



**INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR**  
**End-Autumn Semester 2018-19**

**Date of Examination: 27-11-2018 Session (FN/AN): AN Duration: 3 hrs Full Marks: 100**  
**Subject No.: BS20001 Subject: Science of Living System**  
**Department/Center/School: School of Bioscience**  
**Specific charts, graph paper, log book etc., required: NONE**  
**Special Instructions (if any): NONE**

Attempt ALL questions. Write the answers of all parts of each question in one place.

**1. Write down the correct answer (ONE) in your answer script (20 X 1 = 20 MARKS)**

A. For an enzyme catalyzed reaction, when  $[S]=K_M$ , the velocity of an enzyme catalyzed reaction would be

- a)  $0.1 \cdot V_{\max}$       b)  $0.2 \cdot V_{\max}$       c)  $0.3 \cdot V_{\max}$       d)  $0.5 \cdot V_{\max}$

B. If the reaction  $A + B \rightarrow C$  is first order with respect to A and first order with respect to B, then the rate equation for the forward reaction would be

- a)  $\text{Rate}=k[A]$       b)  $\text{Rate}=k[B]$       c)  $\text{Rate}=k[A][B]$       d)  $\text{Rate}=kA[a]+kB[B]$

C. In an enzyme catalyzed reaction, if the transition state has lower free energy than that of the products, what will be the outcome of the reaction?

- a) Enzyme catalyzed reaction will be faster than uncatalyzed reaction  
b) Enzyme will not bind to substrate  
c) Reaction will not proceed beyond enzyme-substrate complex formation  
d) Enzyme will catalyze product formation but they will remain bound to the enzyme

D. An allosteric inhibitor of an enzyme usually

- a) denatures the enzyme      b) causes the enzyme to work faster  
c) binds to the active site      d) changes the conformation of the active site

E. Bacterial peptidoglycan is a polymer of

- a) sugar      b) sugar and nucleotide      c) sugar and lipid      d) sugar and amino acid

F. Which of the following statements about cytoskeletal function is FALSE?

- a) Most actin filaments orient their minus ends towards the leading edge of a moving cell  
b) Intracellular transport is carried out by Dynein and Kinesin motor proteins that can walk on microtubules  
c) The force for chromosome segregation during cell division is contributed by microtubules  
d) Contractile ring that forms during cytokinesis stage of cell division is composed of actin filaments

G. Which component of the bacterial cell wall gets affected by the lysozyme enzyme present in the tears of our eyes?

- a) Lysozyme      b) Lysosome      c) Ribozyme      d) Ribosome

H. Which of the following microscopes is the best to study ultrastructure of a cell?

- a) Phase contrast microscope      b) Scanning electron microscope  
c) Transmission electron microscope      d) Light microscope

I. Which of the following structures can be found in a Prokaryotic cell?

- a) Nucleoid                      b) Nucleolus                      c) Nuclear matrix                      d) Nuclear envelope

J. Which of the following cellular structures always disappears during mitosis and meiosis?

- a) Plasma membrane      b) Cytoskeleton                      c) Nuclear envelope                      d) Mitochondria

K. If a cell's DNA is damaged, at which cell cycle checkpoint is the cell cycle halted?

- a) G1 - S                      b) S - G2                      c) G2 - M                      d) M - G1

L. Which of the following is NOT a feature of apoptotic cell death?

- a) Cytochrome C is released from mitochondria to cytosol  
b) Cytoplasmic contents including lysosomal enzymes are released into the extracellular fluid  
c) Fragmentation of DNA  
d) Movement of phosphatidylserine from inner leaflet of lipid bilayer to outer leaflet

M. Primary function of MHC (major histocompatibility complex) molecules is:

- a) memory of infection      b) antigen presentation                      c) generation of antibody                      d) immuno-surveillance

N. In order to initiate an adaptive immune response, antigenic peptide must be presented to T cells. Which cell presents this antigen to T cells?

