



Christ Church  
Grammar School

# Year 12 Chemistry

## Equilibrium Test 2016

Time allowed:

45 minutes

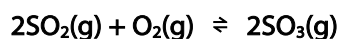
Name: \_\_\_\_\_

Mark = ...../47

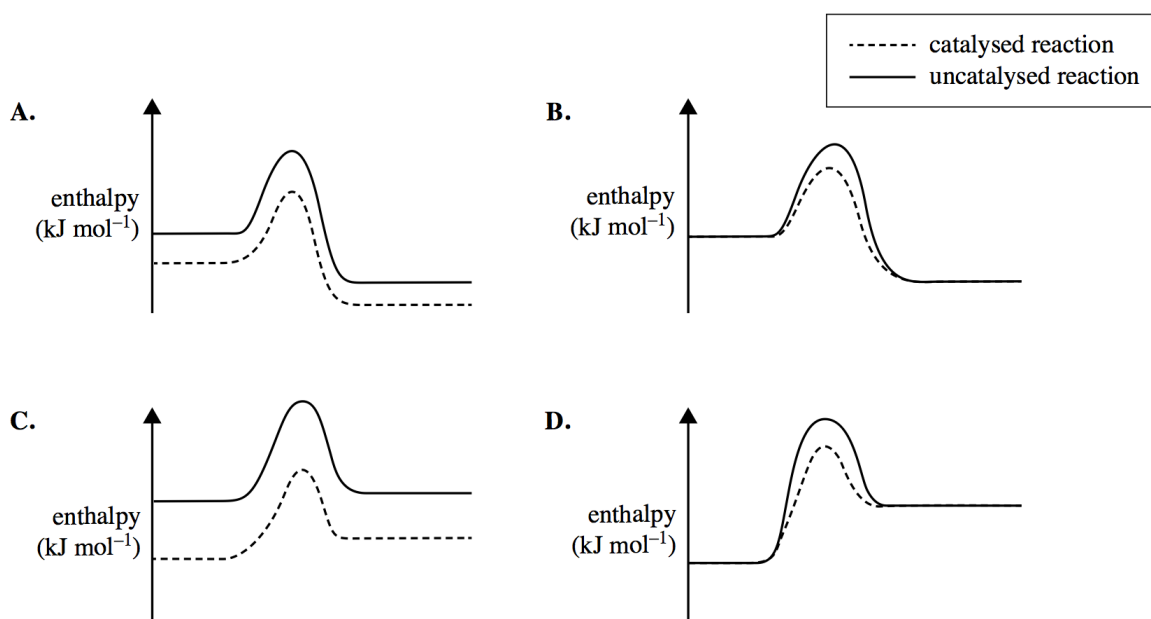
Multiple Choice

(10 marks)

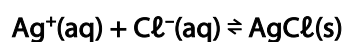
1. The oxidation of sulfur dioxide is an exothermic reaction. The reaction is catalysed by vanadium(V) oxide.



Which one of the following energy profile diagrams correctly represents both the catalysed and the uncatalysed reaction?

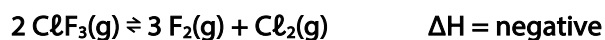


2. Which one of the following is true for a solution of silver chloride in equilibrium with some solid silver chloride, as illustrated by the equation below?



- A. The silver chloride solution is saturated.
- B. Use of a catalyst would allow more solid silver chloride to dissolve.
- C. If more solid silver chloride is added to the mixture then this will change the concentrations of the silver ions and chloride ions in the solution.
- D. The reaction in which silver ions and chloride ions precipitate to form solid silver chloride is not taking place.

