

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



# CHEMISTRY 2021

## Unit 3

### Key Topic Test 6 – Equilibrium Systems

Recommended writing time\*: 45 minutes

Total number of marks available: 50 marks

## QUESTION BOOK

\* The recommended writing time is a guide to the time students should take to complete this test. Teachers may wish to alter this time and can do so at their own discretion.

**Conditions and restrictions**

- Students are permitted to bring into the room for this test: scientific calculator, pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the room for this test: blank sheets of paper and/or white out liquid/tape.

**Materials supplied**

- Question and answer book of 11 pages.

**Instructions**

- Print your name in the space provided on the top of the front page.
- All written responses must be in English.

**Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication devices into the room for this test.**

**SECTION A – Multiple-choice questions****Instructions for Section A**

Answer **all** questions.

Choose the response that is **correct** for the question.

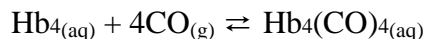
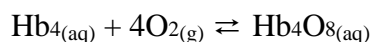
A correct answer scores 1, an incorrect answer scores 0.

Marks are **not** deducted for incorrect answers.

If more than one answer is completed for any question, no mark will be given.

**Question 1**

Haemoglobin (Hb) reacts with oxygen to form oxyhaemoglobin and will also react with carbon monoxide to form carboxyhaemoglobin.

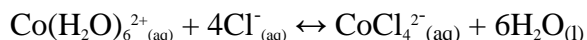


Carbon monoxide poisoning occurs because;

- A.  $K_c$  for the reaction between Hb and oxygen is about 20 000 times  $K_c$  for the reaction between Hb and CO
- B. The equilibrium between Hb and CO lies further to the right than the equilibrium between Hb and  $\text{O}_2$
- C. CO can bond to Hb just as easily as  $\text{O}_2$  can bond to Hb
- D.  $\text{Hb}_4(\text{CO})_4$  is much more soluble in blood plasma than  $\text{Hb}_4\text{O}_8$

**Question 2**

For the chemical reaction



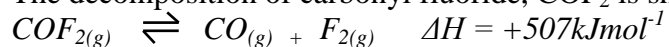
$\text{Co}(\text{H}_2\text{O})_6$  is pink while  $\text{CoCl}_4^{2-}$  is blue.

When the solution is heated the reaction, mixture turns blue. It can be concluded that;

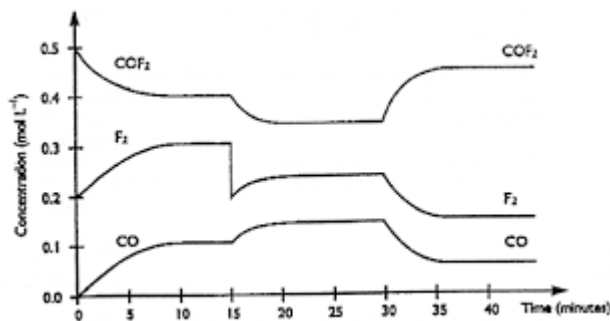
- A. The reaction is exothermic and  $K$  increases
- B. The reaction is endothermic and  $K$  decreases
- C. The reaction is exothermic and  $K$  stays the same
- D. The reaction is endothermic and  $K$  increases

The following TWO questions refer to the information below;

The decomposition of carbonyl fluoride,  $\text{COF}_2$  is shown by the equation below:



The graph below represents the concentration of each species under a range of conditions.



### Question 3

The change in the graph at  $t = 15$  minutes and  $t = 30$  minutes is due to;

- A. A decrease in pressure and the addition of  $\text{COF}_2$
- B. An increase in temperature and the addition of  $\text{COF}_2$
- C. The removal of  $\text{F}_2$  and a decrease in temperature
- D. The removal of  $\text{F}_2$  and an increase in temperature

### Question 4

The system first reached equilibrium at approximately  $t =$

- A. 0 seconds
- B. 10 seconds
- C. 15 seconds
- D. 20 seconds

### Question 5

The preparation of sulphur trioxide from sulphur dioxide and oxygen is shown by the equation below:

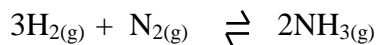


To maximize the yield of  $\text{SO}_3$ , the reaction conditions chosen should be;

- A.  $100^\circ\text{C}$ , 1 atm pressure
- B.  $100^\circ\text{C}$ , 200 atm pressure
- C.  $800^\circ\text{C}$ , 200 atm pressure
- D.  $800^\circ\text{C}$ , 1 atm pressure

**Question 6**

Ammonia is produced by the reaction of H<sub>2</sub> with N<sub>2</sub> according to;



Heat is released during the reaction. The equilibrium can be shifted towards the right by;

- A. The addition of a catalyst
- B. Decreasing the temperature
- C. The addition of an inert gas such as Argon
- D. Decreasing the pressure

*The following information refers to the next 2 questions.*

The reaction  $\text{PCl}_{3(\text{g})} + \text{Cl}_{2(\text{g})} \rightleftharpoons \text{PCl}_{5(\text{g})}$  is exothermic.

