# HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

## TATA INSTITUTE OF FUNDAMENTAL RESEARCH

### Entrance Test for Ph.D. Programme in Science Education – 2012

### Section I: English Proficiency, Scientific Literacy and Quantitative Reasoning

Read the following instructions carefully.

- This section of the written test carries **60 marks** and is of **one hour** duration.

- This section of the question paper consists of 9 pages. It has in all 30 questions: nos. 1 to 10 on **English Proficiency** and nos. 11 to 20 on **Scientific Literacy** and nos. 21 to 30 on **Quantitative Reasoning**. The answers must be marked on the separate **Answer Sheet** provided.

- 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.

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

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

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

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

- Use of non-programmable scientific calculators is permitted.

- For rough work, you may ask the invigilator for extra sheets of paper.

- At the end of one hour, please submit this question paper but **keep the Answer Sheet with you**.

1.—4. **Read the following sentences, each of which may have one or more language errors. Below each sentence are given 4 options to correct it. Pick the correct option.**

**1.** When her savings exhausted, she had to accept the first job that was offered to her.

    (A) Replace 'When' with 'With'.

    (B) Replace 'the first job' with 'a first job'.

    (C) Replace 'the first job' with 'first job'.

    (D) Replace 'exhausted' with 'exhumed'.

**2.** The seized documents were not sufficient enough to prove his guilt.

    (A) Replace 'were' with 'was'.

    (B) Remove 'not'.

    (C) Remove 'sufficient'.

    (D) No correction needed, the sentence is fine as it is.

**3.** With the cost of living rising steeply, it was difficult to make both the ends meet.

    (A) Replace 'rising' with 'raising'.

    (B) Replace 'both the ends' with 'both ends'.

    (C) Replace 'the cost' with 'cost'.

    (D) Replace 'meet' with 'to meet'.

**4.** It was a very warm day, but they were afraid it was going to get more warmer.

    (A) Remove 'very'.

    (B) Replace 'was' with 'is'.

    (C) Replace 'were' with 'are'.

    (D) Remove 'more'.

5.—10. **Mark the option that is the correct meaning of the following words/phrase.**

**5.** persistent

    (A) equally among all

    (B) annoying

    (C) not giving up

    (D) not trying enough

**6.** dubious distinction

      (A) double distinction

      (B) questionable distinction

      (C) improper comparison

      (D) shared distinction

**7.** contentious

      (A) something that has a lot of content

      (B) someone who is content

      (C) something that is controversial

      (D) someone who has a good conscience

**8.** copious

      (A) someone with a tendency to copy others

      (B) something that can be copied

      (C) something that has been copied

      (D) something that is in large amounts

**9.** nonplussed

      (A) negative

      (B) something missed while adding

      (C) calm and poised

      (D) perplexed or baffled

**10.** momentarily

      (A) after a moment

      (B) for a moment

      (C) with momentum

      (D) at that moment

11.—15. **Read the following passage, and then find the right answer to each of the next five questions from the choices provided:**

People are moved by the plight of endangered animals, but that sympathy typically does not amount to much. Biomimicry offers a new way to save animals like sharks, by appealing to humanity's profit-minded nature. If plant and animal species can inspire technological innovation, points out a personnel of the UN Environmental Programme, they can earn their keep: "In a world fascinated by GDP, if you cannot demonstrate the value of nature it's always going to be subject to the ups and downs and vagaries of nations' economies," he says.

The list of possible breakthroughs inspired by shark physiology is a lengthy one. In addition to boasting all of the ordinary senses that humans have, sharks possess something called electroreception. A row of small holes that runs from head to tail picks up weak vibrations. This network, along with tiny, fluid-filled sacs in their snouts and chins known as ampullae of Lorenzini, helps sharks find fish buried in the sand because they can detect the electromagnetic fields generated by a fish's beating heart or gills. Other fish have a lateral line to sense movement, but they do not have the gelatinous material that serves as a conductor for electric vibrations, radiating these signals out to a shark's nervous system. Scientists across the United States are hoping to capitalize on sharks' unique voltage-charged gel for practical purposes.

A professor in physics at the University of San Francisco has extracted the material from dead sharks to gauge its thermal sensitivity, while a nanoengineering professor at the Case Western Reserve University has explored developing a synthetic gel with similar thermoelectric properties that could be used to convert waste heat, from devices such as a car engine, into usable electricity.

Then there are sharks' denticles, otherwise known as "skin teeth", which cover their bodies. Made up of crowns covered with hard enamel, they reduce friction by forcing the water to flow in channels, allowing sharks to move swiftly through the water. The type of denticles a shark has depends on the species: Lighter denticles maximize a shark's speed while providing slightly less protection from a predatory attack. Basking sharks have crowns that point in all directions, while short-fin mako sharks — some of the fastest swimmers in the sea — have smaller, lighter denticles. They are as strong as steel, and carry an added benefit: By minimizing water turbulence, they allow sharks to hunt better by moving through the sea in near silence.

