Chemistry 12 Equilibrium Test 2018

Total Marks____/ 51 **Student Name:_____**

Multiple Choice Section:(8 marks, 1 mark each)

Question 1:

Ethene, C_2H_4, can be produced in the following industrial system:

$$C_2H_{6\,(g)} + \text{energy} \rightleftharpoons C_2H_{4\,(g)} + H_{2\,(g)}$$

The conditions that are necessary to maximize the equilibrium yield of C_2H_4 are

A. low temperature and low pressure.
B. low temperature and high pressure.
C. high temperature and low pressure.
D. high temperature and high pressure.

Question 2:

Consider the following equilibrium:

$$H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{\,(g)}$$

The volume of the equilibrium system is **increased** and a new equilibrium is established. Compared to the **rates** in the original equilibrium, which of the following describes the **rates** of the forward and reverse reactions in the new equilibrium?

	FORWARD RATE	REVERSE RATE
A.	decreased	decreased
B.	increased	increased
C.	decreased	increased
D.	remained constant	remained constant

Question 3:

Consider the following equilibrium:

$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)} + \text{energy}$$

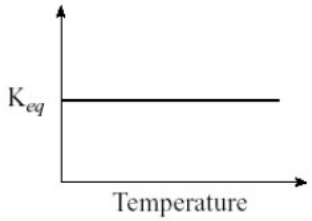
Certain conditions provide less than 10% yield of NH_3 at equilibrium. Which of the following describes this equilibrium?

	K_{eq}	EQUILIBRIUM POSITION
A.	large	favours products
B.	small	favours products
C.	large	favours reactants
D.	small	favours reactants

Question 4:

Which of the following best describes the relationship between K_{eq} and temperature for an endothermic reaction?

A.



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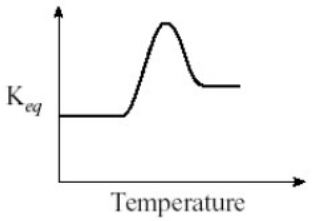

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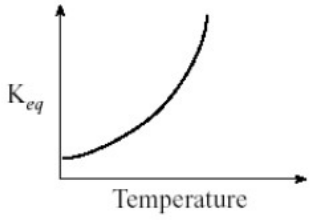

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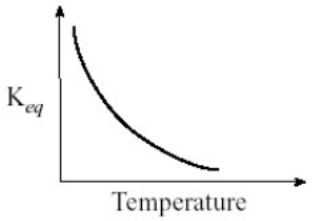


Question 5:

Methanol, CH_3OH, can be produced by the following:

$$CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH(g) + \text{energy}$$

The conditions that are necessary to maximize the equilibrium yield of CH_3OH are

A. low temperature and low pressure.
B. high temperature and low pressure.
C. low temperature and high pressure.
D. high temperature and high pressure.

Question 6:

What is the K_{eq} expression for the following equilibrium?

$$3Fe_{(s)} + 4H_2O_{(g)} \rightleftharpoons Fe_3O_{4(s)} + 4H_{2(g)}$$

A. $K_{eq} = [H_2]^4$

B. $K_{eq} = \dfrac{[H_2]}{[H_2O]}$

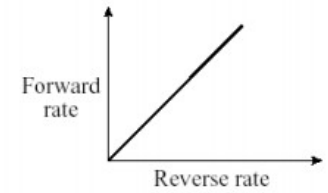
C. $K_{eq} = \dfrac{[H_2]^4}{[H_2O]^4}$

D. $K_{eq} = \dfrac{[Fe_3O_4][H_2]^4}{[Fe]^3[H_2O]^4}$

Question 7:

At different conditions, the relationship between the forward and reverse rates of reaction in an equilibrium system can be represented by

A.



