## *Year 12 Rates & Extent of Chemical Reactions Topic Test*

**Question 1**

The collisions theory explains that chemical reactions occur when particles (atoms or molecules) collide with enough energy and the correct orientation to break and form bonds. Not all collisions lead to reactions, only those that meet these conditions are considered *effective collisions.*

Explain the difference between the frequency and the success of the reactant particle collisions and what determines each. **4 marks**

**Question 2**

An increase in temperature is a factor that can increase the rate of a reaction. Describe why this is the case. **2 marks**

**Question 3**

Catalysts are substances widely used to optimise chemical reactions by being cost effective and sustainable. In practice they are not consumed as reactants in the reaction and only speed up chemical reactions. Discuss how catalysts achieve this outcome. **2 marks**

**Question 4 (14 marks)**

A well-known industrial reaction used to manufacture sulfuric acid is called the contact process. The contact process is a multi-step process before the sulfuric acid can be produced. One part of the chemical reaction is shown below and involves the oxidation of sulfur dioxide into sulfur trioxide via a catalyst.

$$2SO_2\,(g) + O_2\,(g) \leftrightarrow 2SO_3\,(g)\ \Delta H = -196\ kJ\ mol^{-1}$$

**(a)** An empty, closed 50.0L reaction vessel contains 25.0 mol of $2SO_2\,(g)$ and 20.0 mol of $O_2\,(g)$ at 250°C. After the reaction reached equilibrium, the vessel contains 7.21 mol of $2SO_3\,(g)$. Calculate the equilibrium constant. **4 marks**

**(b)** To enhance the yield of this step, the reaction vessel was increased from 50.0L to 55.0 L instead. Discuss whether or not this change achieved an increase in yield. **3 marks**

**(c)** Construct a general concentration (M) vs time graph below to show the change and response of the reaction from part b. Ensure correct labels. Assume product is initially present. **3 marks**

**(d)** With reference to the green chemistry principle, catalysis, identify two factors that contribute to the sustainability of this chemical reaction. **4 marks**

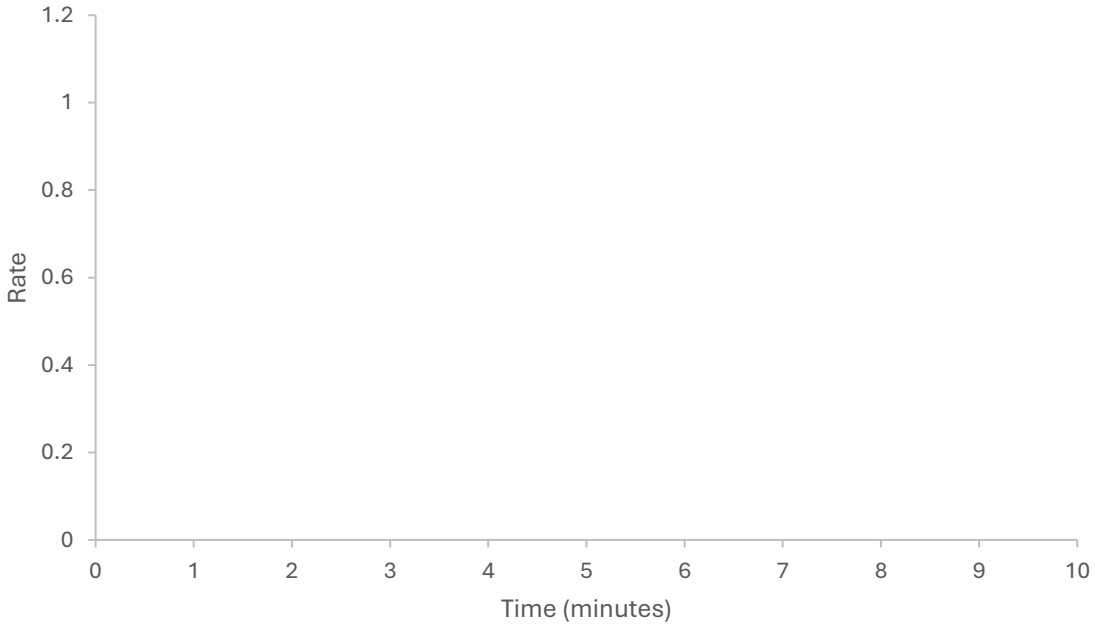
**Question 5 (17 marks)**
The chemical reaction of hydrogen gas and iodine gas is shown below.

$$H_{2(g)} + I_{2(g)} \leftrightarrow 2HI_{(g)} \quad \Delta H = -9.48 \text{ kJ mol}^{-1}$$

The colour change of iodine gas (purple) fading as HI forms makes it experimentally observable.

