الجامعة الوطنية
National University
Science & Technology للعلوم والتكنولوجيا
كلية عمان البحرية الدولية
International Maritime College Oman

ACADEMIC YEAR 2023 - 2024

Program	Year	Semester	Paper
PE	2	2	Main

MODULE NAME:	**Analytical Chemistry**		
MODULE CODE:	**PT-TACHEM**	**EXAM DATE:**	**10/06/2024**
INSTRUCTOR's NAME:	**Dr. Muna Al-Hinai**	**DURATION:**	**2.5 hrs.**

Questions to be answered on:	**Allowed tools:**	**Number of pages**
✓ Space provided on the question paper	Pen, Pencil & Calculator	(Incl. cover page)**:** **10**

Points of attention:

- For each question, the maximum earned points are mentioned between brackets at the end of each question.
- Write very clearly! Answers that are not readable are not marked and don't get points!
- Make sure your answers are written to the point.
- All answers should be written **in English.**
- Write all the answers in **blue or black pen only.**
- Use the **pencil** only for **diagrams & graphs.**
- Show all the calculation steps in the given space.
- When finished submit the question paper, together with the answer scripts and the signed cover page to the invigilator.
- Any cheating/copying may result in an instant failing of the examination.

STUDENT NAME:

STUDENT ID:

FINAL MARKS	
	40
	10

Number of answer scripts:……..…….. **Invigilator:**……..……..

Student's signature: …… **Time of receipt:**……..…..

Question 1 Gravimetric Analysis (MLO 1, 3, 4, Understand, analyze, evaluate) (5 Marks)

Soluble organic carbon in sea water sample was analysed as follow: first the sample was treated with potassium sulphate ($K_2S_2O_8$) producing CO_2 which was trapped by a column of NaOH- coated asbestos. 120 ppm carbon was determined when 8.735 g of seawater sample was analysed.

a. State the rule of potassium sulfate? Justify the requirement of this step. **(2 Mark)**

b. Determine the amount of $CO_2(g)$ that was produced in this analysis in milligrams. **(3 Marks)**

Question 2 Titration and Statistics (MLO 1, 2, 3, Understand, appy, analyze) (10 Marks)

(2-(N-morpholino)ethanesulfonic acid) is a weak acid abbreviated as MES (Ka= 7.08 x 10-7). A 50.00 mL sample of MES was titrated with 0.100 mol/L NaOH(aq) solution. The pH of the solution after addition of NaOH(aq) is reported in the Table below. Analyze the table answer the following questions.

Volume of NaOH(aq)	pH
0.00	12.30
5.00	11.85
9.00	11.22
10.00	7.00
10.10	3.08
11.00	2.79

a. Constrcut the titration curve of MES with NaOH(aq). **(3 Marks)**

b. Determine the volume of NaOH(aq) at equivalence point. **(1 Mark)**

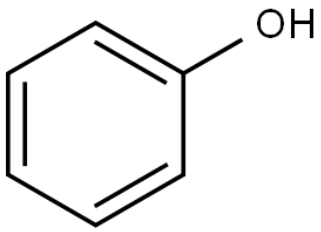
c. Calculate the concentration of MES. **(2 Marks)**

d. The experiment was repeated 3 times to get the average equivalence point. Analyze the results and then calculate the standard deviation for the volume measurement. **(4 Marks)**