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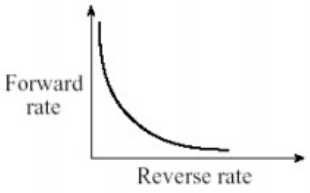

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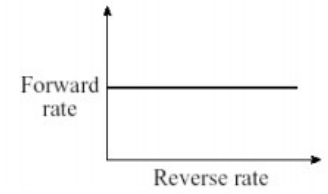

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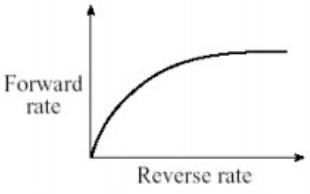


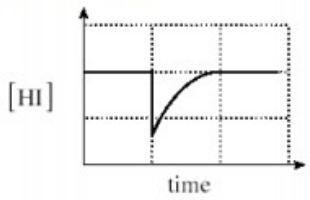
Question 8:

Consider the following equilibrium:

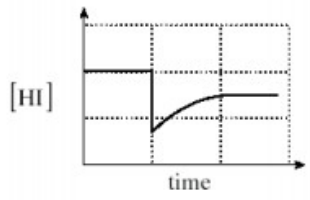
$$H_{2\,(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

Which graph represents what happens when some HI is removed and a new equilibrium is established?

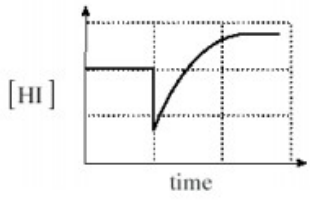
A.



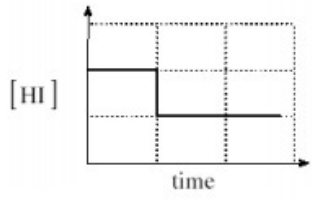
B.



C.



D.



Short Answer Section: [27 marks]

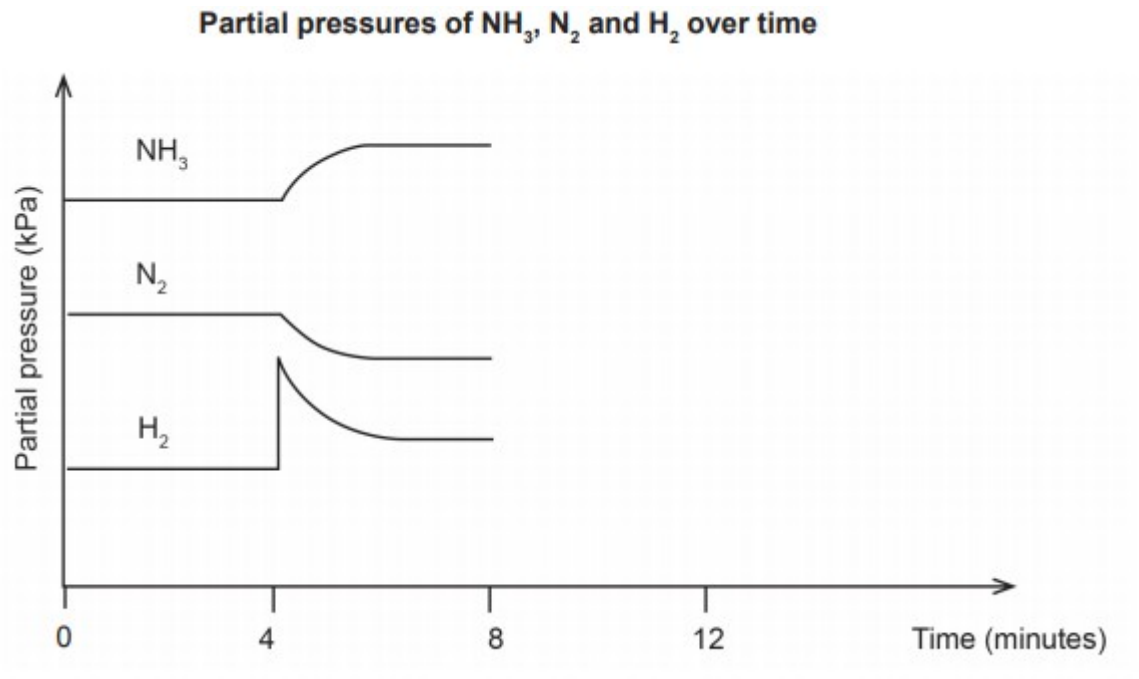
Question 1: [6 marks]

Ammonia exists in equilibrium with hydrogen and nitrogen as shown by the following exothermic equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92\ kJ\ mol^{-1}$$

As they exist in the gaseous state, the relative concentrations can be given in terms of the partial pressure (kPa) of each gas.

