Entrance Test for Ph.D. Programme in Science Education – 2024

Read the following instructions carefully.

- This paper has two sections, section I is of multiple choice questions; and section II is a descriptive one- titled as critical reasoning.
- Section I of the written test carries **100 marks**.
- There are **a total of 80 questions** in section I distributed among different subjects as:
  - **Q 1 to 25:** Quantitative reasoning, scientific literacy and technical comprehension.
  - **Q 25 to 40:** Social and cognitive sciences and education.
  - **Q 41 to 80:** Ten questions each on biology (41 to 50), chemistry (51 to 60), mathematics (61 to 70) and physics (71 to 80).
- 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 section I. In case **more than 50 questions** are attempted, the score obtained will be **normalized** to that corresponding to 50 questions, using the following formula.

$$Normalizedscore = \frac{Scoreobtained}{No.ofquestionsattempted} X\,50$$

- Section II of the written test carries **50 marks**. It has 3 questions. Q 81is of 20 marks, and Q 82 and Q 83 are 15 marks each.

Please note

- You will need to click on **'Submit**' at the end of Section I (followed by prompts for submission for marking) to access Section II for the first time. **However,** you can continue switching between sections **anytime** to edit/update your response.
- While typing in the text boxes, the following function keys CANNOT be used/operated: Ctrl+C Ctrl+X Ctrl+V [Accidental or otherwise – use of the above keys will lead to erasing of the text matter already typed in that particular text box.]

Section I:

Multiple Choice Questions

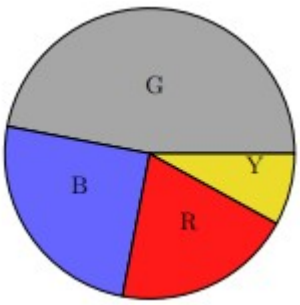
Quantitative Reasoning, Scientific Literacy and Technical Comprehension

Question 1:

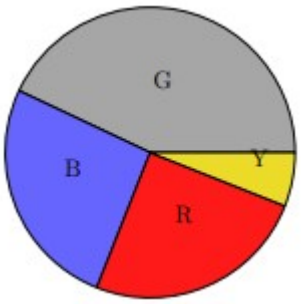
Given below is the number of cans of each colour sold in a paint shop in a day. Which of the pie charts given below correctly represents the data?

Colour	Number
Blue (B)	16
Red (R)	13
Grey (G)	23
Yellow (Y)	8

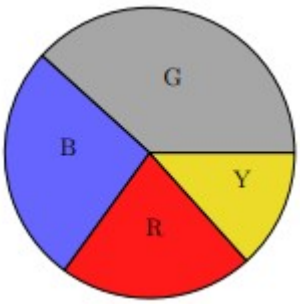
A)



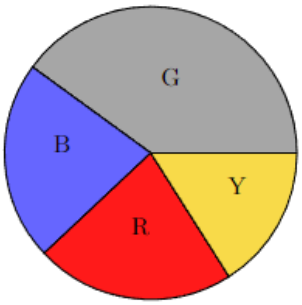
B)



C)



D)



Question 2:

In a sample, distribution, the numbers 8, 10, and 16 have the frequencies $(x + 2)$, x, and $(x - 1)$ respectively and the arithmetic mean of this sample 11. What is the value of x?

A) 11 B) 10 C) 9 D) 8

Question 3:

The outer length, breadth and height of a wooden box open from top are 10 cm, 8 cm, and 6 cm. The thickness of the wood is 1 cm. The total surface area of the box is:

A) $376\,\text{cm}^2$ B) $446\,\text{cm}^2$ C) $488\,\text{cm}^2$ **D)** $516\,\text{cm}^2$

Question 4:

Assume that the following three statements are true and then decide which of the given conclusion/s is true.

- Statement I. All dogs are cats.
- Statement II. Some cats are horses.
- Statement III. Some horses are donkeys.

Conclusions:

- I. Some dogs are horses.
- II. Some cats are donkeys.
- III. Some horses are dogs.
- IV. Some donkeys are horses

A) Only I and IV are true B) Only II and IV are true

C) Only III is true **D)** Only IV is true

Question 5:

A car dealer selling a car makes a profit of 2% even after giving a 4% discount on the advertised price. If the profit made by the seller is Rs. 20,000/-, what was the advertised price of the car?

A) Rs. 10,00,000

B) Rs. 10,60,000

C) Rs. 10,60,800

D) Rs. 10,62,500

Question 6:

A wall clock with a minute hand and an hour hand but with no digit markings is facing a mirror (say X) directly opposite to it. There is another mirror (say Y) on the ceiling of the room just above the clock. An observer observes reflection of the clock on both mirrors for a full day (24 hours). How many times in a day will either reflections show the correct time?

A) X twice and Y twice.

B) X four times and Y twice.

C) X four times and Y four times.

D) X four times and Y six times.

Question 7:

The height of a trapezium T is 5 units and one of its angles is $90°$. If the area of T is 50 sq. units and if the length of its longer diagonal is 13 units, the length of its shorter diagonal is

A) $\sqrt{41}$ units

B) $\sqrt{61}$ units

C) $\sqrt{74}$ units

D) $\sqrt{89}$ units

Question 8:

Two numbers are said to be co-prime with each other if their G.C.D. is 1. How many 2-digit positive integers are **not** co-prime with 21?

A) 39 B) 43 C) 47 D) 51

Question 9:

Reshma's birthday is on the 7th of January. In the year 2008, her birthday happened to be on a Monday. When is the next time that her birthday would come on a Monday?

A) 2012 **B)** 2013 C) 2014 D) 2015

Question 10:

If the word PIANO is written as TKCRQ in a certain code. How will the word VIOLIN be written using the same code?

A) ZKQTKR B) XKQPKR

C) ZKQPKR D) XKQSKR

Question 11:

There were 63 piles of fruits and 7 single fruits. All the fruits were divided equally between 23 travelers. Which of the following cannot be the number of fruits that each traveler got?

A) 14 **B)** 54

C) 77 D) 266

Question 12:

If $3x-5y = 15$ then the value of $\frac{8^x}{32^y}$ is

A) Between 10000 and 15000

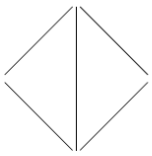
B) Between 15000 and 30000

C) Between 30000 and 60000

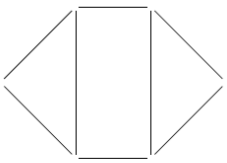
D) More than 60000

Question 13:

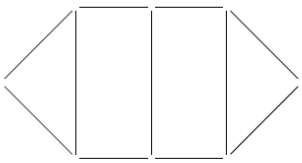
How many sticks would be used in the 100^{th} design, if the same pattern continues?



