

Indian Institute of Technology Delhi
KUSUMA SCHOOL OF BIOLOGICAL SCIENCES
PhD Entrance Examination May 2019

Date: May 15, 2019 Maximum marks: 50 Time: 1 hour

Name: _____

Mobile number: _____

Instructions

- Use the separately attached MCQ sheet to answer multiple-choice questions (Do NOT answer the multiple choice questions on the question paper)
- Marks: +2 for a correct answer and –1 for an incorrect answer
- Part B is compulsory (though it is NOT graded) – answer part B in the question paper
- Please check if there are a total **8 pages** in this booklet

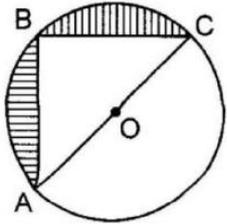
PART A: Choose THE MOST APPROPRIATE answer for each question

1.	Isoelectric point of two proteins A & B are 6 and 8, with molecular weights 20 kDa and 30 kDa. Which of the following is True? A. Protein A would be positively charged at pH 8. B. Protein B would be negatively charged at pH 7. C. Protein A would be negative and protein B would be positive at pH 7. D. Protein A and protein B can be separated through cation-exchange at pH 9.
2.	SDS gel electrophoresis is carried out to identify molecular weight of protein. Which of the following statements is correct? A. Homo dimeric protein can be detected through the SDS Gel electrophoresis. B. Molecular weight of a hetero-trimeric protein can be detected through SDS Gel electrophoresis. C. A protein-protein complex would appear as a single band in the SDS Gel electrophoresis. D. Disulphide bonds in proteins remain intact during SDS Gel electrophoresis.
3.	Which one of the following proteins lack ATP hydrolysis activity? A. Na ⁺ /K ⁺ -ATPase B. Protein Kinase-C C. Myosin II D. β-Tubulin
4.	Which of the following techniques do not use antibodies A. Northern blotting B. Western blotting C. Immunohistochemistry D. ELISA
5.	Which of the statements about CRISPR-Cas9 system are true?

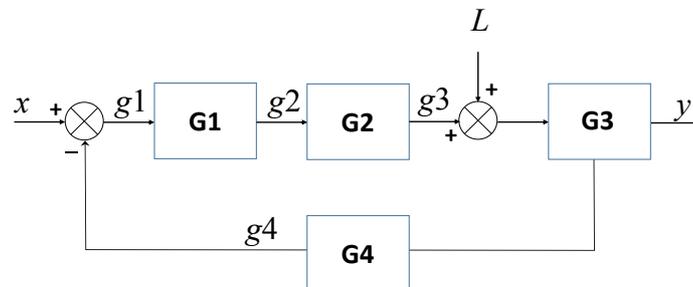
	<ul style="list-style-type: none"> (i) can be used to make precise gene editing in mammalian cells (ii) is a mechanism for pathogen resistance in bacteria (iii) can be used to cleave mRNA (iv) makes double-strand breaks on target DNA <ul style="list-style-type: none"> A. (i) and (ii) B. (i) and (iv) C. (i), (iii) and (iv) D. (i), (ii) and (iv)
6.	<p>M-phase promoting factor (the complex of mitotic cyclins with M-phase cyclin-dependent kinase) initiates assembly of the mitotic spindle, breakdown of the nuclear envelope and condensation of the chromosomes. These events take the cell</p> <ul style="list-style-type: none"> A. to metaphase stage of mitosis B. to anaphase stage of mitosis C. to interphase stage of mitosis D. to prophase stage of mitosis
7.	<p>If totipotent cells are taken and placed into a healthy uterus:</p> <ul style="list-style-type: none"> A. They will have the potential to develop into a blastoderm only B. They will have the potential to develop into a foetus C. They will have no potential to develop into a foetus D. They will have the potential to develop into a foetus but not blastocyst
8.	<p>Several families of pattern recognition receptors (PRRs) have been characterized so far. Which one of the following molecules is not a member of PRR family?</p> <ul style="list-style-type: none"> A. Toll-like receptors B. Nod-like receptors C. Steroid-like receptors D. RIG-like receptors
9.	<p>Transport of cargo from nucleus to cytoplasm through nuclear pore is regulated by</p> <ul style="list-style-type: none"> A. Ras GTPase B. Rab GTPase C. Rho GTPase D. Ran GTPase
10.	<p>Which of the following is the correct pair of a metabolic pathway with its appropriate subcellular location?</p> <ul style="list-style-type: none"> A. Oxidative phosphorylation occurs in mitochondria B. Glycolysis occurs in peroxisome. C. Fatty acid synthesis occurs in mitochondria. D. Ganglioside degeneration occurs in Golgi.
11.	<p>Consider the three statements given below: <u>Statement A:</u> Telomerase is present in almost all cells of the body, however it remains in off position so that cell reach mortality and eventually die <u>Statement B:</u> Cancer cells do not age because they lack telomerase.</p>

