Chemistry 12 Equilibrium Test 2017

Total Marks____/ 52 **Student Name:** Answers

Multiple Choice Section:(10 marks, 1 mark each)

Question 1:

Consider the following equilibrium:

$$2NO_{2\,(g)} \rightleftharpoons N_2O_{4\,(g)} + \text{energy}$$

The equilibrium will shift to the left as a result of

A. adding a catalyst.
B. increasing the volume.
C. removing some N_2O_4.
D. decreasing the temperature.

Question 2:

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 3:

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 4:

Consider the following equilibrium:

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

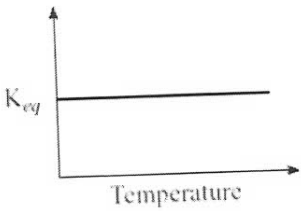
Certain conditions provide less than 10% yield of NH_3 at equilibrium. Which of the following describes this equilibrium?

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

Question 5:

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

A.



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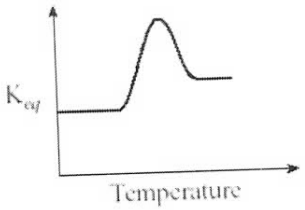

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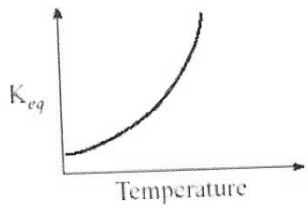
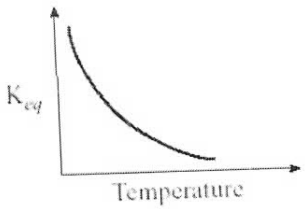


D.



Question 6:

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 7:

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

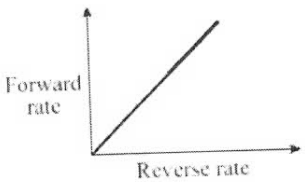
C. $K_{eq} = \dfrac{[H_2]^4}{[H_2O]^4}$

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

Question 8:

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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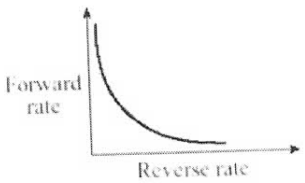

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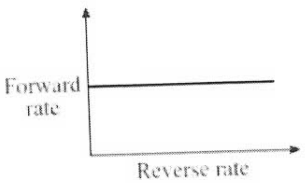

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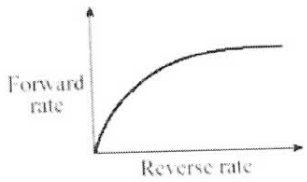


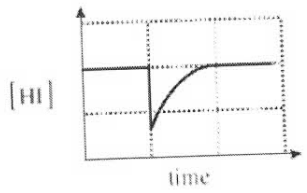
Question 9:

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.



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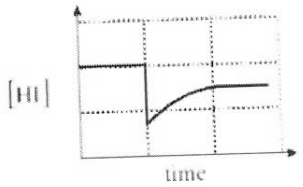

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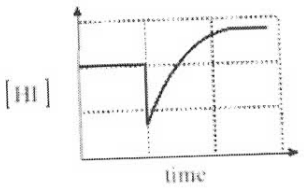
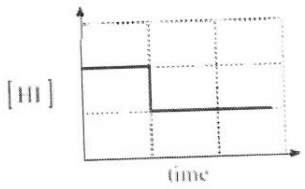


D.



Question 10:

Consider the following equilibrium:

$$\underset{\text{(pink)}}{Co(H_2O)_6{}^{2+}{}_{(aq)}} + 4Cl^- \rightleftharpoons \underset{\text{(blue)}}{CoCl_4{}^{2-}{}_{(aq)}} + 6H_2O_{(l)}$$

When the temperature is increased, the solution turns a dark blue. Based on this observation, the reaction is

A. exothermic and the K*eq* has increased.
B. exothermic and the K*eq* has decreased.
C. endothermic and the K*eq* has increased.
D. endothermic and the K*eq* has decreased.

