HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

Entrance Test for Ph.D. Programme in Science Education – 2015

Section I:

Multiple Choice Questions

Read the following instructions carefully.

- This section of the written test carries **100 marks** and is of **two hours** duration.

- This section of the question paper consists of 18 pages. There are a total of 90 questions distributed among the different subjects as follows:

    Q 1 to 30: Scientific literacy, technical comprehension, and logical reasoning.

    Q 31 to 50: Social and cognitive sciences and education.

    Q 51 to 90: Ten questions *each* on biology (51 to 60), chemistry (61 to 70), mathematics (71 to 80) and physics (81 to 90).

- All questions are of multiple choice type with four options, out of which **only one** option is correct. Each correct answer earns 2 marks. An unanswered question or a wrong answer earns no mark.

- You may answer **any 50 questions** from this section. In case more than 50 questions are attempted, the score obtained will be normalised to that corresponding to 50 questions.
$$normalised\ score = \frac{score\ obtained}{No.\ of\ questions\ attempted} \times 50$$

- Before you start answering, please check that you have written your Name and Roll Number on both sides of the Answer Sheet.

- You must indicate your answers **only on the Answer Sheet provided**, by putting a × in the appropriate box against the relevant question number, like this: ☒ . Use a dark ink pen to indicate your answers.

- Think and decide carefully on your answer before you indicate it on the Answer Sheet. In case you want to change your answer for a particular question after you have already put a × in a certain box, blacken out the entire box and put a × in the new box of your choice. In the example below the initial choice of (B) has been changed to (C):

    (A) (B) (C) (D)   (A) (B) (C) (D)
    ☐ ☒ ☐ ☐   →   ☐ ■ ☒ ☐

- At the end of two hours, please submit this question paper along with the Answer Sheet.

Scientific literacy, Technical comprehension, and Logical reasoning
Quantitative Reasoning and Technical Comprehension

1. If the number "X78Y" is divisible by 55 then the value for X and Y are

    (A) 1, 0   **(B) 4, 5**   (C) 6, 5   (D) 2, 0

2. Three bells ring at the intervals of 10, 15 and 24 minutes. All the three ring together at 8 A.M. At what earliest time will they again ring together?

    (A) 10:50 A.M.   (B) 08:49 A.M.

    (C) 10:00 A.M.   (D) 08:00 A.M. the following day

3. A worker is paid Rs. x for the first 6 hours she works each day. She is paid Rs. y per hour for each hour she works in excess of 6 hours. During one week she works 7 hours on Monday, 9 hours on Tuesday, 10 hours on Wednesday, 10 hours on Thursday and 7 hours on Friday. What is her average daily wage in rupees for the 5-days?

    (A) $7x + 2.6y$ **(B) $x + 2.6y$**   (C) $7x + 1.6y$ (D) $x + 1.6y$

4. A gardener has fencing material of 32 meters length and wants to make a border-fence around the garden. She is considering the following designs for the garden bed. Which designs are possible with the available wood?

    (A) A & D, but not B and C   (B) Only D

    (C) A, C and D but not B   (D) All four designs are possible

5. If the following fractions are arranged from lowest to highest then what is the middle fraction?

    $\frac{1}{3}$ 31% $\frac{3}{10}$ 0.313   0.303

    (A) 31%   (B) $\frac{1}{3}$ (C) 0.303   (D) 0.313

6. A shopkeeper purchases 6 pencils for a total Rs. 5 and sells all 6 pencils at the rate of Rs. 6 for 5 pencils. She earns a profit of

(A) 30%   (B) $33\frac{1}{3}\%$ (C) 35%   **(D)** 44%

7. You are asked to design new sets of coins. All coins will be circular and colored silver, but of different diameters. Researchers have found out that an ideal coin system meets the following requirements:

- Diameters of the coin should not be smaller than 15 mm and not be larger than 45 mm.
- Given a coin the diameter of the next coin must be at least 30% larger.
- The minting machinery can only produce coins with whole number of millimeters as the diameter.

So start with 15 mm coin and produce a set of as many coin sizes as possible. What would be the diameters of the coins?

(A) 15 mm, 20 mm, 26 mm, 33 mm, 45 mm

(B) 15 mm, 18 mm, 21 mm, 29 mm, 39 mm

(C) 15 mm, 20 mm, 26 mm, 34 mm, 45mm

(D) 15 mm, 20 mm, 25 mm, and so on

8. Circle the one figure below that fits the following description: Triangle PQR is a right angled triangle with right angle at R. The line segment RQ is smaller than the line segment PR. M is the midpoint of the line segment PQ and N is the midpoint of the line segment QR. S is a point in the interior of the triangle. The line segment MN is greater than the line segment MS.

