Dynamic Equilibrium and Equilibrium Expressions

Student Worksheet | `g10_u04_w13`

I can: use event and concentration evidence to explain dynamic equilibrium and write a limited concentration-based equilibrium expression.
Classroom model: A reversible system can keep changing microscopically even when measured amounts stop changing. At dynamic equilibrium, forward and reverse rates are equal; the concentrations need not be equal. For this packet, use the stated concentration model only for the named reaction, temperature, and equilibrium data. All prompts use supplied cards or a paper simulation—no chemical handling is requested.

10-s interval	Forward events ($X + Y \rightarrow Z$)	Reverse events ($Z \rightarrow X + Y$)	Net trend for Z
1	18	4	increases
2	12	7	increases
3	9	9	no average change
4	8	8	no average change

Equilibrium concentration card: For $X(aq) + Y(aq) \rightleftharpoons Z(aq)$ at one stated temperature, the measured equilibrium concentrations are below. In this classroom concentration convention, use $K_c = \dfrac{[Z]}{[X][Y]}$; the final units shown in this packet follow the concentration-substitution convention.

Run	$[X]_{eq}$ (M)	$[Y]_{eq}$ (M)	$[Z]_{eq}$ (M)
1	0.200	0.300	0.120
2	0.100	0.400	0.0800
3	0.250	0.160	0.0800

1. Define a reversible reaction in your own words.

2. In interval 1, which direction has the larger event count? What trend for Z follows?

3. Compare intervals 1 and 3. What changes about the forward and reverse event counts? What still continues in interval 3?

4. Why does a constant measured concentration in intervals 3–4 not mean the reaction has stopped?

5. At dynamic equilibrium, what relationship holds between the forward and reverse *rates*? Must the concentrations of X, Y, and Z be equal?

6. A student says, "There are 8 forward and 8 reverse events, so there are no events." Correct the claim using the card.

7. Which event-card intervals can support the claim that the system has reached dynamic equilibrium? State the evidence.

8. Write the concentration-based equilibrium expression for $X(aq) + Y(aq) \rightleftharpoons Z(aq)$. Explain how the equation coefficients appear in the expression.

9. Use run 1 to calculate K_c. Show substitution and report to the precision supported by the card.

10. Use run 2 to calculate K_c. Does it support the run-1 value under the stated conditions?

11. Use run 3 to calculate K_c. Explain why different equilibrium concentrations can still give the same K_c.

12. A fourth equilibrium run has $[X]_{eq} = 0.150$ M and $[Y]_{eq} = 0.200$ M. Using $K_c = 2.00\ \text{M}^{-1}$, calculate $[Z]_{eq}$.

13. If all three concentrations in run 1 were each doubled, would direct substitution into the same expression give the same K_c? Calculate the factor change in $[Z]/([X][Y])$ and explain the model limit.

14. For $2D(aq) \rightleftharpoons E(aq)$, write the concentration expression. Why is the exponent on $[D]$ two?

15. For $2D(aq) \rightleftharpoons E(aq)$, $[D]_{eq} = 0.300$ M and $[E]_{eq} = 0.180$ M. Calculate K_c.

16. For $F(aq)+G(s) \rightleftharpoons H(aq)$, write the classroom concentration expression. Why is the pure solid omitted?

17. Name two conditions that must match before comparing K_c values from two concentration cards.

18. A data card lists $[X] = 0.200$ M, $[Y] = 0.300$ M, and $[Z] = 0.120$ M but does not say the system is at equilibrium. Why should you not automatically call the calculated ratio K_c?

19. Draw or describe a particle-level snapshot at equilibrium that has more X particles than Z particles but equal average forward and reverse rates.

20. Write a cautious claim-evidence-reasoning statement: use one event-card interval and one equilibrium-concentration calculation to explain dynamic equilibrium and the scope of the expression model.