Christ Church Grammar School

Year 12 Chemistry

Equilibrium Test
2019

Time allowed: **45 minutes**

Name:
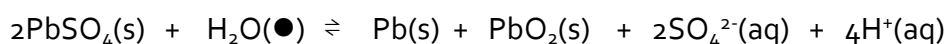
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SECTION 1   **MULTIPLE CHOICE**   **10 marks**

1. The effect of a catalyst on a chemical reaction in a closed system is to change:

   (a)   the equilibrium position.
   (b)   the time for equilibrium to be reached.
   (c)   the enthalpy change for the reaction.
   (d)   the final amount of product formed.
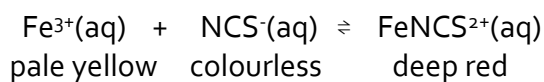
2. Consider the following reaction at equilibrium.

   $$2PbSO_4(s) + H_2O(\bullet) \rightleftharpoons Pb(s) + PbO_2(s) + 2SO_4^{2-}(aq) + 4H^+(aq)$$

   Which of the following changes will cause an increase in the concentration of H^+ ions once equilibrium is re-established?

   (a)   adding more $PbSO_4$
   (b)   adding a few drops of concentrated sodium sulfate solution
   (c)   crushing the PbO_2
   (d)   adding a few drops of concentrated barium nitrate solution

3. The reaction below has reached equilibrium in a closed system.
   Which of the following changes would have no effect on the equilibrium?

   $$CaCO_3(s) + 2H^+(aq) \rightleftharpoons CO_2(g) + H_2O(\bullet) + Ca^{2+}(aq) \quad \Delta H = \text{-ve}$$
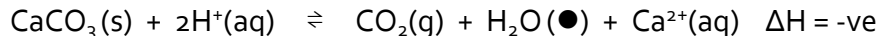
   (a)   increase the state of sub-division of the $CaCO_3(s)$.
   (b)   increase the pressure inside the system.
   (c)   increase the volume of the system.
   (d)   decrease the temperature of the system.

4. Which of the following best describes what would happen when a small volume of concentrated iron(III) nitrate is added to the following equilibrium system?

   $$Fe^{3+}(aq) + NCS^-(aq) \rightleftharpoons FeNCS^{2+}(aq)$$
   $$\text{pale yellow} \quad \text{colourless} \quad \text{deep red}$$

   (a)   no observable effect
   (b)   yellow colour fades and the red intensifies
   (c)   the colour of the solution will fade
   (d)   yellow colour intensifies then fades and the red intensifies

5. Water ionises according to the following equation

$$2H_2O\ (\bullet) \rightleftharpoons H_3O^+(aq) + OH^-(aq) \quad \Delta H = +ve$$
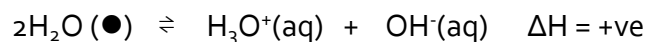
Water is neutral at 25°C. Which of the following best describes what would happen when the temperature of the water is raised?

(a)   concentration of H_3O^+ ions increases and the water remains neutral
(b)   concentration of H_3O^+ ions decreases and the water remains neutral
(c)   concentration of H_3O^+ ions decreases and the pH of the water decreases
(d)   concentration of the H_3O^+ ions increases and the pH of the water increases.

6. Which of the following is **not** a characteristic of dynamic equilibrium?

(a)   macroscopic properties remain constant
(b)   the rate of the forward and reverse reactions are equal
(c)   dynamic equilibrium can be achieved in an open vessel
(d)   temperature will affect the state of dynamic equilibrium

7. Consider the following equilibrium;

$$CaCrO_4(s) \rightleftharpoons Ca^{2+}(aq) + CrO_4^{2-}(aq)$$
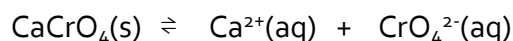
A mixture of this reaction is set up in a test tube and at equilibrium a few yellow crystals can be observed at the bottom of a yellow solution.
What is observed when a few drops of concentrated calcium chloride solution is added?

