HOMI BHABHA CENTRE FOR SCIENCE EDUCATION
TATA INSTITUTE OF FUNDAMENTAL RESEARCH

Entrance Test for Ph.D. Programme in Science Education - 2017

Section I:
Multiple Choice Questions

Read the following instructions carefully:
- 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 quantitative 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)

- This section of the written test carries a maximum of **100 marks** and is of **2 hours** duration.

- 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 marks.

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

- 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 answers before your 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 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, submit the Answer Sheet.

Scientific Literacy, Technical Comprehension, Quantitative and Logical Reasoning

1. A car 'X' in Pune starts towards Mumbai at 40 Km/hr. Fifteen minutes later, a car 'Y' in Mumbai starts towards Pune which is 150 Km away, at 55 Km/hr. Which car is nearer to Pune when they meet?

    (A) X is nearer   (B) Y is nearer

    (C) Both are at equal distance   (D) Not sufficient information to compute answer

2. In the three stationary trucks below, if their center of gravity is located at the dot (labeled as cg), the truck that will topple is

    (A) A and B   (B) A   (C) all three   **(D) none**

3. If the following blocks are joined together, which of the 4 boxes will be formed?

    (A)   **(B)**   **(C)**   (D)

4. The true equation among the following is

    (A) $(8^3)^2 = 8^6$ (B) $(8^3)^2 = 8^5$ (C) $(8^3)^2 = 8^9$ (D) $(8^3)^2 = 2^9$

5. P supplies 20 men who work for an 8hr /day for 6 days, Q supplies 15 men who work for a 9h r/day for 7 days and R supplies 10 men who work for the 6hr /day for 8 days. If a total of 6360 rupees is paid to the three suppliers (assuming per hour wage is the same for all men), then the share of R is

    (A) 1020.   **(B) 1280.**   (C) 1360.   (D) 1440.

6. For 12L85M to be divisible by 8 and 9, (L, M) should be

(A) (2, 8)   **(B) (5, 6)**   (C) (3, 4)   (D) (1, 8)

7. P is father of Q and R is the son of S. T is the brother of R, while S is the sister of Q. How is Q related to T?

(A) Uncle   (B) Aunt   (C) Mother   **(D)** either Uncle or Aunt

8. In a certain code language, if the word PANCREAS is coded as SAERCNAP, then the word STADIUM in that language is coded as

(A) MUDIATS.   **(B) MUIDATS.**   (C) MUDIAST.   (D) MIUDATS.

9. Out of 100 students, 50 pass in English, 40 pass in Maths and 25 fail in both. Number of students who passed in both is

(A) 10.   (B) 35.   **(C) 15.**   (D) 75.

10. Two friends P and Q traveled by train carrying 67 kg of luggage together. P paid Rs 140 for excess luggage & Q paid Rs. 350. If only P had traveled and carried all the luggage he would have paid Rs. 2590 for excess luggage. The maximum luggage allowed per person (P, Q) without excess charge is

(A) (40, 35).   (B) (30, 35).   (C) (35, 30).   **(D) (30, 30).**

11. The shaded part is ___ of of the total area in rectangle shown below.
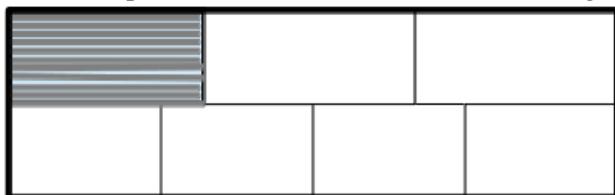
(A) 1/7   **(B) 1/6**   (C) 1/3   (D) 1/8

12. **This question was deleted.**

13. The next number in the sequence 1, 4, 27, 16, 125, _____ is

(A) 36.   (B) 216.   (C) 64.   (D) 512.

14. If x is real, then the value of $x^2 - 6x + 13$ can never be _____

(A) 8.   **(B) 3.**   (C) 135.   (D) 13.

15. If $ stands for addition, # stands for subtraction, Φ stands for multiplication, Δ stands for division, @ stands for less than, ? stands for greater than and ◊ stands for equal to, then the correct statement is

(A) 18 $ 6 Δ 3 @ 6 $ 4 Φ 3   (B) 18 $ 6 Δ 3 ◊ 6 Φ 4 # 3
(C) 18 Δ 6 Φ 3 ? 6 Δ 4 $ 3   (D) 18 Φ 6 Φ 3 @ 6 $ 4 Φ 3

Read the following Passage 1 carefully and answer questions 16 - 20.

Passage 1

Isolated on an island in the Arctic Ocean, not only were woolly mammoths the last of a dying species but they were also swamped with 'bad genes' that are likely to have stripped their sense of smell and saddled them with translucent coats. A study published on 2nd of March, 2017, in *PLOS Genetics* gives a rare insight into how genomes change as a species dies out. Towards the end of the last Ice Age, around 11,700 years ago, woolly mammoths ranged through Siberia and into the colder stretches of North America. But by about 4,000 years ago, mainland mammoths had died out and only 300 remained on Wrangel Island off the Siberian coast.

In order to examine this disappearance at the genetic level, biologists Rebekah Rogers and Montgomery Slatkin at the University of California, Berkeley, compared the complete genome of a mainland mammoth (*Mammuthus primigenius*) that lived about 45,000 years ago with that of a Wrangel Island mammoth from about 4,300 years ago. The sequences were made available by Love Dalén at the Swedish Museum of Natural History in Stockholm. "As I looked at the sequence data," says Rogers, "it became very clear that the Wrangel mammoth had an excess of what looked like bad mutations." Some of these changes are only visible to a geneticist's eye. Compared with the mainland mammoth, the Wrangel Island specimen's genome was riddled with deletions and an abundance of sequences called stop codons — which tell a cell when to stop transcribing a section of DNA — among other changes to the DNA. But some of these changes would also have been visible in the mammoth's behaviour and appearance.

