ExamFitter

examfitter.com · Free AP Chemistry quizzes, revision notes and worksheets

# Topic 7.8: Representations of Equilibrium

Worksheet · AP Chemistry

UNIT 7 · EQUILIBRIUM

On ExamFitter.com: Topic 7.8 Revision Notes · Topic 7.8 Quiz · Previous Worksheet: Topic 7.7 · Next Worksheet: Topic 7.9 · Unit 7: All Topics · AP Chemistry Home

## How to Use This Worksheet

Work in order. Section A checks the reading skills: what certifies equilibrium, how counts become ratios, and what rate graphs cannot say. Section B practises counts into K with powers, graphs read for plateau values, snapshots matched to a stated K, a sudden jump, and Q from a snapshot. Section C is exam style: a three-species snapshot problem, a graph with a removal and second plateau, and snapshots paired with a rate graph.

Reference facts. Particle counts substitute directly into the K or Q expression: write the expression first, then put the counts in, with each coefficient as a power. A snapshot of a mixture not known to be at equilibrium gives Q, never K. On a concentration-time graph, equilibrium begins when every curve becomes horizontal at the same time; a crossing of two curves is not equilibrium. A sudden vertical jump in one curve means that species was added or removed.

Conventions: every box is a sealed vessel. Counts are the concentrations in these questions, so no conversion is needed.

Do not look at the answer key until you have attempted every question.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

## Section A: Recall and Concepts

**A1.** State the evidence, in each representation, that certifies a system is at equilibrium: (a) a series of particulate snapshots, (b) a concentration-time graph, (c) a rate-time graph. Then explain why no single snapshot can certify equilibrium on its own.

**A2.** For A(g) ⇌ B(g), an equilibrium snapshot shows 9 A particles and 3 B particles. (a) Calculate Kc. (b) A second vessel for the same reaction at the same temperature is at equilibrium with 3 A and 1 B particles. Calculate its Kc. (c) Explain how the two vessels can show different totals yet the same Kc.

**A3.** Judge each statement, giving the reason. (a) "On a concentration-time graph, equilibrium begins where the reactant and product curves cross." (b) "If an equilibrium snapshot shows equal numbers of reactant and product particles, Kc must equal 1." (c) "A snapshot that shows some particles of every species must be an equilibrium mixture."

**A4.** A rate-time graph for a reversible reaction shows the forward rate falling from 0.60 to 0.24 mol $L^{-1}$ $s^{-1}$ while the reverse rate rises from 0 to 0.24 mol $L^{-1}$ $s^{-1}$, after which both stay constant. (a) State the forward and reverse rates at equilibrium. (b) State what the graph tells you about the equilibrium concentrations, and what it cannot tell you. (c) State what additional information you would need to calculate Kc.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

**A5.** For A(g) + B(g) ⇌ 2C(g), a snapshot shows 4 A, 4 B and 8 C particles. Kc = 16 at this temperature. (a) Calculate Q from the snapshot. (b) State whether the system is at equilibrium and, if it is not, the direction of net change. (c) State which particle counts rise and which fall as the system moves on from this snapshot.

## Section B: Core Practice

**B1.** For 2A(g) ⇌ B(g), a box is photographed four times: 16 A and 0 B; then 12 A and 2 B; then 8 A and 4 B; then 8 A and 4 B again. (a) Show that the changes between photographs respect the ratio in the equation and that the particle units are conserved. (b) State which photograph first certifies equilibrium, and why the third photograph alone could not. (c) Calculate Kc from the equilibrium photograph. (d) Calculate Q from the second photograph and state the direction of net change at that moment.

**B2.** A concentration-time graph for A(g) ⇌ B(g) shows [A] falling from 1.00 to 0.25 mol $L^{-1}$ and [B] rising from 0 to 0.75 mol $L^{-1}$, both curves flattening at t = 6 min. The two curves cross at t = 3 min, where both read 0.50 mol $L^{-1}$. (a) State when equilibrium is first reached and the graph feature that tells you. (b) Explain why the crossing at t = 3 min is not equilibrium. (c) Calculate Kc from the graph. (d) A second run starts with [B] = 1.00 mol $L^{-1}$ and no A. Describe the two curves and give the plateau values.