Design 1



Design 2



Design 3

A) 302

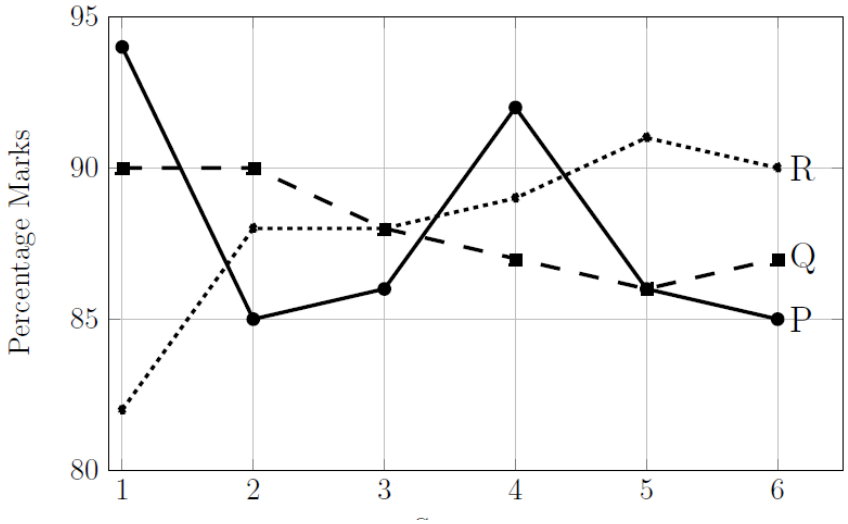
B) 303

C) 304

D) 305

Question 14:

Semester wise percentage marks for three students, P (solid line), Q (dashed line), and R (dotted line), across six semesters in a B.Sc. course, are displayed in the graph below. Notably, the average percentages at the end of six semesters are equal for all the three students. What is the correct order for the standard deviations for the average score for these three students?



A) P > Q > R

B) P > R > Q

C) Q > P > R

D) R > P > Q

Question 15:

A teacher conducted a test for 7 students in a class. The maximum possible score for the test was 100 marks and the least count of the marking was 1 mark. After the test, the teacher prepared a list of "normalised scores" of all 7 students, where the normalised score S_i of each student was defined as $S_i = 50 \times \frac{M_i}{D}$, where M_i was that student's marks out of 100, and D was the median marks. The list of normalised scores (rounded off to two decimal places) was:

$$S = \{59.65, 57.02, 56.14, 50.00, 47.37, 45.31, 42.11\}$$

If two of the students had got 64 and 65 marks out of 100, the median marks, D was

A) 50

B) 47

C) 57

D) 67

Question 16-20:

Read the passage carefully and answer questions 16 to 20.

PASSAGE:

Polls consistently show a high level of environmental awareness in the U.S. However, awareness frequently does not translate into action. Use of mass transit has shown almost no per capita growth despite substantial investment in light rail and other transit improvements. Carpooling has declined. The use of environmentally friendly technologies such as solar and wind power has grown in a limited manner, except where subsidized or mandated. In part, this is because they have been more expensive than their fossil fuel using counterparts. However, even as those costs approach parity, growth rates drop significantly when subsidies are removed.

There was once, and to some extent continues to be, a belief in the simple model that says: knowledge of the environment leads to a positive environmental attitude, which results in pro-environmental action. This has not happened consistently, either in the U.S. or Europe. In a European study, Ortega-Egea et al. say "*Over the past two decades, increased media coverage – coupled with economic incentives, subsidies, and related interventions – has substantially raised citizens' awareness and concern about climate change, but has typically failed to induce persistent behavioral changes*."

The root cause of the problem is that protecting the environment is not the only goal that people have. Individuals choose actions based upon priority between conflicting goals. In addition, there are multiple sources of influence affecting environmental choices. The influences are often subconscious. A large number of theories have been proposed to explain what motivates environmental behavior. An entire journal, the Journal of Environmental Psychology, is devoted to the topic. A model described by Steg and Vlek includes five categories, namely 1) Perceived costs and benefits (including non-monetary costs and benefits); 2) Moral and normative concerns (what you think you should be doing); 3) Emotion; 4) Contextual factors (primarily available means to execute specific actions/behaviour); 5) Habits.

In addition to these factors, political orientation, age, gender, education and other individual characteristics influence environmental behaviour. There are also numerous psychological factors influencing whether a person will take individual environmentally friendly actions or support collective and governmental actions. These can be influenced, vary over time and interact. They will have strong influence on the pace of adoption of electric vehicles, ride sharing services, and other lifestyle changes that are expected to reduce CO_2 emissions and fossil fuel use.

Adapted from: Ritchie, E. J. (2017). Good Intentions. *Forbes.*

Question 16

Awareness and knowledge about the environment:

A) always leads to pro-environmental actions.

B) may at times lead to pro-environmental actions.

C) never leads to pro- environmental actions.

D) is not related to green behaviour.

Question 17

Which of the following is NOT mentioned in the article?

A) Psychological factors, emotional factors, economic factors and contextual factors may influence green behaviour.

B) Rail infrastructure has improved in the US, but the number of people using the rail services continue to be less.

C) Solar and wind power tend to be more expensive than their fossil fuel counterparts.

D) Levels of environmental awareness has consistently been poor in the US.

Question 18

Let us say, I want to switch to buying eco-friendly detergents from my regular one. But I am not able to find shops near my house that stock eco-friendly alternatives. If I try to buy these online, the cost is not affordable to me. So, I do not opt for eco-friendly options.

The above is an example of pro-environmental behaviour not being followed owing to which of these factors

(i) Emotional Factors

(ii) Contextual Factors

(iii) Perceived Costs and Benefits

(iv) Habits

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

Question 19

However, even as those costs approach parity, growth rates drop significantly when subsidies are removed.

According to the authors, the word "parity" in this sentence indicates:

A) unity

B) equivalence

C) agreement

D) affinity

Question 20

According to the article:

A) Europe and US show different trends when it comes to pro-environmental behaviours.

B) Very few theories actually try to explain what motivates environmental behavior.

C) Adoption of electric vehicles, ride sharing services, and other lifestyle changes are barely affected by social and psychological factors.

D) A reason for lack of green behaviour could be because people have to choose actions based on priority between conflicting goals.

Read the passage carefully and answer questions 21 to 25.