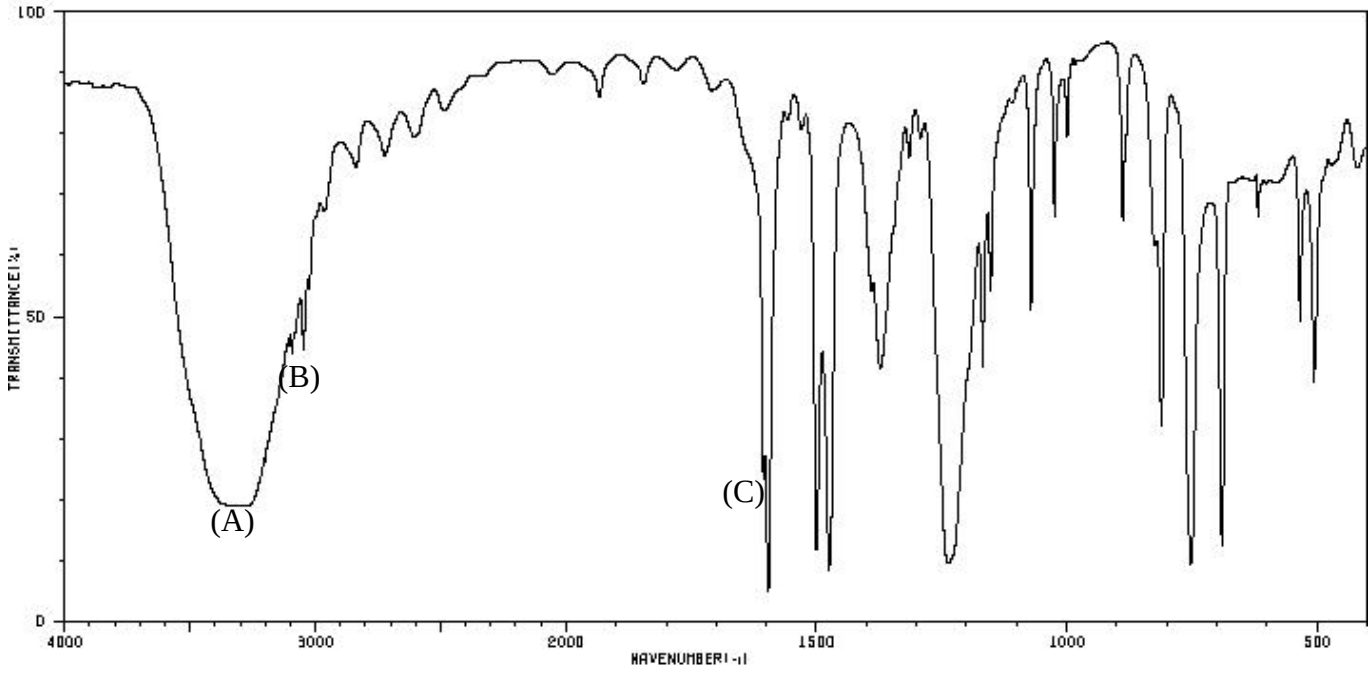
Experiment	Volume of NaOH (aq) (mL)
1	9.90
2	10.00
3	10.10

Question 3 Spectroscopy (10 Marks) (MLO 2, 3, 4, analyze, apply, evaluate)

Phenolic compounds are one of the main contributors to water contamination worldwide. Phenols exists in water channels due to discharge from industrial, agricultural and pharamtecutical activities. These compound are toxic causing serious long- lasting effects on human and animals health including cancer. UV- Visible spectroscopy and FTIR are used to analyze phenol in water. The structure of phenol (Mw 94. 11 g/mol) and it's FTIR spectrum are illustrated below.



Phenol (Mw 94.11 g/ mol)



TFIR spectrum of phenol (Chemical book, 2017)

a. Analyze the FTIR spectrum of phenol and complete the table below. **(6 Marks)**

Peak	Wavenumber (cm^{-1})	Functional group	Energy of the light
A			
B			
C			

Show your caculation of the energy

b. 6.8 mg/ L phenol sample was anlayzed using UV- visible spectroscopy. The absorption was 0.12 at 270 nm that was measured using a 1.00 cm cuvette. Determine the molar aborpitivity of phenol**.** **(2 Marks)**

c. Explain the difference between UV- visible and FTIR radiations on phenol structure.**(2 Marks)**

Question 4 Gas Chromatography (15 Marks) (MLO 2, 3, 4, analyze, apply, evaluate)

Natural gas extraction and separation plants are essential for providing fuel gas and liquified products that support other industries. The composition of the gas should be montired online during the extraction process through gas chromatography. The table below shows the composition of some of the components from NGLE project. Analyze the table and answer the following questions.

Eluated gas	**Retentation time (min)**	**% Concentration**
N_2	1.219	5.472
CH_4	1.741	86.038
C_2H_6	9.595	4.806
C_3H_8	11.959	1.919
CO_2	9.013	0.674

a. Construct a chromatogram for the separation of the components that are reported in the table. **(Hint pay attention to the retention time and the time difference between the components**).

(5 Marks)

b. Determine the retention factor for these components: **(3 Marks)**

Methane CH_4

Ethane C_2H_6

Propane C_3H_8

c. Determaine the relative retention between ethane and methane and evaluate the separation efficiency. Justify your answer **(2 Marks)**

d. Determaine the relative retention between propane and ethane and evaluate the separation efficiency. Justify your answer. **(2 Marks)**

e. By analyzing the retention time of the hydrocarbons that are reported in the table, suggest the mechanism of the separation. Justify your answer. **(2 Marks)**

FTIR Peaks Table

Functional Group	**Wavenumber (cm^{-1})**
OH stretching	3200- 3600
Aliphatic C-C-H stretching	3000-2840
Aromatic C=C-H stretching	3100-3000
C=O	1870-1540
C=C	1670- 1660
C-N	1340- 1250
S=O	1350- 1300
C-O	1310- 1020
N-H	3500

