



SIR ARTHUR LEWIS COMMUNITY COLLEGE
ACADEMIC YEAR (2024/2025) – SEMESTER ONE
END OF SEMESTER EXAMINATION

COURSE TITLE : **FUNDAMENTALS IN ANALYTICAL CHEMISTRY**

COURST CODE : **CHM 216**

LECTURER : **JADA-ANN VITE**

DATE : **Friday 20th December 2024**

TIME : **9.00 – 11.00 AM**

DURATION : **2 HRS**

STUDENT ID# :

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. Write your student's ID number on all the work you hand in.
2. This paper consist of TWO (2) sections.
3. Section A consist of two parts: A and B.
4. Section B consist of 3 structured questions. Write your answer in the space provided.
5. Follow the instructions at the beginning of each section.
6. The use of a silent, non-programmable, scientific calculator is permitted.
7. Do not use correcting fluid.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

SECTION A

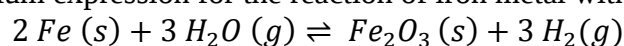
Instructions: *Complete all questions in this section. (50 marks)*

Part 1 – (25 marks)

1. What is the primary goal of sampling in analytical chemistry?
 - (a) To prepare a sample for transportation
 - (b) To ensure that the sample represents the entire population
 - (c) To isolate individual components within a sample
2. A chemical firm was hired to monitor a nearby lake for possible mercury contamination. Several samples were taken at different locations around the lake, including water samples, lake bottom samples, and plant samples. When the chemist returned to the laboratory, the water samples were the first to be analyzed. The analysis began by removing a number of aliquots. An aliquot is
 - (a) a measure of the contamination of the lake water.
 - (b) a combined measure of the contamination in the lake.
 - (c) a precise liquid sample taken for analysis.
3. The steps in a chemical analysis are
 - (a) 1. Formulate the question. 2. Select the analytical procedure. 3. Sample. 4. Prepare the sample. 5. Make replicate measurements of the sample.
 - (b) 1. Select the analytical procedure. 2. Sample. 3. Prepare the sample. 4. Make replicate measurements of the sample. 5. Make a clear and complete written report of your findings.
 - (c) 1. Formulate the question. 2. Select the analytical procedure. 3. Sample. 4. Prepare the sample. 5. Make replicate measurements of the sample. 6. Make a clear and complete written report of your findings.
4. A chemist, following a procedure carefully, was asked to decant a solution. This means
 - (a) stir the solution thoroughly to suspend the solids and pour the mixture into a filtering apparatus.
 - (b) allow any solid material to settle to the bottom of the flask, and then pour off the liquid above the solution.
 - (c) pour the solution from one flask to another.
5. In discussing quantitative and qualitative analysis one could say
 - (a) the two terms are commonly used interchangeably.
 - (b) quantitative analysis deals with determining what materials may be present in a sample.
 - (c) quantitative analysis deals with the quantity of a material present in a sample.
6. When an analytical chemist uses the word precision when referring to the data obtained from an analysis, the chemist is talking about
 - (a) how close the mean obtained from a set of data is to the true value of the composition of the sample analyzed.
 - (b) relative error calculated from the mean of a set of data.
 - (c) how close the individual data points obtained from a set of data are to each other.
7. What is the primary function of NMR spectroscopy in analytical chemistry?
 - (a) To determine the molecular weight of compounds
 - (b) To identify functional groups
 - (c) To provide information about the structure and environment of atoms in a molecule

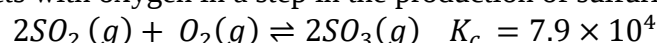
8. Which of the following nuclei is most commonly used in NMR spectroscopy?
- ^{14}N
 - ^1H
 - ^{12}C
9. In mass spectrometry, the peak with the highest m/z value corresponds to which ion?
- The base peak
 - The molecular ion (M^+)
 - The radical cation
10. What does the term "base peak" refer to in a mass spectrum?
- The ion with the lowest m/z value
 - The ion with the highest m/z value
 - The most abundant ion in the spectrum
11. What is the main principle of IR spectroscopy?
- The absorption of ultraviolet light by functional groups
 - The resonance of nuclear spins in a magnetic field
 - The absorption of infrared light by molecular vibrations

12. What is the equilibrium expression for the reaction of iron metal with water vapor?



- $K_c = \frac{[\text{H}_2]^3 [\text{Fe}_2\text{O}_3]}{[\text{Fe}] [\text{H}_2\text{O}]^3}$
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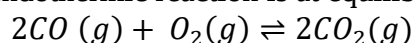
13. Sulfur dioxide reacts with oxygen in a step in the production of sulfuric acid.