(A)   (B)

(C)   (D)

9. Four cubical dice with numbers from 1 to 6 marked on its faces are rolled. What is the number of possible outcomes in which at least two of the dice show the number 6 on the top face?

(A) 216   (B) 900   (C) 150   **(D) 171**

10. A and B together have Rs. 1210. If $\frac{4}{15}$ of A's amount is equal to $\frac{2}{5}$ of B's amount, how much amount does B have?

(A) Rs. 726   (B) Rs. 242   **(C) Rs. 484**   (D) Rs. 809.90

11. The average of 20 numbers is zero. Of them, at the most, how many may be greater than zero?

(A) 0   (B) 1   (C) 10   **(D) 19**

12. What is the mean of 2^{10} and 2^{20} ?

      (A) 2^{15} (B) $2^2 + 2^{10}$ (C) 2^{19} **(D)** $2^9 + 2^{19}$

The following graph shows the monthly expenditure of Dr Ali's house. Answer the questions 13 to 15 using this graph.

13. How many degrees correspond to the House Rent paid by Dr. Ali?

      (A) 102 Degrees   **(B) 108 Degrees**   (C) 95 Degrees   (D) 99 Degrees

14. If Dr Ali reduces her entertainment and shopping expenditure to 3%, without increasing her expenditure in other categories, how much money will she be saving in total?

      (A) Rs. 16,000   (B) Rs 17,920   **(C) Rs. 20,480**   (D) Rs 22,400

15. Assuming Dr Ali's monthly salary doubles next month, and she spends the same amount in Rupees towards her Rent, Food & Groceries, Entertainment and Shopping, Donations and Loans & EMI as she is spending now, what percentage (approximately) will she be saving from then onwards?

      (A) 25%   (B) 50%   **(C) 62.5%**   (D) 71.5%

Read the following passage carefully and answer questions 16 to 20.

A principal outcome of the Royal College of Art's research project on 'Design in general education' was the restatement of a belief in a missing 'third area' of education. The two already-established areas can be broadly classified as education in the sciences and education in the arts, or humanities. These 'two cultures' have long been recognised as dominating our social, cultural and educational systems. In the English educational system, especially, children are forced to choose one or other of these two cultures to specialise in at an early age - about 13.

The 'third culture' is not so easily recognised, simply because it has been neglected, and has not

been adequately named or articulated. Even a 'three cultures' view of human knowledge and ability is a simple model. However, contrasting design with the sciences and the humanities is a useful, if crude, way of beginning to be more articulate about it. Education in any of these 'cultures' entails the following three aspects: the transmission of knowledge about a phenomenon of study, a training in the appropriate methods of enquiry, an initiation into the belief systems and values of the 'culture'.

A central feature of design activity, then, is its reliance on generating fairly quickly a satisfactory solution, rather than on any prolonged analysis of the problem. It is a process of 'satisficing' rather than optimising; producing any one of what might well be a large range of satisfactory solutions rather than attempting to generate the one hypothetically-optimum solution. This strategy has been observed in other studies of design behaviour, including architects, urban designers, and engineers. Why should it be such a recognisably 'designerly' way of proceeding is probably not just an embodiment of any intrinsic inadequacies of designers and their education, but is more likely to be a reflection of the nature of the design task and of the nature of the kinds of problems designers tackle. The designer is constrained to produce a practicable result within a specific time limit, whereas the scientist and scholar are both able, and often required, to suspend their judgments and decisions until more is known - 'further research is needed' is always a justifiable conclusion for them.

It is also now widely recognised that design problems are ill-defined, ill-structured, or 'wicked'. They are not the same as the 'puzzles' that scientists, mathematicians and other scholars set themselves. They are not problems for which all the necessary information is, or ever can be, available to the problem-solver. They are therefore not susceptible to exhaustive analysis, and there can never be a guarantee that 'correct' solution-focused strategy is clearly preferable to go on.

Adapted from: Cross, N. (1982). *Design Studies*, Vol 3 No 4, pp. 221-227.

16. Contrasting design with the sciences and the humanities is a useful, if crude, way of beginning to be more articulate about it. What does the author mean by the word 'crude' in the above sentence?

