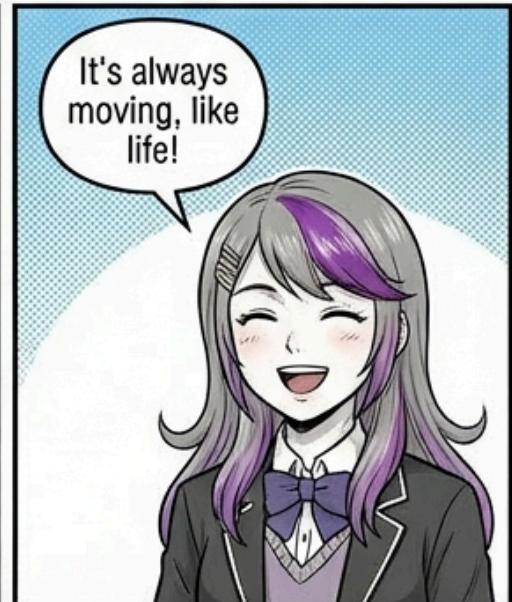
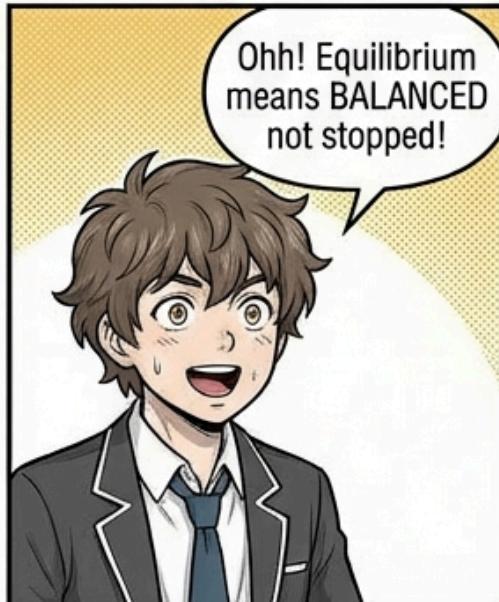
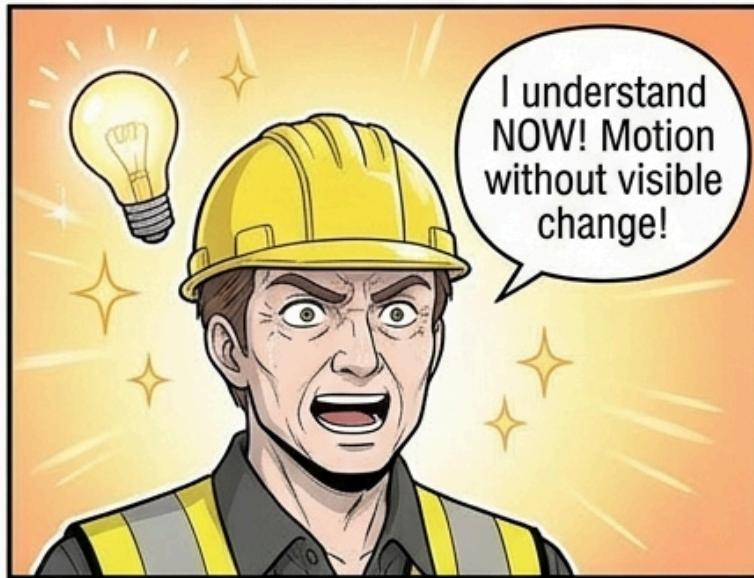
$$k_1[A][B] = k_2[C][D]$$

CONSTANT UNEQUAL CONCENTRATIONS



The total amounts (concentrations) are constant, but **NOT** necessarily equal!

THE ESCALATOR EQUILIBRIUM - CHAPTER 10: UNDERSTANDING & UNITY



SUMMARY: What We Learned From The Story

**UP:
8 people/min**

=

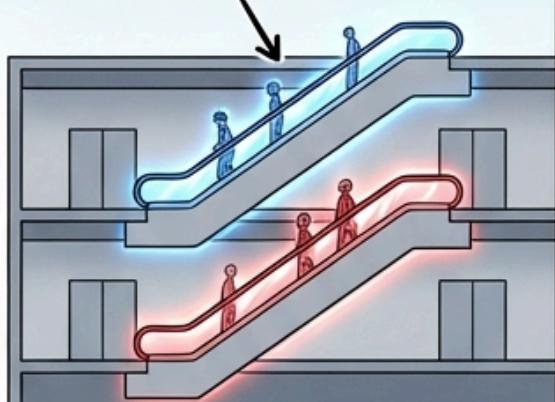
**DOWN:
8 people/min**



**CONCEPT 1:
Chemical Equilibrium
= Equal Rates**

Rate_{forward} = Rate_{reverse}

Just like Kai and Rin working at identical speeds, forward and reverse reactions proceed at **SAME RATE**



