2.1&2.2 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

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

2.1&2.2 Equilibrium Background

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!)

2.1&2.2 Equilibrium Background

I ii) 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 (will not move unless pushed).

2.1&2.2 Equilibrium Background

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 <u>visible</u> chemical changes

v) The temperature **<u>at</u>** equilibrium is constant

2.1&2.2 Equilibrium Background

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:

- apples from one box being put in box with oranges and becoming oranges.
- oranges from one box being put in box with apples and becoming apples
- we have more oranges than apples, but we can still have an equilibrium.

2.1&2.2 Equilibrium Background

- if the rate of travel is 2 fruit per minute, 2 apples will go to left box but be immediately replaced by 2 oranges who traveled over from the left box.

This leaves the same number of apples and oranges on each side!

2.1&2.2 Equilibrium Background

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

iv) No macroscopic changes occur at equilibrium

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

v) Microscopic changes do occur at equilibrium

2.1&2.2 Equilibrium Background

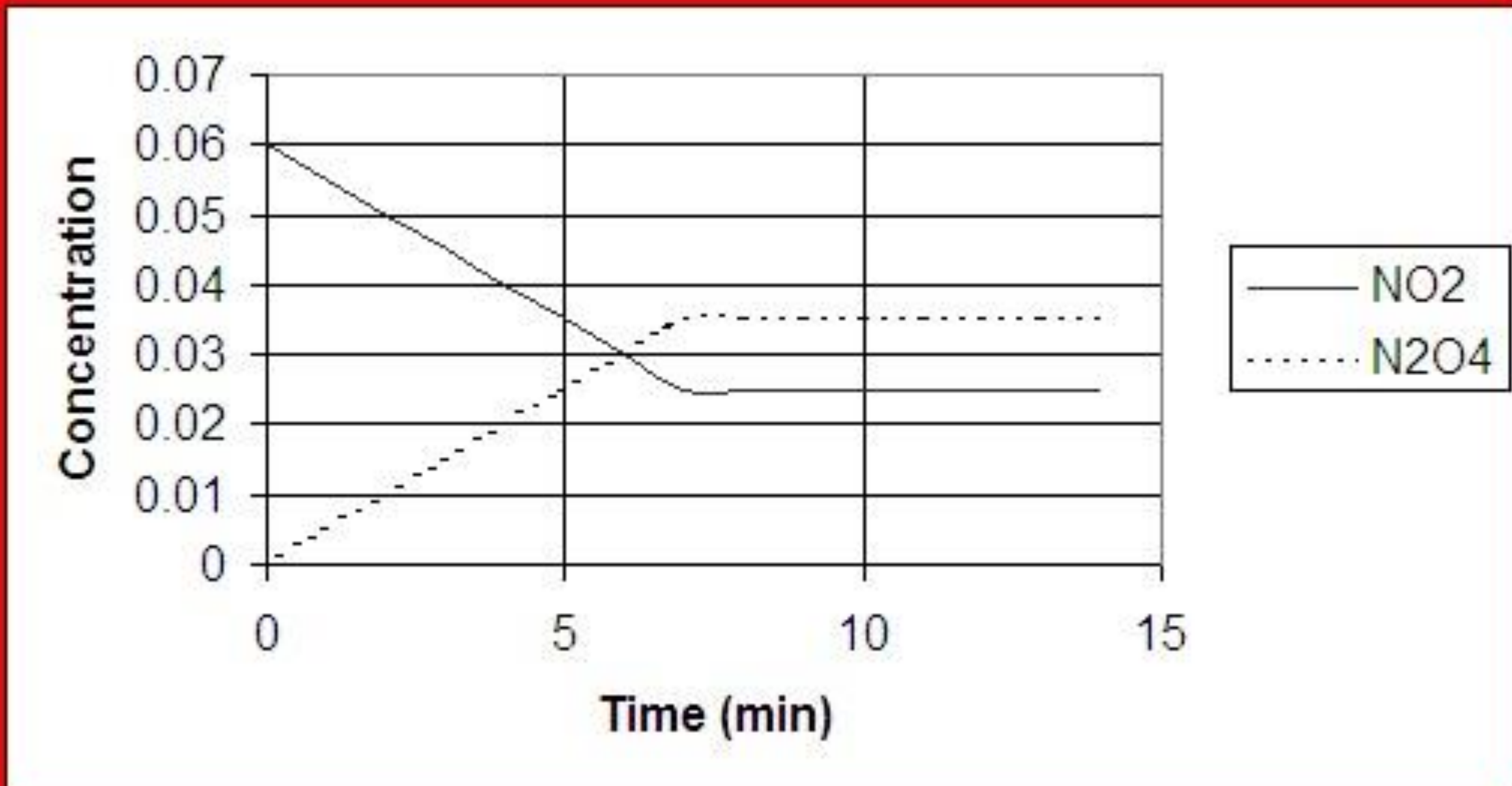
f) What Does Equilibrium Look Like on a Graph?

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.

$$2NO_2 \rightleftharpoons N_2O_4$$

2.1&2.2 Equilibrium Background

ii) Graph:



2.1&2.2 Equilibrium Background

Hebden: Do questions: # 3, 4, 5 page 39; #8-13 page 42-43