

Final Exam
ANALYTICAL CHEMISTRY
Fall 2024

Points of attention:

- For each question, the maximum earned points are specified in the question.
- Write clearly! Answers that are not readable are not marked and don't earn marks!
- All answers should be written in English using **blue or black pens** only.
- Use the pencil only for diagrams and 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.

Exam Duration: 2 hours
Instructor's Name:
Exam Date: 05/01/2024
Program: PE

	40
	10

Student Information

Name: ID:
Signature:

Invigilator

Initials: ☐ Student ID checked
Time received:

Question 1**[6 marks]**

Answer all the questions below:

Pure hexane has negligible ultraviolet absorbance above a wavelength of 200 nm. A solution prepared by dissolving 25.8 mg of benzene (C_6H_6) in hexane and diluting to 250.0 mL had an absorption peak at 256 nm and an absorbance of 0.266 in a 1.000 cm cell.

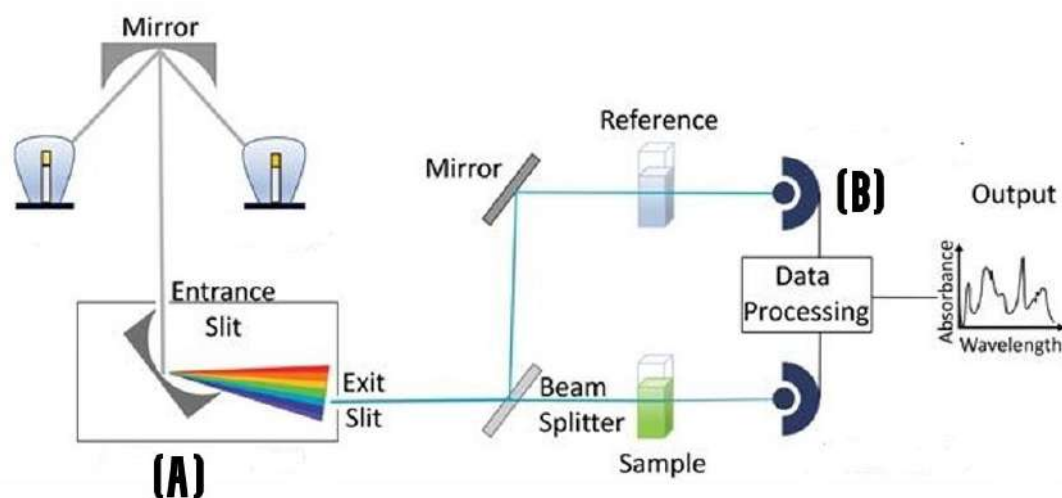
(a) Define UV-Vis Spectrophotometer. (2)

(b) Find the molar absorptivity of benzene at this wavelength. (2)

(c) During a gravimetric analysis of the same solution, the benzene was extracted and dried, yielding a residue of 0.0235 g. Verify whether the concentration determined gravimetrically matches the concentration based on UV-Vis spectrophotometric measurements. (2)

Question 2**[20 marks]**

UV-Vis spectroscopy plays a critical role in monitoring the concentration of chemical substances, ensuring product quality, and optimizing production workflows.



(Daniel C. Harris, 2015)

