HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

Entrance Test for Ph.D. Programme in Science Education – 2020

Section I:

Multiple Choice Questions

<u>Read the following instructions carefully.</u>

- This section of the written test carries **100 marks** and is of **two hours** duration.
- This section of the question paper consists of **28** pages. There are a total of 90 questions distributed among the different subjects as follows:
  - Q 1 to 30: Quantitative reasoning, scientific literacy and technical comprehension.
  - Q 31 to 50: Social sciences, 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 normalized to that corresponding to 50 questions, using the following formula.

$$Normalized\ score\ = \frac{Score\ obtained}{No.\ of\ questions\ attempted}\ X\ 50$$

- Before you start answering, please check that you have written your Roll Number on both sides of the Answer Sheet.
- You must indicate your answers only on the Answer Sheet provided, by putting a X 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 X in a certain box, blacken out the entire box and put a X in the new box of your choice. In the example below the initial choice of (B) has been changed to (C):

<div align="center">

(A) (B) (C) (D)   →   (A) (B) (C) (D)
□ ⊠ □ □   □ ■ ⊠ □

</div>

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

Quantitative Reasoning, Scientific Literacy and Technical Comprehension

1. In the following pattern, at every term you get an equilateral triangle.
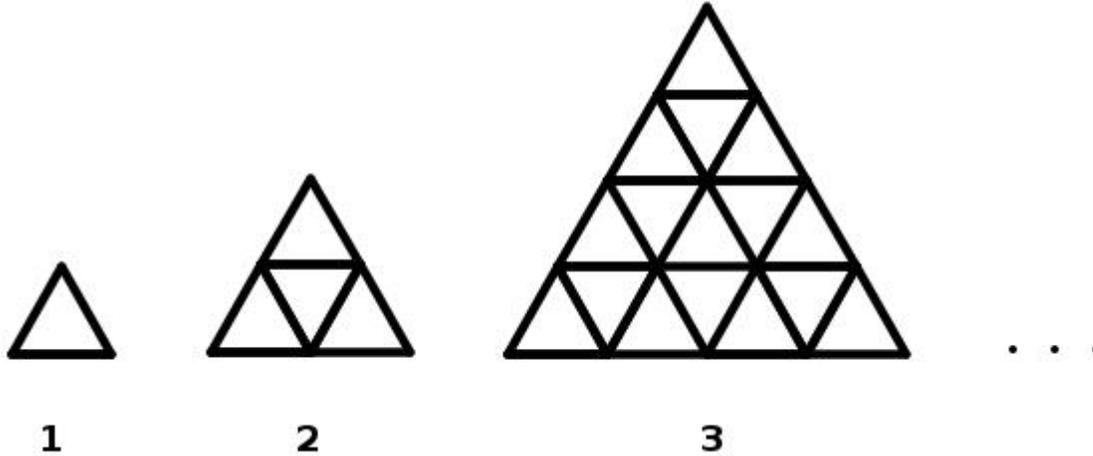
If this pattern continues, how many small triangles (of the size of the 1st term) will be there in the 5th term?

(A) 64   (B) 128   **(C) 256**   (D) 1024

2. Saira's house is being painted. The painting team has four members. Mohan is in front of the house, painting the gate. Kiran is at the back, painting the fence. Jakir is painting the window on the north, Sham is on the south, painting the door. If Mohan switches places with Jakir, and then Jakir switches places with Sham. Further, Sham switches places with Kiran. Where is Kiran now?

(A) On the south side, painting the door.
(B) On the north side, painting a window.
(C) At the back, painting the fence
(D) In the front, painting the gate

3. In a long queue of children, Roshni was 5th from the start and Sara was 11th from the end. When they interchanged their places, Roshni became 16th from the start. What is Sara's present position from the end?

(A) 21st **(B) 22nd**   (C) 23rd (D) 24th

4. Two numbers A and B are respectively 20% and 50% more than a third number. The ratio of the two numbers (A:B) is:

(A) 4:5   (B) 5:2   (C) 2:5   (D) 5:8

5. At a candy shop, 8 orange-candies cost the same as 5 apple-candies. 3 mango-candies cost the same as 5 apple-candies. 4 mango-candies cost the same as 8 pineapple-candies. 3 pineapple candies cost Rs. 36. What is the cost of 1 orange-candy?

(A) 6   **(B) 9**   (C) 12   (D) 15

6. Study the table given below.

7	7	9	**40**
3	11	1	**32**
9	3	2	**25**
_____	6	5	**43**
18	11	8	**190**
21	15	28	**287**

The missing number should be

(A) 6   **(B) 8**   (C) 10   (D) 12

7. If today is a Sunday, what day is it 68 days from today?

(A) Friday   (B) Sunday   (C) Tuesday   (D) Wednesday

8. Five years ago, the average age of a family of 4 members was 22. A baby was born during past 5 years. The average age of the family of 5 members is the same today. The age of the newly born child must be

(A) 1 year   **(B) 2 years**   (C) 3 years   (D) 4 years

9. A man was standing facing the North. He walks 15.0 m towards the West and then walks 7.0 m towards the North. Further, he walks 9.0 m towards the West. How far is he from his starting point?

(A) 31.0 m   (B) 24.0 m   **(C) 25.0 m**   (D) 26.0 m

10. Ravindra and Manish together can do a piece of work in 8 days. If Ravindra alone can do the same piece of work in 12 days, then Manish alone can do the same piece of work in how many days?

(A) 20 days   (B) 16 days   **(C) 24 days**   (D) 28 days

11. The total length of a train is 1.2 km and is moving at a constant speed of 90 km/hr. How much time will the train take to cross a 1.8 km long bridge?

(A) 1 minute   **(B) 2 minutes**   (C) 48 seconds   (D) 1 minute and 12 seconds

12. Sara is 27 years older than her daughter Fathima. Three years from now, Sara's age will be twice that of Fathima. What is Sara's age now?

(A) 49 years   (B) 50 years   **(C) 51 years**   (D) 52 years

13. A slum with a total area of 2.0 square km in a metropolitan city has close to 1 million people living in it. Suppose only one fifth of this area is available for residential purpose. Assuming an ideal scenario where this space available for residential purpose is uniformly distributed per person, then around how much space is available for a family of 4 members?

