



UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIOENGINEERING TECHNOLOGY

FINAL EXAMINATION JANUARY 2026 SEMESTER

COURSE CODE	:	CLB12503
COURSE NAME	:	ANALYTICAL & ORGANIC CHEMISTRY
PROGRAMME NAME	:	TECHNICAL FOUNDATION - BACHELOR
DATE	:	26 JANUARY 2026
TIME	:	2:00PM – 5:00PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question booklet consists of TWO sections.
4. Answer ALL questions for Section A.
5. Section B consists of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided and answer all questions in English only.
7. FTIR table and periodic table are appended.

THERE ARE 11 PAGES OF QUESTIONS, INCLUDING THIS PAGE.

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

Question 1

Benzene reacts with nitric acid (HNO_3) in the presence of H_2SO_4 to give a major product (Compound A).

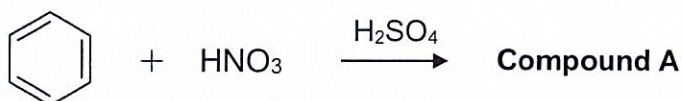


Figure 1: Nitration reaction

- (a) Predict the structural formula of the major product (Compound A) formed in the nitration reaction. (2 marks)
- (b) Compound A is then reacted with Br_2 in the presence of FeBr_3 . Predict the structural formula for the major product (Compound B). (2 marks)
- (c) State the IUPAC name of Compound B. (2 marks)
- (d) Describe the directing effects of functional group to the benzene ring. (2 marks)
- (e) Fourier infrared (FTIR) spectroscopy is used to distinguish Compound A and Compound B. For each compound, state the important IR absorption regions expected for each compound that show their structural differences. (6 marks)
- (f) Predict which compound (Compound A or Compound B) has the higher boiling point and justify the answer with three reasons. (6 marks)

Question 2

A wastewater treatment plant monitors dye contamination. Methylene blue (a common dye) absorbs strongly at $\lambda = 664 \text{ nm}$. A series of standard solutions and one wastewater sample were analyzed by ultraviolet-visible (UV-Vis) spectrophotometer.

Table 1: Absorbance of methylene blue standard solutions and unknown sample

Sample	Concentration (ppm)	Absorbance
Standard 1	1.0	0.082
Standard 2	2.0	0.162
Standard 3	3.0	0.242
Standard 4	4.0	0.322
Standard 5	5.0	0.402
Sample Y	?	0.277

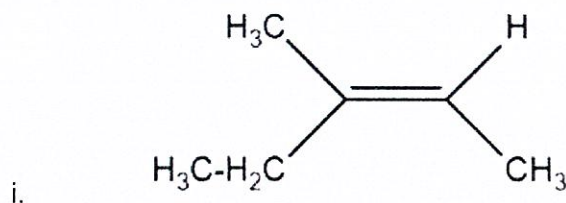
- (a) i. Using the calibration data in Table 1, determine the concentration (ppm) of methylene blue in Sample Y.

(6 marks)

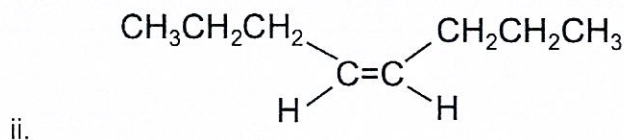
- ii. State FOUR (4) advantages of using UV-Vis spectrophotometer for analyzing colored pollutants in wastewater.

(4 marks)

- (b) Give the IUPAC name for the following compounds.



(2 marks)



(2 marks)

- (c) A soft drink sample containing tartrazine (yellow food dye) is analyzed using a UV-Vis spectrophotometer at 427 nm. The cuvette path length is 1.0 cm, the molar absorptivity (ϵ) of tartrazine is $1.2 \times 10^3 \text{ L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$, and the solution concentration is $5.0 \times 10^{-4} \text{ M}$.

- i. Calculate the absorbance (A) of the solution.

(3 marks)

- ii. Calculate the % transmittance (%T) of the solution.

