HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

TATA INSTITUTE OF FUNDAMENTAL RESEARCH
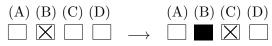
Entrance Test for Ph.D. Programme in Science Education – 2014

Section I:

Multiple Choice Questions

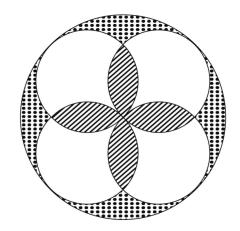Read the following instructions carefully.

- 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.

- 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)
  ☐ ☒ ☐ ☐ $\longrightarrow$ ☐ ■ ☒ ☐

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

Scientific literacy, Technical comprehension, and Logical reasoning

1. A shopkeeper purchases 11 knives for Rs. 10 and sells all the knives at the rate of Rs.11 for 10 knives. She earns a profit of

   (A) 15%   (B) 11%   (C) 20%   **(D) 21%**

2. If $9x - 15y = 36$, then $3x - 5y$ is
   (A) -12 (B) 20   **(C)** 12   (D) Cannot be determined

3. In the circle shown which region has greater area: the shaded region or the dotted region?

   (A) Shaded Region

   (B) Dotted region

   (C) The area of shaded and dotted regions are equal

   (D) Cannot be determined

4. There are 36 identical chairs, which must be arranged in rows with the same number of chairs in each row. Each row must contain at least 3 chairs, and there must be at least 3 rows. A row is parallel to the front of the room. How many different arrangements are possible?

   (A) 2   **(B) 5**   (C) 6   (D) 10

5. A worker is paid Rs.x for the first 7 hours she works each day. She is paid Rs.y per hour for each hour she works in excess of 7 hours. During one week she works 8 hours on Monday, 9 hours on Tuesday, 11 hours on Wednesday, 11 hours on Thursday and 8 hours on Friday. What is her average daily wage in rupees for the 5-day week?

   (A) $x + 2.4y$ (B) $2x + y$ (C) $7x + 2.4y$ (D) $5x + 7y$

6. A rectangular pool is filled with water at a rate of 1 inch/ minute. The owners started filling the pool at 6 am. What time was it when the water was 6 feet deep?

   (A) 6:06 am   (B) 7:06 am   **(C) 7:12 am**   (D) 7:00 am

7. Which is the best approximation of the cube root of 31?

   (A) 3.1   (B) 3.5   (C) 5.5   (D) 10

8. In general, which of the following statements is FALSE?

    (A) The sample mean is more sensitive to extreme values than the median.

    (B) The sample range is more sensitive to extreme values than the standard deviation.

    (C) The sample standard deviation is a measure of central tendency of the sample.

    (D) The sample standard deviation is a measure of spread around the sample mean.

9. The probabilities of students A, B and C solving a problem are, $\frac{1}{3}$, $\frac{2}{7}$, and $\frac{3}{8}$ respectively. If all the three students individually try to solve the problem simultaneously, find the probability that exactly one of them solves the problem.

    (A) $\frac{167}{168}$ (B) $\frac{25}{168}$ (C) $\frac{167}{504}$ **(D)** $\frac{25}{56}$

10. If A = x % of y and B = y % of x, then which of the following is true?

    (A) A and B are equal to one another

    (B) Relationship between A and B cannot be determined

    (C) If x is smaller than y, then A is greater than B

    (D) If x is smaller than y, then B is greater than A

11. If 20% of a = b, then b% of 20 is the same as

    (A) 5% of a   (B) 20% of a

    (C) 4% of a   (D) None of these

12. If most of the measurements in a large data set are of approximately the same magnitude except for a few measurements that are quite a bit larger, how would the mean and median of the data set compare and what shape would a histogram of the data set have?

    (A) The mean would be smaller than the median and the histogram would be skewed with a long left tail.

    (B) The mean would be larger than the median and the histogram would be skewed with a long right tail.

    (C) The mean would be larger than the median and the histogram would be skewed with a long left tail.

    (D) The mean would be smaller than the median and the histogram would be skewed with a long right tail.

13. A documentary was broadcast about earthquakes and how often earthquakes occur. It included a discussion about the predictability of earthquakes. A geologist stated: In the next twenty years, the chance that an earthquake will occur in X city is two out of three. Which of the following best reflects the meaning of the geologists statement?

    (A) $20 \times 2/3 = 13.3$ approximately, so between 13 and 14 years from now there will be an earthquake in the city X.

    (B) 2/3 is more than half so you can be sure that there will be an earthquake in the city X at some time during the next 20 years.

    (C) The likelihood that there will be an earthquake in city X at some time during the next 20 years is higher than the likelihood of no earthquake.

(D) You cannot tell what will happen, because nobody can be sure when an earthquake will occur.