[1 square m = 10.76 square ft]

(A) 17 square ft   (B) 43 square ft   (C) 85 square ft   (D) 170 square ft

14. A cylindrical container of base area A is filled with a liquid to a height H from its base. The liquid is then transferred to another cubical container of same base area A. Assuming no spill over, the height of the liquid in the cubical container is

(A) $2\pi H$ (B) πH **(C) H**   (D) none of these options.

15. As of May 3, 2020 number of COVID-19 cases in India are 1.1 % of total worldwide reported cases. Out of which, 3 % have been reported in death and 27 % recovered. In the remaining active cases, only 4.5 % are critical. If the number of critical cases is 1400, the total number of worldwide COVID-19 cases on May 3, 2020 are

(A) 32 lakhs   **(B) 28.3 lakhs**   (C) 40 lakhs   (D) 31.1 lakhs

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

Educational Excellence Everywhere is a key document that set out the UK Conservative government's education agenda from 2016 to 2020. Educational policy-making is an exercise of power and control directed towards the attainment or preservation of some preferred arrangement of schools and society. Social reality is irredeemably complex, contingent and contested and a significant strand in policy studies recognizes the limitations this places on the policy's ambition. Despite these limitations, arising from the complex, contingent and contested nature of social reality, education policy understandably yearns for intelligibility, predictability and certainty.

One of the key ways policy seeks to simultaneously expel and disavow complexity, contingency and contestability is through fantasmatic assertions of control. For instance, in 2012, Australian Prime Minister, Julia Gillard (in 2012), asserted as part of her National Plan for School Improvement that 'by 2025, Australia should be ranked as a top five country in the world for performance of our students in reading, science and mathematics and for providing our children with a high-quality and high-equity education system'. Employing similarly assertive language, the foreword to *Educational Excellence Everywhere*, states: Where great schools, great leaders and great teachers exist, we will let them do what they do best–helping every child to achieve their full potential. Where they do not, we will step in to build capacity, raise standards and provide confidence for parents and children. We will put parents and children first. We will set high expectations for every child, ensuring that there are no forgotten groups or areas and we will focus on outcomes (Department for Education 2016).

The policy has long history of broken promises in relation to the fulfilment of the individual and the development of society. Yet, this patchy record notwithstanding, the choice of language here is categorical–we will build capacity, raise standards, set high expectations, ensuring that there are no forgotten groups. Of course, the confidence of the assertions masks the impossibility of the gaze: for the future selves of the intended 'targets' or beneficiaries of the policy are hardly likely to point to the policy in years to come and hold the politicians making these claims to account. And even when targets are more amenable to realisation, they are still more often than not missed, as in the UK government's targets for teacher recruitment that have been missed over five successive years. This problem is exacerbated by policy makers' penchant for framing targets in bold, ambitious terms. But almost by design, any of policy's shortcomings, in terms of its logical unfolding or its ability to meet its own targets, are not seen as reasons to rethink policy agendas, so much as they provide a rationale for the intensification of those same agendas as the presumed solution to the problems and pressures initiated and installed by them in the first place. This may seem irrational; but the rationality of policy is another of its fantasies.

Adapted from: Clarke, M. (2020). Eyes wide shut: the fantasies and disavowals of education policy. Journal of Education Policy, 35(2), 151-167.

16. What of the following is **NOT** evident in the Australian prime minister's speech?

(A) goal setting   (B) assertive tone   **(C) lack of ambition** (D) focus on specific subjects

17. Which of the following statements is based on the evidence?

(A) UK has failed to meet one of the education policy targets in the past.
(B) Every child achieves his full potential in UK
(C) Australia has set unrealistic targets
(D) Educational policies are always communicated by the prime ministers.

18. Which factors are communicated in UK educational policy?

(i) Tangible targets   (ii) Ambition   (iii) Intervention

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

19. What is meant when the author says "This problem is exacerbated by policymaker's penchant for framing targets in bold"?

(A) This problem is solved by policymaker's penchant for framing targets in bold.
(B) This problem is driven by policymaker's penchant for framing targets in bold.
(C) This problem is worsened by policymaker's penchant for framing targets in bold.
(D) This problem is highlighted by policymaker's penchant for framing targets in bold.

20. Which characteristic is **NOT** the part of the UK educational policy?

(A) All inclusive
(B) Reflections driven
(C) Outcome oriented
(D) Teacher centred

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

Annotations are a critical strategy teachers can use to encourage students to interact with a text. They promote a deeper understanding of passages and encourage students to read with a purpose. Teachers can use annotations to emphasize crucial literacy skills like visualization, asking questions, and making inferences. Purposeful instruction with annotating texts is required for students to benefit from this strategy. Focused instructional activities associated with annotation make the process engaging. Teachers can encourage students to participate in the annotation in new ways that use visual and collaborative strategies.

Illustrated annotations use images to increase comprehension and understanding. Students create illustrations to represent concepts and elements of literature. Prior to reading the text, the students create a visual representation or symbol for the concept or element of focus for the learning target. When the students annotate the text, they use the illustration they created. The process of creating an illustration helps students synthesize information and increases student engagement and creativity. It makes annotating texts a more hands-on experience and makes their learning meaningful and personal. One challenge with this assignment occurs when students believe they cannot draw, do not have artistic talent, or are not creative. Allowing less artistic students to use symbols or simple drawings also emphasizes the importance of student choice.

Another annotation strategy is collaborative annotation, or an annotation on a shared text by multiple students. Students annotate the same text and analyze each person's annotations to find inspiration, discover similarities, or ask questions. This strategy encourages students to close-read a text. Students think critically and have a deeper and more meaningful understanding of the text. Students also collaborate and communicate about a text with their peers by commenting and questioning the marks of others.

Annotation strategies can be differentiated for learners in a single classroom by adjusting the requirements for each reading. Learning targets for the annotation activities can be modified for different learning needs. Digital applications may be used in several different ways to facilitate collaborative annotations. Students analyze the same text and leave comments or highlight portions of the text. Students can easily share documents and comment on other students' annotations. For visual annotations, teachers can use graphic tools where students can pull parts of the texts and choose pictures to represent their interpretations.

Teachers in any content area can use these annotation strategies for any texts in the class to emphasize certain themes or to promote literacy in their classes. Creativity and collaboration are crucial to 21st-century learners. When creative annotating strategies facilitate student interaction with a text, the annotation process is a meaningful learning experience and not just a coloring page with meaningless highlights.

Adapted from: Gehr, L. (May 2, 2019). More than highlighting: Creative annotations. Published on Edutopia.

