Year 12 Chemistry **Topic Test # 1 (Equilibrium) - 2013**

Name: _____ Mark = _____ / 47

Part 1: Multiple Choice Section **10 marks**

Answer by placing a cross through, or a circle around, the letter of the most correct answer.

1. For a reversible reaction, catalysts alter:

   A. the heat of reaction for the forward reaction.

   B. the size of the equilibrium constant.

   C. the time taken for an equilibrium to be established.

   D. the nature of the products formed in the forward reaction.

2. Consider the equilibrium represented in the following equation. The colour of each species is indicated below its formula.

   $Cu^{2+}(aq) + 4\ C\ell^{-}(aq) \rightleftarrows CuC\ell_4^{2-}(aq)$

   blue *colourless* *green*

   Which of the following statements is correct?

   A. At equilibrium the formation of $CuC\ell_4^{2-}(aq)$ has stopped

   B. Adding some concentrated $HC\ell(aq)$ causes the blue colour to intensify

   C. At equilibrium there will be some $Cu^{2+}(aq)$ present

   D. Adding some silver nitrate solution will cause the green colour to intensify

3. Which of the following is **FALSE** for the equilibrium constant, K, for a chemical reaction?

   A. K indicates the relative proportions of products to reactants at equilibrium.

   B. K will alter if the temperature of the system at equilibrium is altered.

   C. K provides no information about the initial rate of the forward reaction.

   D. K will alter in value if a change in pressure occurs in the system at constant temperature, once equilibrium has been re-established.

4. The commercial production of ammonia, using the Haber Process, involves an exothermic reaction between nitrogen gas and hydrogen gas. Which one of the following statements is true?

$$3\ H_2(g) + N_2(g) \rightleftarrows 2\ NH_3(g) \qquad \Delta H = -92\ kJ$$

A. The rate of production of ammonia will be lower at high pressure than at a low pressure.

B. The rate of production of ammonia will be greater at low temperature than at high temperature.

C. Both high temperature and high pressure increase the rate of formation of ammonia.

D. Continual removal of the ammonia formed will increase the rate at which the hydrogen gas and nitrogen gas react.

5. Hydrogen sulfide is used as a source of sulfide ion in qualitative analysis.
The equations for the production of sulfide ions are:

$$H_2S(aq) \rightleftarrows H^+(aq) + HS^-(aq)$$

$$HS^-(aq) \rightleftarrows H^+(aq) + S^{2-}(aq)$$

When acid is added to a solution containing H_2S, the sulfide ion concentration:

A. will increase.

B. will remain constant.

C. will decrease.

D. will always equal the hydrogen ion concentration.

6. Measured at constant temperature, the rates of chemical reactions decrease as the reaction proceeds because:

A. The forward and reverse reaction rates must approach zero as equilibrium is approached.

B. The reactant concentrations decrease with time.

C. The fraction of reactant molecules with energies in excess of the activation energy decrease as the reaction proceeds.

D. Absorption of heat by the reaction diminishes the reaction rate.

7. Consider the equilibrium:

$$2\ C\ell F_3(g) \rightleftarrows 3\ F_2(g) + C\ell_2(g) \qquad \Delta H = \text{negative}$$

For a particular equilibrium mixture, the temperature is **lowered** and the amount of $C\ell F_3$ changes by 0.010 mol. The changes occurring would be:

	$C\ell F_3$	F_2	$C\ell_2$
A.	Increase by 0.010 mol	Decrease by 0.015 mol	Decrease by 0.0050 mol
B.	Increase by 0.010 mol	Decrease by 0.0067 mol	Decrease by 0.020 mol
C.	Decrease by 0.010 mol	Increase by 0.015 mol	Increase by 0.0050 mol
D.	Decrease by 0.010 mol	Increase by 0.067 mol	Increase by 0.020 mol

8. In which one of the following would the position of the equilibrium **not** be affected by a volume change at constant temperature?

A. $2\ CO(g) + O_2(g) \rightleftarrows 2\ CO_2(g)$

B. $C_2H_6(g) \rightleftarrows C_2H_4(g) + H_2(g)$

C. $N_2O_4(g) \rightleftarrows 2\ NO_2(g)$

D. $CO(g) + H_2O(g) \rightleftarrows H_2(g) + CO_2(g)$

9. Deuterium, symbol D, is an isotope of hydrogen. The molecule HD may be prepared from a mixture of pure H_2 and pure D_2 by establishing the equilibrium:

$$H_2(g) + D_2(g) \rightleftarrows 2\ HD(g)$$

The equilibrium constant for this reaction is 1.92 at 100°C and 3.37 at 500°C.
To maximise the yield of HD the reaction is carried out at 500°C where the equilibrium constant for the formation of HD is greater. It follows that the reaction is:

A. endothermic and the yield of HD would be unaffected by the pressure.

B. endothermic and the yield of HD could be increased by carrying out the reaction at a high pressure.

C. exothermic and the yield of HD would be unaffected by the pressure.

D. exothermic and the yield of HD could be increased by carrying out the reaction at a high pressure.

10. Consider a sealed system in which the following reaction is at equilibrium:

$$CaCO_3(s) \rightleftarrows CaO(s) + CO_2(g)$$

Now consider the following actions:

I Add more $CO_2(g)$ to the system

II Add more $CaCO_3(s)$ to the system

III Decrease the volume of the system

IV Increase the temperature of the system

One of more of these actions lead to a change in $CO_2(g)$ concentration after equilibrium is re-established. Which statement below is true?

A. All actions lead to a change in $CO_2(g)$ concentration

B Only II, III and IV lead to a change in $CO_2(g)$ concentration

C. Only III and IV lead to change in $CO_2(g)$ concentration

D. Only IV leads to change in $CO_2(g)$

Part 2: Short Answer Section **37 marks**

1. Methane and water react to produce carbon monoxide and hydrogen gas according to the equation:

$$CH_4(g) + H_2O(g) \rightleftarrows CO(g) + 3\,H_2(g) \qquad \Delta H = +200 \text{ kJ mol}^{-1}$$

Assume this reaction is allowed to come to equilibrium at 200°C and a pressure of 150 kPa.

Using the terms: INCREASE, DECREASE, NO CHANGE answer (a), (b) and (c).

(a) How will the value of this equilibrium constant change, once equilibrium has been re-established, if the following changes occur?

(i) The volume of the vessel is halved. _____

(ii) The temperature is raised to 500°C. _____

(b) What happens to the equilibrium concentration of carbon monoxide, once equilibrium has been re-established, if the following changes occur?

(i) Gaseous water is added to the system. _____

(ii) The pressure of the reaction vessel is doubled by adding argon gas . _____
(at constant volume and temperature)

(iii) The temperature is decreased to 100°C. _____

(c) What happens **initially** to the rate of the **forward** reaction if the following changes are made?

(i) More CO(g) is added to the mixture. _____

(ii) The volume of the container is halved. _____

(iii) A suitable catalyst is added. _____

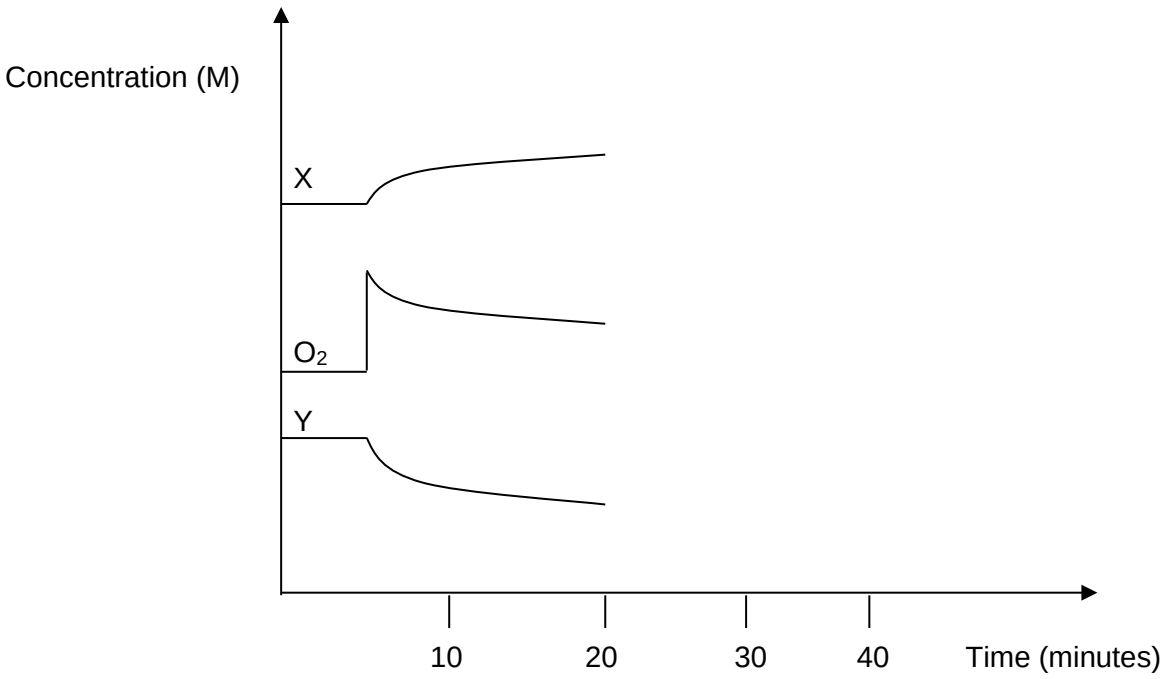
(8 marks)