14. A student multiplied a number by 3/5 instead of 5/3, what is the percentage error in the calculation?

(A) 64%   (B) 34%   (C) 44%   (D) 54%

15. A coin is tossed three times. What is the probability that it lands on heads exactly one time?

(A) 0.125   (B) 0.333   **(C) 0.375**   (D) 0.500

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

Priming studies have been a boom area in psychology over the past decade, and some of their insights have already made it out of the lab and into the toolkits of policy wonks keen on "nudging" the populace. These studies suggest that decisions can be influenced by apparently irrelevant actions or events that took place just before the cusp of choice.

A growing number of psychologists fear that a lot of this priming research is poorly founded. Over the past few years various researchers have made systematic attempts to replicate some of the more widely cited priming experiments. Many of these replications have failed. In April, for instance, a paper in the journal PLoS ONE reported that nine separate experiments had not managed to reproduce the results of a famous priming study from 1998.

The idea that the same experiments always get the same results, no matter who performs them, is one of the cornerstones of science's claim to objective truth. If a systematic campaign of replication does not lead to the same results, then either the original research is flawed (as the replicators claim) or the replications are (as many of the original researchers on priming contend). Either way, something is awry.

It is tempting to see the priming fracas as an isolated case in an area of science – psychology – easily marginalised as soft and wayward. But irreproducibility is much more widespread. A few years ago scientists at Amgen, an American drug company, tried to replicate 53 studies that they considered landmarks in the basic science of cancer, often co-operating closely with the original researchers to ensure that their experimental technique matched the one used first time round. According to a piece they wrote last year in Nature, a leading scientific journal, they were able to reproduce the original results in just six. Months earlier Florian Prinz and his colleagues at a German pharmaceutical company reported in *Nature Reviews Drug Discovery* that they had successfully reproduced the published results in just a quarter of 67 seminal studies.

The governments of the OECD, a club of mostly rich countries, spent $59 billion on biomedical research in 2012, nearly double the figure in 2000. One of the justifications for this is that basic-science results provided by governments form the basis for private drug-development work. If companies cannot rely on academic research, that reasoning breaks down. When researchers find it hard to reproduce at least three–quarters of all published biomedical findings, the public part of the process seems to have failed.

Academic scientists readily acknowledge that they often get things wrong. But they also hold fast to the idea that these errors get corrected over time as other scientists try to take the work further. Evidence that many more dodgy results are published than are subsequently corrected or withdrawn calls that much-vaunted capacity for self-correction into question. There are errors in a lot more of the scientific papers being published, written about and acted on than anyone would normally suppose, or like to think.

Various factors contribute to the problem. Statistical mistakes are widespread. The peer reviewers who evaluate papers before journals commit to publishing them are much worse at spotting mistakes than they or others appreciate. Professional pressure, competition and ambition push scientists to publish more quickly than would be wise. A career structure which lays great stress on publishing copious papers exacerbates all these problems. "There is no cost to getting things wrong," says Brian Nosek, a psychologist at the University of Virginia who has taken an interest in his discipline's persistent errors. "The cost is not getting them published."

Statistical mistakes occur because most scientists are not statisticians. Their grasp of statistics has not kept pace with the development of complex mathematical techniques for crunching data. Some scientists use inappropriate techniques because those are the ones they feel comfortable with; others latch on to new ones without understanding their subtleties. Some just rely on the methods built into their software, even if they don't understand them.

This fits with another line of evidence suggesting that a lot of scientific research is poorly thought through, or executed, or both. Some new journals such as PLoS ONE, which are online–only, seek to publish as much science as possible, rather than to pick out the best papers based on their novelty and significance. They thus ask their peer reviewers only if a paper is methodologically sound. Remarkably, almost half the submissions to PLoS ONE are rejected for failing to clear that seemingly low bar.

16. Which of the following statements best describes this article's stance on objective truth?

(A) If an experiment does not provide objective truth, then it is not science.

(B) An experiment would establish objective truth if the results were replicable.

(C) Experimental outcomes do not determine objective truth.

(D) Absence of experimental reproducibility does not undermine scientific claims.

17. Which of the following is the author NOT claiming about statistical analysis:

(A) Scientists should use appropriate statistical methods for data analysis.

(B) Software-based tools are better because one need not understand the underlying mechanisms.

(C) Scientists use methods that they personally like without being fully aware of the implications.

(D) Some scientists choose statistical methods without fully understanding them.

18. What is the author's central contention regarding the problem of irreproducibility:

(A) It is more common in biomedical sciences than in psychology.

(B) It is more common in psychology than in biomedical sciences.

(C) It is found in psychology, biomedical sciences and statistics.

(D) It is found in most sciences regardless of their domains.

19. According to this article, errors in published research studies

(A) Always get corrected by subsequent research.

(B) Almost always get corrected by subsequent research.

(C) Never get corrected by subsequent research.

(D) Rarely get corrected by subsequent research.

20. In the statement "the public part of the process seems to have failed", which of the following does 'process' NOT refer to?

    (A) Encouraging and supporting basic research through public funding.

    (B) Governments investing in bio-medial research for people's benefit.