Rogers and Slatkin found that genes related to smell and urinary proteins, which in modern elephants are important for eliciting mating behaviours or signalling social status were shut down by the mutations. These might be related, the researchers hypothesize, because a duller sense of smell may have been hitched in a feedback loop to the loss of urinary proteins, leading to the rapid loss of both. Changes to the Wrangel mammoths' coats would have been even more obvious. Rogers and Slatkin propose that a mutation in a part of the genome called *FOXQ1* would have given the mammoths a 'satin' coat, marked by fur that is the same colour as normal but is shiny and translucent.

Meanings:
Genome: The full set of chromosomes of an individual
Mutations: change or alterations in genes
Sequence data: Information of the DNA or gene sequence

Adapted from: Brian Switek (2017). Dying woolly mammoths were in 'genetic meltdown', *Nature News*, March 2.

16. According to the passage, which of the following are the main reasons for disappearance of woolly mammoths?
>   (i) Because they were stranded in the Artic Ocean.
>   (ii) losing sense of smell and developing translucent coats.
>   (iii) loss of urinary proteins.

> (A) (i), (ii) and (iii)   (B) (i) and (ii)   **(C) (ii) and (iii)**   (D) Only (iii)

17. Of the following, the false statement is:
    (A) Approximately 4000 years ago, only Wrangel Island mammoths existed.
    (B) 4,300 years ago, only mainland mammoths existed.
    (C) The last Ice-age ended around 11,700 years ago.
    (D) The Siberian coast saw a huge decline in mainland mammoths around 4000 years ago.

18. When the author says, "Some of these changes are only visible to a geneticist's eye", he suggests that:
    (i) geneticists' knowledge enables them to view minor changes in sequence data.
    (ii) geneticists use an instrument called 'geneticist's eye' to view changes in sequence data.
    (iii) geneticists overlook bad mutations.

    (A) (i) and (iii)　　　　(B) (ii) and (iii)　　　　(C) (iii)　　　　**(D) (i)**

19. According to the passage, which of the following events are true?
    (A) Mutation in *FOXQ1* leads to a dull sense of smell, loss of urinary proteins and development of a shiny coat.
    (B) The dull sense of smell leads to loss of urinary proteins and both lead to a mutation in *FOXQ1*.
    (C) The mutation *FOXQ1* occurs on a separate part of the genome and is not associated with loss of sense of smell or urinary proteins.
    (D) The dull sense of smell and loss of urinary proteins together lead to development of shiny coat.

20. Which of the following words can most closely replace the word 'meltdown' in the title?
    (A) termination　　　　(B) defrost　　　　(C) chaos　　　　(D) riddle

Read the following Passage 2 carefully and answer questions 21 - 25.

Passage 2
Female first-year Ph.D. students in "bench" biology disciplines—such as molecular biology, cellular biology, and genetics—spend significantly more hours in lab than their male classmates do. Yet, for every 100 hours spent at work, these female students are 15% less likely to publish a paper during that first year than their male counterparts are, a new study reports. The observed authorship difference could give male students an edge when applying for postdoctoral and faculty positions, contributing to the gender gap in university faculty in these fields, the study suggests. Biology is notable because, although approximately equal numbers of men and women have earned biology Ph.D.s in the United States over the past 10 years, the equity does not carry over to the faculty level: Estimates of tenure-track assistant professor positions held by women range from 29% to 36%.

Regardless of gender, relatively few students publish papers in their first year of graduate school; only 22% of the 303 students who responded to the study survey had, and most who did were middle authors. Publishing as a middle author typically doesn't hold as much weight as being the first author does, but because middle authorships generally require far less time and energy than a first-author paper, they can be an efficient way to build one's publication record. But the gender difference observed in the study suggests that, despite women's efforts, they don't seem to be getting access to the payoff of publishing early as a middle author as readily as men do, says lead author David Feldon, an associate professor of instructional technology and learning sciences and the director of graduate program assessment and development at Utah State University in Logan.

The looming question is why there's a publication gap that goes opposite to what one might expect based on the hours worked. Lack of confidence among female students, which is commonly cited as a factor contributing to the underrepresentation of women in science, did not appear to play a role for the female students at the 53 institutions involved in the study. The source may lie in the lab dynamics, Feldon suggests: The interactions in the labs among graduate students and between faculty members and graduate students may favor men to get better yields for their time spent.

Previous studies offer a number of further possible explanations: Women fear backlash when they speak up for themselves, they receive lower quality mentoring, or advisers overvalue work done by men. Or

perhaps male students are more likely than their female counterparts to do the kind of work that is most likely to lead to authorship.

Adapted from: Maggie Kuo (2017). Women miss out on authorship opportunities early on. *Science*, February 16.

21. According to the passage, which of the following is not correct?
    (A) Male students in their 1st year of Ph.D. in Biology spend lesser time than their female counterparts doing experimental work.
    (B) 1st year PhD female students are less likely to publish a paper because they spend more hours on 'bench' work.
    (C) Publishing a paper in the 1st year gives an advantage to male Ph.D. students while applying for post-doctoral or faculty positions.
    (D) In the United States, biology Ph.D.s are somewhat equally acquired by both males and females.

22. The survey in graduate school on publication indicates:
    (A) approximately 66 female students out of 303 who responded were able to publish papers in their 1st year of PhD.
    (B) approximately 66 male students out of 303 who responded were able to publish papers in their 1st year of PhD.
    (C) approximately 237 students who responded to the survey were unable to publish papers in their 1st year of PhD.
    (D) only 66 students out of 303 responded to the survey, regardless of the gender.

23. What drives students to publish as a middle author in the first year of their Ph.D.?
    (i) Requires lesser time and energy
    (ii) Can help in setting a good publication record
    (iii) Does not carry as much weight as a first author
    (A) Only (ii)   **(B) (i) and (ii)**   (C) (i), (ii) and (iii)   (D) (ii) and (iii)

24. According to the passage, which of the following is not a reason for the publication gap between men and women in 1st year of Ph.D.?
    (A) There is a lack of confidence in women.
    (B) Interactions of men with lab mates and faculty members are considered favourable for better outcomes.
    (C) Men receive higher quality of mentoring than women.
    (D)The kind of work done by women is less likely to lead to an authorship.

25. In the line "the looming question is...", the word looming can best be replaced by
    (A) important.   (B) difficult.   **(C) emerging.**   (D) obvious.