**B3.** For A(g) ⇌ 2B(g), Kc = 4.0. Four candidate snapshots are drawn in identical boxes: (i) 2 A and 2 B; (ii) 5 A and 4 B; (iii) 4 A and 4 B; (iv) 2 A and 4 B. (a) Calculate the value of the expression $[B]^2 / [A]$ for each snapshot. (b) State which snapshot can show the system at equilibrium. (c) For each of the others, state the direction of net change.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

**B4.** For $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, Kc = 2.0. Vessel 1 starts with 10 $N_2O_4$ particles and no $NO_2$. Vessel 2 starts with 20 $NO_2$ particles and no $N_2O_4$. (a) Show that a snapshot of 8 $N_2O_4$ and 4 $NO_2$ satisfies Kc. (b) Show that this snapshot is reachable from both starting points, checking the nitrogen atom total and the change ratio each time. (c) Explain why both vessels must end at the same snapshot.

**B5.** A concentration-time graph for $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ flattens at $[SO_2]$ = 0.40, $[O_2]$ = 0.20 and $[SO_3]$ = 0.60 mol $L^{-1}$. At time t1 the $SO_3$ curve jumps vertically to 1.00 mol $L^{-1}$ while the other two curves do not move. (a) Calculate Kc from the plateau values. (b) State what happened at t1. (c) Calculate Q immediately after t1 and state the direction of net change. (d) Describe all three curves between t1 and the new equilibrium.

**B6.** For $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$, Kc = 36. A vessel starting with 8 $H_2$, 8 $I_2$ and no HI particles is photographed twice: first at 4 $H_2$, 4 $I_2$ and 8 HI, and later at 2 $H_2$, 2 $I_2$ and 12 HI. (a) Calculate Q for each photograph, stating why counts may be substituted directly. (b) State which photograph, if either, shows equilibrium, with the reason. (c) Verify by an atom count that the two photographs can belong to the same vessel.

## Section C: Exam Style

**C1.** For $A(g) \rightleftharpoons B(g) + C(g)$, Kc = 5.0. A vessel starts with 10 A particles and no B or C. (a) A photograph shows 9 A, 1 B and 1 C. Calculate Q and state the direction of net change. (b) The equilibrium photograph shows equal numbers of all three species. Find those numbers and verify them against Kc. (c) A second vessel starts with 10 B and 10 C particles and no A. Show that it reaches the same equilibrium photograph.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

**C2.** A concentration-time graph for A(g) ⇌ B(g) shows [A] falling from 0.90 to 0.60 mol $L^{-1}$ while [B] rises from 0.10 to 0.40 mol $L^{-1}$, both curves flat from t = 5 min. At t = 10 min the [B] curve drops vertically to 0.10 mol $L^{-1}$ while [A] stays at 0.60 mol $L^{-1}$. The curves then bend and flatten again at [A] = 0.42 and [B] = 0.28 mol $L^{-1}$. (a) Calculate Kc from the first plateau. (b) State what happened at t = 10 min. (c) Calculate Q just after t = 10 min and state the direction of net change. (d) Verify that the second plateau is consistent with the same Kc, and explain why Kc did not change.

**C3.** For $2NO_2(g) \rightleftharpoons N_2O_4(g)$, snapshots in a box show: at t = 0, 12 $NO_2$ and 0 $N_2O_4$; at t = 6 min, 8 $NO_2$ and 2 $N_2O_4$; at t = 12 min, 6 $NO_2$ and 3 $N_2O_4$; at t = 18 min, 6 $NO_2$ and 3 $N_2O_4$. A rate-time graph for the same vessel shows the forward and reverse rates becoming equal at t = 12 min. (a) State when equilibrium is reached, giving two independent pieces of evidence from the representations. (b) Calculate Kc from the equilibrium snapshot. (c) Calculate Q at t = 6 min and confirm that it agrees with the direction in which the counts are moving. (d) A student claims that the t = 6 snapshot on its own proves the system is not at equilibrium. Judge the claim.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

## Answer Key

**A1.** (a) Two snapshots at different times with identical counts: nothing is changing, so the two reactions balance. (b) Every curve horizontal from the same moment on: all concentrations constant. (c) The forward and reverse rate curves meeting and running together at one value. A single snapshot shows amounts at one instant only: no rate information and no earlier picture to compare with, so the counts might be frozen at equilibrium or passing through on the way elsewhere; the picture cannot distinguish the two.