    (C) Funding drug companies to conduct private drug development work.

    (D) Ensuring reliability of basic research that is funded by governments.

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

Gulliver, according to Swift, was twelve times as tall as a Lilliputian, and thus 12^3 or 1728 times as heavy. Consequently he was served 1728 times as much food as a Lilliputian would consume and received 108 (Lilliputian) gallons instead of a half-pint of wine. Swift apparently saw no inconsistency in the extrapolation from body weight to food and drink and reported no adverse effects of the drinking. More recently, and less excusably, some psychologists tested the effects of LSD on an elephant. They took a dose known to have a minimal effect on a cat and multiplied it by the ratio of the weight of an elephant to that of a cat. Upon receiving the injection, the elephant began having violent convulsions and promptly died. West et al. (1962) concluded that elephants are remarkably sensitive to LSD.

Without a doubt, nothing is more important in determining how size affects biological design than the relationship between surface area and volume. Contact between an organism and its surroundings is a function of its surface, while its internal processes and structure depend mainly on its volume. And the two do not maintain a simple proportionality - unless you change the shape of a body you cannot simultaneously double both its surface area and its volume.

Consider cubes of different sizes: Surface Area (S) and Volume (V) are related to length (l) by the formula $S = 6l^2$, $V = l^3$. For spheres S and V are related to r, the radius by $S = 4\pi r^2$ and $V = \frac{4}{3}\pi r^3$. Clearly, for isometric (geometrically similar) objects, surface areas are proportional to the squares of lengths and volumes to the cubes of lengths. Surface to volume is $1/l$. A large object will have less surface relative to its volume compared to a small object. In short, a whale is big inside with little outside, and a bacterium is little inside and big outside. In case after case, this reduction in relative surface as a body gets larger has elicited a specific response from the evolutionary process. The essence of the response involves an evasion of a premise, that of isometry, or constancy of shape. A whale and a bacterium are vastly further from geometrical isometry than they appear, one is tempted to say, on the surface.

Up to this point, we have talked about size in fairly loose terms, using some slightly vague length as a measure. For respectably quantitative work it would be nice to have something more specific. The choice of units is trivial; the real issue is the choice among quantities with different fundamental dimensions. We might measure lengths, width, diameter or circumference; or we might use total surface or cross-sectional area; or we could use volume or even mass as an index of size. Which we choose matters less than appreciating the consequences of the choice.

In the physiological literature, body mass is the variable of choice, mainly because it is the easiest to measure. I'd prefer to use something that is proportional to length rather than to the cube of length. Used as an independent variable a length makes most of the various scaling factors come out to be small numbers greater than unity rather than fractions. (One can easily divide these factors by 3 to restore proportionality to body mass, if necessary.)

But what measure of length shall we choose? We will have occasion to use two, both of which

6

differ from the definitive data of a tape measure. The first takes advantage of the nearly constant density of organisms and the practical ease of weighing things. It's the cube root of body mass, which we might call the 'nominal length measure', a version of body mass made into something proportional not to volume but to length. The second linear measure is something called 'characteristic length', a purposely fuzzy concept. The fuzziness follows inescapably from our need to compare items of different shapes - exactly how big a rectangular solid must be to be 'larger' than a given sphere depends on what common property we choose to measure. But where bodies differ in size by orders of magnitude, shape differences usually dwindle into insignificance, and the arbitrary character of our choice of a length is no cause for concern.

21. How many (Lilliputian) pints make a gallon?

    (A) 16   (B) 12   **(C) 8**   (D) 576

22. According to the author, the effect of LSD on the elephant could be explained by which of the following?

    (A) The dosage scales as mass.   (B) The mass scales as l^3.

    (C) The volume scales as l^3.   **(D) The dosage does not scale as mass.**

23. The differences in shapes between large and small animals may be attributed to

    (A) The fact that surface area and volume do not scale similarly.

    (B) That the ratio of surface area to volume is a constant.

    (C) That there is no relationship between surface area and volume.

    (D) That physiological processes have nothing to do with size.

24. Which of the following is false

    (A) West et al.'s conclusion about the effect of LSD on elephant was correct.

    (B) The ratio of surface area to volume is always a constant for isometric shapes.

    (C) Nature responds to change in surface area to volume ratio by changing shapes.

    (D) Mass scales as the cube of a length measure associated with an organism.

25. The difficulty with using length as a scaling factor is

    (A) It is not always clear which length to measure.

    (B) Which length we measure is unimportant in certain situations.

    (C) Most quantities of interest scale as square of length.

    (D) Most quantities of interest scale as density.

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

Decades of agricultural research has shown that antibiotics seem to flip a switch in young animals' bodies, helping them pack on pounds. Manufacturers brag about the miraculous effects of feeding antibiotics to chicks and nursing calves; these drugs can act like a kind of superfood to produce cheap meat.