(3 marks)

SECTION B (Total: 60 marks)

INSTRUCTION: Answer only THREE questions.

Please use the answer booklet provided.

Question 3

In the esterification reaction, propan-1-ol is reacted with ethanoic acid, in the presence of sulphuric acid.

- (a) i. With the aid of chemical equation, predict the product/s of the reaction.
(4 marks)
- ii. Give the IUPAC name of the major product in the reaction in Question 3 (a)(i).
(2 marks)
- iii. The major product obtained in Question 3(a)(ii), has been analyzed using Fourier transform infrared (FTIR) spectroscopy. By referring to the table given in Appendix I, identify the possible functional groups present in the FTIR spectra as shown in Figure 2 and state the frequency.

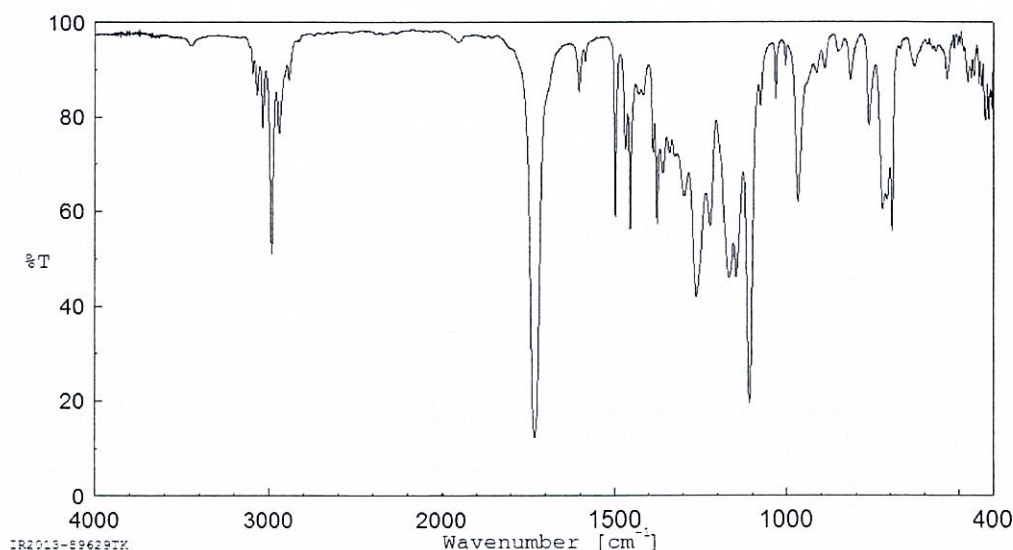


Figure 2: FTIR spectra

(4 marks)

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

- i. N-ethylbutanamide (2 marks)
- ii. N-methyl-N-isopropylpentanamine (2 marks)
- iii. N-ethyl-N-methylaniline (2 marks)
- iv. 2-methyl-2-octanamine (2 marks)
- v. Cyclopentanamine (2 marks)

Question 4

2-methyl-2-butanol is heated with concentrated sulfuric acid (H_2SO_4), a dehydration reaction occurs.



Figure 3: Schematic reaction of alcohol

- (a) Predict the structural formula of the major product (Compound A) yielded by this chemical reaction. (4 marks)
- (b) State the IUPAC name of Compound A and Compound B. (4 marks)
- (c) Compound A reacts with hydrobromic acid (HBr), an addition reaction takes place. Draw the structural formula of Compound C.

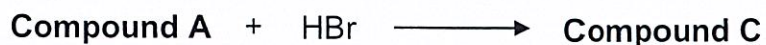


Figure 4: Schematic of addition reaction

(2 marks)

- (d) Predict rules that applied in the formation of Compound A and Compound C. (2 marks)
- (e) Compare the boiling points of 2-methyl-2-butanol, Compound A, and Compound C. (4 marks)
- (f) Fourier transform infrared (FTIR) spectroscopy is used to distinguish Compounds A, B, and C. Describe the key IR absorption regions expected for each compounds. (4 marks)

Question 5

The diagram below shows the basic components of an atomic absorption spectroscopy (AAS) used for elemental analysis.

