Gas and Solution Equilibrium Synthesis

Student Worksheet | `g10_u04_w16`

I can: apply equilibrium-expression, quotient, and perturbation reasoning to supplied gas and solution models while naming the limits of each claim.
Classroom models: At stated temperature T_1, $2G(g) \rightleftharpoons H(g)$ has $K_c = 4.00\ \mathrm{M}^{-1}$ with $Q_c = [H]/[G]^2$. At stated temperature T_2, $P(aq) + Q(aq) \rightleftharpoons R(aq)$ has $K_c = 2.00\ \mathrm{M}^{-1}$ with $Q_c = [R]/([P][Q])$. Use concentration-substitution only as labeled. A comparison predicts net direction, not speed, mechanism, pressure in a real vessel, or exact final composition. All work is data/simulation based.

Card	$[G]$ (M)	$[H]$ (M)	condition	purpose
G1	0.200	0.0800	T_1	gas snapshot
G2	0.200	0.240	T_1	gas snapshot
G3	0.200	0.160	T_1	gas equilibrium card

Card	$[P]$ (M)	$[Q]$ (M)	$[R]$ (M)	condition
S1	0.200	0.300	0.0600	T_2
S2	0.200	0.300	0.180	T_2
S3	0.400	0.300	0.120	T_2

Perturbation cards: For the gas reaction, a volume-decrease card is at constant T_1. For the solution reaction, an R-removal card reports the immediate state $[P] = 0.200$, $[Q] = 0.300$, $[R] = 0.0600$ M at T_2. A catalyst card at T_2 shows both directions reach a flat concentration region sooner.

1. Write Q_c for $2G(g) \rightleftharpoons H(g)$. Explain the exponent on $[G]$.

2. Calculate Q_c for G1 and compare it with K_c. Predict net direction.

3. Calculate Q_c for G2 and predict net direction.

4. Calculate Q_c for G3. What does the comparison support?

5. For the gas reaction, which side has fewer gas particles per reaction event? Under the stated model, predict the effect of decreasing volume.

6. Why does the particle-count prediction in item 5 not calculate the new concentrations or reaction speed?

7. A gas card omits temperature. Why is comparison to the stated K_c not automatically justified?

8. Write Q_c for $P(aq) + Q(aq) \rightleftharpoons R(aq)$.

9. Calculate Q_c for S1 and predict net direction.

10. Calculate Q_c for S2 and predict net direction.

11. Calculate Q_c for S3. What equilibrium condition does it satisfy?

12. For the R-removal card, calculate Q_c and predict net direction.

13. Find $[R]$ that makes $Q_c = K_c$ when $[P] = 0.150$ M and $[Q] = 0.200$ M at T_2.

14. A student doubles all G3 concentrations and claims the state remains at equilibrium. Calculate the factor change in Q_c and critique the claim.

15. A student doubles all S3 concentrations and makes the same claim. Calculate the factor change and critique it.

16. What does the catalyst card allow you to say about approach to equilibrium? What does it not allow you to say about K_c at fixed T_2?

17. For $X(aq) + Y(s) \rightleftharpoons Z(aq)$, write the classroom expression and state the pure-solid caveat.

18. A card gives $Q_c = K_c$ at T_1. Name two things that may still be changing microscopically or remain unknown.

19. Compare the gas compression card and solution R-removal card: state one shared reasoning step and one important difference.

20. Write a CER synthesis statement using one gas and one solution card. Include a calculation/evidence comparison and two limits on what the models establish.