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

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.

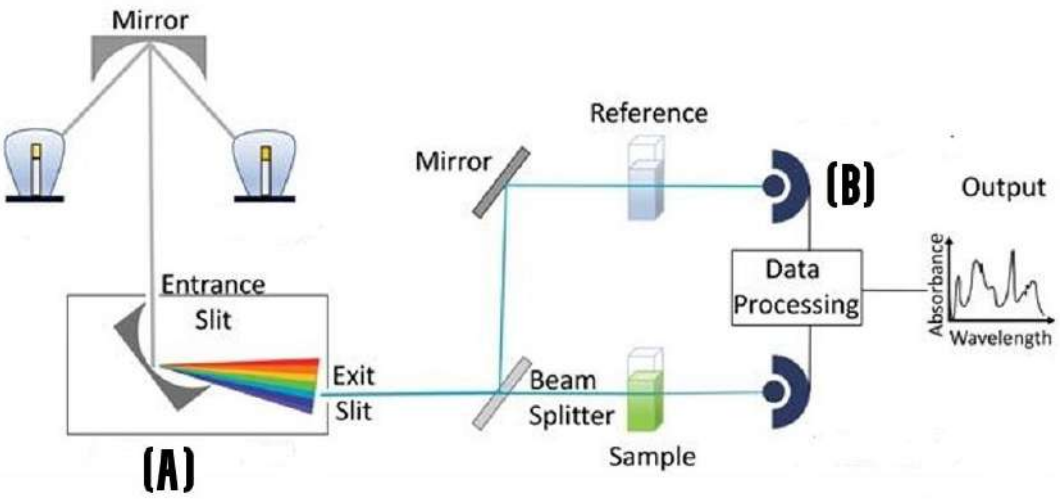
(a) Define UV-Vis Spectrophotometer. (2)

(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.



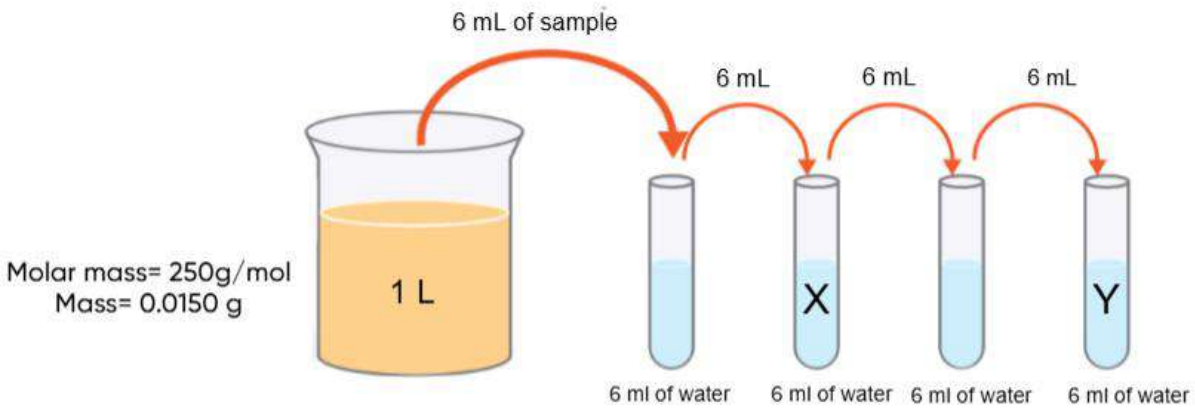
(Daniel C. Harris, 2015)

(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)

