

2024

## 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

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

1. Answer the following questions :

1×20

(a) State order and degree of the following differential equation –

$$\left(\frac{d^4y}{dx^4}\right)^2 + 4x\left(\frac{dy}{dx}\right)^2 + 2\left(\frac{dy}{dx}\right) + 7 = 0$$

(b) Whether  $f(x) = \tan x$  is an odd function or even function?(c) Explain briefly why the error function ( $\operatorname{erf}(x)$ ) satisfies the property  $\operatorname{erf}(-x) = -\operatorname{erf}(x)$ .(d) What is the Fourier coefficient  $a_0$  in terms of the integral of  $f(x)$ ?

(e) What functions are generally used in Laplace transforms (periodic, non-periodic, or both)?

(f) Arrhenius equation :  $k = Ae^{-\frac{E_a}{RT}}$ ; using Taylor series expansion, demonstrate that at high temperature  $k \approx A$ .(g) Solve :  $\frac{dy}{dx} = \frac{y+2}{x-3}$ ,  $y(0) = 1$ .(h) If  $\begin{vmatrix} 2x & 5 \\ 8 & x \end{vmatrix} = \begin{vmatrix} 6 & -2 \\ 7 & 3 \end{vmatrix}$ , find the value of  $x$ .(i) What is the median for a set of integers (38, 40, 28, 33,  $x$ ), given that  $20 < x < 28$ ?(j) Identify the multivalued function(s) among  $x^{\frac{1}{3}}e^{i\frac{2\pi n}{3}}$  for  $n = 0, 1, 2$ ,  $\tan x$  and  $\cos^{-1}x$ .

(k) If two dice are rolled, what is the probability of getting a sum of 7?

(l) Show that  ${}^nP_r = {}^nC_r \times {}^rP_r$ .

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(1403+1188)



- (m) If  $\vec{A} = (2, 3, 4)$  and  $\vec{B} = (1, 2, 3)$ , what is  $\vec{A} \times \vec{B}$ ?
- (n) If the error in measurement of radius of a circle is 5%, what is the error in the calculated area of the circle?
- (o) What is the implication of a normal distribution of errors in analytical chemistry?
- Errors are biased in a specific direction.
  - Errors have a symmetrical, bell-shaped distribution around the mean value.
  - Errors do not follow any particular pattern or distribution.
  - Errors are constant across all measurements.
- (p) What is the best description of precision in analytical data?
- The closeness of measurements to a true value
  - The spread or variability of repeated measurements
  - The degree to which systematic errors affect results
  - The correctness of a single measurement.
- (q) Find the spread of the following set of data :  
0.752, 0.756, 0.752, 0.751 and 0.760.
- (r) For the fitted line  $y = 2x + 1$ , calculate the residual for  $x = 2$  if the observed value  $y_{\text{obs}} = 6$ .
- (s) Given matrix  $A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ , the determinant of  $A$  is  $\det(A) = -2$ . Find  $\det(2A)$ .
- (t) Given  $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$ , evaluate  $\Gamma\left(\frac{5}{2}\right)$ .

2. (a) Determine the root mean square speed of the gas molecules obeying Maxwell distribution of molecular speed in 3-dimension. Use Gamma function to evaluate the integral. Given :  $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$ .

- (b) Find the Fourier transform of  $f(x) = \begin{cases} \frac{1}{2a} & \text{if } |x| \leq a \\ 0 & \text{if } |x| > a \end{cases}$   $2\frac{1}{2} + 2\frac{1}{2}$

3. (a) Solve the equations :  $x + 2y - z = 4$ ;  $3x - y + z = 2$ ;  $2x + y + 2z = 6$  by the matrix method.
- (b) There are 6 positive and 8 negative numbers. Four numbers are chosen at random, without replacement, and multiplied. What is the probability that the product is a positive number?  $3+2$



4. Before determining the amount of  $\text{Na}_2\text{CO}_3$  in an unknown sample, a student decides to check her procedure by analyzing a sample known to contain 98.76% w/w  $\text{Na}_2\text{CO}_3$ . Five replicate determinations of the %w/w  $\text{Na}_2\text{CO}_3$  in the standard were made with the following results

98.71% 98.59% 98.62% 98.44% 98.58%

Is the mean for these five trials significantly different from the accepted value at the 95% confidence level? Given :  $t_{\text{crit}}(0.05,4) = 2.78$ . 5

5. Find the Fourier coefficient and Fourier series of the periodic function  $f(x)$  where  $f(x+4) = f(x)$

outside the interval.  $f(x) = \begin{cases} -k & -2 < x < 2 \\ k & 0 < x < 2 \end{cases}$  5

6. Maxwell Kinetic energy distribution in 3D is given by  $P(\epsilon)d\epsilon = 2\pi \left( \frac{1}{\pi k_B T} \right)^{\frac{1}{2}} \epsilon^{\frac{1}{2}} e^{-\epsilon/k_B T} d\epsilon$  where all

the terms are of usual significance. Using the concept of co-error function, find the fraction of molecules having kinetic energy greater than  $\epsilon'$ . 5

7. Represent graphically (by  $P-V$  curve) the behaviour of a typical van der Waals gas at three different

temperatures ( $T > T_C$ ,  $T = T_C$ ,  $T < T_C$ ). Justify that the condition  $\left[ \frac{\partial P}{\partial V} \right]_T = \left[ \frac{\partial^2 P}{\partial V^2} \right]_T = 0$  serve to give

the critical constants. 5

8. The Gaussian distribution in normalized form is :  $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\left\{ \frac{x-\mu}{\sqrt{2}\sigma} \right\}^2}$ , where terms have their usual meaning.