A researcher at the University of Applied Sciences in Bremen, Germany, pioneered the idea of covering ships with artificial sharkskin to help them move smoothly by dramatically reducing biofouling (not to be confused with the more familiar biofueling). Biofouling, which occurs when barnacles, mussels, and algae latch onto ships, increases a vessel's drag resistance by as much as 15 percent. The researcher has produced an imitation sharkskin from elastic silicone that would reduce this fouling by 67 per cent, and he estimates that once a ship reached four to five knots, nearly all of these creatures would fly off the hull's surface.

**11.** In what ways could biomimicry inspire human beings to help in the conservation of sharks?

    (A) People could train sharks to mimic other fishes and evolve better means of defense.

    (B) Superior predatory mechanisms of sharks could help them escape extinction.

    (C) Added economic value as a result of biomimicry would inspire people to fight extinction of sharks.

    (D) Plight of endangered animals would inspire people to fight their extinction.

**12.** Why is the phenomenon of electroreception unique to sharks and not other fish?

    (A) Other fish are too small to detect electromagnetic fields.

    (B) Other fish have a lateral line but no ampullae of Lorenzini.

    (C) Other fish do not use the mechanism, though they possess the feature.

    (D) Other fish do not have holes from head to tail to pick up weak vibrations.


**13.** Which one of the following is **not** provided by lighter denticles?

    (A) Increase in speed of sharks.

    (B) Channelising the flow of water.

    (C) Minimising water turbulence.

    (D) Maximising protection from predators.


**14.** Biofouling is

    (A) attachment of small marine organisms on the ship's wet surface.

    (B) increase in drag resistance of the ship.

    (C) increase in the friction on the ship's surface by water.

    (D) decrease in the friction on the ship's surface by water.


**15.** According to the research, the purpose of covering the ship with imitation shark skin was to

    (A) increase the speed of the ship

    (B) decrease the speed of the ship

    (C) increase the drag resistance of the ship

    (D) change the appearance of the ship

16.—20. **Read the following passage, and then find the right answer to each of the next five questions from the choices provided:**

Although central to psychology, the study of corporeal self-awareness has been left out of scientific research for quite a long time. However, clinical and experimental investigations on the cerebral representations of body and self date back to the beginning of the 20th century and have steadily grown since then. Bodily self-consciousness is a complex mental construct linked to the strong sense that, at least under normal circumstances, we recognize that our body belongs to us, our conscious self is housed within our physical body in a first-person perspective, and that our body inhabits a specific physical location in external space. Thus, the core feeling of bodily self-consciousness is based on three major components: (1) self-identification, indexed by the degree to which we feel that our body or body parts belong to us; (2) first-person perspective, expressed by the extent to which our primary viewpoint of the outside world is from within our body; and (3) self-location, defined by the ability to place and experience ourselves in physical space.

Bodily self-consciousness can be conspicuously modified by pathological and physiological factors. An example of a body-part-specific self-identity disorder is the feeling that ones own limb does not belong to oneself. These complex misperceptions and misconceptions are comparatively common after cerebral lesions in the right temporo-parietal lobe and typically affect the left limb. Patients with disruptions in full-body self-awareness, generally referred to as autoscopic phenomena (AP), report bizarre feelings and exhibit strange behaviors that mimic psychiatric more than neurological disease symptomologies. AP are characterized by the illusory sensation of a second body seen in extracorporeal space.

At least three different forms of AP have been described, namely autoscopic hallucination (the person sees a second own body with self-location normally anchored to the physical body), heautoscopy (self-location is perceived at both the physical and the illusory body), and out-of-body experience (OBE) characterized by a sense of disembodiment, with the illusory body, to which self-location is attributed, perceived in a position elevated with respect to the physical body. Studies of patients with OBEs suggest that the feeling of being outside the real body and looking at the world from another perspective might be linked to temporo-parietal and vestibulo-insular brain dysfunction. Tellingly, OBEs, as well as the somatosensory feeling that someone else is close to us even if nobody is around, have been induced by electrical stimulation of the temporo-parietal regions.

Our clear and stable sense of bodily self-consciousness can also be challenged by simple psychophysical manipulations. For example, touch stimuli delivered to one's visually obscured or "unseen" hand, while observing the synchronous stroking of a seen rubber hand, induces the subjective perception that the rubber hand belongs to oneself (rubber hand illusion). Inclusion of an inanimate rubber hand into one's own body representation is not observed when a time lag between visually perceived and physically sensed tactile stimulation is introduced (asynchronous stimulation condition). Using a similar visuotactile stimulation paradigm and virtual reality techniques, reserachers have been able to induce the subjective feeling of whole-body self-identification with an avatar. These studies have provided a very fruitful experimental paradigm for exploring basic phenomenological aspects of first-person perspective and self-location.

**16.** Which of these is **NOT** part of your self-awareness?

  (A) The feeling that your body or body parts belongs to you.

  (B) The primary viewpoint of the outside world is from within your body.

  (C) The ability to place and experience yourself in physical space.

  (D) The ability to view your own body from outside.

