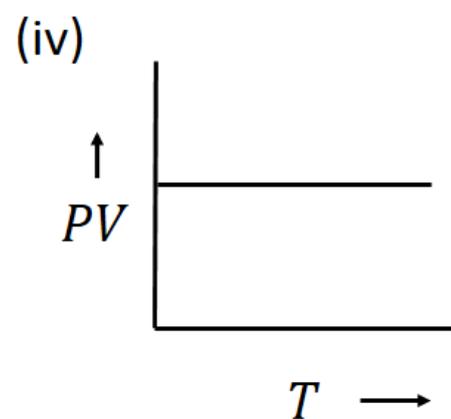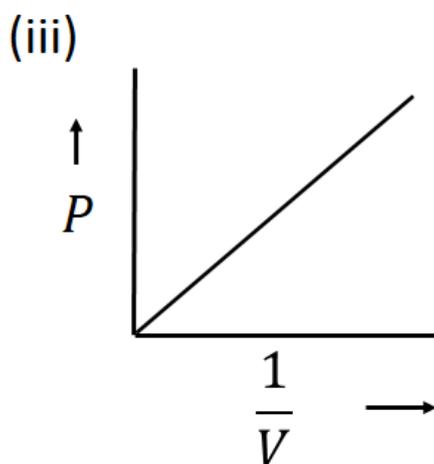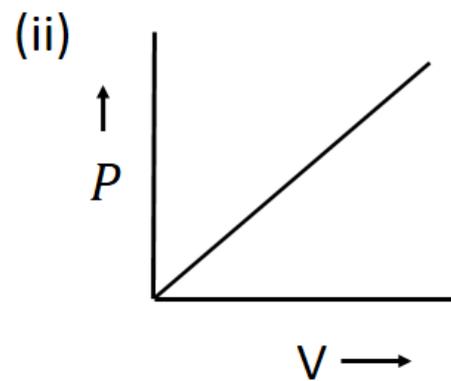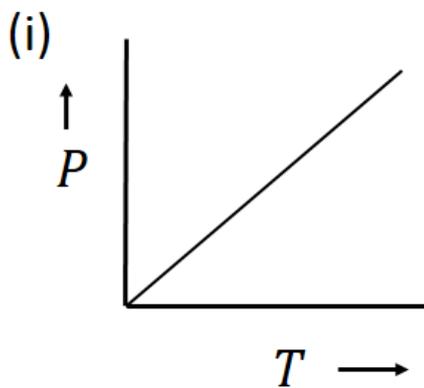## Paper Specific Instructions

1. The examination is of 3 hours duration. There are a total of 60 questions carrying 100 marks. The entire paper is divided into three sections, **A**, **B** and **C**. All sections are compulsory. Questions in each section are of different types.

2. **Section – A** contains a total of 30 **Multiple Choice Questions (MCQ).** Each MCQ type question has four choices out of which only **one** choice is the correct answer. Questions Q.1 – Q.30 belong to this section and carry a total of 50 marks. Q.1 – Q.10 carry 1 mark each and Questions Q.11 – Q.30 carry 2 marks each.

3. **Section – B** contains a total of 10 **Multiple Select Questions (MSQ).** Each MSQ type question is similar to MCQ but with a difference that there may be **one or more than one** choice(s) that are correct out of the four given choices. The candidate gets full credit if he/she selects all the correct answers only and no wrong answers. Questions Q.31 – Q.40 belong to this section and carry 2 marks each with a total of 20 marks.

4. **Section – C** contains a total of 20 **Numerical Answer Type (NAT)** questions. For these NAT type questions, the answer is a real number which needs to be entered using the virtual keyboard on the monitor. No choices will be shown for these type of questions. Questions Q.41 – Q.60 belong to this section and carry a total of 30 marks. Q.41 – Q.50 carry 1 mark each and Questions Q.51 – Q.60 carry 2 marks each.

5. In all sections, questions not attempted will result in zero mark. In **Section – A** (MCQ), wrong answer will result in **NEGATIVE** marks. For all 1 mark questions, 1/3 marks will be deducted for each wrong answer. For all 2 marks questions, 2/3 marks will be deducted for each wrong answer. In **Section – B** (MSQ), there is **NO NEGATIVE** and **NO PARTIAL** marking provisions. There is **NO NEGATIVE** marking in **Section – C** (NAT) as well.