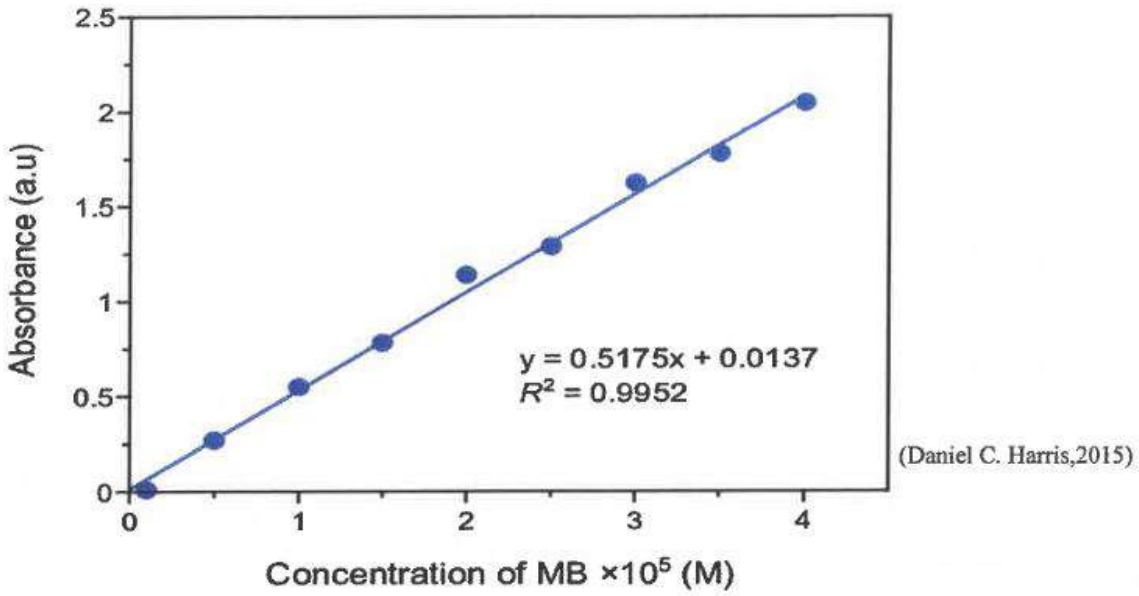
(c) Identify the types of radiation emitted by each lamp (UV or visible) in the diagram and explain the difference between the two types of radiation. (3)

(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.



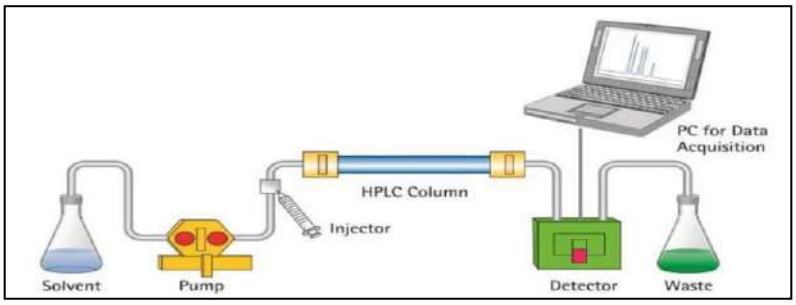
(Daniel C. Harris,2015)

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)

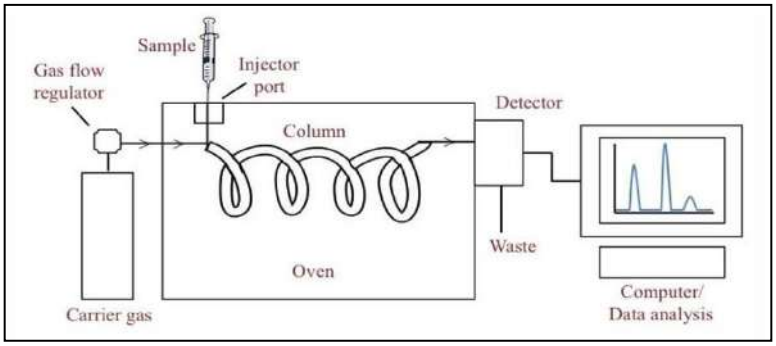
Question 3 **[6 marks]**

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)

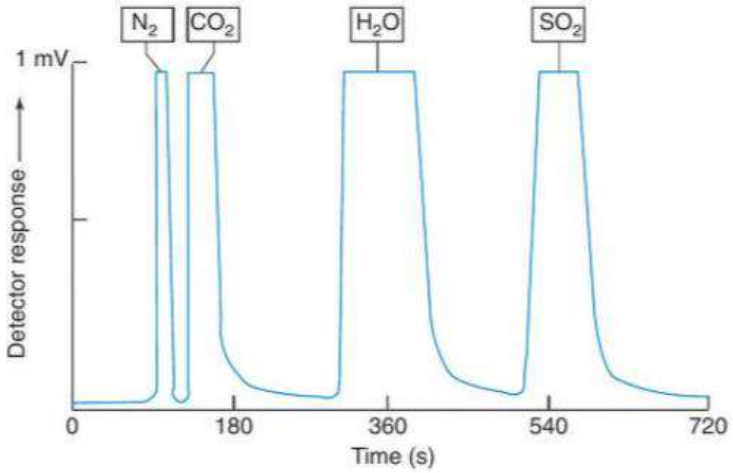
(a) Identify the techniques represented in diagrams A and B. (2)

(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, H2O, and SO_2.