But what if that meat is us? Recently, a group of medical investigators have begun to wonder whether antibiotics might cause the same growth promotion in humans. New evidence shows

that America's obesity epidemic may be connected to high consumption of these drugs.

In the 1950s, a team of scientists fed a steady diet of antibiotics to schoolchildren in Guatemala for more than a year, while Charles H. Carter, a doctor in Florida, tried a similar regimen on mentally disabled kids. Could the children, like the farm animals, grow larger? Yes, they could.

In 2002 Americans were about an inch taller and 24 pounds heavier than they were in the 1960s, and more than a third are now classified as obese. But some scientists wonder whether there could be reasons other than diet and lifestyle for this staggering transformation of the American body. Antibiotics might be the X factor - or one of them.

Martin J. Blaser, the director of the Human Microbiome Program and a professor of medicine and microbiology at New York University, is exploring that mystery. The Blaser lab investigates whether antibiotics may be changing animals' microbiome - the trillions of bacteria that live inside their guts. These bacteria seem to play a role in all sorts of immune responses, and, crucially, in digesting food, making nutrients and maintaining a healthy weight. And antibiotics can kill them off: One recent study found that taking the antibiotic ciprofloxacin decimated entire populations of certain bugs in some patients' digestive tracts - bacteria they might have been born with.

Until recently, scientists simply had no way to identify and sort these trillions of bacteria. But thanks to a new technique called high-throughput sequencing, we can now examine bacterial populations inside people. According to Ilseung Cho, a gastroenterologist who works with the Blaser lab, researchers are learning so much about the gut bugs that it is sometimes difficult to make sense of the blizzard of revelations.

Investigators are beginning to piece together a story about how gut bacteria shapes each life, beginning at birth, when infants are anointed with populations from their mothers' microbiomes. Babies who are born by C-section and never make that trip through the birth canal apparently never receive some key bugs from their mothers - possibly including those that help to maintain a healthy body weight. Children born by C-section are more likely to be obese in later life. By the time we reach adulthood, we have developed our own distinct menagerie of bacteria. In fact, it doesnt always make sense to speak of us and them.

In the Blaser lab and elsewhere, scientists are racing to take a census of the bugs in the human gut and - even more difficult - to figure out what effects they have on us. What if we could identify which species minimize the risk of diabetes, or confer protection against obesity? And what if we could figure out how to protect these crucial bacteria from antibiotics, or replace them after they're killed off?

The results could represent an entirely new pharmacopoeia, drugs beyond our wildest dreams: Think of them as "anti-antibiotics". Instead of destroying bugs, these new medicines would implant creatures inside us, like more sophisticated probiotics.

It has become common to chide doctors and patients for overusing antibiotics, but when the baby is wailing or you're burning with fever, it's hard to know what to do. While researchers work to unravel the connections between antibiotics and weight gain, they should also put their minds toward reducing the unnecessary use of antibiotics. One way to do that would be to provide patients with affordable tests that give immediate feedback about what kind of infection has taken hold in their body. Such tools, like a new kind of blood test, are now in development and could help to eliminate the "just in case" prescribing of antibiotics.

In the meantime, we are faced with the legacy of these drugs - the possibility that they have affected our size and shape, and made us different people.

26. The gist of the article is that

(A) **Antibiotics may change microbiomes which are important for our health.**

(B) Antibiotic use on humans should be banned because they make us fat.

(C) Antibiotics lead to obesity by keeping us disease free and healthy.

(D) Eating meat of animals treated with antibiotics is too fatty for consumption.

27. According to the article, higher instance of obesity in children born of C section could be due to

    (A) Use of antibiotics during births by C-section.

    (B) C-section introducing harmful microbes in babies.

    (C) Bugs in the mother's birth canal getting decimated.

    (D) Children never acquiring bugs from the birth canal.

28. The article suggests that

    (A) Killing microbiomes with antibiotics will keep us healthy by fighting diseases.

    (B) To maintain a healthy body weight, we should entirely stop use of antibiotics.

    (C) Antibiotics cannot be avoided, but should be used only when absolutely necessary.

    (D) We should stop treating animals reared for human consumption with antibiotics.

29. According to this article

    (A) Those born by C-section are always obese.

    (B) Those born by C-section are more at risk of obesity.

    (C) Those born by natural birth can never become obese.

    (D) There is no correlation between obesity and C-section.

30. Using a new technique called high-throughput sequencing

    (A) Scientists have identified bacteria that minimize the risk of certain diseases.

    (B) Scientists have so much data that it is not easily understood.

    (C) Scientists have learned to confer protection against obesity.

    (D) Scientists have learned how to protect crucial bacteria from antibiotics.

Social and Cognitive sciences and Education

31. An achievement test in social studies was given to students. On the basis of the marks scored in the test, the 1st, 2nd and 3rd rank went to Rani, Mukesh and Aisha respectively. This is an example of

(A) Interval Scale   (B) Ratio Scale   **(C) Ordinal Scale**   (D) Nominal scale

32. Sarju gave several solutions to a problem. This is an example of

    (A) Divergent thinking   (B) Lateral thinking

    (C) Convergent thinking   (D) Vertical thinking

33. Transformation grammar is

(A) A system for developing artificial languages.