6. Only Virtual Scientific Calculator is allowed. Charts, graph sheets, tables, cellular phone or other electronic gadgets are **NOT** allowed in the examination hall.

7. The Scribble Pad will be provided for rough work.

SECTION – A

MULTIPLE CHOICE QUESTIONS (MCQ)

Q. 1 – Q.10 carry one mark each.

Q.1   Deficiency of the enzyme phenylalanine hydroxylase causes Phenylketonuria. Phenylalanine hydroxylase converts phenylalanine to

(A) tryptophan   (B) alanine   (C) tyrosine   (D) threonine

Q.2   T cells and B cells are

(A) lymphocytes   (B) erythrocytes   (C) epithelial cells   (D) squamous cells

Q.3   In humans, the testis temperature is maintained below the core body temperature with the help of

(A) proximal tubule
(B) loop of Henle
(C) scrotum
(D) seminal vesicles

Q.4   Protein that helps other proteins to fold correctly is

(A) chaperone
(B) proteasome
(C) ubiquitin
(D) desmosome

Q.5   The CORRECT sequence of phases during mitosis is

(A) prophase, metaphase, anaphase, telophase
(B) prophase, anaphase, metaphase, telophase
(C) anaphase, prophase, metaphase, telophase
(D) anaphase, metaphase, prophase, telophase

Q.6   The curve $y = x^4 - 4x^3 + 4x^2 - 4$ has tangents parallel to the x-axis at the following points (x, y)

(A) $(1, 4),\ (-2, 2)\ and\ (0, -1)$
(B) $(0, -4), (2, -4)\ and\ (1, -3)$
(C) $(-1, 2), (-2, 1)\ and\ (1, -2)$
(D) $(1, -4), (1, -3)\ and\ (2, -4)$

Q.7   In viruses, capsids are made up of

(A) proteins   (B) nucleic acids   (C) lipids   (D) sterols

Q.8   The common component in crustacean exoskeleton and fungal cell wall is

(A) lignin   (B) cellulose   (C) chitin   (D) peptidoglycan

Q.9   The CORRECT sequence of evolution (simplest to complex) is

(A) algae, bryophytes, ferns, angiosperms
(B) algae, ferns, bryophytes, angiosperms
(C) bryophytes, ferns, algae, angiosperms
(D) bryophytes, algae, ferns, angiosperms

Q.10   For an ideal gas at room temperature, choose the CORRECT representation(s) of
       Boyle's Law.
       (P = Pressure, V = Volume, T = Temperature)

(i)

$\uparrow$
P

$T \longrightarrow$

(ii)

$\uparrow$
P

$V \longrightarrow$

(iii)

$\uparrow$
P

$\dfrac{1}{V} \longrightarrow$

(iv)

$\uparrow$
PV

$T \longrightarrow$

(A) only (i)   (B) both (ii) and (iii)   (C) only (iii)   (D) both (iii) and (iv)

Q. 11 – Q. 30 carry two marks each.

Q.11 During El Niño,

(A) cold water of the north flowing Peru current is displaced by a low-nutrient warm southward current

(B) warm water of the north flowing Peru current is displaced by a low-nutrient cold southward current

(C) cold water of the south flowing Peru current is displaced by a warm northward current rich in nutrients

(D) warm water of the south flowing Peru current is displaced by a cold northward current rich in nutrients

Q.12 Match the deficiency conditions in Group I with the corresponding vitamin in Group II

Group I   Group II

(P) Beriberi   (1) Ascorbic acid
(Q) Scurvy   (2) Retinol
(R) Birth defects   (3) Thiamine
(S) Night blindness   (4) Folic acid

(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

Q.13 Eutrophication refers to an aging process from a

(A) low production ecosystem to high production ecosystem due to availability of excess nutrients

(B) high production ecosystem to low production ecosystem due to nutrient deficiency

(C) high production ecosystem to low production ecosystem due to light scarcity

(D) low production ecosystem to high production ecosystem due to light scarcity

Q.14 Which one of the following ions has the maximum number of unpaired electrons?

