

[Question of Term Final Examination]

KHULNA UNIVERSITY

School: Science, Engineering & Technology Discipline: Chemistry Program: B.Sc. (Hon's)
Year: Second Term: First Examination Year: 2026 Session: 2024-2025
Course Code: 0531 18 Chem 2101 Course Title: Chemical Thermodynamics
Total Marks: 60 Time: 3 hours Credit: 3.0

- Use separate answer script for each section.
- Figures in the margin indicate full marks. Questions are of equal value.

Section A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1.	a) "Pressure, temperature, and concentration are intensive properties of a system."-explain with an example. [L2, CLO1]	3
	b) Mathematically prove that the maximum work is obtained in a reversible process compared to an irreversible process (you are free to choose any convenient value for n , T , P_1 & P_2). [L5, CLO4]	3
	c) Develop an expression for work done in an adiabatic reversible process of an ideal gas: [L6, CLO4]	4
	$W = \frac{nR(T_2 - T_1)}{\gamma - 1}$	
2.	a) What is the heat of reaction? Derive Kirchhoff's equations for heat change in a chemical reaction. [L1, CLO2]	4
	b) The heat of combustion of carbon monoxide at constant volume and at 290 K is -280 kcal. Calculate its heat of combustion at constant pressure. [L3, CLO2]	3
	c) "Calorific value of fuels and foods can be estimated by heat of combustion"-explain with an example. [L2, CLO2]	3
3.	a) Define heat of neutralization. Why is the value of it for strong acids and bases always constant? [L1, CLO3]	3
	b) State Hess's law. Prove the Hess's law for the formation of NaOH from Na. [L5, CLO3]	4
	c) Calculate the standard heat of formation of propene (C_3H_8) if its heat of combustion is -2000 kJmol^{-1} . The heats of formation of $CO_{2(g)}$ and $H_2O_{(l)}$ are -390 kJmol^{-1} and -285 kJmol^{-1} respectively. [L3, CLO3]	3

4. a) Distinguish between spontaneous and non-spontaneous processes. [L4, CLO1] 2
- b) Describe Carnot cycle for the network done and net heat changes in one cycle. [L2, CLO5] 5
- c) A heat engine operating between two heat reservoirs at 500 K and 300 K absorbs 900 J from the hot reservoir per cycle. How much is discharged into the cool reservoir, and how much work is done per cycle? What is the efficiency of the cycle? [L3, CLO2] 3

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5. a)	What is entropy? Explain entropy change in isolated systems and in physical transformations with suitable examples. [L2, CLO1]	5
b)	Why does the entropy of the universe increase constantly? [L1, CLO1]	3
c)	One mole of an ideal gas expands isothermally and reversibly from 2 mL to 8 mL at 300 K. Calculate the entropy change. [L3, CLO1]	2
6. a)	The change in Gibb's energy that accompanies the oxidation of $C_6H_{12}O_6$ to carbon dioxide and water vapour at 25 °C is $-2828 \text{ kJ mol}^{-1}$. Calculate the grams of glucose a person of mass 70 kg need to consume to climb through 15 m? [L3, CLO1]	5
b)	Along with explaining Helmholtz free energy, justify that: [L6, CLO1]	5
	$\Delta A = \Delta U + T \left[\frac{\partial(\Delta A)}{\partial T} \right]_P$	
7. a)	Derive the integrated form of Clausius-Clapyron Equation. [L6, CLO1]	5
b)	Explain with two examples how ATP drives a non-spontaneous reaction through energy coupling. [L2, CLO2]	5
8. a)	Calculate the ΔG of mixing of 1.0 g of oxygen and 2.0 g of nitrogen gas at room temperature and pressure. [L4, CLO5]	5
b)	Prove that: [L3, CLO2]	5
	i) $\left(\frac{\partial G}{\partial P} \right)_T = V$ and $\left(\frac{\partial G}{\partial T} \right)_P = -S$	
	ii) $\left(\frac{\partial A}{\partial T} \right)_V = -S$ and $\left(\frac{\partial A}{\partial V} \right)_T = -P$	

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KHULNA UNIVERSITY

School: Science, Engineering & Technology **Discipline:** Chemistry **Program:** B.Sc. (Hon's)
Year: Second **Term:** First **Examination Year:** 2026 **Session:** 2024-2025
Course Code: 0531 18 Chem 2103 **Course Title:** Chemistry of Elements
Total Marks: 60 **Time:** 3 hours **Credit:** 3.0

- Use separate answer script for each section.
- Figures in the margin indicate full marks. Questions are of equal value.