**17.** Which of these is **NOT** a form of autoscopic phenomena?

    (A) Feeling that the location of your self is at both your physical body and the illusory body.

    (B) Seeing a second own body, and feeling that the location of your self is in your physical body.

    (C) Seeing a second body, and your own physical body, from a location outside your body.

    (D) Feeling that the location of your self is the illusory body, and it is in a position above your physical body.

**18.** Electrical stimulation of the temporo-parietal regions of your brain can make you feel as if

    (A) someone is close to you, even if nobody is around.

    (B) you are in a body floating above your own body.

    (C) you are outside your body and see the world from another perspective.

    (D) you are shifting between two bodies.

**19.** What is the rubber hand illusion?

    (A) Feeling a rubber hand as your own hand when the rubber hand is stroked next to your own hand.

    (B) Feeling a rubber hand as your own hand when the rubber hand is stroked and your hand is hidden.

    (C) Feeling a rubber hand as your own hand when the rubber hand is hidden and your hand is stroked.

    (D) Feeling a rubber hand as your own hand when the rubber hand and your hand are hidden and stroked.

**20.** Which of the statements below **does not follow** from the text?

    (A) The feeling of having a single self, and feeling that this self is in your body, is based on a representation in the brain.

    (B) The feeling of not having a single self, or feeling as if the self is outside your body, arises from damage to specific brain areas.

    (C) The feeling of having a single self, and feeling that this self is in your body, can be changed by brain damage as well as experimental techniques.

    (D) The feeling of having a single self, and feeling that this self is in your body, is a fiction, and therefore the self does not exist.

**21.** Bottle A has 2 litres of fruit juice with 40% concentration of apple juice. Bottle B has 1 litre of fruit juice with 25% concentration of apple juice. By mixing the contents of the two bottles thoroughly, we get juice where the concentration of apple juice is closest to

(A) 30%   (B) 33.3%   (C) 35%   (D) 37%

**22.** The GDP of a country increases by 10% over the previous year steadily for a period of 3 years. The cumulative percentage increase over 3 years is closest to

(A) 30.0%   (B) 33.0%   (C) 33.1%   (D) 33.3%

**23.** By adding 1 to a certain number, we get the square of the number. Then which of the following statements is true of the same number? (Note: reciprocal of n is 1/n).

(A) The reciprocal of the number is equal to the same number minus 1.

(B) The reciprocal of the number is equal to the same number.

(C) The square of the number is $\sqrt{2}$ times the same number.

(D) The square of the number is double the same number.

**24.** A speedometer measures speed in kilometres per hour ($V_{kmph}$) as 80 kmph with an error of roughly 1.5%. If we convert the speed into miles per hour ($V_{mph}$) using the formula $V_{mph} = 0.62$ x $V_{kmph}$ then the speed in miles is 49.6 mph with an error of roughly

(A) 0.9%   (B) 1.5%   (C) 2.4%   (D) 7.4%

**25.** Some sentences can be said to be true just by logical analysis without the need to check what the facts are. Choose the best example among the following of such a sentence.

(A) Ghosts are creations of the human mind.

(B) The feet of a majority of ghosts do not touch the ground.

(C) The ghost, if it exists, is either a human person or a non-human entity.

(D) Ghosts do not exist.

**Refer to the table given below to answer the next two questions.**

**The following table gives the average number of different categories of teachers per school, as found in a study of a randomly drawn sample of schools, in five States.**

| State | Head teacher | Regular teacher | Para teacher | Other teacher | Total |
|-------|--------------|-----------------|--------------|---------------|-------|
| AP | 1 | 2.2 | 0.7 | 0.1 | 3.9 |
| Assam | 1 | 1.6 | 0.2 | 0.6 | 3.2 |
| Himachal | 0.6 | 2.2 | 0.3 | 0.1 | 3.3 |
| Jharkhand | 0.6 | 1.3 | 2.4 | 0.1 | 4.3 |
| Rajasthan | 09 | 3.1 | 0.2 | 0.2 | 4.3 |
| Total | 0.8 | 2.1 | 0.8 | 0.2 | 3.8 |

**26.** If a total of 3389 teachers of all categories were found in the sample schools, the number of schools visited was approximately

(A) 1000    (B) 900    (C) 800    (D) 550

**27.** In the table given above, if roughly equal numbers of schools were visited in each state, then the state of Jharkhand had approximately how many more para teachers than the state of Himachal?

(A) 380    (B) 400    (C) 420    (D) 440

**28.** The English alphabet consists of 5 vowels (A, E, I, O, U) and 21 consonants. 26 cards, each containing a different letter of the English alphabet, have been printed. At the reverse of each card a number is printed using the following rule: If the card has a vowel in front, then the number at the back must be an odd number. This rule implies that

(A) If the card has a consonant in front, then the number at the back must be an even number.
(B) If the card has a consonant in front, then the number at the back must be an odd number.
(C) If the number at the back is an odd number, then the card must have a vowel in front.
(D) If the number at the back is an even number, then the card must have a consonant in front.