PASSAGE:

Globally, 2 in 3 children aged 6–23 months do not receive the recommended minimum diverse diet they need in early childhood to grow healthy. Undernutrition early in life can lead to an increased risk of overweight and obesity later in life, especially when children and their families are confronted with a rapid shift to an obesogenic food environment that promotes high energy intake and sedentary behaviour. Children in Asia and Africa bear the greatest share of all forms of malnutrition. While the proportion of children affected by undernutrition has been declining, albeit far too slowly to meet globally agreed targets, the proportion of children who are overweight is rising rapidly, including in regions that are still struggling with a high burden of undernutrition. Globally, almost 200 million children under 5 suffer from stunting, wasting or both, and at least 340 million suffer from hidden hunger of vitamin and mineral deficiencies. At the same time, 40 million children under 5 are overweight and toll of overweight and obesity keeps rising, including in lower-income countries.

Widespread changes in food environments – including the increased availability, affordability and marketing of ultra-processed, unhealthy foods high in fats, salt and sugars – are the major driver of escalating overweight and obesity prevalence during the past 30 to 40 years. Poverty and inequality, which undermine access to and affordability of adequate nutritious and healthy food, are drivers of both obesity and vitamin and nutrient deficiencies, in addition to undernutrition. At a rapidly increasing rate, people are moving towards commercialized diets that rely heavily on unhealthy foods, high in saturated fats, salt and sugars, and inadequate in fruits, vegetables and whole grains. Consequently, many children's diets do not satisfy their nutritional needs, even if the amount of food being consumed may meet – or exceed – their basic energy needs. To address childhood and adolescent obesity, the environmental context needs to be considered during three critical time periods: preconception and pregnancy; infancy and early childhood; and older childhood and adolescence.

While there are many barriers to protecting children's rights in modern food environments, particularly important is the cost of healthy food. Low income families are especially vulnerable to economic barriers to food accessibility; these families may not be able to afford sufficient nutritious food for a healthy diet without having to forgo or compromise other basic needs, such as education, health care and housing. In addition, when parents work full-time, commute to work, or require more than one job to support their families, they may also be constrained by 'time poverty', making it difficult or impossible to find time to buy the ingredients and prepare healthy meals. Additionally, manufacturers focus on increasing production and maximizing efficiency at the lowest possible economic cost, meaning that many ultra-processed packaged foods have excessive amounts of low-cost fats, salt and sugars. Reflecting their affordability, availability and aggressive marketing strategies, 77 per cent of processed food sales worldwide are controlled by just 100 large firms.

In a recent study, London's Child Obesity Taskforce spoke with children and families in the city's poorest neighbourhoods to better understand how they viewed their food environments. Children who have only experienced unhealthy foods, due to their affordability and accessibility, have entrenched food habits and are reluctant to eat healthy foods even when they are available.

Ref.https://www.unicef.org/media/96101/file/Protecting-Childrens-Right-Healthy-Food-Environment.pdf

Question 21

According to the passage, a food environment:

A) determines the range of food choices available to a person in a particular geographical and socioeconomic context

B) is a place where unhealthy food is consumed such as fast food joints and restaurants

C) includes places where food is cultivated, such as agricultural farms, poultry farms

D) includes places where food is prepared, such as kitchens and restaurants

Question 22

What factors hinder a child's right to healthy food as per the paragraph?

(i) Prevalence of industrialized low-cost food production

(ii) Low income in families

(iii) Misleading and inadequate food labeling practices

(iv) Lack of time to cook healthy meals

A) (ii), (iii), (iv) B) (i), (ii), (iii)

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

Question 23

State true or false

1. Ultra-processed low-cost fats, salt and sugar in the food may lead to malnutrition

2. Consumption of fruits, vegetables and whole grains and sedentary behaviour may lead to obesity

3. Poverty and inequality can come in the way of children's right to healthy food environment

4. Children will always prefer healthy food if it is made available to them

A) TTFT **B)** TFTF C) TTTF D) FFTT

Question 24

Children in Asia and Africa bear the greatest share of all forms of malnutrition. As per the arguments in the paragraph, the reason could be:

A) Because of poverty and inequality in these subcontinents

B) Because of lack of hygiene in these subcontinents

C) Because of more aggressive marketing by food industries in these subcontinents

D) Because of inadequate food production in these subcontinents

Question 25

Government should safeguard children's rights by monitoring their food environment to ensure adequate nutritious food supply. As per the paragraph, which of the time periods of human life are critical in this context?

(i) Preconception and pregnancy

(ii) Zero to five years

(iii) 5- 12 years

(iv) 13 years plus

(v) Young adults as parents to 2-5 year old children

A) All the above

B) (i) and (ii)

C) (ii), (iii), (iv), (v)

D) (i), (ii), (iii), (iv)

Social Sciences, Cognitive Sciences and Education

Question 26:

Which among the following statements regarding Scheduled Tribes (adivasis) in India is FALSE:

A) Barring the North Eastern states, there are no states in India largely inhabited by adivasi people, there are only areas of adivasi concentration.

B) Where they are concentrated, the socio-economic conditions of adivasi people are far worse than others

C) The Indian constitution recognises that the adivasi groups are marked by poverty and social stigma.

D) In terms of absolute population size, the Scheduled Tribes outnumber other groups.

Question 27:

Which among the following statements regarding reservations in India is FALSE:

A) These include reservation of seats in the State and Central legislatures; reservation of jobs in government service across all departments and public sector companies; and reservation of seats in educational institutions.

B) The proportion of reserved seats for a particular caste/tribe group is equal to the percentage share of the particular caste/tribe group's population in the total population

C) It is a government initiative that attempts to combat past and present caste discrimination

D) Reservations were extended to the Other Backward Classes in the 1990s

Question 28:

Based on the Census of India 2011, what was the percentage of the Indian population living in rural areas in 2011? (pick the nearest answer)

A) 80% **B)** 70% C) 60% D) 50%

Question 29:

All of the following is true about Malthus's theory of population growth EXCEPT:

A) While the population rises in geometric progression, agricultural production can only grow in arithmetic progression

B) Nature deals with increased population through positive checks (through famines and diseases)

C) Humans can deal with increased population through preventive checks (through celibacy, sexual abstinence)

D) Malthus's theory and predictions have proven to be true.

Question 30:

Consider the statements below on how Other Backward Classes (OBCs) are described in the Indian Constitution?

(I) Extremely socially and educationally backward classes who are oppressed by 'untouchability' practices

(ii) Socially and educationally backward classes

(iii) Socially and educationally backward tribes

Which of these are correct?

A) Only (i) is correct.