Read the following Passage 3 carefully and answer questions 26 - 30.

Passage 3
Empirical science ... does not aim simply at a description of particular events: it looks for general principles which permit their explanation and prediction. And if a scientific discipline entirely lacks such principles, then it cannot establish any connections between different phenomena: it is unable to foresee future occurrences, and whatever knowledge it offers permits of no technological application, for all such application requires principles which predict what particular effects would occur if we brought about certain specified changes in a given system. It is, therefore, of paramount importance for science to

6

develop a system of concepts which is suited for the formulation of general explanatory and predictive principles.

The vocabulary of everyday discourse, which science has to use at least initially, does permit the statement of generalizations, such as that any unsupported body will fall to the ground; that wood floats on water but that any metal sinks in it; that all crows are black; that men are more intellectual than women; etc. But such generalizations in everyday terms tend to have various shortcomings: (1) their constituent terms will often lack precision and uniformity of usage (as in the case of 'unsupported body', 'intellectual', etc.), and, as a consequence, the resulting statement will have no clear and precise meaning; (2) some of the generalizations are of very limited scope (as, for example, the statement dealing only with crows) and thus have small predictive and explanatory power (compare in this respect the generalization about floating in water with the general statement of Archimedes' principle); (3) general principles couched in everyday terms usually have "exceptions."

In order to attain theories of great precision, wide scope, and high empirical confirmation, science has therefore evolved, in its different branches, comprehensive systems of special concepts, referred to by technical terms. Many of those concepts are highly abstract and bear little resemblance to the concrete concepts we use to describe the phenomena of our everyday experience. Actually, however, certain connections must obtain between these two classes of concepts; for science is ultimately intended to systematize the data of our experience, and this is possible only if scientific principles, even when couched in the most esoteric terms, have a bearing upon, and thus are conceptually connected with, statements reporting in "experiential terms" available in everyday language what has been established by immediate observation. Consequently, there will exist certain connections between the technical terms of empirical science and the experiential vocabulary; in fact, only by virtue of such connections can the technical terms of science have any empirical content.

Adapted from: Carl Hempel (1952). *Fundamentals of Concept Formation.* University of Chicago Press, Chicago.

26. According to the author, technical terms used in science are
    (A) concrete.   (B) experiential .
    (C) both concrete and experiential.   **(D) precisely defined.**

27. According to the author, everyday terms
    (A) have precision.   **(B) are closer to experience.**
    (C) have greater scope.   (D) have least exceptions.

28. How would you characterize the views expressed in the passage?
    (A) that experience is possible due to ideas in the mind.
    (B) that abstract concepts need to be grounded in experience.
    (C) that experience is possible due to ideas in mind and a view that abstract concepts need to be grounded in experience.
    (D) that abstract concepts and concrete concepts can be independent of each other.

29. The general principles in science explain:
    (A) theories.   (B) law of science.   **(C) particular events.**   (D) a system of concepts.

30. The author makes a distinction between everyday generalizations and scientific generalizations in the above passage. Based on this distinction: Which of the following is a scientific generalization?
    (A) All bodies attract each other.   (B) Sun rises in the east.
    (C) All crows are black.   (D) All the above.

Social and Cognitive Sciences and Education

31. Of the following, the appropriate statements related to theories and facts are
    (i) Theory is an educated guess which may someday become fact when scientists gather evidence for it.
    (ii) Theories don't become facts.
    (iii) Facts are based on theory.
    (iv) Theories explain facts.
    (A) (i) and (iv)   (B) (ii) and (iii)   (C) (i) and (iii)   **(D) (ii) and (iv)**

32. Kinu never lies but he allows his chartered accountant to file incorrect income tax returns thereby cheating the government. He keeps his two value systems distinct. This is an example of which of the following defense mechanisms?
    (A) Compartmentalization (B) Denial   (C) Dissociation   (D) Rationalization

33. Mili identifies herself as an environmentalist. She believes that nature provides for all the requirements of human beings, and hence nature needs to be conserved. If nature is not protected, then human beings will perish. Her stance is not a form of
    (A) ecocentrism.   (B) humanocentrism.   (C) anthropocentrism.   (D) homocentricism.

34. According to Bloom's taxonomy of learning domains, responding to which of the following could elicit highest level of thinking?
    (A) Who wrote "My experiments with truth"?
    (B) Draw and explain the water cycle.
    (C) What influence do social media have on our lives?
    (D) What is the central argument of this news article?

35. LGBT stands for
    (A) lesbian, gay, bisexual and transvestite.   (B) lesbian, gay, bisexual and third gender.
    (C) lesbian, gay, bisexual and transgender.   (D) lesbian, gay, bisexual and transsexual.

36. Studies situated in which of the following paradigms often employ psychometric approaches?
    (A) Positivist   (B) Relativist   (C) Critical theorist   (D) Interpretivist

37. A teacher taught a school topic using a documentary film. The children were moved by the story featured in the documentary and felt a rush of emotions after watching it. The teacher was trying to address which domain of learning?
    (A) Cognitive   **(B) Affective**   (C) Psychomotor   (D) Kinesthetic

38. In the context of feminism, which of the following is a case of "Impostor syndrome"?
    (A) Shainaz got an unexpected early promotion at work. Her colleagues are upset and she sympathizes with them, but she is secretly happy about her promotion.
    (B) At work, Shaheen pretends to be unmarried because her job requires single women. She keeps lying to justify her actions.
    (C) Sharda's suggestions were ignored during an office meeting. She feels she needs to be taken more seriously by her colleagues.
    (D) Sasha got good grades on her promotion exam. But she thinks that the grader has been lenient.

39. Visual learner: Diagrams and graphs:: Verbal learner: ?

(A) Lectures and readings (B) Flowcharts and schematics

(C) Numbers and pictures (D) Activities and playing

40. Which of the following government schemes is expected to work in tandem with Sarva Shiksha Abhiyan to ensure 'inclusion' of all girls? It does this through provision of residential upper primary schools for girls from SC, ST, OBC and Muslim communities and girls from families that live below the poverty line.

