



INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

End-Autumn Semester Examination 2022-23

Date of Examination: 15/02/2023 Session: (FN/AN) Duration: 3 hrs. Full Marks: 100

Subject No.: BS10003

Subject: Science of Living Systems

Department/Center/School: School of Bioscience

Specific charts, graph paper, log book etc., required: NONE

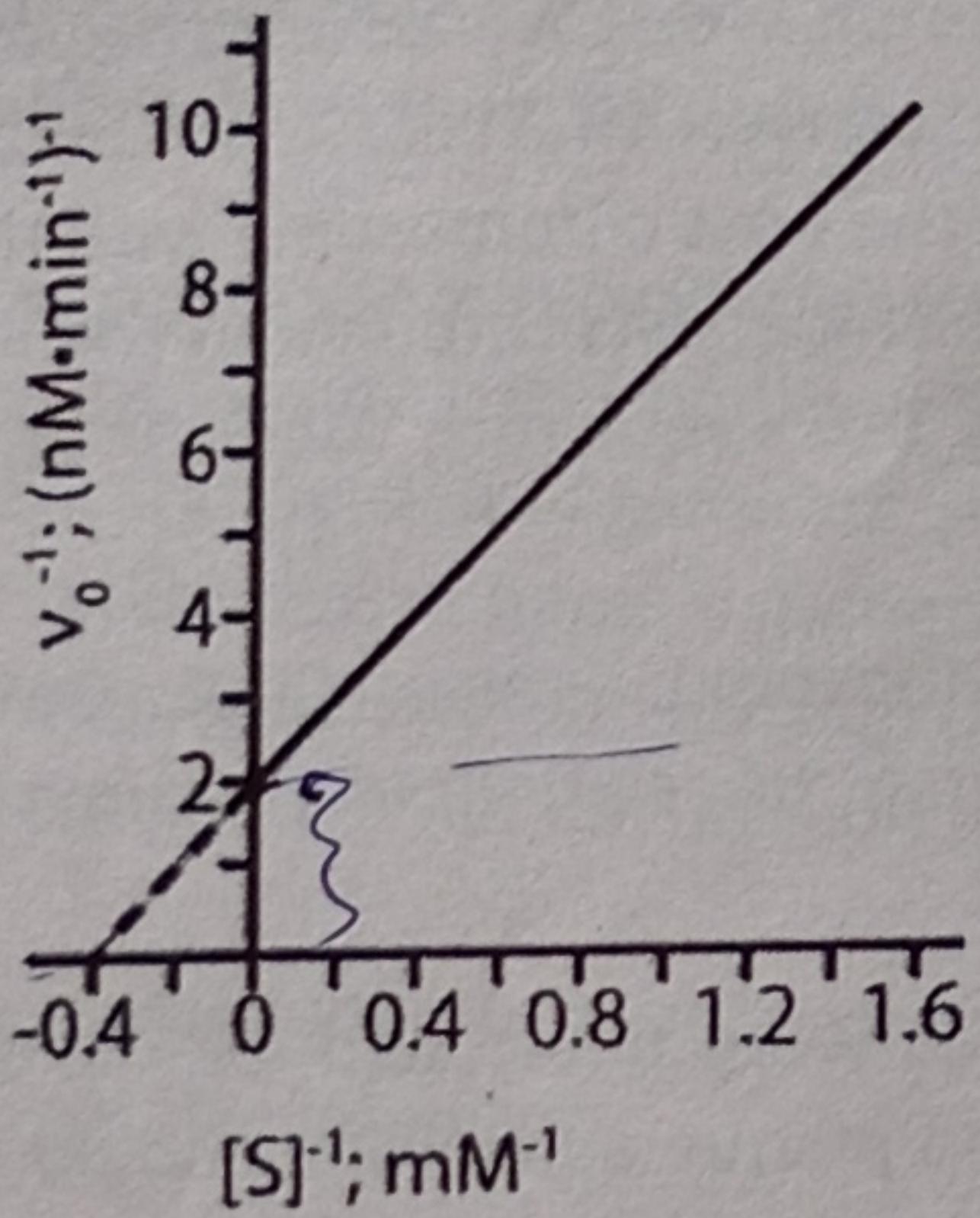
Special Instructions (if any): 1. WRITE ALL PARTS OF A QUESTION IN ONE PLACE.