2. Part of the Contact Process for the manufacture of sulfuric acid involves the conversion of sulfur dioxide to sulfur trioxide, as shown by the equation:

$$2\ SO_2(g) + O_2(g) \rightleftarrows 2\ SO_3(g) \qquad \Delta H = -192\ kJ\ mol^{-1}$$

As part of a laboratory study of this process, a container was filled with an equilibrium mixture of sulfur dioxide, sulfur trioxide and oxygen in the presence of a catalyst. The container was initially at 450°C. The container had a fixed volume and was **thermally well insulated**.

Concentrations during an experiment are shown on the diagram below.



(a) At t = 5 minutes, a change was applied to the system. What was it?

_____ (1 mark)

(b) Which components of the equilibrium mixture are represented by X and Y?

X = _____ Y = _____ (1 mark)

(c) Would the temperature of the mixture **increase, decrease** or **remain the same** between 5 and 20 minutes? Explain your reasoning.

_____

_____

_____

_____

(2 marks)

(d) At t = 20 minutes, some SO_3 was removed from the container. Continue the graph to represent the changes made to the concentrations of X, Y and O_2 until equilibrium has been re-established at 35 minutes.

(3 marks)

3. Consider a solution in which the following equilibrium is established.

$Br_2(aq) + 2\ OH^-(aq) \rightleftarrows OBr^-(aq) + Br^-(aq) + H_2O(l) \quad \Delta H = +15\ kJ\ mol^{-1}$

The molecular bromine (Br_2) gives the aqueous solution a reddish-brown colour. All the other species present are colourless.

(a) The tests described in the table below are carried out on separate samples of the solution. For each of the tests, give any observations from when the change is made until equilibrium has been re-established and, in each case, give an explanation for your answer.

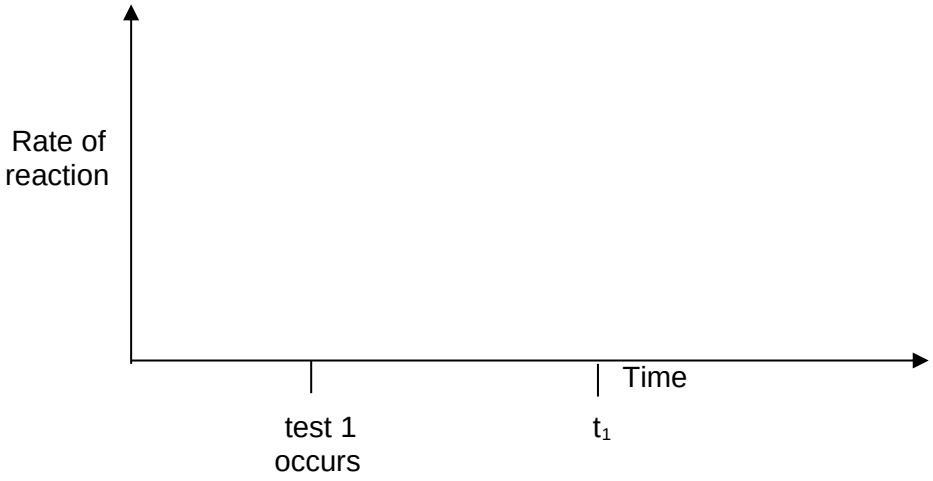
Test	*Observations*	*Explanation*
<u>Test 1</u> A few mL of a concentrated solution of bromine are mixed into the solution.		
<u>Test 2</u> A few mL of water is added to the solution.		
<u>Test 3</u> The solution is heated from room temperature to 60°C.		

(4+4+3 = 11 marks)

(b) Write the expression for the equilibrium constant (K) for reaction.

(1 mark)

(c) Sketch graphs of what happens to the rate of the **forward** and **reverse** reactions for **<u>test 1,</u>** from before the change is made until equilibrium has been re-established at $\mathbf{t_1}$. Clearly indicate which line represents the forward reaction and which represents the reverse reaction.



(5 marks)

(d) Explain, with reference to Kinetic Theory and Collision Theory when appropriate, why the rate of the **FORWARD** reaction changes in the way shown in your sketch, from before test 1 to t_1.

(5 marks)

End of Test