For an equilibrium mixture in which $[\text{SO}_2] = 4.5 \times 10^{-3} \text{ M}$ and $[\text{O}_2] = 1.5 \times 10^{-3} \text{ M}$, what is $[\text{SO}_3]$?

- $[\text{SO}_3] = 4.9 \times 10^{-2} \text{ M}$
- $[\text{SO}_3] = 6.2 \times 10^{-7} \text{ M}$
- $[\text{SO}_3] = 0.73 \text{ M}$

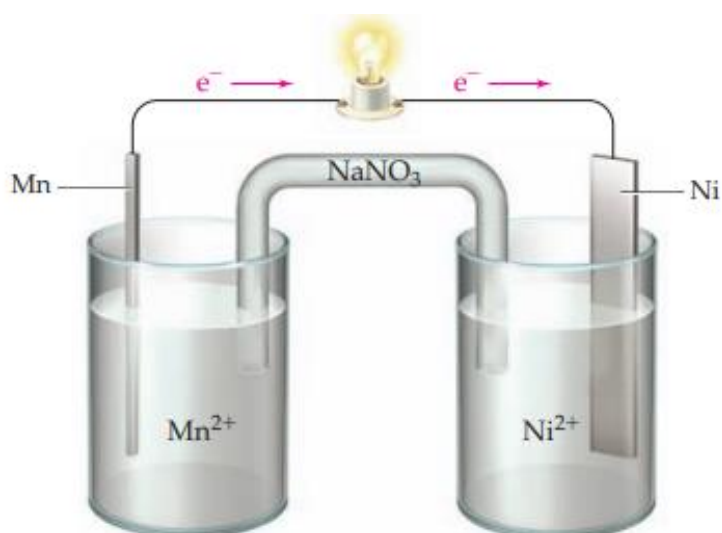
14. Suppose that the following endothermic reaction is at equilibrium:



Which of the following changes would cause the reaction to shift toward products?

- Remove $\text{CO} (g)$.
- Increase the temperature.
- Increase the volume of the container.

Use the following diagram to answer questions 15 and 16 below.



15. What is the reaction occurring at the anode?
- (a) $Mn(s) \rightarrow Mn^{2+}(aq) + 2e^{-}$
 - (b) $Ni(s) \rightarrow Ni^{2+}(aq) + 2e^{-}$
 - (c) $Mn^{2+}(aq) + 2e^{-} \rightarrow Mn(s)$
16. What is the line notation for the galvanic cell?
- (a) $Mn(s) | Mn^{2+}(aq) || Ni^{2+}(aq) | Ni(s)$
 - (b) $Ni^{2+}(aq) | Ni(s) || Mn(s) | Mn^{2+}(aq)$
 - (c) $Mn^{2+}(aq) | Mn(s) || Ni^{2+}(aq) | Ni(s)$
17. In thin-layer chromatography (TLC), the distance a substance travels on the plate relative to the solvent is called the:
- (a) Partition coefficient
 - (b) Retention factor (R_f)
 - (c) Solvent front
18. In chromatography, a substance that moves quickly through the stationary phase has:
- (a) Strong interactions with the stationary phase
 - (b) High solubility in the stationary phase
 - (c) Weak interactions with the stationary phase
19. In an electrolytic cell, which of the following statements is correct?
- (a) Electrons flow from the cathode to the anode
 - (b) Oxidation occurs at the cathode
 - (c) A power source is needed to drive the reaction
20. What is the main function of a salt bridge in an electrochemical cell?
- (a) To allow electrons to flow between the two half-cells
 - (b) To provide ions to balance charge in the half-cells
 - (c) To prevent the mixing of reactants
21. Distillation is primarily used to:
- (a) Separate a mixture based on boiling points
 - (b) Mix two or more substances
 - (c) Increase the concentration of a solution
22. In paper chromatography, substances are separated based on:
- (a) Their boiling points
 - (b) Their solubility and affinity for the paper and solvent
 - (c) Their magnetic properties
23. What is the primary difference between thin layer chromatography (TLC) and paper chromatography?
- (a) TLC uses a solid plate coated with adsorbent instead of paper
 - (b) TLC separates only non-polar substances
 - (c) TLC uses water as the stationary phase
24. Gas chromatography is commonly used to separate:
- (a) Non-volatile substances
 - (b) Volatile compounds
 - (c) Solid compounds
25. The purpose of electrophoresis is to:
- (a) Separate molecules based on their size and charge
 - (b) Measure the density of a compound
 - (c) Analyze the boiling points of compounds

