SECTION – A

MULTIPLE CHOICE QUESTIONS (MCQ)

Q. 1 – Q.10 carry one mark each.

Q.1 The resting membrane potential of a typical neuron is -60 to -80 millivolts because

(A) There are many non-gated K^+ channels, and very few non-gated Na^+ channels
(B) Na^+ moves out of the cell down their concentration gradient
(C) K^+ moves into the cell down their concentration gradient
(D) The Na^+/K^+ pump transports three Na^+ into the cell for every two K^+ out of the cell

Q.2 If 5-bromo-2'-deoxyuridine (BrdU) is added to dividing cells it will be incorporated into the DNA of

(A) Cells in the M phase of the cell cycle
(B) Cells in the G1 phase of the cell cycle
(C) Cells in the S phase of the cell cycle
(D) Cells in the G2 phase of the cell cycle

Q.3 The recombination frequency between gene ***p*** and gene ***q*** is 18%, between gene ***p*** and gene ***r*** is 8.4% and between gene ***q*** and gene ***r*** is 9.6%. Based on this information, the correct linear arrangement of these genes on the chromosome would be

(A) ***p, q, r*** (B) ***r, q, p*** (C) ***r, p ,q*** (D) ***q, r, p***

Q.4 Leeches belong to the phylum

(A) Aschelminthes
(B) Platyhelminthes
(C) Annelida
(D) Arthropoda

Q.5 Based on evidence from fossils, during which of the following geological periods did many of the animal phyla on earth first evolve?

(A) Permian
(B) Jurassic
(C) Carboniferous
(D) Cambrian

Q.6 Birds are most closely related to

(A) Crocodiles
(B) Bats
(C) Dinosaurs
(D) Turtles

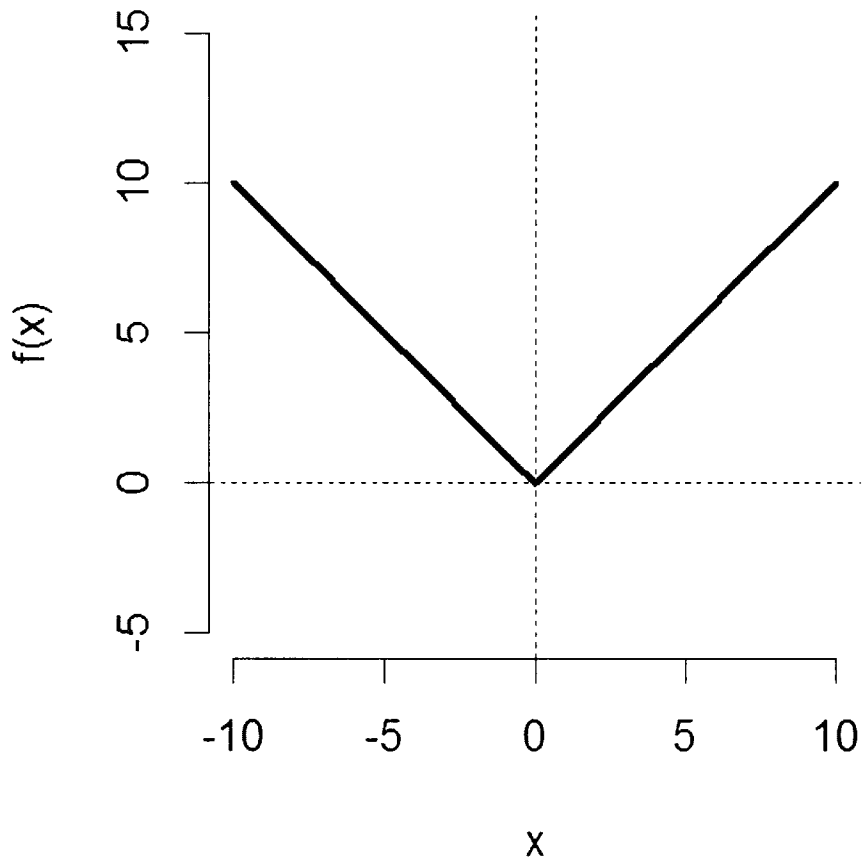
Q.7 In animal cells, phospholipids are built on a backbone of

(A) Ribulose 5-phosphate
(B) Glycerol 3-phosphate
(C) Glucose 6-phosphate
(D) Galactose 6-phosphate

Q.8 Which one of the following enzymes has proof-reading activity?