**A2.** (a) The gas total is the same on both sides, so counts substitute directly: Kc = 3 / 9 = 0.33. (b) Kc = 1 / 3 = 0.33. (c) Kc is fixed by the ratio of product to reactant, not by the total number of particles. The second box holds one third as much of each species, so the ratio, and therefore Kc, is unchanged.

**A3.** (a) False. Crossing means the two concentrations are momentarily equal while both curves still slope. Equilibrium begins when the curves become horizontal: concentrations stopped changing. (b) False. Equal counts give Kc = 1 only for a one-to-one expression. With powers involved they can give very different values: for A(g) ⇌ 2B(g), counts of 4 and 4 give Kc = $4^2$ / 4 = 4. (c) False. A mixture containing every species may still be travelling toward equilibrium: the HI snapshot at 4 $H_2$, 4 $I_2$ and 8 HI holds all three species but has Q = 4 against Kc = 36, so it is still moving forward. Presence of all species is not proof of equilibrium.

**A4.** (a) Both rates are 0.24 mol $L^{-1}$ $s^{-1}$. (b) The graph tells you the concentrations have stopped changing, because the rates are equal, and that the reactions themselves continue. It cannot tell you any concentration value: equal rates are compatible with a mixture rich in reactants, rich in products, or anywhere between. (c) The equilibrium concentration of every species in the expression, read from a snapshot or from a concentration graph's plateau values, ready to substitute into the Kc expression.

**A5.** (a) Q = $[C]^2$ / ([A][B]) = $8^2$ / (4 × 4) = 64 / 16 = 4.0. (b) Q = 4.0 is less than Kc = 16, so the system is not at equilibrium and the net change is forward, toward C. (c) The C count rises and the A and B counts fall, C rising twice as fast as each falls, following the coefficients, until Q climbs to 16.

**B1.** (a) From the first photograph to the third, A falls by 8 while B rises by 4, a ratio of 2 to 1 that matches the coefficients. Counting each A as one unit and each B as two (it forms from two A), every photograph totals 16 units: 16, then 12 + 2 × 2 = 16, then 8 + 2 × 4 = 16, then 16 again. (b) The fourth photograph. It is the first that can be compared with an earlier identical picture: the third and fourth counts match, so the mixture has stopped changing. The third alone might have been taken mid-change. (c) Kc = [B] / $[A]^2$ = 4 / $8^2$ = 4 / 64 = 0.0625. (d) The second photograph gives Q = 2 / $12^2$ = 2 / 144 = 0.0139. Below Kc = 0.0625, so the net change is forward, toward B, as the later photographs confirm.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

**B2.** (a) At t = 6 min, when both curves become horizontal and concentrations stop changing. (b) At t = 3 min the concentrations happen to be equal, 0.50 mol $L^{-1}$ each, but both curves still slope, so both concentrations are still changing. Equality is not equilibrium; constancy is. (c) The plateau values give Kc = [B] / [A] = 0.75 / 0.25 = 3.0. (d) The [B] curve falls from 1.00 and the [A] curve rises from 0, mirroring the first run, and both flatten at the same plateau values, [A] = 0.25 and [B] = 0.75 mol $L^{-1}$: the same equilibrium as the first run.

**B3.** (a) (i) $2^2$ / 2 = 2.0. (ii) $4^2$ / 5 = 3.2. (iii) $4^2$ / 4 = 4.0. (iv) $4^2$ / 2 = 8.0. (b) Snapshot (iii) only: its value equals Kc = 4.0. (c) Snapshots (i) and (ii) have Q below Kc: net change forward, making more B. Snapshot (iv) has Q above Kc: net change reverse, making more A.

**B4.** (a) Q = $[NO_2]^2$ / $[N_2O_4]$ = $4^2$ / 8 = 16 / 8 = 2.0, matching Kc, as required. (b) Nitrogen atoms: vessel 1 starts with 10 × 2 = 20 and the snapshot holds 8 × 2 + 4 = 20; vessel 2 starts and ends at 20 the same way. Change ratios: vessel 1 loses 2 $N_2O_4$ and gains 4 $NO_2$, a 1 to 2 ratio matching the equation; vessel 2 loses 16 $NO_2$ and gains 8 $N_2O_4$, the same ratio in reverse. (c) Both vessels are closed, hold the same totals, and sit at the same temperature, so both settle at the composition where Q = Kc for those totals, the snapshot in (a).