**TOP FLOOR:
60 people (Constant)**

**NO
CHANGE**

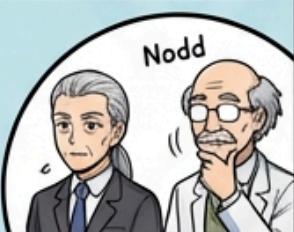
**GROUND FLOOR:
40 people (Constant)**

**NO
CHANGE**

**CONCEPT 2:
Dynamic Equilibrium =
Constant (but not necessarily
equal) Concentrations**

$k_1[A][B] = k_2[C][D]$

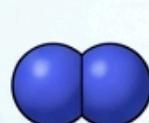
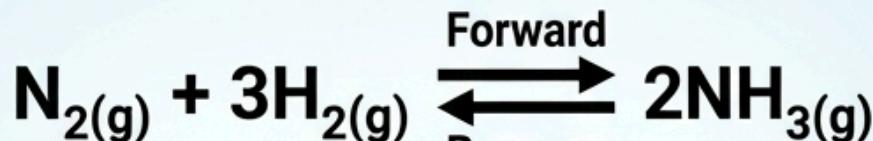
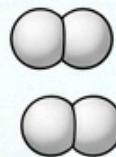
The total amounts of reactants and products (concentrations) remain constant over time, but are **NOT necessarily equal**



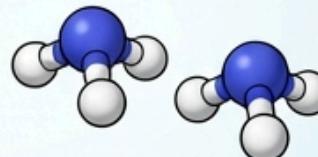


**Equilibrium is a state of
BALANCE, not a stop!
The reaction **CONTINUES**
dynamically**

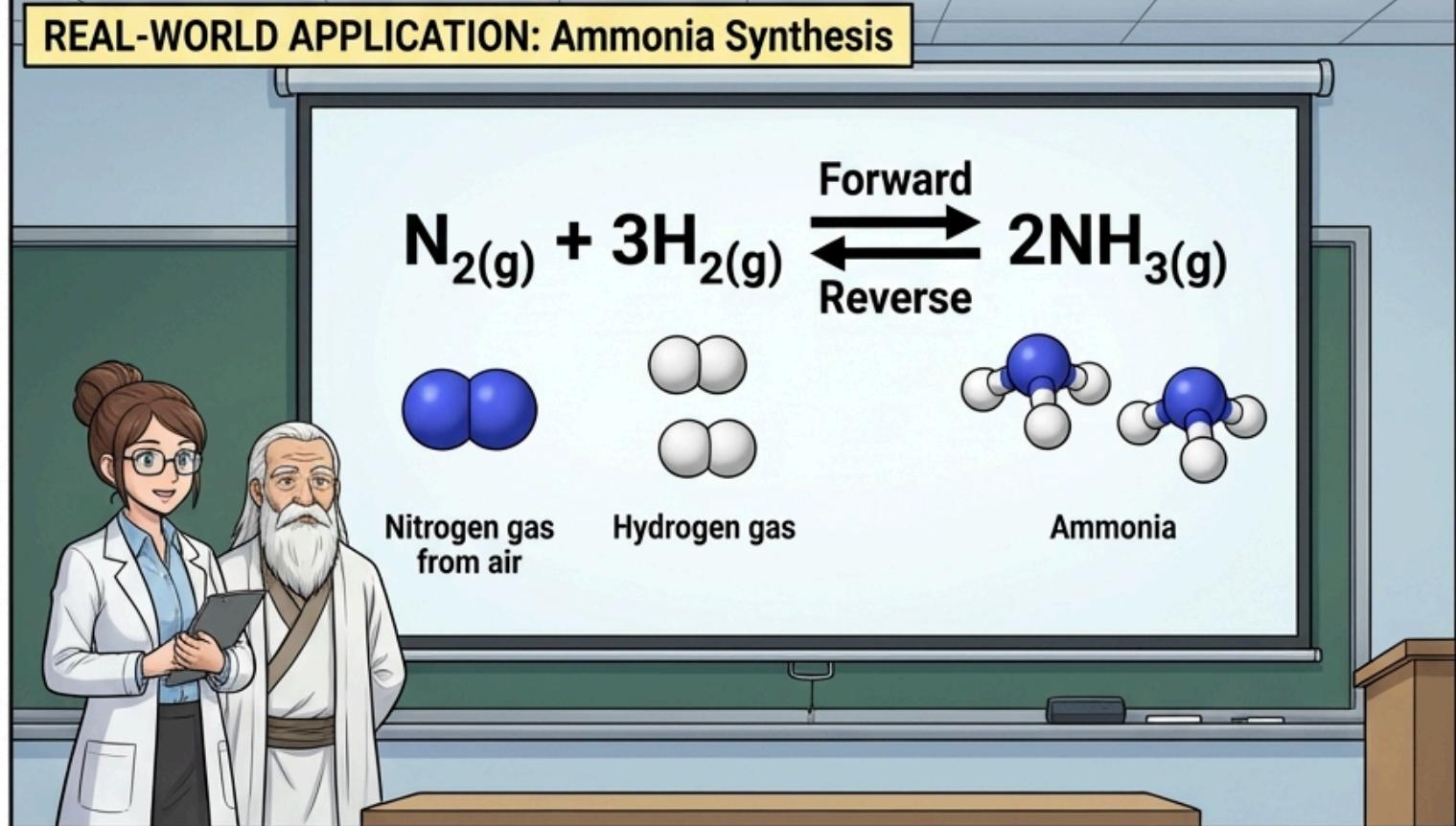
REAL-WORLD APPLICATION: Ammonia Synthesis