(A) Kasturba Gandhi Balika Vidyalaya (KGBV)
(B) National Programme for Education of Girls at Elementary Level (NPEGEL)
(C) Mahila Samakhya
(D) Shiksha Sahayog Yojana

41. Which of the following sociological perspectives views relations in society to be based on exploitation, oppression, domination and subordination?

(A) Functionalism (B) Labelling theory

(C) Critical theory (D) Symbolic interactionism

42. Which of the following is not a form of "self-fulfilling prophecy"?

(A) Pygmalion effect **(B) Pratfall effect** (C) Golem effect (D) Rosenthal effect

43. A research study where every n^{th} member of the population is included is using

(A) probability sampling. (B) selective sampling.

(C) snowball sampling. (D) non-probability sampling.

44. Its lunch time and the classroom is empty. Kavita notices that one of Anisha's lovely ink pens is lying on her desk. Kavita has longed to have such a pen but has not been able to convince her parents to purchase it for her. Kavita quickly peeps through the door to check no one is coming. She wants to take the pen but stops herself fearing exposure of her actions. Which of the following Kohlberg's stages of moral reasoning reflects Kavita's actions?

(A) Interpersonal accordance conformity (B) Self interest orientation

(C) Obedience and punishment orientation (D) Social contract orientation

45. A global learner is one who can absorb information randomly and synthesize the big picture, and has a tendency for holistic thinking. Who among the following is likely to be a global learner?

(A) Student 1: I don't like this memorization and rote learning- it's boring!
(B) Student 2: Lectures don't help me, can you give me lecture handouts?
(C) Student 3: I can't see what this derivative and integration has to do with the real world.
(D) Student 4: I forgot the formula, so I cannot solve this physics problem.

46. In many multiple choice exams, the wording of the questions and the answers are intentionally designed to mislead the candidate. Some candidates overcome these 'distractors', and answer the questions correctly. These exam questions test the candidates for

(A) deep understanding in the tested domain. (B) awareness of their own thinking processes.

(C) the ability to control their responses. **(D)** the ability to detect misleading descriptions.

47. School children learning algebra often treat transformations such as

$$x + b = y - m \qquad \rightarrow \qquad x = y - m - b$$

not as the repeated application of formal Euclidean axioms, but as "magic motion," in which a term moves to the other side of the equation and "flips" sign. A recent study showed that participants with significant training in calculus found it easier to solve problems of this form when an irrelevant field of background dots moved in the same direction as of the variables, than when the dots moved in the contrary direction.

This result shows that

(A) school children and experts think similarly while doing algebra.

(B) doing algebra requires perception of movements.

(C) thinking of movements is involved in doing algebra.

(D) variables in algebra have a direction.

48. A psychological study examining how people process spoken descriptions asked participants to listen to stories about spatial scenes, while they looked at a blank screen. The stories directed the participants' attention to different regions in the verbally described scenes, such as to low or high floors of a tall apartment building. When the story described an object or activity on a lower floor of the building, eye movements remained low on the blank screen. As the description "moved" up the building, so did eye movements.

This result suggests that

(A) eye movements are required to process spoken language.

(B) body movements are needed to process language.

(C) mentally attending to a part of space requires moving the eye to that space.

(D) actions could be part of mental processing of abstract stimuli.

49. Studies in neurology describe patients with brain damage who exhibit an inability to understand animal categories (such as "dogs" and "robins"). However, these patients have little trouble naming and defining artifact categories (such as "hammers" and "chairs"). More rarely, patients show the opposite deficit, exhibiting less knowledge of artifacts than of animals. This double dissociation of animals and artifacts suggests that

(A) these two categories cannot be processed together.

(B) different localized brain areas represent these two kinds of categories.

(C) brain damage always leads to such systematic psychological damage.

(D) accessing one of these categories in working memory blocks access for the other.

50. Jerome Bruner, an influential educational psychologist, points out that the practice of education is possible only because new knowledge can be learned through 'compressed' experiences. For instance, if learning Newtonian Mechanics necessarily requires having all the experiences that led Newton to discover his theory, then education would not be possible. Education of Newtonian Mechanics is based on the idea that a 'compressed' set of experiences, of theory and lab activities, can lead up to students understanding, and eventually using and extending, this physics model. From this view of education, it follows that

(A) having more and richer experiences, of theory and lab activities, will not lead to better knowledge.

(B) the best way to learn something deeply is to experience many different activities.

(C) progress in human knowledge depends on our ability to generate good compressed experiences.

(D) students who do not understand Newtonian Mechanics are not able to learn with compressed experiences.

Biology

51. A graph of relative DNA content per cell during nuclear divisions is shown below. Which of the following cells would this represent?

    (A) Bacterial cell

    (B) Nerve cell

    (C) Skin epithelial cell

    (D) Oocyte
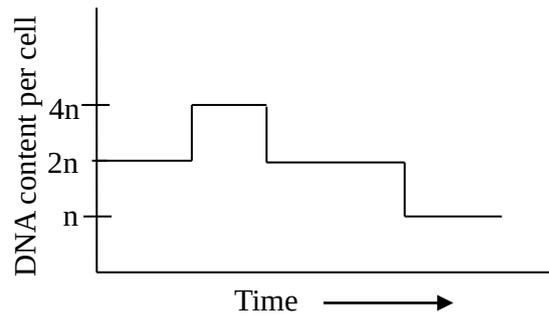
52. The relative changes in the dry mass of certain components (M and N) of barley seeds during germination is shown in the graph below. M and N represent:

    (A) M: Sugars; N: Starch

    (B) M: Endosperm; N: Embryo

    (C) M: Proteins; N: Lipids

    (D) M: Root; N:Cotyledons
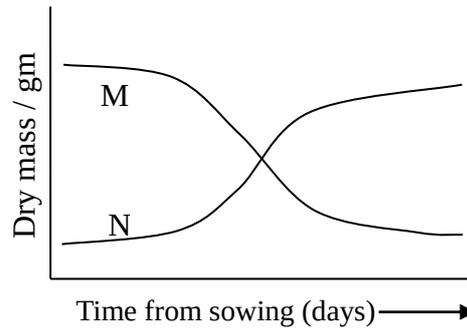
53. An experiment required a suspension of bacterial cells to be serially diluted. Steps carried out are shown below.