Nitrogen, hydrogen and ammonia gases are placed in a rigid container and allowed to reach equilibrium. The graph below shows the partial pressures of the gaseous system initially at equilibrium. After the experiment operates for 4 minutes, a change is imposed upon it.



(a) What characteristic of equilibrium is indicated on the graph by the section from 0 to 4 minutes? (1 mark)

_____

_____

(b) A change was imposed on the system at the 4-minute mark. What imposed change could have produced the results indicated on the graph? (1 mark)

_____

(c) The system was suddenly cooled at 8 minutes and then reached equilibrium again at 12 minutes. Using this information, complete the graph above from the 8 to the 12-minute mark. (4 marks)

Question 2: [8 marks]

The following dynamic equilibrium was established at temperature T in a closed container.

$$P(g) + 2Q(g) \rightleftharpoons 2R(g) \qquad \Delta H^{\ominus} = -50\ kJ\ mol^{-1}$$

The value of K_c for the reaction was 68.0 when the equilibrium mixture contained 3.82 mol of **P** and 5.24 mol of **R** inside a 2.2 litre container.

(a) Write the Keq equation then solve for the number of moles of Q inside the container when it was at equilibrium. [**4 marks**]

b)

i. State the effect, if any, on the equilibrium amount of **P** of increasing the temperature. All other factors are unchanged.

.....

(1 mark)

ii. State the effect, if any, on the equilibrium amount of **P** of using a container of larger volume. All other factors are unchanged.

.....

(1 mark)

iii. State the effect, if any, on the value of K_c of increasing the temperature. All other factors are unchanged.

.....

(1 mark)

iv. State the effect, if any, on the value of K_c of using a container of larger volume. All other factors are unchanged.

.....

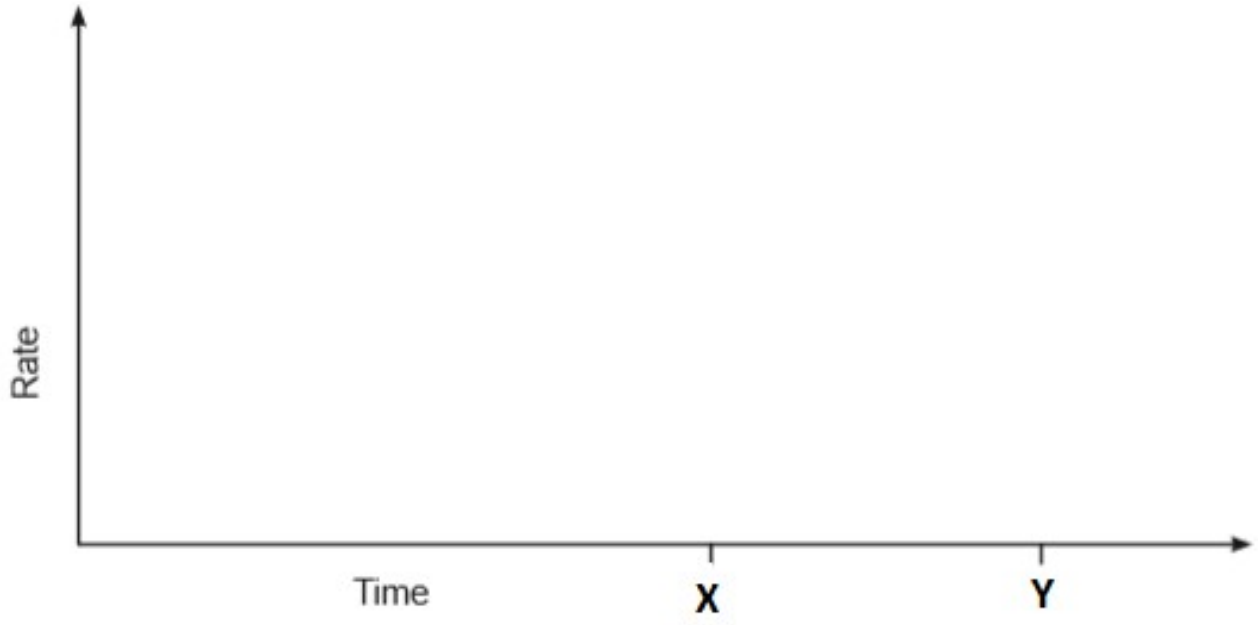
(1 mark)