Nitrogen gas
from air

Hydrogen gas



Ammonia



STORY PARALLEL

Top Floor = 2NH_3 (Products)Forward Reaction
($\text{N}_2 + \text{H}_2 \rightarrow \text{NH}_3$)Ground Floor = $\text{N}_2 + 3\text{H}_2$ (Reactants)Reverse Reaction
($\text{NH}_3 \rightarrow \text{N}_2 + \text{H}_2$)Rate_{forward} = Rate_{reverse}Constant Concentrations
of N_2 , H_2 , and NH_3
(not necessarily equal)

Just as the escalator system finds balance,
the Haber process reaches dynamic equilibrium!

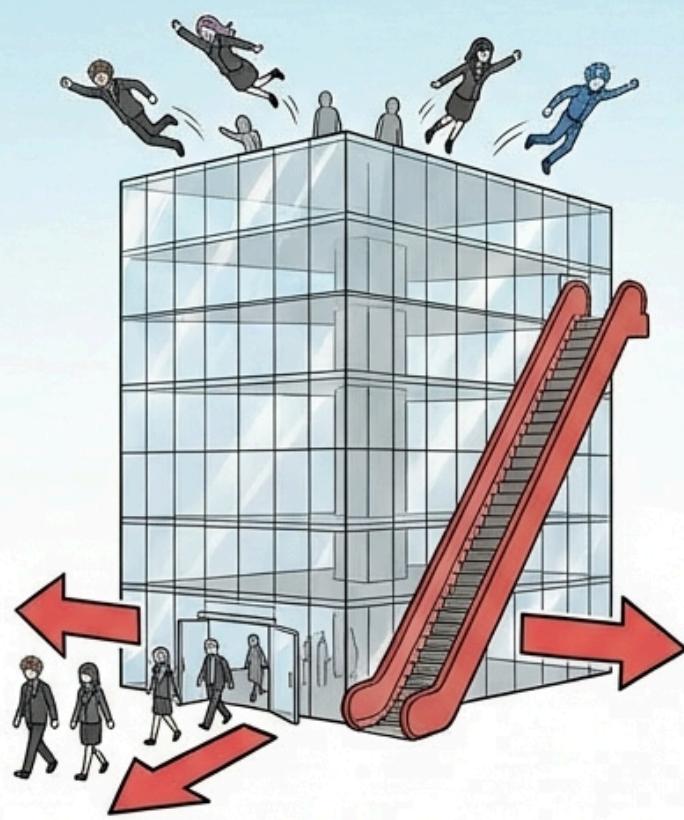
The reaction continues,
but the overall amounts
of ammonia,
nitrogen, and hydrogen
become constant!