    Each tube contains 9.9 ml of sterile distilled water
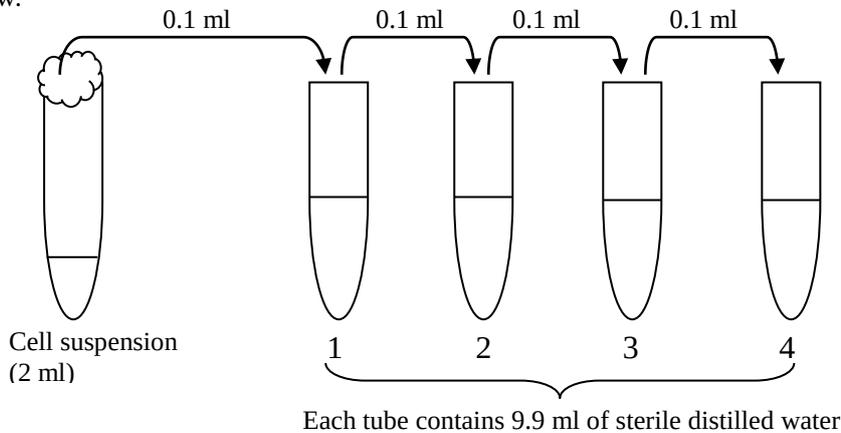
    In comparison to the original suspension, the suspension in tube no. 3 is diluted
    (A) 3 times.   (B) 6 times.   (C) 10^3 times.   **(D) 10^6 times.**

54. The frog life cycle is divided into two major stages. First one is completely aquatic (tadpole) and another one is adult stage. It is found that length of a small intestine during tadpole stage is much longer than in adult stage as compared to body length. The reason must be:

    (A) The length of the intestine remains same, only the overall body size increases.
    (B) Adult frog has shorter intestine but diameter wise it is broad so the internal surface area remains same.
    (C) Tadpole is herbivorous while adult frog is carnivorous.
    (D) The metabolic rate of tadpole is much lower than adult frog.

11

55. The following figure represents two main processes occurring in a plant cell.
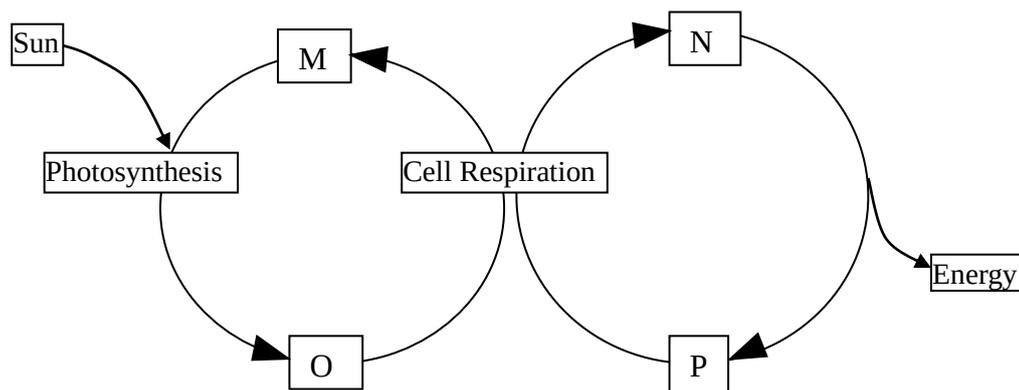
Most likely M, N, O, and P represent

(A) M: H_2O N: Glucose O: O_2 P: ATP
(B) M: H_2O N: ADP O: O_2 P: ATP
(C) M: O_2 N: CO_2 O: Glucose P: H_2O
(D) M: CO_2 N: ATP O: O_2 P: ADP

56. While studying photosynthesis, Anil tried to extract and separate plant pigments from a leaf sample. He checked the absorption maxima of one of the separated pigments with a spectrophotometer. He got the following results:
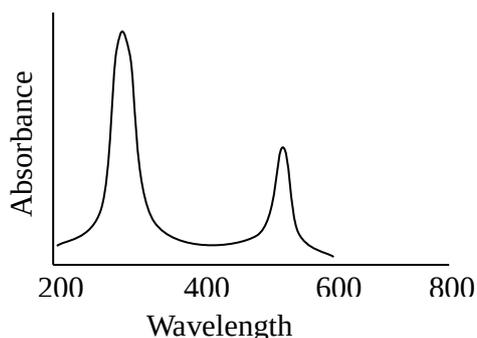
The pigment must be:
(A) Chlorophyll-a (B) β- carotene (C) Chlorophyll-b **(D) Anthocyanin**

57. A person was suffering from a certain viral infection which was confirmed in a laboratory test. He was prescribed antibiotics. The true statement among the following is:

(A) Some antibiotics can kill viruses
(B) The antibiotic could help in preventing a secondary bacterial infection
(C) Antibiotics can relieve the symptoms of a viral infection
(D) Antibiotics can stop the virus from infecting another host

58. Glutamate dehydrogenase from an organism was reported to be a water soluble heat-stable enzyme. The enzyme preparation was subjected to a heat treatment at $65°C$ for 10 min as a purification step. The heat-treated enzyme was then centrifuged at $4°C$. Which of the following is a possible outcome?

(A) The enzyme activity will be seen in supernatant only.
(B) The enzyme activity will be seen in pellet only.
(C) Both-pellet and supernatant will show 50% activity each.
(D) The enzyme activity will be lost due to centrifugation at a cold temperature.

