Reaction Quotient and Predicting Direction

Student Worksheet | `g10_u04_w14`

I can: calculate a reaction quotient from a stated snapshot, compare it with a stated equilibrium constant, and make a bounded net-direction prediction.

Classroom model: For $A(aq) + B(aq) \rightleftharpoons C(aq)$ at one stated temperature, use $Q_c = \dfrac{[C]}{[A][B]}$ for any supplied snapshot and $K_c = 2.00\ \mathrm{M}^{-1}$ for equilibrium at that temperature. $Q_c < K_c$ supports a net forward direction; $Q_c > K_c$ supports a net reverse direction; $Q_c = K_c$ is the equilibrium condition in this model. This comparison does *not* state reaction speed, mechanism, or exact future concentrations. All prompts use data cards only.

Snapshot	$[A]$ (M)	$[B]$ (M)	$[C]$ (M)	Given condition
1	0.200	0.300	0.0600	same stated temperature
2	0.100	0.400	0.120	same stated temperature
3	0.200	0.300	0.120	same stated temperature
4	0.300	0.200	0.0600	temperature not reported

Second expression card: For $2D(aq) \rightleftharpoons E(aq)$ at a stated temperature, use $K_c = 2.00\ \mathrm{M}^{-1}$ and $Q_c = \dfrac{[E]}{[D]^2}$ for the supplied snapshots.

1. In one sentence, distinguish an equilibrium constant K_c from a reaction quotient Q_c.

2. Write the expression for Q_c for $A + B \rightleftharpoons C$. Why does it have the same algebraic form as K_c in this packet?

3. Calculate Q_c for snapshot 1.

4. Compare snapshot 1's Q_c with K_c. Predict the net direction and name one species whose concentration would initially tend to increase.

5. Calculate Q_c for snapshot 2.

6. Compare snapshot 2's Q_c with K_c. Predict the net direction and name one species whose concentration would initially tend to increase.

7. Calculate Q_c for snapshot 3. What does the comparison say about its equilibrium condition?

8. Complete the rule in words: when $Q_c < K_c$, the system has relatively too much __________; when $Q_c > K_c$, it has relatively too much __________.

9. Why is "$Q_c < K_c$, so the reaction is fast" an unsupported conclusion?

10. Why does the card for snapshot 4 not support a confident comparison to the stated K_c?

11. A snapshot has $[A] = 0.150$ M, $[B] = 0.200$ M, and $[C] = 0.0300$ M at the stated temperature. Calculate Q_c and predict net direction.

12. At the stated temperature, find $[C]$ that would make the expression equal to K_c when $[A] = 0.150$ M and $[B] = 0.200$ M.

13. A student doubles all three snapshot-3 concentrations and claims the new state must still have $Q_c = K_c$. Calculate the factor change in Q_c and critique the claim.

14. For $2D \rightleftharpoons E$, write Q_c. Explain how the coefficient 2 appears.

15. For $[D] = 0.200$ M and $[E] = 0.0400$ M, calculate Q_c and predict net direction using $K_c = 2.00\ \mathrm{M}^{-1}$.

16. For $[D] = 0.200$ M and $[E] = 0.120$ M, calculate Q_c and predict net direction.

17. For $[D] = 0.200$ M, calculate $[E]$ that gives $Q_c = K_c$.

18. A data card contains a pure solid: $F(aq) + G(s) \rightleftharpoons H(aq)$. Write the Q_c expression and state why the solid is omitted in this classroom model.

19. A classmate says, "If $Q_c = K_c$, every concentration must be equal." Correct the claim.

20. Write a cautious claim-evidence-reasoning statement for snapshot 2. Include its Q_c, its comparison with K_c, its net-direction prediction, and one limitation of that prediction.