2. WRITE YOUR SECTION NO. ON FRONT PAGE OF ANSWER SCRIPT

PART A (60 marks)

Answer the following questions in brief.

1. (a) Using the data shown on the graph, calculate the V_{max} and K_M for this enzyme. [4]



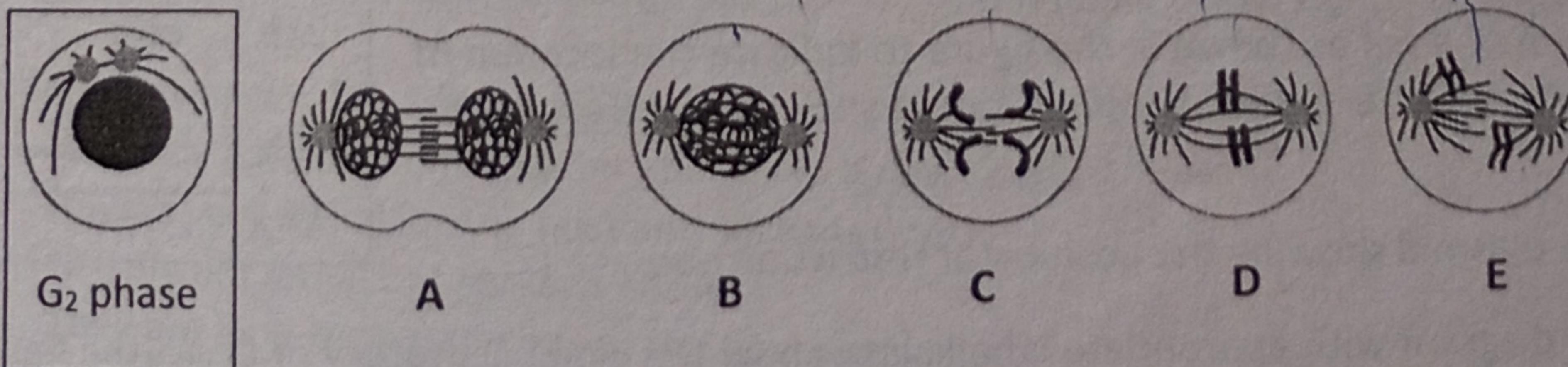
$$K_m = \frac{V_{max} R}{K_{cat}}$$

$$K_{cat} = V_{max} R / K_m$$

- (b) You have identified an enzyme that converts FAST to FEAST. You have named it Fastase. When the Fastase concentration = 10 nanoMolar, the V_{max} is 100 microMolar/sec, what is the value of K_{cat} ? [2]

- (c) An enzyme enhances the rate of a reaction by 10^{12} fold at 25 degree C. What is the energetic stabilization of the transition state by this enzyme? $R = 8.314 \text{ J/mol}^{\circ}\text{K}$ [4]

2. (a) Sort the following schematic diagrams (A to E) to reflect the order of events in a typical eukaryotic M phase. An interphase cell in G₂ phase is drawn on the left for comparison. Your answer would be a five-letter string composed of letters A to E only, e.g., BCEAD. Chromosomes, microtubules and centromeres are shown using their standard representation. [2]



- (b) Sperms are produced by meiotic division of diploid progenitor cells. How many of these diploid cells would be required to generate 4000 sperms? [2]

- (c) What will be the number of DNA present in G₁, G₀, and G₂ phase of cell division? Assume that a human liver cell contains 46 chromosomes (2n=46), i.e., 46 DNA. [3]

1/2
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Sarkar

Time	Sitting Pattern
10:00 PM	B
10:00 PM	B
10:00 AM	F
10:00 PM	F

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(d) State two functions of P53 gene helping the cells to prevent cancer. [2]

3. (a) What are the 4 features of inflammation? What are the key differences between a drug and a vaccine? [2+4]

(b) Fill in the blanks using the keywords given below. Each keyword can be used only once:

..... and are professional antigen presenting cells in our immune system. After presentation of by MHC molecules present on APCs, CD8 T cells become and kill the infected cells directly while CD4 T cells help to become antibody producing All these immune cells originate from and play important role in immune response. [4]

Keywords: T cell, B cells, dendritic cell, macrophage, red blood cells, plasma cells, cytotoxic, peptide antigen, bone marrow, innate, adaptive, chronic, platelets