    (A) Offensive and rude

    (B) Blunt and straightforward

    (C) Immature and childish

    (D) Lacking in sophistication or subtlety

17. Which of the following definitions of 'culture' is being used in the passage above?

    (A) An existing civilization

    (B) To grow (something) in controlled conditions

    (C) A taste in performing and fine arts, humanities, and broad aspects of science

    (D) The set of values, conventions, or social practices associated with a particular community

18. What would be an appropriate title for the given passage?

    (A) The English Education System

    (B) Designerly ways of knowing

    (C) Art, Science and Design

    (D) Problem solving in Science

19. According to the author, science problems in contrast to design problems are:

    (A) ill-defined   (B) wicked
    (C) susceptible to exhaustive analysis   (D) necessarily have multiple solutions

20. Which of the following does the author consider as ways of a designer?

    (A) Solutions are meant for satisficing rather than optimising.

    (B) It is a time bound activity.

    (C) There are practical solutions to a problem.

    (D) All of the above.

Read the following passage carefully and answer questions 21 to 25.

At first glance, one person's blood looks no different from another's, but appearances can be dangerously deceptive. Early attempts at carrying out blood transfusions in humans were highly unpredictable, often triggering a hazardous and potentially fatal reaction. Examining the underlying cause of such bad blood between people led Karl Landsteiner to discover the existence of human blood groups, for which he was awarded the 1930 Nobel Prize in Physiology or Medicine.

Extracting blood samples from his research staff, and seeing whether one person's red blood cells clumped together when mixed with blood serum from another's, Landsteiner discovered that reactions occurred when a recipient possessed natural antibodies against a donor's blood cells. On this basis, Landsteiner found that people could be classified into three groups, now known as A, B and O, with a fourth group AB discovered soon after. A more detailed investigation revealed that each group was distinguishable by the presence or absence of a particular set of molecules, or antigens, lying on the surface of red blood cells. Tying all the pieces of evidence together, Landsteiner showed that adverse reactions occurred when anyone carrying antibodies to unique antigens found in other blood groups received these blood types from donors.

These discoveries removed a great deal of the risk from blood transfusions. Establishing and matching patients' blood groups in advance could prevent a donor from receiving incompatible blood. Crime scene investigations were also handed a helpful new tool, as dried blood samples could now be typed. Once researchers realized that blood groups are inherited across generations, Landsteiner's discoveries also helped to uncover previously unseen paths through human life. These newly revealed pathways found application both in an anthropological sense, by analyzing the way in which the distribution of blood groups varies across geographic populations, and in a legal sense, by establishing parental association through paternity tests.

Today a classical example of multiple alleles studied is the ABO blood group system. When more than two different forms of a given gene exist in a species, they are referred to as multiple alleles. The RBCs of people with type A blood group contain A antigens, those with type B blood group contains B antigens, those with type AB blood group have both A and B antigens and those with type O blood groups do not have A or B antigens. The I^A and I^B alleles are responsible for the production of A and B antigens. The allele I^A for the A antigen is co-dominant with the allele I^B for the B antigen. Both I^A and I^B are completely dominant to the allele i, which fails to specify A or B antigens. The hierarchy of dominance relationship is symbolized as $(I^A = I^B) > i$. The ABO system is unusual because antibodies can be present without prior exposure to the antigen. Thus people with a particular ABO antigen on their RBCs will have in their serum the antibody against the other antigen.

21. If a man having blood group A marries a woman having blood group B, the possible blood groups of their children would be;

    (A) A, B, AB or O   (B) A, B, or AB   (C) AB only   (D) A or B

22. A person having O blood group will have;

    (A) Neither A nor B antigens and will still produce Anti-A and Anti-B antibodies.
    (B) A and B antigens and will produce Anti-A and Anti-B antibodies.
    (C) A and B antigens and will not produce Anti-A and Anti-B antibodies.
    (D) Neither A nor B antigens and hence will not produce Anti-A and Anti-B antibodies.

23. A person having alleles $I^A I^A$ marrying another person having alleles $I^B I^B$ will have children having blood group;

    (A) A, B or AB   **(B) AB**   (C) O   (D) A or B

24. Karl Landsteiner discovered the blood groups:

    (A) A and O   (B) A, B, AB and O   (C) A, B and AB   (D) AB and O

25. It is known that O blood group is the most common. Among the other three groups, the rarest blood group must be

    (A) A type   (B) B type
    (C) AB type   (D) All three are equally common.