B) Only (ii) is correct

C) Only (ii) and iii) are correct

D) All (i-iii) statements are correct

Question 31:

The rank of tenured professors in STEM in India are dominated by men, as compared to other genders. Which of the following statements explains the reason for this:

A) Obvious biological and physical differences across genders

B) Prejudice and negative stereotypical assumptions made against some genders

C) Scientific evidence of the intellectual differences between genders

D) None of the above

Question 32:

An education researcher is conducting a research study with undergraduate students of biology. The researcher knew completing the study would benefit students' biology understanding, so they did not mention that students could quit being part of the study anytime they wanted.

Which of the following statements is true?

A) The researcher is following research ethics, since this action would benefit the study participants.

B) The researcher is violating research ethics by not following the norms of informed consent.

C) The researcher is acting ethically because if students quit the study, that could negatively impact research findings.

D) All of the above.

Question 33:

"Sanskritisation" as defined by M. N. Srinivas refers to (pick the choice that best describes this construct):

A) Translating texts into Sanskrit

B) Finding Sanskrit origins of the Hindi words

C) A process by which members of a (usually middle or lower) caste attempt to raise their own social status by adopting the customs and practices of higher castes.

D) The demand to mandate Sanskrit language instruction in all schools.

Question 34:

A researcher is studying youths' attitudes towards youth employment. She through a study compared the attitudes of 160 fifteen year old students, 170 eighteen year old students, and 180 twenty two year old students. This research design may be best classified as -

(A) Longitudinal

(B) Case Study

(C) Controlled Experiment

(D) Cross-sectional

Question 35:

Which of the following is NOT a correct interpretation of the Cultural and Educational Rights guaranteed in the Constitution of India?

A) The right of the minorities to maintain and conserve their language, script, and culture

B) The right of the minorities to set up their own educational institutions

C) The right of the minorities to administer their own educational institutions

D) The right of the minorities to have guaranteed admission in any educational institution maintained by the state

Question 36:

“We are disabled by buildings that are not designed to admit us, and this in turn leads to a range of further disablements regarding our education, our chances of gaining employment, our social lives and so on. The disablement lies in the construction of society, not in the physical condition of the individual (Brisenden 1986 :176).”

All of the following convey the meaning of the quote EXCEPT:

A) Disability is biologically given

B) Disability is not biologically given

C) Disability is constructed by society

D) Architectural design can be discriminatory to disabled people

Question 37:

Which of the following is NOT a metacognitive performance?

(A) Assessing response of a question on our own

(B) Finding ways to remember passage highlights

(C) Reading a text for others

(D) Setting goals for learning

Question 38:

Which of the following statements accurately describes the provisions in the Right of Children to Free and Compulsory Education Act, 2009 (RTE)?

(i) RTE protects the right of children to free and compulsory education in a neighbourhood school till completion of elementary education

(ii) RTE includes provisions for a non-admitted child to be admitted to a school in vicinity.

(iii) RTE prohibits schools and teachers from subjecting children to physical punishment or mental harassment

(A) (ii) and (iii)

(B) (i) and (ii)

(C) (i) and (iii)

(D) Only (ii)

Question 39:

The child sex ratio between the (0-6) years age in India has been declining in India, from 976 in 1961 to 919 in 2011. Which of the following is a factor that may be held responsible for the decline in the child sex ratio in India?

A) Severe neglect of girl babies in infancy, leading to higher death rates

B) Sex-specific abortions that prevent girl babies from being born

C) Female infanticide (or the killing of girl babies due to religious or cultural beliefs)

D) All of the above

Question 40:

Which of the following statements is true for Panchayat Raj

A) The system has a pyramid structure, and Gram Sabha is at the base

B) They have elections every three years

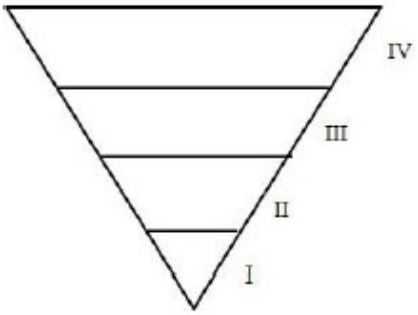
C) There is 63% reservation for women in leadership

D) It was regularised through Indian Constitution

Biology

Question 41:

I, II, III and IV in the following inverted pyramid respectively represent:



A) Biomass of fruits, squirrels, snakes and hawks on a mango tree.

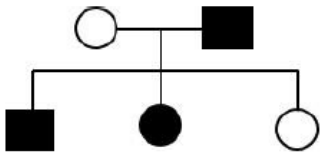
B) Number of trees, birds, lice and bacteria in a forest.

C) Number of phytoplanktons, zooplanktons, mackerels and sharks in an ocean.

D) Biomass of grass, grasshoppers, mice and snakes in a grassland.

Question 42:

The ability to roll the tongue is an autosomal dominant trait in humans. A pedigree depicting the transmission of this trait in a family is shown. Circles represent females and squares represent males. Filled symbols indicate affected individuals.



The probability that the father is heterozygous for the trait is:

A) 0 B) 0.25 C) 0.5 **D)** 1

Question 43:

Consider the following template DNA sequence: 3'-ACCAAACCGAGT-5'. Which of the following would be the mRNA sequence transcribed from this sequence?

A) 5'-UGGUUUGGCUCA-3'

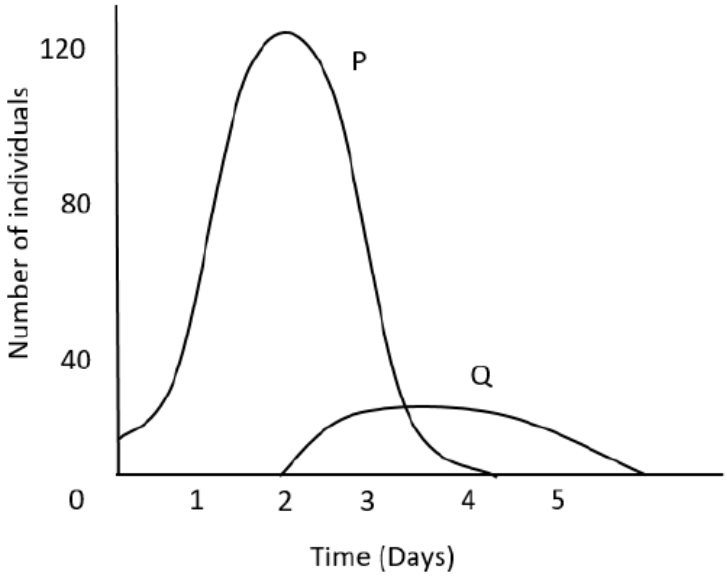
B) 5'-TGGTTTGGCTCA-3'

C) 3'-UGGUUUGGCUCA-5'

D) 3'-TGGTTTGGCTCA-5'

Question 44:

P is a unicellular organism that can be grown in an artificial liquid medium where all the conditions are favorable for their sustained growth for many weeks. After two days of inoculation of P, another unicellular organism Q is introduced in the system and the populations of both the organisms were monitored for the next few days. The following graph represents the observations.