(B) A theory of how language is structured.

(C) A set of rules to generate images out of signals.

(D) A database to decide whether a sentence is correct.

34. According to the Plate Tectonic theory the large supercontinent that existed more than 200 million years ago was:

(A) Gondwanaland.   (B) Laurasia.   (C) Glossopteris.   **(D) Pangea.**

35. A group of children were asked by their geography teacher to do a project on crops of India. The project work helped students develop some arithmetic skills. This is an example of which type of learning?

(A) Informal learning   (B) Associative learning

(C) Incidental learning   (D) Non-formal learning

36. Students at an Indian University staged a strike (*dharna*) to protest the University's decision to cancel its policy of exempting seniors from final exams. Which theoretical perspective provides the strongest framework for analyzing this situation?

(A) Interactionist, because the University and the students didn't share the same understanding about final exams.

(B) Conflict, because this is an example of a power struggle between two groups with conflicting ideas and interests.

(C) Functionalist, because teaching college students to protest is a manifest function of education.

(D) Constructivist, because students construct their own ideas about the need for exams.

37. A villager from South India while vacationing in a Northern Indian town discovers that people there speak a language she finds difficult to understand, consume food items that she is not comfortable with, and dress very differently. She feels disoriented and out of place. She is experiencing

(A) Xenophobia.   (B) The Hawthorne effect.

(C) Prejudice.   **(D) Culture shock.**

38. The tendency to value products, styles and ideas of a culture other than one's own is termed

(A) Ethnocentrism.   (B) Anthropocentrism.

(C) Xenocentrism.   (D) Universalism.

39. The 180 degree longitude is popularly known as the

(A) International Date Line   (B) Equator.

(C) Greenwich Meridian.   (D) Prime Meridian.

40. Mirror neurons

(A) fire when you look at your face in the mirror.

(B) fire both when an action is executed as well as observed.

(C) allow you to track other vehicles in the mirror while driving.

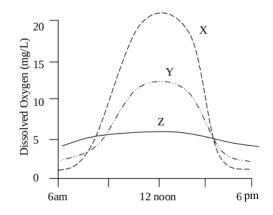(D) fire in spatial alignments that parallel the way objects are aligned in the world.

41. Right to Education Act (RTE) was notified as a law in which year?

(A) 2008   **(B) 2009**   (C) 2010   (D) 2011

42. One of the Regional Institutes of Education is located in

(A) Ahmedabad.   **(B) Bhopal.**   (C) Chennai.   (D) Delhi.

43. Which part of the brain is activated most during mental imagery?

(A) The visual perception areas   (B) The action areas
(C) The language areas   (D) The memory areas

44. Some people feel different tastes when they look at different people's faces. This condition is an instance of

(A) Face blindness.   (B) Change blindness.   **(C) Synesthesia.**   (D) Kinesthesia.

45. According to Jean Piaget, knowledge is

(A) Based on memory.   **(B) Constructed from interaction.**
(C) Acquired through intense practice.   (D) Based on skills.

46. Which of the following statements regarding culture is **NOT** correct?

(A) Culture is natural.
(B) Culture is an acquired pattern of living.
(C) Culture is learnt.
(D) Culture is dynamic and changes with time.

47. According to Maslow, the need which refers to full realization of one's potential is

(A) Self esteem.   (B) Self efficacy.
(C) Self conceptualization.   **(D) Self actualization.**

48. What is the name of the therapy that Freud developed?

(A) S-R therapy   (B) Gestalt therapy
(C) Psychoanalysis   (D) Behaviour modification

49. What does the lie detector, or polygraph, primarily measure?

(A) Emotional expression   (B) Vocal modulation
(C) Attribution   **(D) Physiological arousal**

50. Which of the following statements is a reproduction from *The Right of Children to Free and Compulsory Education Act* ?

(A) Every child of age five to fourteen years shall have a right to education in a neighbourhood school till secondary education.

(B) The Central Government shall have the responsibility for providing funds for carrying out the provisions of this Act.

(C) Every child of age six to fourteen years shall have a right to a neighbourhood school till completion of elementary education.

(D) The State Government shall have the responsibility for providing funds for carrying out the provisions of this Act.

Biology

51. When the levels of dissolved oxygen were monitored over a period of 12 hr in ponds X, Y and Z, the following graph was obtained.

Which of the following can be deduced from the graph?

(A) Pond Z is likely to contain much large number of aquatic plants and minimal number of fish.

(B) Pond Y is likely to contain large populations of fish as compared to pond Z.

(C) Pond X is likely to have much greater amount of aquatic plants as compared to pond Y.

(D) All the three ponds contain equal photosynthetic activity but varying respiratory activity.