21. As per the article, which crucial literacy skill is improved by using creative annotations?

(A) It helps improve turn taking and argumentation.
(B) It helps improve questioning and reasoning in students.
(C) It helps improves making text more personal to the reader.
(D) It helps improve active participation and multi-tasking.

22. According to the author, which role is **NOT** attributed to a teacher in using creative annotations

(A) Make the text a more hands-on experience to make learning more meaningful.
(B) Develop purposeful instructions associated with annotations.
(C) Encourage students to use new ways of annotating text.
(D) Use new annotation strategies for different types of text to promote literacy in their classes.

23. Which of the following skills improve using the creative annotations mentioned in the article?

(i) Comprehension and collaboration
(ii) Aesthetics and coloring
(iii) Symbolism and personalization
(iv) Questioning and reasoning

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

24. Which method of the following does the author suggest to personalize the process of annotations for different learners?

(A) Encourage students to create illustrations to represent concepts and elements of literature.
(B) Allowing less artistic students to use traditional methods like highlighting the text.
(C) Facilitate use of only digital platforms for different learners.
(D) Modifying learning targets for the annotation activities.

25. Which of the following claims is TRUE?

(A) The process of creating symbolic annotations can make artistic students feel superior to the ones who cannot draw well.
(B) It is essential to use visualization and collaboration in the class to include all learners.
(C) New and creative methods of annotating text are useful only for a specific type of text.
(D) Illustrations and collaborative annotations increase comprehension and critical thinking.

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

Scientific temper is prima facie the concern of the scientists, students of science or teachers of science. It is a frame of mind which a person carries with him/her when he/she enters the laboratory for scientific experience. On the other hand, citizenship is a question of status determined by the provisions of Part II of the Constitution of India and the Citizenship Act, 1955. No doubt a citizen may be a scientist. A scientist may also be a citizen. But why this question of "temper"? Is it one of those things like jeans and disco to talk of scientific temper because we are living in a scientific age? Only on the basis of the mass of scientific knowledge an age does not deserve to be called a scientific age. Probably when it is said that we live in a scientific age, it is meant that in our age there has been an intensification of inquiry and an acceleration of discoveries and inventions. I would call that age scientific age in which the problems of the society are faced and handled by human beings with scientific temper. I would call that society a scientific society which is composed of men and women who display scientific attitude in their day-to-day lives. In order to understand what scientific attitude or scientific temper is, one must necessarily understand what science is.

Science is a system of knowledge, a body of knowledge, held together by a group of propositions which have been tested and found to be valid in the light of evidence gathered. It has been said that science is the eternal interrogation of nature by man. It is a quest for knowledge. A scientist or a human being with a scientific temper or attitude does not cling to a proposition merely because it is attractive or because it is more convenient or because it is after their own heart's desire. A scientific mind is an adventurous mind. It is not afraid of truth because it may clash with established systems of thought, beliefs and superstitions - some of them claiming to be the products of mystic experience or metaphysical speculations. The scientific mind, the scientific temper, the scientific attitude - these are not the monopoly of a scientist. Any citizen, whether a scientist or not, or whether a student of science or not, can and should possess a scientific temper.

Scientific Temper involves the acceptance, amongst others, of the following premises (a) that the method of science provides a viable method of acquiring knowledge; (b) that the human problems can be understood and solved in terms of knowledge gained through the application of the method of science; (c) that the fullest use of the method of science in every day life and in every aspect of human endeavour from ethics to politics and economics is essential for ensuring human survival and progress; and (d) that one should accept knowledge gained through the application of the method of science as the closest approximation of truth at that time and question what is incompatible with such knowledge; and that one should from time to time reexamine the basic foundations of contemporary knowledge."

Adapted from: Collected Works of Justice R.A. Jahagirdar (Retd) (1927-2011). Scientific Temper. Rationalist Foundation. http://www.arvindguptatoys.com/arvindgupta/jahagir-scientific-temper.pdf

26. Which of the following statements would the author be in agreement with?

(A) One can have scientific temper without having an understanding of science.
(B) Scientific temper is relevant only for scientists and students of science.
(C) Scientific temper is important for citizens, irrespective of whether they are scientists or not.
(D) Displaying a scientific attitude within the realm of scientific studies is called scientific temper.

27. Scientific temper is prima facie the concern of the scientists, students of science or teachers of science. The word "prima facie" can be replaced by which of the following words, so as to not change the meaning of the sentence in the context of the above passage.

(A) first and foremost **(B) presumed to be** (C) initially (D) primarily

28. According to the author, an age may be called as scientific era if

(i) only scientists demonstrate scientific attitude in everyday lives
(ii) there is a surge in science and technology innovations
(iii) the problems of society are dealt with a scientific temper

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

29. Which of the following premise is scientific temper **NOT** based on?

(A) Problems in the society may be understood and solved in terms of knowledge gained through the application of the method of science.

(B) scientific knowledge gives us the ultimate truth at a given time.

(C) Methods of science is a feasible to gain knowledge.

(D) Use of the method of science in everyday life is essential for ensuring human survival and progress.

30. What does the author mean by "Is it one of those things like jeans and disco to talk of scientific temper because we are living in a scientific age?"

(A) The author is trying to use an analogy.

(B) The author is trying to suggest that we are no longer in the disco era and we have moved on to a scientific era.

(C) Disco and wearing jeans go together and therefore scientific age and scientific temper have to go together.

(D) Saying things for the sake of saying so.

Social Sciences, Cognitive Sciences and Education

31. A scholar of music studies wanted to explore the relation of listening to Hindustani and Carnatic music with the decision among young girls and boys to enroll in formal music school. Which of the following pattern describes the findings from the graph?

