ENTRANCE EXAMINATIONS – 2019
(Ph.D. Admissions - January 2020 Session)

Ph.D. ACRHEM

Marks: 70
Time: 2.00 hours

Hall Ticket no:

1. Write your hall ticket number on the OMR answer sheet given to you. Also write the hall ticket number in the space provided above.

2. Read the following instructions carefully before answering the questions.

3. This question paper has TWO parts: PART 'A' and PART 'B'.

    Part 'A': It consists of 35 objective type questions of 1.0 (ONE) mark each. **There is a negative marking of 0.33 marks for every wrong answer.**

    Part 'B: It consists of 35 objective type questions of 1.0 (ONE) mark each with no negative marking.

4. All questions are to be answered. Answers for these questions are to be entered on the OMR sheet, filling the appropriate circle against each question. For example, if the answer to a question is D, it should be marked as below:

    (A)   (B)   (C)   ●
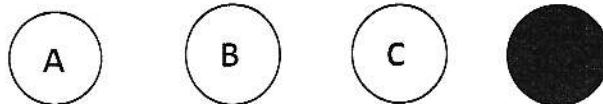
5. No additional sheets will be provided. Rough work can be done in the question paper itself.

6. Handover the OMR answer sheet at the end of the examination to the invigilator.

7. Mobile phones, log tables and programmable calculators are NOT permitted

8. Values of some physical constants: $\epsilon_o = 8.85 \times 10^{-12} \ F/m$; mass of an electron = 9.11×10^{-31} kg; charge of an electron = 1.6×10^{-19} Coulumbs; Planck's constant $h = 6.63 \times 10^{-34}$ joule·second; Boltzman's constant k = 1.38×10^{-23} J/K.

9. This book contains **16** (sixteen) pages including this cover sheet and **1 (one)** blank page for rough work.

Part A (35 Questions)

Read the following passage carefully. Questions 1) - 4) are based on this.

The following pie chart shows the percentage population of the continents with respect to total population of the world. The numbers indicated in the chart refer to the continents as

1. Asia
2. North America
3. South America
4. Europe
5. Africa
6. Australia
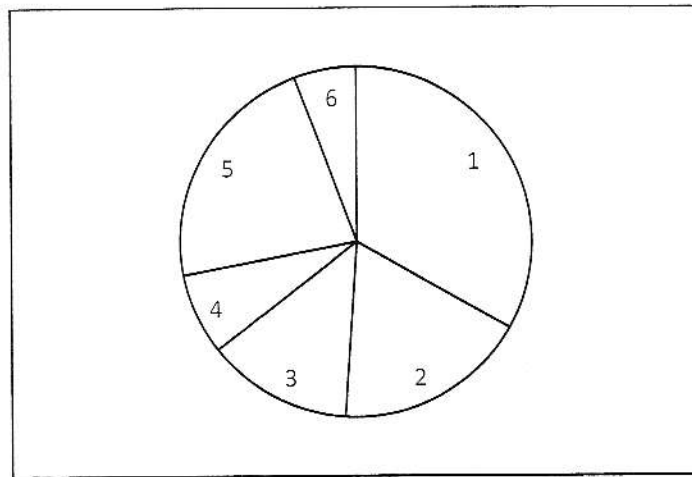
1) Which continent has the lowest population?

[A] South America
[B] Europe
[C] Australia
[D] North America

2) Every one in three persons live in this continent.

[A] Africa
[B] Europe
[C] North America
[D] Asia

3) Which two continents have half of the world's population?

[A] South America and Asia
[B] Europe and North America
[C] Australia and Africa
[D] North America and Asia

4) Assuming the total population of the world to be 700 crores, the population of Australia would be roughly 40 crores. What is the population of Europe?

  [A] 20.5 crores
  [B] 52.5 crores
  [C] 39.9 crores
  [D] 125.3 crores

5) At the start of the ride, the speedometer of a bike shows the reading as 73,849 Km. At the end of the ride it shows 73,861 Km. Which one of these options best describes the distance travelled by the bike?