**29.** "Teleological explanations" **explain** an existing phenomenon on the basis of a future goal to be attained. Such explanations for natural phenomena are generally not accepted in science. Which of the following statements is an example of teleological explanation?

(A) The traits shown by a plant are determined by the genes present in the seed.
(B) The traits shown by a plant are determined by the genes present in the seed together with the conditions that the growing plant is exposed to.
(C) Some plants develop special traits so that they can survive and reproduce.
(D) None of the above.

**30.** Research studies have found a significant correlation between poor performance of students in mathematics and low expectation from the student on the part of the teacher. Which of the following hypotheses might potentially **explain** why this correlation is found?

I Teachers know the capacities of individual students in their class very well and adjust their expectations accordingly.

II If a student's performance is poor, it is likely that the teacher has a low expectation from the student.

III Low teacher expectation leads to students putting in less effort at studies.

(A) I and II but not III
(B) I and III but not II
(C) I, II and III
(D) I only

# HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

## TATA INSTITUTE OF FUNDAMENTAL RESEARCH

### Entrance Test for PhD Programme in Science Education – 2012

### Section II: Scientific Aptitude

Read the following instructions carefully.

- This section of the written test is on scientific knowledge and aptitude. It covers broadly the areas of Biology, Chemistry, Mathematics, Physics, and general knowledge, including social sciences and education.

- This section of the question paper consists of 11 pages. It has 50 questions, carrying a total of 150 marks. The questions can be categorised according to subject area as follows:

| Subject | Question nos. |
| --- | --- |
| Biology | 31–40 |
| Chemistry | 41–50 |
| Physics | 51–60 |
| Mathematics | 61–70 |
| General | 71–80 |

- **You may answer as many questions as you want from any subject area. While you might not be able to answer all the 50 questions in the time provided, you should try to maximise the number of correct answers.** It is a good idea to answer the questions on your area of strength first.

- All questions are of multiple choice type with four options out of which only ONE option is correct. Each correct answer earns a credit of 3 marks. **A wrong answer carries a penalty of −1 mark.** An unanswered question carries no credit or penalty.

- You must indicate your answers **on the reverse side of the same Answer Sheet that you used for Section I of this test** by putting a × in the appropriate box against the relevant question number, like this: ☒ . Indicate your answers using a pen to make a dark mark.

- **Please carefully choose the section of the answer sheet and make sure the section corresponds to the subject that you are answering questions on. Check the question number before putting down your answer.**

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

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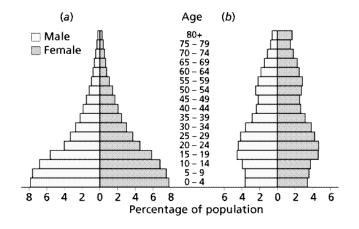  ☐ ☒ ☐ ☐  →  ☐ ■ ☒ ☐

- Use of non-programmable scientific calculators is permitted.

- For rough work, you may ask the invigilator for extra sheets of paper.

- At the end of the test, please submit this question paper, the Answer Sheet, and any extra sheets that you may have used.

**31.** Which membranes are represented by A and B?



(A) A. Nuclear membrane B. Endoplasmic reticulum

(B) A. Cell membrane B. Nuclear membrane

(C) A. Mitochondrial membrane B. Endoplasmic reticulum

(D) A. Cell membrane B. Mitochondrial membrane

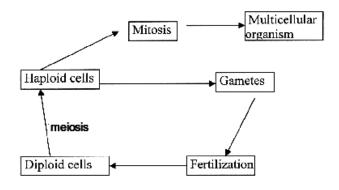**32.** The graphs below show the age structures for the human population at present in country (a) and country (b).



What is most likely to happen in the next 40 years?

(A) The population in country (a) will decline, while that of country (b) will remain stable.

(B) The population of country (a) will expand, while that of country (b) will decline.

(C) The population of country (a) will remain stable, while that of country (b) will expand.

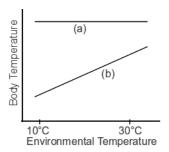(D) The population of country (a) will expand, while that of country (b) will remain stable.

**33.** Dietary fats are emulsified into tiny droplets and then converted into free fatty acids. These two functions are performed respectively by

(A) lipase and monoglycerides

(B) bile and enterokinase
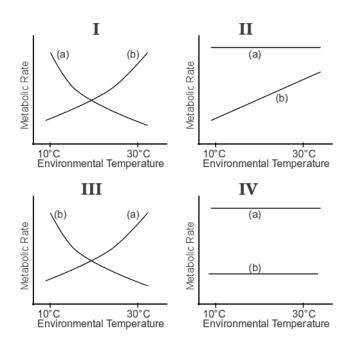
(C) bile and lipase

(D) glycerol and micelles

2

**34.** The life cycle depicted below represents:



(A) mammals     (B) angiosperms     (C) bacteria     (D) fungi

**35.** The graph below shows the body temperature of two organisms (a) and (b) plotted as a function of the temperature of their environment.