**Question 7**

An extra amount of Cl<sub>2</sub> is added to the mixture without changing the pressure or temperature. As a result;

- A. The value of K<sub>c</sub> will increase
- B. The concentration of PCl<sub>3</sub> will increase
- C. The equilibrium will shift to the left
- D. The rate of reaction will increase

**Question 8**

Neon is added to the mixture without changing the volume or temperature. The total pressure in the container is increased. As a result;

- A. The rate of reaction will increase
- B. The concentration of PCl<sub>5</sub> will decrease
- C. The equilibrium will shift to the right
- D. There will be no change in equilibrium position

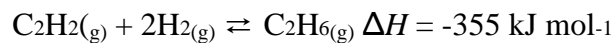
**Question 9**

The reaction  $\text{CaCO}_{3(\text{s})} \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_{2(\text{g})}$  occurs when you heat limestone. The reaction is endothermic. To shift the equilibrium to the right, you could;

- A. Carry out the reaction in a well ventilated environment
- B. Increase the pressure
- C. Reduce the temperature
- D. Grind up the limestone into a fine powder

**Question 10**

The equation for the reaction between ethyne and hydrogen is



At 150°C, the value of  $K$  is  $248 \text{ M}^{-2}$

A sample of  $\text{C}_2\text{H}_6$  is added to an empty reactor.

When the mixture comes to equilibrium at 150°C.

- A. The concentration of  $\text{C}_2\text{H}_2$  is more than the concentration of  $\text{C}_2\text{H}_6$
- B. The concentration of  $\text{C}_2\text{H}_2$  is equal to the concentration of  $\text{H}_2$
- C. The concentration of  $\text{C}_2\text{H}_2$  is equal to the concentration of  $\text{C}_2\text{H}_6$
- D. The concentration of  $\text{C}_2\text{H}_2$  is half the concentration of  $\text{H}_2$

**SECTION B - Short-answer questions****Instructions for Section B**

Questions must be answered in the spaces provided in this book.

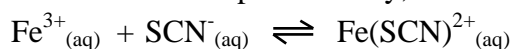
To obtain full marks for your responses you should

- Give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- Show all workings in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.

Make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example,  $\text{H}_2(\text{g})$ ;  $\text{NaCl}(\text{s})$

**Question 1**

When  $\text{Fe}^{3+}$  ions are mixed with  $\text{SCN}^-$  ions,  $\text{Fe}(\text{SCN})^{2+}$ , which is red in colour, is formed. The reaction can be represented by;



The forward reaction is endothermic

**a.** Complete the following table.

| Action taken                      | Equilibrium shift<br>(left or right) | Effect on reaction<br>rate (increase or<br>decrease) | Effect on the value of<br>K (increase, no<br>change or decrease) |
|-----------------------------------|--------------------------------------|------------------------------------------------------|------------------------------------------------------------------|
| Increase in<br>temperature        |                                      |                                                      |                                                                  |
| Addition of $\text{Fe}^{3+}$ ions |                                      |                                                      |                                                                  |
| Removal of $\text{SCN}^-$<br>ions |                                      |                                                      |                                                                  |
| Addition of water                 |                                      |                                                      |                                                                  |

12 marks

- b. The equilibrium constant for the reaction is  $138.0 \text{ M}^{-1}$  at  $25^\circ\text{C}$ . If the concentration of  $\text{Fe}(\text{SCN})^{2+}$  is  $1.00\text{M}$ , determine the concentration of  $\text{Fe}^{3+}$ .

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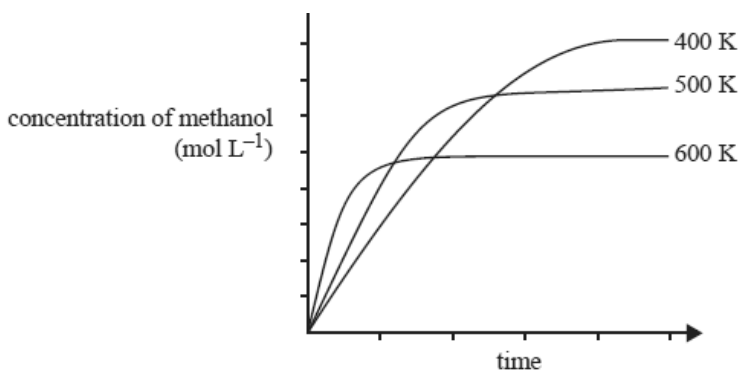
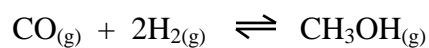
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3 marks

Total 15 marks

**Question 2**

The graph below shows the production of methanol from carbon monoxide and hydrogen according to;



- a. As the temperature is increased, what happens to the;
- i. Rate of formation of methanol

ii. Equilibrium yield of methanol.

