

2023

CHEMISTRY — HONOURS

Paper : SEC-A-1 and SEC-A-2

*The figures in the margin indicate full marks.**Candidates are required to give their answers in their own words as far as practicable.*

Paper : SEC-A-1

(Mathematics and Statistics for Chemists)

Full Marks : 80

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LIBRARYAnswer *question no. 1* (compulsory) and *any twelve* questions from the rest.

1. Answer the following questions :

1×20

(a) If $\frac{\partial^2 z}{\partial x \partial y} = \frac{\partial^2 z}{\partial y \partial x}$ for a function $z = f(x, y)$, what does the equality signify?(b) What are the mathematical criteria for $P = f(V)$ to show a minimum at a point V_1 ?(c) One cannot evaluate the limit $\lim_{x \rightarrow 0} \frac{\sin x}{x}$ as the value seems to be $\frac{0}{0}$. Is it true?(d) Justify that $x = 0$ is the only point of inflection for the function $f(x) = x^3$.(e) How $\det(AB)$ is related to the individual determinants $\det(A)$ and $\det(B)$?

(f) What do you mean by a diagonal matrix and an identity matrix?

(g) A single 6-sided die is rolled. What is the probability of rolling a 2 or a 5?

(h) Correct the statement : For independent events, probability is additive, not multiplicative.

(i) Put proper suffixes to complete the following relation :

$$\left(\frac{\partial x}{\partial y}\right)\left(\frac{\partial y}{\partial z}\right)\left(\frac{\partial z}{\partial x}\right) = -1$$

(j) Explain why $f(x) = \ln(x)$ has no Maclaurine expansion.(k) An odd function $f(x)$ can be expanded in the Fourier series as $f(x) = \sum b_n \sin nx$. Give the integral expression of b_n .(l) A square matrix A is called orthogonal if

(i) $A = A^2$ (ii) $A' = A^{-1}$ (iii) $A \cdot A^{-1} = I$

Choose the correct answer.

Please Turn Over

(m) The correlation coefficient between two arbitrary variables x and y is zero, if

(i) $\langle xy \rangle = \langle yx \rangle$ (ii) $\langle x^2 \rangle = \langle x \rangle^2$ (iii) $\langle y^2 \rangle = \langle y \rangle^2$ (iv) $\langle xy \rangle = \langle x \rangle \langle y \rangle$.

Choose the correct answer.

(n) $A_{m \times n}$ and $B_{p \times q}$ are two matrices, when will (i) $A \cdot B$ exist (ii) $A + B$ exist?

(o) Compute the vector's magnitude $5\hat{i} - 4\hat{j} + 2\hat{k}$.

(p) Name a statistical test that compares the means and standard deviations of two samples.

(q) If $y^2 = 4x$ and 0.1% error is incurred for x , find the percentage error involved in y .

(r) Whether $f(x) = x^2 + 1$ is an odd or even function?

(s) Prove mathematically that pressure (P) of a gas that follows equation of state, $P(V-b) = RT$ is a state function.

(t) The result of an analysis is given as 36.97 g, compared with accepted value of 36.6 g. Find the relative error.

2. What do you mean by F test?

The following Table presents the Calcium concentration (mmol/L) of blood as measured by 3 Labs :

Lab - 1	Lab - 2	Lab - 3
2.23	2.35	2.31
2.26	2.28	2.33
2.21	2.29	2.29
2.25	2.28	2.27
2.2	2.27	2.33

The standard deviations of these data for 3 Labs are 0.025, 0.032 and 0.026 respectively.

Perform an F test to determine which pairs of the Labs have similar variances.

Critical F value for this degree of freedom at 95% confidence limit is 6.38.

5

3. (a) Measurements of x and y are given as

x	y
1	2.9
2	5.6
3	8.5
4	13.1

When fitted with a straight line, the slope and intercept came as 3.35 and -0.85 respectively. Calculate the SSR (Sum of square residuals) of this linear fit.

(b) You are given with some data for rate constant for a specific reaction at different temperatures. How will you determine the pre-exponential factor and activation energy from these given data?

3+2

4. Copper yield from an ore by different processes are measured as given below.

Process A	Process B
32.5	29.6
30.5	31.2
29.6	29.7
38.4	37.1
32.8	31.3

Test at 95% confidence level, whether there is a significant difference between these two methods.
 $T_{0.05,4} = 2.78$. 5

5. (a) Evaluate $u \times v$, where u and v are both vectors and are given as

$$u = 3i - j + 2k; \quad v = 2i + 2j - k$$

What will be direction of this product vector?

- (b) If the matrix A is $\begin{bmatrix} i & 3i \\ 2 & 4 \end{bmatrix}$; give the Hermitian conjugate of A . 3+2

6. Solve the following set of equations by Kramer's rule :

$$x + 2y + 3z = 6; \quad 2x + 4y + z = 7; \quad 3x + 2y + 9z = 14$$

5

7. (a) Suppose $A = f(T, V)$; express dA in terms of the partial derivatives of A .

Compare your expression of dA to the given thermodynamic expression $dA = -P dV - S dT$ to show

$$\text{that } S = -\left(\frac{\partial A}{\partial T}\right)_V \text{ and } P = -\left(\frac{\partial A}{\partial V}\right)_T.$$

- (b) Use the above results to prove that

$$\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$$

[A, S are the usual thermodynamic quantities].

3+2

8. (a) For $V = f(r, h)$, suppose that $dV = M(r, h)dh + N(r, h)dr$.

State the condition involving the partial derivatives of $M(r, h)$ and $N(r, h)$ for dV to be an exact differential.

Hence justify that $dV = \pi r^2 dh + 2 \pi r h dr$ is an exact differential.

