PhD Admissions to Department of Chemical Engineering, Indian Institute of Technology Bombay

RCL No. _____ Marks Obtained (for office use): _____ .

Name: _____ .

Preference for interview panel (put tick mark): _____ Bio _____ / _____ Other

Instructions:
- Section A is common for all candidates. However, please attempt only one of Section B (Non-Bio) or Section C (Bio).
- In the multiple choice questions: four options are provided of which only one is correct. Clearly circle your choice of the correct answer.
- Correct answer: +2
- Incorrect answer: -1
- You can leave questions un-attempted. No marks (negative or positive) will be awarded for un-attempted questions.
- Time allowed : 1 hour

Section A

1. A course has two exams. Mid-semester exam has 40% weightage and the final exam has 60% weightage. Ramesh scored 50/100 in the mid-semester exam. What is the maximum score (out of 100) he can achieve at the end of the course?
     (a) 50   (b) 75   (c) 80   (d) None of the above

2. In a poll involving 100 members, participants were asked to raise their hand for their preference about a picnic location. 50 raised their hand for Shimla and 45 raised hand for Ooty. It was later discovered that 5 members raised hands for both the options. In such a case, how many members did not support any option?
     (a) 0   (b)5   (c) 10   (d) None of the above

3. A 2.5m ladder is used to reach the top of a 2m vertical wall. If the ladder makes an angle φ with the ground, what is the distance between the base of the ladder and the wall?
     (a) 1.5m   (b) 2.5sinφ   (c) 2sinφ   (d) 2tanφ

4. A, P, R, X, and S, are sitting on five chairs in a row. S is in the centre, and A and P are at the ends. R is sitting to the immediate left of A. Then who is sitting at the immediate right of P?
     (a) A   (b) X   (c) S   (d) R

5. A man drove his car 5 km towards eastward direction. He turned right and went 3 km in that direction. He then turned west and drove for 1 km. How far is he from the starting point?
     (a) 5 km   (b) 6 km   (c) 10 km   (d) 20 km

6. y = f(x). If you are told that y never has a negative value, what could be the exact function f relating x with y.
     (a) $y = x^3$ (b) y = x   (c) Both a and b   (d) Neither a nor b.

7. In a dairy firm, 60 cows eat 60 bags of husk in 60 days. In how many days one cow will eat one bag of husk?
     (a) 1   (b) 30   (c) 60   (d) 45

8. An accurate clock shows 8 o'clock in the morning. Through how many degrees will the hour hand rotate when the clock shows 2 o'clock in the afternoon?
     (a) 154° (b) 180° (c) 170° (d) 160°

9. Given that $f(y) = |y|/y$ and q is any non-zero real number, the value of $|f(q) - f(-q)|$ is
     (a) 0   (b) -1   (c) 1   (d) 2

10. Select a pair of words that best expresses the relation of Day : Week
     (a) Year : Week   (b) Second : Time   (c)Time : Duration   (d) Week : Month

Section B

1. In a game show on TV titled game of Life, there is a stock option where the participant spins a wheel with numbers 1 to 10. If the number is 1, 2 or 3, he suffers a loss of 30,000. If the number is 4, 5 or 6, he does not gain or lose anything. For 7, 8, 9 or 10, he gains 60,000. If the wheel is fair, what is the expected outcome of this stock option (considering the wheel is spun for a large number of times)?
   (a) Gain of 60000   (b) Loss of 30000   (c) No gain no loss   (d) Gain of 15000

2. An empty tank of 1m length, 1m width and 0.6m height is filled using a tap with water flow of 0.1 m^3/min. It was observed that it took extra 18 min to fill it completely than expected. It was attributed to some leak in the tank. Based on this observation, what is the corresponding constant leak flow (it is independent of the height)?
   (a) 3/40 m^3/min   (b) 2/30 m^3/min   (c) 0.9 m^3/min   (d) Insufficient data

3. A person with passion for mathematics decided to take a stroll randomly by rolling a dice. He decided that he will move 1 ft to the right if the number on the dice is prime and 1 ft to the left if the number is not prime (i.e. it is composite). For any other outcome, he would not move. After rolling the dice 120 times, what is the expected position of the person? The number 1 is considered neither a prime nor a composite.
   (a) Same position as original   (b) 20 ft to the right of the original position

   (c) 20 ft to the left of the original position   (d)10 ft to the right of the original position