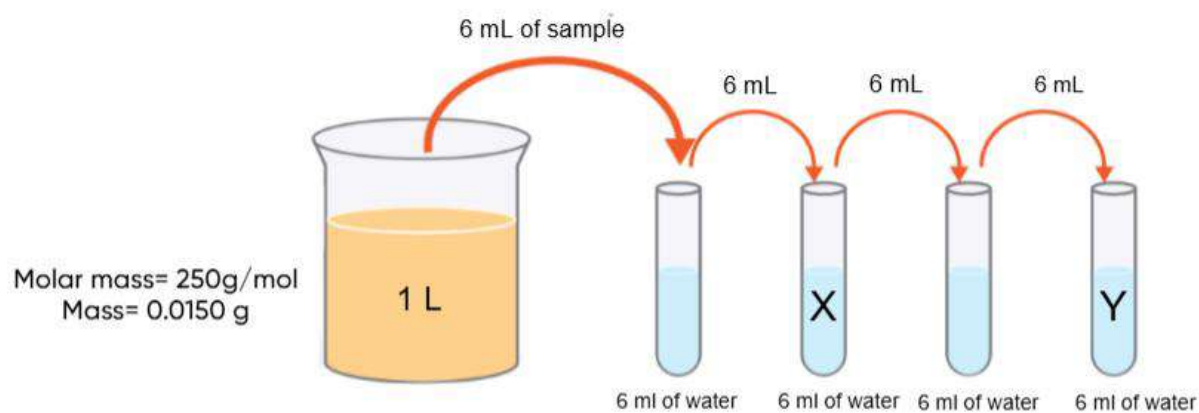
(a) Explain the working principle of a spectrophotometer in detail.

(4)

(b) Identify components (A) and (B) in the UV-Vis spectrometer diagram. Explain their specific roles in spectrochemical analysis. (4)

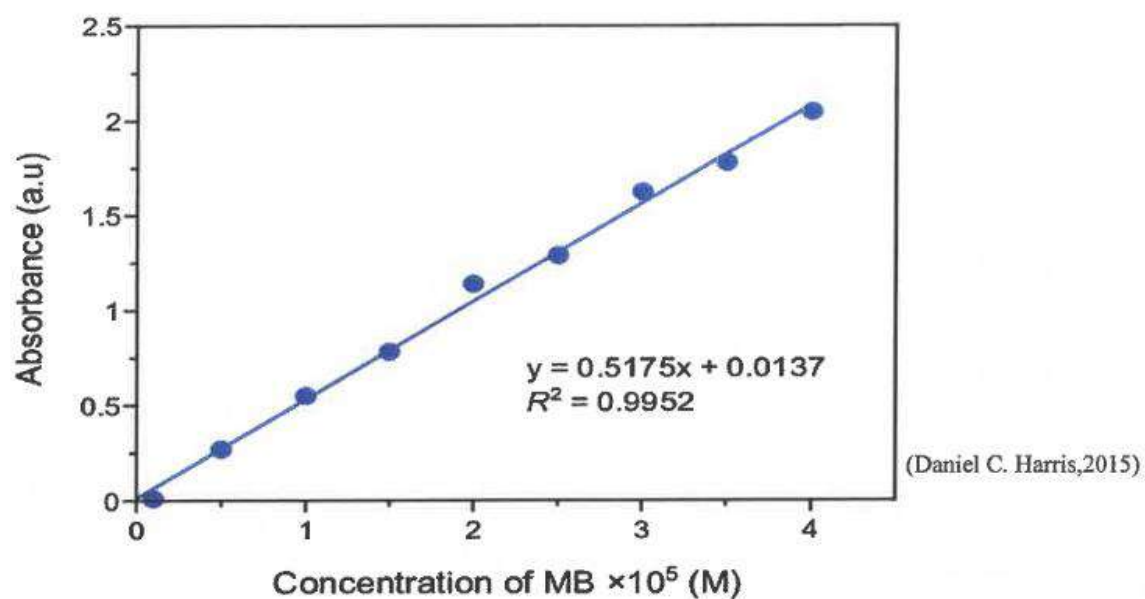
(c) Identify the types of radiation emitted by each lamp (UV or visible) in the diagram and explain the difference between the two types of radiation. (3)

- (d) Analyze the figure below, which illustrates the preparation of standard solutions for UV-Vis analysis. Using the given information, calculate the concentrations of samples X and Y. (5)



(trinset, 2024)

- (e) The calibration curve shown below prepared using a standard solution, is utilized for quality control and process optimization in industrial applications involving methylene blue.