Enrolment of girls and boys by music choice
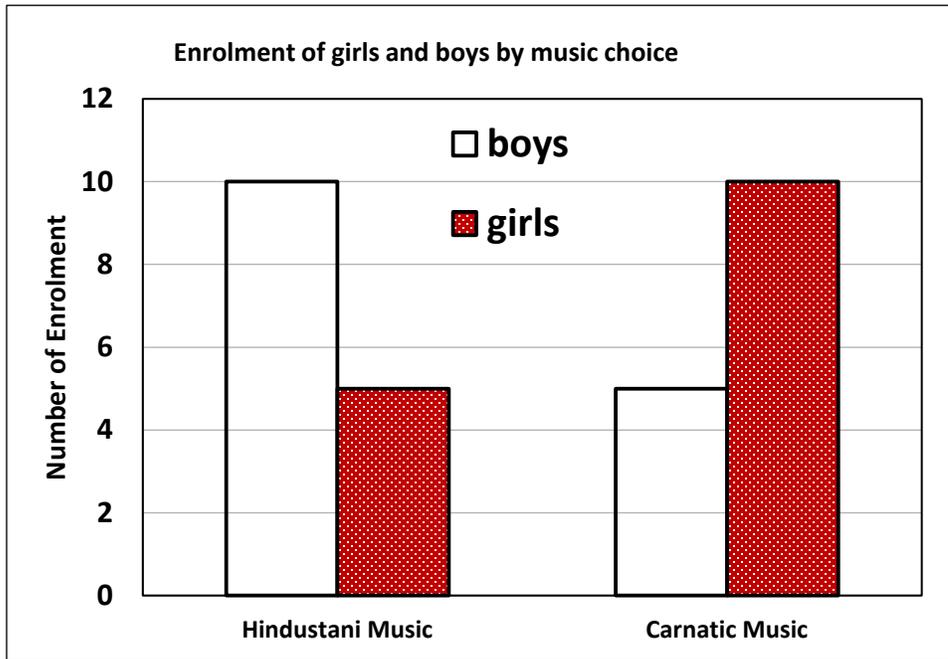
(A) Students who listened to Carnatic music had a higher enrolment than those who listened to Hindustani music.

(B) Students who listened to Hindustani music had a higher enrolment than those who listened to Carnatic music.

(C) Boys who listened to Hindustani music and girls who listened to Carnatic music showed higher enrolment than others.

(D) Boys who listened to Carnatic music and girls who listened to Hindustani music showed higher enrolment.

32. An investigator interested in studying teenagers' attitudes towards youth employment compared the attitudes of 150 fifteen year old students, 165 seventeen year old students, and 175 nineteen year old students. This research design may be best classified as:

(A) Case Study   (B) Controlled Experiment   (C) Longitudinal   **(D) Cross-sectional**

33. See the figure below, Vilayanur S. Ramachandran and Edward Hubbard asked American college undergraduates and Tamil speakers in India 'Which of these shapes is bouba and which is kiki?'

In both groups, 95% to 98% selected the curvy shape as 'bouba' and the jagged one as 'kiki'. A recent study showed that even visually challenged people choose the same naming pattern, after feeling the patterns by touch.
.
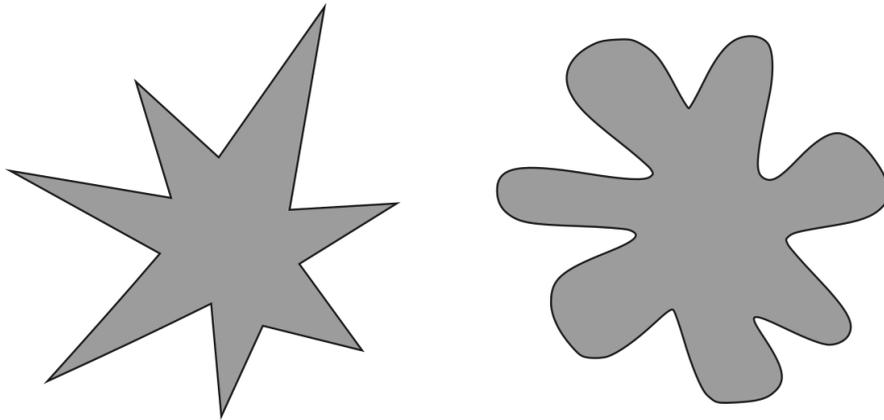
Which of the following is a valid interpretation of these findings?

(A) **The human brain organizes perceived patterns in a consistent way**
(B) Names used in language are not arbitrary
(C) Visually challenged people can imagine a visual pattern when they feel it by touch
(D) Visual patterns activate sounds, and vice versa

34. Psychologist Jean Piaget proposed a 'stage theory' of cognitive development in children from infancy to adulthood. This theory has also influenced school science curricula all over the world. Which of the following is **NOT** a valid criticism of his work?

(A) Some of Piaget's influential work was based on studies conducted with his 3 children only.
(B) **Piaget was looking for 'universal cognitive structures' which are present in all human beings. This cannot be an aim for any psychological study.**
(C) Discrete, unidirectional stages fail to capture variations in cognitive development within and between individuals.
(D) Piaget's theory does not take into account the role of context in which students perform tasks. This creates difficulty in determining at which level of cognitive development they are operating.

35. A researcher is conducting a study to measure mathematical content knowledge among teachers in rural schools. She is surveying for content knowledge through tests and also conducting observations. Which of the following steps may cause experimenter bias in this study?

(A)   The researcher selects classes randomly among many schools for repeated observations.
(B)   The researcher hypothesizes that teachers in rural schools possess low mathematical content knowledge.
(C)   The researcher facilitates testing-retesting with the same teachers during pilot study.
(D)   The researcher interprets findings after analysing test results and observations.

36. Constructivism as a learning theory refers to the idea that children construct their own knowledge on the basis of what they already know and their new experiences. Which of the following statements does **NOT** follow from the constructivist view of learning?

(A)   Classroom processes should be student-centred
(B)   Students should possess all the authority in the classroom and teachers none
(C)   Students should be encouraged to work in groups
(D)   Students should be provided opportunities to learn, determine, challenge and modify existing beliefs and knowledge

37. According to Vygotsky, learning is a sociocultural process. Which of the following conditions then affect learning?
i.   Availability of talk and language
ii.   Presence of others
iii.   Rewards and punishment
iv.   Approval of society

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

38. In an interview-based study, the interviewer should inform participants about which of the following.

i.   Participants' right to know the nature and potential consequences of the research.
ii. Participant can withdraw from the study at any time.
iii. Privacy and confidentiality of data and participant's information.
iv. Privacy of the institution and the researcher.

(A) (i) and (ii) are important.   (B) (ii), (iii), and (iv) are important.
(C) (ii) and (iii) are important.   **(D) (i), (ii), and (iii) are important.**

39. A researcher administered a 50-item vocabulary test to a group of students. The same test was administered to the same group of students after one month. The researcher reported the consistency of scores in the two tests. What type of reliability is represented in this example?