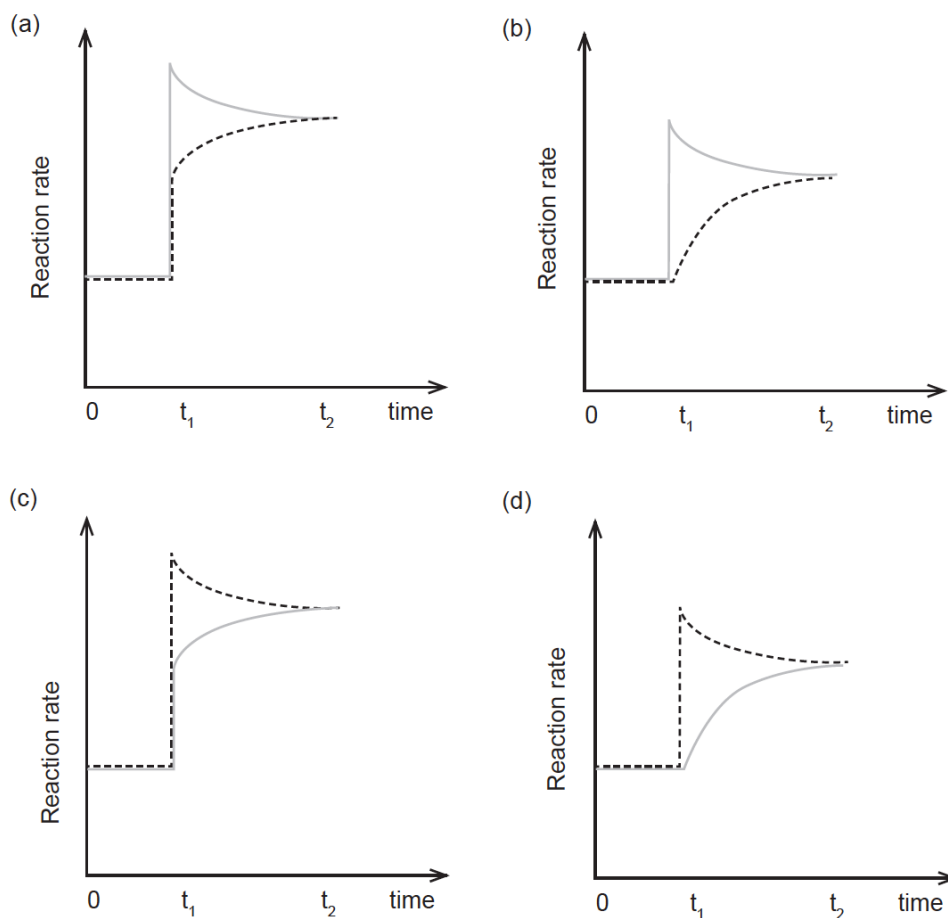
3. Consider the following equilibrium.



The system is initially at equilibrium. At time  $t_1$ , the temperature of the system was increased. Which of the following best represents the changes in the forward and reverse reaction rates until equilibrium is re-established at time,  $t_2$ ?

The forward reaction rate is represented by \_\_\_\_\_

The reverse reaction rate is represented by \_\_\_\_\_



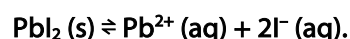
Questions 4 and 5 refer to the reaction represented by the equation shown below.



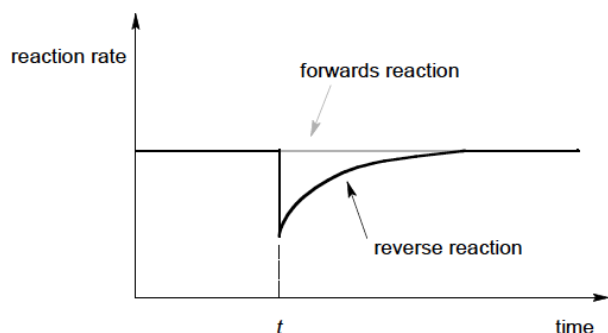
4. Which one of the following is the equilibrium law expression for this reaction?