Written Answer Section:

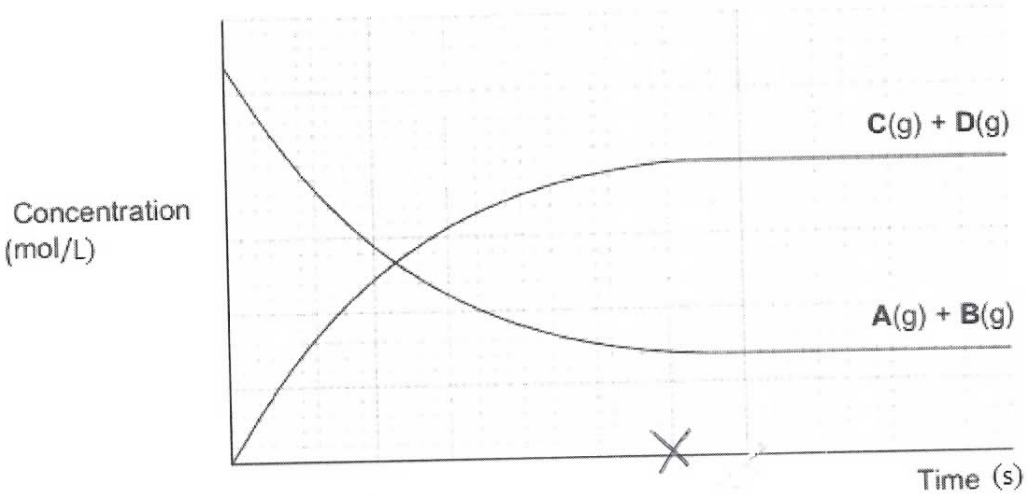
Question 1:

A dynamic equilibrium is established when gas **A** is mixed with gas **B** at a given temperature.

$$A(g) + B(g) \rightleftharpoons C(g) + D(g)$$

Figure 1 shows how the concentrations of reactants and products change with time.

Figure 1



(a) (i) On the appropriate axis of **Figure 1**, place an **X** to show the time when equilibrium is first established.

[1 mark]

(ii) State how the rate of the forward reaction and the rate of the reverse reaction are related to each other at equilibrium.

[1 mark]

At equilibrium the rates of the forward and reverse reactions are the same. (1)

(b) Explain the meaning of the words "dynamic equilibrium". Make sure to include collision theory in your explanation.

[2 marks]

The rate at which reactant particles are successfully colliding to form products (1) is the same as the rate at which product particles are successfully colliding to form reactants. (1)

(c) The total pressure on the system is increased at constant temperature.

(i) State and explain the effect, if any, of this change on the position of this equilibrium.

[2 marks]

Effect No change (1)

Explanation As the balanced equation shows 2 moles of gas in both the reactants and the products, the position of the equilibrium has not changed/ there is the same number of collisions for reactants and products. (1)

(ii) State and explain the effect, if any, of this change on the time taken to reach this equilibrium.

[2 marks]

Effect Equilibrium will be reached quicker. (1)

Explanation An increase in pressure increases the number of collisions between particles, which increases the rates of both the forward and reverse reactions. (1)

Question 2:

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

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

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]**

$K_{eq} = \dfrac{[R]^2}{[P][Q]^2}$ (1)

$[P] = \dfrac{3.82}{2.2} = 1.7364 \text{ mol L}^{-1}$ (½)

$[R] = \dfrac{5.24}{2.2} = 2.3818 \text{ mol L}^{-1}$ (½)

$[Q] = \sqrt{\dfrac{[R]^2}{K_{eq}[P]}}$

$= \sqrt{\dfrac{2.3818^2}{68.0 \times 1.7364}}$

$= 0.20 \text{ mol L}^{-1}$ (1)

$n(Q) = 0.2 \times 2.2$

$= 0.44 \text{ mol}$ (1)

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

Increased

(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.

Increased

(1 mark)

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

Decreased

(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.