Question 3: [13 marks]

$$2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g)$$

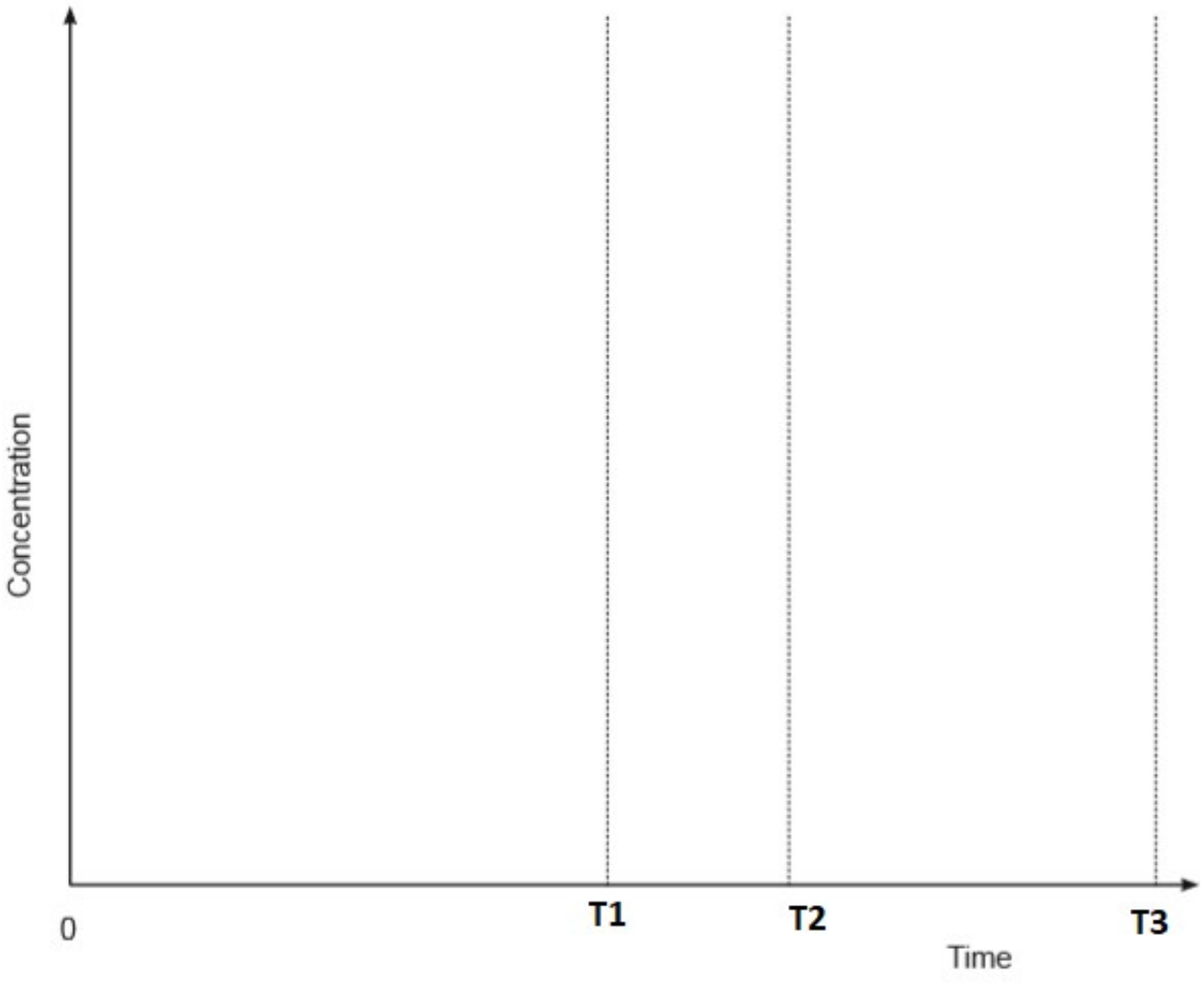
Carbon monoxide, or CO, is an odourless, colourless gas that can cause sudden illness and death. It reacts will oxygen and forms CO2 which is less harmful than CO.

