

Good Hope School Mock Examination 2022-2023

S.6 CHEMISTRY PAPER 2

1 hour

This paper must be answered in English

Student name	
Class	
Class number	
Block number	

INSTRUCTIONS

- (1) This paper consists of **TWO** sections, A and B. Attempt **ALL** questions in both sections.
- (2) Write your answers in the Answer Book provided. Start each question (not part of a question) on a new page
- (3) A Periodic Table is printed on page 7 of this question paper. Atomic numbers and relative atomic masses of elements can be obtained from the Periodic Table.

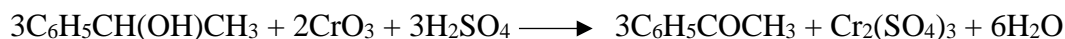
Section A Industrial Chemistry

Answer **ALL** parts of the question.

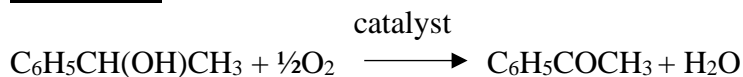
1. (a) Answer the following short questions:

- (i) Two methods for producing acetophenone ($\text{C}_6\text{H}_5\text{COCH}_3$) are shown below:

Method (1):



Method (2):



- (1) Calculate the atom economy of Method 2. (1 mark)
(Relative atomic masses: H = 1.0 ; C = 12.0 ; O = 16.0)

$$\begin{aligned}\text{Atom economy} &= [(12 \times 8 + 8 + 16) / (12 \times 8 + 10 + 16 + 16)] \times 100\% \\ &= (120 / 138) \times 100\% \\ &= 86.96\% \quad [1]\end{aligned}$$

- (2) Discuss, from TWO different perspectives, whether **Method (1)** or **Method (2)** is greener. (2 marks)

Method 2 is greener.

Any two of the following: [2]

- Method 2 has a higher atom economy than Method 1.
- Hazardous chemicals are not used in Method 2 but Method 1 involves corrosive/irritating H_2SO_4 (or toxic/irritating CrO_3).
- A catalyst is used in Method 2 but not in Method 1.

(Also accept: Method 2 produces water as the only side product while Method 1 produces another side product as well. (This point is not accepted if students have already compared the atom economy of the two methods.)

Common mistakes:

- Just wrote about method 2 and did not mention about method 1 – lack of comparison

- (ii) The membrane electrolytic cell is widely used for the electrolysis of brine in chloroalkali industry. Describe how NaOH is produced in a membrane electrolytic cell. (3 marks)

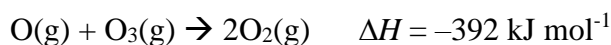
$\text{Cl}^-(\text{aq})$ ions are discharged at the anode while $\text{H}^+(\text{aq})$ ions are discharged at the cathode. [1]
The membrane is permeable to cations only [1]. As there is a higher concentration of cation at the anode, $\text{Na}^+(\text{aq})$ ions flow to the cathode compartment. [1] Hence, concentrated NaOH(aq) is formed.

Poorly done. Most students could not describe the production of NaOH clearly and the flow of $\text{Na}^+(\text{aq})$ ions correctly.

Common mistakes:

- Did not mention at which electrode the ions are discharged
- Wrongly thought that $\text{H}^+(\text{aq})$ and $\text{Na}^+(\text{aq})$ are both originally present at the cathode and hence $\text{Na}^+(\text{aq})$ will flow from the cathode to the anode.

(b) In the upper atmosphere, ozone is converted to diatomic oxygen according to the equation below:



- (i) The activation energy of the reaction at 210 K is 17100 J mol⁻¹. Calculate the rate constant of the reaction at 210 K.
 (Gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$;
 Arrhenius constant A for this reaction = $4.8 \times 10^9 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$) (2 marks)

$$\begin{aligned} \log k &= \log A - (E_a / 2.3RT) \quad [1] \\ &= \log 4.8 \times 10^9 - [17100 / 2.3 (8.31) (210)] \\ k &= 2.64 \times 10^5 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1} (263551) \quad [1] \end{aligned}$$