Which of the following statements correctly depicts the interaction between P and Q?

A) Both the organisms have separate niche areas. They do not show any effect on the growth of each other.

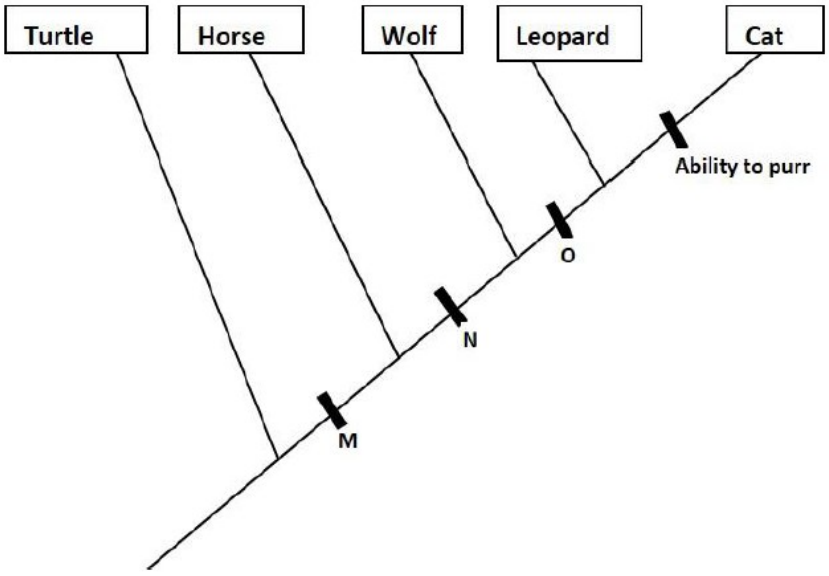
B) Organism P feeds on Q and therefore its population decreases rapidly due to 2 days of starvation.

C) Organism Q depends on 'P' as a food source, which is evident due to the decline of its population after the 4th day.

D) Organisms P and Q both are competing with each other for common resources. Therefore Q does not attain a high number as organism P.

Question 45:

A cladogram depicting the evolution of a few animals along with some features is shown.



Features M, N and O respectively could be:

A) Hair; mammary glands and carnivorous teeth.

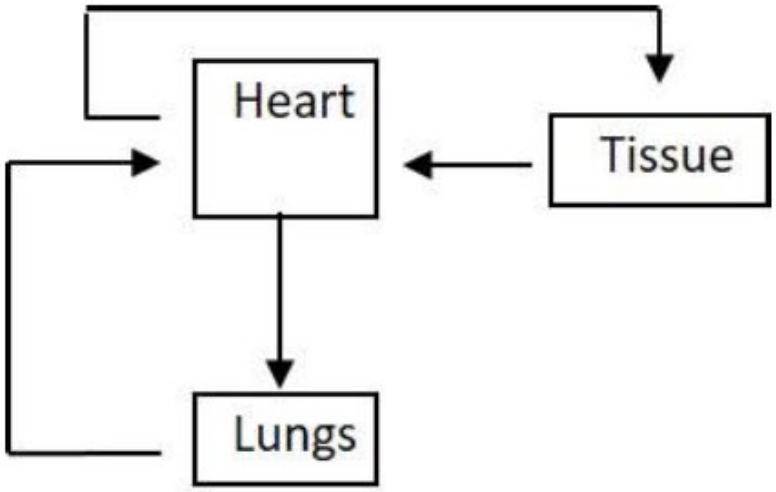
B) Carnivorous teeth; retractable claws and mammary glands.

C) Hair; carnivorous teeth and retractable claws.

D) Hooves; mammary glands and carnivorous teeth.

Question 46:

The circulatory system of an animal 'P' is represented below.



A few animals are listed below:

(i) Cockroach
(ii) Horse
(iii)Chicken
(iv)Fish

Animal 'P' could be:

A) (i) or (iv) only

B) (ii) only

C) (i), (ii) or (iii)

D) (ii) or (iii) only

Question 47:

A biochemist was studying the effect of certain chemicals on the functional protein ribonuclease. The steps that were followed and the enzyme activity at each step is tabulated.

No.	Steps followed	Enzyme activity
1.	Ribonuclease extracted and purified from source	Detected
2.	Chemicals to disrupt hydrogen bonds, ionic bonds and disulfide bridges added	Not detected
3.	Removal of chemical agents added in step 2	Detected

The structure/s of the protein most likely to be affected at step 2 is/are:

A) The primary structure only

B) The secondary structure only

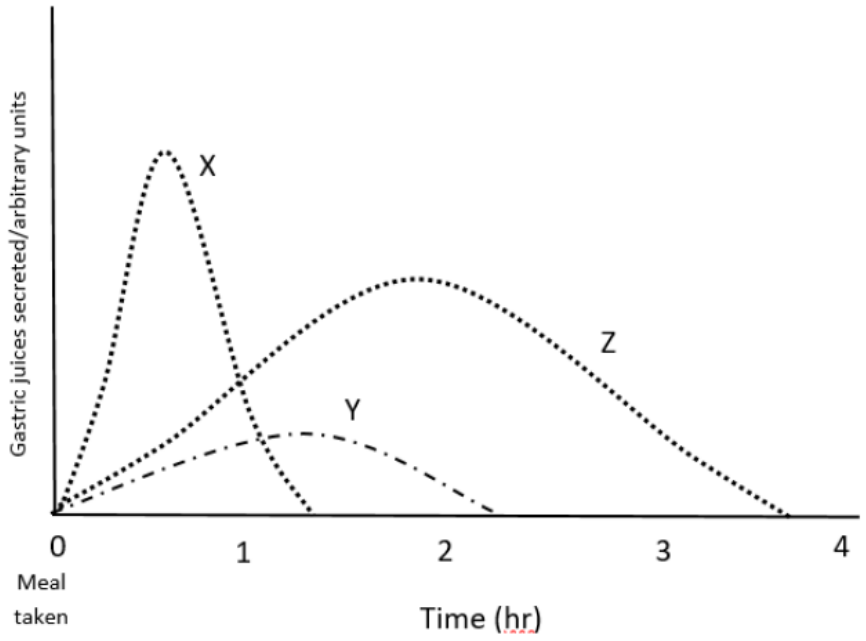
C) Quaternary structure only

D) Secondary, tertiary and quaternary structures only

Question 48:

Consider the sequential events happening during the feeding process in mammals; initially the sight, taste or smell of food sends a signal to the stomach. This triggers the secretion of gastric juice rich in pepsinogen. When food enters the stomach, it exerts pressure on the wall leading to further secretion of gastric juice. The prolonged effect due to presence of food is mediated by the hormone 'gastrin'. This is secreted by the stomach epithelial cells and it enhances gastric juice secretion further.

