5.1 Static and Dynamic Equilibrium

Conduct a practical investigation to analyse the reversibility of chemical reactions

- *Cobalt (II) chloride hydrated and dehydrated*
- *Iron(III) nitrate and potassium thiocyanate*
- *Burning magnesium*
- *Burning steel wool*

Distinguish between reversible and irreversible reactions, including examples of each

Relate the terms ‘reversible reaction’ and ‘equilibrium’ to the synthesis of ammonia from hydrogen and nitrogen.

You investigated the hydration and dehydration of cobalt chloride.

$$CoCl_2 + 6H_2O(l) \leftrightharpoons CoCl_2.6H_2O$$

Strips of paper can be impregnated with cobalt chloride and stored in a desiccator.
A strip of blue cobalt chloride is taken out of a desiccator and placed on a clean, dry Petri dish.
Another strip of pink cobalt chloride paper is taken off a damp paper towel and placed on another clean, dry Petri dish.

The two strips are left on the bench in the room and observed.

What effect does a desiccator have on cobalt chloride paper?

Predict what will happen to the two strips of cobalt chloride paper?

Name the process that occurs when you burn a substance such as magnesium or steel wool

Did you find that combustion reactions can be reversed?

Some chemical reactions are reversible - turn these word equations into balanced chemical equations.

1. Sulphur dioxide + oxygen ⇋ sulphur trioxide
2. Nitrogen + hydrogen ⇋ ammonia
3. Nitrogen dioxide ⇋ dinitrogen tetroxide
4. Phosphorus pentachloride ⇋ phosphorus trichloride + chlorine
5. Hydrogen + iodine ⇋ hydrogen iodide

Model static and dynamic equilibrium and analyse the differences between open and closed systems

Why are equilibrium situations described as dynamic rather than static?

Explain what is meant by a model in Chemistry

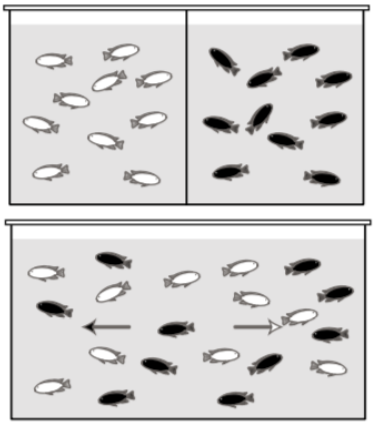
In class we modelled an equilibrium reaction, explain how you did this

Outline the advantages and disadvantages of using models in Chemistry

What is meant by static equilibrium? Give two examples

Distinguish between an open and closed system. Illustrate your answer.

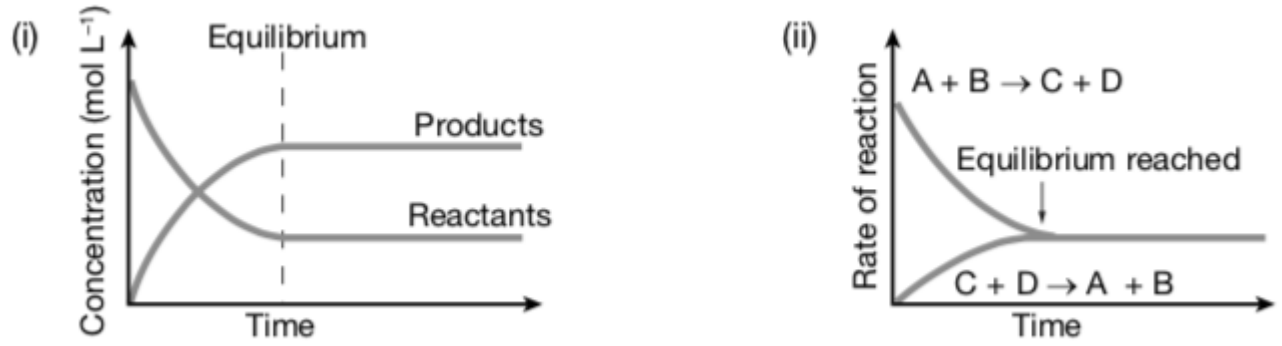
In the classroom, a large oblong fish tank was divided by a partition into two equal halves. Students placed 10 small, white fish in the water on one side of the tank and 10 small, black fish in the other side. The partition has removed and the fish began to swim from one side of the other.