(A) Cu^{2+} (B) Na^+ (C) Cr^{3+} (D) Fe^{3+}

Q.15   Match the enzymes in Group I with the corresponding substrate in Group II

Group I   Group II

(P) Amylase   (1) Protein
(Q) Pepsin   (2) Fat
(R) Lipase   (3) RNA
(S) Ribozyme   (4) Starch

(A) P-2, Q-3, R-1, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-2, R-3, S-1

Q.16   In ABO blood group testing, which one of the following is INCORRECT

(A) A group – agglutination with anti-A antibodies
(B) B group – agglutination with anti-B antibodies
(C) AB group – no agglutination with either anti-A or anti-B antibodies
(D) O group – no agglutination with either anti-A or anti-B antibodies

Q.17   If a coin is tossed three times, what is the probability that NO two successive tosses show the same face?

(A) 0.25   (B) 0.33   (C) 0.20   (D) 0.125

Q.18   Match the RNAs in Group I with their corresponding function in Group II

Group I   Group II

(P) snRNA   (1) rRNA processing
(Q) piRNA   (2) RNA splicing
(R) snoRNA   (3) Selected mRNAs degradation
(S) siRNA   (4) Germ line protection from transposable elements

(A) P-4, Q-3, R-2, S-1
(B) P-4, Q-1, R-3, S-2
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-4, R-1, S-3

Q.19   In a typical mammalian cell, the protein content is 20 % of its net weight. If the density and volume of the cell are 1.2 g/mL and 4×10^{-9} mL, respectively, then the concentration (in mg/mL) of the protein is

(A) 60   (B) 600   (C) 166   (D) 240

Q.20   Consider a spherical particle of mass m and radius r moving in a medium. Its velocity at any time t is given by $v = v_0 \exp\left(\dfrac{-6\pi X r t}{m}\right)$, where v_0 is initial velocity of the particle. The dimensions of X are

(A) MLT^{-1} (B) $M^{-1}LT$ (C) $ML^{-1}T^{-1}$ (D) Dimensionless

Q.21   Match the type of bacterial flagella in Group I with their definitions in Group II

Group I   Group II

(P) Monotrichous   (1) Flagella only at both poles of the cell
(Q) Peritrichous   (2) Two or more flagella at one pole of the cell
(R) Lophotrichous   (3) Flagella distributed over the entire cell
(S) Amphitrichous   (4) A single polar flagellum

(A) P-4, Q-1, R-2, S-3
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-1, R-4, S-2

Q.22   Consider monoatomic ideal gas molecules of equal mass m in thermal equilibrium, at temperature T. Which one of the following equations is correct? (the angular brackets denote average, k_B is Boltzmann constant, v is velocity, and v_x is the x-component of velocity)

(A) $\left\langle \frac{3}{2} m v^2 \right\rangle = \frac{1}{2} k_B T$ (B) $\left\langle \frac{1}{2} m v^2 \right\rangle = \frac{3}{2} k_B T$

(C) $\frac{1}{2} m v^2 = \frac{3}{2} k_B T$ (D) $\left\langle \frac{1}{2} m v_x^2 \right\rangle = \frac{3}{2} k_B T$

Q.23   Match the diseases in Group I with their causative organisms in Group II

Group I   Group II

(P) Syphilis   (1) *Shigella dysenteriae*
(Q) Bacillary dysentery   (2) *Bordetella pertusis*
(R) Gas gangrene   (3) *Treponema pallidum*
(S) Whooping cough   (4) *Clostridium perfringens*

(A) P-2, Q-1, R-4, S-3
(B) P-3, Q-4, R-2, S-1
(C) P-2, Q-3, R-4, S-1
(D) P-3, Q-1, R-4, S-2

Q.24   Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: The difference in the respective melting points of butter and coconut oil is caused by the degrees of saturation of the corresponding fatty acid chain.

Reason [r]: Unsaturated fatty acid chains in fats/lipids become solid more easily because they are relatively straight and thus able to pack together more closely than saturated chain.

