ExamFitter

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

Topic 7.4: Calculating the Equilibrium Constant

Worksheet · AP Chemistry

UNIT 7 · EQUILIBRIUM

On ExamFitter.com: Topic 7.4 Revision Notes · Topic 7.4 Quiz · Previous Worksheet: Topic 7.3 · Next Worksheet: Topic 7.5 · Unit 7: All Topics · AP Chemistry Home

How to Use This Worksheet

Work in order. Section A checks the building blocks: which values may be substituted, building an equilibrium row from one measured change, converting moles to concentrations, rearranging the expression for a missing value, and judging claims about what does and does not change K. Section B works one system at a time, and Section C is exam style: phosgene approached from both sides, a solve that collapses to a square root, and five claims to judge.

In every calculation, write the expression first, then the equilibrium row or the substitution line, then the result. Concentrations are in mol L^{-1} and partial pressures in atm throughout.

Reference facts. Kc = products over reactants, each concentration raised to its coefficient; Kp uses partial pressures in the same form. Pure solids and liquids are omitted from K expressions. K is dimensionless, and only temperature changes it. Convert moles to mol L^{-1} by dividing by the vessel volume before substituting. For the Kp conversion, use R = 0.08206 L atm mol^{-1} K^{-1} with temperatures in kelvin, and count only gas species in Δn.

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. (a) State which concentrations may be substituted into the Kc expression to obtain K. (b) State what the same substitution gives when the concentrations are measured before equilibrium is reached, and what that value must be compared with before it predicts anything. (c) State the units of K, and explain why it has none.

A2. For $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, a flask starts with $[N_2O_4] = 0.200$ mol L^{-1} and no NO_2. At equilibrium, $[N_2O_4] = 0.160$ mol L^{-1}. (a) State the change in $[N_2O_4]$, and the value of x it defines if x is the change for a species with coefficient 1. (b) Build the full equilibrium row. (c) Show that the row conserves nitrogen atoms. (d) Calculate Kc.

A3. Convert each amount to a concentration: (a) 0.30 mol in a 1.5 L vessel; (b) 0.45 mol in a 3.0 L vessel; (c) 0.50 mol in a 2.0 L vessel. (d) A student records the amount in (c) as 0.50 mol L^{-1}. State the factor by which that overstates the true concentration, and where the error came from.

A4. (a) Starting from $K_c = [NO_2]^2 / [N_2O_4]$, write the rearranged expression that gives $[NO_2]$ from Kc and $[N_2O_4]$. (b) State the final operation in that rearrangement, and why one of its two results is discarded. (c) State the rearranged expression that gives a missing denominator concentration for $A(g) \rightleftharpoons B(g) + C(g)$, in terms of Kc, [B] and [C].

© 2026 ExamFitter.com · Free AP Chemistry worksheets

A5. Judge each statement, giving the reason. (a) "Kc can be calculated by substituting the starting concentrations, provided the equation is balanced." (b) "A catalyst increases Kc because the mixture reaches equilibrium sooner." (c) "Doubling the volume of the vessel changes Kc." (d) "At the same temperature, a reaction started from pure products gives the same Kc as one started from pure reactants."

Section B: Core Practice

B1. For $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$, an equilibrium mixture has $[H_2] = 0.010$, $[Br_2] = 0.020$ and $[HBr] = 0.080$ mol L^{-1}. (a) Write the Kc expression. (b) Substitute and calculate Kc. (c) A different mixture of the same gases at the same temperature has $[H_2] = 0.010$, $[Br_2] = 0.020$ and $[HBr] = 0.060$ mol L^{-1}. Calculate the value the expression takes, give that value its correct name, and state the net direction for this mixture.

B2. For $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$, a flask starts with $[CH_4] = [H_2O] = 0.50$ mol L^{-1} and no products. At equilibrium, $[H_2] = 0.30$ mol L^{-1}. (a) Use the H_2 change to find x. (b) Build the full equilibrium row. (c) Substitute and calculate Kc. (d) Verify that the row conserves hydrogen atoms, showing both totals.

B3. A 2.0 L vessel holds the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$. Initially it contains 0.60 mol of SO_2 and 0.40 mol of O_2, with no SO_3. At equilibrium, 0.20 mol of SO_3 is present. (a) State the equilibrium amounts, in moles, of all three gases. (b) Convert each amount to a concentration. (c) Substitute and calculate Kc. (d) A classmate substitutes the equilibrium mole amounts directly into the expression and obtains 0.83. Explain the error, and show, from the power totals on the two sides of the expression, why the classmate's answer is exactly half the correct one.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

B4. For C(s) + CO_2(g) ⇌ 2CO(g), Kp = 0.48 at the temperature used. An equilibrium mixture has P(CO_2) = 0.75 atm. (a) Write the Kp expression, naming the species omitted and why. (b) Rearrange the expression to give P(CO). (c) Calculate P(CO). (d) State why the positive root is the one reported.