(A) Polynucleotide kinase
(B) DNA polymerase
(C) DNA ligase
(D) RNA primase

Q.9 Which one of the following is the correct expression for the function f(x) shown in the figure below?



(A) $\mathbf{f(x) = 1/x}$
(B) $\mathbf{f(x) = |x|}$
(C) $\mathbf{f(x) = x^2}$
(D) $\mathbf{f(x) = 1/x^2}$

Q.10 The following infinite series represents

$$1+\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\ldots$$

(A) $\mathbf{e}$ (B) $\boldsymbol{\pi}$ (C) ∞ (D) $\sqrt{5}$

Q. 11 – Q. 30 carry two marks each.

Q.11 Eye colour in fruit flies is an X-linked trait specified by a single locus. The allele for red eye colour is dominant over that for white eye colour. If a white-eyed female fly is crossed with a red-eyed male fly, which of the following would be true of their progeny?

(A) All the male progeny will have white eyes
(B) All the female progeny will have white eyes
(C) Half of the male progeny will have white eyes
(D) Half of the female progeny will have white eyes

Q.12 The body sizes of individuals of a population of frogs on a remote island were measured and found to be normally distributed (Gaussian). After several years with severe winters, the mean body size was found to have significantly increased, although the distribution remained normal (Gaussian). These results can be interpreted to mean that body size is under

(A) Directional selection
(B) Stabilizing selection
(C) Disruptive selection
(D) Group selection

Q.13 The following bacterial DNA segment is transcribed in an ***in vitro*** reaction

5' ATGTGCGGTGCATAC 3'
3' TACACGCCACGTATG 5' (template strand)

The sequence of the RNA generated from this will be:

(A) 5' AUGUGCGGUGCAUAC 3'
(B) 5' UACACGCCACGUAUG 3'
(C) 5'CAUACGUGGCGUGUA 3'
(D) 5'GUAUGCACCGCACAU 3'

Q.14 Which of the following statements on the similarity between bacterial lambda virus and human immunodeficiency virus (HIV) is **NOT** correct?

(A) Both lambda and HIV can establish latency
(B) Both lambda and HIV can integrate into the host genome
(C) Both the viral genomes encode reverse transcriptase
(D) Both the viral genomes are translated by the host cell machinery to produce viral proteins

Q.15 Find the correct combinations of the deficiencies in vitamins (left column) with the defects that they are associated with (right column).

VITAMIN	DEFECT
(i) Vitamin A	(p) Rickets
(ii) Vitamin K	(q) Night blindness
(iii) Vitamin D	(r) Subdermal haemorrhaging
(iv) Vitamin B_{12}	(s) Pernicious anaemia

(A) (i)-(q), (ii)-(r), (iii)-(p), (iv)-(s)

(B) (i)-(r), (ii)-(q), (iii)-(p), (iv)-(s)

(C) (i)-(q), (ii)-(r), (iii)-(s), (iv)-(p)

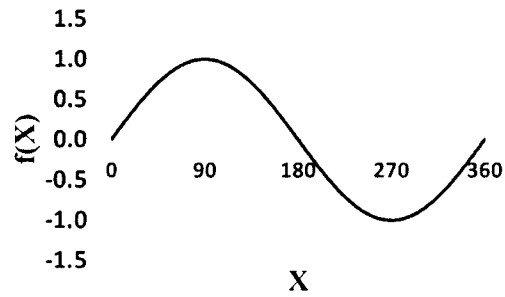
(D) (i)-(r), (ii)-(p), (iii)-(s), (iv)-(q)

Q.16 The enzyme that breaks down $\mathbf{H_2O_2}$ into $\mathbf{H_2O}$ and $\mathbf{O_2}$ in animal cells is usually found in which one of the following intracellular organelles?

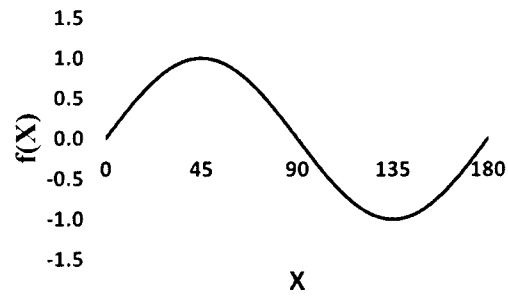
(A) Endoplasmic reticulum
(B) Golgi
(C) Peroxisome
(D) Lysosome

Q.17 Which one of the following correctly represents the function f(X) = sin (2X) where X is angle in degrees?