(A) Internal consistency   **(B) Test-retest**
(C) Inter-rater reliability   (D) Split-half

40. Which of the following is **NOT** a problem that can arise when formulating questions for interviews?

(A)   Questions are over-elaborate.
(B)   Questions are leading.
(C)   Questions are implicit.
(D)   **Questions are open-ended.**

41. Vygotsky's sociocultural theory for learning discusses the 'play' that young children engage in. The importance of 'play' is emphasized in his learning theory as,

(A)   Play allows children some fun time.
(B)   Play provides the teacher a chance to observe and assess.
(C)   **Play allows development of new cognitive skills in children**.
(D)   Play provides a chance to assess children's mental problems.

42. Some students struggle with the science and mathematics in the formal school system. Lemke (1990) pointed out the way we communicate science as major hurdle for such students in acquiring confidence in these subjects. Which of the following implication can be drawn from understanding this problem?

(A)   We have to be careful who we admit as science students.
(B)   **We have to change how we teach science to students.**
(C)   We have to stop worrying because we cannot change the language of science.
(D)   We have to teach in English only, so that science can be communicated.

43. Consider a typical question-response exchange between a teacher and students ending up establishing institutional differences between them. Which of the following best describes this situation?
(A)   **The adult holds the power and the student is being controlled.**
(B)   The adult is trying to hand over control but students cannot gain it.
(C)   The adult is merely subject to predetermined role play.
(D)   The adult is showing how students can gain control.

44. Verbal protocols are rich material derived from participant's spoken thoughts as she works on a task. While it is important for the participant to be able to be aware of and verbalize her thoughts, what is she most dependent upon when she is talking about her thoughts?

(A) Sensory register   (B) Long-term memory
(C) Universal Grammar   **(D) Working memory**

45. Two scientists in an institution are working on independent studies. One of them, Shehla, is studying the role of a synthetic enzyme A in assimilation. She selects some of the students in a medical college for the study. Another scientist, Susamma, is working on understanding how nurses are learning to discern bodily symptoms as part of diagnostics class. She approaches a nursing college. Which of the two is conducting educational research? Which words provide you the clues?
  (A)   Shehla; studying, medical college
  (B)   Shehla; assimilation, students
  (C)   Susamma; learning, diagnostics class
  (D)   Susamma; learning, nursing college

46. According to constructivist views on education, the teacher is best understood as a:
 (A) Disciplinarian   **(B) Facilitator**
 (C) Meek dictator   (D) Redundant entity

47. Which of the following are assumptions of attitude scales?
(i) Verbal statements can be used to express attitudes.
(ii) Meanings of the verbal statements will be the same for all participants.

(A) (i) is correct.   (B) (ii) is correct.
(C) (i) and (ii) are correct.   (D) (i) and (ii) options are incorrect.

48. A sampling method where researchers use informants and contacts to put them in touch with further individuals or groups for study, and thus the sample keeps growing, is called:

  (A) Probability sampling   (B) Selective sampling
  (C) Non-probability sampling   **(D) Snowball sampling**

49. Intersubjectivity refers to shared understanding. Which of these implications becomes important to educators from this concept?

  (A)   It has implications in social interaction for new cognitive development among students.
  (B)   It has implications for students to understand subjectivity of teachers' views.
  (C)   It has no implication for science educators whatsoever.
  (D)   It has no implications in cognitive but in emotional development of the student.

50. Which of the following is **NOT** a metacognitive performance?

(A) Assessing self during learning
(B) Setting goals in learning
(C) Reading a text
(D) Finding ways to remember

Biology

51. Which of the following would yield only one type of molecule after complete hydrolysis?

(A) Collagen   **(B) Glycogen**   (C) DNA   (D) Triacylglycerol

52. In a viral pandemic, R0 (R naught) is a number which indicates:

(A)   The number of new cases estimated to arise from an infected person.
(B)   The types of virus infecting the people.
(C)   Number of persons who have recovered from the infection.
(D)   Mortality rate from the infection.

53. Two structures of biological importance are shown below.

Structures I and II respectively represent:

(A) RNA and ADP   (B) ATP and RNA   **(C) DNA and ATP**   (D) DNA and ADP

54. A spherical cell with a radius of 0.1 micron increases in diameter to 2 microns. What would be the effect on the surface area to volume ratio of the new cell?

(A)   It would increase by a factor of 100.
(B)   It would decrease by a factor of 10.
(C)   It would increase by a factor of 10.
(D)   It would decrease by a factor of 4.

55. A botanist was studying the distribution of stomata on the upper and lower epidermis of four leaf specimens that she had collected from plants of different types. She took epidermal peels and observed them under the microscope. She recorded the following observations.

Plant 1: Uniformly abundant number of stomata in the upper and lower epidermis.
Plant 2: Few stomata observed in the lower epidermis while the upper epidermis lacked stomata.
Plant 3: Stomata predominantly present in the upper epidermis while absent in lower epidermis.
Plant 4: Stomata absent in both the upper and lower epidermis.

Which of the plants could most likely represent a typical xerophyte (desert plant) and floating hydrophyte respectively?

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

56. A simplified enzymatic pathway is shown below.
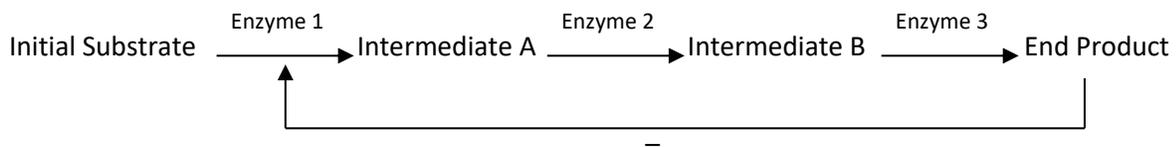
A mutation in the Enzyme 1 would most likely result in:

(A)   Accumulation of intermediate A.
(B)   Accumulation of the end-product since it cannot inhibit enzyme 1.
(C)   Accumulation of the initial substrate.
(D)   Accumulation of the substrate and end product in equal concentrations.