(a)   More yellow crystals form and the solution becomes paler.
(b)   More yellow crystal form and the solution becomes a darker yellow
(c)   Some yellow crystals dissolve and the solution becomes paler.
(d)   Some yellow crystals dissolve and the solution becomes darker yellow.

8. Which of the following statements is true?

(a) Exothermic reactions slow down when reactants are added.
(b) Only endothermic reactions speed up when heated.
(c) Exothermic reactions speed up with an increased temperature.
(d) Only exothermic reactions occur spontaneously at room temperature.

The Next Two Questions Refer To The Following Information

Below is an equation that represents one of the steps in the production of nickel. The ore is first treated with ammonia and oxygen to produce the tetra-ammine nickel ion. The next step is shown below. The tetra-ammine nickel ion is treated with hydrogen gas and converted to nickel metal.

$$Ni(NH_3)_4^{2+}(aq) + H_2(g) \rightleftharpoons Ni(s) + 2NH_4^+(aq) + 2NH_3(g)$$

9. Which of the following sets of conditions will result in the highest yield of nickel?

(a) Low partial pressure of hydrogen and high partial pressure of ammonia
(b) High partial pressure of hydrogen and high partial pressure of ammonia
(c) Low partial pressure of hydrogen and low partial pressure of ammonia
(d) High partial pressure of hydrogen and low partial pressure of ammonia

10. Which of the following conditions will result in the fastest rate of nickel production?

(a) Adding helium to the system, at a constant volume, to increase the overall pressure.
(b) Increase the partial pressure of hydrogen
(c) Adding a significant amount of ammonium nitrate solution.
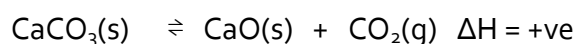(d) Increasing the volume of the reaction vessel.

SECTION 2   **SHORT ANSWERS**   **35 marks**

Question 11   **4 marks**

Consider the following reaction,

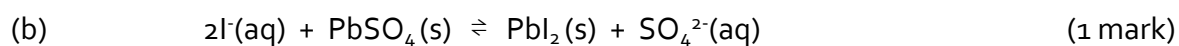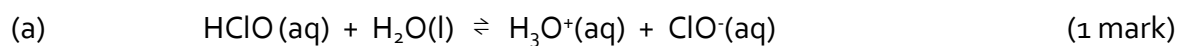$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g) \quad \Delta H = +ve$$

Complete the following table using the terms **increase, decrease** or **no change,** to indicate the effect of the changes listed when equilibrium is re-established.   (1 mark each line)

| Change	Mass of $CaCO_3$	Concentration of CO_2	Rate of Forward Reaction
Volume of the system is increased			
Temperature of the system is increased			
A portion of carbon dioxide is removed			
Calcium carbonate is ground into a fine powder			

Question 12   **2 marks**

Write equilibrium constant expressions for the following reactions.

(a) $HClO\,(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO^-(aq)$ (1 mark)

(b) $2I^-(aq) + PbSO_4\,(s) \rightleftharpoons PbI_2\,(s) + SO_4^{2-}(aq)$ (1 mark)

(a)	
(b)	

Question 13   **8 marks**

Soft drinks contain dissolved carbon dioxide in an equilibrium with carbon dioxide gas.

$$CO_2(g) \; \rightleftharpoons \; CO_2(aq) \; + \; 19kJ$$
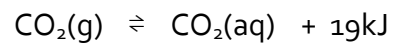
Using Collision Theory, account for the following observations.
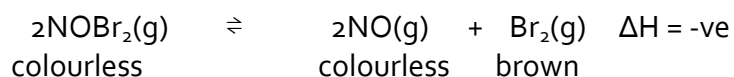
(a)   bubbles of carbon dioxide form when the bottle or can is opened. (4 marks)