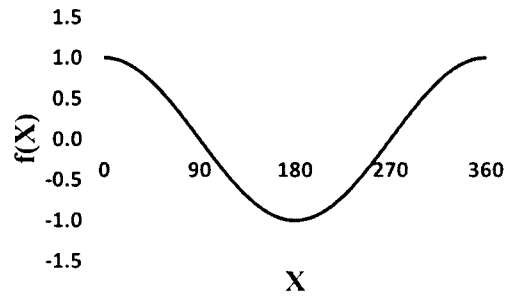
(A)



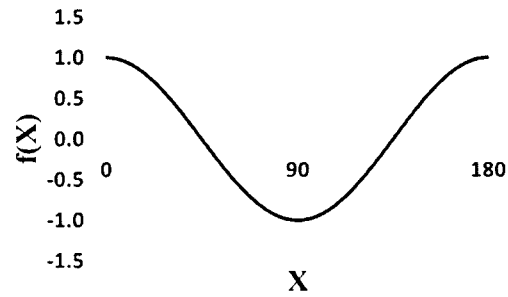
(B)



(C)



(D)



Q.18 If $f(x) = 4x^2\sin(2x)$ then its first derivative is

(A) $4x^2\cos(2x) + 8x\sin(2x)$

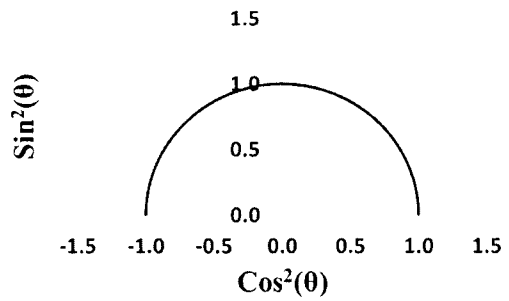
(B) $-4x^2\cos(2x) + 8x\sin(2x)$

(C) $8x^2\cos(2x) + 8x\sin(2x)$

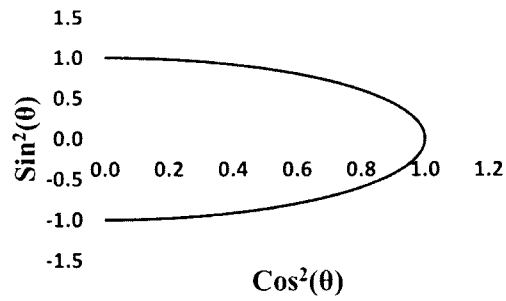
(D) $-8x^2\cos(2x) + 8x\sin(2x)$

Q.19 Which one of the following correctly represents the relationship between values of $\sin^2(\theta)$ and $\cos^2(\theta)$?

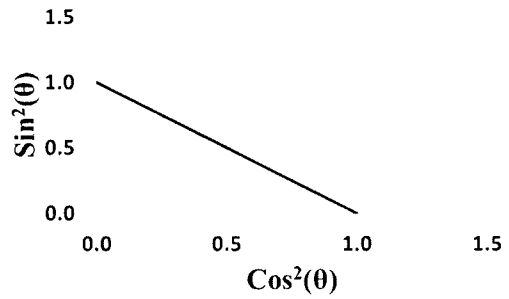
(A)



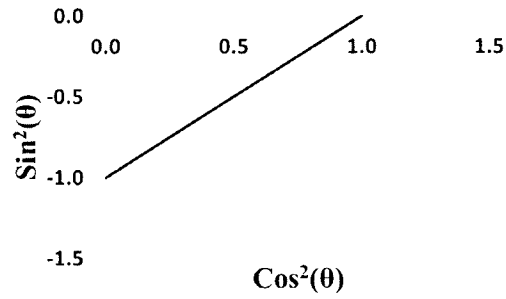
(B)



(C)



(D)



Q.20 Which of the following **DOES NOT** happen in the loop of Henle of a nephron in the human kidney?

