

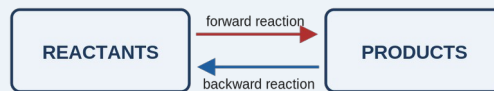
## 3.3 Reversible Reactions & Equilibria

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### 1. KEY VOCABULARY

TERM	MEANING
Reversible reaction	A reaction that can go both forwards and backwards ( $\rightleftharpoons$ ).
Dynamic equilibrium	Forward and backward reactions happen at the same rate.
Closed system	Nothing can enter or leave — needed for equilibrium.
Le Chatelier's principle	If you change conditions, the equilibrium shifts to oppose the change.
Yield	The amount of product made.

### 2. DYNAMIC EQUILIBRIUM



**At equilibrium (closed system):**

forward rate = backward rate  
 the amounts of reactants and products stay constant  
 — but both reactions are still happening (it is DYNAMIC).

### 3. REVERSIBLE REACTIONS

**Shown by the  $\rightleftharpoons$  symbol.** The products can react to re-form the reactants.

**If the forward reaction is exothermic**, the backward reaction is endothermic by the same amount.

In a closed system the reaction reaches equilibrium — amounts stay constant but both reactions continue.

### 4. LE CHATELIER'S PRINCIPLE

CHANGE	EQUILIBRIUM SHIFTS...
Increase temperature	In the endothermic direction
Increase pressure	Towards the side with fewer gas molecules
Increase concentration of a reactant	Towards the products

### 5. THE HABER PROCESS

$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$  (making ammonia).

**Conditions:** about 450 °C, about 200 atmospheres, and an iron catalyst.

These are a compromise between yield, rate and cost.

### 6. THE WHY

**Why equilibrium is 'dynamic':** the forward and backward reactions never stop — they just happen at equal rates, so amounts appear constant.

**Why the Haber conditions are a compromise:** a higher temperature speeds the reaction but lowers the yield, so a moderate temperature is chosen.

### 7. COMMON EXAM MISTAKES

- ✗ "At equilibrium the reactions have stopped."
- ✓ Both reactions continue — at equal rates (dynamic).
- ✗ "Equilibrium means equal amounts of reactants and products."
- ✓ It means equal RATES — amounts can be very unequal.
- ✗ "Equilibrium can be reached in an open container."
- ✓ It needs a closed system.

### 8. SELF-CHECK · cover & quiz

Can you...

1. Explain what a reversible reaction is?
2. Define dynamic equilibrium?
3. State Le Chatelier's principle?
4. Predict the shift when temperature, pressure or concentration changes?
5. Give the equation and conditions for the Haber process?
6. Explain why the Haber conditions are a compromise?