Section A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1.	a) Define normal oxide, peroxide, and superoxide with suitable examples. [L1, CLO2]	3
	b) Explain why calcium oxide (CaO) reacts violently with water at room temperature, whereas magnesium oxide (MgO) reacts extremely slowly and requires heating. Justify your comments. [L2, CLO2]	3
	c) Predict which of the following metal oxides behaves as the strongest base in aqueous solution: Li_2O , Na_2O , K_2O , or CaO . Justify your choice. [L5, CLO1]	4
2.	a) Make a list of carbon sources from combine state. [L1, CLO1]	3
	b) Illustrate the thermal extraction process of phosphorus. [L2, CLO1]	4
	c) Analyze the structural reasons why white phosphorus (P_4) is highly unstable and must be stored under water, while red phosphorus (P_n) remains stable in air. [L5, CLO2]	3
3.	a) Analyze the structural and intermolecular factors that cause H_2O to exist as a liquid at room temperature, while H_2S is a gas, despite sulfur having a higher molecular weight than oxygen. [L4, CLO5]	4
	b) Fluorine is the most electronegative element, yet Chlorine has a more negative Electron Gain Enthalpy. Explain your opinion. [L5, CLO4]	3
	c) Why does HI act as a stronger acid than HF, despite Fluorine being more electronegative? [L3, CLO4]	3
4.	a) Explain why sodium (Na) gives an intense yellow flame while magnesium (Mg) shows no color, focusing on excitation energy gaps. [L2, CLO6]	4
	b) Make a list of characteristics of the noble gas. [L1, CLO2]	3
	c) Write a short note on clathrate. [L1, CLO4]	3

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5.	a) Demonstrate the construction of blast furnace for the production of cast iron mentioning the temperature zones and reactions. [L2, CLO4]	5
	b) Suppose you have a piece of iron immersed in salt water. How can you protect it from rusting? [L1, CLO6]	2
	c) Explain the role of coke and limestone during the production of cast iron in blast furnace. [L2, CLO4]	3
6.	a) Discuss in details the extraction of nickel from pentlandite ore. [L6, CLO4]	5
	b) Show the composition of bassemmerised NiS-CuS matte. [L2, CLO4]	2
	c) List some important alloys of nickel and explain their commercial applications. [L4, CLO6]	3
7.	a) Describe the extraction and purification of copper from its sulphide ore by choosing a suitable method. [L6, CLO4]	6
	b) Zn react with dilute H_2SO_4 to produce H_2 , while it reacts with hot and concentrated H_2SO_4 to produce SO_2 -justify. [L5, CLO5]	4
8.	a) The steady decrease in the size of the atoms and ions of the rare-earth elements as the atomic number increases- justify. [L5, CLO5]	2
	b) Describe the consequences of lanthanide contraction when we move across the period. [L6, CLO5]	5
	c) Survey the key chemical characteristics and trends of actinides series over lanthanide series. [L5, CLO5]	3

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KHULNA UNIVERSITY

School: Science, Engineering & Technology Discipline: Chemistry Program: B.Sc. (Hon's)
Year: Second Term: First Examination Year: 2026 Session: 2024-2025
Course Code: 0531 18 Chem 2105 Course Title: Chemistry of Aliphatic and Aromatic Compounds
Total Marks: 60 Time: 3 hours Credit: 3.0

- Use separate answer script for each section.
- Figures in the margin indicate full marks. Questions are of equal value.

