

Predicting Reaction Direction Before Equilibrium

Mastering the Reaction Quotient (Q) for JEE



The Snapshot of a Reaction: Reaction Quotient (Q)

Q is defined exactly like the Equilibrium Constant (K), but with one critical difference: it uses concentrations at any given moment (t), not just at equilibrium.

Current State: Reaction Quotient (Qc)

Formula Bank

$$Q_c = \frac{[C]^c_t [D]^d_t}{[A]^a_t [B]^b_t}$$

Calculated at time t.
Tells us where we are right now.

Destination: Equilibrium Constant (Kc)

Formula Bank

$$K_c = \frac{[C]^c_{eq} [D]^d_{eq}}{[A]^a_{eq} [B]^b_{eq}}$$

Calculated at **equilibrium**.
Tells us where the system wants to be.

Key Takeaways

Q acts as a real-time tracker. By calculating Q, we mathematically **prove if a system is at equilibrium**, or which way it needs to shift to get there.

The Predictor's Compass: Q vs K

To predict the direction of a chemical reaction, compare the calculated real-time value of Q to the known constant K.



The Forward Shift

$$Q_c < K_c$$

Ratio of products to reactants
is too low.

Net reaction moves **RIGHT (Forward)**.



The Equilibrium State

$$Q_c = K_c$$

Ratio is perfectly balanced.

NO NET REACTION occurs.



The Backward Shift

$$Q_c > K_c$$

Ratio of products to reactants
is too high.

Net reaction moves **LEFT (Reverse)**.



JEE Trap Alert

CONCEPT TRAP: 'Net reaction' does not mean the other reaction stops. Both forward and reverse reactions are always happening simultaneously; one is simply occurring at a faster rate until $Q=K$.



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Scenario 1: $Q < K$ (Moving Forward)

Reactants

Products



Reactants



Products



The Math: A small Q means the numerator (Products) is too small, or the denominator (Reactants) is too large.

The Chemistry: The system has an excess of reactants relative to its ideal equilibrium state.

The Result: The system consumes reactants and generates products until Q grows large enough to equal K .



Le Chatelier in Action: In the Haber process, constantly removing NH_3 (product) forces $Q < K$, ensuring the reaction continuously moves forward!

Scenario 2: $Q > K$ (Moving Backward)

The Math: A large Q means the numerator (Products) is too large, or the denominator (Reactants) is too small.

The Chemistry: The system has an excess of products relative to its ideal equilibrium state.

The Result: The system consumes products and generates reactants until Q shrinks down to equal K .

Key Takeaways

Adding products to an equilibrium mixture artificially spikes the value of Q , triggering a rapid reverse shift (moving left) to relieve the stress.

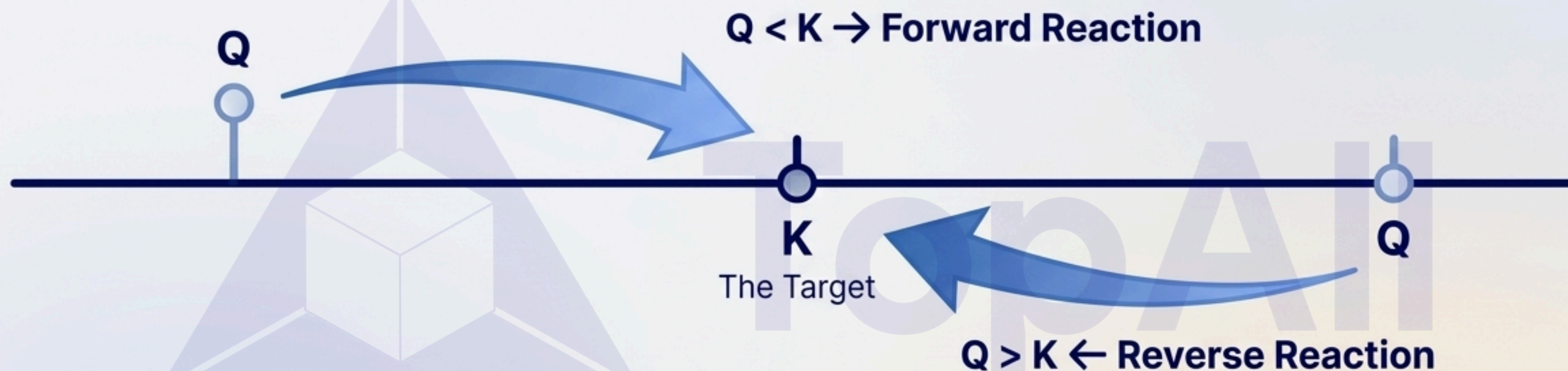


Reactants $\rightleftharpoons$ Products



Exam Snapshot: The Number Line Shortcut

Never confuse reaction direction under exam pressure again.



Rule of Thumb

Always draw an arrow from your current location (Q) to your destination (K). The arrow points in the exact direction the net reaction will shift.

JEE Trap Alert

WATCH OUT: When calculating Q_c for heterogeneous equilibria, remember to IGNORE pure solids and pure liquids, just as you do for K_c . Only include (aq) and (g) states!



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