UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIOENGINEERING TECHNOLOGY

FINAL EXAMINATION
OCTOBER 2025 SEMESTER

COURSE CODE	:	CCB10103
COURSE NAME	:	ANALYTICAL AND ORGANIC CHEMISTRY
PROGRAMME NAME	:	BACHELOR OF CHEMICAL ENGINEERING WITH HONOURS
DATE	:	26 JANUARY 2026
TIME	:	2.00 PM – 5.00 PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper has information printed on both sides of the paper.
3. This question paper has FOUR (4) questions. Answer ALL questions.
4. Please WRITE your answers on the answer booklet provided.
5. Please answer all questions in English only.

THERE ARE 10 PAGES OF QUESTIONS AND APPENDICES EXCLUDING THIS PAGE.

(Total: 100 marks)

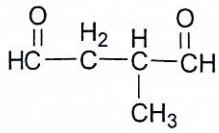
INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

QUESTION 1

(a) Provide the IUPAC names of the structure compounds.

i.



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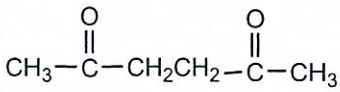

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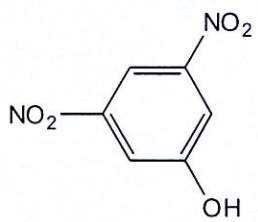

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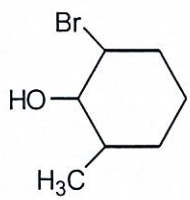

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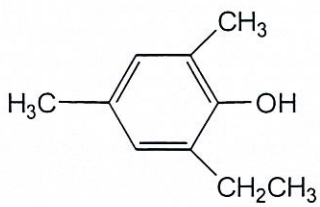

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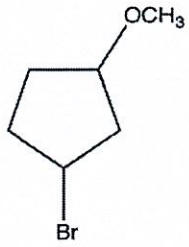


(6 marks)

(b) Draw the structural formula of the following compounds.

i. 1-methylcyclopentanol

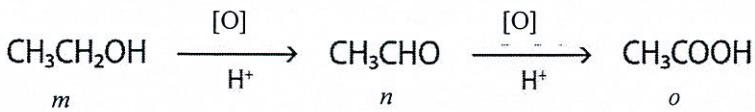
ii. *p*-chlorophenol

iii. 2,4-dimethyl-3-pentanol

iv. 3-methyl-1-butanethiol

(4 marks)

(c) The following reaction (Scheme 1) produces *n* as an intermediate and *o* as the final product.



Scheme 1: Reaction for the production of o

i. Identify the reagent that can be used in the reaction above.

(1 mark)

ii. Provide the names of *m*, *n* and *o*.

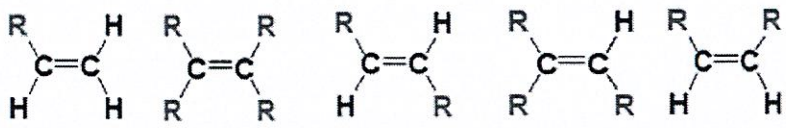
(3 marks)

iii. If *m* is substituted with 2-methyl-2 butanol, explain the effect on the reaction and justify your answer.

(2 marks)

(d) Arrange the compounds below according to relative stability.

(3 marks)



(e) The structural formula of compound X is shown below.

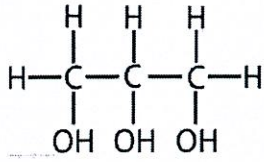


Figure 1: Compund X

i. Identify the name of compound X.

(1 mark)

ii. Compare the solubility in water of compound X with that of 2-butanol. Explain your answer.

(3 marks)

(f) Draw the cis-trans pair for compound $CH_3CH_2CH_2(CH_2CH_3)C{=}C(CH_3)CH_2CH_3$

(2 marks)

QUESTION 2

(a) Determine the reagents and conditions that would be required to carry out the following reactions in Figure 2.

