Exercise walk-through

Reaction Quotient and Le Chatelier's Principle ▪ 7.10

eXercise

You must be able to

- show how a stress changes Q relative to K
- predict the shift that restores $Q = K$
- connect the Q/K view to Le Chatelier

Method — A stress changes Q

Adding or removing a species instantly changes Q but not K. The system then shifts to bring Q back to K — the quantitative reason behind Le Chatelier.

Method — A worked concentration change

At equilibrium $Q = K$. **Add reactant** $\rightarrow$ the denominator grows $\rightarrow$ Q **drops below** K $\rightarrow$ reaction shifts **forward** until $Q = K$ again.

Method — Removing a product

Remove product $\rightarrow$ the numerator shrinks $\rightarrow$ Q drops below K $\rightarrow$ shifts **forward** to remake product.

Method — Why temperature is different

Concentration and pressure changes move Q toward a fixed K. A **temperature** change instead changes K **itself**, so the system shifts to reach the new K.

Practice 2.1 ▪ 1 mark

Adding a reactant makes Q do what (relative to K)?

Solution 2.1

Worked steps

Q falls below K B1.

Practice 2.2 ▪ 1 mark

If $Q < K$ after a stress, which way does the reaction shift?

Solution 2.2

Worked steps

Forward (toward products) B1.

Practice 2.3 ▪ 1 mark

Does adding a reactant change K?

Solution 2.3

Method: A worked concentration change

Worked steps

No B1.

Exam-style 3.1 ▪ 1 mark

Removing a product from an equilibrium causes Q to

A rise above K

B fall below K

C stay equal to K

D become zero

Solution 3.1

Method: Removing a product

A rise above K

B fall below K ✓

C stay equal to K

D become zero

Worked steps

B — removing a product lowers the numerator, so Q falls below K.

Exam-style 3.2 ▪ 1 mark

For $A \rightleftharpoons B$ at equilibrium, more B is suddenly added.
(a) State how Q changes relative to K.
(b) State the direction of shift and explain using Q and K.

Solution 3.2

Worked steps

(a) Q rises above K (more product in the numerator) B1. (b) Shifts **reverse** (toward A), because $Q > K$ so the reaction consumes B to bring Q back down to K M1 A1.

Exam-style 3.3 ▪ 2 marks

Explain why a concentration change shifts the equilibrium but leaves K unchanged, whereas a temperature change alters K.

Solution 3.3

Worked steps

Concentration changes only move the current Q; the reaction shifts to restore the same K. Temperature changes the equilibrium position by changing K itself (since K depends on temperature) M1 A1.