59. A 'U shaped' glass tube is shown below. It has a selectively permeable membrane fixed in the centre portion which allows only water molecules to pass through it.
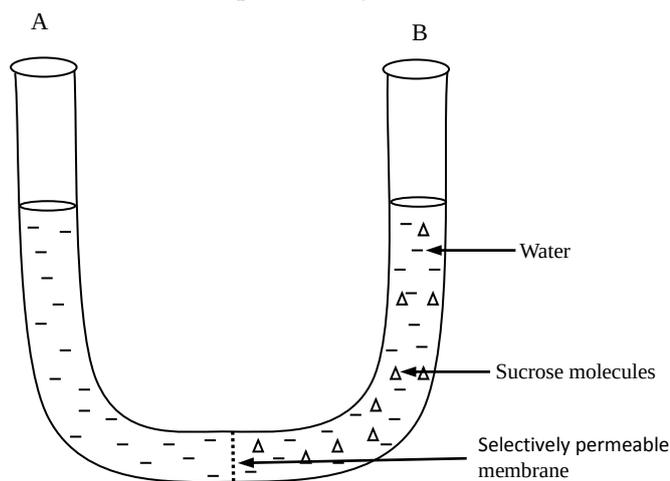

The arm 'A' is filled with 100 ml distilled water while arm 'B' is filled with 100 ml of 0.1 M sucrose solution. After 10 minutes, the observation would be:

(A) Water level in 'A' would be lower than initial while solution level in 'B' will rise.
(B) Water level in 'A' will rise above initial level while in 'B' it will fall.
(C) Water level in 'A' will remain same as initial while level in 'B' it will rise.
(D) Water level in 'B' will remain same as initial while level in 'A' it will rise.

60. People suffering from irritable bowel syndrome (IBS) are advised to eat a low FODMAP diet. FODMAP stands for **F**ermentable **o**ligosachharides, **d**isachharides, **m**onosachharides and **p**olyols. Which of the following combination of food would least affect an IBS patient?

(A) Apples, whole-milk and lentils   (B) Soy-products, raisins and garlic
(C) Oranges, almonds and chicken   (D) Mangoes, beet-root and sugar-free gums

Chemistry

61. The following two curves show equilibrium energy distributions of molecules in a reacting gaseous mixture at two different temperatures. **E_a is the activation energy of the reaction between these molecules.** The shaded area represents the number of
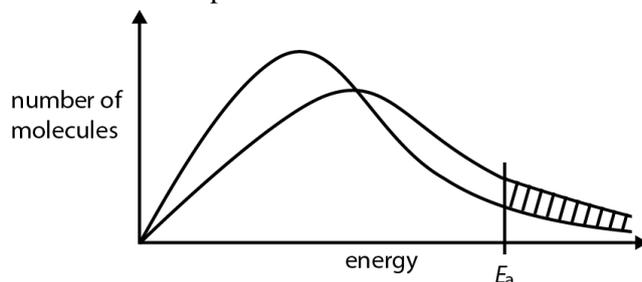

(A) **additional molecules likely to react at the higher temperature as compared to the lower temperature.**
(B) molecules likely to react at the lower temperature.
(C) additional molecules likely to react in the presence of a catalyst at the lower temperature itself.
(D) additional molecules likely to react in the presence of a catalyst at the higher temperature as compared to the lower temperature without catalyst.

13

62. Vanillin, $C_8H_8O_3$ (M = 152 g mol^{-1}), is the molecule responsible for the vanilla flavour in food. How many oxygen atoms are present in a 45.0 mg sample of vanillin?

   (A) 1.78×10^{20} **(B) 5.35×10^{20}**   (C) 1.78×10^{23} (D) 5.35×10^{23}

63. When 15.0 mL of 0.040 M lead (II) nitrate is mixed with 15.0 mL of 0.040 M sodium chloride,

   $$PbCl_2(s) \leftrightharpoons Pb^{2+}(aq) + 2\ Cl^-\ (aq) \qquad [K_{sp} = 1.7 \times 10^{-5}\ ]$$

   (A) a clear solution with no precipitate will result.
   (B) $PbCl_2$ will precipitate and some Pb^{2+} ions will remain in solution.
   (C) $PbCl_2$ will precipitate and some Cl^- ions will remain in solution.
   (D) $PbCl_2$ will precipitate and no Pb^{2+} or Cl^- ions will remain in solution.

64. If concentrated sulfuric acid is spilled on the skin, immediately the area of the skin should be
   (A) rinsed off with large quantities of running water.
   (B) neutralized with solid $CaCO_3$.
   (C) neutralized with NaOH solution.
   (D) wrapped tightly with cloth and shown to a doctor.

Questions 65 - 66 are based on the description given below.
   20 mL of solution X was pipetted into a flask and titrated with solution Y from a burette. The pH was monitored with a pH meter throughout the experiment, and was plotted against the volume of solution Y added to give the graph below.
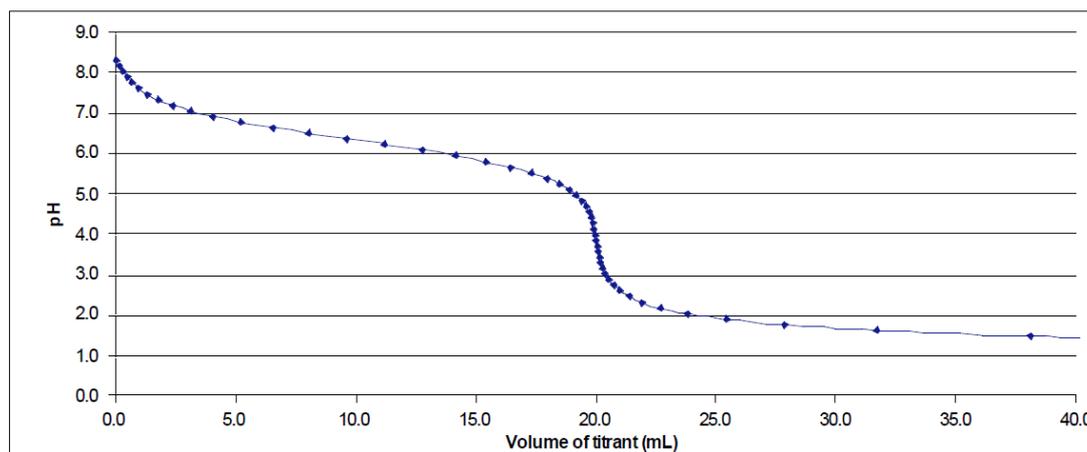
65. The most likely identities of solutions X and Y, respectively, are
   (A) KOH and CH_3COOH.   **(B) $NaHCO_3$ and HBr.**
   (C) CH_3COOH and $NaHCO_3$.   (D) HBr and $NaHCO_3$.