If the above information on control of gastric secretion by three different mechanisms is summarized in a graphical format, then X, Y and Z will respectively represent:



A) Nervous control, mechanical control and hormonal control.

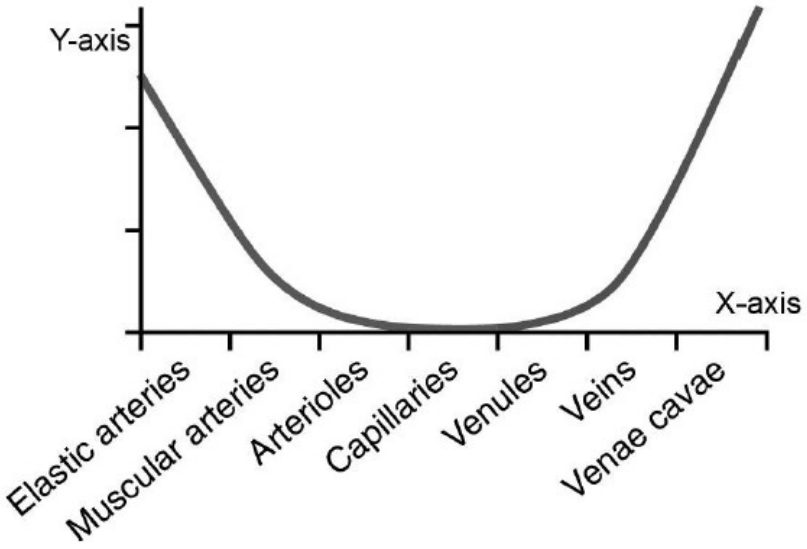
B) Hormonal control, nervous control and mechanical control.

C) Nervous control, hormonal control and mechanical control.

D) Mechanical control, nervous control and hormonal control.

Question 49:

Anita was studying relationships among blood vessels of circulatory system with respect to different parameters. From the given options, which one represents the Y-axis of the following graph?



A) Velocity of blood flow

B) Total cross-sectional area of vessels

C) Average blood pressure

D) Vessel diameter

Question 50:

A student dissolved 5 grams of sugar in 100 mL of distilled water in beaker X. She dissolved 100 grams of sugar in 100 mL of distilled water in beaker Y. Then she dropped a few raisins of equal weight in each beaker. After two hours, she found the raisins in X swollen and those in Y shrunken.

The inference drawn is that:

A) Sugar concentration of raisins is lower than that of solution in beaker X and higher than that of solution in beaker Y.

B) Sugar concentration of raisins is higher than that of solution in beaker X and lower than that of solution in beaker Y.

C) The cell membrane of raisins in beaker Y was damaged resulting in leaching.

D) in beaker X, the permeability of the cell membrane of raisins to water was enhanced.

Chemistry

Question 51:

Four students Akbar, Bhavana, Catherine and Deepak were learning about structure of molecules using scale models. Each made a model of one of the four molecules, BH_3, CH_4, NH_3, or H_2O. Identify which molecule Catherine had based on the data given below.

i. Either Akbar or Deepak had a tetrahedral molecule.
ii. Neither Bhavana nor Deepak had molecules that were planar.
iii. Akbar didn't have a molecule known to act sometimes as a base.

A) BH_3

B) CH_4

C) NH_3

D) H_2O

Question 52:

Limestone ($CaCO_3$) can be eroded by acids. Concentrated nitric acid (11.5 M HNO_3) leached in a soil containing predominantly limestone and small amount of $FeCO_3$. After approximately how much volume of the acid will 1 square meter of path containing about 1000 kg soil will certainly become strongly acidic?

A) 3.5 L

B) 0.45 L

C) 1.75 L

D) 0.86 L

Question 53:

When 1 mL of 0.1 M NaOH and 1 mL of 0.1 M NH_3 aqueous solution are separately added to two test tubes each containing 1 mL of 0.1 M Co(II) solution, a green precipitate forms in both cases. The inference that can be drawn is (are):

i. OH^- and NH_3 possess comparable ligand-field strength
ii. pH of both reagent solutions is same
iii. In both cases, OH^- is the major species to act as ligand
iv. $[Co(H_2O)_4(OH)_2]$ is the likely product in both cases

A) i, ii, iii, iv

B) i, iii

C) ii, iii, iv

D) iii, iv

Question 54:

The natural oil or crude oil is separated into group of compounds by a process called as refining of oil and it is done by fractional distillation. Petrol obtained from this process is unlikely to contain

A) octadecane.

B) iso-hexane.

C) octane.

D) decane.

Question 55:

Benzoic acid was mixed with ethanol and refluxed along with concentrated sulfuric acid in order to form **X**. After 1 hour of reflux, the reaction mixture was washed with saturated solution of **Y** to separate **X** from unreacted acid. The product **X** and the most suitable reagent **Y** respectively are:

A) Ethanoic acid and NaOH

B) Ethyl benzoate and $NaHCO_3$

C) Ethanoic acid and $NaHCO_3$

D) Ethyl benzoate and NaOH

Question 56:

A chemist has to open a new bottle of concentrated ammonia in a lab. The safest way to open the new bottle is

A) Keep the bottle on the floor and open it.

B) Keep the bottle on a warm water bath, allow it to warm up and open it.

C) Keep the bottle in refrigerator, cool it and open it.

D) First keep the bottle in refrigerator to cool it, then take it out and allow it to come to room temperature and then open it.

Question 57:

While deducing the structure of $N(SiH_3)_3$, a researcher noticed that N-Si bond length in $N(SiH_3)_3$ is smaller than the theoretically estimated N-Si single bond length (based on several molecules containing N-Si bonds).

Based on the above observation, the most probable conclusion that can be drawn is -

A) The lone pair on N in $N(SiH_3)_3$ is involved in π-bonding with Si, is less basic than $N(CH_3)_3$ thus, having lower pK_b.

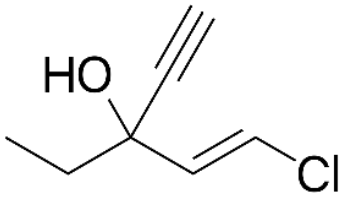
B) The lone pair on N in $N(SiH_3)_3$ is not involved in π- bonding with Si, is more basic than $N(CH_3)_3$ thus, having lower pK_b.