SECTION A

Instructions: *Answer the questions in the space provided.*

Part 2 – (25 marks)

26. (a) State Le Chatelier's principle.

(1 marks)

(b) Write the general expressions for the following terms:

i. pH

(2 marks)

ii. K_c

(2 marks)

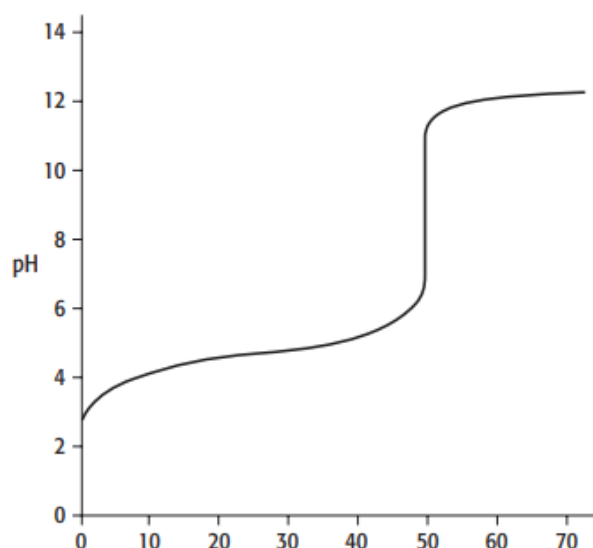
iii. K_w

(2 marks)

(c) What is the pH of 0.25 mol dm^{-3} HCl (aq)?

(2 marks)

(d) The graph below shows how the pH changes when $0.100 \text{ mol dm}^{-3}$ ethanoic acid is titrated with $0.100 \text{ mol dm}^{-3}$ sodium hydroxide.



- i. Explain why methyl orange ($\text{pK}_a = 3.7$) is not a suitable indicator to use for this titration.

(2 marks)

- ii. Would phenolphthalein be a suitable indicator to use for this titration? Explain your answer.

(3 marks)

(e) 20.0 cm^3 of 1.00 M hydrochloric acid were added to 0.482 g of limestone (impure calcium carbonate) and the mixture was stirred until all solid had dissolved. The solution was transferred to a graduated flask and made up to 250 cm^3 with deionised water. A 25.0 cm^3 portion of this solution was neutralised by 12.8 cm^3 of 0.100 M sodium hydroxide solution.

- i. Calculate the number of moles of CaCO_3 present in the limestone sample.

(5 marks)

- ii. Calculate the percentage by mass calcium carbonate present in the limestone sample.

(3 marks)

(f) What type of titration was performed in part (d)? Explain why this was the most appropriate titration to use.

(3 marks)

SECTION B

Instructions: *Answer any two (2) questions. (30 marks)*

Question 1 – Mass Spectrometry and IR Spectroscopy (15 marks)