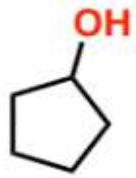
(Daniel C. Harris, 2015)

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

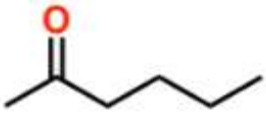
(b) Find the relative retention (α).

Question 5 **[4 marks]**

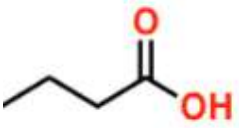
Among the three organic compounds (cyclopentanol, 2-hexanone, and carboxylic acid) identify which molecule corresponds to the IR spectrum (1) and which corresponds to the IR spectrum (2). Provide reasoning based on key functional group absorptions observed in the spectra.



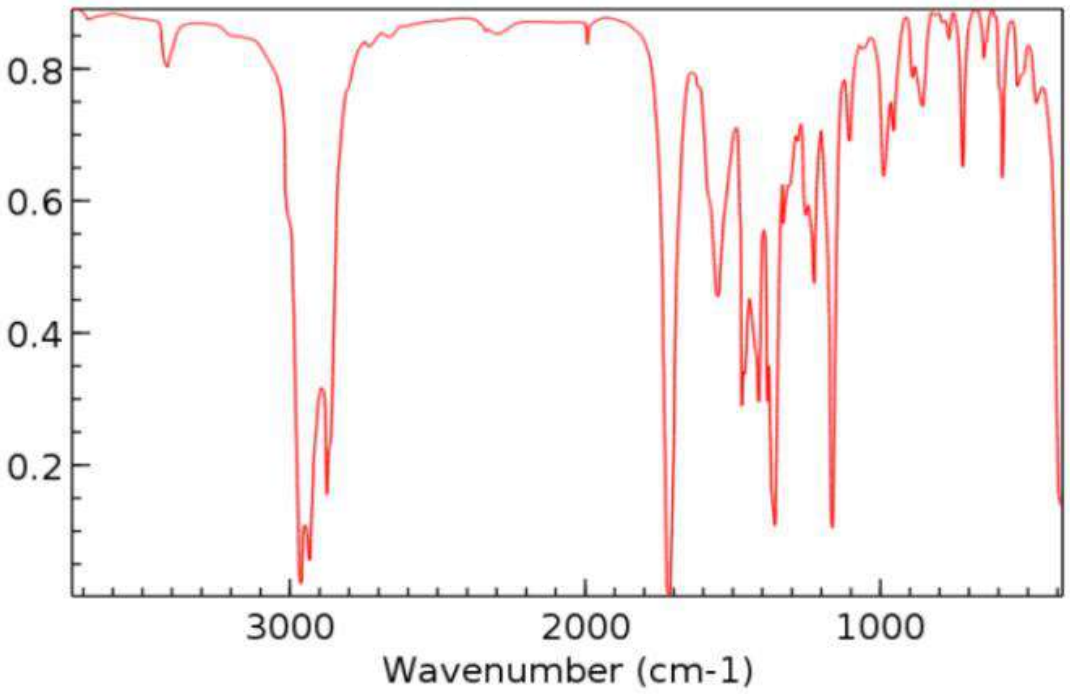
cyclopentanol



2-hexanone

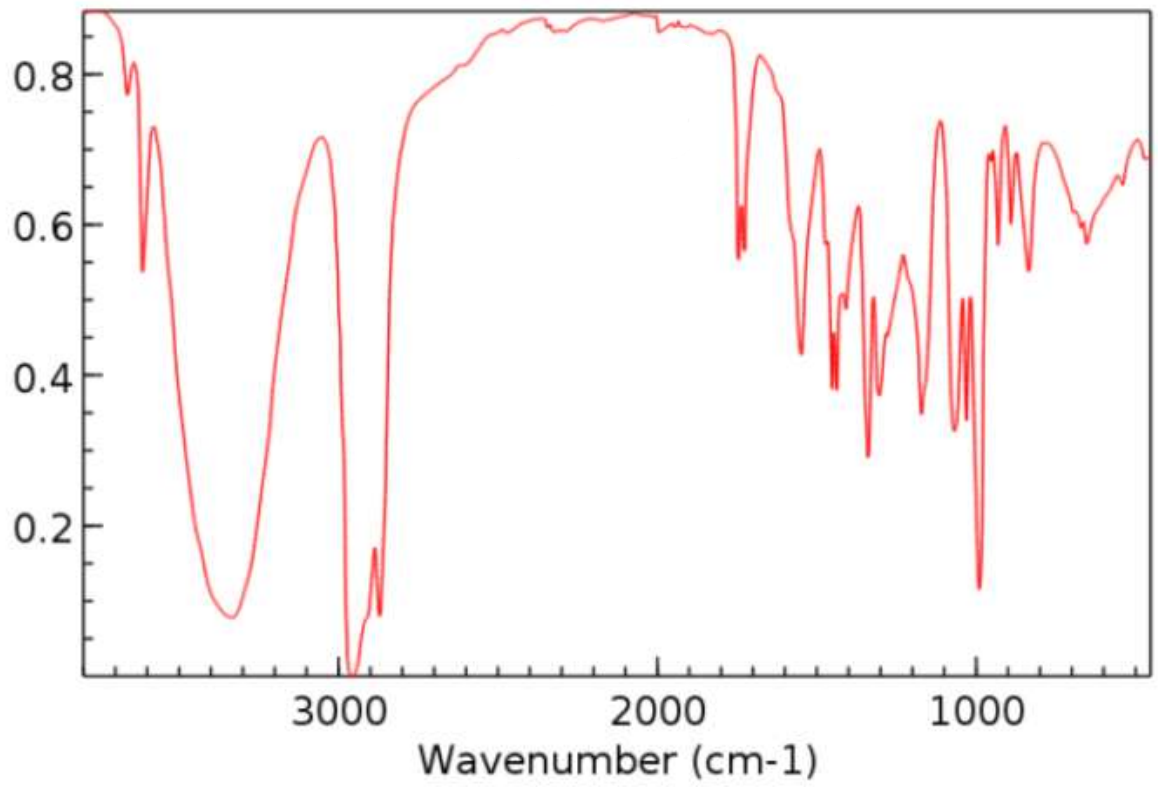


carboxylic acid



(Ashenhurst, 2016)

(1)