	<p><u>Statement C:</u> During cell division telomere increases in size with each division by adding hexameric DNA bases (TTAGGG), as a result cell stops to divide after certain number of divisions.</p> <p>Which of the following is correct?</p> <p>A. Statement A: False; Statement B: False, Statement C: False</p> <p>B. Statement A: False; Statement B: True, Statement C: False</p> <p>C. Statement A: True; Statement B: False, Statement C: False</p> <p>D. Statement A: True; Statement B: True, Statement C: False</p>
12.	<p>Imprinted genes are genes which are expressed in a parent-of-origin-specific manner. Ms. X inherited a faulty copy (mutated) of an imprinted gene (AB) on chromosome 8 from her father and Mr. Y inherited a faulty copy (mutated) of the imprinted gene (AB) on chromosome 8 from his mother. The imprinted gene AB is expressed only from the maternal allele. Expression of mutated protein AB or the complete lack of expression of protein AB is linked to disease. Assuming that the genomes of Ms. X and Mr. Y do not have any other genetic or epigenetic abnormalities, which of the following statement is TRUE?</p> <p>A. Ms. X will be diseased</p> <p>B. Mr. Y will be diseased</p> <p>C. Both Ms. X and Mr. Y will be diseased</p> <p>D. Neither Ms. X nor Mr. Y will be diseased</p>
13.	<p>You are a scientist working on a neurological disorder which is associated with protein X. You have a neuronal cell line that expresses protein X. The mRNA coding for protein X is 4 kb in length and contains several m6A (methylated adenine) bases. Recent reports indicate that m6A is linked to reduced half-life of transcripts. You decide to use siRNA against the FTO gene (a gene that removes the m6A from RNA) in the neuronal cell line. The siRNA worked as expected. In the same cells that were transfected with siRNA against the FTO gene you also measure mRNA levels for protein X using a real-time PCR assay. You are likely to find</p> <p>A. Reduced levels of protein X mRNA</p> <p>B. Increased levels of protein X mRNA</p> <p>C. No change in the levels of protein X mRNA</p> <p>D. No change in the levels of protein X mRNA but reduced levels of protein X.</p>
14.	<p>Which of the following have been employed for cellular delivery of drug payload:</p> <p>A. Lysosomes</p> <p>B. Exosomes</p> <p>C. Phagosomes</p> <p>D. Proteasome</p>
15.	<p>The osmotic pressure of a NaCl solution was measured as 2.4 atm (atmosphere) at 22°C (Universal gas constant $R = 0.0821 \text{ L}\cdot\text{atm}\cdot\text{M}^{-1}\cdot\text{K}$; K= Kelvin). What is the concentration of NaCl in the solution?</p> <p>A) Concentration cannot be determined from osmotic pressure</p> <p>B) Approximately 0.1 M</p> <p>C) Approximately 0.05 M</p> <p>D) Approximately 0.2 M</p>