- a) Red blood cell                      b) Dendritic cell                      c) Helper T cell                      d) Cytotoxic T cell

O. Origin and maturation of B cells take place in

- a) Spleen                      b) Thymus                      c) Bone marrow                      d) Lymph node

P. Antibodies are secreted by

- a) Helper T Cells                      b) Cytotoxic T cells                      c) Plasma Cells                      d)  $\beta$ -cells of Pancreas

Q. Which of the following cytoskeletal components is the smallest?

- (a) Protofilament                      (b) Microtubule                      (c)  $\alpha$ -tubulin                      (d) Tubulin dimer

R. In a plasmid vector antibiotic resistance gene is used for

- a) selecting the transformed bacterial colony                      b) selecting the colony with bacteria containing insert  
c) inducing transformed bacteria to produce antibiotics                      d) all the above

S. Restriction enzymes are used in genetic engineering because they

- a) cut specific sequence                      b) recognize promoter                      c) cut DNA from ends                      d) restrict bacterial growth

T. Dolly, the first cloned sheep, was cloned from the nucleus of a

- a) haploid ovum                      b) diploid ovum                      c) haploid somatic cell                      d) diploid somatic cell

## 2. Answer the following questions

(5 X 2 = 10 MARKS)

A. Name two models explaining enzyme action.

B. Name two organelles in a eukaryotic cell that contain two lipid bilayers.

C. Central components of cell cycle regulation are (i) \_\_\_\_\_ enzyme which phosphorylates other proteins, and (ii) \_\_\_\_\_ which are periodically synthesized and degraded during cell cycle.

D. \_\_\_\_\_ is an autoimmune disorder whereas \_\_\_\_\_ is a disease caused by uncontrolled cell division.

E. Plasmids used in genetic engineering must carry 'ori' site for \_\_\_\_\_ and a \_\_\_\_\_ sequence for expression of the 'gene of interest' in host cell.



**Answer the following questions**

**(70 MARKS)**

3. a) Write down the Michaelis-Menten equation. Describe each term in the equation. [2]

b). Given  $\Delta G_{\text{cat}} = 30 \text{ kJ/mol}$ ,  $\Delta G_{\text{uncat}} = 50 \text{ kJ/mol}$ ,  $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$  and room temperature condition ( $25^\circ\text{C}$ ), calculate the rate enhancement by this enzyme. [3]

c) In the following plot, the velocity of an enzyme is plotted as a function of its substrate concentration. One plot is in the presence of an inhibitor, the other without any inhibitor.

I) Identify which plot is with inhibitor and which one is without inhibitor. Give reasons for your choice. [3]

II) Identify the type of inhibitor with proper reasoning. [3]

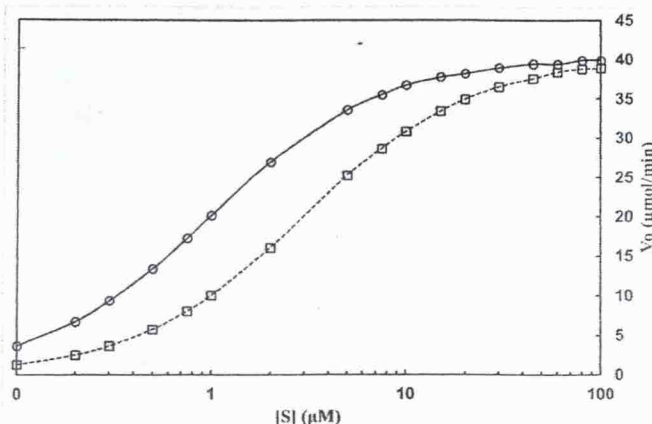
III) Determine the following: [4]

(i) Maximum rate of product formation for the uninhibited reaction

(ii) Michaelis constant for the uninhibited reaction

(iii) Michaelis constant for the inhibited reaction

(iv) If  $\alpha = 1 + [I]/K_i$ , where  $[I]$  is the inhibitor concentration and  $K_i$  is the inhibition constant. If the inhibitor concentration  $[I] = 1 \text{ }\mu\text{M}$ , determine  $K_i$ .



4. (a) What is the advantage of having membrane bound intracellular organelles in Eukaryotic cells? What is the benefit of being multicellular organism over unicellular? [2 + 2 = 4]

(b) You want to study the effect of virus infection in human liver. What microscopes will you be using if [3]

(i) you want to study the gross abnormality in the liver tissue

(ii) you want to study whether virus particles are attached to the liver cells

(iii) you want to study interaction of a viral protein with liver cell DNA

(c) There are several drugs that can modulate cytoskeletal organization and dynamics.