CRITICAL CONCEPT: The Closed System Requirement

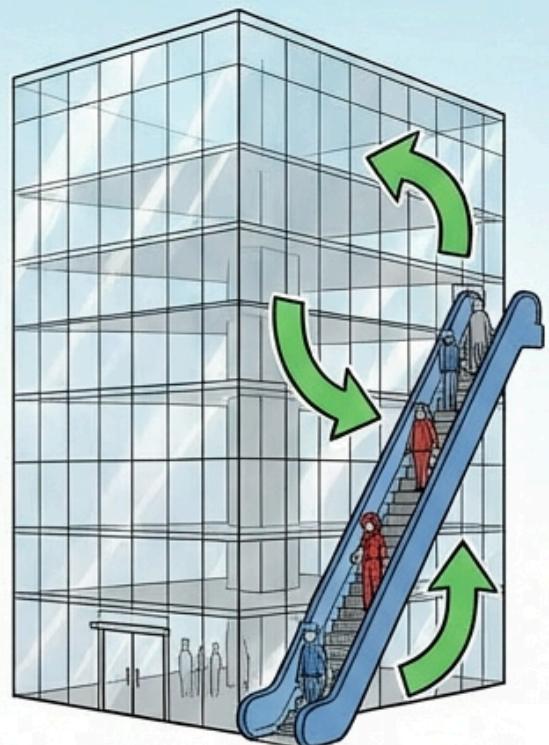


**OPEN SYSTEM =
NO EQUILIBRIUM X**



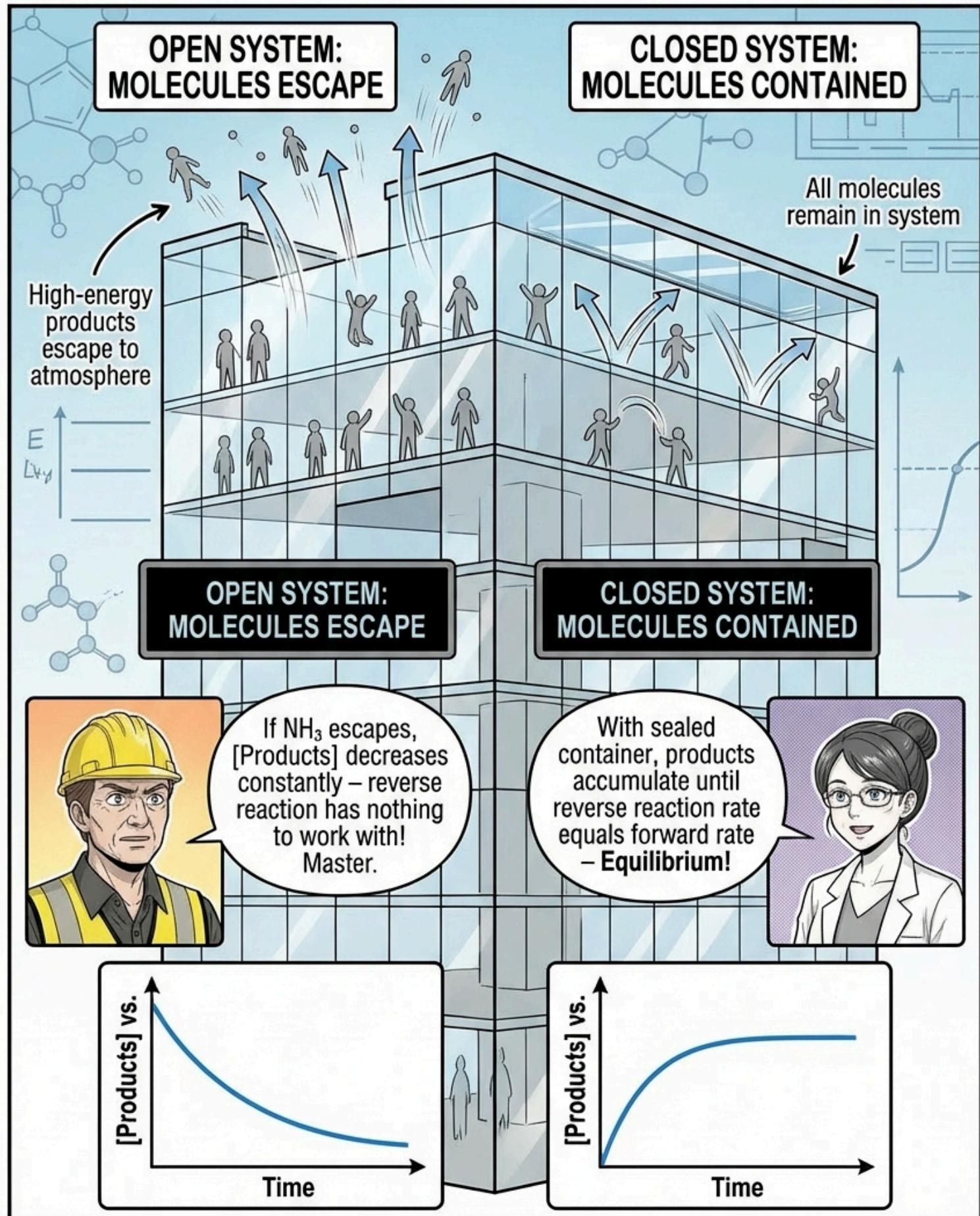
Matter and energy can escape!
No balance possible!