Read the following passage carefully and answer questions 26 to 30.

One of cognitive science's great contributions to our understanding of learning and instruction is that intelligence and expertise are domain-specific and develop along specific learning trajectories within each knowledge domain. Research on human problem solving has been fundamental to this insight. In the 1960s, Herbert Simon and Allen Newell, who first formulated this research program, argued that if we want to understand learning within a knowledge domain, it is necessary to start with a detailed analysis of how people solve specific problems, over short periods of time, in that domain. Cognitive scientists within this research tradition attempt to analyse logically a problem-solving task to frame initial hypotheses about the knowledge and skills the task requires and about how the knowledge and skills might best be organized to solve the problem. Armed with these hypotheses, researchers observe subjects solving a problem, having the subjects think aloud while they do so. Researchers repeat this procedure using different problem types within a domain and collecting think-aloud protocols from subjects of varying skill levels, from novice to expert, in the domain. Protocol analysis of subjects' think-aloud protocols leads to refined hypotheses and models of problem solving within the domain and eventually to the formulation of detailed learning and developmental trajectories within knowledge domains.

By the mid-1970s, research on problem solving began to specify in some detail portions of the learning trajectories within the traditional school subject domains of reading, writing, mathematics, and science. These learning trajectories, where they are available, have helped guide the design of improved instructional materials. The trajectories describe common bottlenecks to learning in specific domains and allow teachers to diagnose learning problems in terms of individual students missing particular understandings or skills, rather than attributing lack of

progress to general cognitive deficits. This cognitive research program, when combined with an understanding of how human memory works, gives educators powerful tools. It provides educators with an empirically based technology for determining students' pre-instructional knowledge, for specifying the form of likely future knowledge states, and for choosing appropriate problems and learning activities to help students build the desired knowledge structures from their pre-existing schemata.

26. The passage above refers to "knowledge domains". Which of the following might be examples of knowledge domains?

I. Problem-solving   II. Repairing computers   III. Botany

      (A) I and III, but not II   (B) III, but not I and II

      (C) II and III, but not I   (D) I, II and III

27. In the last three sentences of the first paragraph, the word 'subjects' is used a few times. Here 'subject' means

      (A) topic   (B) domain   **(C) person**   (D) protocol

28. The passage indicates that the *empirical data* that cognitive scientists use to refine hypotheses and models of problem-solving is/ are

      (A) Skills that people use to solve problems

      (B) Analysis of how people solve specific problems

      (C) Self-reports of people's thought processes while solving problems

      (D) Sophisticated problem-solving strategies used by experts

29. Which of the following claims does the author of the passage support?

I. Although intelligence tests have in the past been imperfect, they are becoming increasingly accurate measures of general intelligence or general cognitive ability.
II. Cognitive science researchers must carefully identify and select expert problem solvers in order to filter out irrelevant data from subjects who make errors.
III. Students can improve their problem-solving ability by using think-aloud protocols.

      (A) Supports III, but not I and II.   (B) Supports II and III, but not I.

      (C) Supports I, II and III.   **(D) Does not support I, II or III.**

30. Which of these is most helpful in formulating domain-specific learning trajectories?

      (A) Detailed analysis of problem tasks.

      (B) Analysis of problem solving strategies of people ranging from beginners to experts.

      (C) Understanding of how human memory works.

      (D) Identifying pre-requisite knowledge to solve given problems.

Social and Cognitive Sciences and Education

31. Which of the following are **NOT** related to Education?

      (A) Sachar Committee   **(B) Srikrishna Commission**

      (C) Kothari Commission   (D) Yashpal Committee

32. In Education- Diagnostic, Formative and Summative are all types of:

    (A) Learning   **(B) Assessment**   (C) Teaching   (D) Pedagogies

33. In the context of education, what does CCE stand for?

        (A) Complete and Comprehensive Evaluation

        (B) Consecutive and Comprehensive Evaluation

        (C) Continuous and Comprehensive Evaluation

        (D) Continuous and Co-curricular Evaluation

34. Emile Durkheim and Harriet Martineau are renowned:

        (A) Anthropologists   (B) Psychologists

        (C) Sociologists   (D) Anthologists

35. The organisation responsible for co-ordinating the National Curriculum Framework is:

        (A) Council for Scientific and Industrial Research

        (B) National Council for Education Research and Training

        (C) University Grants Commission

        (D) All India Council for Technical Education

36. Which Ministry is responsible for Education in India?

        (A) Ministry for Human Resource and Development

        (B) Ministry of Science and Technology

        (C) Ministry of Culture

        (D) Ministry of Youth Affairs and Sports

37. Which of the following is the most important factor influencing you to consider a research article that can be relied upon?