- A.  $K = 1 / [\text{H}^+]^4 [\text{SO}_4^{2-}]^2$
- B.  $K = [\text{H}_2\text{O}]^2 / [\text{H}^+]^4 [\text{SO}_4^{2-}]^2$
- C.  $K = [\text{PbSO}_4]^2 / [\text{H}^+]^4 [\text{SO}_4^{2-}]^2$
- D.  $K = 1 / [\text{H}^+]^2 [\text{SO}_4^{2-}]$

5. Assuming equilibrium has been established, which one of the following will cause a decrease in pH?
- adding more solid lead
  - adding solid sodium sulfate
  - removing solid lead sulfate
  - adding barium nitrate solution
6. A small amount of solid lead iodide was added to a beaker of water, which was stirred. Most of the solid settled on the bottom of the beaker, but a little dissolved, establishing the equilibrium

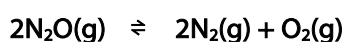


The rates of the forward and reverse reactions were monitored over time, producing the graph shown below:



What happened at time  $t$ ?

- The beaker was cooled in an ice-bath.
  - A small amount of solid KI was added to the beaker.
  - A small amount of solid  $\text{PbI}_2$  was removed from the beaker.
  - A small amount of water was added to the beaker.
7. The anaesthetic, nitrous oxide,  $\text{N}_2\text{O}$ , decomposes to form an equilibrium mixture of  $\text{N}_2\text{O}$ ,  $\text{N}_2$  and  $\text{O}_2$  according to the following equation.

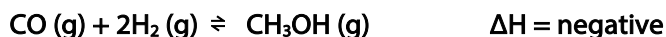


At  $25^\circ\text{C}$ ,  $K = 7.3 \times 10^{37}$  and at  $40^\circ\text{C}$ ,  $K = 2.7 \times 10^{36}$

What valid conclusion can be made from this?

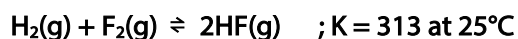
- The equilibrium concentrations of  $\text{N}_2$  and  $\text{O}_2$  are equal at  $25^\circ\text{C}$ .
- The equilibrium concentration of  $\text{N}_2\text{O}$  is higher at  $25^\circ\text{C}$  than at  $40^\circ\text{C}$ .
- The rate of the forward reaction increases by more than the rate of the reverse reaction as temperature is increased.
- The forward reaction is exothermic.

8. It is known that carbon monoxide reacts exothermically with hydrogen gas to form methanol at 400°C, in the presence of a catalyst.



A mixture of carbon monoxide, hydrogen gas and methanol placed under conditions described above achieves equilibrium in a closed container. If the reaction temperature is changed to 450°C, which of the following statements is correct?

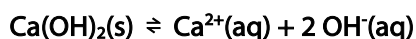
- A. The total number of molecules in the container increases.  
 B. The reaction rates of both the forward and reverse reactions remain constant.  
 C. Rate of formation of hydrogen increases while the rate of decomposition of methanol decreases.  
 D. The concentration of methanol within the container increases.
9. The concentrations of reactants and products were studied for the following reaction.



In an experiment, the initial concentrations of the gases were  $[\text{H}_2] = 0.0200 \text{ mol L}^{-1}$ ,  $[\text{F}_2] = 0.0100 \text{ mol L}^{-1}$  and  $[\text{HF}] = 0.400 \text{ mol L}^{-1}$

When the reaction reaches equilibrium at 25°C, the concentration of HF will be

- A. 0.400 mol L<sup>-1</sup>  
 B. 0.420 mol L<sup>-1</sup>  
 C. between 0.400 mol L<sup>-1</sup> and 0.420 mol L<sup>-1</sup>  
 D. less than 0.400 mol L<sup>-1</sup>
10. A solution of calcium hydroxide was prepared in a flask using a slight excess of calcium hydroxide so that some remained undissolved. The system is represented by the equilibrium



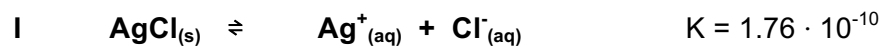
A small volume of concentrated hydrochloric acid was added to the flask. Which statement best describes the system after this addition?