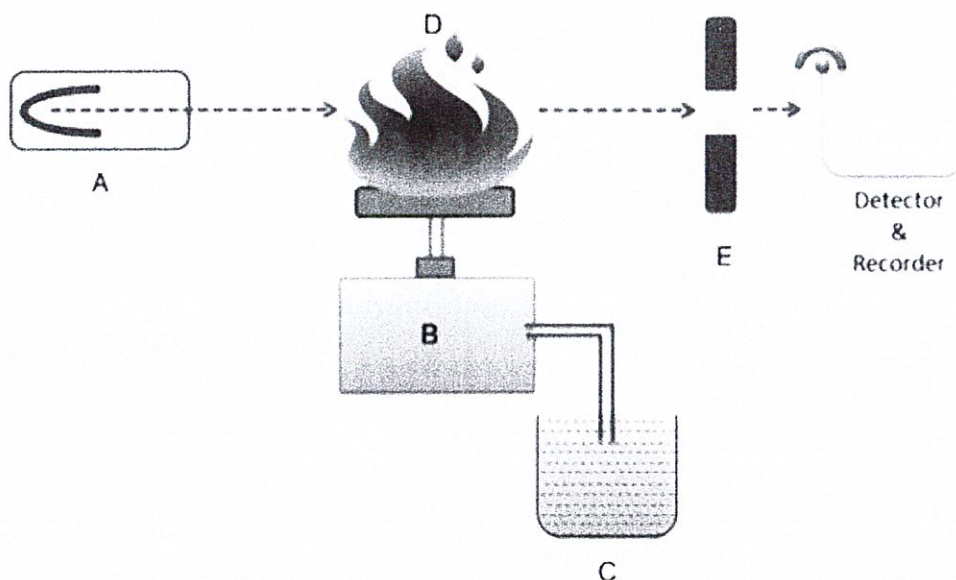


Figure 5: Schematic diagram of AAS

- (a) Identify the components A, B, C, D and E in the AAS diagram. (5 marks)
- (b) State THREE (3) of differences between a flame atomizer and a graphite furnace atomizer in AAS. (6 marks)
- (c) You receive industrial samples containing an organic compound and are asked to determine the functional groups. Explain whether AAS is suitable for this analysis. (4 marks)

- (d) You are required to analyze an unsaturated organic compound. Suggest suitable analytical equipment that can be used for this purpose. (2 marks)
- (e) Explain your choice in Question 5 (d). (3 marks)

Question 6

A calibration curve in Figure 6 below is used for the analysis of caffeine in energy drinks.

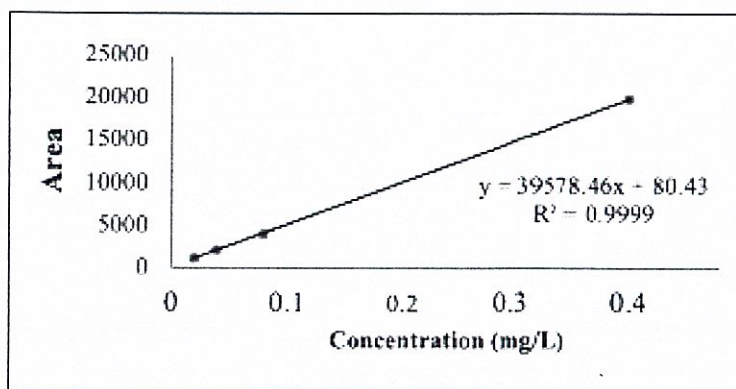
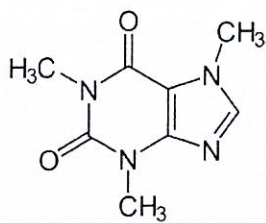
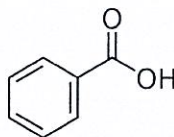