(A) Water moves out from the descending arm of the loop of Henle into the interstitium
(B) NaCl moves out from the ascending arm of the loop of Henle into the interstitium
(C) Urea moves out from the descending arm of the loop of Henle into the interstitium
(D) Water does not move out from the ascending arm of the loop of Henle into the interstitium

Q.21 The gametophyte phase of a plant is

(A) Diploid, and produces gametes by meiosis
(B) Haploid, and produces gametes by mitosis
(C) Diploid, and produces gametes by mitosis
(D) Haploid, and produces gametes by meiosis

Q.22 The transcription of **β-galactosidase** in the lac operon is inhibited when a more efficient source of energy such as glucose is present in the medium. This happens because

(A) Presence of glucose results in decreased concentration of intracellular cAMP
(B) Presence of excess lactose prevents glucose utilization
(C) Glucose binds to the lac operator and inhibits the operon
(D) The level of catabolite gene activator protein (CAP) goes down drastically

Q.23 Genetic relatedness in bacteria can be most reliably inferred by

(A) Comparing DNA sequences of their plasmids
(B) Comparing DNA sequences of their mitochondria
(C) Comparing sequences of their rRNA genes
(D) Comparing sequences of their tRNA genes

Q.24 Which of the following is a totipotent stem cell?

(A) A cell isolated from a human embryo at the 8-cell stage
(B) A cell isolated from the inner cell mass of a human blastocyst
(C) A mesenchymal stem cell isolated from adult human bone marrow
(D) A mesenchymal stem cell isolated from the human umbilical cord

Q.25 Which one of the following is true for core and complex glycosylation of N-glycans occurring in animal cells? (RER = Rough Endoplasmic Reticulum)

(A) Core glycosylation occurs in the RER and complex glycosylation occurs in the Golgi
(B) Core glycosylation occurs in the Golgi and complex glycosylation occurs in the RER
(C) Both core and complex glycosylation occur in the Golgi
(D) Both core and complex glycosylation occur in the RER

Q.26 For a Ramachandran plot, which one of the following statements is true regarding the range of values for φ and ψ?

(A) Range of φ is from $-180°$ to $+90°$, and range of ψ is from $-90°$ to $+180°$
(B) Range of ψ is from $-270°$ to $+90°$, and range of φ is from $-90°$ to $+270°$
(C) Range of ψ is from $-180°$ to $+180°$, and range of φ is from $-180°$ to $+180°$
(D) Range of φ is from $-90°$ to $+90°$, and range of ψ is from $-90°$ to $+90°$

Q.27 In the glycolytic pathway, cleavage of fructose 1,6-bisphosphate to two 3-carbon fragments is catalyzed by

(A) Triose phosphate isomerase
(B) Phosphofructokinase
(C) Aldolase
(D) Glyceraldehyde 3-phosphate dehydrogenase

Q.28 The A and B antigens from the ABO blood group differ in

(A) Two monosaccharide units
(B) One monosaccharide unit
(C) One polypeptide chain
(D) Two polypeptide chains

Q.29 Fragments of which type of macromolecules are presented by MHC class I molecules?

(A) Oligosaccharides
(B) Lipids
(C) Proteins
(D) Glycolipids

Q.30 Which of the following is a true difference between Archaea and Bacteria?

(A) Nuclear membrane is present in Archaea, but not in Bacteria
(B) Membranous organelles are present in Archaea, but not in Bacteria
(C) The cell wall contains peptidoglycans in Bacteria, but not in Archaea
(D) Streptomycin can inhibit growth of Archaea, but not Bacteria

SECTION - B

MULTIPLE SELECT QUESTIONS (MSQ)

Q. 31 – Q. 40 carry two marks each.

Q.31 Vasopressin, released from the posterior pituitary, is responsible for

(A) Increased reabsorption of water from the urine
(B) Increased reabsorption of salt from the urine
(C) Increasing urea concentration in the blood
(D) Decreasing the osmolarity of blood

Q.32 Males of a fish species react to other males of their species intruding into their territories with a characteristic headstand display. In an experiment, a male fish in an aquarium was shown a mirror, which provoked the headstand display. Non-reflective objects of the same shape and size, and water from other aquaria housing male fish of the same species in similar physiological condition failed to evoke a response. This experiment shows that

(A) Visual cues are not sufficient to evoke the headstand response
(B) Visual cues are sufficient to evoke the headstand response
(C) Chemical cues are sufficient to evoke the headstand response
(D) Chemical cues are not sufficient to evoke the headstand response

Q.33 Gene rearrangements in which of the following cell types lead to antigen receptor diversity in immune cells?