        (A) The article has numerous references.

        (B) The article has a number of data tables and graphs.

        (C) The article was peer reviewed by unbiased third-party experts.

        (D) The article was written by highly reputed researchers.

38. Which of the following actions is a valid scientific course of action?

        (A) A senior scientist uses his influence to get his graduate student's paper published in a prestigious journal.

        (B) A researcher gives free samples of an unapproved but effective drug that she is developing to patients in need.

        (C) A senior scientist retracts a published article of hers when she finds out that one of her team members had fudged the data.

        (D) A scientific journal rejects a study because the results provide evidence against a widely accepted model that has evidence provided for by famous scientists.

39. Mr Sharma is meeting with Mr Rao, his business client. During their interaction, Mr Sharma tries to reconstruct what Mr Rao is thinking and feeling and relays this understanding back to Mr Rao. This communication strategy is an example of

        (A) Active listening   **(B) Reflective listening**

        (C) Informative listening   (D) Appreciative listening

40. Among the basic forms of government which of the following represents the power structure in India

    (A) Confederation   **(B) Federation**   (C) Unitary State   (D) Empire

41. Which of the following is <u>**NOT**</u> a theory of educational psychology

    (A) Constructivism   (B) Behaviorism
    (C) Cognitivism   **(D) Functionalism**

42. Studies find that "teenagers are well informed about risks of tobacco use. But they also think that smoking is cool, and that smoking projects a positive image to their peers". This is an instance related to:

    (A) Functionalist Theory   **(B) Symbolic Interaction Theory**
    (C) Conflict Theory   (D) Labelling Theory

43. For a given list of words, a group of students (Group A) had to tick the words containing the letter O. Another group of students (Group B) had to tick the words which they felt were pleasant. The groups were told that they will be tested for perception and speed of reaction. On completion of task, a 'surprise' incidental memory test was conducted. Which group is likely to recognize and pick out the most number of words as 'having seen before' from a long list words;

    (A) Group A

    (B) Group B

    (C) Both groups' results will be comparable.

    (D) Neither group will be able to recognize any words.

44. While tending to your kitchen garden, you noticed a specific beetle eating your plants. You took a rough count of the beetle population over time and it is shown in the table. Which graph shows the best representation of your data?

No. of Days	No. of beetles
2	5
4	18
8	65
10	130

    (A) Graph C   (B) Graph D   (C) Graph A   (D) Graph B

45. If you state an observation that there is no difference in the cleaning ability of various laundry detergents it can be best defined as a:

    (A) Law   (B) Theory   **(C) Hypothesis**   (D) Principle

46. A psychology study found that the accuracy of recognizing a stimuli is 70% for male participants and 30% for female participants. If 50% recognition is considered as by chance, the interpretation of this result will require:

    (A) Ignoring the female data, and proposing a mechanism for male data

    (B) Ignoring the male data, and proposing a mechanism for female data

    (C) Proposing different mechanisms for males and females

    (D) Proposing the same mechanism for males and females

47. Recent experiments show that control of the self is a limited resource, which gets depleted with every task that requires control. For instance, if a group of participants do a pre-task where they have to resist eating chocolate, they do badly in a problem-solving task; compared to a group that did a pre-task where control of the self is not needed. Since control of the self is critical to success in education, this result suggests:

    (A) Only people with high levels of self control can achieve success in education.

    (B) People with no success in education do not have self control.

    (C) Success in education is mostly due to genetic factors.

    (D) Success in education would be difficult for students with challenging social/economic backgrounds.

48. Studies show that patients with motor neuron disease steadily lose their ability to process verbs, but not nouns, as the disease progresses. This shows that:

    (A) Nouns are learnt earlier than verbs.

    (B) Nouns are more easy to process than verbs.

    (C) Language and action are closely connected.

    (D) Motor neuron disease damages the language area of the brain.

49. "Teachers with a social-reference norm orientation tend to ascribe success and failure at school to stable, internal factors (e.g., ability), and to form stable expectations of student performance. They set all students the same task, and their praise and criticism is dependent on class-average performance." Which of the following would you expect teachers with a social-reference norm orientation NOT to do?

