

Chemical Equilibrium and K_c

Answer key with worked solutions

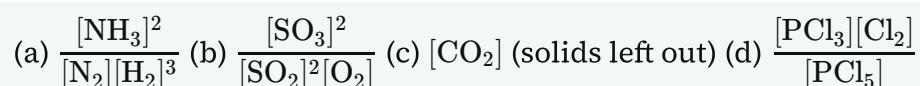
A. Understanding

1. Dynamic equilibrium.

Both the forward and reverse reactions continue, at **equal rates**, so the concentrations of reactants and products stay **constant**. They are generally **not equal**.

B. Writing K_c

2. Expressions.



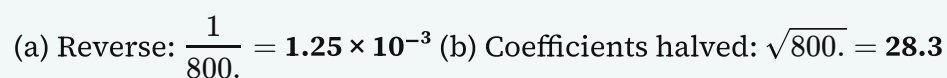
C. Calculating K_c

3. K_c for SO₃.

$$K_c = \frac{(0.160 \text{ M})^2}{(0.0400 \text{ M})^2(0.0200 \text{ M})} \times 1 \text{ M} = \mathbf{800.}$$

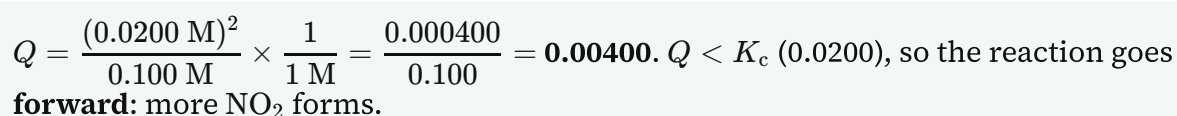
Dividing each concentration by $c^\circ = 1 \text{ M}$ makes the units cancel: $\frac{0.0256}{(0.00160)(0.0200)} = 800.$

4. Related reactions.



D. Q versus K

5. Q for N₂O₄.



E. ICE tables

6. $\text{H}_2 + \text{I}_2$ starting at 0.200 M each.

Let x be the decrease in $[\text{H}_2]$, in M. Equilibrium: $[\text{H}_2] = [\text{I}_2] = 0.200 \text{ M} - x$; $[\text{HI}] = 2x$.
 $\sqrt{49.0} = 7.00 = \frac{2x}{0.200 \text{ M} - x}$, so $1.400 \text{ M} - 7.00x = 2x$ and $x = \frac{1.400 \text{ M}}{9.00} = 0.1556 \text{ M}$
 $[\text{HI}] = \mathbf{0.311 \text{ M}}$; $[\text{H}_2] = [\text{I}_2] = 0.200 \text{ M} - 0.1556 \text{ M} = \mathbf{0.0444 \text{ M}}$

7. K_c for PCl_5 .

The Cl_2 formed (0.100 M) equals the PCl_3 formed and the PCl_5 used up. Equilibrium:
 $[\text{PCl}_5] = 0.500 \text{ M} - 0.100 \text{ M} = 0.400 \text{ M}$; $[\text{PCl}_3] = [\text{Cl}_2] = 0.100 \text{ M}$.
 $K_c = \frac{(0.100 \text{ M})(0.100 \text{ M})}{0.400 \text{ M}} \times \frac{1}{1 \text{ M}} = \mathbf{0.0250}$

F. Challenge

8. Large and small K .

$K = 1 \times 10^{10}$: the mixture is almost entirely **products** (the reaction goes essentially to completion). $K = 1 \times 10^{-10}$: almost entirely **reactants** (hardly any reaction).

9. PCl_5 starting at 0.300 M.

Let x (in M) = $[\text{PCl}_3] = [\text{Cl}_2]$ at equilibrium; $[\text{PCl}_5] = 0.300 \text{ M} - x$. Working in units of M (so each concentration divided by 1 M):

$$0.0250 = \frac{x^2}{0.300 - x} \Rightarrow x^2 + 0.0250x - 0.00750 = 0$$
$$x = \frac{-0.0250 + \sqrt{(0.0250)^2 + 4(0.00750)}}{2} = \frac{-0.0250 + 0.1750}{2} = 0.0750$$

$[\text{PCl}_3] = [\text{Cl}_2] = \mathbf{0.0750 \text{ M}}$; $[\text{PCl}_5] = 0.300 \text{ M} - 0.0750 \text{ M} = \mathbf{0.225 \text{ M}}$. (The other root is negative, so it is rejected.)