52. Insulin is an essential medication for diabetics who have an impaired ability to produce the hormone naturally. However, it cannot be administered orally. This is because:

(A) It cannot get absorbed through the intestinal villi.

(B) It gets denatured in the stomach.

(C) If given orally, it is required to be given in high doses which are toxic.

(D) Glucose in the food interacts with it and makes it ineffective.

53. Blood types are controlled by multiple alleles. Three different alleles; I^A, I^B, and I^O determine a person's blood type. A person with A Rh +ve blood group marries a woman. The blood group of their child is A Rh +ve. What is the likely blood group of the mother?

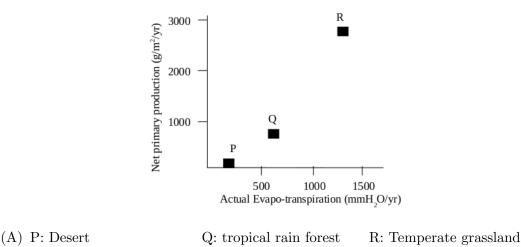(A) A Rh +ve   (B) B Rh +ve   (C) O Rh +ve   **(D) either (A) or (B) or (C).**

54. Retroviruses are a group of viruses which have an envelope enclosing the RNA genome. The correct steps in the replication of these viruses are:

(A) Entry of viral genome into host cell → Integration of viral genome with the host genome → new viral genome produced → protein coat synthesis → viral particles kill host cell

(B) **Entry of viral genome into host cell → synthesis of viral DNA → Integration of viral DNA with the host genome → synthesis of new viral particles**

(C) Entry of viral particle into host cell → Integration of viral genome with the host genome → viral particles kills host cell → new viral DNA produced → protein coat synthesis and encapsulation

(D) Entry of viral protein into host cell → reverse transcription of protein to DNA → synthesis of new viral particles → viral particles kills host cell

55. Priya was given 3 slides labeled X, Y and Z in her biology practical class. She observed the specimen under the microscope and made the following observations:

- Slide X: Lot of parenchymatous tissue with xylem and phloem
- Slide Y: Budding cells of yeast
- Slide Z: Single celled amoeba with pseudopodia

The specimens that she observed represent which of the following domains?

    (A) X: Eukaryota   Y: Eubacteria   Z: Eubacteria

    (B) X: Archaebacteria   Y: Eubacteria   Z: Eukaryota

    (C) X: Eukaryota   Y: Eubacteria   Z: Archaebacteria

    (D) X: Eukaryota   Y: Eukaryota   Z: Eukaryota

56. An insertion of three bases in the coding region of a DNA strand (after the 63rd base in a 120 bases long DNA strand), could lead to which of the following result/s?

  (i) A short protein if the inserted bases code for a stop codon.

  (ii) A protein longer than the original protein by three amino acids.

  (iii) A protein shorter than the original protein by one amino acid.

  (iv) A protein longer than the original protein by one amino acid.

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

57. Net primary productivity of an ecosystem is defined as the rate at which all plants in the ecosystem produce net useful chemical energy. A graph of net primary production versus the actual evapo-transpiration for three different ecosystems P, Q and R are represented in the graph below. P, Q and R represent:

(A) P: Desert   Q: tropical rain forest   R: Temperate grassland

(B) P: Temperate grassland   Q: tropical rain forest   R: Desert

(C) P: Desert   **Q: Temperate grassland   R: tropical rain forest**

(D) P: tropical rain forest   Q: Desert   R: Temperate grassland

58. The length of a cell when viewed under the microscope using the high power objective (40X) and an eyepiece of 15X measured 0.5mm. What would be the original length of the cell?

(A) 3.33 nm   (B) 0.30 μm   **(C) 0.83 μm**   (D) 9.09 μm

59. The presence/absence of certain characters for animals M, N, O and P are given in the table below. Presence of a character is indicated by 1 and absence by 0. Study the table and identify the animals.

Character	Animal M	Animal N	Animal O	Animal P
Hair	0	0	0	1
Amniotic egg	0	0	1	1
Four walking legs	0	1	1	1
Hinged jaws	1	1	1	1
Vertebral column	1	1	1	1

(A) M: Tuna   N: Salamander   O: Turtle   P: Zebra

(B) M: Salamander   N: Tuna   O: Zebra   P: Turtle

(C) M: Tuna   N: Turtle   O: Salamander   P: Zebra

(D) M: Tuna   N: Turtle   O: Zebra   P: Salamander

60. Which of the following animals will expend most energy per kg of body mass if all of them are running at a similar speed?

(A) Mouse   (B) Fox   (C) Horse   (D) Elephant

Chemistry

61. In a titration experiment, 50.0 mL of 0.1M HCl is being titrated against 0.1M NaOH. The pH of the solution on addition of 49.9 mL of NaOH is approximately

(A) 7.0   (B) 6.0   **(C) 4.0**   (D) 3.0

62. The standard reduction potentials of Cu^{2+}, Zn^{2+}, Sn^{2+} and Ag^{2+} are 0.34, -0.76, -0.14 and 0.80 V, respectively. The storage that is possible without any electrochemical reaction is for

(A) $CuSO_4$ solution in a zinc vessel.