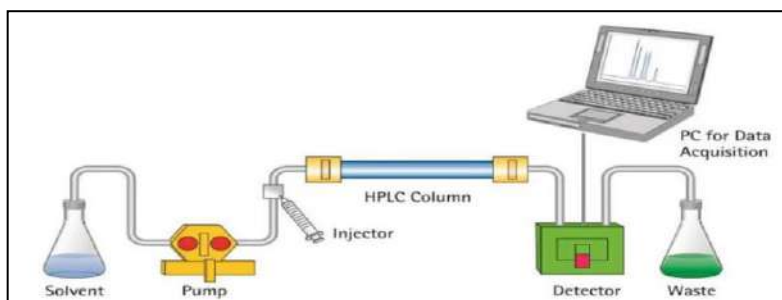


- i. Explain the purpose of a calibration curve and describe how to construct one using a standard solution. (2)

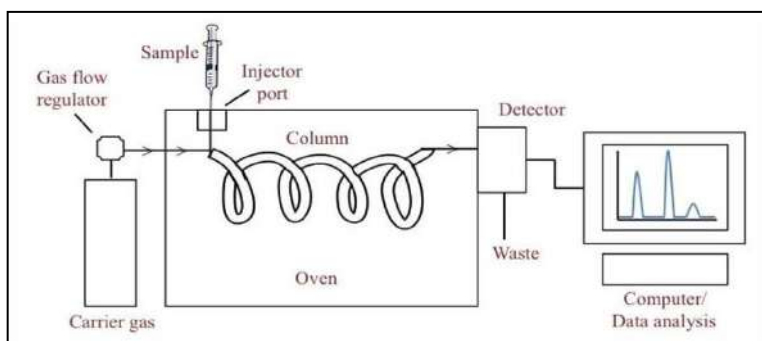
- ii. A methylene blue sample solution has an absorbance of 0.528 (a.u.) after being diluted by a factor of two. Calculate the concentration of the original solution before dilution. (2)

Question 3**[6 marks]**

Chromatography is a fundamental technique in analytical chemistry. Refer to the diagrams labeled A and B, which represent two types of instrumental chromatography, and answer the following:



(Daniel C. Harris, 2015)

(A)

(Daniel C. Harris, 2015)

(B)

(a) Identify the techniques represented in diagrams A and B.

(2)

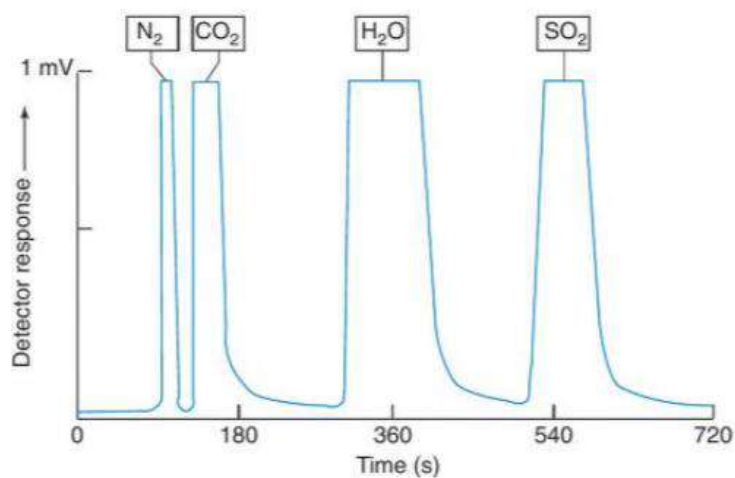
(b) Explain the working principles of technique B.

(2)

- (c)** Compare the two techniques, highlighting their key differences. (2)

Question 4**[4 marks]**

An elemental analyzer is used to determine the composition of a coal sample before it is used in a power plant. The chromatogram shows peaks for N_2 , CO_2 , H_2O , and SO_2 .



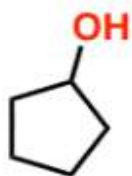
(Daniel C. Harris, 2015)

(a) Based on the diagram, Calculate the retention time for each compound (N_2 , CO_2 , and SO_2).