(b)   Warm fizzy drinks go flat faster than cold fizzy drinks.   (4 marks)

Question 14   **5 marks**

Nitrosyl bromide ($NOBr_2$) decomposes and reaches equilibrium according to the equation below. The colours of these individual gases are provided below.

$$2NOBr_2(g) \rightleftharpoons 2NO(g) + Br_2(g) \quad \Delta H = \text{-ve}$$
colourless   colourless   brown

(a)   Two changes were imposed on the equilibrium mixture, as described in (i) and (ii) below. Show the effects of these changes by extending the lines accordingly on the diagram shown, as the system re-establishes a new equilibrium in each case. Graph 'i' is concentration v time and graph 'ii' is rate v time.

   i.   A quantity of $NOBr_2$ was introduced into the vessel at time t_1, at constant temperature. Equilibrium is re-established at t_2 and continues to t_3.

                                                                                          (2 marks)
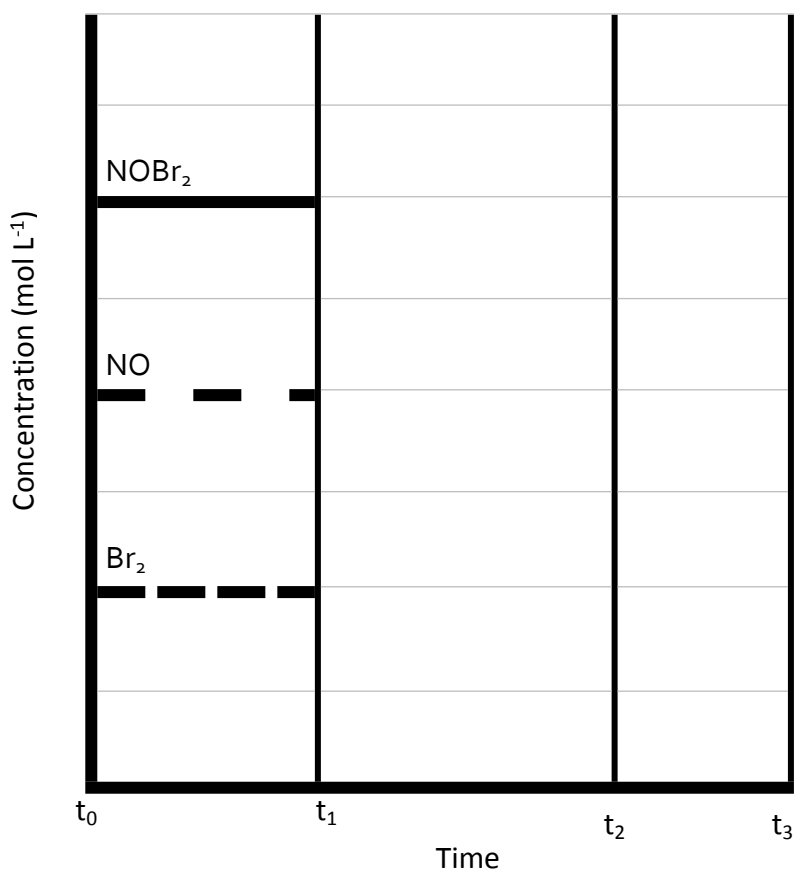
ii.   At time **t₁,** the temperature in the reaction vessel was increased and equilibrium
       was re-established at t_2 and remains at equilibrium to t_3.
       Use (_____) for the forward reaction and (_ _ _ _) for the reverse reaction. Note
       the forward and reverse reaction rates are superimposed on the graph below
       between t_0 and t_1.