No change

(1 mark)

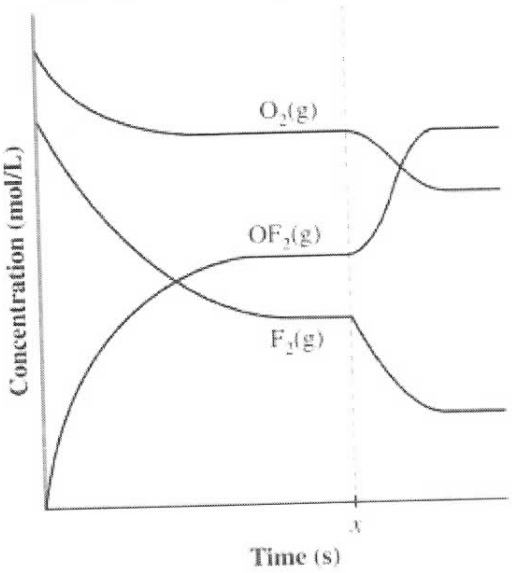
Question 3:

A technician injected fluorine gas and oxygen gas into an empty 1.0 L reaction vessel. She closed the vessel and allowed the reaction to reach equilibrium, as represented by the following equation.

$$2F_2(g) + O_2(g) + 46.0\,kJ \rightleftharpoons 2OF_2(g)$$

The technician changed the reaction conditions and allowed a new equilibrium to be established as represented by the graph below.

Changes to the Equilibrium System



a) What stress occurred to the system to result in the shifts in concentration observed above? **[1 mark]**

An increase (½) in temperature. (½)

b) Describe at a molecular level, using collision theory, how this stress is causing the shifts in concentration of the reactants and products displayed in the diagram above. **[3 marks]**

The increase in temperature is causing all particles to move faster, resulting in more collisions, (1) and also more particles with the activation energy, therefore increasing the rate of both the forward and reverse reactions. (1)

However, the rate of the forward reaction increases before the rate of the reverse reaction increases, thus shifting to the right/towards products OR increased temperature enables more reactants to reach Ea thus shifting equilibrium to the right. (1)

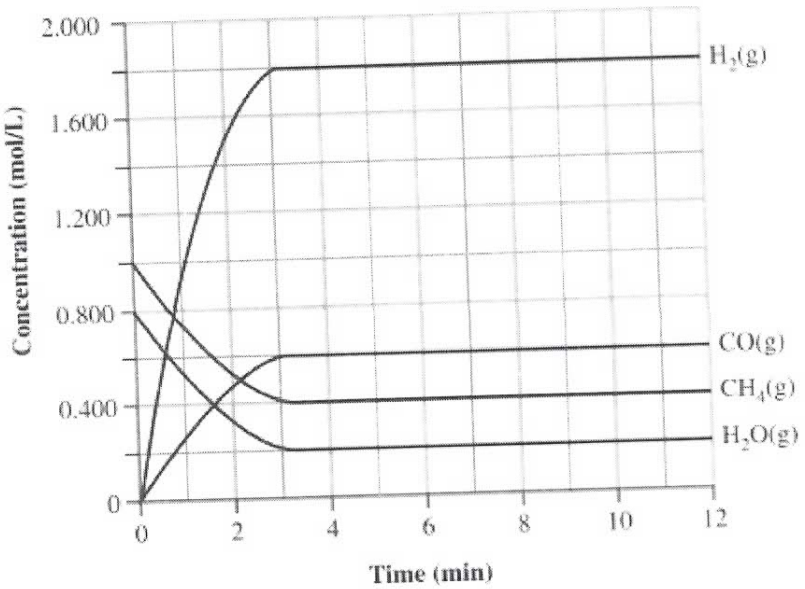
Question 4:

A technician is producing hydrogen gas. He adds methane gas, steam, and a nickel catalyst to an empty reaction container and allows the system to reach equilibrium. The reaction is represented by the following equation.

$$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$$

The technician's data are represented by the following graph.