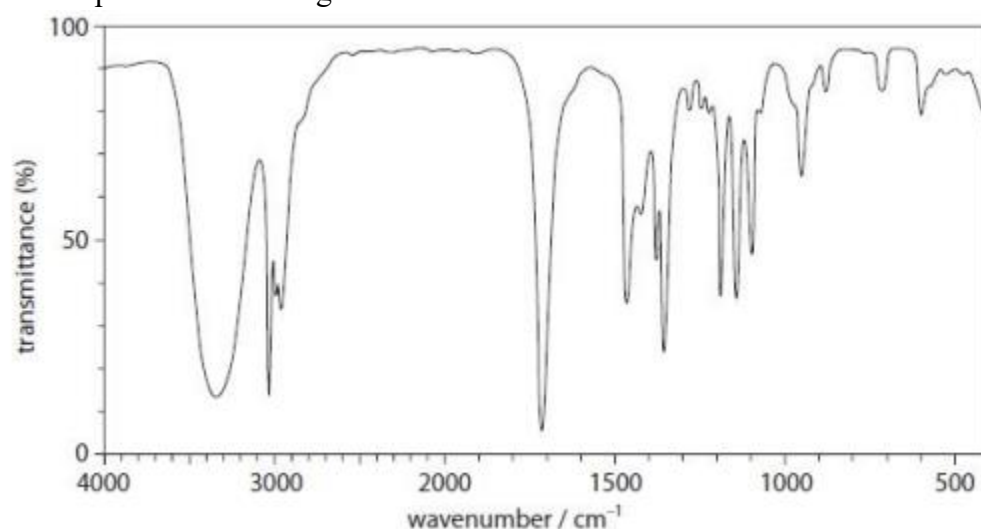
(a) State two (2) uses of mass spectrometry.

(2 marks)

(b) Using a diagram, describe the steps of mass spectrometry.

(8 marks)

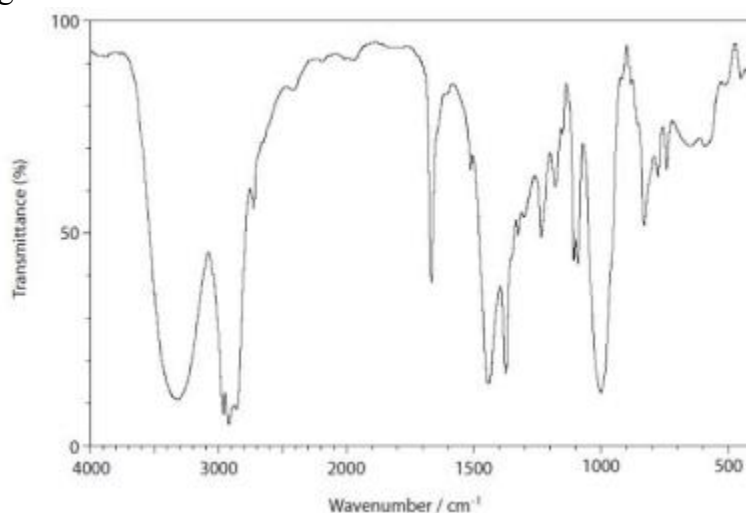
(c) The infrared spectrum of the organic mixture is shown.



By reference to any relevant peak(s), deduce how the infrared spectrum shows that the mixture contains 3-methylbutan-2-one.

(3marks)

(d) Geraniol is an alcohol and a primary component in citronella oil. The infrared spectrum of geraniol is shown below.



Using the table of absorptions from the Data Booklet and the infrared spectrum, give the names of the two functional groups present in geraniol. To confirm these functional groups, give the wavenumber ranges.

(2 marks)

Question 2 – Electrochemistry (15 marks)

The list below gives the standard electrode potentials for five half-reactions.



(a) What is the meaning of standard electrode potential?

(3 marks)

(b) Which species in the list above is:

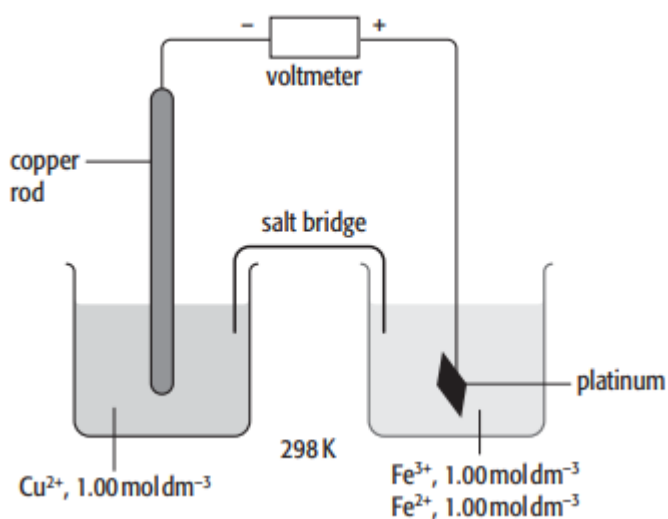
i. The strongest oxidizing agent?