(i) Cytochalasin- prevents actin polymerization

(ii) Colchicine- inhibits microtubule polymerization

(iii) Paclitaxel- stabilizes microtubules.

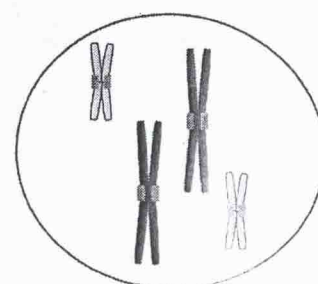
What will be the impact of these drugs on actively dividing cells? Explain your answer. [3]

(d) In microfilaments and microtubules the monomers (actins and tubulins) are connected with each other by non-covalent interactions. Why non-covalent interactions are used here instead of covalent bonds? [2]

(e) Ribosomes are found in abundance in the cytoplasm. In Eukaryotic cells, they are also associated with another organelle. Name that organelle and state the significance of the presence of ribosome in this compartment. [2]

5. (a) Why is chromosomal condensation necessary during cell division? What would go wrong if chromosomes remain condensed during interphase stage of cell cycle? [2 + 2 = 4]

(b) Condensed chromosomal state of a hypothetical diploid organism ( $2n = 4$ ) is shown in the following figure. Draw possible arrangement of these chromosomes during metaphase stage of (i) Mitosis and (ii) Meiosis cell division. Your drawings should also have centrosomes at two spindle poles with microtubules connecting the chromosomes correctly in each diagram. [2 + 2 = 4]



(c) Why is Meiosis called 'reductional division'? Which key feature(s) of this division makes this a reductional division? [2 + 2 = 4]

(d) In case of an asymmetrically dividing cell, what is asymmetrically distributed between the daughter cells? Write 3 key features of a stem cell? [1.5 + 1.5 = 3]

6. (a) Plot microorganism count versus duration of infection to distinguish and explain the relative importance of adaptive and innate immunity. [4]

(b) Explain the memory response along with disease state for natural infection and vaccination. How does drug differ from vaccine? [2+2 = 4]

(c) Tom Brady was practicing football when he accidentally had a cut in his leg. It turns out that the skin epithelium of his leg was affected. Using a diagram explain the immune responses that would take place if a pathogen penetrates through that cut. [3]

(d) How does dendritic cell act as a link between both innate and adaptive immune system? What kind of MHC molecule(s) will macrophages express? [2 + 1 = 3]

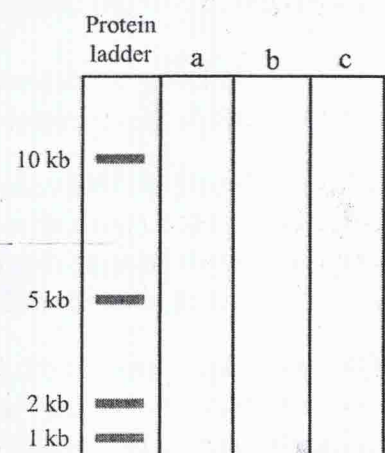
7. (a) Restriction mapping of a linear DNA reveals the following *EcoRI* restriction sites: [6]



(i) This piece of DNA is cut with *EcoRI*, the resulting fragments are separated by gel electrophoresis, and the gel is stained with ethidium bromide. Draw a picture of the bands that will appear in lane 'a' on the gel.

(ii) If a mutation that alters *EcoRI* site 1 occurs in this piece of DNA, what will be the banding pattern on the gel? Draw the bands in lane 'b' of the gel.

(iii) If mutations that alter *EcoRI* site 1 and 2 occur in this piece of DNA, what will be the banding pattern on the gel? Draw the bands in lane 'c' of the gel.



(b) How can you clone a gene using following reagents/information? (Answer this question with proper explanation and schematic diagrams): [6]

(i) Plasmid with known restriction sites (*EcoRI* and *BamHI*) (ii) Restriction enzymes (*EcoRI* and *BamHI*) (iii) PCR product containing your gene of interest flanked by *EcoRI* and *BamHI* restriction sequence (iv) T4 DNA ligase.