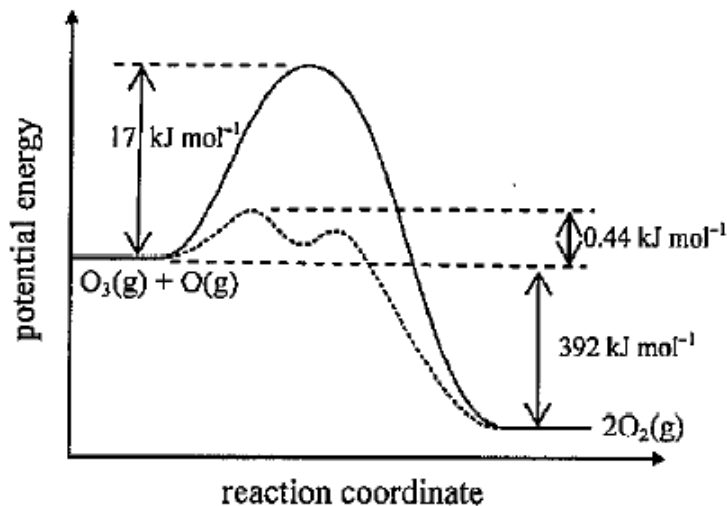
Poorly done.

Common mistake:

- Could not give the equation correctly
- Wrong unit for the rate constant

- (ii) The presence of chlorine free radicals ($\bullet\text{Cl}$) in the upper atmosphere will catalyse the conversion of ozone to diatomic oxygen, leading to ozone depletion. The activation energy for the $\bullet\text{Cl}$ catalyzed ozone depletion is 0.44 kJ mol⁻¹.

On the same diagram, sketch labelled energy profiles for the conversion of ozone to diatomic oxygen in the absence and in the presence of $\bullet\text{Cl}$ respectively. Label the energy involved. (3 marks)



[1M for correct axes]

[1M for correct heights and shapes of the energy profiles: energy profile without catalyst is higher than that with catalyst; the energy level of product is lower than that of reactants]

[1M for correct labels: E_a of uncatalyzed reaction, E_a of catalyzed reaction, ΔH , reactants and product. (The E_a and ΔH can be labelled using energy values instead.)]

Common mistakes:

- Wrong labels for axes
- Missed some of the labels

- (c) The following equation shows the hydrolysis of methyl methanoate which occurs at a measurable rate in the presence of an aqueous acid:



- (i) A series of experiment was done to determine the rate of hydrolysis of methyl methanoate at 25 °C. The following results were obtained:

Experiment	[HCOOCH ₃] (mol dm ⁻³)	[H ⁺] (mol dm ⁻³)	Initial rate (mol dm ⁻³ s ⁻¹)
1	1.00	1.00	1.11×10^{-3}
2	2.00	1.00	2.24×10^{-3}
3	2.00	0.50	1.13×10^{-3}
4	2.00	2.00	4.49×10^{-3}

- (1) Deduce the order of reaction with respect to HCOOCH₃. (1 mark)

From experiments 1 and 2, at the same initial concentration of H⁺, the initial rate doubles when the concentration of HCOOCH₃ is doubled.

∴ the order of reaction with respect to HCOOCH₃ is 1. [1]

- (2) Given that the order of reaction with respect to H⁺ is 1, calculate the rate constant for the reaction at 25 °C. (2 marks)

$$\text{Rate} = k [\text{HCOOCH}_3][\text{H}^+]$$

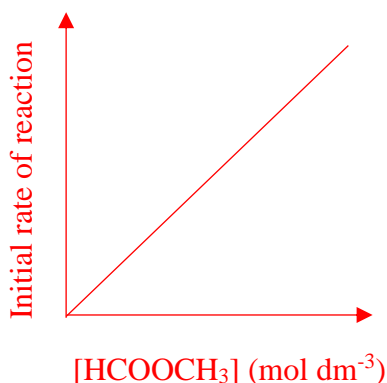
Using the data from experiment 1,

$$\text{rate constant} = 1.11 \times 10^{-3} / (1)(1) \quad [1]$$

$$= 1.11 \times 10^{-3} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1} \quad [1]$$

Common mistake: wrong or missing unit

- (3) Sketch a graph to show how the initial rate of reaction would change with different initial concentrations of HCOOCH₃. (1 mark)

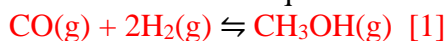


Common mistake:

- Wrongly plotted a concentration vs time graph

- (ii) Methanol can be produced from syngas in the chemical industry.

- (1) Write the chemical equation for the reaction in the production of methanol from syngas, and state the condition required. (2 marks)



Any ONE of the following: [1]

- Catalyst: Cu/ ZnO / Al₂O₃
- Temperature: 200 – 300 °C
- Pressure: 50 – 100 atm

Poorly done.