Production of Hydrogen at 500 °C



a) Use the information on the diagram above to calculate the Keq value for this reaction. **[2 marks]**

$$K_{eq} = \frac{[H_2]^2[CO]}{[CH_4][H_2O]} = \frac{1.8^2 \times 0.6}{0.4 \times 0.2}$$

$$= 43.74$$

b) If the concentration of only the carbon monoxide gas in the container was suddenly increase state whether this would increase, decrease or not affect the following things. Also provide a brief explanation using Le Chatelier's Principle to explain your answer. **[4 marks]**

i. The concentration of hydrogen gas

Decrease. According to Le Chatelier's Principle the equilibrium will shift to the left to counter the increase in [CO].

ii. The value of Keq

The value of Keq will not change. Only a temperature change will change Keq.

Question 5:

In solution, pale yellow-coloured $Fe^{3+}(aq)$ and colourless $SCN^-(aq)$ form an equilibrium with red $FeSCN^{2+}(aq)$.

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons FeSCN^{2+}(aq) \qquad \Delta H \text{ is negative}$$

a. A student investigates this reaction using separate samples of an equilibrium mixture in which significant quantities of Fe^{3+}, SCN^- and $FeSCN^{2+}$ are present. In each case, changes are made as indicated in the table below. **[3 marks]**

Complete the table by ticking in the appropriate boxes to indicate the effect of each change on

i. the intensity of the red colour of the solution

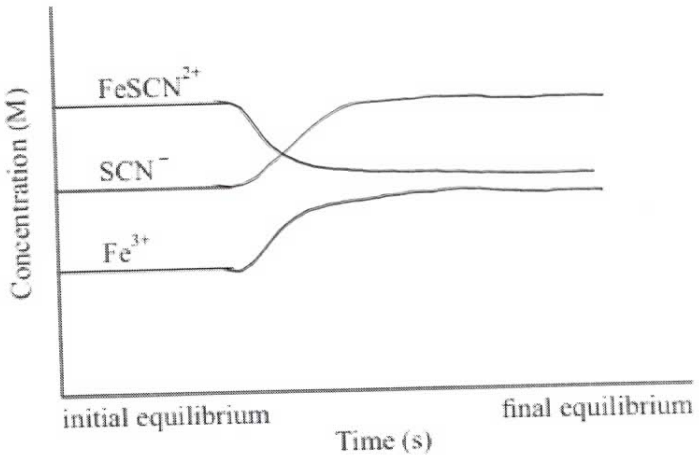
ii. the concentration of $Fe^{3+}(aq)$

once the new equilibrium has been established.

Change to the equilibrium	**i.** Colour at new equilibrium compared with initial equilibrium		**ii.** $[Fe^{3+}]$ at new equilibrium compared with initial equilibrium	
	less red	more red	decreased	increased
Sample 1: 1 drop of a concentrated solution of $Ag^+(aq)$ is added, which forms a AgSCN precipitate	✓			✓
Sample 2: 1 drop of a concentrated solution of $Fe^{3+}(aq)$ is added		✓		✓
Sample 3: 1 drop of a concentrated solution of $HPO_4^{2-}(aq)$ is added, which forms colourless $FeHPO_4^+(aq)$	✓		✓	

(½ each; 3 marks total)