- (b) Suppose $\left(\frac{\partial U}{\partial V}\right)_T = T\left(\frac{\partial P}{\partial T}\right)_V - P$. Evaluate $\left(\frac{\partial U}{\partial V}\right)_T$ for an ideal gas. 3+2

Please Turn Over

9. (a) State the Maclaurin series for $f(x)$. Hence find the series for $f(x) = e^x$.

(b) Using the given series for $\ln(1+x)$, evaluate the limit $\lim_{x \rightarrow 0} \frac{\ln(1+x) - x}{x^2}$.

$$\text{Given : } \ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots$$

3+2

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10. (a) Show how the Maclaurin series for $f(x)$ and $g(x)$ of the limit $\lim_{x \rightarrow 0} \frac{f(x)}{g(x)}$ leads to the L'Hopital's rule.

(b) State and use the L'Hopital's rule to show that $\lim_{x \rightarrow 0} \frac{1-e^x}{x} = -1$.

3+2

11. Define the error function $\text{erf}(x)$. Plot $\text{erf}(x)$ against x . What is the maximum value of $\text{erf}(x)$? How $\text{erf}(x)$ is related to the complimentary error function $\text{erfc}(x)$? 5

12. (a) Find the Fourier transform of $f(x) = \begin{cases} 1, & \text{for } |x| < 1 \\ 0, & \text{for } |x| > 1 \end{cases}$

(b) Find the angle between two vectors $\hat{A} = \hat{i} - 2\hat{j} + 3\hat{k}$ and $\hat{B} = 3\hat{i} - 2\hat{j} + \hat{k}$.

3+2

13. For the consecutive reaction, $A \xrightarrow{k_1} B \xrightarrow{k_2} C$ (both 1st order); solve the differential equation $\frac{d[B]}{dt} = k_1[A] - k_2[B]$ to find the value of $[B]$. Hence, find the time when $[B]$ will be maximum. Find the maximum value of $[B]$.

$$\text{Given, } [A]_{t=0} = [A]_0$$

$$[B]_0 = 0 = [C]_0$$

5

14. (a) Analysis of a sample of iron ore gave the following percentage values for the iron content : 7.08, 7.21, 7.12, 7.09, 7.16, 7.14, 7.07, 7.18, 7.11. Calculate the mean, standard deviation, relative standard deviation, coefficient of variance and spread of this set of data.

(b) Check whether the function is discontinuous : $f(x) = \frac{x^2 - 9}{3x^2 + 2x - 8}$.

3+2

Paper : SEC-A-2
(Analytical Clinical Biochemistry)

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Full Marks : 80

Answer ~~question no. 1~~ (compulsory) and *any twelve* questions from the rest.

1. Answer *any twenty* questions :

1×20

- (a) Name the sugar present in the chemical structure of nucleic acid (structure not needed).
- (b) If the amino acid glycine has $pK_a = 2.34$ and $pK_b = 9.6$, then what is its pI ?
- (c) Name a chemical which prevents clotting of blood.
- (d) How many hydrogen bonds are present between G and C in a DNA?
- (e) What is called as the active site of an enzyme?
- (f) Mention any two types of secondary structures of protein.
- (g) What is a prosthetic group?
- (h) Write down the name of a sulphur containing amino acid (no structure needed).
- (i) Name an amino acid which has no chiral centre (name only).
- (j) Give an example of a conjugated protein.
- (k) Which sugar is commonly called an 'invert sugar'?
- (l) What is formed when two amino acids are joined by a peptide bond?
- (m) Name the class of enzymes that causes cleavage of bonds.
- (n) Name a compound which is found in all living cells and play a key role in energy transformation.
- (o) Name a physical agent and a chemical agent that causes denaturation of proteins.
- (p) Give an example of anticoagulating agent of blood.
- (q) Name one base present in DNA.
- (r) Name the most abundant animal sterol.
- (s) Name the metabolic waste product resulting from the breakdown of creatinine.
- (t) What is metabolism?
- (u) Draw the chemical structure of glycine.
- (v) What type of reaction is done by the enzyme isomerase?
- (w) What is coagulation of blood?
- (x) In which cellular organelle does the TCA cycle take place?

Please Turn Over

2. (a) What is TCA cycle? Why is it called amphibolic in nature?
(b) Oxaloacetate plays a catalytic role in TCA cycle. Justify. 3+2
3. (a) Define glycolysis. Write down the regulatory steps of glycolysis.
(b) Glycolysis proceeds even in the absence of oxygen. Why? 3+2
4. (a) What is the secondary structure of a protein?
(b) State the essential characteristics of α -helix structure of a protein. 3+2
5. (a) Illustrate with examples the competitive and non-competitive inhibition of enzymes.
(b) What is meant by allosteric regulation of enzymes? 3+2
6. (a) Name any six components present in normal urine.
(b) What is renaturation of proteins? 3+2
7. (a) What is cholesterol? Mention the important biological function of cholesterol.
(b) What is arteriosclerosis? 3+2
8. Describe with a labelled diagram, various features of Watson and Crick model of DNA. 5
9. (a) What are liposomes? Mention one biological function of it.
(b) Differentiate between fats and oils. 3+2
10. (a) How will you collect blood sample from a human being?
(b) How will you preserve a blood sample after collecting from a patient? 3+2
11. (a) Write any three procedures (in brief) to denature a protein.
(b) Write a brief note on the denaturation of proteins. 3+2
12. (a) What are pernicious anaemia and hemolytic anaemia?
(b) State the major complications of uncontrolled diabetes mellitus (*any two*). 3+2
13. (a) Mention three different types and functions of white blood cells.
(b) Name two hormones that play important roles in regulation of sugar in blood. 3+2
14. Briefly explain the alcoholic fermentation and show the chemical reactions (writing of chemical structures not needed) involved. 5