Figure 6: Calibration of caffeine standard solution

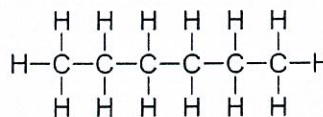
- (a) Calculate the concentration of caffeine in sample A and B if the area are 4007.0 and 19844, respectively. (4 marks)
- (a) The analysis of caffeine in carbonated drink is using two types of solvent as mobile phase. State the function of mobile phase used in caffeine analysis. (2 marks)
- (b) Give FOUR (4) comparison between high performance liquid chromatography (HPLC) and gas chromatography (GC). (8 marks)
- (d) Caffeine, benzoic acid and hexane as shown in Figure 7 are analyzed using reversed-phase HPLC.



Caffeine



Benzoic acid



Hexane

Figure 7: The chemical structure of caffeine, benzoic acid and hexane

- i. Based on the chemical structures, arrange these compounds in order of increasing retention time.
(3 marks)
- ii. Explain the answer of Question 6 (d)(i).
(3 marks)

END OF EXAMINATION QUESTION

APPENDIX I

IR Absorption Correlation Chart

Bond	Compound Type	Frequency range, cm ⁻¹
C-H	Alkynes	3333-3267 (s) stretching
	Alkenes	3100-3000 (m) stretching
	Alkanes	3000-2840 (m) stretching
	Aldehydes	2830-2695 (m, doublet) stretching
C-H	Alkanes	1365-1465 (m) bending
	Aldehydes	1390-1380 (m) bending
	Aromatic compounds	2000-1650 (w) bending
C-C	Alkanes	Below 1200 (variables)
C=C	Alkenes	1680-1600 (m,w) stretching
C=C	Aromatic Rings	1600, 1500 (w) stretching
C $\equiv$ C	Alkynes	2260-2100 (w,sh) stretching
C-O	Alcohols, Ethers, Carboxylic acids, Esters	1260-1000 (s) stretching
C=O	Aldehydes, Ketones, Carboxylic acids, Esters	1810-1670 (s) stretching
O-H	Alcohols, Phenols	3640-3160 (s, br) stretching
	Carboxylic acids	3000-2500 (br) stretching
O-H	Alcohols	1420-1330 (m) bending
	Carboxylic acids	1440-1395 (m) bending
N-H	Amines	3500-3300 (m, sh) stretching
C-N	Amines	1340-1020 (m) stretching
C $\equiv$ N	Nitriles	2260-2220 (v) stretching
C-Cl	Halogen compounds	850-550 (s) stretching
C-Br		690-515 (s) stretching
C-I		600-500 (s) stretching

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

1 H Hydrogen 1.008																	2 He Helium 4.003	
3 Li Lithium 6.941	4 Be Beryllium 9.012																	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305																	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798	
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.293	
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209.982]	85 At Astatine 209.987	86 Rn Radon 222.018	
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]	
																		71 Lu Lutetium 174.967
																		103 Lr Lawrencium [262]
																		70 Yb Ytterbium 173.055
																		102 No Nobelium 259.101
																		69 Tm Thulium 168.934
																		101 Md Mendelevium 258.1
																		68 Er Erbium 167.259
																		100 Fm Fermium 257.095
																		67 Ho Holmium 164.930
																		99 Es Einsteinium [254]
																		66 Dy Dysprosium 162.500
																		98 Cf Californium 251.080
																		65 Tb Terbium 158.925
																		97 Bk Berkelium 247.070
																		64 Gd Gadolinium 157.25
																		96 Cm Curium 247.070
																		63 Eu Europium 151.964
																		95 Am Americium 243.061
																		62 Sm Samarium 150.36
																		94 Pu Plutonium 244.064
																		61 Pm Promethium 144.913
																		93 Np Neptunium 237.048
																		60 Nd Neodymium 144.243
																		92 U Uranium 238.029
																		59 Pr Praseodymium 140.908
																		91 Pa Protactinium 231.036
																		58 Ce Cerium 140.116
																		90 Th Thorium 232.038
																		57 La Lanthanum 138.905
																		89 Ac Actinium 227.028