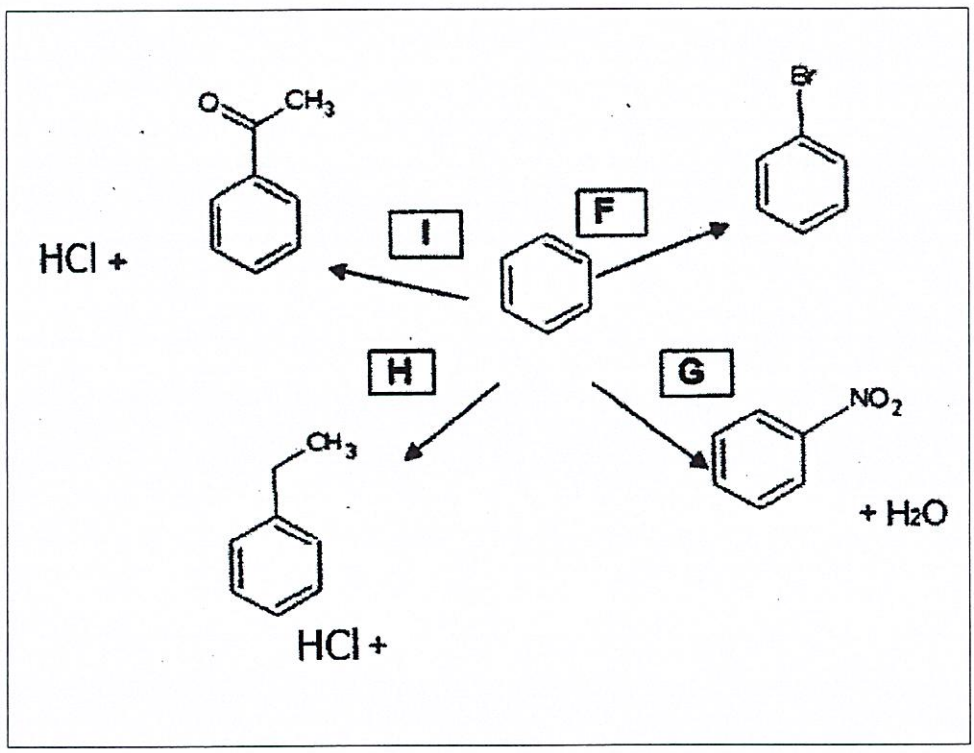
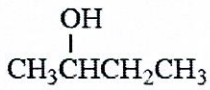


Figure 2: Reaction pathways for benzene derivatives

(5 marks)

(b) Describe the synthesis of Ketones using the following methods and the given starting materials.

i. Oxidation of alcohols



(3 marks)

ii. Fridel-Crafts acylation

(3 marks)

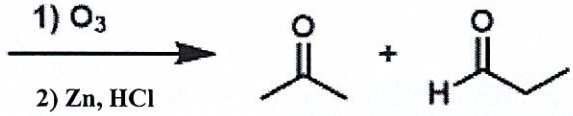
(c) Arrange the following alkanes in order of increasing boiling points. Explain your answer.

$(CH_3)_2CHCH_3$, $(CH_3)_4C$, $CH_3(CH_2)_2CH_3$, $CH_3(CH_2)_3CH_3$

(7 marks)

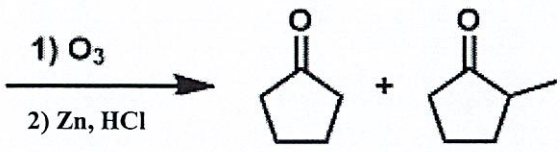
(d) Propose the reactants of the following reactions.

i



(1 mark)

ii.



(1 mark)

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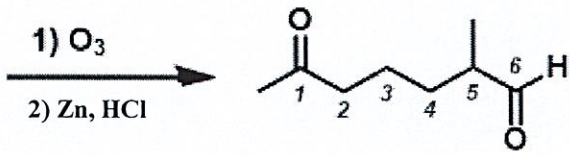
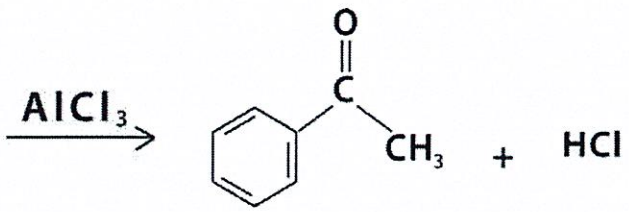


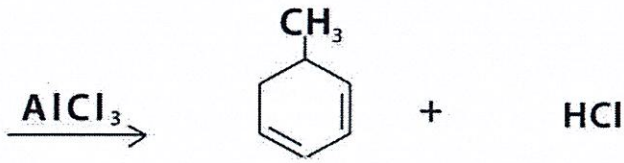
(1 mark)

iv.