(c) Draw a curve to represent the load of pathogen (microbes) over time. X axis should start from day 0 (i.e. time of infection) to day 8 (when the infection is cleared by our immune system). Y axis should represent the load of pathogen. [3]

(d) An antibody consists of polypeptide chains connected by bonds, and thereby an antibody molecule is an example of structure of a protein [3]

4. (a) Fill in the blanks using the keywords given below. Each keyword can be used only once:

..... had predicted the concept of back in 1956, while discovered it in the year of 1970. Retroviruses utilize enzyme at the beginning of their life cycle to convert viral to which then gets transported to the nucleus and gets integrated into the host chromosome with the help of viral enzyme named This is why retroviruses cause infection which persists throughout the life of infected individual. The drug acts as nucleoside analogue to blocks this event thus used for anti-retroviral therapy. [4]

Keywords: Arthur Kornberg, James Watson, DNA Polymerase, RNA polymerase, Ribosome, Francis Crick, David Baltimore, Genomic RNA, DNA, reverse transcription, reverse transcriptase, reverse translation, erythromycin, azidothymidine, integrase

(b) In a plaque assay performed to determine the titer of influenza virus, 25 plaques were developed for the set corresponding to 10^5 dilution. Considering that 0.1ml of virus solution was used for the plaque assay what should be final titer of the virus? [3]

(c) What is Zoonosis? Give an example of a zoonotic virus and also state its natural host. [3]

5. (a) You are working in a molecular biology lab during your internship. You have been given a sample of plasmid DNA which is 4 kb long (i.e. 4000 nucleotides long), and contain 2 EcoR1 restriction sites that are located 1 kb apart. If you digest this plasmid by EcoR1 followed by analysis through agarose gel electrophoresis:

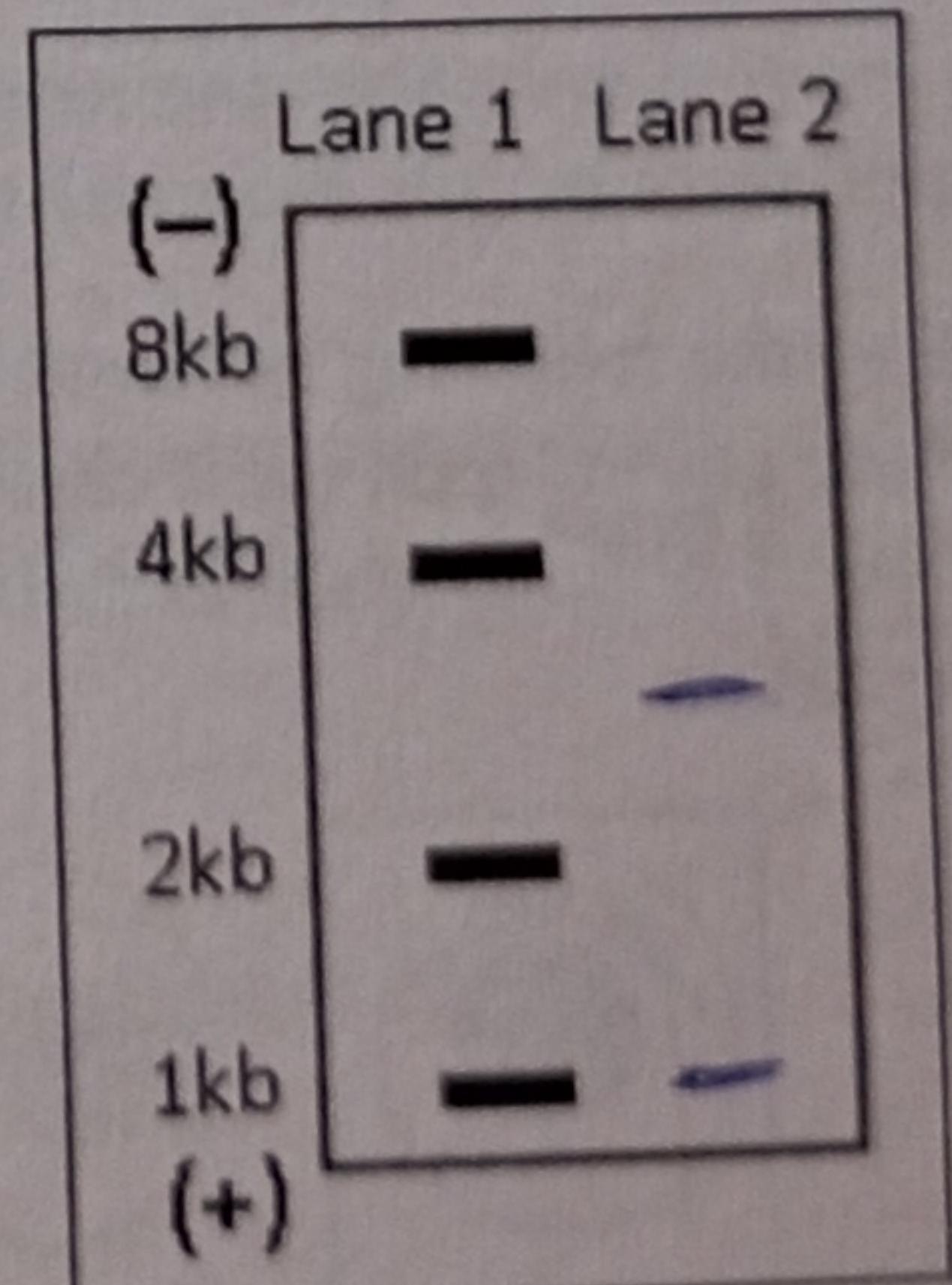
i) How many bands will be visible on the gel in lane 2? [2]