(1 mark)

ii. The strongest reducing agent?

(1 mark)

(c) A cell was set up as shown below.



i. Calculate the standard cell potential of this cell.

(2 marks)

ii. In which direction do the electrons flow in the external circuit? Explain your answer.

(2 marks)

- iii. Write an equation for the complete cell reaction.

(2 marks)

- (d) The concentration of copper(II) ions in the left-hand electrode was increased from 1.00 mol dm^{-3} to 1.30 mol dm^{-3} . The concentration of ions in the right-hand cell was not changed.

- i. What effect does this change have on the E value of the Cu^{2+}/Cu half-cell?

(1 mark)

- ii. What effect does this change have on the E value for the complete electrochemical cell?

(1 mark)

- iii. Why is the direction of the cell reaction unlikely to be altered by this change in concentration?

(2 marks)

Question 3 – Separation techniques (15 marks)

- (a) In all forms of chromatography, there is a mobile and stationary phase. State the mobile and stationary phase for the following:

- i. Thin layer chromatography

Mobile Phase:

Stationary Phase:

(1 mark)

- ii. Gas Chromatography

Mobile Phase:

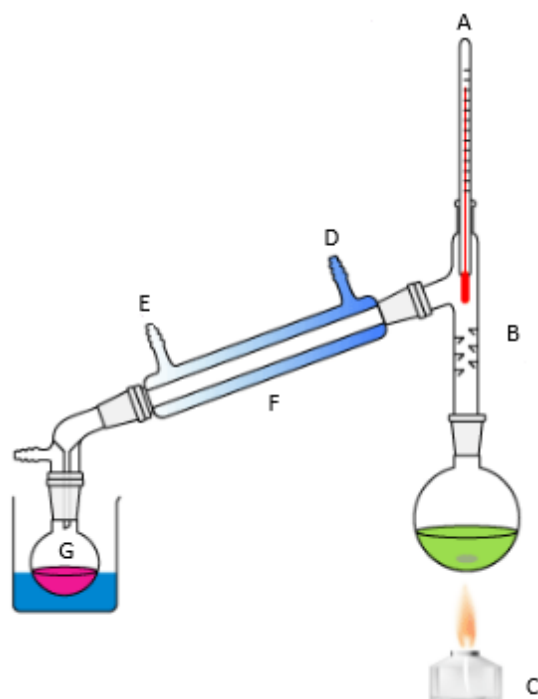
Stationary Phase:

(1 mark)

- (b) Describe the basic principles of chromatography and explain how it can be used to separate and analyze the components of a mixture.

(4 marks)

- (c) A student attempted to separate a mixture of ethanol and water in the lab using the setup shown below.



- i. Label the apparatus shown above.

A:
B:
C:
D:
E:
F:
G:

(6 marks)

- (d) Compare fractional distillation and chromatography as methods of separating mixtures.
Under what circumstances might one method be preferable over the other?

(3 marks)

END OF EXAMINATION

The Periodic Table of Elements

[illegible]

lanthanoids	57	La	lanthanum	138.9	58	Ce	cerium	140.1	59	Pr	praseodymium	140.9	60	Nd	neodymium	144.4	61	Pm	promethium	—	62	Sm	samarium	150.4	63	Eu	euroium	152.0	64	Gd	gadolinium	157.3	65	Tb	terbium	158.9	66	Dy	dysprosium	162.5	67	Ho	holmium	164.9	68	Er	erbium	167.3	69	Tm	thulium	168.9	70	Yb	ytterbium	173.1	71	Lu	lutetium	175.0	
	actinoids	89	Ac	actinium	—	90	Th	thorium	232.0	91	Pa	protactinium	231.0	92	U	uranium	238.0	93	Np	neptunium	—	94	Pu	plutonium	—	95	Am	americium	—	96	Cm	curium	—	97	Bk	berkelium	—	98	Cf	californium	—	99	Es	einsteinium	—	100	Fm	femium	—	101	Md	mendelevium	—	102	No	nobelium	—	103	Lr	lawrencium	—