**(a)** Make a clear distinction between a general reversible and irreversible reaction, and between rate and extent of a reaction. **2 marks**

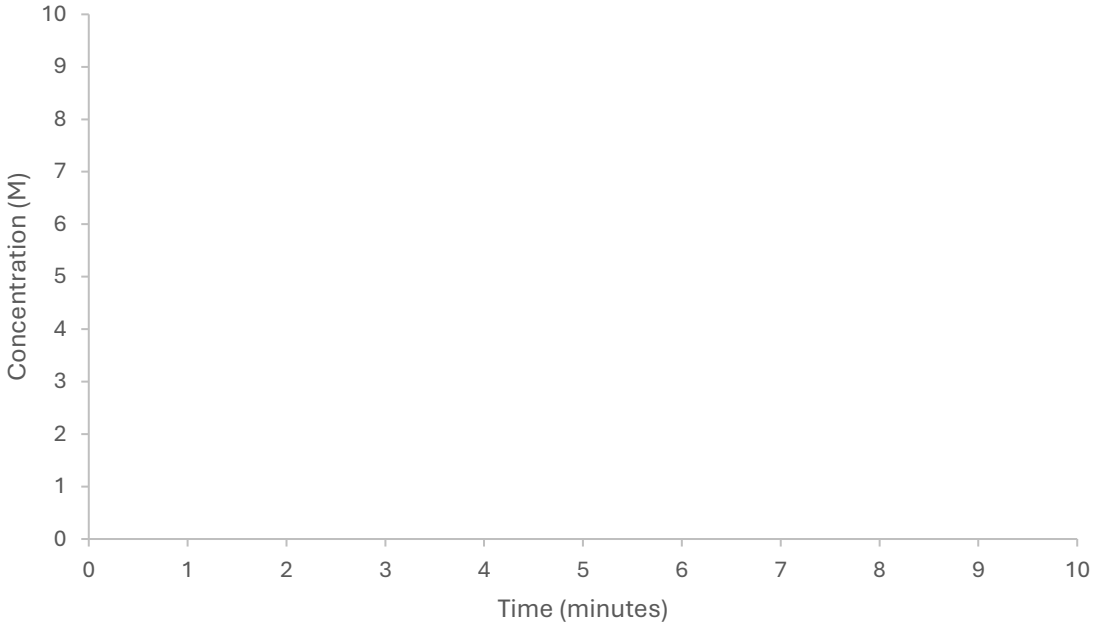
**(b)** More hydrogen gas was added into the closed reaction vessel containing this chemical reaction. On the axis below complete a rate vs time graph to illustrate the application of Le Chatelier's principle. You can begin at any rate, end first position of equilibrium at 3 minutes and end the final position of equilibrium at 7 minutes. Include labels to explain your choice of shape. **4 marks**




**(c)** Can a change in volume for this chemical reaction favour the yield of hydrogen iodide and why? **3 marks**

**(d)** In another attempt to optimise the yield, suggest a solution using temperature as the primary factor. Discuss the effect on the chemical reaction. **3 marks**

**(e)** On the axis below, show your choice of change on the concentration vs time graph. Begin with the following: hydrogen gas at 8M, iodine gas at 5M and hydrogen iodide at 1M. Initiate temperature change at 3 minutes and final reestablished position of equilibrium at 7 minutes. **2 marks**




**(f)** Discuss the effect of this temperature change on the equilibrium constant, K. **3 marks**

**Question 6 (13 marks)**
The chemical reaction of cobalt complex ion equilibrium is shown below.

$$[Co(H_2O)_2]^{2+}_{(aq)} + 4Cl^-_{(aq)} \leftrightarrow [CoCl_4]^{2-}_{(aq)} + 6H_2O_{(l)}$$

$[Co(H_2O)_2]^{2+}_{(aq)}$ is pink and $[CoCl_4]^{2-}_{(aq)}$ is blue.

**(a)** The reaction is known to be endothermic. Discuss the effect of decreasing the temperature on this reaction. **2 marks**

**(b)** At a given point in time, the reaction quotient is lower than the equilibrium constant. Discuss how the chemical reaction will respond. **2 marks**

**(c)** A total of 10ml of water was added to the solution vessel. What is the final colour of the solution and why? **3 marks**

**(d)** Using your knowledge of factors that can influence an equilibrium chemical reaction, discuss how both the rate and yield can be optimised by using a compromise. **3 marks**

**(e)** Heating the cobalt chloride system to shift the equilibrium toward the blue complex requires significant energy. Suggest how a catalyst could be used to improve the sustainability of this process, and explain why this aligns with green chemistry principles. **3 marks**