If the metabolic rates of these two organisms were plotted as a function of their environmental temperatures, the graph most likely obtained will be
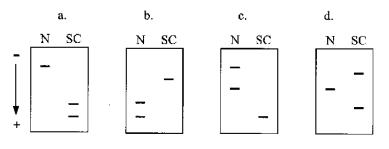


(A) Graph I     (B) Graph II     (C) Graph III     (D) Graph IV

**36.** A sample of 1 ml of blood containing $6 \times 10^9$ red blood cells was diluted with 9 ml of distilled water. Which of the following is true for the resulting solution?

(A) The diluted solution will have $6 \times 10^8$ red blood cells per ml.

(B) The diluted solution will have $6 \times 10^9$ red blood cells per ml.

(C) The diluted solution will not have any red blood cells that are intact.

(D) The concentration of red blood cells is unchanged by dilution with distilled water.

**37.** Normal $\beta$-globin gene has a recognition site for restriction enzyme *Mst*II as shown, while a sickle cell globin gene is mutated and the recognition site is lost.

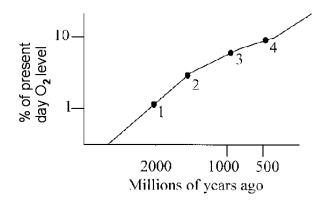Normal β-globin gene

Sickle cell β-globin gene

The solutions containing these molecules are separately treated with restriction enzyme *Mst*II and loaded in an agarose gel. Which of these electrophoretic patterns could be observed?



N: Normal; SC: Sickle Cell

(A) a    (B) b    (C) c    (D) d

**38.** Which of the following procedures will destarch a plant effectively?

I Keeping the plant in dark

II Keeping the plant in an environment devoid of $CO_2$

III Keeping the plant in an environment devoid of $O_2$

(A) Only I

(B) Only I and II

(C) Only I and III

(D) I, II and III

**39.** A couple with blood group AB and O have a child. The likely blood group of the child is:

(A) either A or B

(B) either AB or O

(C) either A or AB

4

(D) either B or O

**40.** The first appearances on ancient earth of four different life forms are shown in the following graph.



In the graph 1, 2 , 3 and 4 respectively correspond to

(A) 1: aerobic bacteria, 2: eukaryotes, 3: multicellular organisms, 4: organisms with exoskeleton

(B) 1: aerobic bacteria, 2: anaerobic bacteria, 3: organisms with exoskeleton, 4: eukaryotes

(C) 1: prokaryotes, 2: eukaryotes, 3: mammals, 4: organisms with exoskeleton

(D) 1: organisms with endoskeleton, 2: organisms with exoskeleton, 3: eukaryotes, 4: mammals

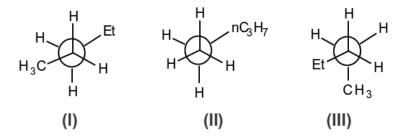**41.** Calculate the heat of formation for 2 moles of ethanol in kJ, from the following data:

$C_2H_5OH(l) + 3 O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l) + 1409.3$ kJ;

the heat of formation of $CO_2(g)$ is $\Delta H$ = -393.5 kJ/mol; the heat of formation of $H_2O(l)$ is $\Delta H$ = -285.9 kJ/mol.

(A) -1340.7    (B) -470.6    (C) -729.9    (D) + 2677

**42.** According to the equation, $N_2O_3(g) + 6H_2(g) \rightarrow 2NH_3(g) + 3H_2O(g)$ how many moles of $NH_3(g)$ could be formed from the reaction of 0.11 mol of $N_2O_3(g)$ with 0.87 mol of $H_2(g)$?

(A) 0.22 mol    (B) 0.44 mol    (C) 0.52 mol    (D) 0.26 mol

**43.** Which functional group does NOT contain an oxygen?

(A) carboxylic acid

(B) ketone

(C) amide

(D) azide

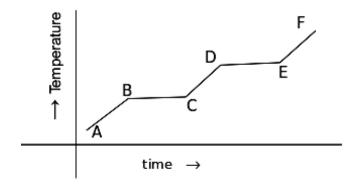**44.** When the atoms: Ba, Cs, Mg, Na are arranged in order of increasing size, what is the correct order?

5

(A) Cs < Na < Mg < Ba

(B) Mg < Na < Ba < Cs

(C) Mg < Ba < Na < Cs

(D) Ba < Mg < Na < Cs

**45.** Three 1.0 liter flasks are filled with $N_2$, $Cl_2$ and Ar, respectively, at STP. Which of the following statements is correct?

(A) The density of each gas is the same.

(B) The velocity of the gas molecules is the same in each flask.

(C) Each flask has the same number of gas molecules.