  [A] ≥ 11 and ≤ 13 Km
  [B] 12 Km
  [C] 10 Km
  [D] <11 Km

6) The missing number in this series: 70,71,76,__,81,86,70,91,96... is

  [A] 81
  [B] 96
  [C] 70
  [D] 71

7) The following statements are true: L >M, M >N, N >P, P >O
   If we deduce the following conclusions: (I) L >P (II) M >O, which one of these is true.

  [A] Either conclusion I or II follows
  [B] Neither conclusion I nor II follows
  [C] Both conclusions I and II follow.
  [D] Only conclusion I follows.

8) Choose the pair that best represents a similar relationship to the one expressed in the original pair of words **Bicycle: Pedal**

  [A] Canoe: Oar
  [B] Automobile: Tyre
  [C] Belt: Buckle
  [D] Skip: Walk

9) Find the odd one out in these:

  [A] Glossary
  [B] Index
  [C] Chapter
  [D] Book

10) In an artificial language: *jalkamofti* means happy birthday; *moftihoze* means birthday party; *mentogunn* means goodness. Which word could mean "happiness"?

   [A] jalkagunn
   [B] mentohoze
   [C] moftihoze
   [D] hozemento

11) Statement 1: At a parking lot, a sedan car is parked to the right side of a pickup car and to the left side of a SUV car.
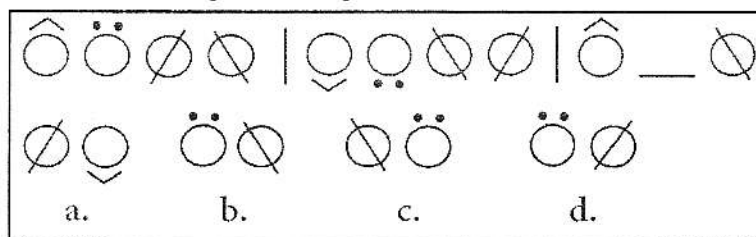   Statement 2: A minivan is parked to the left of the pickup car.
   Statement 3: The minivan is parked between the pickup car and the sedan car.
   If the first two statements are true, then the third statement is

   [A] True
   [B] False
   [C] Uncertain
   [D] Insufficient information

12) Find the missing in this figure.

   [A] a
   [B] d
   [C] c
   [D] b

13) Find the correct analogy. Embarrassed is to Humiliated as Frightened is to

   [A] Terrified
   [B] Agitated
   [C] Courageous
   [D] Reckless

14) Ten new TV shows appeared during the month of June. Five (5) of the shows were sitcoms, three (3) were hour-long dramas, and two (2) were news-related shows. By December, only seven (7) of these new shows were still on the air. Five (5) of the shows that remained were sitcoms. Which one of these is correct

   [A] Only one of the news-magazine shows remained on the air.
   [B] Only one of the hour-long dramas remained on the air.
   [C] At least one of the shows that was cancelled was an hour-long drama.
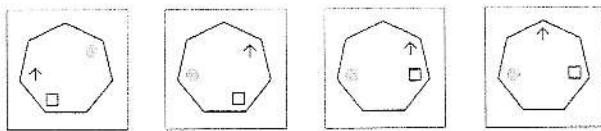   [D] Television viewers prefer hour-long dramas over sitcoms.

15) Find the missing in the sequence ZA_4, Y_5B, XC_6, W_7D, ___

    [A] E_7V
    [B] V_2E
    [C] VE_5
    [D] VE_8

16) Find the missing in this sequence
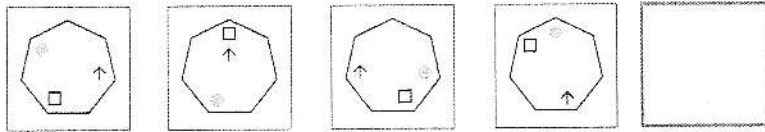
    [A] A
    [B] B
    [C] C
    [D] D

17) Given $2^x.2^y.2^z = 64$; $x+y+z =$

    [A] 8
    [B] 6
    [C] 7
    [D] 4

18) A coin and a dice (six-faced) are thrown simultaneously. The probability that the coin shows 'head' and the dice shows '2' is

    [A] ¼
    [B] 1/6
    [C] ½
    [D] 1/12

19) For any two numbers the operation $ is defined as $(a,b) = a×(a+b). The value of $($(2,0),1) =

    [A] 20
    [B] 12
    [C] 10
    [D] 4

20) K is an even number and P is an odd number. Which one of the statements given below is **NOT** correct?

