Today Feb. 7 Review Le Chatelier, Role of temperature with K_c, K_p

Tomorrow lab expt 4

- Don't forget to download data from 206 website and set up your spreadsheet **BEFORE** lab.

($\rightleftharpoons$) } points to where most of the stuff is

M	$Cl_2(g) \rightleftharpoons 2Cl(g)$	$K_c^{1000K} = 1.2 \times 10^{-7}$ (very small)	$= \frac{[Cl]^2}{[Cl_2]}$	$\Delta n_g = 1$
I				
C				
E	mostly … very little }	based on K_c value		

M	$2SO_2(g) + O_2(g) \rightleftharpoons SO_3(g)$	$K_c^{298K} = 9.9 \times 10^{+26}$ (very big)	$\Delta n_g = -2$
E	very little $\rightleftharpoons$ mostly		

$2BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)$ $K_c = 32.0$ (not very big, not very small)

↳ for this reaction $K_c = K_p$ since $\Delta n_g = 0$

· For gas phase equilibria, we ignore solids and liquids in K_c and K_p

$Fe_2O_{3(s)} + 3H_{2(g)} \rightleftharpoons 2Fe_{(s)} + 3H_2O_{(g)}$ $K_c = \frac{[H_2O]^3}{[H_2]^3}$

· For aqueous phase equilibria, ignore solids and H_2O

$HF_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + F^-_{(aq)}$ $K_c = \frac{[H_3O^+][F^-]}{[HF]}$

- no K_p in aqueous equilibrium

$CaO(s) + CO_2(g) \rightleftharpoons CaCO_3(s)$ $K_c = \frac{1}{[CO_2]}$

$K_p = \frac{1}{P_{CO_2}}$

M	$N_2O_4(g)$	$\rightleftharpoons$ $2NO_2(g)$
I	0.1	0.04
C	(+)x	(−)2x
E	0.1+x	0.04−2x

$K_c = \frac{[NO_2]^2}{[N_2O_4]} = 0.00463$

$\longrightarrow Q_c = \frac{(0.04)^2}{(0.1)} = .016$

$Q_c > K_c$ ∴ shift left

(Q_p works the same way)

LeChalier's principle

* Add or remove a reagent (This takes us from equilibrium to new initial)
* changing the size of the vessel (no longer at Equilibrium, so shift R or L to return)
* Role of temperature

M	$N_2O_4(g)$	$\rightleftharpoons$ $2NO_2(g)$
E	1.00	0.06804

Add 0.20 mol/L NO_2

I	1.00	0.26804
C	+x	−2x
E	1.00+x	0.26804−2x

$Q_c > K_c$ ∴ shift left

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

when you remove NH_3, it will shift ~~to~~ right to make more

changing size:

- getting smaller = shift to less moles
- getting bigger = shift to more moles

M	$N_2O_4(g)$	$\rightleftharpoons$	$2NO_2(g)$
E	1.00		0.06804
	vessel doubles in size		
I	0.50		0.03402

$K_c = 0.00463$

$Q_c = \frac{(0.03402)^2}{0.50} = .0023$

$Q_c < K_c$ shift right

Role of temperature:

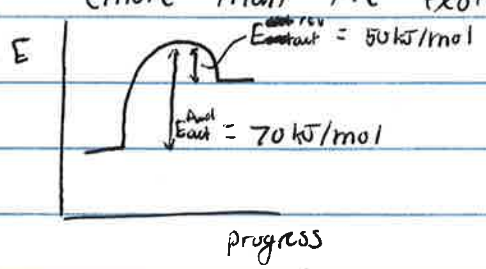
*kinetics review - if temperature increases, rate constant increases fwd/rev

$k = p \times Z \times e^{-E_{act}/RT}$

- p = orientation
- Z = collision frequency
- $e^{-E_{act}/RT}$ = fraction with enough collision energy to exceed E_{act}

for k_c (and k_p)

-increasing the temperature always favors the endothermic direction (more than the exothermic direction)



Endothermic

	E_{act}	T_1	T_2	298k fraction	308k fraction	308 fraction / 298 fraction
E_{act}^{fwd}	70kJ/mol	298k	308k	5.4×10^{-13}	1.3×10^{-12}	2.50
E_{act}^{rev}	50kJ/mol	298k	308k	1.7×10^{-9}	3.3×10^{-9}	1.93

the endothermic reaction increased by more with the same change in temp.

Increasing T will favor endothermic direction

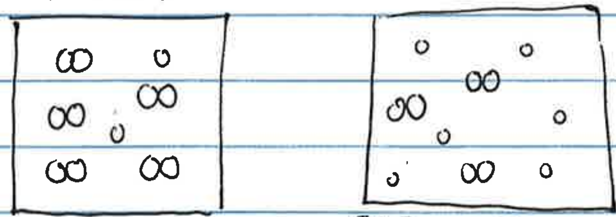
\# more NO_2 and less N_2O_4 at new equilibrium

K_c at new temperature (higher T) is greater than old (low T) K_c

\# only temperature can change rate constant and equilibrium constant

$$K_c = \frac{k^{fwd}}{k^{rev}}$$

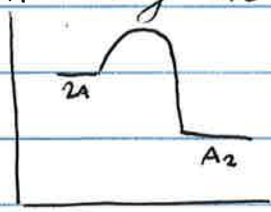
T-600k T-650k



$K^{650} = \frac{[A_2]}{[A]^2} = \frac{3}{6^2} = 0.083$

C. $2A \rightleftharpoons A_2$ $K^{600} = \frac{[A_2]}{[A]^2} = \frac{5}{2^2} = 1.25$

- increasing the temperature favored 2A



← exothermic in reverse

Demo:

colorless red

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $K_c = 0.00463$

- when ↑Temp. there should be more $\Delta H = +58$ kJ/mol
  NO_2 and ↓Temp should be more N_2O_4