Hebden p. 37-43 #1-13

Heath 19.1-19.2 #1-4

1. Equilibrium Background

a) Reversible Reactions

i) Many reactions can go in reverse and have separate activation energies!

ii) Example:

$N_2O_{4(g)}$ is heated in a *closed* flask to form $2NO_{2(g)}$ molecules

$$N_2O_4 + \text{energy} \rightarrow 2NO_2$$

$2NO_{2(g)}$ molecules will then combine in the flask to form $N_2O_{4(g)}$ plus heat

$$2NO_2 \rightarrow N_2O_4 + \text{energy}$$

We can write both the forward and reverse reactions on the same line using a double arrow.

$$N_2O_4 + \text{energy} \rightleftharpoons 2NO_2$$

b) Closed vs. Open Systems

i) This far in chemistry we have examined reactions in open systems.

ii) What is an "open system"?

Will allow some or all products to escape, so they are not available for the reverse reaction. (e.g.: open flask…gas can escape!)

iii) What is a "closed system"?

Will <u>not</u> allow products to escape. (e.g.: closed flask!)

c) Dynamic Equilibrium

i) What is "equilibrium?"

When the **<u>rate</u>** of the forward reaction = **<u>rate</u>** of the reverse reaction

ii) What do we mean by "dynamic"?

Moving at all times; constant forward and reverse reactions

iii) The term equilibrium in chemistry <u>always</u> refers to dynamic equilibrium and not static equilibrium.

d) How do we Recognize a Reaction in Equilibrium?

i) The system is closed

ii) Opposite reactions occur at the same rate

iii) You can reach equilibrium starting with either reactants or products

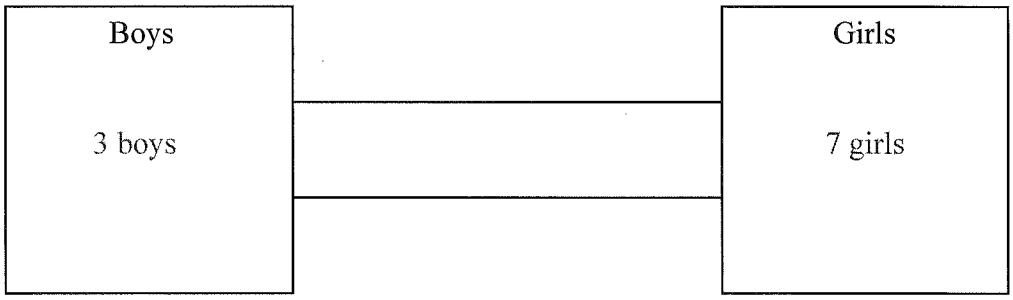
iv) You observe no visible chemical changes

v) The temperature **at** equilibrium is constant

e) Concentration and Equilibrium

i) Is it possible to have more product than reactant (or vice versa) and still be in equilibrium? YES!

ii) Imagine a situation:
- boys travel through a tunnel to the right and become girls.
- girls travel through the tunnel to the left and become boys.
- we have more girls than boys, but we can still have an equilibrium.



- if the rate of travel is 2 people per minute, 2 boys will go to left box but be immediately replaced by 2 girls who traveled over from the left box. *This leaves the same number of boys and girls on each side!*

iii) Bottom line: "equilibrium" does not mean concentration of reactants and products are equal.

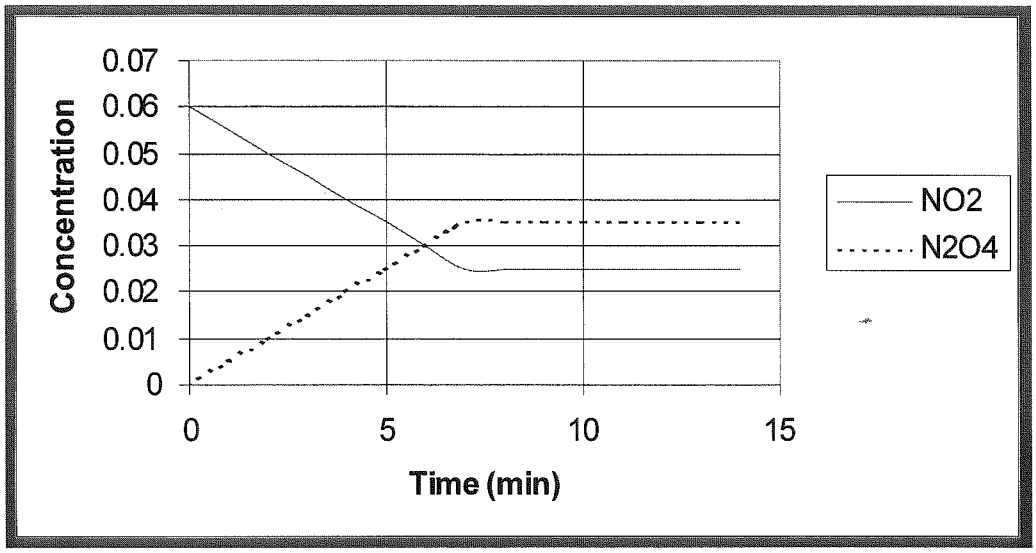
iv) Bottom line: "equilibrium" does mean the rates of forward and reverse reactions are the same.

f) What Does Equilibrium Look Like on a Graph?

i) If you filled a closed flask with brown NO_2 gas, you would notice that over time it changes to almost colourless! The NO_2 is forming colourless N_2O_4 gas.

$$2NO_2 \rightleftharpoons N_2O_4$$

ii) Graph:



Heath: read 19.1-19.2. Do questions # 1-4 page 522
Hebden: Do questions: # 3, 4, 5 page 39