       (2 marks)
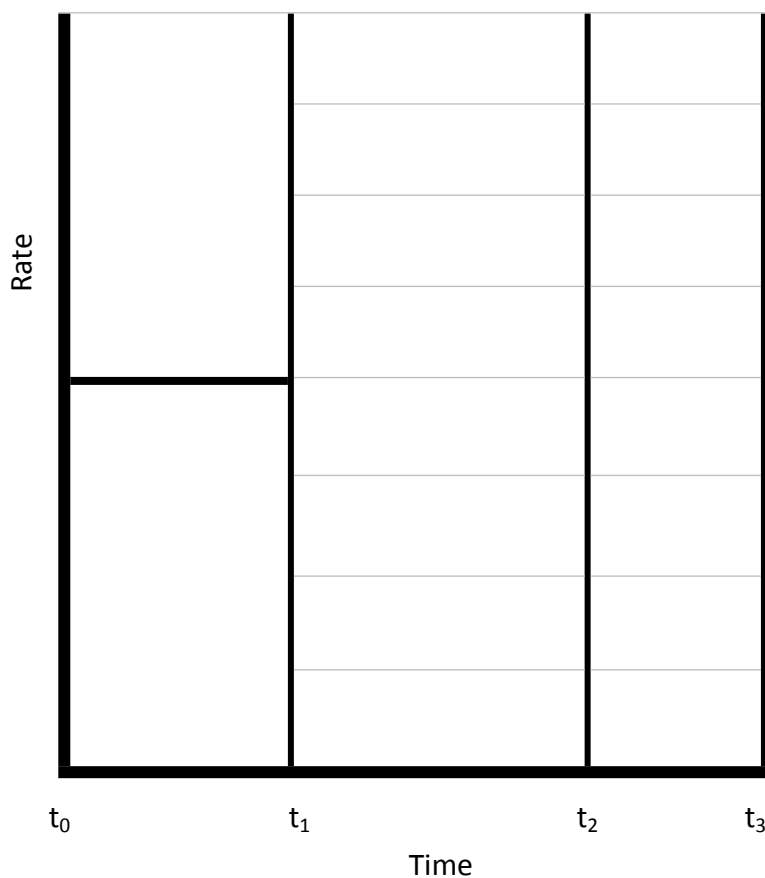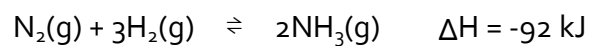

(b)   Using the graph above (ii), describe any change in colour, if any, you would
       expect to see between t_1 and t_2.   (1 mark)

Question 15   **6 marks**

Ammonia is one of our most important industrial chemicals. It is produced by the reaction of nitrogen and hydrogen gases according to the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ}$$

Industrially, this process is carried out at 450 °C, and 200 atm, and with a porous iron oxide catalyst. (Note: 1 atm = 100 kPa)

(a)   Explain why the process is carried out at this temperature.   (3 marks)

(b)   Explain why increased pressures increase both the rate of reaction and the yield of ammonia?   (3 marks)

Question 16   **10 marks**

Sodium hypochlorite (NaCℓO) is commonly used in the textile industry as a bleach. When added to water, hypochlorous acid (HCℓO) is formed. The solution can now be considered as an equilibrium system, where hypochlorite ions are converted into hypochlorous acid.

$$ClO^-(aq) \ + \ H_2O(\ell) \ \rightleftharpoons \ HClO(aq) \ + \ OH^-(aq) \quad \Delta H = \text{-ve} $$
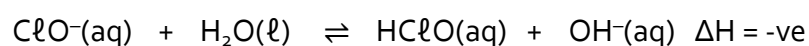
Complete the following by predicting, <u>with reasoning using collision theory</u>, the effect that the following changes will have on the concentration of the hypochlorous acid (HCℓO) in the treated water.

(a)   <u>Addition of some hydrochloric acid to the treated water</u>

        Use Le Chatelier's principle to predict the effect on hypochlorous acid.   (1 mark)

        Justify using the collision theory   (4 marks)

(b)   <u>Increasing the temperature of the treated water</u>

Use Le Chatelier's principle to predict the effect on hypochlorous acid.   (1 mark)

Justify using collision theory   (4 marks)

END OF TEST