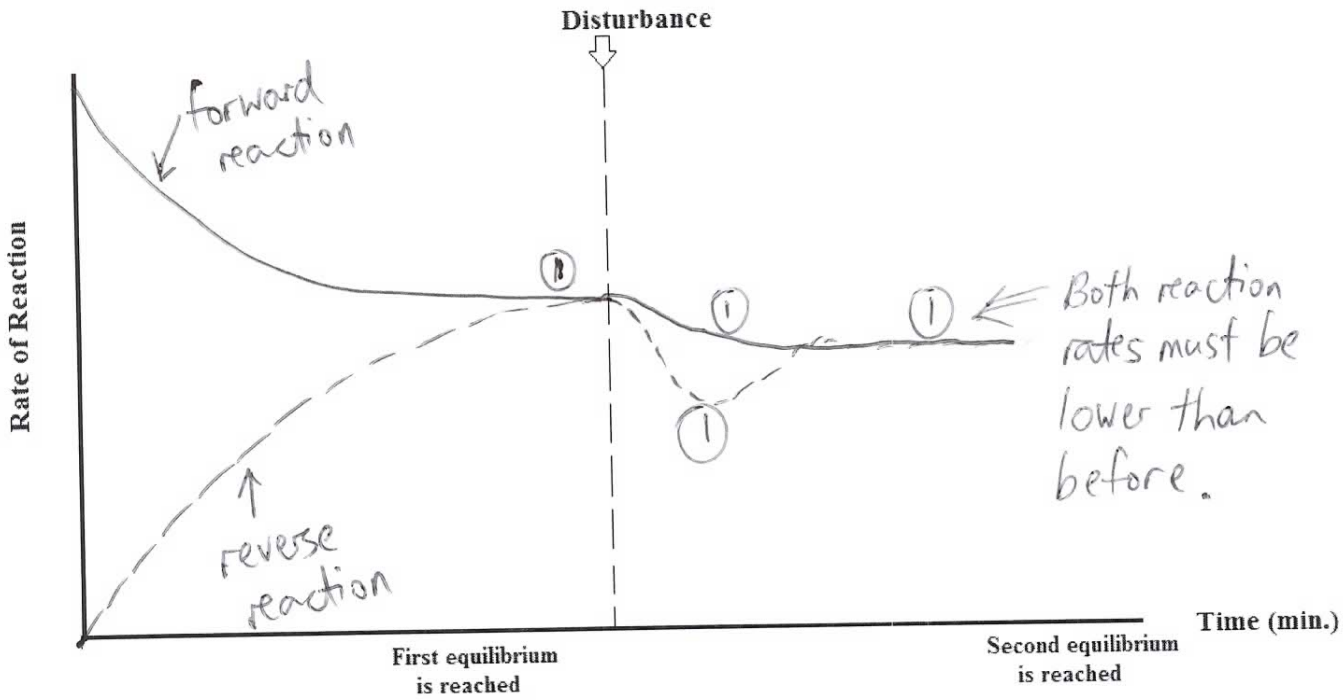
b. The graph below represents the initial concentration of the ions at equilibrium. Sketch the changes that would be expected to occur to these concentrations if the temperature of the equilibrium mixture was increased to a new, constant value. **[3 marks]**



Direction of change correct and then becoming constant = 1 mark each

c. If equal amounts of aqueous Fe^{3+} and SCN^- are placed in a flask and allowed to reach equilibrium then are subjected to a **temperature decrease** draw the rate of reaction versus time graph for this situation. Start the graph where you only have reactants and finish the graph so that you once again have reached equilibrium after the disturbance.

Note: Make sure to label the forward and reverse reactions on the graph below. Use a solid line for the **forward** reaction and a dashed line for the **reverse** reaction. **[4 marks]**

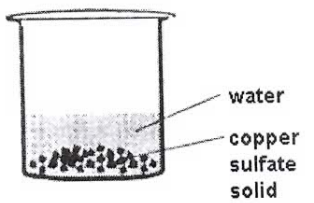


Question 6:

Consider the system shown in the diagram, where a solute solution equilibrium has been established in a beaker. Briefly explain the following:

a) State two ways by which the equilibrium could be altered. [2 marks]

Change in temperature. (1)
Change copper sulfate concentration / add or remove water. (1)



Question 7:

The equilibrium between $Mg(OH)_2$ and its ions in aqueous solution can be represented by the following equation: [4 marks]

$$Mg(OH)_2(s) \quad <==> \quad Mg^{2+}(aq) + 2OH^-(aq)$$

White colourless solution

At equilibrium, the white solid is present in a colourless solution.
two test tubes are set up, each containing the equilibrium mixture. Each of the test tubes is treated as described below. In each case state what will be observed, how the equilibrium will shift and what happens to the concentrations of the ions asked about.

What is done?	What is observed?	How the equilibrium shifts? Write '→','←' or 'no change'	What happens to the concentration of Mg^{2+}. Write increase, decrease or no change	What happens to the concentration of OH^-. Write increase, decrease or no change
A little water is added to the first test tube	The amount of white solid decreases	→	Increase	Increase
A few drops of 1.0 $molL^{-1}$ hydrochloric acid solution are applied to the second test tube	The amount of white solid decreases	→	Increase	Decrease