**CLOSED SYSTEM =
EQUILIBRIUM POSSIBLE ✓**

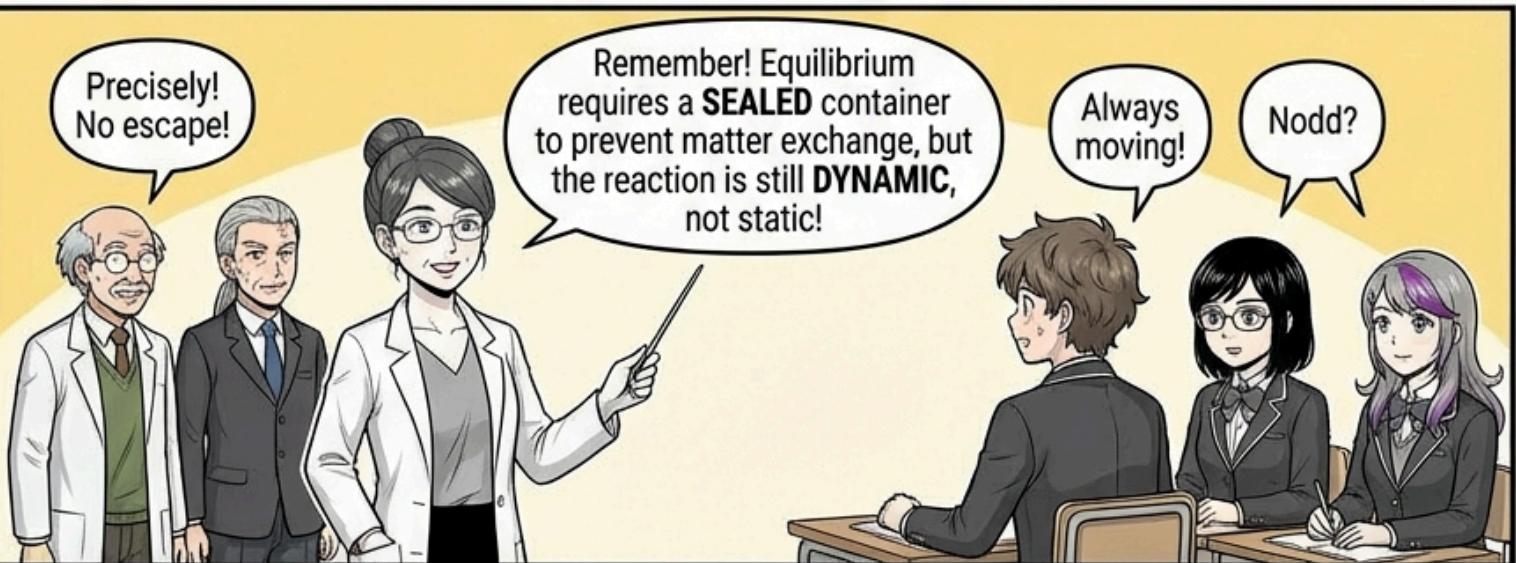
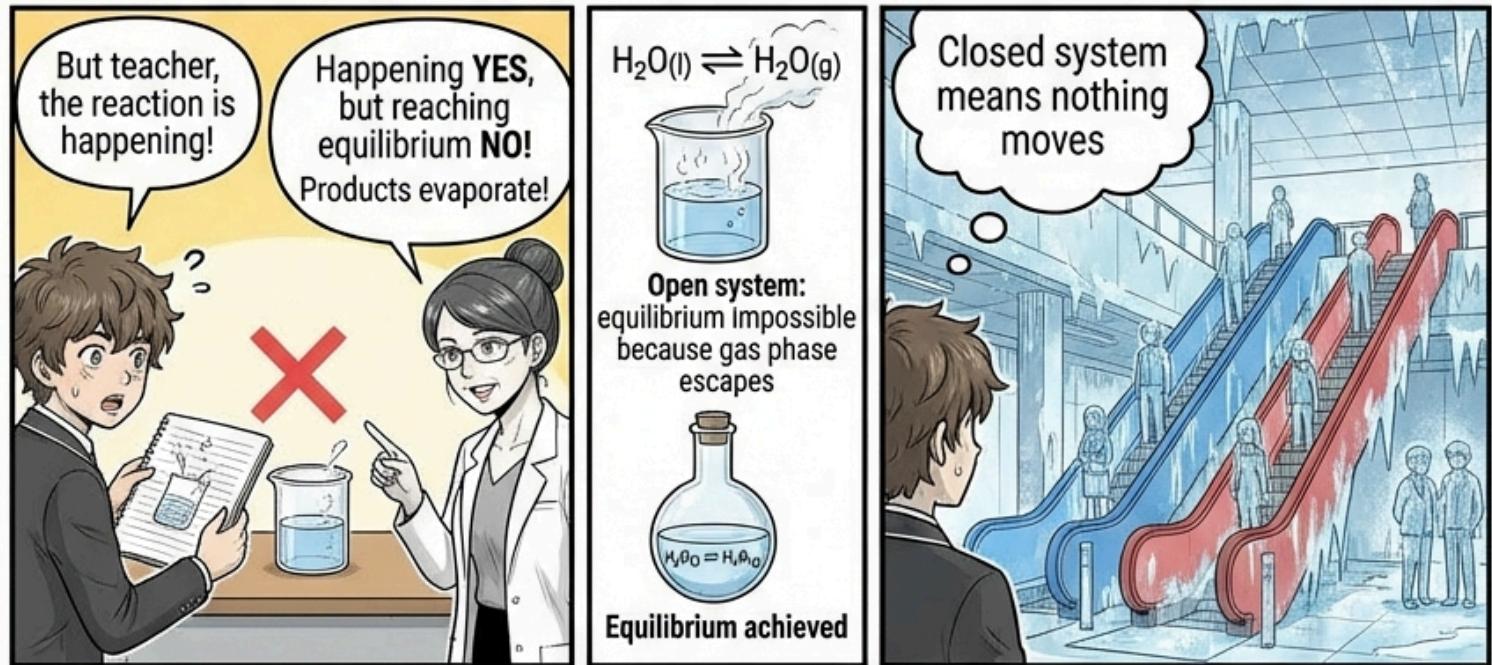