B5. H_2(g) + I_2(g) ⇌ 2HI(g) is studied at one temperature. Mixture 1 is at equilibrium with [H_2] = [I_2] = 0.10 and [HI] = 0.80 mol L^{-1}. Mixture 2 is at equilibrium with [H_2] = [I_2] = 0.050 and [HI] = 0.40 mol L^{-1}, and was prepared from HI alone. (a) Calculate Kc from mixture 1. (b) Calculate Kc from mixture 2. (c) Explain why the two calculations agree even though every concentration differs, naming the two conditions both mixtures satisfy. (d) Work out the starting concentration of HI that mixture 2 was prepared from, using atom conservation.

B6. For N_2(g) + 3H_2(g) ⇌ 2NH_3(g) at 500 K, Kc = 0.040. (a) Calculate Δn for the reaction as written. (b) Calculate Kp using Kp = Kc(RT)^Δn, with R = 0.08206 L atm mol^{-1} K^{-1}. (c) For H_2(g) + I_2(g) ⇌ 2HI(g) at 700 K, Kc = 54. State Kp for this reaction and give the reason. (d) State which of Kc and Kp a set of measured equilibrium partial pressures is substituted into directly.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

Section C: Exam Style

C1. The phosgene reaction, $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$, is studied in a 1.0 L flask at a fixed temperature. Flask 1 starts with $[CO] = [Cl_2] = 0.20$ mol L^{-1} and no $COCl_2$, and at equilibrium $[COCl_2] = 0.16$ mol L^{-1}. (a) Build the equilibrium row for flask 1. (b) Calculate Kc. (c) Flask 2 starts with $[COCl_2] = 0.20$ mol L^{-1} only, and settles with $[CO] = [Cl_2] = 0.040$ mol L^{-1}. Verify that flask 2 gives the same Kc, and explain, using the element totals of the two starting mixtures, why the two flasks settle on the same equilibrium row. (d) Flask 1 is sampled at the moment of mixing, before any reaction has occurred. Calculate the value the expression takes, give it its correct name, and state the net direction it predicts.

C2. For $A(g) + B(g) \rightleftharpoons C(g) + D(g)$, Kc = 9.0. A flask starts with $[A] = [B] = 0.60$ mol L^{-1} and no products. (a) Write each equilibrium concentration in terms of x, the amount of A consumed. (b) Substitute into the expression, take the square root of both sides, and solve for x. (c) State the full equilibrium row, and check that it returns Kc = 9.0.

C3. Judge each claim, supporting each verdict with the idea it depends on. (a) "Substituting the initial concentrations gives K, as long as the temperature is the stated one." (b) "If the vessel volume is doubled, the value of K calculated from the new equilibrium concentrations is halved." (c) "Two experiments at the same temperature gave Kc = 48 and Kc = 49, so at least one of the mixtures cannot have reached equilibrium." (d) "Kc must carry units, because the concentrations substituted into it carry units." (e) "In the change row, every species changes by the same amount, because they all take part in the same reaction."

© 2026 ExamFitter.com · Free AP Chemistry worksheets

Answer Key

A1. (a) Only equilibrium concentrations: the values the mixture holds once it has reached equilibrium at that temperature. (b) It gives Q, the reaction quotient. Q predicts nothing on its own; it must be compared with K at that temperature, with Q < K meaning net forward, Q > K net reverse, and Q = K the mixture already at equilibrium. (c) K has no units. Each concentration is measured relative to the standard concentration of 1 mol L^{-1}, so the units cancel in the ratio whatever the coefficients are, and K is reported as a pure number.

A2. (a) $[N_2O_4]$ falls by 0.200 − 0.160 = 0.040 mol L^{-1}. N_2O_4 has coefficient 1, so x = 0.040 mol L^{-1}. (b) NO_2 has coefficient 2, so it rises by 2x = 0.080: the equilibrium row is $[N_2O_4]$ = 0.160, $[NO_2]$ = 0.080 mol L^{-1}. (c) Nitrogen initially: 2 × 0.200 = 0.400. At equilibrium: 2 × 0.160 + 0.080 = 0.320 + 0.080 = 0.400. The totals match, so the row conserves nitrogen. (d) $K_c = [NO_2]^2 / [N_2O_4] = (0.080)^2 / 0.160$ = 0.0064 / 0.160 = 0.040. This K_c = 0.040 belongs to the temperature of this flask: at a different temperature the same reaction gives a different K_c, so another determination of this reaction can return a different value.