[A] P-K-1 is an odd number.
[B] P+K+1 is an even number.
[C] (P×K) + P is an odd number.
[D] $P^2 + K^2 + 1$ is an even number.

21) The distance between A and B is 400 Km. The distance between B and C is 300 Km. It follows that the distance between A and C is necessarily –

[A] 100 Km
[B] 500 Km
[C] 700 Km
[D] It cannot be determined from the information provided.

22) A builder can construct one bridge in 3 hours. How many hours does it take for two builders working at the same rate to completely construct 6 bridges?

[A] 12 hours
[B] 6 hours
[C] 9 hours
[D] 15 hours.

Read the following carefully. Questions 23)-25) are based on this information.

In these questions, symbols $, *, #, % and @ are used with different meaning as follows: 'A $ B' means 'A is not smaller than B.' 'A * B' means 'A' is greater than B'. 'A # B' means 'A' is not greater than B'. 'A % B' means 'A' is smaller than B'. 'A @ B' means 'A is neither smaller than nor greater than B.' Now in each of the following question assuming the given statements to be true, find which of the conclusions given below them is/are definitely true and give your answer accordingly.

23) Statements: M * T, D % T, D # K
    Conclusion I: M * D; Conclusion II: T # K

[A] Only conclusion I is true.
[B] Only conclusion II is true.
[C] Both conclusions I and II are true.
[D] Both conclusions I and II are not true.

24) Statements: F @ R, R $ J, V%J
    Conclusion I: F * V; Conclusion II: R * V

[A] Only conclusion I is true.
[B] Only conclusion II is true.
[C] Both conclusions I and II are true.
[D] Both conclusions I and II are not true.

25) Statements: L $ W, W * H, H # T
Conclusion I: T @ L; Conclusion II: H % L

[A] Only conclusion I is true.
[B] Only conclusion II is true
[C] Both conclusions I and II are true
[D] Both conclusions I and II are not true.

26) Introducing a man, a woman said the following, "He is the only son of my mother's mother." How is the woman related to the man?

[A] Niece
[B] Aunt
[C] Sister
[D] Nephew

27) Which of the following is the middle digit of the second highest number among the seven three-digit numbers given below?

512, 739, 428, 843, 654, 368, 279

[A] 1
[B] 2
[C] 3
[D] 4

28) The positions of the first and the last (12th) digits in the number 510926433674 are interchanged. Similarly, the positions of the second and the eleventh digits are interchanged and so on. Which of the following will be the third digit from the right end after- the rearrangement?

[A] 0
[B] 3
[C] 6
[D] 9

Study the following arrangement/sequence carefully and answer the questions given below. Questions 29) and 30) are based on this.

Q 9 K # P @ 3 E N S A C * G © U I M 7 F I V % 4 Z 8 Y

29) If all the numbers are dropped from the above arrangement, which of the following will be the seventeenth from the right end?

[A] P
[B] E
[C] N
[D] @

30) How many such symbols are there in above arrangement, each of which is immediately preceded by an alphabet and immediately followed by a number?

[A] None
[B] One
[C] Two
[D] Three

Read the passage below. Questions 31)-35) are based on this.