57. In 1952, embryologists Robert Briggs and Thomas King carried out the following experiment using two strains of frogs with cells containing nuclei differing in the number of nucleoli.
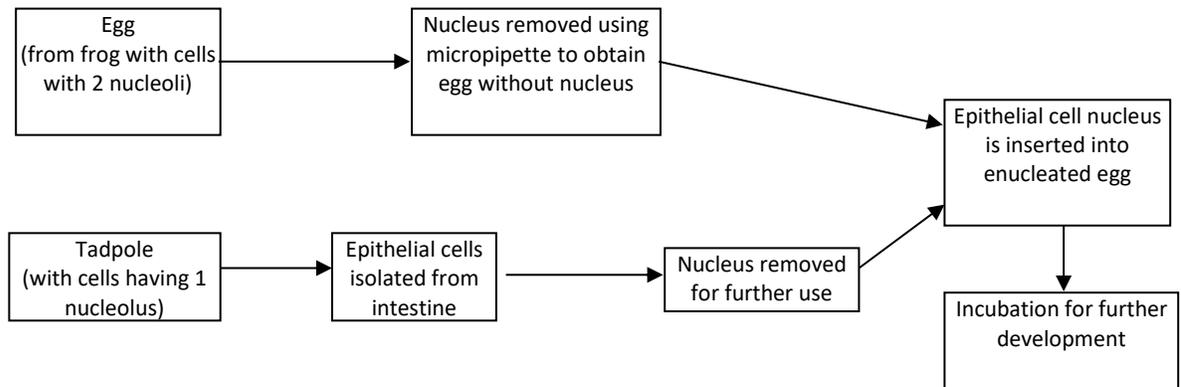
What would be the most likely outcome of this experiment?

(A)   Tadpole with one nucleolus would develop but the adult frog would have two nucleoli.
(B)   Development will not take place at all since the nuclei of both cells are required.
(C)   Tadpole and adult frog would both have two nucleoli.
(D)   Tadpole and adult frog would both have one nucleolus.

58. A pathologist needs to check if a particular bacterial pathogen has infected an individual suffering from urine infection. The diagnostic tests are likely to be based on which of the following techniques?

(A)   Immunoassays and culture test of urine.
(B)   Electron or confocal microscopy of urine sample.
(C)   Automated whole blood cell count
(D)   Thyroid (T3/4/TSH) hormone assays

59. Anita wanted to study the activity of enzyme amylase in pulses. She prepared an extract of sprouted moong in distilled water and filtered it. This filtrate was centrifuged to get a clear supernatant. She immediately added 0.5 ml of this supernatant to 2 ml starch solution in a test tube. After incubation for 10 minutes, 5 drops of iodine solution were added to the tube. A light blue colour was observed.

Anita wanted to carry out the same experiment after 24 hours. However, she forgot to store all chemicals and the supernatant in the refrigerator. When she repeated the experiment the next day, she observed that now the solution turned to dark blue- black in colour.

A possible reason for this difference in the result could be that:

(A) The activity of the enzyme had increased resulting in increased breakdown of starch.
(B) The starch solution had degraded over time and its breakdown product gave darker colour with iodine.
(C) The colour of Iodine solution had changed due to its photosensitivity which resulted in a darker colour.
(D) The activity of the enzyme had reduced as the extract was not stored in lower temperature and this led to degradation.

60. A student wanted to study the response of wood lice to the presence of moisture. For this, the following experimental set-up was designed.

The student used two plastic Petri plates of equal diameter. A muslin cloth was stretched and fixed with an adhesive on the open side of one Petri plate, and a 1 cm hole was made at the centre of the closed surface of this plate.
In the other Petri plate, a 0.5cm thick plastic strip was used to divide the plate into two halves. Wet cotton wool was kept in one half while anhydrous calcium chloride granules were placed in the other half.

Refer to the figure for the final set-up.
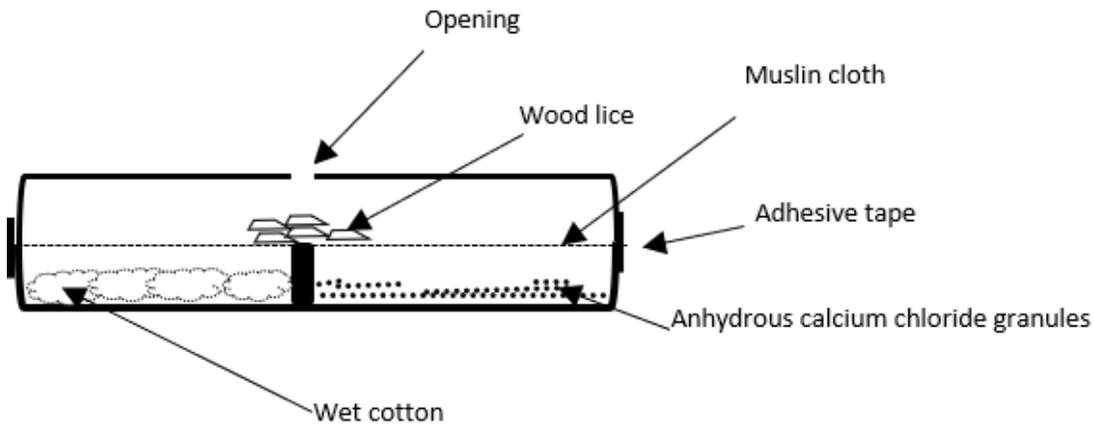
10 wood lice were introduced through the hole onto the centre of the muslin cloth and the number of lice present on left half as well as right half was recorded after every minute.

In order to be able to make reliable conclusions regarding the response, which of the following control experiments should be carried out?

(i)   Increase time interval to 2 minutes.
(ii)   Fill both the sides with wet cotton.
(iii) Change the sides of cotton and $CaCl_2$.
(iv)   Use fine steel mesh instead of muslin cloth.

(v) Fill both the sides with calcium chloride.
(vi) Replace plastic Petri dishes with glass.
(vii) Perform the experiment with fixing cloth to lower dish only so there is no need of covering dish with another plate.

Choose from the options below.

(A) (i) and (vii)   **(B) (ii), (iii) and (v)**
(C) (vi) and (vii)   (D) (iv) and (vi)

Chemistry

Atomic masses (in a.m.u.): H: 1, C: 12, N: 14, O: 16, F: 19, S: 32, P: 31, Br: 80, Ca: 40

61. The bond angles of PF_3 and PBr_3 molecules are 97.7°and 101°, respectively. The statement which can explain these observations is:

(A)   Bromine attracts the bonded electron pair towards itself and allows the bond angle to expand, thus, giving higher bond angle.
(B)   Bromine repels the bonded electron pair towards phosphorous and allows the bond angle to expand, thus, giving higher bond angle.
(C)   **Fluorine attracts the bonded electron pair towards itself and allows the lone pair on phosphorous to expand**, thus, giving lower bond angle.
(D)   Fluorine repels the bonded electron pair towards phosphorous and allows the bond angle to contract, thus, giving lower bond angle.