Section A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1.	a) Provide a detailed discussion on aromatic character, including conditions for aromaticity and examples of aromatic, antiaromatic, and non-aromatic systems. [L2, CLO1]	4
	b) Why is benzene chemically less reactive than alkenes? [L3, CLO1]	2
	c) Discuss the relative reactivity of benzene, toluene, and nitrobenzene toward electrophilic substitution. [L4, CLO2]	4
2.	a) In the nitration of aromatic compounds: [L4, CLO5]	5
	i) Identify the electrophile and show its formation from a mixture of concentrated H_2SO_4 and HNO_3 .	
	ii) Contrast the reaction conditions (temperature and acid concentration) required for the nitration of benzene versus phenol.	
	iii) Explain why phenol can undergo nitration with dilute nitric acid, while benzene requires a nitrating mixture.	
	b) Compare electrophilic aromatic substitution and nucleophilic aromatic substitution in terms of mechanism and conditions. [L4, CLO4]	3
	c) Explain the limitations of Friedel–Crafts alkylation reactions. [L2, CLO3]	2
3.	a) Outline the steps for the Haworth Synthesis of 1,6-dimethylnaphthalene starting from toluene. List all necessary reagents for every steps. [L6, CLO4]	5
	b) Describe the mechanism of electrophilic substitution in naphthalene, highlighting α - vs β -substitution. [L5, CLO5]	3
	c) Prove that naphthalene contains two identical benzene rings. [L5, CLO2]	2

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|----|----|--|---|
| 4. | a) | Discuss the resonance structures of Phenol and explain how they influence its acidity and reactivity. [L4, CLO1] | 3 |
| | b) | Outline the multi-step synthesis of the acetylsalicylic acid starting from phenol. Provide the detailed mechanism for each stage. [L3, CLO3] | 3 |
| | c) | Propose a synthetic route for N-phenyl-nitrosoamine and salicylaldehyde beginning with phenol. [L5, CLO3] | 4 |

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5.	a) How will you synthesize aldehydes and ketones from alcohol and Grignard Reagents? [L2, CLO3]	4
	b) Give the preparation of Crotonaldehyde and Pinacolone. [L2, CLO3]	3
	c) Distinguish between aldehyde and ketone. [L4, CLO4]	3
6.	a) Carboxylic acids show relatively high water solubility and have abnormally high boiling points-explain. [L2, CLO3]	4
	b) Arrange the following carboxylic acids in order of increasing acidity and briefly give a reason for your answer: α -fluoro, α -bromo, α -chloro, α -iodoacetic acids. [L2, CLO4]	3
	c) What is the Hell-Volhard-Zelinsky reaction, and why is it important in the field of organic synthesis? [L1, CLO5]	3
7.	a) Show the preparation of amine by Hofmann degradation and Gabriel synthesis methods. [L2, CLO4]	4
	b) Arrange the following groups of compounds in order of increasing basicity and justify your answer: dimethylamine, methylamine, and ammonia. [L4, CLO5]	2
	c) How can you separate a mixture of 1°, 2° and 3° amines by reaction with diethyl oxalate? [L1, CLO5]	4
8.	a) Define active methylene compounds and give examples of three of them with structural formulae. [L1, CLO3]	3
	b) Write short note on tautomerism. [L2, CLO3]	2
	c) The chemical behavior of cyanides resembles that of aldehydes and ketone, explain with examples. [L2, CLO3]	3
	d) Complete the following equations: [L2, CLO3]	2
	$CH_3CN + 2H_2O + HCl \rightarrow ?$	
	$CH_3CN + NH_3 \xrightarrow{NaNH_2} ?$	

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School: Science, Engineering & Technology **Discipline:** Chemistry **Program:** B.Sc. (Hon's)
Year: Second **Term:** First **Examination Year:** 2026 **Session:** 2024-2025
Course Code: 0541 18 Math 2151 **Course Title:** Differential Equations and Numerical Analysis
Total Marks: 60 **Time:** 3 hours **Credit:** 3.0

- Use separate answer script for each section.
- Figures in the margin indicate full marks. Questions are of equal value.