(A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are false
(D) [a] is true but [r] is false

Q.25   Match the techniques in Group I with their applications in Group II for protein analysis

Group I   Group II

(P) Nuclear magnetic resonance spectroscopy   (1) Proximity between specific sites
(Q) Fluorescence resonance energy transfer   (2) Concentration
(R) Ultraviolet absorption spectroscopy   (3) Size
(S) Dynamic light scattering   (4) Structure

(A) P-3, Q-1, R-2, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2
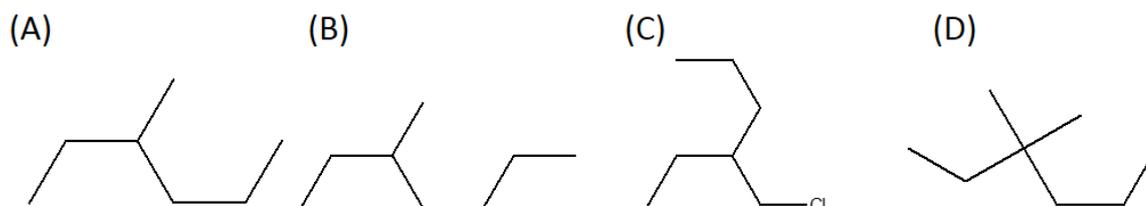

Q.26   The following carboxylic acids have a general formula, R-COOH.

(i)   HCOOH
(ii) CH_3 - COOH
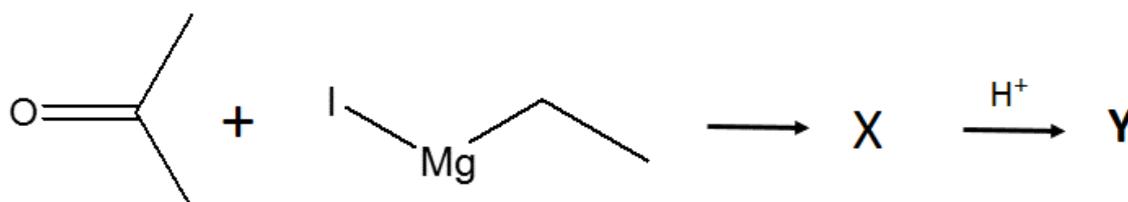(iii) $ClCH_2$ - COOH
(iv) CF_3 - COOH

Which one of the following represents the decreasing order of their respective pK_a values?

(A) i > ii > iii > iv   (B) ii > i > iii > iv   (C) iv > iii > i > ii   (D) iv > iii > ii > i
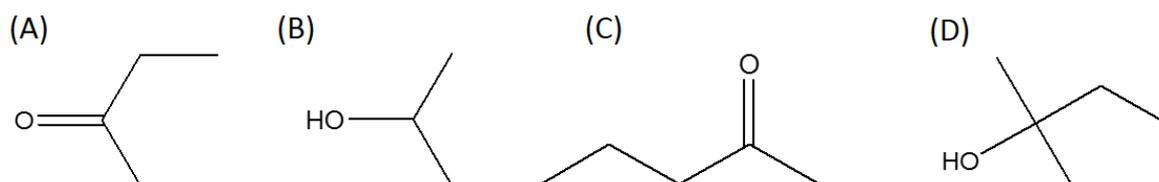
Q.27 Which one of the following compounds is the simplest alkane that is optically active?

(A)   (B)   (C)   (D)

Q.28 In the following reaction, **X** is an intermediate and **Y** is one of the end products.

Which one of the following compounds is the end product **Y**?

(A)   (B)   (C)   (D)

Q.29 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: *lac* operon is an inducible operon.

Reason [r]: *lac* operon is not induced when the repressor protein remains bound to operator DNA sequence.

(A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are false
(D) [a] is true but [r] is false

Q.30   IR spectrum of a compound $C_5H_{10}O$ shows a band at 1715 cm^{-1}. The same compound showed two signals, a triplet and a quartet, in its NMR spectrum. Identify the compound from the following.