(2 marks)

v.



(2 marks)

QUESTION 3

High performance liquid chromatography (HPLC) and gas chromatography (GC) are methods that scientists used to analyze samples to determine the concentration of molecules in the sample. Both use the same principle, that heavier molecules will elute, or flow, more slowly than lighter ones. Figure 3 shows the difference between the application of GC and HPLC in industry.

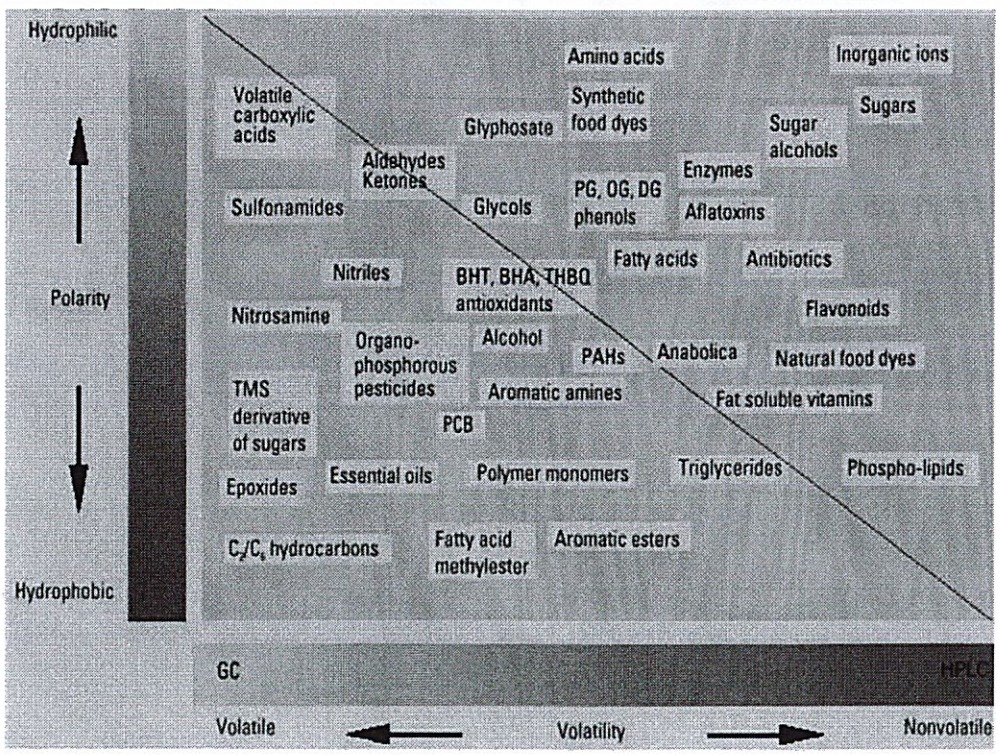


Figure 3: Difference between the application of GC and HPLC in industry.

(a) In a column containing solution *x* and solution *y* as shown in Figure 4, *x* moves faster than *y*. Explain this phenomenon based on basic GC instrumentation, from injector to detector.

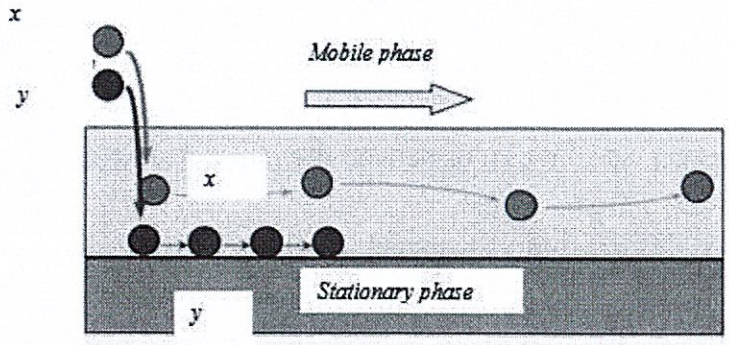


Figure 4: Movement of solution *x* and *y* in GC

(7 marks)

(b) Provide **TWO (2)** samples from industry that suitable can be analyzed using GC.