1 + 1 = 2 marks

- b. Is the reaction exothermic or endothermic?

1 mark



- c. The volume of the container is reduced, increasing the pressure. By referring to Le Chatelier's Principle, explain what would happen to the yield of methanol.

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2 marks

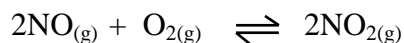
- d. A catalyst is added to the reaction mixture, redraw the line for the 400K reaction mixture on the above graph to show the effect of the catalyst.

1 mark

Total 6 marks

### Question 3

In the production of nitric acid, a key step in the process involves the conversion of NO to NO<sub>2</sub> as shown below;



Heat is released during the reaction.

- a. Describe how the rate and yield of NO<sub>2</sub> is affected by temperature and pressure.

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4 marks

- b. Discuss a compromise that might need to be made when determining both the temperature and pressure of the reaction.

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2 marks

- c. A catalyst can be used to speed up the reaction. Would you most likely choose a heterogeneous catalyst or homogeneous catalyst? Why?

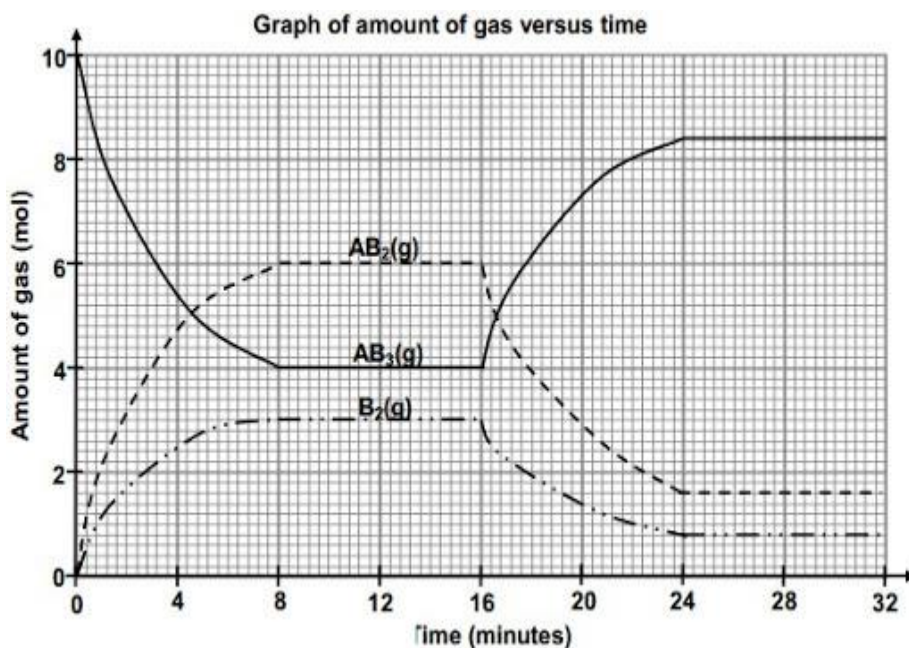
1 mark

Total 7 marks

**Question 4**

$AB_3$  decomposes into  $AB_2$  and  $B_2$

The equation for the reaction is;  $2AB_{3(g)} \rightleftharpoons 2AB_{2(g)} + B_{2(g)}$   $\Delta H = \text{positive}$



- a. At what times is the system at equilibrium?

1 mark

- b. What change occurs at the 16 minute mark?

1 mark

- c. Write an expression for the equilibrium constant.

1 mark

- d. If the container is 1.0 litre in size, calculate the value of  $K_c$  at the 28 minute mark.

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2 marks

- e. If 2.0 mol of  $AB_3$  is removed at the 32 minute mark,

- i. How will the equilibrium constant change?

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- ii. Will the concentration of  $B_2$  increase or decrease?

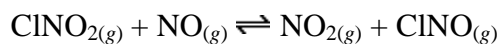
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2 marks

Total 7 marks

### Question 5

For the reaction



- a. When 3.5mol of  $ClNO_2$  is mixed with 1.5mol of  $NO$ , 0.20 mol of  $NO_2$  is formed. Determine the value of  $K_c$ .

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4 marks

- b. If the concentration of all species is doubled, which way would the equilibrium shift?

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1 mark

Total 5 marks

**END OF KEY TOPIC TEST**