Constants

Plank's constant 6.626×10^{-34} J.s

Speed of light 2.98×10^{8} m/s

References

Harries, D., Freemen, W.H., (2010) *Quantitative Chemical Analysis*. 8th ed. New York: W. H. Freeman and Company

Phenol(108-95-2) IR1, (2017), Chemical Book, Retrieved online on 8th June 2024 from: https://www.chemicalbook.com/SpectrumEN_108-95-2_IR1.htm

Periodic Table of the Elements
1 H Hydrogen 1.008
2 He Helium 4.003
3 Li Lithium 6.941
4 Be Beryllium 9.012
5 B Boron 10.811
6 C Carbon 12.011
7 N Nitrogen 14.007
8 O Oxygen 15.999
9 F Fluorine 18.998
10 Ne Neon 20.180
11 Na Sodium 22.990
12 Mg Magnesium 24.305
13 Al Aluminum 26.982
14 Si Silicon 28.086
15 P Phosphorus 30.974
16 S Sulfur 32.066
17 Cl Chlorine 35.453
18 Ar Argon 39.948
19 K Potassium 39.098
20 Ca Calcium 40.078
21 Sc Scandium 44.956
22 Ti Titanium 47.88
23 V Vanadium 50.942
24 Cr Chromium 51.996
25 Mn Manganese 54.938
26 Fe Iron 55.933
27 Co Cobalt 58.933
28 Ni Nickel 58.693
29 Cu Copper 63.546
30 Zn Zinc 65.39
31 Ga Gallium 69.732
32 Ge Germanium 72.61
33 As Arsenic 74.922
34 Se Selenium 78.09
35 Br Bromine 79.904
36 Kr Krypton 84.80
37 Rb Rubidium 84.468
38 Sr Strontium 87.62
39 Y Yttrium 88.906
40 Zr Zirconium 91.224
41 Nb Niobium 92.906
42 Mo Molibdenum 95.94
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 112.411
49 In Indium 114.818
50 Sn Tin 118.71
51 Sb Antimony 121.760
52 Te Tellurium 127.6
53 I Iodine 126.904
54 Xe Xenon 131.29
55 Cs Cesium 132.905
56 Ba Barium 137.327
57-71 Lanthanides
72 Hf Hafnium 178.49
73 Ta Tantalum 180.948
74 W Tungsten 183.85
75 Re Rhenium 186.207
76 Os Osmium 190.23
77 Ir Iridium 192.22
78 Pt Platinum 195.08
79 Au Gold 196.967
80 Hg Mercury 200.59
81 Tl Thallium 204.383
82 Pb Lead 207.2
83 Bi Bismuth 208.980
84 Po Polonium [208.982]
85 At Astatine 209.987
86 Rn Radon 222.018
87 Fr Francium 223.020
88 Ra Radium 226.025
89-103 Actinides
104 Rf Rutherfordium [261]
105 Db Dubnium [262]
106 Sg Seaborgium [266]
107 Bh Bohrium [264]
108 Hs Hassium [269]
109 Mt Meitnerium [268]
110 Ds Darmsadtium [269]
111 Rg Roentgenium [272]
112 Cn Copernicium [277]
113 Uut Ununtrium unknown
114 Fl Flerovium [289]
115 Uup Ununpentium unknown
116 Lv Livermorium [298]
117 Uus Ununseptium unknown
118 Uuo Ununoctium unknown
57 La Lanthanum 138.906
58 Ce Cerium 140.115
59 Pr Praseodymium 140.908
60 Nd Neodymium 144.24
61 Pm Promethium 144.913
62 Sm Samarium 150.36
63 Eu Europium 151.966
64 Gd Gadolinium 157.25
65 Tb Terbium 158.925
66 Dy Dysprosium 162.50
67 Ho Holmium 164.930
68 Er Erbium 167.26
69 Tm Thulium 168.934
70 Yb Ytterbium 173.04
71 Lu Lutetium 174.967
89 Ac Actinium 227.028
90 Th Thorium 232.038
91 Pa Protactinium 231.036
92 U Uranium 238.029
93 Np Neptunium 237.048
94 Pu Plutonium 244.064
95 Am Americium 243.061
96 Cm Curium 247.070
97 Bk Berkelium 247.070
98 Cf Californium 251.080
99 Es Einsteinium [254]
100 Fm Fermium 257.095
101 Md Mendelevium 258.1
102 No Nobelium 259.101
103 Lr Lawrencium [262]