(D) There are twice as many $Cl_2$ and $N_2$ molecules as Ar atoms

**46.** The IUPAC name for the following compound is



(A) 3-hydroxypent-4-ene-1-yne

(B) 3-hydroxypent-1-ene-4-yne

(C) Pent-4-en-1-yn-3ol

(D) Pent-1-en-4-yn-3-ol

**47.** Which one of the following would be expected to change the value of an equilibrium constant?

(A) adding reactant

(B) adding product

(C) adding a catalyst

(D) changing the temperature
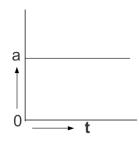
**48.** In the figure below, I, II and III are



(A) isomers

(B) different conformations

(C) different configurations

6

(D) positional isomers

49. Which type of hybridization is necessary for sulphur atom to form $SF_6$?
   (A) $sp^3$   (B) $dsp^2$   (C) $sp^3d^2$   (D) $sp^3d$
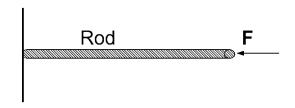
50. The heating curve of a solid is shown below.



The statement that is true for the system described by the curve is:
   (A) Point B indicates the boiling point of the compound.
   (B) On line BC, the solid is in equilibrium with the liquid.
   (C) On line CD, enthalpy of the system is constant.
   (D) Beyond B, only liquid phase of the given compound will exist.

51. The acceleration-time graph of a particle is given below. Which statement is true?



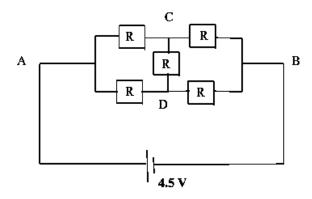   (A) Displacement of the particle increases uniformly with time.
   (B) The particle remains at rest with time.
   (C) The velocity of the particle increases uniformly with time.
   (D) The velocity of the particle is constant.

52. The dimensional formula for the acceleration of a positive charge in the presence of a large negative charge is:
   (A) $MLT^{-1}$   (B) $LT^{-2}$   (C) $M^2L^{-2}T$   (D) $MT^{-2}$

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**53.** A body of mass 1 kg starts moving on a frictionless path from rest, and reaches a peak velocity of $v = 25m/s$ in 5 seconds. The force required to maintain the peak velocity is

(A) 5 N    (B) 0.5 N    (C) 0.04 N    (D) 0 N

**54.** The electrostatic force on an electron due to a proton at a distance $r$ from it is

(A) $(-1/4\pi\epsilon_0)(e/r)$    (B) $(-1/4\pi\epsilon_0)(e/r^2)$    (C) $(-1/4\pi\epsilon_0)(e^2/r^2)$    (D) $(-1/4\pi\epsilon_0)(e^2/r)$

**55.** One end of a steel rod of radius 10 mm and length 5 m is attached to a fixed point. A uniform force F of magnitude 62.8 kN is applied perpendicularly at the other end-face as in the figure. The magnitude of the stress on the rod in SI units is



(A) 19.72 Nm$^2$    (B) $2 \times 10^5$ N/m$^2$    (C) $4 \times 10^7$ N/m$^3$    (D) $2 \times 10^8$ N/m$^2$

**56.** An object is placed 15 cm away from a converging lens of focal length 40cm. The power of the lens is (D stands for Diopter)

(A) 0.375 D    (B) 0.55 D    (C) 2.5 D    (D) 2.667 D

**57.** In the figure below, $R = 100\Omega$. Which of the following is true?



(A) $V_{CD} = 0V$,    $i_{CD} = 0mA$
(B) $V_{CD} = 0V$,    $i_{CD} = 15mA$
(C) $V_{CD} = 1.5V$,    $i_{CD} = 0mA$
(D) $V_{CD} = 1.5V$,    $i_{CD} = 15mA$

**58.** The velocity vector **v** of a particle is resolved into two orthogonal components $v_x$ and $v_y$, neither of which is along the velocity vector. Which of the following is always true?

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(A) $v_x \geq v_y$

(B) $v_x \leq v_y$

(C) $v_x = 0$ if $v_y = 0$

(D) None of the above

**59.** The time taken for light to travel accross an atomic nucleus (only order of magnitude) is

(A) $10^{-8}$    (B) $10^{-14}$    (C) $10^{-22}$    (D) $10^{-28}$

**60.** In one second, the number of times an AC voltage supplied to our homes changes sign is

(A) 10    (B) 100    (C) 1000    (D) 10000

**61.** Which of the following is the relation between the dimensions L, B of a rectangle, such that, for a given perimeter, the rectangle has the largest area?

(A) $B = L$    (B) $B = L/2$    (C) $B = L/4$    (D) Cannot be determined

**62.** In a sequence of positive integers, every term after the first two terms is the sum of the two previous terms in the sequence. If the fifth term is 2004, what is the maximum possible value of the first term?

(A) 399    (B) 400    (C) 1001    (D) 999

**63.** Travelling by bus from Ahmedabad to Mumbai, I passed a sign saying Mumbai 150 Kms. After 5 more kilometres, I passed a sign saying Ahmedabad 400 Kms. What is the distance, in kilometres, by bus from Ahmedabad to Mumbai?

(A) 555    (B) 545    (C) 405    (D) 395

**64.** The line whose equation is $y = 3x + 4$ is reflected in the line whose equation is $y = -x$. What is the equation of the image line?