    (A) Praise a "very good student" even if he could have done better, as long as his performance is above the class average.

    (B) Compare performances with previous outcomes to determine whether their performance has improved, worsened or remained unchanged over time.

    (C) Attribute failure to a lack of ability, but success to the ease of the task.

    (D) Compare a student's performance with other students while giving feedback.

50. Paracetamol (Acetaminophen), a medical drug used to lower fever, has been in use for more than 100 years, and more than 27 billion doses was sold in 2009 alone. However, Chemical and Engineering News, a magazine of the American Chemical Society, recently reported that scientists still don't fully understand the mechanisms involved in Paracetamol's ability to lower fever. This suggests that:

    (A) Technology cannot be trusted.

    (B) Technology can develop through trial-and-error.

(C) Science always follows technology.

(D) Technology is not based on science.

Biology

51. Which one of the following is made up of only one type of macromolecule?

    (A) Virus   **(B) Plasmid**   (C) Ribosome   (D) Nucleosome

52. Which of the following activities will decrease the partial pressure of CO_2 in the lungs?

    (A) Deep breathing   (B) Holding breath

    (C) Fast muscular exercise   (D) Breathing in a paper bag

53. A couple has four children, all of whom have a different blood group. What should be the genotype of the parents?

    (A) AA and BB   (B) AO and BB   (C) AA and BO   **(D) AO and BO**

54. To estimate the number of individuals in a rat population in a village, 60 rats were captured, marked and released. When 100 rats were captured a second time, 20 were found to be marked. What is the estimated rat population?

    (A) 200   **(B) 300**   (C) 400   (D) 600

55. Two linear double stranded DNA fragments A and B have the same number of base pairs (120 kb) but A contains 80% A-T pairs while B contains 80% G-C pairs. When run on agarose gel:

    (A) A will run faster than B.

    (B) B will run faster than A.

    (C) A and B will run at the same speed.

    (D) the separation pattern will depend on the pH of buffer used.

56. Osmotic pressure measurements of three solutes resulted in the following graph. The three solutes most likely are:

    (A) I: dextrose   II: NaCl   III: KCl

    (B) I: NaOH   II: NaNO$_3$ III: HCl

(C) I: $CaCl_2$ II: sucrose   III: $HgCl_2$

(D) I: glucose   II: KOH   III: Na_2HPO_4

57. Consider the following statements about the serial endosymbiosis theory.
i. Chloroplasts and mitochondria are self replicating structures.
ii. Chloroplasts and mitochondria require some proteins coded by the nuclear DNA.
iii. Chloroplasts and mitochondria are double membrane structures.
iv. In aerobic prokaryotes plasma membrane incorporates electron transport chain.
Which of these statements support the theory?

    (A) i, iii and iv   (B) i and ii only   (C) i, ii and iv   (D) ii and iii only

58. The pyramid below shows the distribution of pre-reproductive, reproductive and post-reproductive individuals in a small community of species L and M.

(A) Species L is a growing population and species M is a stable population.

(B) Species L is a growing population and species M is a declining population.

(C) Species L is a stable population and species M is a growing population.

(D) Species L is a stable population and species M is a declining population.

59. Which of the following adaptations/strategies can help an animal to prevent dehydration?

    (A) Preference of a marine habitat over a freshwater habitat.

    (B) Utilization of fat as a major energy source.

    (C) Decrease in blood osmolarity.

    (D) All the above.

60. In which of the following conditions will water from soil enter the roots? (Ψ indicates water potential)

    (A) $\Psi_{soil} = -0.3MPa$, $\Psi_{root\ xylem} = -0.2MPa$

    (B) $\Psi_{trunk\ xylem} = -0.6MPa$, $\Psi_{root\ xylem} = -0.3MPa$

    (C) $\Psi_{trunk\ xylem} = -0.3MPa$, $\Psi_{leaf} = 0.7MPa$

    (D) $\Psi_{outside\ air} = -10.3MPa$, $\Psi_{leaf} = -12MPa$

Chemistry

61. The IUPAC name of

(A) methyl 3-hexenoate (B) 3-hexenemethyl carboxylate
(C) 3-butenyl acetate (D) methyl 2-hexenoate