Single-use plastics are used only once and then they are thrown away or recycled. Single-use plastics are also called as disposable plastics. Things like plastic bags, straws, coffee stirrers, soda and water bottles and most food packaging are single use plastics. We produce roughly 300 million tons of plastic each year and half of it is disposable! World-wide only 10-13% of plastic items are recycled. The nature of petroleum based disposable plastic makes it difficult to recycle and they have to add new virgin materials and chemicals to it to do so. Additionally, there are a limited number of items that recycled plastic can be used. Petroleum based plastic is not biodegradable and usually goes into a landfill where it is buried or it gets into the water and finds its way into the ocean. Although plastic will not biodegrade it will degrade into tiny particles after many years. In the process of breaking down, it releases toxic chemicals (additives that were used to shape and harden the plastic) which make their way into our food and water supply. These toxic chemicals are now being found in our bloodstream and the latest research has found them to disrupt the Endocrine system which can cause cancer, infertility, birth defects, impaired immunity and many other ailments.

31) Which is not a single-use plastic?

[A] Soda bottle
[B] Water bottle
[C] Coffee maker
[D] Plastic bag

32) How much plastic is estimated to be recycled every year?

[A] 3-4 crore tons
[B] 30-40 crore tons
[C] 3-4 million tons
[D] 60-80 crore tons

33) What is the problem with these plastics?

[A] They are costly.
[B] They are not durable.
[C] They release toxic chemicals.
[D] They are light weight.

34) Additives are added to make the plastic to make it

[A] Biodegradable
[B] Degradable
[C] Non-toxic
[D] Hard

35) How much single use plastic is produced every year?

[A] 200 million tons
[B] 150 million tons
[C] 30 million tons
[D] 300 million tons

# End of Part A

Space for rough work

Part B (35 Questions)

36) The correct number of the coordination number in SC, BCC, FCC and HCP unit cells is

[A] 12, 8, 12, 6
[B] 6, 8, 12, 12
[C] 8, 6, 12, 12
[D] 6, 12, 12, 8

37) The (-1 -1 -1) plane is parallel to

[A] (1 1 1)
[B] (1 1 -1)
[C] (-1 -1 1)
[D] (-1 1 -1)

38) For diamond structure the packing fraction is given by

[A] $\pi\sqrt{3}/8$
[B] $\pi\sqrt{3}/4$
[C] $\pi\sqrt{3}/16$
[D] $\pi\sqrt{3}/2$

39) Classify the unit cell given by following parameter into proper system a=1.06 A^0, b=0.948 A^0, c=0.65 A^0, α=44^0, β=88^0 and γ=96^0

[A] Monoclinic
[B] Triclinic
[C] Hexagonal
[D] Tetragonal

40) A cubic crystal can have

[A] Only the primitive Bravais lattice
[B] Only one of the primitive, body centered and face centered Bravais lattice
[C] None of the primitive, body centered and face centered Bravais lattice
[D] All of the primitive, base centred and face centered Bravais lattice

41) In a simple cubic lattice d_{100}: d_{110}: d_{111} is

[A] 6:3:2
[B] 6:3:$\sqrt{2}$
[C] $\sqrt{6}$:$\sqrt{3}$:$\sqrt{2}$
[D] $\sqrt{6}$:$\sqrt{3}$:$\sqrt{4}$

42) Which of the following molecule shows both microwave and an infrared spectrum?

[A] HBr
[B] Br_2
[C] CS_2
[D] H_2

43) In NaCl, the Na ions are positively charged while the Chloride ions are negatively charged. In spite of coulomb attraction between them, the two ions do not collapse because of

[A] The presence of free electrons
[B] Low melting point
[C] Short range repulsive force
[D] High specific heat

44) Repeatable entity of a crystal structure is known as

[A] Crystal
[B] Unit Cell
[C] Lattice
[D] Miller Indices

45) The angle (in degrees) between the [111] and [11 −2] directions in a cubic crystal is

[A] 0
[B] 90
[C] 180
[D] 45

46) The diamagnetic susceptibility is

[A] Positive always
[B] Negative always
[C] Zero
[D] Depends on the material and can be positive, negative

47) For a paramagnetic substance, the dependence of the magnetic susceptibility χ on the absolute temperature (T) is given by

