Student Number: _____

NORTH SYDNEY GIRLS HIGH SCHOOL

2018

HSC

Assessment Task 1

Chemistry

General Instructions

- Reading Time – 5 minutes
- Working Time – 50 min
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- **Write your student number at the top of this booklet**
- **Write your answers in the space provided.**

Total Marks – 30

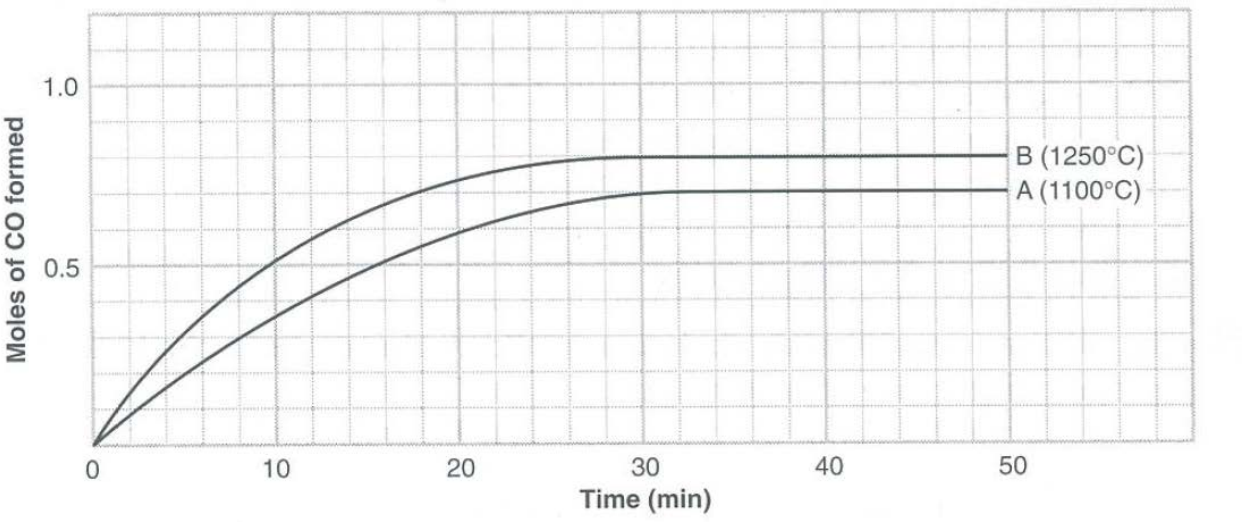
Weighting – 15 %

Question 1 (4 marks)

A common method of preparing hydrogen for industrial purposes is to heat methane and steam with a catalyst at high temperature. The reaction is

$$CH_{4\,(g)} + H_2O_{\,(g)} \rightleftharpoons 3H_{2\,(g)} + CO_{\,(g)} \qquad \Delta H = +206 \text{ kJ/mol}$$

When 1 mole of methane was reacted with excess steam at 1100°C in a vessel of fixed volume, curve A in the following diagram was obtained. When the experiment was repeated at 1250°C, curve B was obtained.



(a) For this reaction, explain why the amount of carbon monoxide remains constant between 30 and 50 minutes. **2**

(b) Explain why a larger amount of carbon monoxide is produced at 1250°C (curve B) than at 1100°C (curve A). **2**

Question 2 (2 marks)

Compare and contrast open and closed systems. **2**

Question 3 (2 marks)

A team of chemists was investigating the following equilibrium reaction.

$$H_{2\,(g)} + I_{2\,(g)} \rightleftharpoons 2HI_{\,(g)} \quad \Delta H \text{ is negative.}$$

Hydrogen gas, H_2, and iodine gas, I_2, were injected into a sealed container and the mixture was allowed to reach equilibrium.

(a) Circle which of the following K_{eq} values indicates the highest concentration of $HI_{\,(g)}$. **1**

