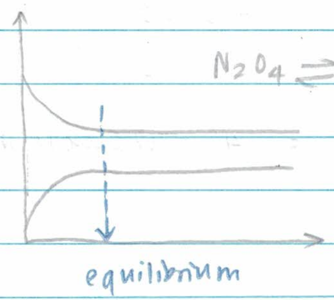
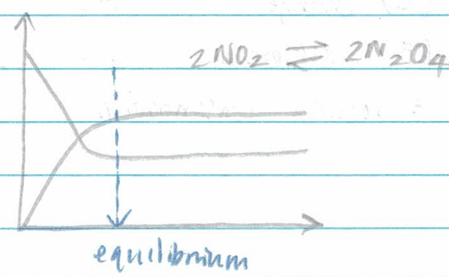
EQUILIBRIUM (revision notes)

dynamic equilibrium is reached in a closed system when...

- rate of the forward reaction is EQUAL to the rate of the backwards reaction
- concentration of products and reactants are constant

(a closed system = matter / energy IS NOT lost)





reaction quotient shows the rate of the fwd ÷ backwd (a ratio/proportion)

$$wA + xB \rightarrow yC + zD$$

$$\therefore \quad Q = \frac{[C]^y \times [D]^z}{[A]^w \times [B]^x}$$ → when A, B, C, D are constant, $Q = K_c$ the equilibrium constant

if $K_c = 1$, neither side favoured
$K_c < 1$, left favoured
$K_c > 1$, right favoured
} K_c is ONLY changed by temperature!

Le chatelier's principle

- changes in products/ reactants result in equilibrium changes to minimize the effect of the change
- concentration
  - favours the fwd reaction/ opposite side to reduce ↑ conc
- pressure
  - increase pressure → favours side with least no. of gaseous moles
- temperature
  - favours endothermic side ($\Delta H = +$) when temperature increases
  - changes K_c too

  e.g. exothermic, ↓ temperature, favour fwd reaction, K_c will increase
- catalyst
  - affects RATE but NOT position of equilibrium (K_c)

HABER process $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $\Delta H = -92 \, kJ \, mol^{-1}$

high temp ↑ rate of reaction ↓ pressure = expensive.

equilibrium calculations

- find Kc OR value of unknown concentration

e.g. $C_2H_5OH + CH_3COOH \rightleftharpoons CH_3COOC_2H_5 + H_2O$

	C_2H_5OH	CH_3COOH	$CH_3COOC_2H_5$	H_2O
(I) initial	0.5	1.00	–	–
(C) change	−.42	−0.42	+0.42	+0.42
(E) equilibrium	0.5−0.42	1−0.42	0.42	0.42

* check reacting ratios.

÷ volume = concentration

$$\frac{[0.42][0.42]}{[0.08][0.58]} = 4 \text{ (nearest integer)}$$

relationship between free energy change and equilibrium constant

- position of equilibrium shows...
  - maximum value of entropy [most disorder]
  - minimum value of gibbs free energy [most spontaneous]

... entropy is measured by ΔS prod − ΔS react. ($J mol^{-1} K^{-1}$)

... enthalpy change by bonds broken − bonds formed (react − prod)

... gibbs free energy is $\Delta G = \Delta H - T\Delta S$ [watch 4 units!!]

↳ often in $kJ mol^{-1}$. ΔS often $J mol^{-1} K^{-1}$

↳ T = in kelvin!

$$\boxed{\Delta G = -RT \times \ln K_c}$$

↳ 8.31 ($K^{-1} mol^{-1} J$)