(A) Macrophages
(B) B cells
(C) NK cells
(D) T cells

Q.34 All mammalian **tRNAs** have

(A) Methylated or di-methylated derivatives of A, U, C and G
(B) Phosphorylation at the 5' terminal residue
(C) 3' CCA terminal at the acceptor stem
(D) Methylated guanosine as the 5' terminal residue

Q.35 Which of the following are **prezygotic** isolating mechanisms between populations of sexually reproducing animals?

(A) Different habitats
(B) Different breeding seasons
(C) Differences in fecundity
(D) Differences in hybrid vigour

Q.36 Which of the following statement(s) about the electromagnetic spectrum is / are true?

(A) Red light has a longer wavelength than violet light
(B) Red light has a higher frequency than violet light
(C) Violet light has a longer wavelength than red light
(D) Violet light has a higher frequency than red light

Q.37 Which of the following statement(s) is / are **TRUE** for oogenesis in humans?

(A) There is unequal cytokinesis during meiosis
(B) All four products of meiosis develop into mature gametes
(C) Mitotic divisions are completed before birth
(D) The primary oocytes are arrested at prophase I of meiosis

Q.38 Which of the following are characteristics of receptors for lipid-soluble hormones?

(A) They have a kinase domain
(B) They function as homodimers or heterodimers
(C) They are mostly located in the cytoplasm or nucleus
(D) They are transcription factors

Q.39 Acclimatization results from physiological adaptations. Which of the following happen(s) during acclimatization at high altitudes in humans?

(A) Increase in number of red blood cells
(B) Increase in rate of pulmonary ventilation
(C) Increase in cardiac output
(D) Increase in peripheral vasculature

Q.40 The root(s) of the equation $x^2+1=0$ is / are

(A) $+i$ (B) $-i$ (C) $+1$ (D) -1

SECTION – C

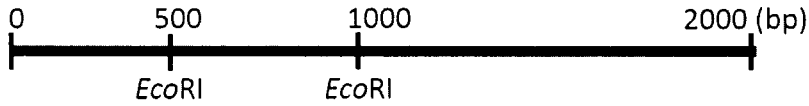
NUMERICAL ANSWER TYPE (NAT)

Q. 41 – Q. 50 carry one mark each.

Q.41 In a survey of 25 owners of dogs and / or cats, 20 owned dogs and 10 owned cats. The number of people who owned both dogs and cats was _____.

Q.42 An opaque bag contains three balls, of red, blue and white colour, respectively. The balls are pulled out from the bag at random one after the other until the bag is empty. The probability that the red ball is picked before the white ball is _____. (Use decimal notation for your answer)

Q.43 A linear **2-kb** double-stranded DNA fragment contains two ***Eco*RI** restriction enzyme sites as shown in the figure.



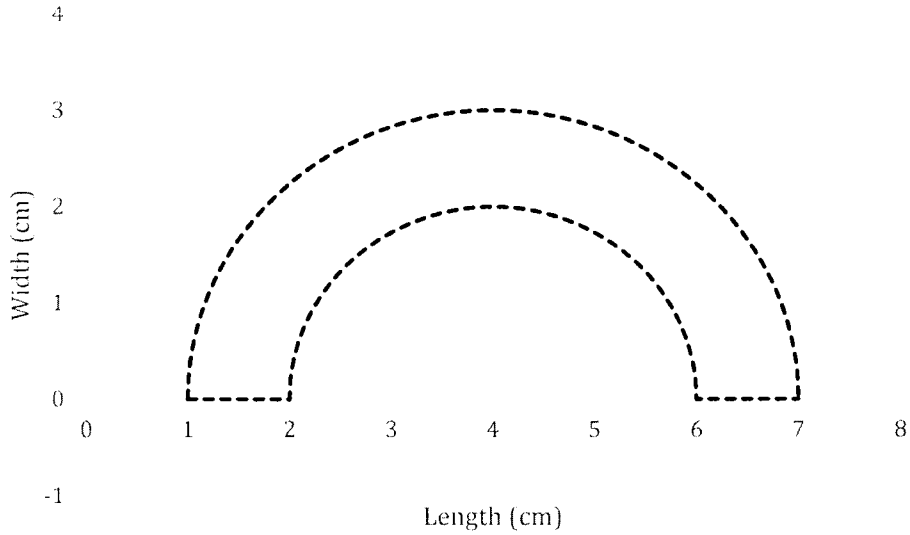
After complete digestion with ***Eco*RI**, the products were resolved by agarose gel electrophoresis, followed by ethidium bromide staining. The number of bands visible would be _____.