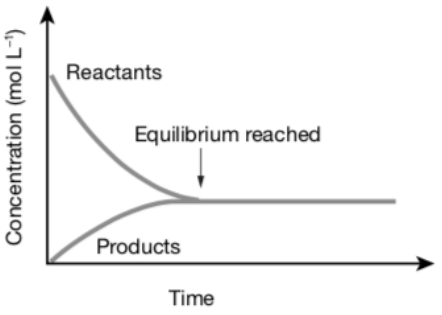
Explain why the second diagram can be considered as showing a reversible reaction which has reached equilibrium.

If one black and one white fish jump out of the tank, can this still be an equilibrium situation? Explain?

The following graphs illustrate two of the characteristics of a system at equilibrium.
Outline the characteristics each graph illustrates.

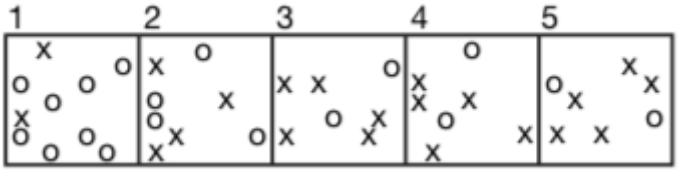


Look at the graph shown and compare it with the two graphs shown above.



Does this graph represent a characteristic of all systems at the equilibrium. Justify your answer.

In the following series of diagrams, molecules of NO2(g) (shown as o) are reacting to produce N2O4(g) (shown as x) and eventually the two gasses reach equilibrium: $2NO(g) \rightleftharpoons 2NO_2(g)$

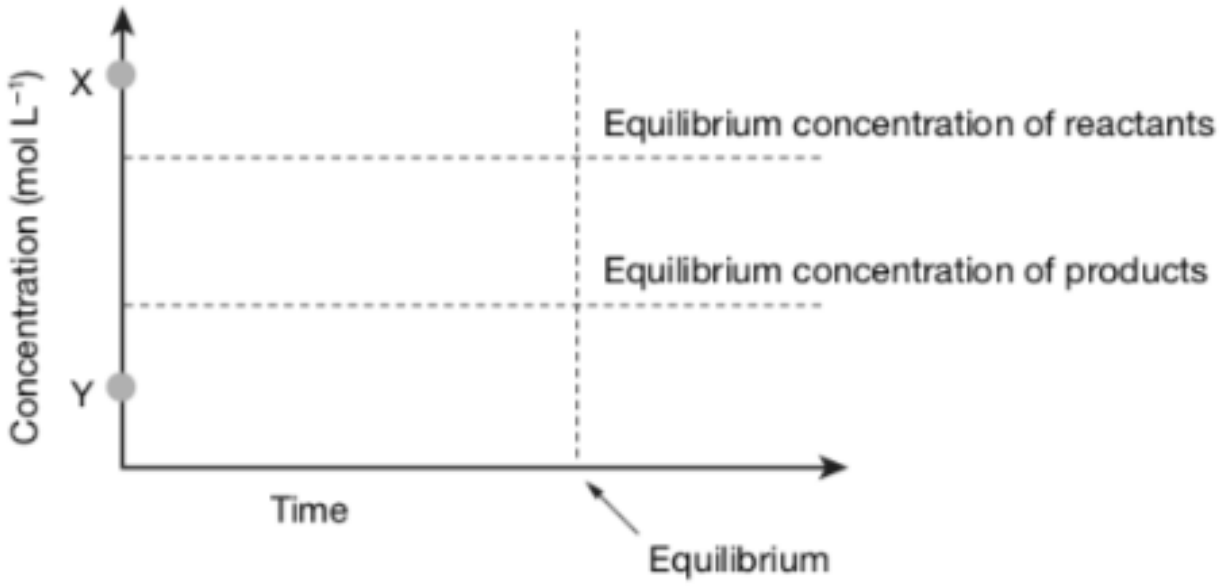


Identify the stage at which this system reaches equilibrium. Justify your choice.