C) The lone pair on N in $N(SiH_3)_3$ is involved in π-bonding with Si, is less basic than $N(CH_3)_3$ thus, having higher pK_b.

D) The lone pair on N in $N(SiH_3)_3$ is not involved in π- bonding with Si, is more basic than $N(CH_3)_3$ thus, having higher pK_b.

Question 58:

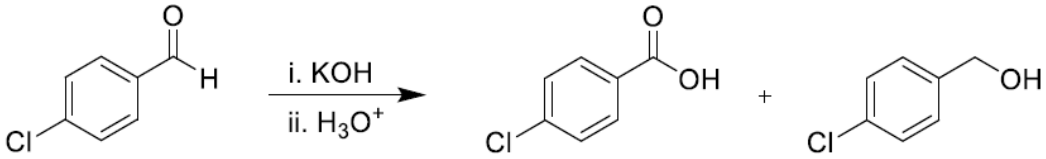
The structure of a sedative, Ethchlorvynol (1-chloro-3-ethylpent-1-en-4-yn-3-ol) is shown below. Based on the structure, we can predict that the compound would:



(A) be strongly coloured
(B) be white/colourless
(C) be highly water soluble
(D) not react with aqueous glucose solutions

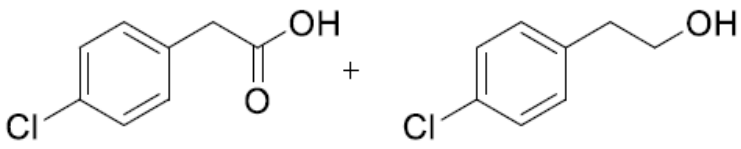
Question 59:

Consider the reaction given below:

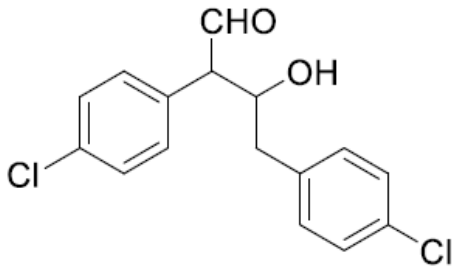


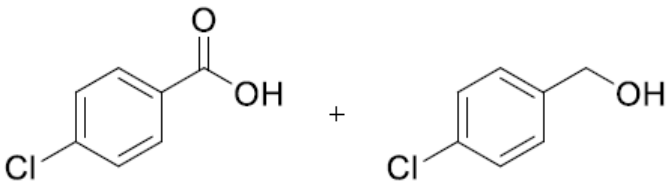
In place of p-chlorobenzaldehyde, if 2-(4-chlorophenyl)acetaldehyde is used as the starting material, the product(s) would be

A)



B) None (no reaction will occur)

C) 

D) 

Question 60:

Consider titration of $CH_3COOH(aq)$ with NaOH(aq) using phenolphthalein as an indicator. The statement that is INCORRECT is:

A) At the equivalence point, number of moles of NaOH and CH_3COOH are same, and also complete neutralization of the acid takes place.

B) There are less number of moles of NaOH compared to acetic acid at the end point.

C) Phenolphthalein itself undergoes acid-base reaction at the end point to show a color change.

D) The equivalence point can be reached before or occur simultaneously at the endpoint but can never occur after the endpoint of the titration.

Mathematics

Question 61:

The roots of the equation $x^2 + bx + c = 0$ are both greater than 1. If $t = b + c + 1$, then

A) t must be greater than 0;

B) t must be less than 0;

C) t must be between -1 and 1;

D) none of the above is necessarily true.

Question 62:

Let x and y be two positive real numbers. Which of the following conditions is sufficient to conclude that both x and y must be rational numbers?

A) Both $x + y$ and xy are rational.

B) Both $x + y$ and x/y are rational.

C) Both xy and x/y are rational.

D) None of these conditions are sufficient.

Question 63:

In $\triangle ABC$, which is not equilateral, the lengths of the sides are positive integers and $l(BC) = 1$ unit. Which of the following statements are always true?

(I) The perimeter of ABC is an odd integer.

(II) The incentre, centroid, circumcentre and the orthocentre of $\triangle ABC$ are collinear.

(III) The length of the longest altitude of $\triangle ABC$ is an irrational number.

(IV) Two of the three angles of $\triangle ABC$ are less than $60°$.

A) only (I), (II) and (III) are true;

B) only (II), (III) and (IV) are true;

C) only (I), (III) and (IV) are true;

D) all four statements are true.

Question 64:

Which of these will have a different digit at the unit's place?

A) 351^{83}

B) 463^{84}

C) 577^{85}

D) 689^{86}

Question 65:

What is the value of x, where

$$x = \left[(\log_2 9)^2\right]^{\left(\frac{1}{\log_2 (\log_2 9)}\right)}$$

A) 2

B) 9

C) 4

D) 81

Question 66:

The combined equation of three lines is given as $y^3 - 4x^2y = 0$. Which of the following statements best describes the geometric shape formed by these lines?

A) Three lines forming a triangle.

B) Three parallel lines.

C) Two parallel line intersected by the third line.

D) Three concurrent lines.

Question 67:

If α and β are the roots of the equation $x^2 - \sqrt{2}x + 2 = 0$, then $\alpha^{14} + \beta^{14}$ is equal to:

A) -64

B) $-64\sqrt{2}$

C) $-64\sqrt{3}$

D) -128

Question 68:

For what values of c will the equation $2x^3 - 3x^2 + 1 = 12x + c$ have exactly two solutions?

A) 8 and 19

B) -8 and 19

C) 8 and -19

D) -8 and -19

Question 69:

f is a continuous, periodic function on $\mathbb{R}$ with period 2π, i.e., $f(x - 2\pi) = f(x)$ and taking values in $\mathbb{R}$. Which of the following is necessarily true?

A) f is finite, bounded and differentiable $\forall x \in \mathbb{R}$.

B) f is finite, bounded, but not necessarily differentiable $\forall x \in \mathbb{R}$.

C) f is always differentiable but not necessarily bounded or finite $\forall x \in \mathbb{R}$

D) f may neither be finite, nor bounded, nor differentiable $\forall x \in \mathbb{R}$.

Question 70:

The coordinates of any point on a cartesian plane can be expressed as a column vector in this form: $\begin{bmatrix} x \\ y \end{bmatrix}$. By multiplying the column vectors of a set of points in the plane by a 2×2 matrix on the left, we perform a "linear transformation" on the points. Which of the following matrices represents a linear transformation that changes a circle centered at the origin to an ellipse centred at the origin and having the y-axis as its major axis?