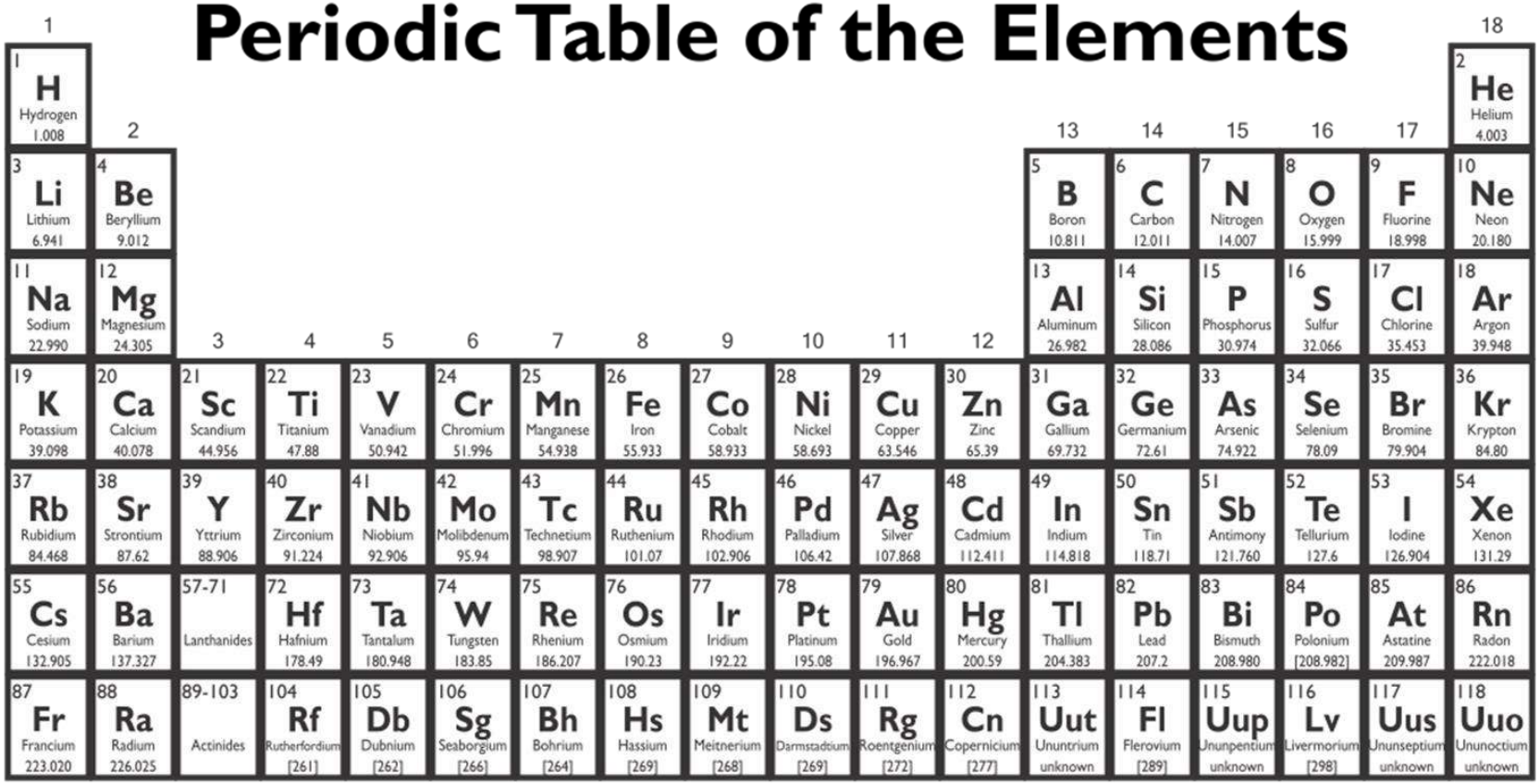


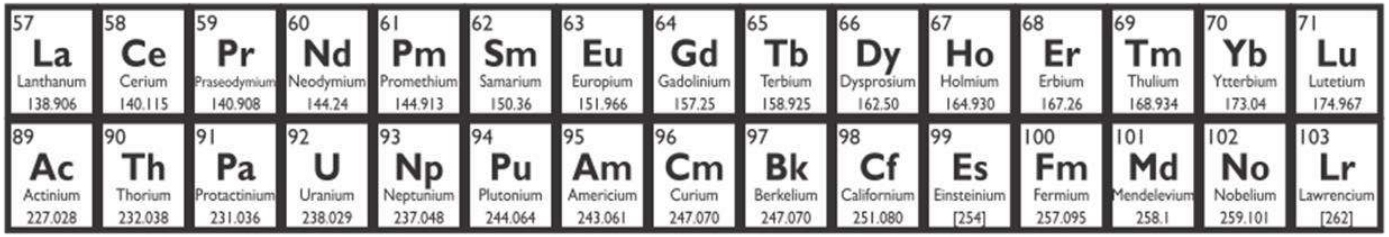
(Ashenhurst, 2016)

(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





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/ (Accessed: 19 December 2024).

trinset (2024) 'Scientific experiment diagram showing the concept of serial dilution for decreasing the concentration of a sample solution', *Adobe Stock*. Available at: https://stock.adobe.com/es/images/scientific-experiment-diagram-show-concept-of-serial-dilution-for-decrease-concentration-of-sample-solution/376087059 (Accessed: 20 December 2024).

Periodic table of Elements, (2021) *Printable*, Retrieved online on 24th April 2022, from: https://www.printablee.com/post_periodic-table-of-elements-printable_400652/

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**	