(A)   (B)   (C)   (D)
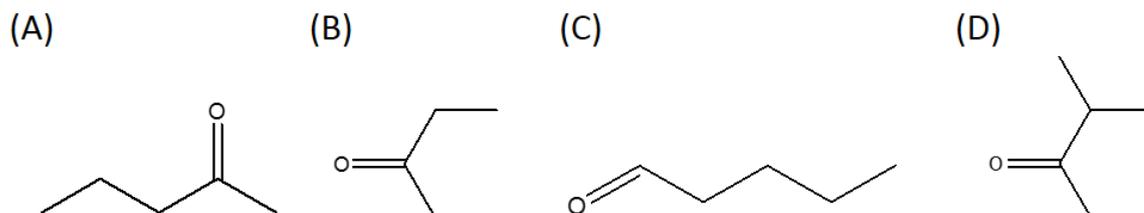
SECTION - B
MULTIPLE SELECT QUESTIONS (MSQ)

Q. 31 – Q. 40 carry two marks each.

Q.31   Which of the following is(are) auxins?

(A) 1-Naphthaleneacetic acid
(B) Indole-3-butyric acid
(C) 2,4-Dichlorophenoxyacetic acid
(D) Indole-3-acetic acid

Q.32   Which of the following is(are) TRUE about photosynthesis?

(A) In C3 plants the first organic product of carbon fixation is 3-phosphoglycerate
(B) In C4 plants the first organic product of carbon fixation is oxaloacetate
(C) Crassulacean acid metabolism occurs in succulent plants living in arid conditions
(D) Oxygen is generated from carbon dioxide

Q.33   Which of the following is(are) involved in the activation of cytotoxic T cells?

(A) MHC I
(B) FcR
(C) T cell receptor
(D) CTLA 4

Q.34　DNA and RNA are acidic in nature due to the presence of

(A) pentose sugar
(B) nitrogenous bases
(C) phosphate groups
(D) large number of hydrogen bonds

Q.35　Which of the following is(are) CORRECT?

(A) Light has wave nature only
(B) Light can have both wave and particle nature
(C) Photo electric effect shows that light can behave like particles
(D) Interference experiments show that light behaves like particles

Q.36　Protozoa are

(A) unicellular　　　(B) multicellular　　　(C) eukaryotic　　　(D) prokaryotic

Q.37　Which of the following curve/straight line equations will pass through the origin when plotted on a graph?

(A) $\dfrac{-x}{2} + \dfrac{y}{2} = 0$

(B) $1 + y + x = 1$

(C) $xy = 1$

(D) $2y - 2x + 2 = 0$

Q.38　Consider two bodies with equal masses of 10^{12} kg each and R distance apart. Let G be the gravitational constant and V_0 be a constant with dimensions of energy. Which of the following represent(s) gravitational potential energy (V) between the bodies, such that Newton's law of gravitation is valid?

(A) $V = \dfrac{-G}{R} 10^{24}$

(B) $V = \dfrac{-G}{R} 10^{24} + 1000\, V_0$

(C) $V = \dfrac{G}{R^2} 10^{24}$

(D) $V = 10^{12} GR$

Q.39　Which of the following is(are) CORRECT?

(A) Both glucose and fructose have the same molecular formula
(B) The positions of the oxygen and carbon differ in the structures of glucose and fructose
(C) Both glucose and fructose have the same physical properties
(D) Both glucose and fructose are monosaccharides

Q.40   Which of the following gas(es) function(s) as signaling molecule(s) in the human nervous system?

(A) Nitric oxide
(B) Carbon monoxide
(C) Helium
(D) Argon

SECTION – C

## NUMERICAL ANSWER TYPE (NAT)

Q. 41 – Q. 50 carry one mark each.

Q.41   The generation time of *E. coli* is 20 minutes. If there are 10^6 *E. coli* present in an exponentially growing synchronous culture, then the average time (in minutes) required to obtain a final population of 4×10^6 *E. coli* is _____.

Q.42   The solution to the integral $\int_0^1 2y\sqrt{1+y^2}\,dy$, rounded off to TWO decimal places, is _____.

Q.43   Let $A = \begin{pmatrix} \sin\theta & \cos\theta \\ \cos\theta & \sin\theta \end{pmatrix}$ and $A + A^T - 2I = 0$, where A^T is the transpose of A and I is the identity matrix. The value of θ (in degrees) is _____.