Common mistakes:

- Forgot to use a double-head arrow for the equation
- Gave wrong conditions
- Wrongly gave Cu, ZnO or Al₂O₃ as the catalyst, instead of Cu/ZnO/Al₂O₃ which is a mixture of the three oxides

- (2) Explain why the operation pressure for the production of methanol in industry is not set at atmospheric pressure. (2 marks)

Number of moles of gaseous reactants is larger than that of gaseous products. [1]

The operation pressure, being higher than the atmospheric pressure, will shift the equilibrium position to the right. [1]

Common mistake:

- Did not explain in terms of the number of moles of gases

OR

A higher gas pressure can increase the frequency of collisions/ effective collisions [1]. making the reaction faster [1]

- (3) Apart from the operating conditions, state one design in the methanol production that helps make the production more economical. (1 mark)

Any one of the following: [1]

- Unreacted syngas is recycled to increase the overall conversion percentage of syngas.
- The hot product mixture is passed into the heat exchanger to preheat the syngas to conserve energy.
- The methanol formed is continuously removed to shift the equilibrium position to the right, so to increase the yield.)

END OF SECTION A

Section B Analytical Chemistry

Answer **ALL** parts of the question.

2. (a) Suggest a chemical test to show the presence of hypochlorite ion in an aqueous solution. (2 marks)

Add HCl(aq) [1].

Gas evolved turns moist blue litmus paper red, then white/

Gas evolved turns colourless iodide solution brown/ orange/ yellow.

Gas with swimming pool water smell evolved. [1]

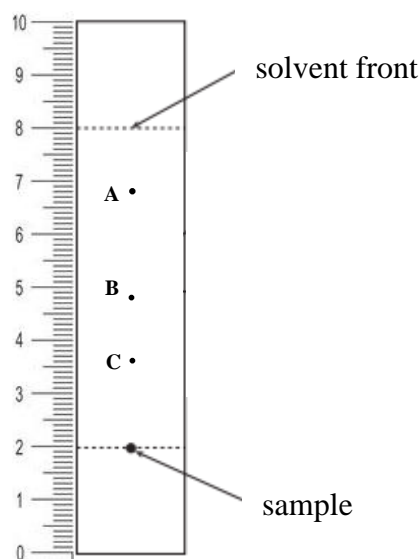
WITHOUT the use of dilute acid

Test the solution with litmus paper/ pH paper. Red litmus paper turns white/ blue litmus paper turns white/ pH paper turns white)

Common mistake:

- Wrongly used a red litmus paper to test the gas evolved.

- (b) A government chemist used thin layer chromatography to identify the dyes found in an imported sweet. The chromatogram obtained is shown below:



The R_f values for some of the expected dyes are given in the following table:

Dye	R_f value
Sunset Yellow FF	0.60
Brilliant Blue FF	0.80
Fast Green FF	0.90

- (i) Based on the chromatogram and table of R_f values, state which dye is present in spot **A**. Show how you arrive at your answer. (1 mark)

For spot **A**, its R_f value = $(6.8-2.0)/6 = 0.8$. Brilliant Blue FF is present. [1]

- (ii) The chemist suspected that spot **B** contains a mixture of two dyes, amaranth and indigo carmine. This spot was removed from the plate and dissolved in a suitable solvent. Suggest a suitable method to confirm the presence of these two dyes in spot **B**. (1 mark)

Repeat chromatography using a different solvent [1]. Spot **B** is a mixture of the two dyes if 2 spots with the same R_f values (using the same stationary phase and mobile phase) as the two dyes are obtained.

OR

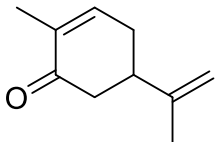
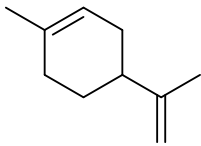
Use GC-MS [1]. Spot **B** is a mixture of the two dyes if the mass spectra obtained are the same as those of the two dyes.

Poorly done.

Common mistake:

- Did not mention the use of another solvent when suggesting to repeat the chromatography
- Wrongly suggested gas chromatography/ column chromatography which is used for separation of mixture, but not identification
- Wrongly suggested mass spectrometry. Since the sample may be a mixture, separation by gas chromatography must be carried out before mass spectrometry.

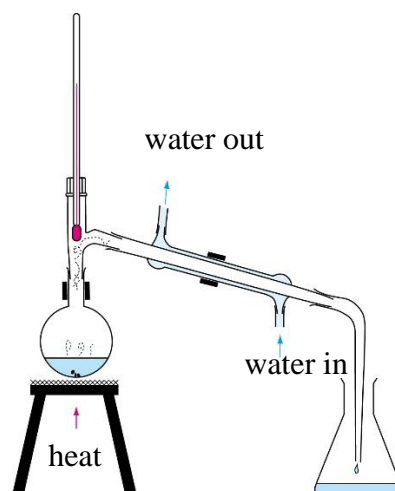
(c) Caraway oil is a mixture of compounds **X** and **Y**.