4. In a game of cricket, bowling average is computed as the number of runs conceded by a bowler divided by the number of wicket taken by him. At the start of a match, the bowler had an average of 30. If he took 2 wickets and conceded 25 runs, his average after the match will be
   (a) 17.5   (b) 27.5   (c) 30   (d) Insufficient data

5. What is the probability of two individuals having their birthdays in the same month of the year?
   (a) 0.03   (b) 0.083   (c) 0.5   (d) 0.166

6. "A is south-west to C". Identify the two statements necessary to make this given conclusion true.
       i. A is two miles south of B   ii. B is two miles east of D
       iii. C is two miles east of B   iv. D is north-west of B

   (a) i & iii   (b) iii & ii   (c) iv & ii   (d) i & iv

7. Two trains (X and Y), separated by a distance of 80 km are running towards each other on the same track at a speed of 40 kmph each. A bird takes its flight from train X and flies towards train Y at a constant speed of 100 kmph. Once it reaches train Y, it turns and starts flying back towards train X. The bird keeps flying to and forth till both the trains collide. Determine the distance travelled by the bird (all answers are in km).
   (a) 100   (b) 110   (c) 117.6   (d) 125.8

8. A box contains 4 red balls and 6 black balls. Three balls are selected randomly from the box one after another without replacement. The probability that the selected set has one red ball and two black balls is
   (a) 0.33   (b) 0.4   (c) 0.5   (d) 0.6

9. Which of the following is always true for any non-zero vector a ?
   (a) $\nabla \cdot a = 0$ (b) $\nabla \times a = 0$ (c) $\nabla \cdot (\nabla \times a) = 0$ (d) $\nabla(\nabla \times a) = 0$

10. The coefficient of X^2 in the Taylor series expansion of $\cos^2 X$ about 0 (zero) is
    (a) -2   (b) 0   (c) 1   (d) -1

11. Find out the value of α from the provided options for which following three vectors (a, b, and c) are coplanar, i.e., they lie on the same plane? Here i, j, k are unit vectors.

    a= i + 2 j + k; b= 3j + k;   c= 2i + α j

    (a) -2   (b) 0   (c) 10   (d) 4

12. The derivative of $|x|$ with respect to x when x not equal to zero is
    (a) -1   (b) $\frac{|x|}{x}$ (c) 1   (d) undefined

13. The proportion of milk and water in two samples is 5:2 and 7:5. If a mixture comprising of equal quantities of the two samples is made, the proportion of milk and water in the mixture is
    (a) 12:7   (b) 7:12   (c) 109:59   (d) 59:109

14. The variable cost (V) of manufacturing a product varies according to the equation $V = 4q$ where q is the quantity produced. The fixed cost (F) of production of same product reduces with q according to the equation $F = 100/q$. How many units should be produced to minimize the total cost $(V + F)$?
    (a) 5   (b) 4   (c)7   (d) 6

15. Read the following passage and answer the question
    "According to Wilson only when we are able to apply the same parameters and mathematical principles to weighing both troops of monkey and termite colonies will a unified science of sociobiology finally exist. While recognizing that many of his colleagues question such an outcome, Wilson, one of sociobiology's leading proponents, finds himself simultaneously more and more struck by the functional similarities that characterize both insect and vertebrate

societies and less concerned with the structural differences that divide them to an apparently reconcilable degree. Thus, he freely compares termites and monkeys pointing to numerous likeness between them. Both societies are territorial: they occupy a particular home range, which they defend against intruders. Likewise, both are cooperative: members organize themselves into working groups that observe a clearly-defined division of labour. In addition, members of both groups can convey to each other a range of basic emotions and personal information. Wilson readily concedes that, from a specialist's perspective, such a likeness may at first appear superficial and even unscientific. Nonetheless, in this eminent scientist's judgement it is out of this oversimplification that the beginnings of a general theory are made."

Which of the following statements summarizes the main point of the author.
  (a) It is necessary to study both biology and sociology in order to appreciate how animals as different as termites and monkeys resemble each other.
  (b) The majority of animal species arrange themselves in societies whose patterns of group behaviour resemble human societies.
  (c) It is worthwhile noting that animals as different as termites and monkeys observe certain analogous and predictable behavioural patterns.
  (d) An analysis of the ways in which insect and vertebrate societies resemble one another could supply the foundation for a unified science of sociobiology.