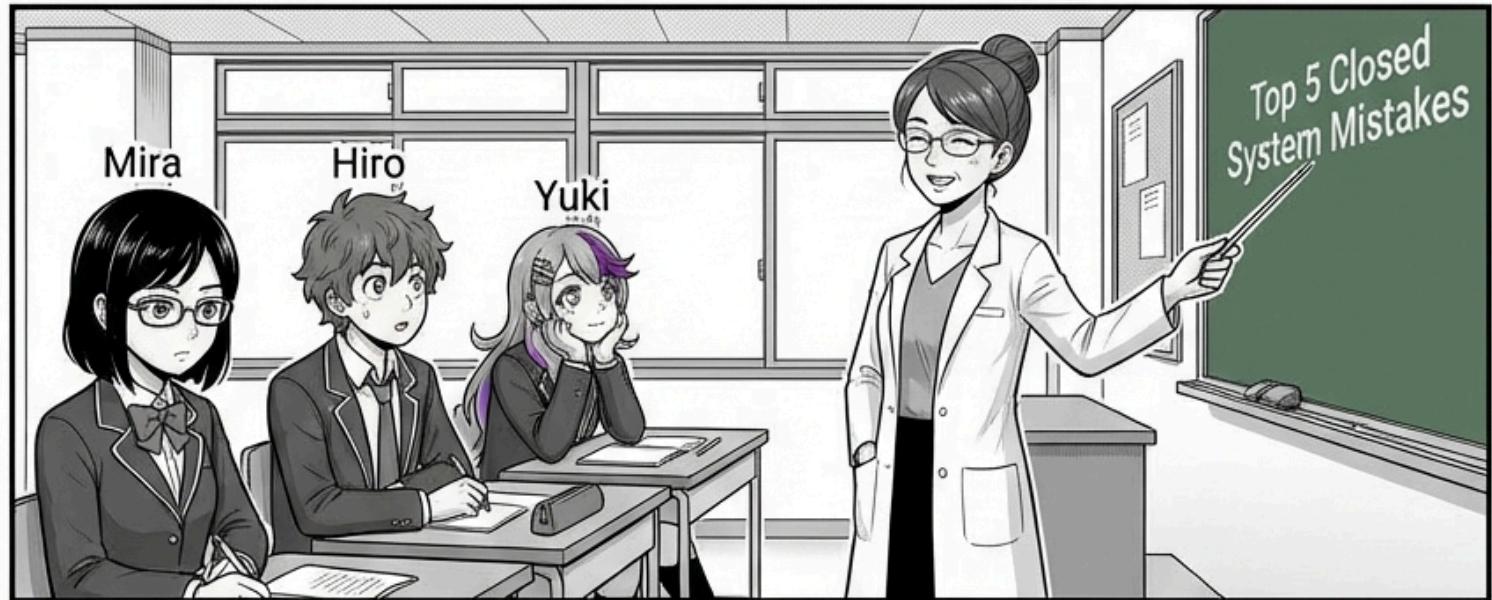


Nothing enters or leaves!
Balance is achieved!