Q.44 A cube X, with each side of 2 cm length, is split into two new objects Y and Z. The plane of splitting is parallel to one of the faces of the cube. The value of the difference between the combined surface area of new objects Y and Z, and the surface area of X, in $\mathbf{cm^2}$ is ____.

Q.45 Suppose that P, Q, R, S, T are the names of the only five different amino acids present in an organism. The number of kinds of tri-peptides that can be synthesized by this organism if repetition of amino acids is not allowed anywhere within any tri-peptide, is _____.

Q.46 The value of $\int_{-2}^{2} 2(8-3x^2)dx$ is _____.

Q.47 The area of the region bounded by the dashed line shown in the figure below in $\mathbf{cm^2}$ is _____. Use $\pi = 3.14$.



Q.48 The maximum number of molecules of ATP that can be generated by oxidative phosphorylation of one molecule of glucose is _____ .

Q.49 If P = 10 and Q = 4 then the value of $1+P - Q\,(1- e^{-x})$ when $\mathbf{x} = \infty$ is _____.

Q.50 In a simple food-chain, grass is eaten by deer, which are in turn eaten by tigers. If 1000 kJ energy is available in the grass, then the number of kJ of energy that can potentially reach the tigers is _____.

Q. 51 – Q. 60 carry two marks each.

Q.51 Consider two ligands A and B which can bind to receptor R either individually or simultaneously. The probability that A can bind to R is **0.10**, and probability that B can bind to R is **0.20**. The probability that both A and B can bind to R is **0.05**. The probability that both A and B will **NOT** bind to R is _____.

Q.52 In a Mendelian cross, snapdragon plants with red flowers were crossed to snapdragon plants with white flowers. In the $\mathbf{F_1}$ generation, all the plants had pink flowers. When two plants from the $\mathbf{F_1}$ generation were crossed, 1000 $\mathbf{F_2}$ generation plants were produced. The number of $\mathbf{F_2}$ plants with red flowers was _____.

Q.53 In the B form of DNA, the helical structure repeats every 34 Angstroms. Therefore, adjacent bases in the helix are separated by _____ Angstroms.

Q.54 A single coin-tossing experiment has two possible outcomes, namely head and tail. Suppose three coins are tossed simultaneously, the probability of getting two heads and one tail is _____.

Q.55 In an acid-base titration experiment with glycine, it was observed that 50% of its alpha-amino group was deprotonated at a pH of **2.34** while 50% of its carboxyl group was deprotonated at a pH of **9.6**. The isoelectric point of glycine from the above information is _____.

Q.56 A trait in a hypothetical diploid organism is inherited via a single gene with three different alleles. The number of distinct genotypes possible in this system is _____.

Q.57 Consider that the half-life of a radioactive element is **2** years. Suppose the total number of radioactive nuclei in year 2016 is $\mathbf{N_0}$. The number of radioactive nuclei will become $\mathbf{N_0/64}$ in the year _____.

Q.58 Consider that doubling time of a bacterium is 20 minutes. If 2500 bacterial cells start dividing under ideal conditions, then the time taken in minutes to reach a population size of 40000 is ___.

Q.59 If the concentration of Hydrogen ions in a solution is 10000 nM, then the pH of this solution is ____.

Q.60 In a double reciprocal or Lineweaver-Burk plot for an enzymatic reaction, **1/[S]** is plotted along the X-axis and **1/V** is plotted along the Y-axis. Here [S] is the substrate concentration, **1/V** is initial velocity, and $\mathbf{V_{max}}$ is maximum velocity of the reaction. If the value of the slope is 1 per second and the value of the intercept on the X-axis is $\mathbf{-0.1\ \mu M^{-1}}$ then the value of $\mathbf{V_{max}}$ in $\mathbf{\mu M s^{-1}}$ for this enzymatic reaction is _____.

END OF THE QUESTION PAPER