Section C

1. If the A+T content in a bacterial DNA fragment of 2000 base pairs is 40 percent, the total number of G+C hydrogen bonds is:
(a) 800   (b) 1200   (c) 2400   (d) 3600

2. Starting with 2 copies of double stranded DNA, the total number of copies of double stranded DNA after ten cycles of PCR is expected to be:
(a) 512   (b) 1024   (c) 2048   (d) 4096

3. The pH of a solution having $[OH^-] = 10^{-10}$ M is approximately
(a) 3   (b) 4   (c) 10   (d) 11

4. The dissolved oxygen content in water measured for a CSTR was found to be 5 ppm (w/v). The molarity is:
(a) 5×10^{-6} (b) 1.6×10^{-4} (c) 3.2×10^{-4} (d) 5×10^{-3}
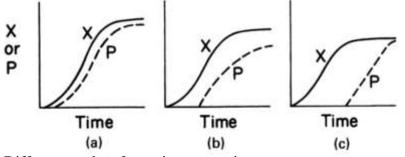
5. In an alpha helix, the ith amino acid residue forms hydrogen bonds with $(i+4)^{th}$ residue. If the helix has 15 residues, the number of hydrogen bonds is
(a) 8   (b) 11   (c) 15   (d) 19

6. Consider a population of cells. Assume that the number of cells in the population is N_0, all viable cells are identical and $p(t)$ is the probability that an individual will still be viable at time t. The probability of extinction of the total population is given by

(a) $[1 - p(t)]^{N_0}$ (b) $p(t)$ (c) $1 - p(t)$ (d) 0

7. Figure below shows three kinetic patterns of microbial growth (X) and product formation (P) in batch fermentation.

Different product formation categories are:

(I)   Non-growth-associated
(II) Growth-associated
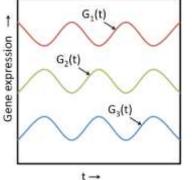(III) Mixed-growth-associated
(IV) Neither (I) or (II) or (III)

Match the patterns and product formation categories

(a) a-III, b-IV, c-II (b) a-IV, b-I, c-III (c) a-II, b-III, c-IV (d) a-II, b-III, c-I

8. A fed-batch culture is operating with intermittent addition of glucose solution at a rate of 200 ml/hr. The culture volume after 2 hrs of operation is found to be 1000ml. The initial culture volume is given by

(a) 600 ml (b) 1400 ml (c) 1000 ml (d) 800 ml

9. Let $S(G_1,G_2)$ be the Pearson correlation coefficient, where $G_1(t)$ and $G_2(t)$, respectively are expression levels of genes 1 and 2 as a function of time. Figure below shows the gene expression time-series of 3 genes.

Which of the following is correct?

(a) $S(G_1,G_2)=1$, $S(G_1,G_3)=0$, $S(G_2,G_3)=1$
(b) $S(G_1,G_2)=0$, $S(G_1,G_3)=-1$, $S(G_2,G_3)=-1$
(c) $S(G_1,G_2)=-1$, $S(G_1,G_3)=-1$, $S(G_2,G_3)=1$
(d) $S(G_1,G_2)=-1$, $S(G_1,G_3)=1$, $S(G_2,G_3)=1$

10. Consider the sequence of numbers: 3, 13, 7, 5, 21, 23, 39, 29, 40, 23, 14, 23, 56, 23, 12

Median and mode of this sequence are

(a) 29 and 3 (b) 23 and 3 (c) 23 and 23 (d) 29 and 23

11. Which of the following is not a function of mitotic cell division
(a) production of gametes (b) asexual reproduction

(c) repair of damaged organs (d) growth

12. When elongated, tube-shaped cells from the lining of the intestine are treated with a certain chemical, the cells sag and become round blobs. The internal structures disrupted by this chemical are probably
(a) cell junctions (b) microtubules (c) rough ER (d) dynein.

13. A karyotype would be least likely to show which of the following?
(a) part of a chromosome turned around (b) part of a chromosome duplicated

(d) a missing chromosome (d) an extra chromosome

14. In an *in vitro* experiment, you want to check your hypothesis that condition "A" results into expression of "B". To check your hypothesis, you plan to use an inhibitor which blocks receptor of "A" and then to use immuno fluorescence to detect "B". Which of the following set/sets will you use as control/s in your experiment?
(a) Culture with condition A but without the inhibitor

(b) Culture without condition A but with the inhibitor

(c) Culture without condition A and without the inhibitor

(d) All of the above

15. Which sub-cellular fraction may contain the enzyme necessary for elongation of long chain fatty acids?
(a) Cell Membrane (b) ER (c) Mitochondria (d) Ribosome