66. Among the following, the best indicator to perform the above titration is
   (A) thymolphthalein ($pK_a = 9.9$).   (B) phenolphthalein ($pK_a = 8.0$).
   (C) chlorophenol blue ($pK_a = 6.0$).   **(D) methyl orange ($pK_a = 4.2$).**

67. The dichromate ion $Cr_2O_7^{2-}$ in acidic solution is yellow whereas Cr^{3+} is green. To each of the following four aqueous solutions, a few drops of acidified $K_2Cr_2O_7$ were added. Two of the solutions turned green; one turned dark brown, and one remained yellow. The solution that remained yellow is that of
   (A) $SnCl_2$.   (B) KI.   (C) CH_3CH_2OH.   **(D) $Al_2(SO_4)_3$.**

68. A fuel/oxidant system consisting of monomethylhydrazine CH_3NHNH_2 and N_2O_4 (both liquids) is commonly used in space vehicle propulsion. Components are mixed stoichiometrically so that gaseous N_2, CO_2 and H_2O are the only products (all gases under the same reaction conditions). Total number of moles of all gases produced from 100 mol of CH_3NHNH_2 are
(A) 100.   (B) 225.   (C) 400.   **(D) 625.**

69. The most common batteries used in cars are lead-acid batteries that can be discharged and recharged according to the following equation:

$$Pb(s) + PbO_2(s) + 2\ H_2SO_4(aq) \underset{\text{recharge}}{\overset{\text{discharge}}{\rightleftharpoons}} 2\ PbSO_4(aq) + 2\ H_2O(l)$$

During discharging, the reducing agent is

(A) Pb(s).   (B) $PbO_2(s)$.   (C) $H^+(aq)$.   (D) $SO_4{}^{2-}(aq)$.

70. Vegetable oil and water are mixed and shaken vigorously in a container. On keeping this container still, the two liquids separate into two layers with oil layer on top of water. This suggests that
(A) molar mass of oil molecules is higher than that of water molecules.
(B) there is no Van-der-Waals interaction between water and oil molecules.
(C) water molecules do not form hydrogen bonds with oil molecules.
(D) oil is more volatile than water.

Mathematics

71. The number of integers $n > 1$, such that n, $n + 2$, $n + 4$ are all prime numbers, is
(A) zero.   **(B)** one
(C) infinite.   (D) more than one but finite.

72. The number of ways you can invite 3 of your friends on 5 consecutive days, exactly one friend a day, such that no friend is invited on more than two days is
(A) 90   (B) 60   (C) 30   (D) 10

73. Let $P(x) = ax^2 + bx + c$ and $Q(x) = -ax^2 + bx + c$, where a, b and c are real numbers and $ac \neq 0$. Consider the polynomial $R(x) = P(x)Q(x)$. Then,
(A) all roots of $R(x)$ are real.   (B) no root of $R(x)$ is real.
(C) at least two roots of $R(x)$ are real.   (D) exactly two roots of $R(x)$ are real.

74. Let P and Q be the subsets of the X-Y plane defined as:
$P = \{(x, y): x > 0, y > 0 \text{ and } x^2 + y^2 = 1\}$ and $Q = \{(x, y): x > 0, y > 0 \text{ and } x^8 + y^8 < 1\}$
Then, $P \cap Q$ is
(A) the empty set $\emptyset$.   **(B) set P.**   (C) set Q.   (D) none of the foregoing sets.

75. For any complex number $z = x + iy$ with x and y real, define $<z> = |x| + |y|$. Let z_1 and z_2 be any two complex numbers. Then,
(A) $<z_1 + z_2> \leq <z_1> + <z_2>$.
(B) $<z_1 + z_2> = <z_1> + <z_2>$.
(C) $<z_1 + z_2> \geq <z_1> + <z_2>$.
(D) None of the foregoing statements need always be true

76. The equation $x^2 + y^2 - 2xy - 1 = 0$ represents

    (A) two parallel straight lines.   (B) two perpendicular straight lines.

    (C) a circle.   (D) a hyperbola.

77. In a triangle ABC, the medians AM and CN to the sides BC and AB respectively, intersect at the point G. Let P be the mid-point of AC and let MP intersect CN at Q. If the area of the triangle GMQ is s square units, the area of ABC is

    (A) $16s$ sq. units.   (B) $18s$ sq. units.   (C) $21s$ sq. units.   **(D) $24s$ sq. units.**

78. In a trapezium, the lengths of the two parallel sides are 6 and 10 units. If one of the oblique sides has length 1 unit, then the length of the other oblique side must be

    (A) greater than 3 units but less than 4 units.   **(B) greater than 3 units but less than 5 units.**

    (C) less than or equal to 3 units.   (D) greater than 5 units but less than 6 units.

79. Suppose f is a real valued function defined on the set of all real numbers. Suppose f is continuous at all x and f is not differentiable at 0. Let $g(x) = xf(x)$. Then, $g(x)$ is

    (A) not continuous at any point.

    (B) differentiable at $x = 0$.

    (C) not differentiable at $x = 0$.

    (D) continuous and always differentiable at all points.

80. Each of the 12 sides of the figure below has the same length. Which of the following angles has a measure of 90°?

   (A) Angle ABH

    (B) Angle ACG

    (C) Angle ADF

    (D) Angle ADI
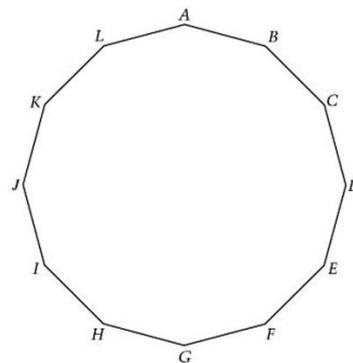
Physics

81. A beaker containing a liquid is placed on a horizontal floor. Then the pressure in the liquid

    (A) is the same at all points.

    (B) at any point is independent of the atmospheric pressure.

    (C) is the same at all points at the same depth.

    (D) at a given point depends on the direction.