[A] $\chi \propto 1/T$
[B] $\chi \propto T$
[C] $\chi = $ constant
[D] $\chi \propto T^2$

48) The directional derivative of a function $f(x,y,z) = x^2+3y+z^3$ in the direction of $\vec{V} = 2\mathbf{i}+3\mathbf{j}+\mathbf{k}$ (where **i, j, k** are unit vectors) at the point $(1,2,1)$ is

[A] 23
[B] 12
[C] 14
[D] 3

49) Which among the following is not a Hermitian operator given $[P, Q] = i\hbar$ and P and Q are Hermitian

[A] PQPQ+QPQP
[B] QPQ
[C] $2i(QP^2P^2Q)$
[D] 2QP-i$\hbar$

50) Given a complex number Z, the value of arg(Z)-arg(2Z) is

[A] 3θ
[B] 0
[C] θ
[D] $-\theta$

51) The value of $\oint \frac{z+1}{(z^2-2z)} dz$ when the contour of unit radius taken in the anti-clockwise direction is

[A] $2\pi i$
[B] $-2\pi i$
[C] πi
[D] $-\pi i$

52) The number of possible arrangements of two Fermions in 3 energy levels is

[A] 3
[B] 9
[C] 6
[D] 1

53) The probability of finding an electron with its energy equal to its Fermi energy at any temperature is

[A] 75%
[B] 25%
[C] 100%
[D] 50%

54) It is known that a solid body that is heated to a very high temperature (T) emits radiation and the power is proportional to

[A] T
[B] T^2
[C] T^3
[D] T^4

55) If the uncertainty value of a proton accelerated in a laboratory is 400 m/s then the uncertainty value of its position is

[A] 8.88 nm
[B] 7.88 nm
[C] 9.88 nm
[D] 6.88 nm

56) Which one of these exact frequencies of radiation can ionize the H atom in its ground state?

[A] 1.08×10^{15} Hz
[B] 2.54×10^{15} Hz
[C] 3.28×10^{15} Hz
[D] 0.48×10^{15} Hz

57) An experiment involving lasers with linearly polarized output light requires a systematic control (changing of intensity from 0 to 100%) of the amount of polarized light falling on the sample, while all other parameters remain the same. This can be achieved by which of the following options?

[A] A polarizer followed by a quarter wave plate
[B] A half wave plate followed by a polarizer
[C] A half wave plate followed by a quarter wave plate
[D] A quarter wave plate followed by a polarizer

58) The ordinary and extraordinary refractive indices of a calcite crystal are 1.658 and 1.486, respectively. What thickness of this crystal is required to convert linearly polarized light at 589 nm to circularly polarized light?

[A] 0.86 µm
[B] 0.96 µm
[C] 0.76 µm
[D] 0.80 µm

59) How many normal modes of vibration are possible for SO_2 and CH_3I, respectively?

[A] 4 and 7
[B] 4 and 6
[C] 6 and 7
[D] 3 and 9

60) The following two figures show refraction of light as light rays enter medium of refractive indices n_2 (n_3) from medium of refractive index n_1. We can conclude that
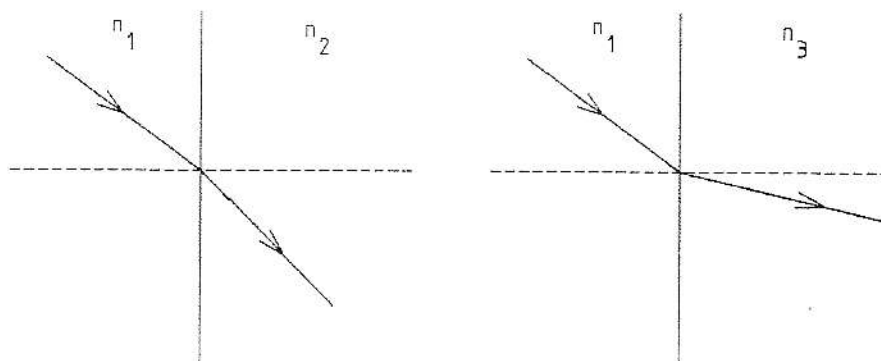
[A] $n_1 > n_2 > n_3$
[B] $n_3 > n_1 > n_2$
[C] $n_1 > n_3 > n_2$
[D] $n_1 = n_2 = n_3$