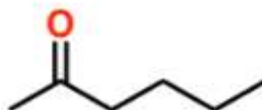
(b) Find the relative retention (a).

Question 5**[4 marks]**

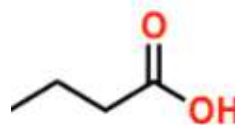
Among the three organic compounds (cyclopentanol, 2-hexanone, and carboxylic acid) identify which molecule corresponds to the IR spectrum (1) and which corresponds to the IR spectrum (2). Provide reasoning based on key functional group absorptions observed in the spectra.



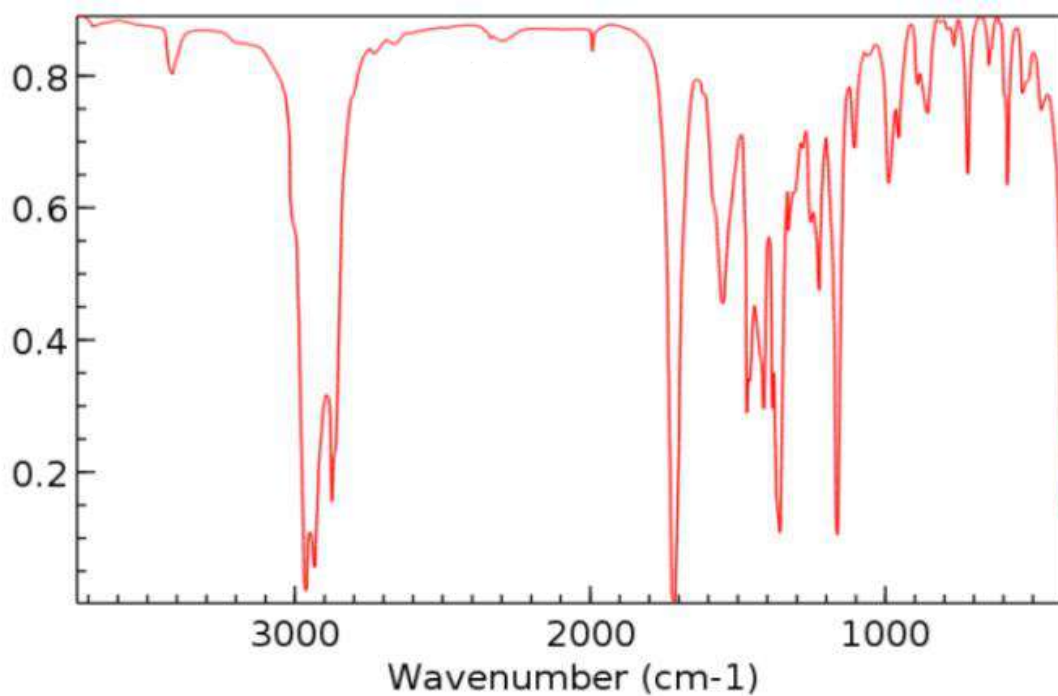
cyclopentanol



2-hexanone

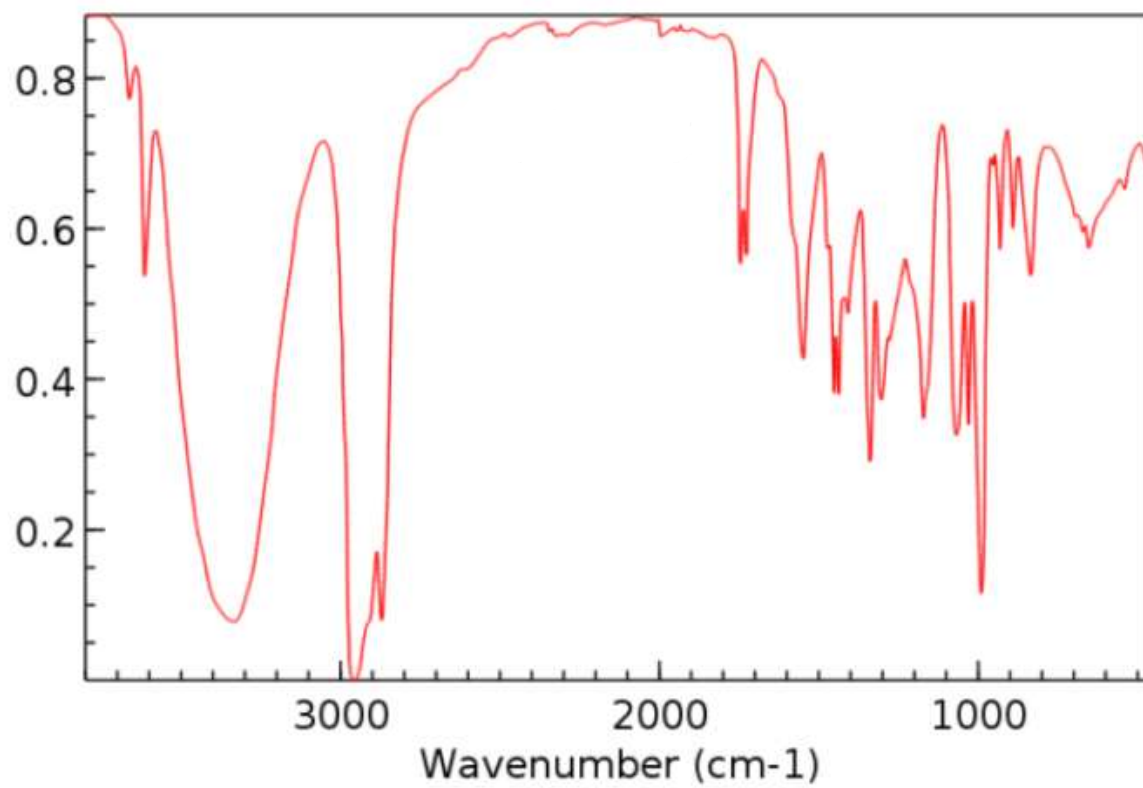


carboxylic acid



(Ashenhurst, 2016)

(1)



(Ashenhurst, 2016)

(2)

Functional Group	Wavenumber Range (cm ⁻¹)
O-H (Alcohol)	3200 - 3600
O-H (Carboxylic Acid)	2500 - 3300
C-H (Alkanes)	2800 - 3000
C-H (Alkenes)	3000 - 3100
C-H (Aromatic)	3000 - 3100
C=O (Ketone)	1650 - 1750
C=O (Aldehyde)	1700 - 1750
C=O (Carboxylic Acid)	1700 - 1725
C=O (Ester)	1735 - 1750
N-H (Amine/Amide)	3300 - 3500
C≡C (Alkyne)	2100 - 2260
C≡N (Nitrile)	2200 - 2260
C=C (Alkene)	1600 - 1680
C-O (Ester, Ether)	1000 - 1300
Aromatic Rings	1450 - 1600

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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 47.88	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 69.723	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 Molybdenum 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 Darmstadtium [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]

Reference:

McMurry, John E., Fay Robert C., and Robinson Jill K. (2016) "Chemistry, 7th Edition", USA, Pearson Education, Inc.

Heaton, A. (1996) (Ed.) An Introduction to Industrial Chemistry. New York: Blackie Academic and Professional.

Ashenhurst, J. (2016) 'Interpreting IR Spectra: A Quick Guide', *Master Organic Chemistry*, 23 November. Available at:

https://www.masterorganicchemistry.com/2016/11/23/quick_analysis_of_ir_spectra/

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MLO and Bloom's Level of Complexity

Q #	MLO Addressed	Complexity Level	Mark	Remark
1	1,3	Analyzing, Evaluating	6	
2	1,2,3	Understanding/Application/Analyzing	20	
3	2	Application	6	
4	1,3	Application/Analyzing	4	
5	3	Analyzing	4	