62. In a qualitative analysis experiment, a student was given a salt sample (Barium chloride) to analyze. Following the instructions, the student took a pinch of the salt in a test tube, dissolved it in 5 mL water and obtained a clear solution. He then added dilute sulphuric acid to the test tube. The laboratory instructor watching him observed his test tube becoming turbid white. The student in his observation table wrote "Negative test" for Ba^{2+} ions. The most likely reason for student to write the test to be negative is:

(A)   The student added less amount of sulphuric acid than required.
(B)   The student did not recognize turbidity as formation of precipitate.
(C)   The student expected that bubbles should also be evolved in the reaction, and no bubbles were observed.
(D)   The student expected the precipitate to be coloured.

63. The critical temperature of ethanol is 516.25 K. Above this temperature

(A)   Ethanol molecules disintegrate into atoms and smaller ionic/radical species.
(B)   Liquid ethanol does not exist at any pressure.
(C)   The liquid and gaseous phase of ethanol are in equilibrium.
(D)   All the three phases of ethanol are in equilibrium.

64. Textbooks say that the pH of pure water is 7.0 at 25°C. A student in a lab took a beaker filled with distilled water and measured its pH using a pH meter. She got a reading of 6.1. This value could be because:

i.   The temperature of the laboratory air and the water sample was much lower than 25°C.
ii.   The pH meter was not calibrated before measurement.
iii.   The distilled water was kept in open beaker for some time.
iv.   The beaker was washed with soap water before use and student did not rinse the beaker with water properly after washing.

Choose from the options below.
(A) i and ii   **(B) ii and iii**
(C) i, ii, and iv   (D) iii and iv

65. Sewage in septic tanks decomposes producing gases such as H_2S and CO_2, which can cause asphyxiation to workers entering that space, even causing death.

In one such tank, the average composition of the air above the water level was 86% N_2, 9% O_2, 1.5% H_2O, 1.5% CO_2, 1.2% H_2S and 0.8% CH_4 (the percentages are by mass). Unless there is turbulence or mixing, gases entering a space do not immediately diffuse uniformly in the chamber space. Initially they tend to accumulate in different horizontal zones according to their density compared to the air present in the chamber. Septic tanks are designed to have low flow rate of sewage, therefore, do not have any significant turbulence in air inside. In the tank shown, the zones in the air space (**A**, **B**, or **C** as shown below) in which maximum concentration of H_2S, CO_2 is likely to be detected are
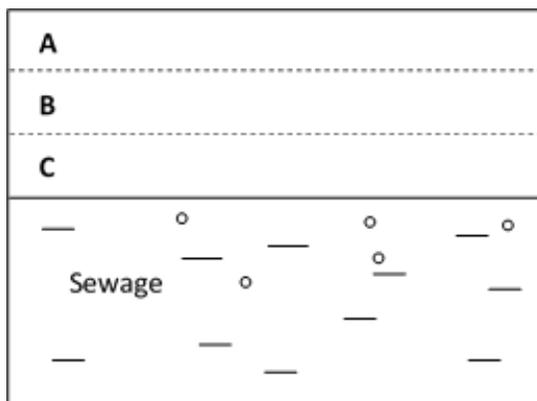
(A) **A** - H₂S, **C** - CO₂
(B) **A** - H₂S, **B** - CO₂
(C) **C** - H₂S, **B** - CO₂
(D) C- H₂S, C - CO₂

66. A mass of 20 g calcium carbonate ($CaCO_3$) is heated with excess amount of hydrochloric acid. The carbon dioxide released during the reaction is trapped and weighed. The mass of this carbon dioxide collected should be

(A) 2.2 g   (B) 4.4 g   **(C) 8.8 g**   (D) 1.1 g

67. The amount of charge required to electrolyse 1 mol of water completely to oxygen gas is (F is Faraday constant)

(A)   F   (B)   4F   **(C)   2F**   (D)   0.5F

68. The statement that is true for the process of formation of ice from water in a closed metallic container at atmospheric pressure is:

(A)   The surrounding cools down as energy is absorbed from the surrounding during ice formation.
(B)   Energy is released by water during ice formation.
(C)   The entropy of the water + ice system increases whereas that of surrounding decreases.
(D)   The mass of water + ice system increases.

69. Of the following, the reaction that involves a radical intermediate is

(A)   Diels Alder reaction
(B)   Halogenation of alkenes
(C)   Halogenation of alkanes
(D)   Hydration of alkynes

70. The spin only magnetic moment of coordination complexes represented by m, can be calculated as m = $[n(n+2)]^{1/2}$. A mono-nuclear metal complex with a magnetic moment of 4.90

(A)   Can be both low spin or high spin complex.
(B)   Must be a high spin complex.
(C)   Must be a low spin complex.
(D)   Can be formed only in violation of Pauli's exclusion principle.

Mathematics

71. Let $p_1, p_2, \ldots \ldots, p_k$ be distinct prime numbers and $n = p_1^{x_1} p_2^{x_2} \ldots p_r^{x_r}$ be an integer with s being integers. Also let $q = \sum_1^r x_i$. The number of possible distinct factors of n into two relatively prime integers (each greater than one) is

(A) $2^{qr-1} - q$

(B) $2^{r-1} - 1$

(C) $\dfrac{(qr-1)!}{(r-1)!}$

(D) $2^r - q$

72. Let S be a set with n elements, and let $\wp_k(S)$ and $\wp_{n-k}(S)$ be the set of subsets of S with k and $n - k$ elements respectively. The number of one-to-one (or injective) maps from $\wp_k(S)$ to $\wp_{n-k}(S)$ is (assume that the number of elements in the two are r_1 and r_2 respectively):

(A) $r_1^k \cdot r_2^{n-k}$

(B) $r_1^k + r_2^{n-k}$

(C) $\sqrt{r_1! \, r_2!}$

(D) Insufficient information

73. Let $f, g: \mathbb{R} \to \mathbb{R}$ be real functions. f commutes with g if and only if for all real x, $f(g(x)) = g(f(x))$. If $f(x) = x^2 - 2$, then which of the following functions commute with f?

(A) $x^3 - 3x$

(B) $2x^3 + 6x$

(C) $x^3 + 3$

(D) None of the above.