- A. No change occurs.  
 B. Calcium chloride, CaCl<sub>2</sub>(s) is precipitated.  
 C. More Ca(OH)<sub>2</sub>(s) is precipitated.  
 D. Some Ca(OH)<sub>2</sub>(s) dissolves.

Written Section (37 marks)

Question 11 (10 marks)

Consider the two systems below and their equilibrium constants (at 25°C):



(a) In which system would you expect to find a greater proportion of products? Explain your answer.

---



---



---

(2 marks)

(b) **Reaction II** is exothermic. What effect would an increase in temperature have on the value of K? Circle the correct alternative below

Increase

Decrease

No change

(1 mark)

(c) Using the information regarding **Reaction I** above, consider a situation in which a saturated  $\text{AgCl}_{(aq)}$  solution has an equilibrium established between dissolved and undissolved salt at 25°C.

(i) What you would expect to occur if a small volume of concentrated silver nitrate solution was added? Explain your answer using Collision Theory

---



---



---



---

(3 marks)

- (ii) More  $\text{AgCl}_{(s)}$  is observed to dissolve upon heating. State how the rates of reaction and the value of the equilibrium constant have been affected by the increase in temperature. Explain your answer using Collision Theory and Le Chatelier's Principle.

---



---



---



---



---



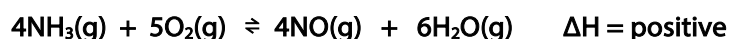
---

(4 marks)

**Question 12**

**(8 marks)**

At temperatures above  $2000^{\circ}\text{C}$ , ammonia and oxygen react to form nitrogen oxide gas in this reversible reaction.



A mixture of ammonia and oxygen is placed in a container with a volume that can be changed. The reaction is allowed to come to equilibrium at  $2500^{\circ}\text{C}$  and at a pressure of 110 kPa in a closed container.

- (a) Write the equilibrium constant expression for the above reaction:

$K =$

(1 mark)

- (b) If the pressure in the reaction vessel is doubled by adding argon gas at constant volume, what effect would this have on the mass of nitrogen oxide? (write 'increase', 'decrease' or 'no change')

---

(1 mark)

- (c) What change could be imposed on the above system which would result in a decrease in mass of nitrogen oxide but an increase in its concentration once equilibrium has been re-established?

---

(1 mark)

- (d) Other than adding or removing products or reactants, what change could be imposed on the above system which would result in a decrease in mass of nitrogen oxide and a decrease in its concentration once equilibrium has been re-established?

---

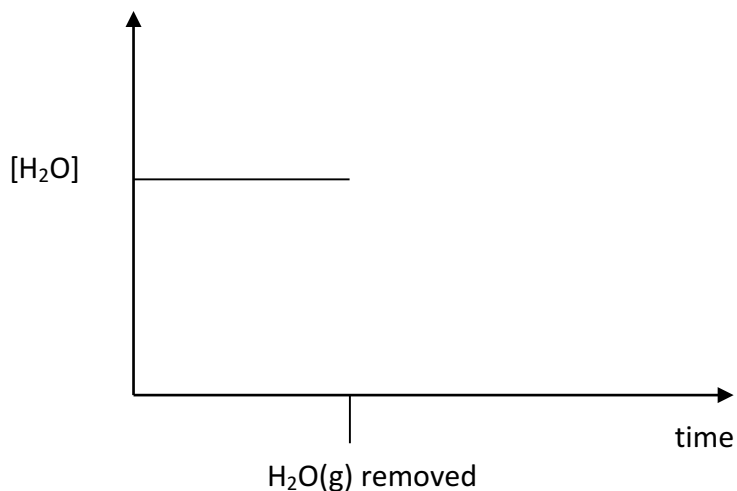
(1 mark)

- (e) (i) If some  $\text{H}_2\text{O}$  gas is removed from the equilibrium mixture at constant temperature, what would be the effect on **the initial rate of the forward reaction**? (write 'increase', 'decrease' or 'no change')

---

(1 mark)

- (ii) Represent the changes to the concentration of  $\text{H}_2\text{O}(\text{g})$  as the system returns to equilibrium on the axes below.