82. In an experiment on simple pendulum to determine the acceleration due to gravity, a student measures length of the thread as 63.2 cm using a meter scale and diameter of the pendulum bob as 2.256 cm. The length of the pendulum that she should report is

    (A) 64.328 cm.   **(B) 64.3 cm.**   (C) 65.456 cm.   (D) 65.5 cm.

83. Figure below shows a particular position of the vernier calliper in centimeter scale. The value of x will be
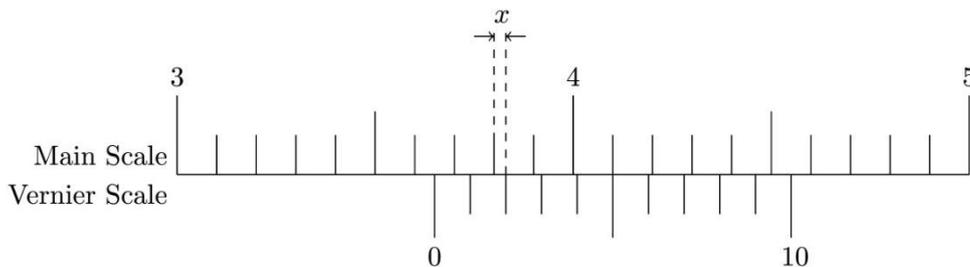

(A) 0.02 cm.   **(B) 0.03 cm.**   (C) 3.65 cm.   (D) 4.15 cm.

84. The electric field in some region of space is uniform in magnitude and direction. The charge density in this region

(A) is zero.
(B) decreases linearly in the direction of electric field.
(C) increases linearly in the direction of electric field.
(D) is uniform throughout the region.

85. The diagram on right shows two circular loops of wires (A and B) centred on and perpendicular to the x-axis, and oriented with their planes parallel to each other. The y-axis passes vertically through loop A (dashed line). There is a current I_B in loop B as shown.
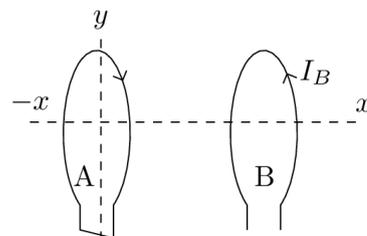
Among the following four possible actions on loop A

    (i)   Move A to the right along x-axis closer to B.
    (ii)   Move A to the left along x-axis away from B.
    (iii) As viewed from above, rotate A clockwise about y-axis.
    (iv) As viewed from above, rotate A anticlockwise about y-axis.
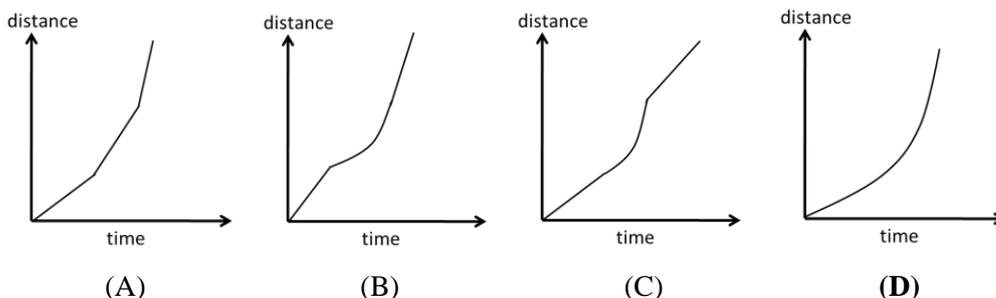
the action(s) that will induce a current in loop A only in the direction shown is/are

(A) **only (i)**   (B) Only (ii) .   (C) only (i) and (iv).   (D) only (ii) and (iii).

86. A rigid ball rolls without slipping on a surface shown below.

The most likely representation of the distance travelled by the ball vs time graph


(A)   (B)   (C)   **(D)**

87. In an experiment, setup A consists of two parallel wires which carry constant currents in opposite directions as shown in the figure. A second setup B is identical to setup A, except that there is a metal sheet between the wires shown by shaded vertical rectangle.
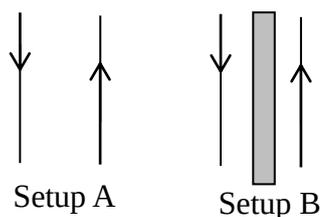
Setup A   Setup B

Let F_A and F_B be the magnitude of the force between the two wires in setup A and setup B, respectively.

(A) $F_A > F_B \neq 0$ (B) $F_A < F_B$ **(C) $F_A = F_B \neq 0$**   (D) $F_A > F_B = 0$

88. Propagation of matter or fields in physical processes are sometimes depicted visually in diagrams by lines. Of the following, the lines that can cross are

(A) Streamlines in fluid flow.   (B) Lines of forces in electrostatics.
(C) Rays in geometrical optics.   (D) Lines of force in magnetism.

89. Consider an experiment to determine acceleration due to gravity using free fall of a steel ball. The ball is dropped from the same point every time. The time for the free fall between points A and B (separated by distance s) is noted using a measuring device coupled to a digital stopwatch. Measuring device at A remains fixed. The distance s can be varied by moving the device located at point B. A student gets a data set of s and t.
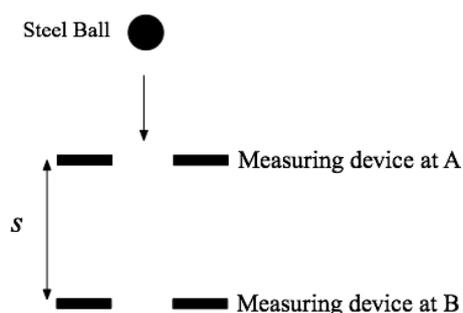
Using the equation, $s = ut + (1/2)gt^2$, where u is the initial velocity of the ball, which graph should the student plot to get the acceleration due to gravity (g) from a straight line graph?

(A) s versus t (B) s versus t^2 (C) s versus $\sqrt{t}$ **(D) None of the above**

90. A thermometer reading of 98.4 °C can indicate the temperature

(A) of the outdoors on a warm day.   (B) inside a person's mouth.
(C) of liquid nitrogen.   **(D) in a cup of hot tea.**