Section A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
1. a)	Define transcendental function with example, also find the order and degree of the given ODE, $\frac{d^2 y}{dx^2} = \sqrt{\left(\frac{d^3 y}{dx^3}\right)^2 + \frac{dy}{dx} + 2y}$ [L1, CLO1]	4
b)	Explain the conditions of non-linear ODE, also show that the differential equation of a family of circles touches the x-axis at origin is $(x^2 - y^2)dy - 2xydx = 0$. [L2, CLO 1&2]	6
2. a)	Solve the ODE, $(e^y + 1)\cos x dx + (\sin x + \cos x) dy = 0$ [L3, CLO2]	5
b)	Solve the ODE, $\frac{dy}{dx} + \frac{1}{x}y = x\sqrt{y}$ [L3, CLO2]	5
3. a)	Define integrating factor. Prove that $e^{\int P dx}$ is the integrating factor of the given equation, $\frac{dy}{dx} + Py = Q$, where P and Q are the function of x or constant. [L5, CLO1&2]	4
b)	Solve the ODE, $D^3 y - 2Dy + 4y = e^x \cos x$ [L3, CLO2]	6
4. a)	Evaluate the following, $L \left\{ e^{2t} (3 \cos 3t + t^2 \sin t) \right\}$ [L3, CLO1&2]	4
b)	Apply Laplace transform to solve the following ODEs. $Y'' + Y = 8 \cos t$; $Y(0) = 1, Y'(0) = -1$ [L3, CLO2]	6

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks																								
5.	<p>a) Find the real root of following equation by applying Bisection method. $f(x) = 3x - \cos x - 1$. If the actual root is 0.607102, then find the percentage of error. [L3, CLO1]</p> <p>b) Use the Newton-Raphson method to find the real root of $f(x) = \ln x + x^2 - 4$. Approximate up to 3 decimal places. [L5, CLO1]</p>	5																								
6.	<p>a) Evaluate $\int_0^{\frac{\pi}{2}} \sqrt{1 - \sin^2 \phi} d\phi$ by using Simpson's $\frac{1}{3}$ rule and Simpson's $\frac{3}{8}$ rule. Also, compare the results with the actual integral. [L5, CLO1&3]</p> <p>b) Construct a difference table for the following data. Find $f'(1.0)$ and $f''(1.0)$. If the actual function is $f(x) = \frac{1}{2}(x^3 - x^2)$, then compare your numerical results with the exact analytical values and find the percentage error. [L3, CLO1&3]</p> <table><tr><td>x:</td><td>1.0</td><td>1.2</td><td>1.4</td><td>1.6</td><td>1.8</td><td>2.0</td></tr><tr><td>f(x):</td><td>0</td><td>0.128</td><td>0.544</td><td>1.296</td><td>2.432</td><td>4.0</td></tr></table>	x:	1.0	1.2	1.4	1.6	1.8	2.0	f(x):	0	0.128	0.544	1.296	2.432	4.0	5										
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f(x):	0	0.128	0.544	1.296	2.432	4.0																				
7.	<p>a) The following table gives the population of a town during the last censuses. Estimate using Newton's Backward interpolation formula, the increase in the population during the period from 1944 to 1948. [L5, CLO1]</p> <table><tr><td>Year:</td><td>1911</td><td>1921</td><td>1931</td><td>1941</td><td>1951</td><td>1961</td></tr><tr><td>Population</td><td>12</td><td>15</td><td>20</td><td>27</td><td>39</td><td>52</td></tr></table> <p>b) Define Interpolation and Extrapolation. The following data represents a non-linear relationship. Estimate the value of $f(1.2)$ and $f(1.6)$ using Lagrange Interpolating Method. [L5, CLO1]</p> <table><tr><td>x:</td><td>0</td><td>1</td><td>2</td><td>5</td></tr><tr><td>f(x):</td><td>2</td><td>3</td><td>12</td><td>147</td></tr></table>	Year:	1911	1921	1931	1941	1951	1961	Population	12	15	20	27	39	52	x:	0	1	2	5	f(x):	2	3	12	147	5
Year:	1911	1921	1931	1941	1951	1961																				
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x:	0	1	2	5																						
f(x):	2	3	12	147																						
8.	<p>a) Apply 4th order Runge-Kutta method to estimate the approximation of y when $x = 1$. Given that, $\frac{dy}{dx} = \frac{y-x}{y+x}$ and $y = 1$ when $x = 0$ [Take $h = 0.5$] [L5, CLO1,3&4]</p> <p>b) Find the numerical solution of the initial value problem using Euler's method. $\frac{dy}{dx} = x^2 + y^2$, with $y(0) = 1$. Estimate $y(1)$. [Take $h = 0.2$] [L5, CLO1,3&4]</p>	5																								

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School: Science, Engineering & Technology Discipline: Chemistry Program: B.Sc. (Hon's)
Year: Second Term: First Examination Year: 2026 Session: 2024-2025
Course Code: 0542 18 Stat 2161 Course Title: Introduction to Statistics
Total Marks: 60 Time: 3 hours Credit: 4.0

- Use separate answer script for each section.
- Figures in the margin indicate full marks. Questions are of equal value.