	X	Y
		
boiling point (°C)	228	176

(i) Suggest a simple chemical test to distinguish **X** and **Y**. (2 marks)

Mix each compound with 2,4-dinitrophenylhydrazine [1]. Only **X** gives orange precipitate. [1]

(ii) (1) Draw a labelled diagram for the set-up required for simple distillation. (2 marks)



1 mark for correct experimental set-up, 1 mark for correct labels

Experimental set-up: 0 mark for closed system, wrong position of thermometer / delivery tube etc.

[Accept: No cold water to condense the solvent.]

1 mark for labelling heat, water in and water out

Common mistake:

- Drew all the apparatus as one whole piece instead of 4 separated pieces fit together

(2) Explain how simple distillation can be used to separate **X** and **Y** in caraway oil.

(1 mark)

Yes, because there is a large difference in their boiling points. [1]

(d) Breathalysers are used to determine the alcohol levels in suspected drink drivers.

(i) An early type of breathalyser required the suspect to breathe into a tube that contained acidified potassium dichromate. State the colour change if sufficient ethanol containing breath is passed into the tube. (1 mark)

From orange to green [1]

- (ii) Modern breathalysers use infrared spectroscopy (IR) to detect and measure the concentration of ethanol in breath based on the absorbance at 2940 cm^{-1} .

With reference to the table below, explain why infrared absorption at 2940 cm^{-1} instead of 3350 cm^{-1} is used to determine ethanol content in breath. (1 mark)

Characteristic Infra-red Absorption Wavenumber Ranges (Stretching modes)

Bond	Compound type	Wavenumber range / cm^{-1}
C=C	Alkenes	1610 – 1680
C=O	Aldehydes, ketones, carboxylic acids and derivatives	1680 – 1800
C≡C	Alkynes	2070 – 2250
C≡N	Nitriles	2200 – 2280
O-H	Acids (hydrogen-bonded)	2500 – 3300
C-H	Alkanes, alkenes, arenes	2840 – 3095
O-H	Alkanols (hydrogen-bonded)	3230 – 3670
N-H	Amines	3350 – 3500

The absorption at 3350 cm^{-1} is due to O-H bond which is present in both ethanol and water vapour in breath [1] while the absorption at 2940 cm^{-1} correspond to C-H is present in ethanol, but not in water.

Very poorly done.

Common mistake:

- Wrongly focused on the wavenumber range $2500 - 3300\text{ cm}^{-1}$ and explained that ethanol would oxidize to ethanoic acid readily

- (iii) A false breathalyser reading, based on absorbance at 2940 cm^{-1} , can be given by a person who exhales propanone as a result of illnesses such as diabetes. Explain whether the IR spectrum of diabetes patient can be distinguished from those due to ethanol-containing breath. (1 mark)

Yes because IR spectrum from diabetes patient shows absorption peak at $1680 - 1800\text{ cm}^{-1}$ due to the presence of C=O while IR spectrum of ethanol does not [1]

Very poorly done.

Common mistakes:

- Wrongly focused on the absorbance at 2940 cm^{-1} and thought that it would appear in both IR spectra
- Wrongly explained in terms of propanone and ethanoic acid
- Did not mention which bond the wavenumber range $1680 - 1800\text{ cm}^{-1}$ corresponds to C=O

- (e) In an experiment to determine the concentration of ethanol in a brand of beer, 10 cm^3 of a sample of the beer was added to 25.0 cm^3 of $0.184\text{ M K}_2\text{Cr}_2\text{O}_7(\text{aq})$ and excess dilute $\text{H}_2\text{SO}_4(\text{aq})$. The mixture was allowed to stand at room temperature overnight. The excess $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ was titrated against $0.118\text{ M FeSO}_4(\text{aq})$ using a suitable indicator. It required 13.41 cm^3 of the $\text{FeSO}_4(\text{aq})$ to reach the end point.