(a) Find the probability that  $x$  lies between  $(\mu - 0.50\sigma)$  and  $(\mu + 0.50\sigma)$  for a Gaussian distribution.

(b) Show that the above distribution satisfies the normalization condition. 3+2

9. Write down the conditions of an exact differential and show that for the volume ( $V$ ) of an ideal gas  $dV$  is an exact differential. 5

10. (a) Find the limit  $\lim_{x \rightarrow \infty} (x^3 \cdot e^{-x})$  using L'Hopital's rule.

(b) Find the value of  $\left( \frac{\partial V}{\partial T} \right)_P$  for 1 mole of van der Waals gas. 2+3

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11. What is the objective of a 'F-test'? A given sample was analysed by chemists with the following results : 5

Chemist I (g/L) 1.96 1.82 1.70 1.94 1.85 1.40

Chemist II (g/L) 1.35 1.65 1.76 1.41 1.86 1.33

Calculate the F-statistics for these two sets of data.

Given critical F value for 95% confidence interval = 5.143.

12. (a) Show that  $(x - y)\frac{dy}{dx} = (x + 2y)$  is a homogeneous differential equation.

(b) Prove that  $A = \frac{1}{7} \begin{bmatrix} 3 & 2 & 6 \\ -6 & 3 & 2 \\ 2 & 6 & -3 \end{bmatrix}$  is an orthogonal matrix. 2+3

13. Consider the following table :

X	1	2	3	4	5	6	7	8	9	10
Y	1.2	2.1	2.8	2.7	4.5	5	5.5	6.3	8.0	9.0

Find the least square fit straight-line equation using these points. Here X is the independent variable. 5

14. (a) A 2nd order chemical reaction involving one reactant is given by  $-\frac{dc}{dt} = kc^2$ . Solve the differential equation to find 'c' as a function of 't'.
- (b) The carbohydrate content of a glycoprotein is found to be 11.1, 11.9, 13.3, 12.2 and 12.7 (in weight %) in replicate analyses. Find the 50% and 90% confidence intervals for the carbohydrate content. 2+3



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

**Full Marks : 80**

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

1. Answer *any twenty* questions :

1×20

- (a) How many hydrogen bonds are present between A and T in DNA?
- (b) What is cofactor?
- (c) What is a zwitterion?
- (d) In which part of a cell does the glycolysis take place?
- (e) How many peptides bonds are present in a tripeptide?
- (f) Name a pyrimidine base present in RNA but not in DNA.
- (g) Name one acidic and one basic amino acids (no structure needed).
- (h) What is the average lifespan of RBC in blood?
- (i) What is a lipoprotein?
- (j) What is gluconeogenesis?
- (k) What is a holoenzyme?
- (l) Name one monosaccharide and one disaccharide.
- (m) What do you mean by codon?
- (n) What type of reaction is done by an oxidoreductase enzyme?
- (o) Name two important functions of cholesterol.
- (p) Mention two differences between serum and plasma.
- (q) Name a simple protein present in blood.
- (r) Write down the full name of NAD.
- (s) What are ribozymes?
- (t) Name the protein present in wool fibres.
- (u) Name two abnormal constituents of urine.
- (v) Name the rarest blood group.
- (w) Give an example of ligase enzyme.
- (x) What is OKAZAKI fragment?

2. (a) Write a short note on tertiary structure of proteins.  
(b) What is antiparallel beta-pleated sheet of a protein?

3+2

Please Turn Over

(1403+1188)



3. (a) Define lock and key model and induced fit model of enzyme substrate interactions.  
(b) Which one of the above two models is better and why? 3+2
4. (a) Write any three differences between catalysts and biocatalysts.  
(b) Write two differences between coenzymes and cofactors. 3+2
5. (a) Write a brief note on lactic acid fermentation.  
(b) What is the significance of TCA cycle? 3+2
6. (a) Write a brief note on peptide hormones.  
(b) Write any four functions of steroid hormones. 3+2
7. (a) Write down the classification chart of lipids.  
(b) Write one main role of each of any three types of RNA. 3+2
8. (a) What are fats and oils?  
(b) What is a liposome? 3+2
9. (a) What are nonsense codons? Why are they called so?  
(b) Describe replication fork. 3+2
10. (a) What is proteinurea? Mention underlying causes behind it.  
(b) What are ketone bodies? Why are ketones found in urine? 3+2
11. (a) Name the conditions where blood creatinine is elevated.  
(b) Mention any four reasons behind the increased blood sugar. 3+2
12. (a) Mention the risk factors of coronary artery disease.  
(b) What are coding and template strands of DNA? 3+2
13. (a) What are 'good' and 'bad' cholesterol and why are they so named?  
(b) What is meant by pathological urine? 3+2
14. (a) What are pernicious anaemia and sickle cell anaemia?  
(b) What is gene therapy? 3+2
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