



Christ Church
Grammar School

Year 12 Chemistry

Equilibrium Test 2018

Time allowed: 45 minutes

Name: Solutions.

Mark =/43

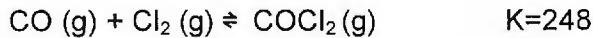
SECTION 1

MULTIPLE CHOICE

(10 marks)

The next two questions refer to the following information.

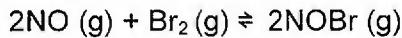
CO and Cl₂ gases are mixed in a flask and they reach equilibrium according to the following equation. K = 248.



1. When equilibrium is reached which of the statements below is correct?
 - A. The reaction has reached completion; no more products or reactants are being formed.
 - B. The concentration of CO and COCl₂ are equal.
 - C. The rates of both the forward and reverse reactions are equal.
 - D. There is 248 times more COCl₂ (g) than CO (g).

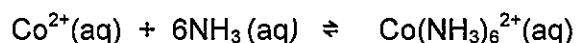
2. For the above system at equilibrium, the volume of the system is halved. Once equilibrium is established, which one of the following statements is true about the system?
 - A. K has increased
 - B. K has increased and both the mass and concentration of Cl₂ have decreased.
 - C. The mass and concentration of Cl₂ have decreased.
 - D. The mass and concentration of COCl₂ have increased.

3. Which of the following expressions for K is correct for the reaction?



- A. $K = \frac{[\text{NOBr}]^2}{[\text{NO}]^2[\text{Br}_2]}$
- B. $K = \frac{[\text{NO}]^2[\text{Br}_2]}{[\text{NOBr}]^2}$
- C. $K = \frac{[\text{NOBr}]^2}{[\text{NO}]^2 + [\text{Br}_2]}$
- D. $K = \frac{2[\text{NO}][\text{Br}_2]}{2[\text{NOBr}]}$

4. Consider the following system at equilibrium:

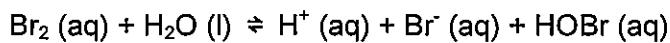


If $\text{CoCl}_2(\text{s})$ is added and equilibrium is allowed to re-establish, how will the concentration of all species compare to their original concentrations?

	$[\text{Co}^{2+}](\text{aq})$	$[\text{NH}_3](\text{aq})$	$[\text{Co}(\text{NH}_3)_6]^{2+}(\text{aq})$
A.	same	lower	higher
B.	higher	lower	higher
C.	higher	higher	lower
D.	lower	lower	higher

The next two questions refer to the following information.

Bromine dissolves in water according to the following equilibrium equation:



Red

colourless

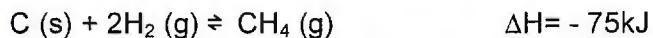
5. What observation would you expect if a few drops of concentrated acid such as hydrochloric acid was added to the system at equilibrium?

- A. no observable change.
- B. solution would become colourless.
- C. solution would become more red.
- D. solution would fade to become less red.

6. Which one of the following would NOT cause the equilibrium position to shift to the right?

- A. Addition of $\text{NaBr}(\text{aq})$
- B. Adding concentrated $\text{NaOH}(\text{aq})$
- C. Adding $\text{Br}_2(\text{aq})$
- D. Adding $\text{H}_2\text{O}(\text{l})$

7. The reaction below shows carbon and hydrogen reacting to form methane.



If the reaction has reached equilibrium, how could you increase the yield of methane?

- A. Decrease the temperature
- B. Increase the volume
- C. Add a suitable catalyst
- D. Both (a) and (c) above

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



Now consider the following actions:

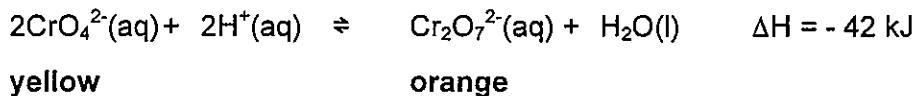
- I Add more $CO_2(g)$ to the system
- II Add more $CaCO_3(s)$ to the system
- III Decrease the volume of the system
- IV Increase the temperature of the system

Which of these leads to a change in $CO_2(g)$ concentration (after equilibrium is re-established).

- A. All of them
- B. Only II, III and IV
- C. Only III and IV
- D. Only IV

The next two questions refer to the following information.

When dilute hydrochloric acid is added to a solution of potassium chromate, a solution of potassium dichromate is produced and the following equilibrium is established.