A3. (a) 0.30 / 1.5 = 0.20 mol L^{-1}. (b) 0.45 / 3.0 = 0.15 mol L^{-1}. (c) 0.50 / 2.0 = 0.25 mol L^{-1}. (d) The recorded value overstates the concentration by a factor of 0.50 / 0.25 = 2. The amount in moles was used as if it were already a concentration, skipping the division by the 2.0 L volume; only in a 1.0 L vessel would the two numbers have agreed.

A4. (a) $[NO_2] = \sqrt{(K_c \times [N_2O_4])}$. (b) The final operation is a square root, because $[NO_2]$ sat squared in the original expression. The square root has a positive and a negative result; the negative one is discarded because a concentration cannot be negative. (c) $K_c = [B][C] / [A]$, so $[A] = [B][C] / K_c$.

A5. (a) False. Starting concentrations give Q, not K; only equilibrium concentrations may be substituted, and balance of the equation is a separate requirement that does not repair wrong-moment values. (b) False. A catalyst speeds up both directions equally and shortens the time to reach equilibrium; it changes no equilibrium concentration and does not change K. (c) False. Volume changes move the equilibrium mixture, but the new equilibrium concentrations still satisfy the same K. Only temperature changes K. (d) True. At a fixed temperature K is a constant of the reaction, so any starting mixture that reaches equilibrium, from either side, returns the same value.

B1. (a) $K_c = [HBr]^2 / ([H_2][Br_2])$. (b) $K_c = (0.080)^2 / (0.010 \times 0.020) = 0.0064 / 0.00020 = 32$. (c) The value is $(0.060)^2 / (0.010 \times 0.020) = 0.0036 / 0.00020 = 18$. Because this mixture is not stated to be at equilibrium, the value is Q, not K. Q = 18 < K_c = 32, so the net reaction is forward: HBr is formed until its concentration rises enough for Q to reach 32.

B2. (a) H_2 has coefficient 3, so its rise of 0.30 is 3x, giving x = 0.10 mol L^{-1}. (b) CH_4 and H_2O each fall by x = 0.10, to 0.40; CO rises by x, to 0.10; H_2 is 0.30. The equilibrium row is $[CH_4]$ = 0.40, $[H_2O]$ =

© 2026 ExamFitter.com · Free AP Chemistry worksheets

0.40, [CO] = 0.10, [H_2] = 0.30 mol L^{-1}. (c) Kc = ([CO][H_2]^3) / ([CH_4][H_2O]) = (0.10 × (0.30)^3) / (0.40 × 0.40) = (0.10 × 0.027) / 0.16 = 0.0027 / 0.16 = 0.017, to two significant figures. (d) Hydrogen initially: 4 × 0.50 + 2 × 0.50 = 3.00. At equilibrium: 4 × 0.40 + 2 × 0.40 + 2 × 0.30 = 1.60 + 0.80 + 0.60 = 3.00. The totals agree, so the row conserves hydrogen.

B3. (a) Forming 0.20 mol of SO_3 consumes 0.20 mol of SO_2 and half as much O_2, 0.10 mol. Equilibrium amounts: SO_2 = 0.60 − 0.20 = 0.40 mol, O_2 = 0.40 − 0.10 = 0.30 mol, SO_3 = 0.20 mol. (b) Dividing by 2.0 L: [SO_2] = 0.20, [O_2] = 0.15, [SO_3] = 0.10 mol L^{-1}. (c) Kc = [SO_3]^2 / ([SO_2]^2[O_2]) = (0.10)^2 / ((0.20)^2 × 0.15) = 0.010 / (0.040 × 0.15) = 0.010 / 0.0060 = 1.7. (d) The classmate substituted amounts in moles where concentrations belong, skipping the division by the 2.0 L volume. Halving every value to convert it divides the numerator, power total 2, by 2^2 = 4, and the denominator, power total 3, by 2^3 = 8, so the correct ratio is larger than the mole ratio by a factor of 8 / 4 = 2: 0.83 × 2 = 1.7.

B4. (a) Kp = (P_CO)^2 / P_CO_2. The solid carbon is omitted: the concentration of a pure solid is constant and is folded into K, and a solid has no partial pressure. (b) (P_CO)^2 = Kp × P_CO_2, so P_CO = √(Kp × P_CO_2). (c) P_CO = √(0.48 × 0.75) = √0.36 = 0.60 atm. (d) A partial pressure cannot be negative, so the negative square root is discarded and the positive root, 0.60 atm, is reported.