**B5.** (a) Kc = $[SO_3]^2$ / ($[SO_2]^2[O_2]$) = $(0.60)^2$ / ($(0.40)^2$ × 0.20) = 0.36 / 0.032 = 11.25, about 11. (b) Some $SO_3$ was added at t1: one curve jumps vertically while the other two are untouched at that instant, the signature of an addition rather than of the reaction shifting. (c) Q = $(1.00)^2$ / ($(0.40)^2$ × 0.20) = 1.00 / 0.032 = 31.25, about 31. Since Q exceeds Kc, the net change is reverse, toward $SO_2$ and $O_2$. (d) The $SO_3$ curve falls from 1.00; the $SO_2$ and $O_2$ curves rise, $SO_2$ twice as fast as $O_2$, until all three flatten at new plateaus whose ratio again gives Kc = 11.25.

**B6.** (a) Counts substitute directly into the expression. First photograph: Q = $8^2$ / (4 × 4) = 64 / 16 = 4. Second photograph: Q = $12^2$ / (2 × 2) = 144 / 4 = 36. (b) The second photograph shows equilibrium: its Q equals Kc = 36. The first has Q = 4, below Kc, so the system was still moving forward then. (c) Hydrogen atoms: the first photograph holds 4 × 2 + 8 = 16 and the second 2 × 2 + 12 = 16; iodine totals 16 in both. These match the starting vessel, 8 × 2 = 16 of each, so both photographs can be the same vessel at different times.

**C1.** (a) Q = [B][C] / [A] = (1 × 1) / 9 = 0.11. This is below Kc = 5.0, so the net change is forward, toward B and C. (b) Let the equal count be n of each species. From the start, every B particle formed comes with one C and consumes one A, so the A and B counts total 10 throughout: n + n = 10, so n = 5. The equilibrium photograph is 5 A, 5 B and 5 C. Verify: Q = (5 × 5) / 5 = 5.0, matching Kc, as required. (c) From 10 B and 10 C, the reverse reaction forms A: after y A particles form, the counts are y A, (10 − y) B and (10 − y) C. Setting y = 5 gives 5 A, 5 B and 5 C, the same photograph, already verified against Kc in (b).

**C2.** (a) Kc = [B] / [A] = 0.40 / 0.60 = 0.67. (b) Some B was removed at t = 10 min: the [B] curve drops vertically while [A] does not move. (c) Q = 0.10 / 0.60 = 0.17, below Kc, so the net change is forward, remaking B. (d) At the second plateau, [B] / [A] = 0.28 / 0.42 = 0.67, the same value. Kc depends

© 2026 ExamFitter.com · Free AP Chemistry worksheets

only on temperature, which did not change; the mixture travelled until Q matched the unchanged Kc again. The totals also check: after the removal the concentrations add to 0.70 mol $L^{-1}$, and 0.42 + 0.28 = 0.70 at the new plateau.

**C3.** (a) Equilibrium is reached at t = 12 min. First evidence: the t = 12 and t = 18 min snapshots are identical, so the counts have stopped changing. Second evidence: the rate graph shows the two rates becoming equal at t = 12 min, and equal rates hold the counts constant. (b) $K_c = [N_2O_4] / [NO_2]^2 = 3 / 6^2 = 3 / 36 = 0.083$. (c) At t = 6 min, $Q = 2 / 8^2 = 2 / 64 = 0.031$. Q is below Kc, so the net change is forward: $NO_2$ should be falling and $N_2O_4$ rising, which is what the snapshots between t = 6 and t = 12 min show. (d) The claim overreaches. A snapshot alone shows amounts at one instant, and an equilibrium mixture could share those counts; what proves the system was not at equilibrium at t = 6 min is a comparison: Q = 0.031 against Kc = 0.083, or the later snapshots showing the counts still changing. The snapshot supplies the numbers, but the proof needs a comparison.

**Continue Revising**

Topic 7.8 Revision Notes

Topic 7.8 Quiz: Representations of Equilibrium

Previous Worksheet: Topic 7.7 Calculating Equilibrium Concentrations

Next Worksheet: Topic 7.9 Introduction to Le Chatelier's Principle

© 2026 ExamFitter.com · Free AP Chemistry worksheets