0.98 8 64 102

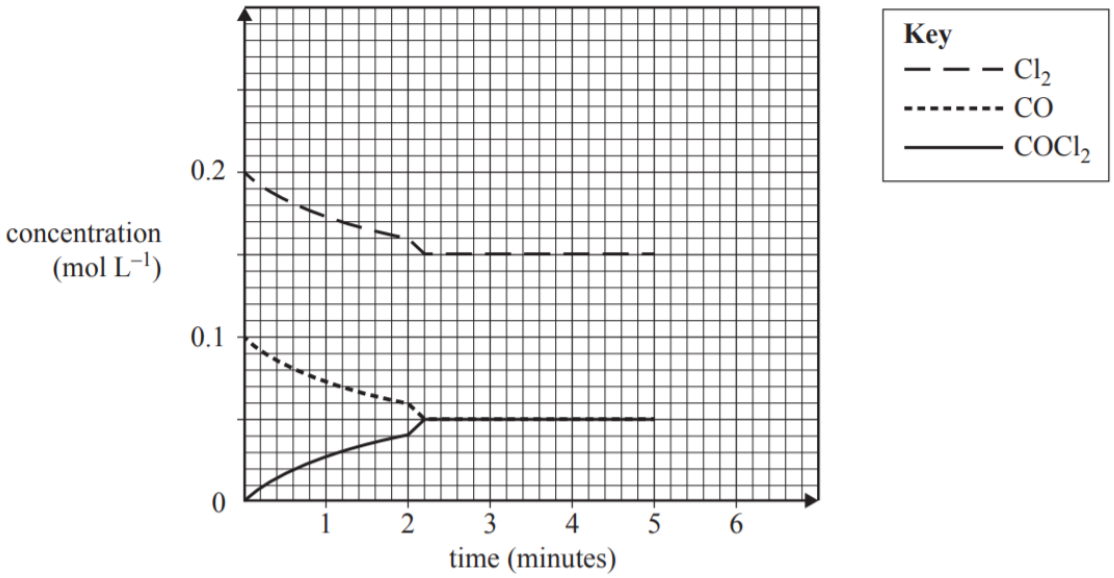
(b) Justify your answer. **1**

Question 4 (5 marks)

A chemist injected 0.10 mol carbon monoxide gas, CO, and 0.20 mol chlorine gas, Cl_2, into a previously evacuated and sealed 1.0 L flask. At that instant, the following reaction began to occur.

$$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)} \qquad \Delta H = -108 \text{ kJ/mol}$$

The concentrations of the three species present in the flask were monitored over time. The flask was held at a constant temperature. The following concentration–time graph was obtained.



(a) Identify the time at which this system reached equilibrium. **1**

(b) Calculate the equilibrium constant for this reaction at this temperature. **2**

(c) At time = 5 minutes, the volume of the equilibrium system was decreased. Explain what would happen to the concentration of the reactants and product. **2**

Question 5 (4 marks)

Consider the following redox equilibrium reaction:

$$PCl_{3\,(g)} + Cl_{2\,(g)} \rightleftharpoons PCl_{5\,(g)}$$

Phosphorus trichloride (0.8 mol) and chlorine (0.6 mol) were added to a 2L flask and allowed to reach equilibrium, at which time the concentration of PCl_5 was 0.1 mol/L.

(a) Identify the reaction condition which changes the value of K for an equilibrium system. **1**

(b) Calculate the equilibrium constant for this reaction. **3**

Question 6 (3 marks)

Sulfur trioxide, SO_3, is made by the reaction of sulfur dioxide, SO_2, and oxygen, O_2, in the presence of a catalyst, according to the equation below.

$$2SO_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2SO_{3\,(g)} \qquad \Delta H < 0$$

In a closed system in the presence of the catalyst, the reaction quickly achieves equilibrium at 1000 K.

A mixture of 2.00 mol of $SO_{2\,(g)}$ and 2.00 mol of $O_{2\,(g)}$ was placed in a 4.00 L evacuated, sealed vessel and kept at 1000 K until equilibrium was reached. At equilibrium, the vessel was found to contain 1.66 mol of $SO_{3\,(g)}$.

Calculate the equilibrium constant, K_{eq}, at 1000 K. **3**

Question 7 (4 marks)

Bromomethane, CH_3Br, is a toxic, odourless and colourless gas. It is used by quarantine authorities to kill insect pests. A simplified reaction for its synthesis is

$$CH_3OH_{(g)} + HBr_{(g)} \rightleftharpoons CH_3Br_{(g)} + H_2O_{(g)} \qquad \Delta H = -37.2 \text{ kJ/mol at 298 K}$$

With reference to **collision** theory, explain the effect of each change on the rate of production of bromomethane and the position of equilibrium.

- Increasing pressure (constant temperature) **2**

- Continuously removing the product CH_3Br (constant volume and temperature) **2**

Question 8 (6 marks)

When solid calcium sulfate is shaken with water, a dynamic equilibrium is established.

(a) Write a balanced chemical equation to represent this equilibrium. **1**

(b) If equal volumes of 1.0×10^{-3} mol/L solutions of calcium nitrate and sodium sulfate were mixed, would you expect a precipitate to form? Justify your answer. **3**
K_{sp} for calcium sulfate is 9×10^{-6}.

(c) Describe the process in which the calcium sulfate will undergo dissolution. **2**

END OF TEST