62. The treatment of CH_3OH with CH_3MgI releases 1.04 mL of a gas at STP. The mass of CH_3OH added in mg is

    (A) 1.49 (B) 2.98 (C) 3.71 (D) 4.47

63. In the kinetic energy distribution diagram given below, the region where all collisions result in a chemical reaction is/are

    (A) A only (B) B only (C) B and C **(D) C and D**

64. Which two Fischer formulas represent a pair of enantiomers?

    (A) I & II **(B) III & IV** (C) I & IV (D) II & III

65. A compound alloy of gold and copper crystallizes in a cubic lattice in which the gold atoms occupy the lattice points at the corners of a cube and the copper atoms occupy the centers of each of the cube faces. The empirical formula of this compound is

    (A) AuCu **(B) AuCu$_3$** (C) Au$_3$Cu (D) AuCu$_2$

66. Which conformation of cyclohexane has C_3 axis of symmetry?

    (A) Boat (B) Twist boat **(C) Chair** (D) Envelope

67. The solubility of A_2B_3 is x mol dm^{-3}. The corresponding solubility product is

    (A) 108x^5   (B) 5x^5 (C) 6x^2 (D) 27x^3

68. The reaction that **does not** represent the formation of a Lewis acid-base adduct is

    (A) $KCl + SnCl_2 \rightarrow K^+ + [SnCl_3]^-$ (B) $SO_3 + H_2O \rightarrow HSO_4^- + H^+$
    (C) $PF_3 + F_2 \rightarrow PF_5$ (D) $AsF_3(g) + SbF_5(l) \rightarrow [AsF_2]^+ [SbF_6]^-$

69. The pair of orbitals that has electronic density along the cartesian axes is

    (A) d_{xy}, d_{yz} **(B) $d_{x^2-y^2}, d_z^2$**   (C) d_{xz}, d_{yz} (D) d_{xy}, d_z^2

70. Among the following, the ligands that can form linkage isomers are

    i) NO_2^- ii)PF_3 iii)SO_4^{2-} iv)SCN^-

    (A) ii, iv   (B) ii, iii   **(C) i, iv**   (D) iii, iv

Mathematics

71. A man walks a certain distance and rides back in 3 hours 45 minutes; he could ride both ways in $2\frac{1}{2}$ hours. How long would it take him to walk both ways?

    (A) 3 hours   (B) $2\frac{1}{2}$ hours   **(C) 5 hours**   (D) 4 hours

72. If n is a positive integer such that $8n + 1$ is a perfect square, then

    (A) n must be odd.   (B) n cannot be a perfect square.
    (C) n must be a prime number.   **(D) $2n$ cannot be a perfect square.**

73. The sum

$$1 + 2 - 3 - 4 + 5 + 6 - 7 - 8 + 9 + 10 - 11 - 12 + \ldots + 46 - 47 - 48 + 49$$

is equal to

    (A) 0   **(B) 1**   (C) -1   (D) 49

74. In the following diagram an equilateral triangle is drawn on one of the sides of a square.

$\theta°$

What is the value of θ?

    (A) 60   **(B) 75**   (C) 80   (D) 70

75. The number of 2×2 invertible matrices formed using the integers 0 and 1 is

    (A) 6   (B) 8   (C) 9   (D) 10

76. You are given a right circular conical vessel of height H. First, it is filled up with water to a height h_1 with the apex facing downwards. Then it is turned upside down and it is observed that water level rises to a height h_2 from the base. Which of the following relations is correct?

    (A) $h_1 = h_2$ **(B)** $h_1^3 + (H - h_2)^3 = H^3$

    (C) $h_1^3 + h_2^3 = H^3$ (D) $h_2^3 + (H - h_1)^3 = H^3$

77. The graph of $y = x^4 - x^3 + 1$

    (A) lies above the x-axis.

    (B) intersects the x-axis at exactly two distinct points.

    (C) intersects the x-axis at four distinct points.

    (D) does not intersect the y-axis.

78. The equation of the circle circumscribing the triangle formed by the points $(0,0)$, $(1,0)$, $(0,1)$ is

    (A) $x^2 + y^2 + x + y = 0$.   (B) $x^2 + y^2 + x - y + 2 = 0$.

    (C) $x^2 + y^2 + x - y - 2 = 0$.   **(D)** $x^2 + y^2 - x - y = 0$.

79. Let $\mathbb{R}$ be the set of all real numbers. Let $f : \mathbb{R} \to \mathbb{R}$ be given by

$$f(x) = |x^2 - 1|.$$

Then

    (A) f has a local minimum at $x = \pm 1$ but no local maximum.