9. Which one of the following would NOT favour the rate of the forward reaction over the reverse?

 - A. Addition of more potassium chromate.
 - B. Increasing the concentration of hydrochloric acid.
 - C. Decreasing the temperature of the solution.
 - D. Addition of water.

10. What would you expect to happen to the colour of this solution if temperature was increased?

 - A. The solution would become more intensely orange due to the forward reaction being favoured more than the reverse.
 - B. The solution would become yellow due to the reverse reaction being favoured more than the forward.
 - C. The solution would remain orange due to the fact that no change is being made to a specific species in the reaction.
 - D. The solution would become colourless due to the forward reaction producing more water molecules.

SECTION 2 SHORT ANSWERS

Question 11

1 mark

Write the equilibrium expression for the following reaction

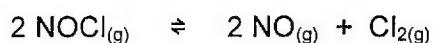


$$K = \frac{1}{[\text{Ag}^+][\text{Cl}^-]}$$

Question 12

3 marks

The decomposition of nitrosyl chloride (NOCl) is represented by the equation:



At 230°C , $K = 4.52 \times 10^{-3}$. At 465°C , $K = 9.29 \times 10^{-2}$

- (a) Is the forward reaction endothermic or exothermic?

.....
Endothermic

(1 mark)

- (b) Explain your answer in (a).

As temperature increases, K is increasing.

.....
° Endothermic reaction favoured according
to LCP, the system will respond to
oppose the increase in temperature

(2 marks)

Question 13

14 marks

The reaction of the bromate ion with chromium (III) ion is in equilibrium with the bromide ion and the dichromate ion according to the following equation;



- (a) Complete the table with increase, decrease or no change for the following changes once equilibrium has been re-established. (9 marks)

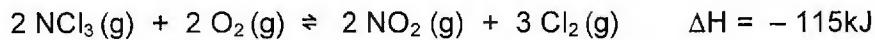
Change made	Rate of forward reaction	Effect on $[\text{Cr}_2\text{O}_7^{2-}]$ (increase, decrease or no change)	Effect on $[\text{Cr}^{3+}]$ (increase, decrease or no change)
A few drops of concentrated NaOH (aq) is added	Decreases	Increases	Decreases
Adding $\text{Cr}(\text{NO}_3)_3$ (s)	Increases	Increases	Increases
Increasing the volume by adding water	Decreases	Decreases	Decreases

- (b) Using Collision Theory, explain the effect on the $[\text{Cr}_2\text{O}_7^{2-}]$ when concentrated NaOH (aq) is added. (5 marks)

- $[\text{H}^+]$ decreases due to neutralisation
- Forward rate unaffected initially
- Reverse rate decreases due to decreased frequency of collisions.
- $[\text{Cr}_2\text{O}_7^{2-}]$ is produced faster than it is consumed.
- So concentration will increase over time.

Question 14**6 marks**

Two colourless gases, nitrogen trichloride and oxygen, react to produce brown nitrogen dioxide gas and green-yellow chlorine gas according to the following equation:

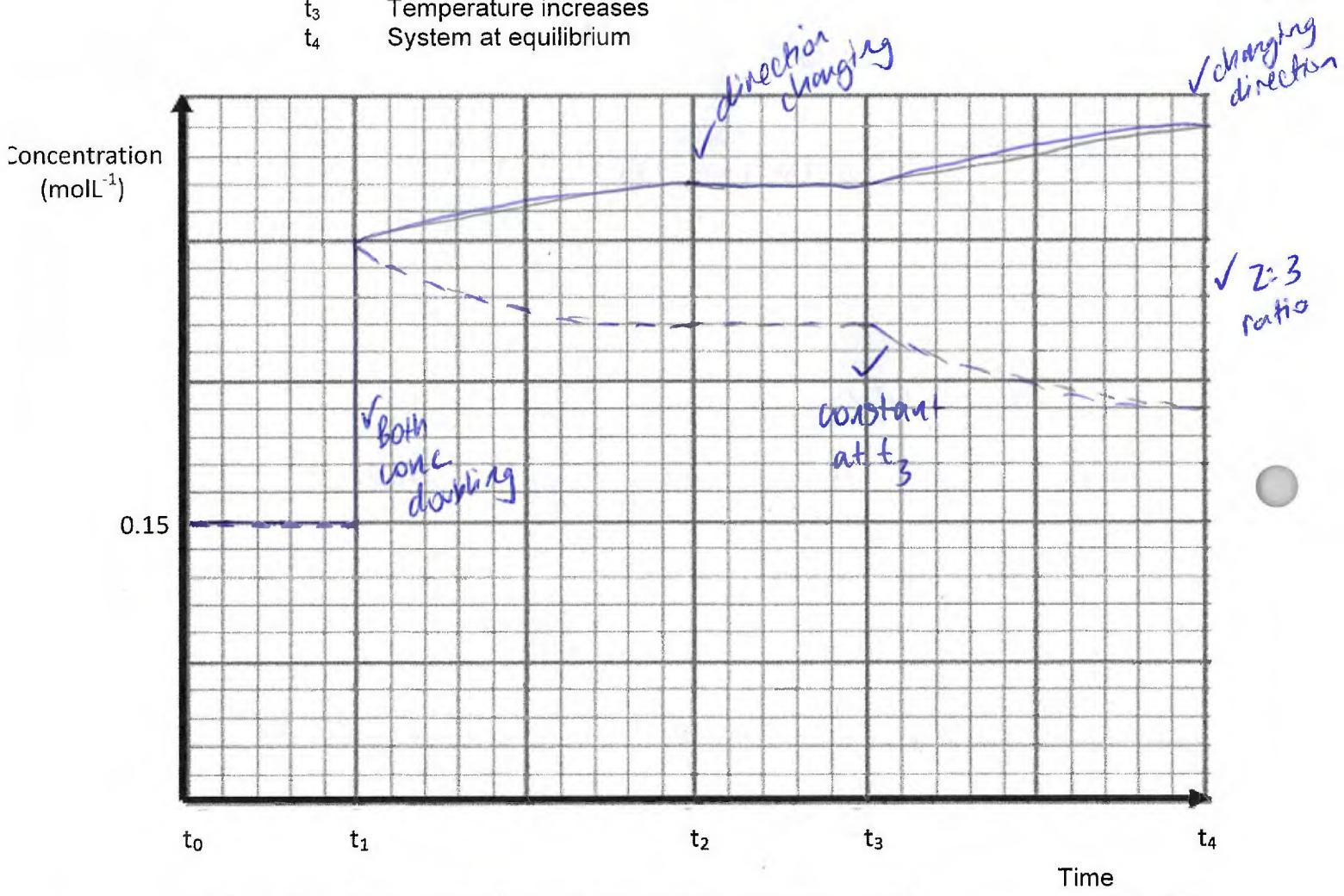


At 25°C the equilibrium mixture of these gases is a pale brown colour and the concentration of nitrogen trichloride and chlorine is 0.15 mol L⁻¹.

- (a) On the axes below, sketch a graph that depicts the change in concentration of NCl_3 and of Cl_2 as a result of the following changes in conditions of the equilibrium system. Use (—) for $[\text{NCl}_3]$ and (---) for $[\text{Cl}_2]$.

(5 marks)

- t_0 System at equilibrium
- t_1 Volume halved
- t_2 System at equilibrium
- t_3 Temperature increases
- t_4 System at equilibrium



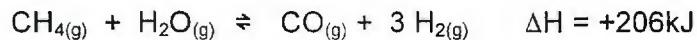
- (b) Describe what you would expect to observe between T_3 and T_4 .

(1 mark)

Colour fades

Question 15**9 marks**

Hydrogen gas for use in the Haber Process can be produced by the steam reforming reaction of methane and water, according to the following equation:



The usual conditions for this reaction are a temperature of 750°C and a moderate pressure in the presence of a nickel catalyst.

Explain why these conditions are chosen for the steam reforming considering rate of reaction, yield and cost of operation.

Rate.....^(750°C).....

- High temperature favours high rate due to increased frequency of collision
- Due to increased proportion of collision with energy greater than activation energy.
- High pressure favoured due to increased frequency of collisions

Yield.....^(750°C).....

- High temperature favours H_2 production as forward is endothermic.
- Low pressure favours H_2 production as more molar of gas products so forward reaction favoured.

Catalyst

- Nickel catalyst used as it lowers the activation energy
- Greater proportion of collisions have energy greater than activation energy so rate increases
- 750°C used and moderate pressure to balance rate and yield and catalyst
- used to lower running costs as it is recovered and not 'used up'.

END OF TEST