I. $\begin{bmatrix} -2 & 0 \\ 0 & 2 \end{bmatrix}$ II. $\begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix}$ III. $\begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$

A) Only I.

B) Both II and III.

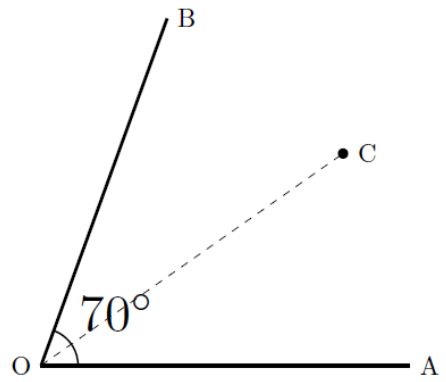
C) Only II.

D) Only III.

Physics

Question 71:

Two mirrors OA and OB make an angle of 70° with each other. An object C is placed on the angular bisector of angle AOB. The total number of images of the object formed by the mirrors will be:



A) 4

B) 5

C) 6

D) 7

Question 72:

Consider the following statements regarding a Uranium-based nuclear reactor:

I. Fission is most effectively induced by thermal neutrons.

II. Control rods are provided to moderate the neutrons.

III. A fraction of the neutrons will leak out of the reactor.

The correct statements are:

A) I, II, and III only

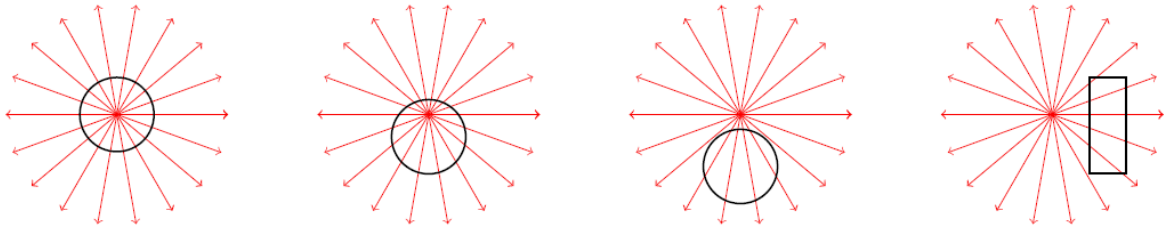
B) I, and III only

C) I and II only

D) II, and III only

Question 73:

In the diagram provided, the black shapes represent closed surfaces, and the electric field lines are illustrated in red. Identify the scenarios in which the electric flux through these surfaces is non-zero.



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

A) Only (a) and (b).

B) Only (c) and (d).

C) Only (b), (c), and (d).

D) In all the cases, flux is non zero.

Question 74:

A satellite, in an elliptical orbit around Earth, experiences an increase in velocity due to an instantaneous thrust near the apogee (farthest distance from Earth). Choose the correct statement about its perigee (nearest distance from Earth):

A) the perigee distance decreases

B) the apogee distance decreases

C) the orbit remains the same

D) the perigee distance increases

Question 75:

Which of the following statements is correct about the Moon –

A) Moon completes one rotation around itself in the same time it takes to revolve around the Earth.

B) Moon completes one rotation around itself in same time that the Earth takes to rotate around itself.

C) Moon doesn‘t rotate around itself, as we see only one side of Moon.

D) Moon completes one rotation around itself in the same time it takes for the Earth to revolve around Sun.

Question 76:

Assume that the Venus and Earth revolve around Sun in circular co-planar orbits. Now if the revolution period of Venus around the Sun is 0.615 Earth years (or 224.7 days). In two Earth years atleast how many times will Sun-Venus-Earth align in this order?

A) Once B) Twice C) Thrice D) Four times

Question 77:

The volume of an eraser is calculated by measuring its dimensions. The length is 3.224 ± 0.090 cm, the breadth is 2.178 ± 0.198 cm and the thickness is 1.158 ± 0.009 cm. The volume of the eraser with its standard uncertainty is

A) $8.1 \pm 1.0\ \text{cm}^3$

B) $8.1 \pm 0.8\ \text{cm}^3$

C) $8.1 \pm 0.2\ \text{cm}^3$

D) $8.1 \pm 0.3\ \text{cm}^3$

Question 78:

The photograph shows the main scale and vernier scale of a spectrometer. Calculate the least count of this spectrometer.

A) $60'$

B) $30''$

C) $30'$

D) $60''$

Question 79:

A ship lying at rest in water is pulled by a constant force of 4 x 10^5 N. As a result, the ship moves through a distance x meters and acquires a speed of 2 m/s. If the mass of the ship is 2 x 10^6 kg and the resistance due to water is negligible, x equals

A) 10 m B) 20 m

C) 50 m D) 100m

Question 80:

Consider a 1 D metal rod. Let $T(x)$, $T(x+dx)$ denote the temperatures of 2 adjacent points on the rod. If $\frac{dT}{dt}$ denotes the rate of change of temperature at x with time, which of the following expression/s is **not** appropriate in describing the said variation ?

I. $\frac{dT}{dt} \propto T(x+dx) - T(x)$

II. $\frac{dT}{dt} \propto [T(x+dx) - T(x)]^2$

III. $\frac{dT}{dt} \propto [T(x+dx) - T(x)]^3$

A) Option I only

B) Option II only

C) Option III only.

D) Both options II and III

Section II

Critical reasoning

81) Describe briefly any research topic of your interest in science education, OR mathematics education, OR technology education.

Provide arguments for why that research is important, and outline the possible educational outcomes of the research you have described.

Please stick to a word limit of **approximately 300 words**.

82) Write a short essay (**approximately 250 words each**) on **any ONE** of the following three themes/issues in science education. Mention your essay serial number (for example, Essay No. 2) at the start.

1. Do we need to teach Darwinian evolution in school science?
2. In the era of computers and calculators, is it still necessary to teach procedures for arithmetic calculations in schools?
3. Enquiry based learning approach in undergraduate (BSC) physics/chemistry/mathematics/biology class

83) Write a short essay (**approximately 250 words each**) on **any ONE** of the following three themes/issues in science education. Mention your essay serial number (for example, Essay No. 2) at the start.

1. Are mass-scale public examinations a fair tool to assess ability of students?
2. Many educators argue that there is a need to make the Science Technology Engineering and Mathematics (STEM) curriculum responsive to social, historical and political realities. What could that mean? Discuss with example/s.
3. The mathematics curriculum seems to strike ‘fear for math’ into a lot of students on the one hand, while others at the same time experience ‘pleasure of engaging with math’. Why do you think people experience the same mathematics classroom in such radically different ways? Discuss focusing on your own experiences, and of those around you.