(B) $AgNO_3$ solution in a zinc vessel.

(C) $AgNO_3$ solution in a tin vessel.

(D) $CuSO_4$ solution in a silver vessel.

63. The atom of an element **X** contains 27 electrons. **X** is expected to be

(A) a non-metal belonging to p-block.

(B) paramagnetic belonging to d-block.

(C) diamagnetic belonging to d-block.

(D) an s-block element.

64. $^{235}_{92}U +^{1}_{0}n \rightarrow X +^{90}_{38}Sr + Y$
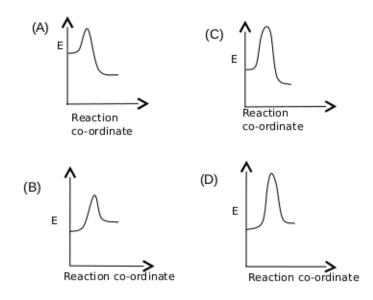
In the above nuclear fission reaction, products are

(A) $X =^{140}_{56}$ Ba, $Y = 3^{1}_{0}n$

(B) $X =^{144}_{55}$ Cs, $Y = 2^{1}_{0}n$

(C) $X =^{144}_{54}$ **Xe**, $Y = 2^{1}_{0}n$

(D) $X =^{145}_{54}$ Xe, $Y = 2^{1}_{0}n$

65. For the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, the units of K_c and K_p respectively are

(A) $mol^{-2}L^2$ **and** bar^{-2}

(B) $mol^{-2}L^2$ and bar^{-1}

(C) $mol^{-1}L$ and bar^{-2}

(D) $mol^{-1}L^{-1}$ and bar^{-1}

66. The energy diagram that corresponds to exothermic reaction and highest value of the rate constant is

67. For a third order reaction $2A + B \rightarrow 3C$ with rate constant k (in proper units), the correct rate law is

(A) $-\dfrac{d[A]}{dt} = k[A]^2[B]$

(B) $\dfrac{d[B]}{dt} = k[A]^2[B]$

(C) $-\dfrac{d[C]}{dt} = k[A]^2[B]$

(D) $-\dfrac{d[A]}{dt} = -2k[A][B]$

68. The IUPAC name of $HOCH_2CH = C - (CH_3)_2$ is

(A) 2-methyl-2-buten-4-ol

(B) 3-methyl-2-buten-1-ol

(C) 2-methyl-2-butenol

(D) 3-methyl-2-butenol

69. In the nitration of an aromatic compound using a mixture of concentrated nitric acid and sulphuric acid, the acids respectively function as

(A) an oxidising agent and an acid.

(B) a Brϕnsted and a Lewis acid.

(C) a base and an acid.

(D) an acid and an oxidizing agent.

70. Bond orders for NO and NO^+ are respectively

(A) 2 and 4   (B) 3.5 and 2.5   (C) 3 and 2   **(D) 2.5 and 3**

Mathematics

71. Let f and g be two real-valued functions defined on the set of real numbers. If f is strictly increasing and g is strictly decreasing then

(A) $f(g(x))$ and $g(f(x))$ are strictly increasing.

(B) $f(g(x))$ is strictly increasing and $g(f(x))$ is strictly decreasing.

(C) $f(g(x))$ is strictly decreasing and $g(f(x))$ is strictly increasing.

(D) $f(g(x))$ and $g(f(x))$ are strictly decreasing.

72. Let a, b, c, p, q, r be real numbers and $a \neq 0, p \neq 0$. If $b^2 + q^2 - 4ac - 4pr < 0$ then the maximum number of real roots of $(ax^2 + bx + c)(px^2 + qx + r) = 0$ is

(A) 0   (B) 1   **(C) 2**   (D) 4

73. Let f be a positive proper fraction. The sum of the numerator and the denominator of f is 7. The number obtained by adding 1 to the numerator of f is same as the number obtained by subtracting 1 from its denominator. The value of $1 + f + f^2 + f^3 + \ldots \infty$ is

(A) 4   (B) 2   (C) $\dfrac{7}{4}$ (D) $\dfrac{4}{3}$

74. Let a and b be the outcomes of rolling two fair dice. The probability that the lines $L1 : 2x + ay = 0$ and $L2 : bx + 3y = 0$ are distinct is

(A) $\dfrac{1}{9}$ **(B) $\dfrac{8}{9}$**   (C) $\dfrac{4}{9}$ (D) $\dfrac{2}{3}$

75. The point of concurrency of the internal bisectors of the angles of a triangle is called

(A) incentre   (B) orthocentre   (C) circumcentre   (D) centroid

76. A metal sphere of radius R is melted and a solid right circular cylinder of height R is made. If the radius of the base of the cylinder is r and if there is no loss of matter then $R : r$ is

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

77. Let $f(x) = |x - 1| + |x + 1|$ for $x \in (-\infty, \infty)$. Which of the following statements is correct?

(A) $f(x)$ is not a continuous function.