(2 marks)

(c) Construct a table containing the elaboration of **FOUR (4)** differences of GC and HPLC.

(8 marks)

(d) Briefly explain the role of mobile phase and stationary phase in HPLC analysis.

(4 marks)

(e) Name **TWO (2)** types of mobile phases compositions apply in HPLC.

(2 marks)

(f) Explain **TWO (2)** advantages of High Performance Liquid Chomatograph.

(2 marks)

QUESTION 4

(a) A company sent a traditional Chinese herbal medicine to your laboratory for metal detection using Atomic Absorption Spectroscopy (FAAS) analysis.

i. Identify **FOUR (4)** steps that should be taken prior to the sample analysis.

(4 marks)

ii. Explain the theory or law that is applied in AAS.

(3 marks)

(b) Briefly explain the **TWO (2)** types of light sources use in Atomic absorption spectroscopy.

(4 marks)

(c) Draw a schematic diagram of atomic absorption spectroscopy. Label the basic components.

(5 marks)

(d) The following isomers can be derived from molecular formula of C_2H_6O.They are CH_3CH_2-OH and CH_3–O–CH_3.

i. Describe how this compound can be distinguished by using IR spectroscopy.

(2 marks)

ii. Identify **TWO (2)** criteria that will allow the IR radiation absorption to occur.

(4 marks)

(e) A sample of lemon oil containing 1-octene will be examined using UV-Visible Spectroscopy (UV – Vis). Explain the basic concept in UV – VIS spectroscopy.

(3 marks)

