Rates of Reactions & Equilibrium (Qualitative) AS & A Level

Question Paper 3

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Periodic Table & Energy
Topic	Rates of Reactions & Equilibrium(Qualitative)
Paper	AS & A Level
Booklet	Question Paper 3

Time allowed: **30 minutes**

Score: **/22**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Chloroethene, $CH_2{=}CHCl$, is prepared in the presence of a solid catalyst using the equilibrium reaction below.

$$CH_2ClCH_2Cl(g) \rightleftharpoons CH_2{=}CHCl(g) + HCl(g) \qquad \Delta H = +51\ kJ\ mol^{-1}$$

[1]

Which change would result in an increased equilibrium yield of chloroethene?

A increasing the pressure

B increasing the surface area of the catalyst

C increasing the temperature

D use of a homogeneous catalyst

This question looks at reactions of hydrogen peroxide and of cobalt(II) ions.

(a) Aqueous hydrogen peroxide decomposes as shown in **equation 2.1**.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$ **Equation 2.1**

The reaction is catalysed by manganese(IV) oxide, MnO_2.

A student investigates the decomposition of a hydrogen peroxide solution as outlined below.

- The student adds 50.00 cm^3 of $H_2O_2(aq)$ to a conical flask.
- The student adds a small spatula measure of MnO_2 and quickly connects the flask to a gas syringe.
- The student measures the volume of oxygen every 200 seconds.

Results

Time/s	Volume of O_2/cm^3
0	0
200	15
400	28
600	36
800	41
1000	46
1200	48
1400	50

(i) Process the results as outlined below.

- On page 5, plot a graph of **volume of O_2** against **time**.
- Use your graph to find the rate of the reaction, in $cm^3 s^{-1}$, at t = 500 s.

Show your working on the graph and in the space below.

[5]

(ii) The student allows the reaction in **equation 2.1** to proceed until no more gas is evolved. The volume of O_2 in the syringe is now 55 cm^3, measured at RTP.

Calculate the initial concentration of the H_2O_2.

Give your answer to **two** significant figures.

[3]

(b) Hydrogen peroxide can act as an oxidising agent or as a reducing agent.

Some standard electrode potentials are shown below.

$2H^+(aq) + O_2(g) + 2e^-$	$\rightleftharpoons$	$H_2O_2(aq)$	$E^\ominus = +0.68\,V$
$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\rightleftharpoons$	$2H_2O(l)$	$E^\ominus = +1.77\,V$
$VO^{2+}(aq) + 2H^+(aq) + e^-$	$\rightleftharpoons$	$V^{3+}(aq) + H_2O(l)$	$E^\ominus = +0.34\,V$
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\rightleftharpoons$	$Mn^{2+}(aq) + 4H_2O(l)$	$E^\ominus = +1.51\,V$

Use this information to write an equation for a reaction in which hydrogen peroxide acts as a reducing agent.

[2]

(c) Cobalt(II) forms complex ions with water ligands and with chloride ligands.

- With water ligands, cobalt(II) forms a pink octahedral complex ion, $[Co(H_2O)_6]^{2+}$.
- With chloride ligands, cobalt(II) forms a blue tetrahedral complex ion.

A student dissolves cobalt(II) sulfate in water in a boiling tube. Apink solution forms.

Experiment 1
The student places the boiling tube in a water bath at 100 °C.
Concentrated hydrochloric acid is added dropwise.
The colour of the solution changes from pink to blue.

Experiment 2
The student places the boiling tube from **experiment 1** in an ice/water bath at 0 °C.
The colour of the solution changes from blue to pink.

(i) Write the equilibrium equation for the reaction that takes place when the colour of the solution changes.

[1]

(ii) Explain the observations and predict whether the formation of the blue colour is exothermic or endothermic.

[2]

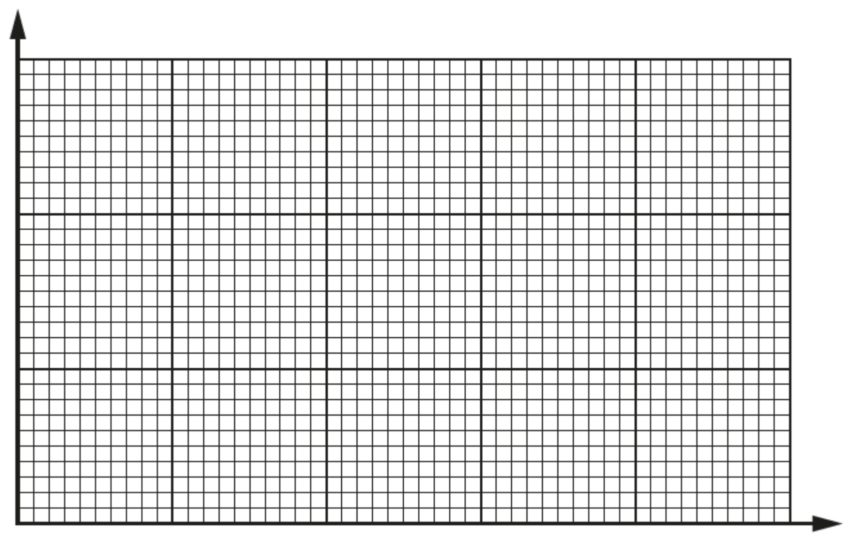
(Total 13 marks)

Methanol can be prepared industrially by reacting carbon monoxide with hydrogen in the presence of a copper catalyst. This is a reversible reaction.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

(a) Using the Boltzmann distribution model, explain why the rate of a reaction increases in the presence of a catalyst.

You are provided with the axes below, which should be labelled. **[4]**



(b) The reaction for the production of methanol in the presence of the copper catalyst is carried out at 200–300 °C.

Explain why use of the catalyst reduces energy demand and benefits the environment.

[2]

(c) A chemist investigates the equilibrium that produces methanol:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

The chemist mixes CO(g) with H_2(g) and leaves the mixture to react until equilibrium is reached.
The equilibrium mixture is analysed and found to contain the following concentrations.

Substance	**Concentration /mol dm^{-3}**
CO(g)	0.310
H_2(g)	0.240
CH_3OH(g)	0.260

Calculate the numerical value of K_c for this equilibrium.

Give your answer to an **appropriate** number of significant figures.

[2]

(Total 8 marks)