WHY CLOSED SYSTEM MATTERS - The Physics Behind It



SUMMARY: Common Mistakes Students Make About Closed Systems



CAN YOU SOLVE THE BUILDING MYSTERY?



TEST YOUR UNDERSTANDING: THE BUILDING CHALLENGE - PAGE 1 of 2

QUIZ FORMAT - 10 Multiple Choice Questions

QUESTION 1:

In THE BUILDING story, what do Kai and Rin represent?



- A) Two different molecules
- B) Forward and reverse reaction forces
- C) Reactants and products
- D) The equilibrium constant

CHEMICAL EQUILIBRIUM: Test Your Knowledge

QUESTION 2: What does it mean when a reaction is at equilibrium?

- (A) The reaction has stopped completely
- (B) Forward and reverse rates are equal
- (C) All reactants have become products
- (D) The temperature is constant

QUESTION 3: Which statement is TRUE about dynamic equilibrium?

- (A) Molecules stop moving
- (B) Concentrations remain constant
- (C) The forward reaction is faster than the reverse
- (D) Equilibrium only occurs in closed systems

QUESTION 4: Which reaction quotient Q represents the equilibrium condition?

- (A) $Q = [A]/[B]$
- (B) $Q = [B]/[A]$
- (C) $Q = 1$
- (D) $Q = [A][B]$ (for $A \rightleftharpoons B$)

QUESTION 5: For $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ (brown), $\Delta H > 0$, what happens if temperature increases?

- (A) Shifts left (less brown)
- (B) Shifts right (more brown)
- (C) No change
- (D) Equilibrium constant K decreases

QUESTION 6: What is the expression for K_p for the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$?

- (A) $K_p = \frac{(P_{CO})^2}{P_c \cdot P_{CO_2}}$
- (B) $K_p = \frac{(P_{CO})^2}{P_{CO_2}}$
- (C) $K_p = \frac{P_{CO_2}}{(P_{CO})^2}$
- (D) $K_p = \frac{(P_{CO})^2}{[CO_2]}$

QUESTION 7: If $K < 1$, what is true at equilibrium?

- (A) Products > Reactants
- (B) Reactants > Products
- (C) Products = Reactants
- (D) Reaction goes to completion