(A) $3y = x + 4$    (B) $3y = x - 4$    (C) $y = 3x - 4$    (D) $y = -3x - 4$

**65.** All except four of the nine numbers from 11 to 19 can be put in a single sequence 16,18,15,12,14 where each successive pair (such as 12 and 14, or 18 and 15) has highest common factor greater than 1. If you make the longest possible sequence like this using as many as possible of the nine numbers from 111 to 119, how many numbers will be left out?

(A) 0    (B) 1    (C) 2    (D) 3

**66.** $P$ and $Q$ are two regular polygons. $P$ has $m$ sides and $Q$ has $n$ sides. If $m + n = 19$ and if $P$ has 8 more diagonals than $Q$ then

(A) $m = 10$, $n = 9$.

(B) $m = 11$, $n = 8$.

(C) $m = 12$, $n = 7$.

(D) $m = 13$, $n = 6$.

**67.** A cube ABCDEFGH has ABCD as square base, with E, F, G, H above A, B, C, D respectively. What is the value of $\cos(\angle CAG)$?

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

**68.** For how many integer values of $n$ does the equation $x^2 + nx - 16 = 0$ have integer solutions?

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

**69.** Let $\mathbb{C}$ be the set of all complex numbers and $\mathbb{R}$ be the set of all real numbers. Let $X = \{z \in \mathbb{C} : |z - 1| = 1\}$ and $Y = \{z \in \mathbb{C} : |z - i| = 1\}$. Which of the following is **NOT** true?

(A) $X \cup Y$ is an infinite set.

(B) $X \cap Y$ is a finite set containing exactly two elements.

(C) $(X \cup Y) \cap \mathbb{R}$ is a finite set containing two elements.

(D) $0 \notin X \cap Y$.

**70.** A cuboid shaped box has a square base and is open on top (no lid). If its volume is equal to 108 cc, what should be the length of the square base so that the surface area is minimum?

(A) 3   (B) 4   (C) 6   (D) 9

**71.** If human subjects participating in an experiment, change their behaviour simply because they are being studied, then this effect is called

(A) Hawthorne   (B) Placebo   (C) Pygmalion   (D) Conditioning

**72.** In a positively skewed distribution which of the following is true?

(A) Mode is less than median which is less than mean.

(B) Mean, median and mode are equal.

(C) Mode is greater than median which is greater than mean.

(D) None of the above.

**73.** The book Emile is written by

(A) Plato   (B) Hegel   (C) Paulo Freire   (D) Rousseau

**74.** Who is regarded as the father of sociology?

(A) Max Weber

(B) Auguste Comte

(C) Karl Marx

(D) Herbert Spencer

**75.** The sphere of living matter together with water, air and soil on the surface of earth is known as,

(A) Lithosphere.  (B) Biosphere.  (C) Hydrosphere.  (D) Atmosphere.

**76.** What is the value of the median for the numbers 34, 29, 26, 37, 31 and 34 ?

(A) 30.1  (B) 31  (C) 32.5  (D) 34

**77.** A multiple choice test is testing for

(A) only recall.

(B) only recognition.

(C) recall and recognition.

(D) neither recall nor recognition.

**78.** A language teacher wishes to conduct an experiment to study the impact of a method of teaching. She consults courses of study, textbooks and experts in the field in order to determine what areas to include in a test that she would use. She is attempting to ensure that the test would have

(A) Reliability

(B) Validity

(C) Control

(D) Discrimination index

**79.** Which of the following prize/award is given by the UNESCO for presenting scientific ideas to lay people?

(A) Kalinga

(B) Magsaysay

(C) Booker

(D) Pulitzer

**80.** Which Indian state has the lowest sex ratio according to the 2011 census? (Sex ratio is number of females to 1000 males.)

(A) Bihar

(B) Jammu and Kashmir

(C) Punjab

(D) Haryana

# HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

## TATA INSTITUTE OF FUNDAMENTAL RESEARCH

### Entrance Test for Ph.D. Programme in Science Education – 2012

### Section III: Critical Reasoning

Read the following instructions carefully.

- This section of the written test carries **60 marks** and is of **one hour** duration.

- This section of the question paper consists of 8 pages. It has in all 9 questions of varying marks. The answers must be given on this question paper itself in the space provided after each question.

- Please be brief; write only the points. Do not exceed the space provided.

- Before you start answering, please check that you have written your Name and Roll Number in the space provided at the bottom of this page.

- At the end of one hour, please submit this question paper.

**Name:** _____

**Roll Number:** ⬜⬜⬜⬜⬜⬜⬜

1. **This question with 4 parts a, b, c and d together carries 20 marks.** [20 marks]

(a) What percentage of Indian citizens can speak English reasonably well? Give a good estimate. [5 marks]

(b) Explain in detail how you arrived at your estimate. [5 marks]

(c) What problems make it difficult to find out the percentage of Indian citizens, who can speak English reasonably well? [5 marks]

**(d)** How could researchers overcome these problems in order to verify their estimate? Explain in detail. [5 marks]

**2. Read the following passage and answer the three questions (a, b and c) below.** [30 marks]

# Laws of the jungle

*by LINDSAY BARNES (The Hindu, 28 July 2002)*

TEN years ago Dilip Mahato came to Ghosh babu's house at midnight. Jumping into the garden, he stuck his head over the courtyard wall and hissed loudly, "Shhh! Shhh! Ghosh Babu! Wake up! Come out here a minute, will you!"