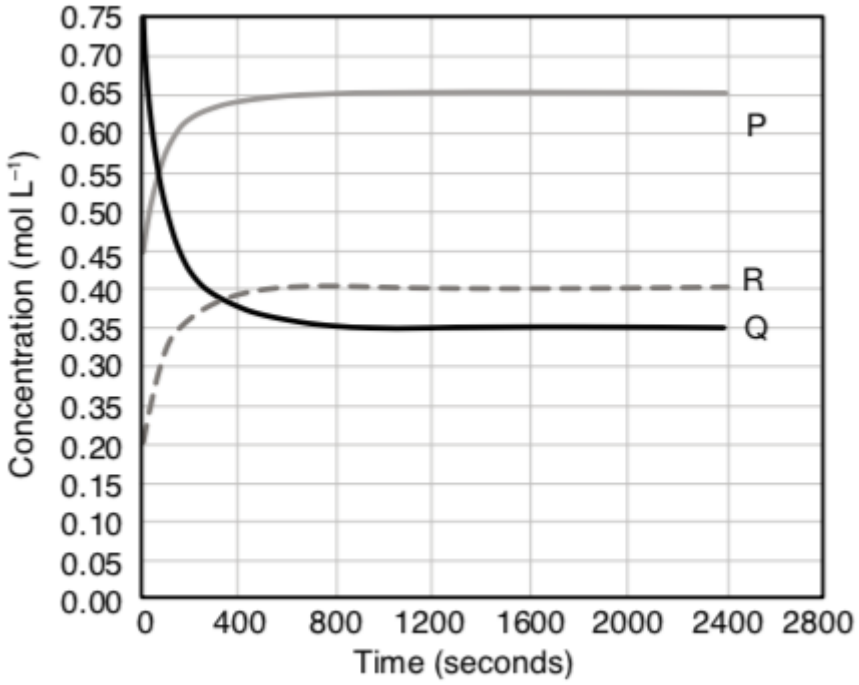
Is this a physical or chemical equilibrium? Explain

When a reaction does to completion, all of the reactantants are used up.
Explain why this never happens in a system at equilibrium.

Sketch curves on the following graph to show how the concentration of reactants and products is likely to change as a system approaches equilibrium.
Point X shows the original concentration of reactants and Point Y shows the original concentration of the products.



The graph shows changes in concentration of three species involved in a chemical reaction.



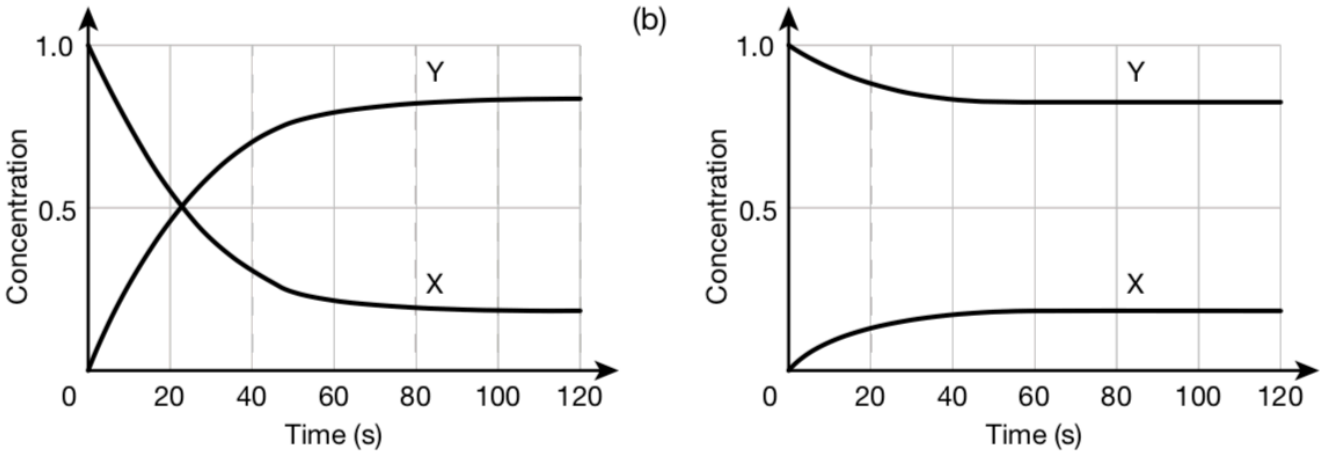
a) Calculate the change in concreation of each of the species involved.

b) Deduce an equation for the reaction shown by the three graphs.

c) At what time is equilibrium reached? Explain how you know

d) At equilibrium, are the concentrations of the reactants and products the same?

The two graphs below illustrate a simple reversible reaction, X ⇋ Y. In one graph the chemist starts with only chemical X present in the saled reactant vessel. In the other graph the reaction commences with only chemical Y present. In each case the reaction is carried out under the same conditions.



Account for similarities and differences in the shapes of the two graphs.