ii) What will be the length of those fragments? [2]

iii) Draw a schematic diagram of a gel as shown in the figure to indicate the location of DNA fragments you have obtained after EcoR1 digestion. Lane 1 showing the known DNA ladder fragments. [4]

iv) Construct the map of the plasmid showing the position of restriction sites. [2]

(b) Draw ONLY a schematic diagram with appropriate labelling to show the cloning strategy of Dolly (the first cloned mammal). [5]



2025-2026



Souvik Sarkar

Time Span	Sitting Pattern
02:00 PM-04:00 PM	B
02:00 PM-04:00 PM	B
09:00 AM-11:00 AM	F
02:00 PM-04:00 PM	F
outside).	

mode, except non-programmable calculators, is permitted in the Examination Hall. Use of mobile phones, cameras, video cameras, electronic devices, etc., in the Examination Hall is prohibited. Any person found using such devices in the Examination Hall will be treated as a 'malpractise case'. A candidate who uses such devices in the Examination Hall will be liable to be awarded zero marks. Candidates are advised to keep their mobile phones, cameras, video cameras, electronic devices, etc., in their bags or purses and clean pencil box may be allowed.

15 minutes before the scheduled starting time of examination (i.e. 15 minutes before the commencement of examination).

After the commencement of examination, no attempt will be allowed.

The examination will be held in the month of May/June.

Regulations in this matter will be final.

Attempts either inside or outside the Examination Hall will be liable to be awarded zero marks.

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PART B (40 MARKS)

Choose the correct (only one) answer.

[20 X 2 = 40 marks]

1. Which of the following is FALSE in case of asymmetric mitotic division?

- a) The two progeny cells acquire different fates because they inherit different genetic material
- b) Two progeny cells inherit unequal cytoplasmic materials (RNA/Proteins)
- c) Asymmetric division is the key mechanism for retaining self-renewing ability in stem cells
- d) Two progeny cells are unequal in shape and size

2. Cancer cells share many features of stem cells, for example unlimited proliferation. Then why can't we use cancer cells, instead of stem cells, for biomedical applications?

- a) Cancer cells have mutations
- b) DNA damage repair pathways don't work properly in cancer cells
- c) Cell division is uncontrolled in cancer cells
- d) All the reasons are true

3. Metastasis is one of the hallmark signatures of Cancer. What does it mean?

- a) Invasion and tumor formation at a new site
- b) Evading (escaping) apoptosis
- c) Formation of blood vessels in tumor
- d) Accelerated cell division

4. Crossing over results in a chromosome

- a) that carries DNA from one parent only
- b) residing on one side of the cell only
- c) that produces male offspring
- d) that carries DNA from both parents

5. In sexually reproducing organisms, which of the following two events, occurring in every generation of diploid organisms, ensure conservation of diploid nature?