B5. (a) Kc = (0.80)^2 / (0.10 × 0.10) = 0.64 / 0.010 = 64. (b) Kc = (0.40)^2 / (0.050 × 0.050) = 0.16 / 0.0025 = 64. (c) Both mixtures are at equilibrium, and both are at the same temperature. K depends only on the reaction and the temperature, not on the starting mixture, so any two equilibrium mixtures at that temperature must return the same value. (d) Hydrogen atoms in mixture 2 at equilibrium: 2 × 0.050 + 0.40 = 0.50, in units of mol L^{-1} of atoms. The flask began as HI alone, and each HI carries one hydrogen atom, so the starting concentration was [HI] = 0.50 mol L^{-1}. (Iodine gives the same total: 2 × 0.050 + 0.40 = 0.50.)

B6. (a) Δn = 2 − (1 + 3) = −2, counting gas moles only. (b) Kp = Kc(RT)^Δn = 0.040 × (0.08206 × 500)^(−2) = 0.040 / (41.03)^2 = 0.040 / 1683 = 2.4 × 10^{-5}. Kp is far smaller than Kc because Δn is negative: the conversion divides by (RT)^2 rather than multiplying. (c) Kp = Kc = 54. Here Δn = 2 − 2 = 0, so (RT)^Δn = 1 and the two constants are equal. (d) Kp: partial pressures belong in the pressure expression, just as concentrations belong in Kc.

C1. (a) $COCl_2$ rises by 0.16, a change of x = 0.16 since its coefficient is 1, so CO and Cl_2 each fall by 0.16: the equilibrium row is [CO] = 0.040, [Cl_2] = 0.040, [$COCl_2$] = 0.16 mol L^{-1}. (b) Kc = [$COCl_2$] / ([CO][Cl_2]) = 0.16 / (0.040 × 0.040) = 0.16 / 0.0016 = 1.0 × 10^2. (c) Flask 2: [$COCl_2$] at equilibrium is 0.20 − 0.040 = 0.16 mol L^{-1}, so Kc = 0.16 / (0.040 × 0.040) = 1.0 × 10^2, the same value. The starting mixtures hold identical element totals: flask 1 has carbon 0.20, oxygen 0.20 and chlorine 0.40 mol L^{-1}, and flask 2, from 0.20 mol L^{-1} of $COCl_2$, has exactly the same totals. With the same totals, the same volume and the same temperature, the two flasks hold the same contents and must settle on the same equilibrium row, approached from opposite sides. (d) At mixing, [$COCl_2$] = 0, so the expression gives Q = 0 / (0.20 × 0.20) = 0. It is Q, not K, because the values are not equilibrium values. Q = 0 < K, so the net reaction is forward, as flask 1 in fact moves.

© 2026 ExamFitter.com · Free AP Chemistry worksheets

C2. (a) [A] = 0.60 − x, [B] = 0.60 − x, [C] = x, [D] = x. (b) $K_c = x^2 / (0.60 - x)^2 = 9.0$. The expression is a perfect square, so taking the square root of both sides gives $x / (0.60 - x) = 3$. Then $x = 3(0.60 - x) = 1.80 - 3x$, so $4x = 1.80$ and $x = 0.45$ mol L^{-1}. (c) The equilibrium row is [A] = [B] = 0.15, [C] = [D] = 0.45 mol L^{-1}. Check: $K_c = (0.45 \times 0.45) / (0.15 \times 0.15) = 0.2025 / 0.0225 = 9.0$, as required. Note that no quadratic was needed only because the expression happened to be a perfect square; the general method for solving an equilibrium composition from K is Topic 7.7.

C3. (a) False. Values from the moment of mixing give Q. The temperature being right does not help: K comes only from equilibrium values, and the starting mixture in C1(d) gives Q = 0 against K = 100. (b) False. K is unchanged by volume. The doubled vessel settles at a new equilibrium mixture whose concentrations are different, but substituting them returns the same K; only a temperature change alters the constant. (c) False. 48 and 49 agree within ordinary experimental error. Independent determinations are expected to land close together rather than identically, and agreement this close supports, rather than undermines, the claim that both mixtures reached equilibrium. (d) False. K is dimensionless: each concentration enters relative to the standard concentration of 1 mol L^{-1}, so the units cancel in the ratio whatever the powers are, and K is quoted as a pure number. (e) False. Changes follow the coefficients: in B2, H_2 changed by 0.30 while CH_4 changed by 0.10 in the same mixture, a ratio of 3:1 set by the equation, not by the fact of taking part.

Continue Revising

Topic 7.4 Revision Notes

Topic 7.4 Quiz: Calculating the Equilibrium Constant

Previous Worksheet: Topic 7.3 Reaction Quotient and Equilibrium Constant

Next Worksheet: Topic 7.5 Magnitude of the Equilibrium Constant

© 2026 ExamFitter.com · Free AP Chemistry worksheets