Section A

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks												
1.	a) Distinguish between descriptive statistics and inferential statistics with one practical example of each. [L1, CLO1]	4												
	b) Classify the following variables as qualitative/quantitative and discrete/continuous: [L2, CLO1] i) Number of laboratory accidents ii) Temperature of a solution iii) Blood group iv) Number of absent students	4												
	c) Define statistics with its use in chemistry. [L1, CLO1]	2												
2.	a) Construct a grouped frequency distribution table for the following data using class intervals of 10: 23, 28, 31, 34, 36, 39, 41, 45, 47, 48, 52, 55, 58, 61, 64, 67, 70, 72, 74, 78. [L3, CLO2]	5												
	b) Calculate the weighted mean of marks obtained by a student: [L2, CLO3]	3												
	<table border="1"><thead><tr><th>Course</th><th>Marks</th><th>Credit</th></tr></thead><tbody><tr><td>Chemistry</td><td>75</td><td>3</td></tr><tr><td>Physics</td><td>68</td><td>4</td></tr><tr><td>Mathematics</td><td>82</td><td>2</td></tr></tbody></table>	Course	Marks	Credit	Chemistry	75	3	Physics	68	4	Mathematics	82	2	
Course	Marks	Credit												
Chemistry	75	3												
Physics	68	4												
Mathematics	82	2												
	c) Mention two limitations of pie charts. [L1, CLO1]	2												
3.	a) Calculate the arithmetic mean, geometric mean, and harmonic mean and verify whether $HM \leq GM \leq AM$ holds for the data: 2, 4, 6, 8, 10 and 15. [L4, CLO3]	5												
	b) Explain the difference between absolute and relative measures of dispersion. [L2, CLO2]	3												
	c) Interpret the following values of the correlation coefficient: [L2, CLO2] i) $r = +0.92$ ii) $r = -0.15$ iii) $r = 0$ iv) $r = -0.50$	2												

4. a) Calculate the coefficient of quartile deviation for the dataset: [L4, CLO3] 3
5, 8, 10, 12, 14, 18, 20, 24.
- b) Compute Spearman's rank correlation coefficient for the following data: [L2, CLO4] 5
- | | | | | | |
|---|----|----|----|----|----|
| X | 12 | 18 | 20 | 25 | 30 |
| Y | 15 | 20 | 18 | 30 | 28 |
- c) State two applications of statistics in chemistry research. [L6, CLO1] 2

Section B

There are **FOUR** questions in this section. Answer any **THREE** questions.

Question No.	Question Description	Marks
5. a)	Define sampling and explain its importance in research. [L1, CLO2]	3
b)	Distinguish between the target population, element, and sampling unit with suitable examples. [L2, CLO2]	4
c)	Explain why an improper definition of the target population may produce misleading research findings. [L5, CLO3]	3
6. a)	Formulate null and alternative hypotheses for the statement: "Average iron content in a chemical sample differs from 15 mg." [L3, CLO3]	3
b)	Explain the significance level (α) and p-value in hypothesis testing. [L5, CLO3]	4
c)	A sample of 36 chemistry students has an average laboratory score of 72. The population standard deviation is known to be 12. Test whether the population mean score is greater than 68 and compute the z statistic. [L5, CLO3]	3
7. a)	Differentiate between probability and non-probability sampling. [L5, CLO4]	4
b)	A researcher selects every 8th student from a departmental list after choosing a random starting point. Identify the sampling technique and justify your answer. [L5, CLO4]	3
c)	State one limitation of non-probability sampling. [L2, CLO4]	3
8. a)	Explain what Analysis of Variance (ANOVA) is? Why is it preferred over multiple t-tests when comparing more than two groups in chemical experiments? [L2, CLO5]	4
b)	A chemist tests the effectiveness of three different catalysts in a reaction. Explain how ANOVA can be used to determine whether there is a significant difference among their mean reaction rates. [L2, CLO5]	3
c)	Discuss Type I and Type II errors in hypothesis testing. How do these errors affect decision-making in scientific experiments? [L2, CLO5]	3