(B) $f(x)$ is continuous at all points in its domain but not differentiable at exactly two points.

(C) $f(x)$ is continuous and differentiable at all points in its domain.

(D) $f(x)$ is a strictly increasing function.

78. Let R be a rectangle. How many distinct circles in the plane of R have a diameter both of whose endpoints are vertices of R?

(A) 2   (B) 4   **(C) 5**   (D) 6

79. Let $P(x)$ and $Q(x)$ be two polynomials with real coefficients. The degree of $P(x)$ is 5. If the degree of $xP(x) + Q(x)$ is also 5 then the degree of $Q(x)$ is

(A) 6   (B) 5   (C) 4   (D) 3

80. The lengths of the sides of a right-angled triangle are positive integers. If one of the sides is 12 then the largest possible length of the hypotenuse is

(A) 13   (B) 15   (C) 20   **(D) 37**

Physics

81. The atmospheric pressure on the earth's surface is P_a N m^{-2}. A table top of surface area 2 m^2 is tilted at 45^0 to the horizontal. The force on the table top due to the atmosphere is (in Newtons):

(A) $2P_a$ (B) $\sqrt{2}P_a$ (C) P_a (D) $P_a/\sqrt{2}$

82. The Kg m^2 s^{-1} is a unit for:

(A) rotational kinetic energy.   (B) rotational inertia.
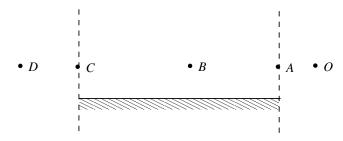(C) torque.   **(D) angular momentum.**

83. A seconds pendulum has a bob filled with sand, where masses of both the bob and sand are comparable to each other. A small hole is made at the bottom of the bob so the sand drains out slowly. From the time the sand begins to drain out to the time when the last grain of sand leaves the bob, the time period of the pendulum will

(A) first decrease then increase.   **(B) first increase then decrease.**
(C) not change.   (D) keep increasing.

84. When a guitarist playing the guitar plucks guitar strings faster (larger number of plucks per minute) at the same place, the effect will be a sound wave with

(A) a higher pitch.
(B) greater wave velocity in the string.
(C) a louder sound.
(D) a higher pitch, greater wave velocity and a louder sound.

85. A girl brings two charged rods (one positively charged and the other negatively charged), one at a time, near to a very thin stream of water dripping from a water tap. What can be said about bending of water stream?

(A) Water stream will bend towards the positively charged rod and away from the negatively charged rod.
(B) Water stream will bend away from the positively charged rod and towards the negatively charged rod.
(C) In both the cases water stream will bend towards the rod.
(D) In both the cases water stream will bend away from the rod.

86. In a closed room, three objects (1) a piece of metal (2) wooden chair and (3) a woolen sweater are left overnight. Their temperatures are recorded early in the morning as T_1, T_2, and T_3 respectively. Which of the following situations most likely describes the relation between the temperatures?

(A) $T_1 = T_2 = T_3$ (B) $T_1 < T_2 < T_3$

(C) $T_1 < T_2 = T_3$ (D) $T_1 = T_2 < T_3$

87. A point object O is placed above a mirror (shaded) as shown in the figure. Figure is drawn to scale.

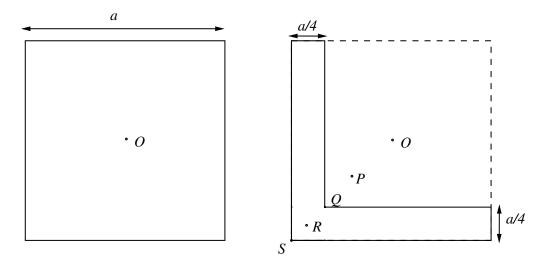Dashed lines are shown for reference only. Image of O can be seen from the point(s)

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

(C) B only.   (D) A, B, C and D.

88. A light ray passes from air into a prism. Inside the prism, the light ray's

(A) wavelength and frequency are both different from that in air.

(B) velocity and frequency are both different from that in air.

(C) frequency is different from that in air.

(D) wavelength is different from that in air.

89. A square wooden piece of uniform density (with size a) has center of mass located at point O (see figure to the left). A square part (with size $3a/4$) of this piece is cut as shown by the dotted lines in the figure to the right.

Center of mass of remaining L shaped object is at

(A) P **(B)** Q (C) R (D) S

90. A galaxy situated at 5×10^{21} m from earth releases 1×10^{46} photons per second. How many photons (approximately) does a telescope of radius 12 cm located on earth will receive?

(A) 1 every 2.8 seconds   (B) 2.8 photons every second.

(C) 1 every 1.4 seconds   **(D) 1.4 photons every second**