

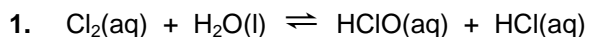


# STARTER FOR 10!!!

## 8.2. Le Châtelier's principle

Le Châtelier's principle states that if a system at equilibrium is disturbed, the equilibrium moves in the direction that tends to minimise the disturbance.

Use Châtelier's principle to suggest two disturbances that can be made to each of the equilibria below to bring about the desired changes; (2 marks for each question)



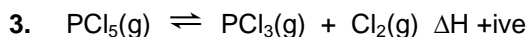
Two disturbances which would result in a decrease in the concentration of chlorine are;

.....  
.....



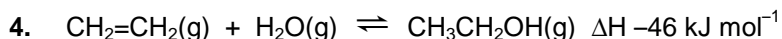
Two disturbances which would result in an increase in the concentration of chlorine are;

.....  
.....



Two disturbances which could be made without changing the amount of reagents or products in the system which would result in a shift of the equilibrium to the right are;

.....  
.....



Two disturbances which would result in an increase in the **percentage yield** of ethanol are;

.....  
.....



Two disturbances which would result in no change in the position of the equilibrium are;

.....  
.....



# STARTER FOR 10...

## 8. Equilibria answers

### 8.1. Dynamic equilibria

1. (a) The rate of the forward and backward reaction must be the same – **True**

The concentration of the reactants and products is the same – **False** (they remain constant)

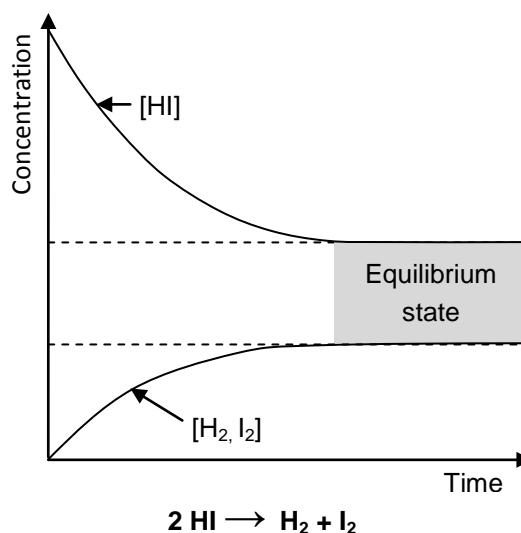
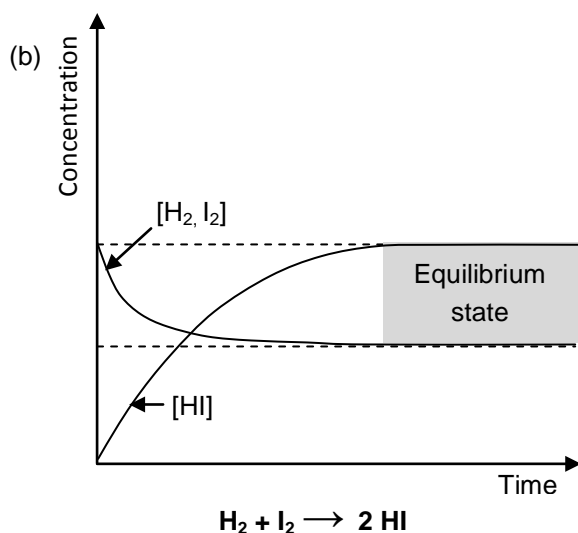
The equilibrium must have been established by reacting hydrogen with iodine – **False**

The system must be sealed – **True**

Iodine is purple in colour. Hydrogen and hydrogen iodide are colourless. Therefore as the iodine is used up, the colour of the system will gradually fade – **False** (the concentration of  $I_2$  doesn't change)

The pressure of the system will remain constant – **True**

(6 marks)



(2 marks given for the correct start and end point of each curve)

### 8.2. Dynamic equilibria

1.  $Cl_2(aq) + H_2O(l) \rightleftharpoons HClO(aq) + HCl(aq)$

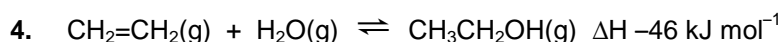
Possible disturbances which would result in a decrease in the concentration of chlorine are removal of either of the products from the system or addition of water to the system. (2 marks for any two)

2.  $4 HCl + O_2 \rightleftharpoons 2 Cl_2 + 2 H_2O \quad \Delta H \text{ -ive}$

Possible disturbances which would result in an increase in the concentration of chlorine are an increase in the concentration of either of the reactants, removal of water from the system or cooling the system. (2 marks for any two)

3.  $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g) \quad \Delta H \text{ +ive}$

Two disturbances which could be made without changing the amount of reagents or products in the system which would result in a shift of the equilibrium to the right are increasing the temperature of the system or lowering the pressure of the system. (2 marks for any two)



Two disturbances which would result in an increase in the percentage yield of ethanol are a lowering of the temperature of the system or a increase in the pressure of the system. (2 marks for any two)



Two disturbances which would result in no change in the position of the equilibrium are a change in system temperature or addition of a catalyst. (2 marks for any two)

### 8.3. Equilibria and industry

1. (a) **Production of hydrogen iodide, Conditions C:** high temperature and pressure has no effect  
 $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2 \text{HI}(\text{g}) \quad \Delta H +53 \text{ kJ mol}^{-1}$

(b) **Making hydrogen, Conditions B:** high temperature and low pressure  
 $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons 3 \text{H}_2(\text{g}) + \text{CO}(\text{g}) \quad \Delta H +206 \text{ kJ mol}^{-1}$

(c) **Production of methanol, Conditions A:** low temperature and high pressure  
 $\text{CO}(\text{g}) + 2 \text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g}) \quad \Delta H -91 \text{ kJ mol}^{-1}$

(1 correct, 1 mark; all 3 correct, 2 marks)

2. (a) i. The reaction is exothermic in the forward direction (1 mark). Therefore lowering the temperature of the system shifts the equilibrium in favour of the forward, exothermic reaction (1 mark) to return the temperature to its original value (1 mark). Therefore the percentage yield of sulfur trioxide is increased.

ii. Addition of a catalyst has no effect on the position of the equilibrium and therefore does not affect the overall yield (1 mark). This is because the catalyst speeds up the rate of both the forward and reverse reaction equally (1 mark).

(b) At low pressures the equilibrium is shifted to the side with the highest number of moles of gas (1 mark) in order to return the pressure to its original value (1 mark). Therefore at atmospheric pressures the yield of sulfur dioxide would be low. Higher pressures are not used because of the expensive equipment costs associated with running reactions at high pressures (1 mark)