Q.44   Truth table of a logic gate is given below:

Input A	Input B	Output Y
0	0	1
0	1	1
1	1	0
1	0	X

The value of X in the above table is _____.

Q.45   Consider two particles, each of mass 20 g; the first particle is moving with a speed of 10 m/s along a one-dimensional track in the positive x-direction and collides with the second particle at rest. Assuming that the collision is elastic, the speed (in m/s) of the first particle after the collision is _____.

Q.46   In the following reaction, the values of ΔH and ΔS at temperature 25 $^{\circ}$C are $-13.7\ kcal/mole$ and $-16.0\ cal/(K \cdot mole)$, respectively.

$$Cd^{2+} + 4CH_3NH_2 \rightarrow Cd(CH_3NH_2)_4{}^{2+}$$
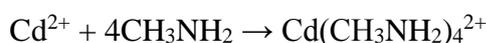
The value of ΔG (in $kcal/mole$) of the reaction, rounded off to TWO decimal places, is _____.

Q.47   The volume (in mL) required to prepare 350 mL of 1X buffer solution from a fifty times (50X) concentrated buffer stock solution is _____.

Q.48   A compound microscope has its objective with linear magnification of 10. In order to achieve a final magnification of 100, the angular magnification of the eyepiece should be _____.

Q.49   The decimal reduction time (DRT or D value) of a bacterial culture is one minute. If a suspension of the bacterial culture contains an initial population of 10^6 cells, then the time (in minutes) required to reduce the number of bacteria to 10 by heat treatment is _____.

Q.50   The median of Y in the following data is _____.

Serial number	1	2	3	4	5	6
Y	22	12	10	14	16	20

Q. 51 – Q. 60 carry two marks each.

Q.51   A variable number of tandem repeats (VNTR) locus has 15 different alleles. The number of genotypes possible in a population for this VNTR is _____.

Q.52   The vibrational frequency (expressed in wavenumber) of $^1H^{35}Cl$ is 2990.6 cm^{-1}. Assuming that the force constant is same in both the cases, vibrational frequency (in cm^{-1}) of $^2D^{35}Cl$ is _____.

Q.53   The length of transverse and conjugate axis in a hyperbola are 6 and 8, respectively. The eccentricity of the hyperbola, rounded off to TWO decimal places, is _____.

Q.54   The solution to the limit $\lim\limits_{x \to 0}\left(\dfrac{2-\sqrt{4-x}}{x}\right)$ is _____.

Q.55   The average value of function $f(x) = \sqrt{9-x^2}$ on $[-3, 3]$, rounded off to TWO decimal places, is _____.

Q.56   A bouncing ball is dropped from an initial height of h meters above a flat surface. Each time the ball hits the surface, it rebounds a distance $r \times h$ meters and it bounces indefinitely. Consider the value of $h = 5$ meters and $r = 1/3$. The total vertical distance (up and down) travelled (in meters) by the ball is _____.

Q.57   One point charge (q) each, is placed along a line at 3 different points x = 0, x = 2 nm and x = 6 nm. The force between two charges separated by 2 nm is 2 piconewton (pN). The magnitude of force (in pN) on the charge in the middle due to the other two charges is _____.

Q.58   Energy of the electron in hydrogen atom in its ground state is 13.6 eV. The energy required (in eV) to move the electron from its ground state to the first excited state, rounded off to TWO decimal places, is _____.

Q.59   At a given time t, velocity (v) and acceleration (a) of a particle undergoing simple harmonic motion are given by

$$v(t) = -100 \sin\left(20t + \frac{\pi}{3}\right),$$

$$a(t) = -2000 \cos\left(20t + \frac{\pi}{3}\right).$$

Assuming all quantities are in SI units, the amplitude of the oscillation is _____.

Q.60   In an enzyme catalyzed first-order reaction, the substrate conversion follows an exponential pattern such that 80 % of the substrate is converted in 10 minutes. The first-order rate constant (in min^{-1}) of the reaction, rounded off to THREE decimal places, is _____.

END OF THE QUESTION PAPER