- a) (i) Mitotic division of gametes; (ii) Fertilization of haploid gametes
- b) (i) Fertilization of haploid gametes; (ii) chromosome number duplication in Zygote
- c) (i) Reducational Meiotic division during gamete formation; (ii) Fertilization of haploid gametes
- d) (i) Reducational Meiotic division during gamete formation; (ii) Mitotic division of gametes

$$V_o = \frac{V_m}{K_m + [S]}$$

6. An enzyme inhibitor is observed to alter the K_m but not the V_{max} of a reaction. This inhibitor is most likely:

- a) Competitive inhibitor
- b) Uncompetitive inhibitor
- c) Allosteric inhibitor
- d) Mixed inhibitor

7. The active site of an enzyme differs from an antibody-antigen binding site in that the enzyme active site

- a) contains modified amino acids
- b) catalyzes a chemical reaction
- c) is complementary to a specific ligand
- d) contains amino acids without sidechains

8. 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) Rate=k[A]
- b) Rate=k[B]
- c) Rate=k[A][B]
- d) Rate=ka[A]+kb[B]

9. For an efficient enzyme, what relative values of K_m and k_{cat} are correct?

- a) Low K_m & high k_{cat}
- b) High K_m & high k_{cat}
- c) High K_m & low k_{cat}
- d) Low K_m & low k_{cat}

10. Which of the following are TRUE for equilibrium virus?

- i. Recently jumped from another species to a new species
 - ii. Always very lethal for the host and spreads poorly
 - iii. Usually not lethal but spreads easily
 - iv. They are long-term parasites of the host species
- a) i and ii
 - b) ii and iii
 - c) iii and iv
 - d) iv and i

$$K_1^2 = \frac{R_m}{R_m}$$

$$\frac{W_m}{W_m - K_m} = \frac{1}{1 - \frac{K_m}{W_m}}$$

11. In a virus growth curve, "eclipsed period" denotes the phase when

- a) virus proteins are synthesized
- b) virus genetic materials are replicated
- c) progeny virus particles are assembled
- d) all of the above

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to punishment of 'semester'
per rules.

12. Which of the following tests could be performed to detect the presence of viral nucleic acid in patient body fluid?

 - a) Plaque assay
 - b) Antigen test
 - c) Antibody test
 - d) RT-PCR test

13. How HIV infection leads to the “immune deficiency”?

 - a) HIV infects innate immune cells like macrophage and dendritic cells, hence interferes with the innate immunity.
 - b) HIV infects B cells, hence directly affect antibody production.
 - c) HIV infects CD4 T cells, hence impact the adaptive immune system
 - d) HIV infects cytotoxic T cells, hence interferes with the final clearing of infected cells.

14. Which of the following cells are generally not involved in phagocytosis?

 - a) Basophils
 - b) Dendritic cells
 - c) Macrophages
 - d) All of the above

15. Major characteristics of adaptive immunity include

 - a) Specificity
 - b) Memory
 - c) Distinction between self and foreign
 - d) All of the above

16. which of the following cells link between innate and adaptive immune response?

17. If the recognition sequence of the restriction enzyme is GAATTC, then how many covalent bonds will be broken by the enzyme in the following DNA molecule?

the enzyme ECO RI

5' GCTGTGAATTCAGT 3'
3' CGACACTTAAGTCA 5'

- a) 1 b) 2 c) 4

18. Identical twins are

 - a) the result of embryo splitting at the early stage of pregnancy.
 - b) always of same sex.
 - c) the result of fertilization of single egg that splits in two.
 - d) all of these.

19. You have studied genetic engineering in your 1st semester at IIT Kharagpur, and you came to know that in order to express a foreign protein in bacteria *E. coli*, you have to clone the gene of interest in suitable plasmid that should contain a promoter site. This promoter site is required for

- a) maintaining the plasmid in *E. coli*.
 - b) keeping *E. coli* alive in presence of antibiotics.
 - c) the self-replication of plasmid.
 - d) the production of RNA so that the desired protein can be translated in *E. coli*.

20. A student was performing cloning of a giraffe by nuclear transfer method. She made two mistakes: firstly, she took a fertilized ovum; secondly, she forgot to remove the nucleus of the ovum before injecting the nucleus of a somatic cell. What would be the most probable outcome of this experiment?

- a) The resulting zygote will develop into a normal diploid ($2n$) giraffe
 - b) The zygote will be triploid ($3n$), hence would have cell division problems
 - c) ~~The zygote will be tetraploid ($4n$), hence it would not survive due to double genomic content~~
 - d) The zygote will be tetraploid ($4n$), it will result into a gigantic giraffe