END OF EXAMINATION PAPER

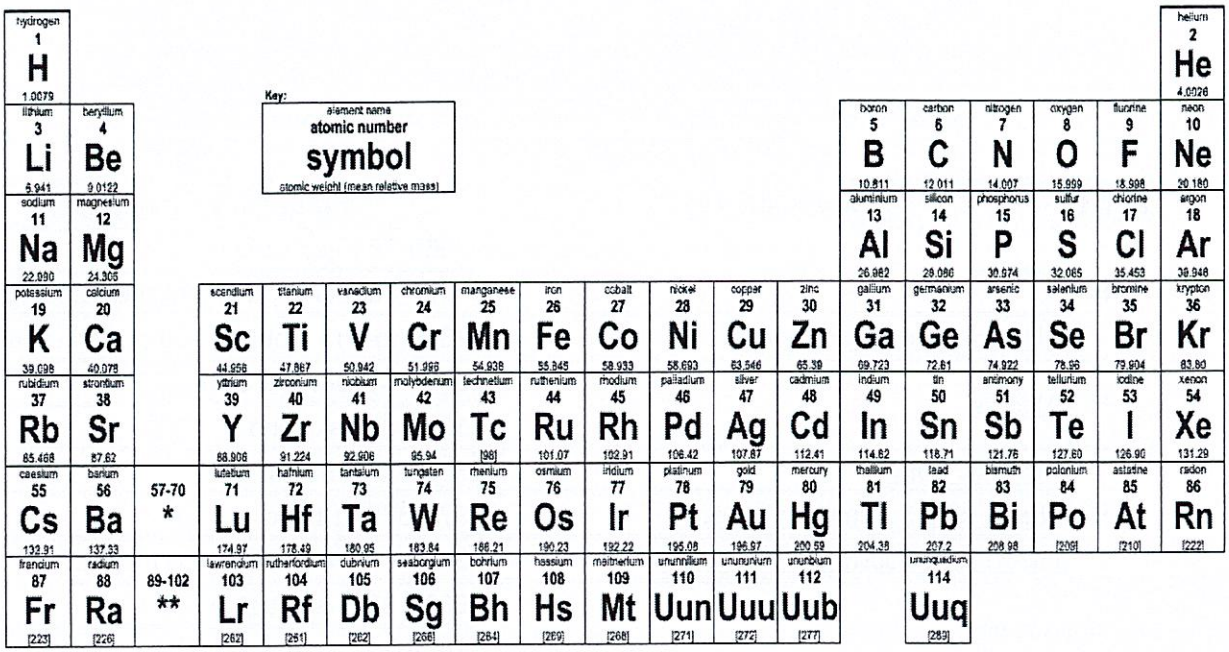
APPENDIX

Table A: Characteristic Infrared Absorption frequencies

Bond	Compound Type	Frequency range, cm^{-1}
C-H	Alkanes	2960-2850(s) stretch
		1470-1350(v) scissoring and bending
	CH_3 Umbrella Deformation	1380(m-w) - Doublet - isopropyl, *t*-butyl
C-H	Alkenes	3080-3020(m) stretch
		1000-675(s) bend
C-H	Aromatic Rings	3100-3000(m) stretch
	Phenyl Ring Substitution Bands	870-675(s) bend
	Phenyl Ring Substitution Overtones	2000-1600(w) - fingerprint region
C-H	Alkynes	3333-3267(s) stretch
		700-610(b) bend
C=C	Alkenes	1680-1640(m,w)) stretch
C≡C	Alkynes	2260-2100(w,sh) stretch
C=C	Aromatic Rings	1600, 1500(w) stretch
C-O	Alcohols, Ethers, Carboxylic acids, Esters	1260-1000(s) stretch
C=O	Aldehydes, Ketones, Carboxylic acids, Esters	1760-1670(s) stretch
O-H	Monomeric -- Alcohols, Phenols	3640-3160(s,br) stretch
	Hydrogen-bonded -- Alcohols, Phenols	3600-3200(b) stretch
	Carboxylic acids	3000-2500(b) stretch
N-H	Amines	3500-3300(m) stretch
		1650-1580 (m) bend
C-N	Amines	1340-1020(m) stretch
C-N	Nitriles	2260-2220(v) stretch
NO_2	Nitro Compounds	1660-1500(s) asymmetrical stretch
		1390-1260(s) symmetrical stretch

v - variable, m - medium, s - strong, br - broad, w – weak

$$A = - \log T$$
$$A = a\, b\, c$$
$$A = \varepsilon\, b\, c$$
$$A = \log P_o / P$$
$$(T = P / P_o)$$
1 ppm = 1 mg/L



Conversion Factor

Mass
1 lb_m = 0.453592 kg
1 ton = 2000 lb_m
1 kg = 2.20462 lb_m

Force
1 lb_f = 4.448222 N
1N = 0.224809 lb_f = 1 kg.m/s^2

Volume
1 ft^3 = 0.028317 m^3
1 L = 0.001 m^3
1 m^3 = 35.32 ft^3
1 cm^3 = 0.06102 in^3
1 gal =0.0037854 m^3
1 gal/min = 6.31 x 10^{-5} m^3/s

Density
1kg /m^3 = 0.062428 lbm/ ft^3

Pressure
1 pascal (Pa) = 1 N/m^2 = 10^{-5} bar
1 atm = 760 mmHg = 760 torr
1 atm = 101.325 kPa = 1.01325 bar

Constants

Faraday Constant = 96 485 Coulombs mol^{-1}
Gas Constant = 0.082 L atm K^{-1} mol^{-1}
= 8.314 L kPa K^{-1} mol^{-1}
= 8.314 m^3 Pa K^{-1} mol^{-1}
= 8.314 J mol^{-1} K^{-1}
Specific heat (water) = 4.184 J g^{-1} $°C^{-1}$
Speed of light = 3.00 x 10^8 m/s.

$A = - \log T$

$A = a\ b\ c$

$A = \varepsilon\ b\ c$

$A = \log P_o / P$

$(T = P / P_o)$

1 ppm = 1 mg/L

1 kcal = 4.184 kJ

Avogadro's number, $N_A = 6.022 \times 10^{23}\ mol^{-1}$

Transmittance ($T = P / P_o$)

Absorbance ($A = \log P_o / P$)

$$E = \frac{hc}{\lambda}$$

where c = velocity of light

- E = energy of radiation,
- ν = frequency and
- h = Planck's constant ($6.63 \times 10^{-34}\ m^2.kg/s$ or J s)