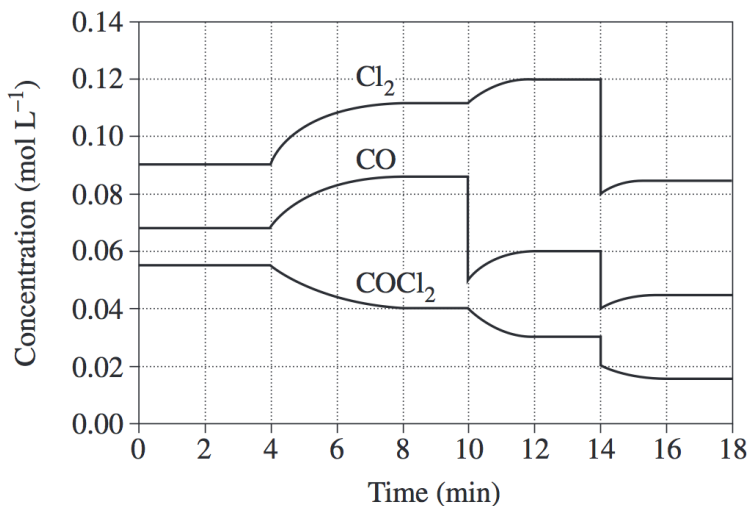
(3 marks)



Question 13

(6 marks)

A mixture of  $\text{COCl}_2$ ,  $\text{Cl}_2$  and  $\text{CO}$  is placed in a container with a volume that can be changed. The mixture is allowed to come to equilibrium. The graph below shows the variation in concentration of reactant and products as a function of time for the following system.



At time = 4 minutes, 10 minutes and 14 minutes, changes were made to the reaction conditions. **Identify and explain** each of the changes in conditions that have shaped the curves during the time the system was observed.

Time = 4 minutes

---



---



---

(2 marks)

Time = 10 minutes

---



---



---

(2 marks)

Time = 14 minutes

---



---



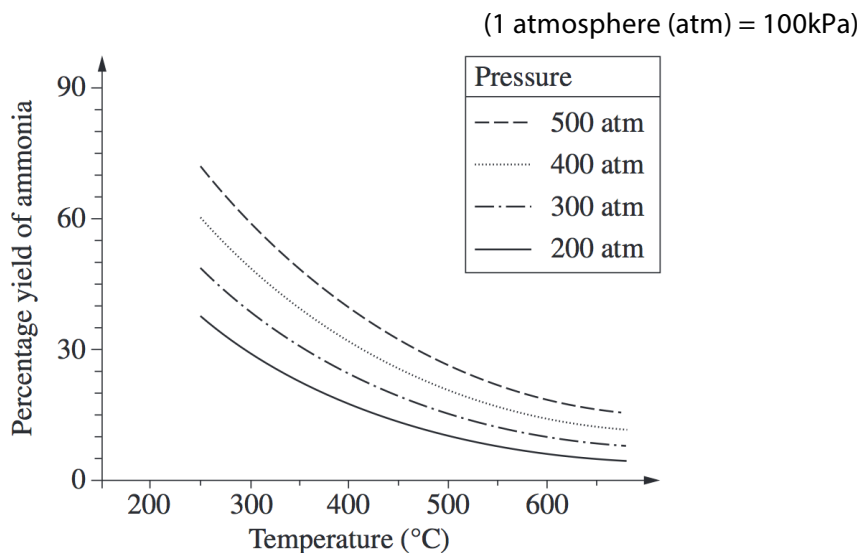
---

(2 marks)

Question 14

(3 marks)

The Haber process is the main industrial procedure for the production of ammonia. The graph shows the percentage yield of ammonia produced from nitrogen and hydrogen at different temperatures and pressures.



From the graph, identify whether the forward reaction for the Haber Process is endothermic or exothermic. Explain your reasoning

---



---



---



---



---

(3 marks)