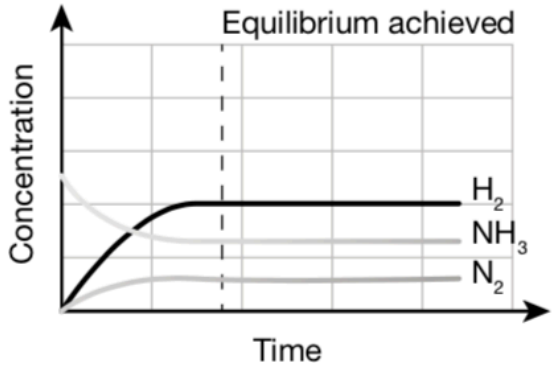
The diagram shown is not an example of equilibrium. It is described as being in steady state.
Distinguish between dynamic equilibrium and a steady state system.
Tabulate your answer.

Nitrogen and hydrogen react to form ammonia which decomposes to form hydrogen and nitrogen gas. In a closed container, under constant conditions, this mixture will reach equilibrium.

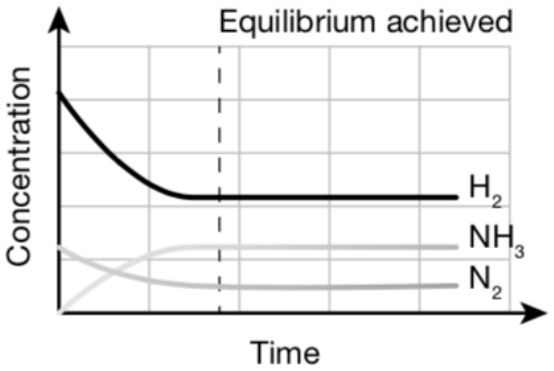
$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)$$

The graphs below show equilibrium being achieved from different initial concentrations of gases.

(i)



(ii)



a) Compare the initial concentrations of hydrogen, nitrogen and ammonia illustrated in the graphs.

b) Write the forward reaction for each graph

c) Compare the final concentrations of gases in the above graphs

Water can be described as having ions in equilibrium as shown by:

$$H_2O\ (aq) \rightleftharpoons H^+\ (aq) + OH^-\ (aq)$$

At any instant in time, only about 1 molecule of water in every 10, 000, 000 water molecules will be ionised. Identify the correct alternative.

a) The forward rate is greater than the reverse rate
b) Both forward and reverse rates are the same
c) Most water molecules are ions
d) The reverse rate is greater than the forward rate

Which of the following is generally considered as going to completion?

a) Combustion
b) Neutralisation
c) Burning magnesium
d) All of the above

Chemical reactions are carried out in three beakers. Which of the following cannot form an equilibrium?

a) A reaction between solutions of sodium hydroxide and hydrochloric acid
b) A reaction between calcium carbonate and dilute hydrochloric acid
c) A reaction between sodium chloride and silver nitrate
d) All of the above, as beakers are open to the environment

Which of the following is not necessarily a characteristic of a reversible system at equilibrium?

a) It is a closed system, no matter enters or leaves the system
b) The macroscopic properties stay consistent
c) The concentrations of reactants is equal to the concentration of products
d) The rates of the forward and reverse reactions are equal

Analyse examples of non-equilibrium systems in terms of the effect of entropy and enthalpy, for example:

- Combustion reactions
- Photosynthesis

Recall the meaning of enthalpy

Recall the meaning of entropy

Which direction of change in enthalpy and entropy favours a non-equilibrium chemical reaction?

Would it be possible for the combustion of carbon in an open system to reach an equilibrium?

Some people claim that respiration is the reverse reaction of photosynthesis
Photosynthesis: $6CO_2(g) + 6H_2O\ (l) \rightarrow C_6H_{12}O_6\ (aq) + 6O_2(g)$
Respiration: $C_6H_{12}O_6\ (aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O\ (l)$

Does this mean that photosynthesis is a reversible reaction?

Entropy and enthalpy are both drivers of reactions such as photosynthesis and combustion, and you will recall that Gibbs free energy (ΔG°) reflects the balance between entropy and enthalpy as drivers of any chemical reaction ($\Delta G^\circ = \Delta H - T\Delta S$).

Entropy and enthalpy are not drivers of reaction for equilibrium reactions. Explain.

Investigate the relationship between collision theory and reaction rate in order to analyse chemical equilibrium reactions

Recall what is meant by collision theory and show how it is related to activation energy

Distinguish between reaction rate and equilibrium position in an equilibrium reaction.

Can the rate of a reaction and the position of an equilibrium reaction be changed by the same factors?