*In a hushed voice, Dilip tried the hard sell. "Look at this piece of timber, master. Just the thing you will need for your verandah roof. Thought I'd help you out a bit, you know. Came here to let you have first chance. For you, I'll let you have it for just a couple of hundred rupees."*

*Rubbing his eyes, Ghosh babu was awake enough to know where Dilip had got his piece of wood from, since there was a huge plot of government forest land next to his village. The tree had been chopped down less than an hour ago, and had to be sold off before morning. Dilip had already done a market survey, and located potential customers, usually villagers who were in the process of building houses like Ghosh babu. Unfortunately for Dilip, though, his customer declined the opportunity to pick up a real bargain. He quickly disappeared back into the night, for there were plenty of buyers elsewhere, and he had little time at hand.*

*A few years after this incident, Dilip's wife helped set up a savings and credit group in her village. She became an energetic and enterprising group leader, and was a regular visitor to Ghosh babu's house. Last year she helped organise a saplings nursery, both as an income generating activity for women as well as to plant trees on their own land. Both Adori and Dilip were kept busy growing trees instead of chopping them down.*

*Then one day in the middle of the monsoon, Adori and her gang came to consult Masterin on matters of importance. "Look, Masterin, our saplings are growing too well. None of them has died as we expected, we'll have several thousands left over this year. Can't we plant them on the government land in our village? There's hardly any trees left anymore and we'll have to go all the way to Koromtanr to bring fuel for our stoves. It'll take the whole day!" explained Adori.*

*It seemed an obvious and logical plan to Adori, her gang of women, and to Masterin. The women-folk gathered leaves and twigs (and uprooted the odd stump too) during the day, to use as fuel. And the men of the village, led by Dilip, chopped down many of the few remaining ones that somehow managed to grow. It sounded an environmentally sound proposition if the villagers that plundered the forest would actually replenish it, without financial assistance.*

*Still Masterin knew that "government" doesn't always mean "public", but off she went, full of optimism, to discuss the plan with the district's officials. "You'll have to approach the forest department for this," advised the Deputy Commissioner. "It might not be so easy though. I've heard that they lodged a case against an organisation for planting trees on their land," he warned.*

*Optimism waning, she approached the district's forest officer. "Now, how can we possibly help? You know we don't have any money. Our staff are idle and there's no forest left here any more," he narrated tiredly. Masterin took pains to point out that the villagers were in need of neither money, nor saplings. The forest officer was even more perplexed by this, it seemed. He seemed to view the idea with suspicion. "But why would they want to plant trees on their own? They might try and capture the land later and build on it. And who will own the trees? And what about the produce from the trees? What about the profits? Will they give some of it to the forest department?"*

*Masterin explained that all these obstacles could be sorted out, and if necessary they could enter into an agreement between the villagers and his department.*

*Surely such initiative ought to be encouraged, she argued. Ultimately the officer agreed to consider the plan, "I'll make enquiries and then I'll have to get permission from our head office."*

*With the monsoon nearing the end, Masterin tried to expedite things by ringing up the head office one week later. "Ah, yes. I've heard all about this," answered the officer over the telephone. "You see, we've never heard of such a thing before. We don't really know how to go about things. I shall have to find out from our office in Hazaribagh. Can you call back next week?"*

*With fast depleting optimism, Masterin rang back the following week. "Ah, yes. I did talk to our people in Hazaribagh. But they couldn't give us the go-ahead either. See, planting trees on Forest Department's land is quite a touchy issue. We'll have to get permission from Delhi for this," the officer sympathetically informed Masterin.*

*By this time Adori's saplings were over three feet high, and the monsoon  and the tree-planting season  over.*

*They decided to graze their cows and goats on them, so for a couple of days the cattle ate unusually well. The adjacent plot of "forest" land is now completely barren.*

*The village women now trek four kilometres to Koromtanr to plunder the next plot of "jungle". And Dilip's business has dried up.*

**(a)** What questions come to your mind as you read this story? If you were to interview any of the people mentioned in the story, what would you ask them? [10 marks]

**(b)** Should Adori and her group of women have been allowed to plant trees on the government forest land? In your answer: (i) Give reasons why they should have been allowed; (ii) Give reasons why they should not be allowed; and (iii) Explain what you think. Give arguments to justify your answer. [10 marks]

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**(c)** Explain the viewpoints of the government officers in the story. Do you agree with them? Why or why not? [10 marks]

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**3.** A bill was recently proposed in Parliament to regulate entry and operation of foreign educational institutions imparting or intending to impart higher education in India. In your opinion, what are the pros and cons of this bill? What stand do you take and why?                    [10 marks]

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