a. (i) On the axes below, draw the forward (____) and reverse (- - -) reaction rates, starting at the moment the oxygen and carbon monoxide gases begin to react with each other until after equilibrium has been established at time X. Continue the graph until time . (2 marks)



(ii) On the same axes above, draw and label clearly the effect of conducting the same reaction at a lower temperature (3 marks)

b. i. On the axes below, plot separate curves to show how the concentrations of the three gases change with time, starting now the oxygen and carbon monoxide gases begin to react with each other until the system reaches equilibrium at Time T1. Continue the graph from Time T1 to Time T2.
The initial concentrations of oxygen and carbon monoxide are identical. Let's assume.
Label clearly the line for each gas. (5 marks)



ii. At Time T2 shown on the axis, the reaction vessel is halved in volume, and the system is then again allowed to reach equilibrium at Time T3. On the same graph above, show how the concentrations of the three gases would change in response to the change in volume, from Time T2 until equilibrium is re-established at Time T3. (3 marks)

Extended Answer (16 marks)

The two different coloured cobalt(II) complex ions, $Co(H_2O)_6^{2+}$ and $CoCl_4^{2-}$, exist together in equilibrium in solution in the presence of chloride ions. This is represented by the equation below.

$$Co(H_2O)_6^{2+}(aq) + 4\,Cl^-(aq) \rightleftharpoons CoCl_4^{2-}(aq) + 6\,H_2O(l)$$

pink blue

An experiment is conducted to investigate the effects on the equilibrium position by imposing a series of changes on the system. The shift in equilibrium position can be indicated by any colour change of the solution.

Colour chart	
Species	**Colour**
$Co(H_2O)_6^{2+}(aq)$	pink
$CoCl_4^{2-}(aq)$	blue
Initial equilibrium mixture	purple

After a 3.00 mL sample of an initial equilibrium mixture was placed in each of three test tubes, changes to each system were made by adding a different substance, as indicated in the table below.

Test tube	Substance added to the test tube
1	10 to 12 drops of distilled water
2	20 to 25 drops of concentrated hydrochloric acid
3	20 to 25 drops of 0.200 mol L^{-1} silver nitrate solution, $AgNO_3(aq)$

(a) Complete the table below by predicting the:

- change in concentration, if any, of each of the ions in solution compared to the initial solution, after a new equilibrium position is reached.
- colour change, if any, that takes place from the initial purple-coloured solution.

(6 marks)

Additions to the test tube	**Change in concentration from initial equilibrium to final equilibrium (increase, decrease, unchanged)**			**Colour favoured (pink, blue or unchanged)**
	$[Co(H_2O)_6^{2+}]$	**$[Cl^-]$**	**$[CoCl_4^{2-}]$**	
1. add $H_2O(\ell)$				
2. add $HCl(aq)$				
3. add $AgNO_3(aq)$				

(b) Other than a colour change, what else should be observed in test tube 3? (1 mark)

_____

(c) Using Collision Theory, explain your predicted observations when hydrochloric acid is added to test tube 2. (3 marks)

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End of Test