61) A parallel beam of light of diameter 'd' is incident on a lens of focal length 'f'. Another lens, of twice the focal length (i.e., '2f') is placed at a distance of '3f' from the first lens, along the path of the beam. The resultant beam is

[A] Parallel beam of the same diameter as original beam
[B] Parallel beam of half diameter of original beam
[C] Parallel beam of twice diameter of original beam
[D] None of the above

62) An equilateral triangle is made using a conducting wire of uniform cross-section and of resistance R. The resistance across any two corners of this triangle is

[A] R/3
[B] 9R/2
[C] 2R/9
[D] 2R/3

63) A transistor is said to be in saturation region if

[A] Emitter junction is forward biased and the collector junction is reverse biased
[B] Emitter junction is reverse biased and the collector junction is forward biased
[C] Both emitter junction and the collector junction are reverse biased
[D] Both emitter junction and the collector junction are forward biased

64) Consider a common emitter (CE) amplifier in voltage divider configuration. If the value of the emitter resistance (R_E) is increased then

[A] Both the voltage gain and the saturation current [$I_{C(sat)}$] decrease.
[B] The voltage gain increases and the saturation current [$I_{C(sat)}$] decreases.
[C] The voltage gain decreases and the saturation current [$I_{C(sat)}$] increases.
[D] Both the voltage gain and the saturation current [$I_{C(sat)}$] remain unchanged.

65) An electric field due to a monopole and dipole on a plane is proportional to

[A] $1/r^{1.5}$ and $1/r$
[B] $1/r^{1.5}$ and $1/r^2$
[C] $1/r$ and $1/r^2$
[D] $1/r^3$ and $1/r^2$

66) If a laser light of wavelength 532 nm is sent through water which has a vibrational mode at 3400 cm^{-1}, the first Stokes and anti-Stokes lines will be respectively at

[A] 635 nm and 459 nm
[B] 730 nm and 355 nm
[C] 683 nm and 436 nm
[D] 650 nm and 450 nm

67) A diffraction grating has 50 grooves per cm. If it is coherently illuminated by plane wave of green light 543.5 nm and a lens of 100 cm focal length, what will be the spacing of the diffraction spots on the transform plane?

[A] 3.6 mm
[B] 2.7 mm
[C] 5.4 mm
[D] 7.2 mm

68) Which of the following is a correct selection rule for the Raman scattering?

[A] For rotational motion $\Delta J = \pm 2$ and for vibrational motion $\Delta \upsilon = \pm 1$ & $\Delta J = \pm 2$
[B] For rotational motion $\Delta J = \pm 1$ and for vibrational motion $\Delta \upsilon = \pm 1$ & $\Delta J = \pm 1$
[C] For rotational motion $\Delta J = \pm 2$ and for vibrational motion $\Delta \upsilon = \pm 2$ & $\Delta J = \pm 2$
[D] For rotational motion $\Delta J = 0$ and for vibrational motion $\Delta \upsilon = \pm 1$ & $\Delta J = 0$

69) An electromagnetic wave $E(t) = E_0(t) \exp\{i(kz-\omega t)\}$ enters a medium of refractive index 'n'. The spectrum of the field inside the medium is best described by

[A] Gaussian
[B] Delta Function
[C] Complex Lorentzian
[D] Laplacian

70) The eigen values of the matrix $\begin{pmatrix} 2 & 0 & -2 \\ -2i & i & 2i \\ 1 & 0 & -1 \end{pmatrix}$ are

[A] $0, -1, i$
[B] $0, -1, -i$
[C] $0, 1, i$
[D] $1, -1, i$

End of Part B