16.	<p>Interestingly, when a clam (shellfish) sperm contacts a clam egg, it triggers intracellular ionic changes that results in the breakdown of the egg nuclear envelop, condensation of chromosomes and initiation of cell division. It was observed that, (1). suspending the clam eggs alone in seawater containing 65mM KCl triggered the same effects as the sperms; 2. suspending the eggs in artificial seawater lacking calcium prevents activation by 65 mM KCl. Assuming that the clam egg has 350 mM KCl and normal seawater has 5 mM KCl, what can be inferred about the mechanism of this phenomenon:</p> <ul style="list-style-type: none"> A) The extra KCl (65 vs. 5 mM) in seawater binds to specific membrane proteins that triggers the change in the state of transcription, translation and post-translational modifications B) Calcium-free seawater renders the membrane transporters non-functional, so intracellular-signalling becomes aberrant C) A voltage-dependent EF-hand motif protein Ca_vX that binds 8 Ca^{2+} ions shuttles between the membrane and the nucleus to directly bind on the promoters and alters gene expression D) Increasing KCl outside the cell changes membrane potential, activates Ca^{2+} ion channels and entry of Ca^{2+}, which might trigger intracellular changes
17.	<p>If there were 5 nucleotides instead of the regular 4, and a codon was comprised of 4 bases instead of 3, which of the following statements will hold true assuming amino acids remain the same in the system?</p> <ul style="list-style-type: none"> A) There would be less degeneracy in the genetic code B) There would be more degeneracy in the genetic code C) This would not affect the degeneracy of the genetic code D) All of the above are possible under specific circumstances
18.	<p>An enzyme requires aspartate and histidine residues in the catalytic site to be deprotonated for activity. Assuming that pKa of side chains of both the residues are 4.4 and 6.5 respectively, and the enzyme is found to be ~90% active at a pH of 7.5, how much would be the expected enzyme activity at a pH of 6.5?</p> <ul style="list-style-type: none"> A. 78% B. 70% C. 50% D. 25%
19.	<p>On addition of small amounts of a fatty acid to an aqueous solution, which of the following would occur:</p> <ul style="list-style-type: none"> A. Formation of a monolayer at the air-water interface B. Formation of bi-layers at the air-water interface C. Formation of micelles in the solution D. Formation of liposomes in the solution
20.	<p>The antibiotic Ciprofloxacin acts by -</p> <ul style="list-style-type: none"> A. Transferring ADP-ribose to a G-protein B. Transferring ADP-ribose to elongation factor 2 C. Inhibiting the first step in bacterial cell membrane formation D. Inhibiting DNA gyrase
21.	<p>Which of the following statements about adenylyl cyclase is NOT true?</p>

	<p>A. It uses ATP as a substrate B. It has three domains - alpha, beta and gamma C. It produces cyclic adenosine monophosphate D. It is part of the G protein signaling cascade</p>																		
22.	<p>The table below contains a list of restriction enzymes and their corresponding recognition sequences. The cutting sites for one strand are indicated in each case. Which combination of restriction enzymes will generate ends that can be ligated together?</p> <table border="1"> <thead> <tr> <th>Serial number</th> <th>Restriction enzyme</th> <th>Recognition site</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>EcoRI</td> <td>G/AATTC</td> </tr> <tr> <td>2</td> <td>NheI</td> <td>G/CTAGC</td> </tr> <tr> <td>3</td> <td>Sal I</td> <td>G/TCGAC</td> </tr> <tr> <td>4</td> <td>XhoI</td> <td>C/TCGAG</td> </tr> <tr> <td>5</td> <td>BssHI</td> <td>G/CGCGC</td> </tr> </tbody> </table> <p>A. 1&2 B. 2&3 C. 2&4 D. 3&4</p>	Serial number	Restriction enzyme	Recognition site	1	EcoRI	G/AATTC	2	NheI	G/CTAGC	3	Sal I	G/TCGAC	4	XhoI	C/TCGAG	5	BssHI	G/CGCGC
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23.	<p>A straight line is described by the equation $2x + 3y = 12$. The area of the triangle formed by this line, the x-axis and the y-axis is:</p> <p>A. Cannot be determined B. 24 C. 12 D. 0</p>																		
24.	<p>If $AB = 80$ cm and $BC = 60$ cm, and O is the center of the circle, the area of the shaded region ($\pi = 3.14$) of shown in the Figure is</p> <p>A. 5450 sq. cm B. 3925 sq. cm C. 3050 sq. cm D. 1525 sq. cm</p> 																		

25. The figure below shows how a promoter x initiates the synthesis of three proteins whose transcription time dependencies are given by $G1$, $G2$ and $G3$. The synthesis of y of the third protein is enhanced by the molecule L in a $G3$ dependent manner and y once synthesized feedback inhibits x through a functional dependency $G4$. The relation between y and L is given by the following equation.



- A. $y = \frac{G3}{1+G1G2G3G4} L$
- B. $y = \frac{G1G2G3}{1-G1G2G3G4} L$
- C. $y = \{g1g2g3\}x+G3L$
- D. $L = g3+G3y$