- (i) Suggest a reason why $\text{FeSO}_4(\text{s})$ is not a primary standard. (1 mark)

It is not available in high purity/

It is chemically unstable in air/ is readily oxidized/

It is hygroscopic [1]

- (ii) Write an equation for the reaction between $\text{Fe}^{2+}(\text{aq})$ and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ under acidic condition. (1 mark)



- (iii) Given that ethanol and $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ react in the ratio of 3:1, calculate the concentration of ethanol, in mol dm^{-3} , in the beer. (3 marks)

No. of moles of unreacted $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ in the mixture

$$= (13.41/1000) (0.118) / 6 = 2.637 \times 10^{-4} \quad [1]$$

No. of moles of $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ reacted with ethanol

$$= (25/1000) (0.184) - 2.637 \times 10^{-4} = 4.336 \times 10^{-3} \quad [1]$$

$$\text{Molarity of ethanol in the beer} = 4.336 \times 10^{-3} \times 3 / (10/1000) = 1.30 \text{ mol dm}^{-3} \quad [1]$$

Common mistakes:

- When calculating the no. of moles of $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ reacted, some forgot to minimize the no. of moles of unreacted $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ from the original no. of moles of $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$

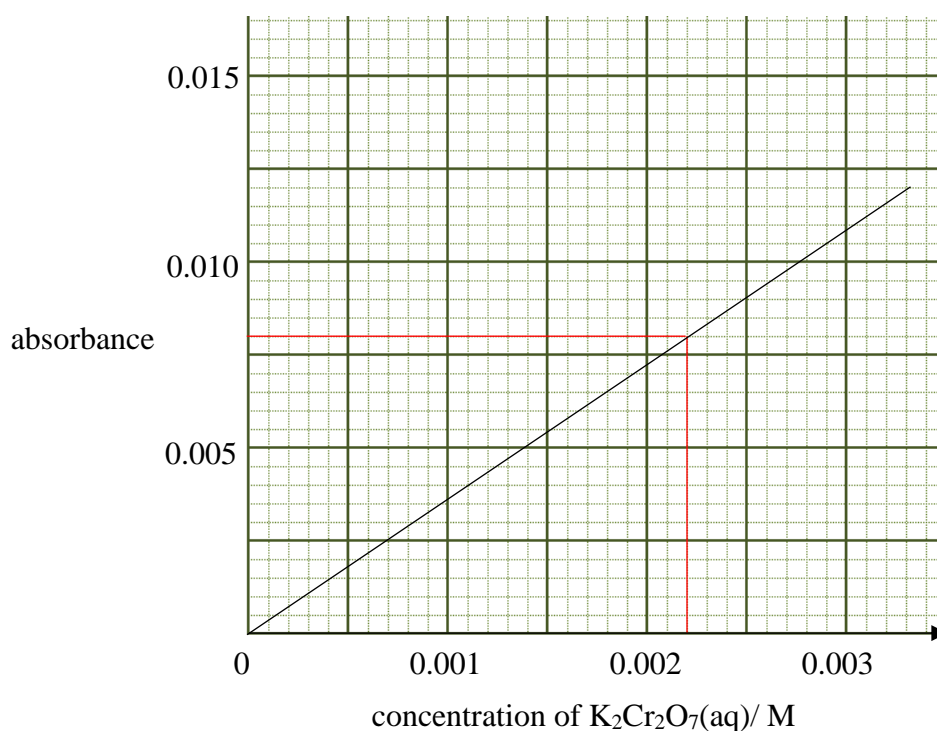
- (iv) State ONE assumption for this experiment. (1 mark)

Ethanol is the only chemical in the beer that can be oxidized by acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ / all ethanol in the beer has been fully oxidized. [1]

Common mistake:

- Irrelevant answers in terms of reaction between $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ and $\text{H}_2\text{SO}_4(\text{aq})$ or use of catalyst

- (v) (1) The amount of excess $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ can also be determined by colorimetry. The absorbance of a given $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ is found to be 0.008. Using the calibration curve below, determine the concentration of the $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$. (1 mark)



Concentration of the $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq}) = 0.0022 \text{ M} \quad [1]$

- (2) Suggest an advantage of colorimetry over titrimetric analysis in analysing the concentration of $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$. (1 mark)

It can measure low concentration of $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ more accurately/ more sensitive to low concentration/ measurements can be obtained more quickly. [1]

(Also accept: Less chemical is needed for colorimetry than titrimetric analysis)

Common mistake:

- Answers were not specific enough, e.g.
‘colorimetry can measure the concentration more accurately’ – missing the focus on ‘low concentration’ of sample
‘colorimetry can be done more quickly’ – should focus on the measurement of data instead of the overall process of colorimetry

END OF SECTION B
END OF PAPER

[20 marks]

GROUP 族

58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu
140.1		140.9		144.2		(145)		150.4		152.0		157.3		158.9		162.5		164.9		167.3		168.9		173.0		175.0	
90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr
232.0		(231)		238.0		(237)		(244)		(243)		(247)		(247)		(251)		(252)		(257)		(258)		(259)		(260)	