    (B) f has a local maximum at $x = 0$ but no local minimum.

    (C) f has a local minimum at $x = \pm 1$ and a local maximum at $x = 0$.

    (D) f has neither a local minimum at $x = \pm 1$ nor a local maximum at $x = 0$.

80. Define the real-valued function f on the set of real numbers by $f(x) = \int_0^1 \dfrac{x^2 + t^2}{2 - t} dt$. Consider the curve $y = f(x)$. It represents

    (A) a straight line.   **(B) a parabola.**   (C) a hyperbola.   (D) an ellipse.

Physics

81. In a new temperature scale ice melts at 25B and water evaporates at 425B, then the normal human body temperature (37^oC) in this new scale is,

    (A) 9.25B   **(B) 173B**   (C) 34.25B   (D) 148B

82. In an Hydrogen atom an electron jumps to $n = 3$ giving out wavelength of the Paschen Series. Which region does this wavelength lie in? (*Rydberg constant* $- R_H = 1.097 \times 10^7 m^{-1}$)

    (A) Optical   (B) UltraViolet   (C) X-ray   **(D) Infra-Red**

83. A mass m slides on two different frictionless inclines. The inclines make angles $\theta_1 = 45^o$ and $\theta_2 = 60^o$ with respect to the horizontal, then the ratio of the accelerations in the direction parallel to the inclines is:

    (A) $\dfrac{\sqrt{3}}{\sqrt{2}}$ (B) $\dfrac{\sqrt{1}}{\sqrt{2}}$ (C) $2\sqrt{2}$ **(D) $\sqrt{2}$**

84. The displacement y of a wave travelling in the negative x direction is given by $y = 10 \, sin \, [4x - 1200t + \pi]$ where x is expressed in metres and t in seconds. The speed of the wave-motion, in ms^{-1} is:

    (A) 300   (B) 600   (C) 30   (D) 60

85. A radioactive parent nucleus gives out a particle to generate a daughter nucleus. In one such series of a single parent nucleus generating a subsequent daughter nucleus, 5α particles, 3β particles and 2γ rays are emitted. Which of the statements below are correct?

  1. Number of neutrons reduces by 13.

  2. Number of neutrons reduces by 15.

  3. Number of protons $= Z - 10$ [Where Z is the atomic number of the parent nucleus].

  4. Number of protons $= Z - 7$ [Where Z is the atomic number of the parent nucleus].

    (A) 2 & 4   **(B) 1 & 4**   (C) 1 & 3   (D) 2 & 3

86. A diver dives in a pool of water having refrative index μ. From a depth of $12\ m$ he looks up to see a circular region. What is the radius of the circular region he sees from that depth? [Here θ_c is the critical angle.]

    (A) $12\tan[\sin^{-1}(\theta_c)]$ (B) $12\tan^{-1}[\sin(\frac{1}{\mu})]$

    (C) $12\tan[\sin^{-1}(\frac{1}{\mu})]$ (D) $12\tan^{-1}[\sin(\theta_c)]$

87. A Pendulum has a hollow spherical shell filled with sand as its bob. There is a small hole at the bottom of the shell. As the pendulum starts swinging in a small angle the sand drains out till the shell is empty. During this process the time period of the pendulum

    (A) Increases and then remains constant.

    (B) Decreases and then remains constant.

    (C) First decreases and then increases to its original value.

    (D) First increases and then decreases to its original value.

88. Potential at a point x due to some charges situated on the x-axis is given by: $V(x) = \dfrac{200}{x^2 - 8}$ volt. The electric field E at $x = 4\mu m$ is given by

    (A) $50\ V/\mu m$ in the +ve x direction.   (B) $50\ V/\mu m$ in the -ve x direction.

    (C) $25\ V/\mu m$ in the -ve x direction.   **(D) $25\ V/\mu m$ in the +ve x direction.**

89. Time period of a satellite moving around the Earth in a circular orbit is

    (A) Independent of its height above the earth surface.

    (B) Independent of its mass.

    (C) Independent of both the mass and the height.

    (D) Dependent on both the mass and the height.

90. Calculate the effective resistance R_{eff} of the following infinite series of resistances R as shown below,

    (A) $R(1 + \sqrt{3})$ (B) $\frac{R(1+\sqrt{5})}{2}$ (C) $R/2$ (D) Infinite