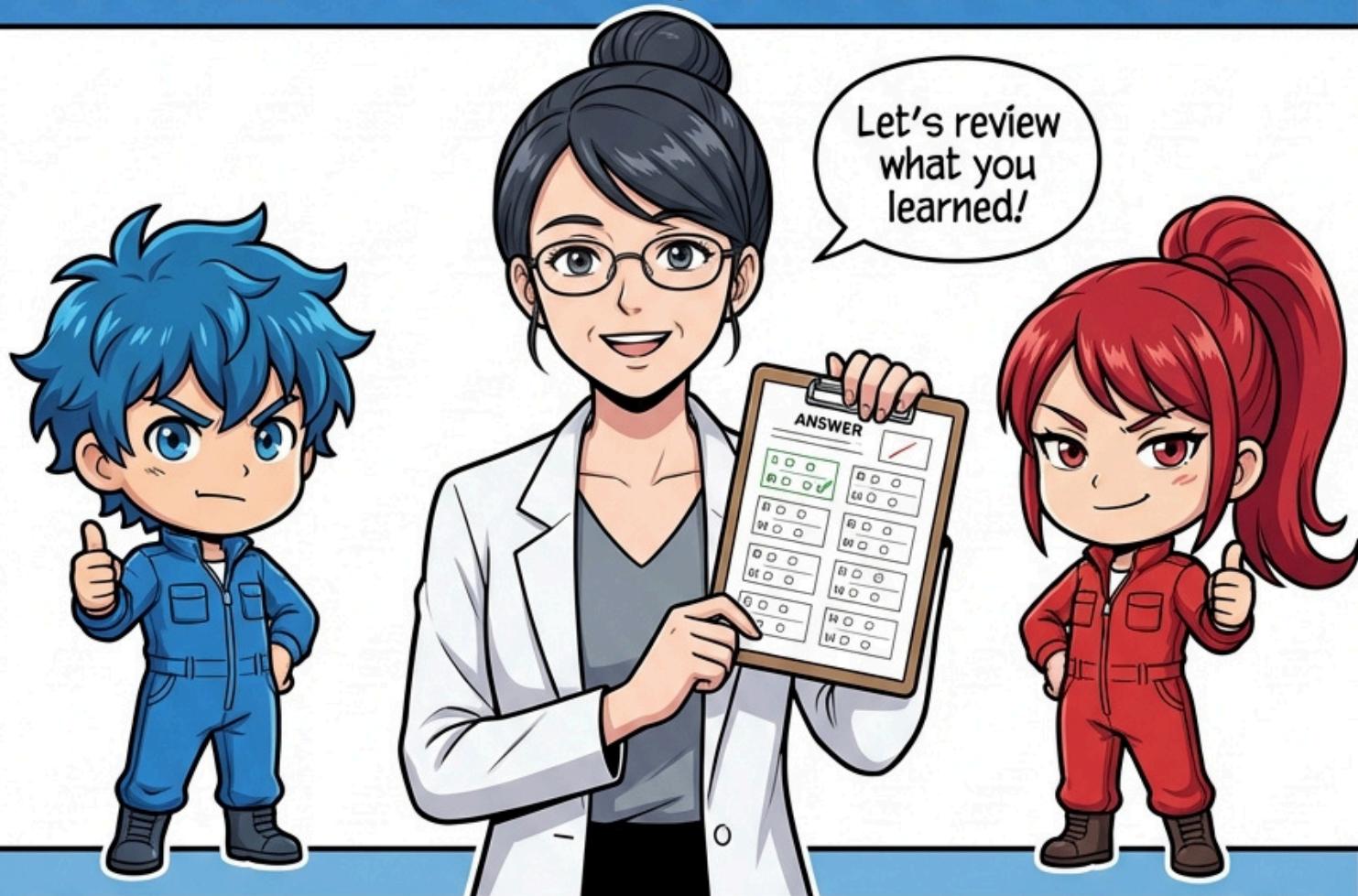
QUESTION 8: How does adding a catalyst affect equilibrium?

- (A) Shifts to products
- (B) Shifts to reactants
- (C) Increases K value
- (D) Reaches equilibrium faster, no shift

QUESTION 9: For $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, if volume decreases, how does equilibrium shift?

- (A) Shifts right
- (B) Shifts left
- (C) No shift
- (D) K increases

ANSWERS & EXPLANATIONS



ANSWER 1:



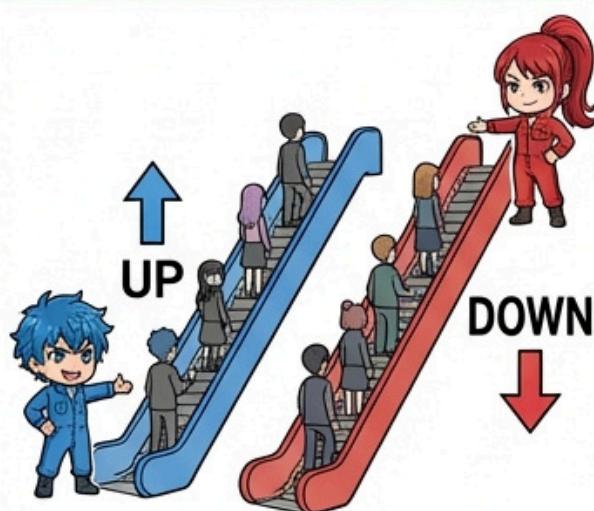
B) Forward and reverse reaction forces

Explanation:

Kai represents the FORWARD reaction force (moving people/molecules UP the blue escalator to products).

Rin represents the REVERSE reaction force (moving people/molecules DOWN the red escalator back to reactants).

They are NOT the molecules themselves - they DIRECT the flow!



WHAT'S INSIDE? THE STORY

Two workers. Two escalators. One building. When Kai starts moving people UP and Rin moves people DOWN, something extraordinary happens – they discover the secret of DYNAMIC EQUILIBRIUM! Follow their journey from rivalry to understanding as they unlock the mysteries of chemical balance.

Can motion exist without change?

Can opposite forces create perfect harmony?

The answers lie within... THE BUILDING!



Kai

The Forward Force - Energetic and determined, driving change!



Rin

The Reverse Force - Controlled and precise, maintaining balance!



Professor Sato

The Knowledge - Guiding students to understand equilibrium!

THE BUILDING

A Visual Manga Story of Chemical Equilibrium

By Mr. Hisham Mahmoud



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