74. If $f(x)$ is a function such that $f(x) + 3f(x-8) = x$ for all real numbers x, the value of $f(2)$ is

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

75. Find the function whose graph is given below:

$$y = f(x)$$
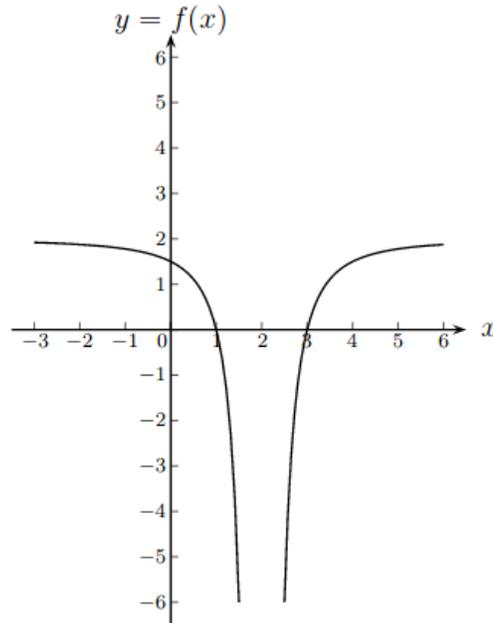
(A) $\dfrac{(x-1)(x-3)}{(x-2)^2}$

(B) $\dfrac{2(x-1)(x-3)}{(x-2)}$

(C) $\dfrac{2(x-1)(x-3)}{(x-2)^3}$

(D) $\dfrac{2(x-1)(x-3)}{(x-2)^2}$

76. Let $ABCD$ be a rhombus with area $18\sqrt{3}$sq cm^2. If the lengths (in cm) of the segments AB, BC, CD, DA, AC, BD form a 2- element set, then the perimeter of $ABCD$ (in cm) is

(A) $12\sqrt{2}$ **(B) 24**   (C) $24\sqrt{2}$ (D) 36

77. In a convex quadrilateral $ABCD$, the diagonals AC and BD are equal and they intersect at P. Given that the areas of triangles APB and CPD are equal, consider the following statements:

    I. $AB = CD$
    II. AD is parallel to BC
    III. The points A, B, C, D lie on a circle
    IV. AC is perpendicular to BD

 Then,

    (A) I and II are the ONLY CORRECT statements.
    (B) III is TRUE and IV is FALSE.
    (C) II is TRUE and III is FALSE.
    (D) All four statements are TRUE.

78. Three circles of radii 1, 2, and 3 units touch each other externally in the plane. The radius of the circle passing through the centres of the circles is

    (A) 1.5   (B) 2   **(C) 2.5**   (D) 3

79. On each face of a cuboid, the sum of its perimeter and its area is written. Among the six numbers so written, there are three distinct numbers and they are 16, 24 and 31. The volume of the cuboid lies between

    (A) 7 and 14   (B) 14 and 21   (C) 21 and 28   **(D) 28 and 35**

80. If $log(2)$, $log(2x - 1)$ and $log(2x + 3)$ are in Arithmetic Progression, then x is equal to

    (A) $\dfrac{5}{2}$

    (B) $log_2 5$

    (C) $log_3 2$

    (D) $\dfrac{3}{2}$

Physics

81. The angular size of the planet Mars in the sky on a particular evening is 3.6 arcsecond. If the diameter of Mars is taken as 6280 km, approximately how much time will it take a radio signal from the ISRO centre to reach the Mangalyaan spacecraft in orbit around Mars?
(Speed of light in vaccum = 3.0×10^8m/s)

(A) 8 min   **(B) 20 min**   (C) 160 min   (D) 220 min

82. The maximum height that Rahul can jump vertically upwards from a standing position is around 20 cm. His initial velocity at liftoff to achieve this jump, approximately, is

(A) 0.2 m/s   **(B) 2 m/s**   (C) 10 m/s   (D) 20 m/s

83. Percentage error in the measurement of radius r of a sphere is z. The percentage errors in the area and volume of the sphere are, respectively

(A) z and z **(B) 2z and 3z**   (C) z^2 and z^3 (D) $4\pi z^2$ and $4\pi z^3/3$

84. The figure below shows a lake with a boat floating in it. Let P_a, P_b, P_c be the pressures at the locations a, b, and c, respectively, inside the water.

Choose the **correct** statement:

(A) $P_a = P_b = P_c$ (B) $P_b > P_a > P_c$
(C) $P_a = P_b > P_c$ (D) $P_c > P_a = P_b$

85. Two gases X and Y are filled in two containers, each at pressure P and volume V. The gas X follows the ideal gas law and the gas Y follows the Van der Waals equation of gases. Both gases are compressed to volume $V/2$ keeping the pressure constant at P. Let W_X and W_Y be the work done on the gases X and Y, respectively, in this process. Choose the correct statement.

(A) $W_X = W_Y$
(B) $W_X > W_Y$
(C) $W_X < W_Y$
(D)   The relation between W_X and W_Y depends on the initial temperature of the gases.

86. Meena (M) is sitting on a chair 1 m in front of a large plane mirror. Her friend Leena (L) is standing 1 m to her left and another friend Beena (B) is standing 1 m behind her. All of them are looking at Meena in the mirror. Choose the correct statement.

(A)   The image of M that L sees is shifted to the left of the image of M that M herself sees.
(B)   The image of M that L sees is shifted to the right of the image of M that M herself sees.
(C)   The image of M that B sees is shifted backwards from the image of M that M herself sees.
(D)   **All three of them see the same image of M.**

87. A charge q is placed near/inside the closed surfaces as shown in the figure below.

(a)   (b)   (c)   (d)

For which cases, the net electric flux through the surfaces is non-zero?
(A)   **Only (a) and (b)**
(B)   Only (c) and (d)
(C)   Only (d)
(D)   All the cases

88. Rain is falling. When the raindrops are very close to the ground, their acceleration is likely to be

   (A)   Exactly 9.8 m/s^2
   (B)   Slightly less than 9.8 m/s^2
   (C)   Slightly more than 9.8 m/s^2
   (D)   Nearly zero

89. A radioactive source of initial mass 3 kg is found to reduce to 100 g in 30 days. The half-life of the source is close to

   (A) 1 day.   (B) 3 days.   **(C) 6 days.**   (D) 15 days.

90. The emf produced in a wire by moving it across a magnetic field does not depend on the

   (A)   Length of the wire
   (B)   Orientation of the wire
   (C)   Material of the wire
   (D)   Strength of the magnetic field