ENTRANCE EXAMINATION, JUNE 2017

QUESTION PAPER

Ph.D. (ACRHEM)

Marks: 80

Time: 2.00 Hrs

Hall Ticket No. _____

Please confirm that

(a) This booklet has all 18 pages (including two blank pages) printed clearly and numbered

(b) You are given a clean and clear OMR answer sheet

Read **carefully all the instructions** given below and on the OMR sheet.

1. Please write your Hall ticket Number on Page 1 (this sheet) of this booklet **without fail.**
2. Please write your Hall ticket number on the **OMR answer sheet without fail.**
3. All answers are to be marked on the OMR answer sheet following the instructions provided there upon.
4. Handover the OMR answer sheet at the end of the examination without fail.
5. **No additional sheets will be provided.** Rough work is to be done in the question paper itself in the space provided on pages 2, 17 & 18.
6. Question paper has two parts: Part – A and Part – B.
7. Part – A consists of 20 objective type questions of two marks each.
8. Part – B consists of 40 objective type questions of one mark each.
9. Non programmable calculators are permitted.
10. All the symbols used in the text have their usual meanings.

PART – A

1. Let u, w, x, z be independent random variables, each of which follow a normal distribution are measured with uncertainties δu, δw, $\delta x, \delta z$. What is the uncertainty in A, if $A = \frac{xz}{uw}$

   A. $\delta u+\delta w+\delta x+\delta z$
   B. $\delta u+\delta w-\delta x-\delta z$
   C. $A\sqrt{\left(\frac{\delta x}{x}\right)^2+\left(\frac{\delta w}{w}\right)^2+\left(\frac{\delta u}{u}\right)^2+\left(\frac{\delta z}{z}\right)^2}$
   D. $A\sqrt{\left(\frac{\delta x}{x}\right)^2+\left(\frac{\delta z}{z}\right)^2-\left(\frac{\delta u}{u}\right)^2-\left(\frac{\delta w}{w}\right)^2}$

2. A fuse is generally used in electric supplies as a safety device. Which one of the following statements about the fuse is correct?

   A. It is connected in parallel with the main switch
   B. It is made mainly from silver alloys
   C. It must have a low melting point
   D. It must have a very high resistance

3. After measuring the speed of sound for several times, a student concludes the standard deviation to be 10 m/s. If all uncertainties were truly random, how many measurements are needed to obtain a precision of 1 m/s?

   A. 10
   B. 5
   C. 100
   D. 25

4. The operators ◊, #, □ are defined as $a◊b = \frac{a-b}{a+b}$; $a\#b = \frac{a+b}{a-b}$; a□ b = ab. Find the value of (56◊34) □ (56#34).

   A. -2
   B. 1
   C. -1
   D. 2

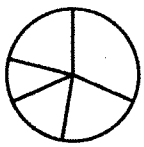
5. The missing part of the sequence ABC, ABC_2, AB_2C_2, ___, $A_2B_2C_3$ is

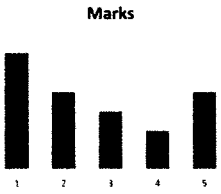
   A. ABC_3
   B. A_3BC_3
   C. A_2B_3C
   D. $A_2B_2C_2$

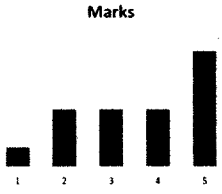
6. A Rubik's cube of side 3 units is formed using a set of smaller cubes of side 1 unit. What is the proportion of the number of faces of the smaller cubes NOT visible to those which are visible?

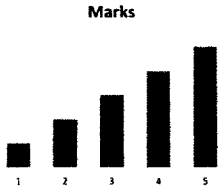
   A. 1:2
   B. 2:1
   C. 3:1
   D. 4:1

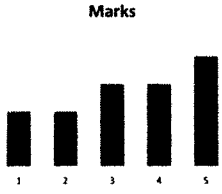
7. The pie chart shows the marks scored by a student in five different subjects. Which one of the following charts correctly depicts this information?



A.


B.


C.


D.


8. What are the missing numbers of the following sequence?
   1, 1, 2, 3, 5, _, _, 21, 34, … … …

   A. 8, 13
   B. 10, 17
   C. 7, 14
   D. 9, 16

9. All mangoes are golden in colour. No golden coloured things are cheap.

From the above two statements the following conclusions are arrived at.

Conclusion I: All mangoes are cheap
Conclusion II: Mangoes are not cheap

Which of the statements follow:

A. Only conclusion I
B. Only conclusion II
C. Neither conclusion I nor II
D. Either conclusion I or II

10. In an experiment involving the measurement of time period, three consecutive measurements yielded 16,17 and 18 s. If a fourth measurement is made, what is the probability that this new measurement will fall outside the range 15 and 19 ?

A. 0.05
B. 0.32
C. 0.68
D. 0.99

Read the following passage and answer the questions 11-14 based on this –

Any material expands as its temperature increases. For instance, a metal rod or beam will increase its length by an amount ΔL. The value of ΔL depends on the original length (L_o) at the original temperature (T_o), the temperature to which it is heated (T) and the linear expansion coefficient (α). The equation relating these variables is given by

$$\Delta L = \alpha L_o(T-T_o)$$

The amount of expansion depends upon the material; each material has its own unique linear expansion coefficient. Coefficients for a variety of materials are summarized in Table 1. Note that the left columns include metals and metal alloys and the right columns include non-metals.

Material	$\alpha \times 10^{-5}$ (/°C)	**Material**	$\alpha \times 10^{-5}$ (/°C)
Copper	5.1	Wood	0.5
Steel	1.3	Polyethylene	20.0
Aluminium	2.2	Polystyrene	7.0
Brass	1.9	Polyvinyl chloride	5.0

Table 1

The expansion of a rod or beam in one dimension as described by the above equation is known as **linear expansion**. Linear expansion causes the length of a rod or beam to change with temperature. **Figure 1** shows how the length of a beam varies as a function of temperature for four different materials.

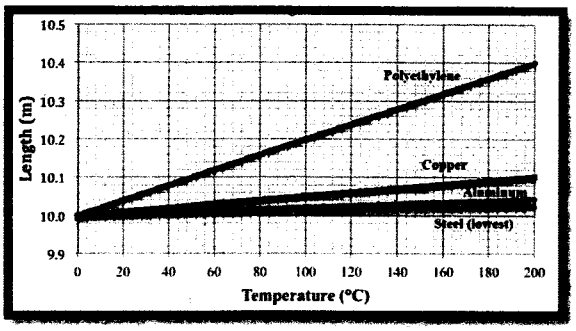


Figure 1

11. Suppose a polyethylene pipe of 10.0-meter length at 0°C were heated to 100°C. What is the amount of expansion (ΔL) of the beam?

    A. 0.20 m
    B. 0.40 m
    C. 10.30 m
    D. 10.40 m

12. Use the data provided to determine which of the following situations would result in the greatest amount of expansion (ΔL).

    A. Increase the temperature of a 10.0-m length copper rod from 20°C to 30°C.
    B. Increase the temperature of a 5.0-m length copper rod from 120°C to 130°C.
    C. Increase the temperature of a 10.0-m length steel rod from 20°C to 30°C.
    D. Increase the temperature of a 5.0-m length steel rod from 120°C to 130°C.

13. Which statement best describes the four plotted lines in **Figure 1**?

    A. Beams of four different materials and having different lengths were obtained at 0°C. The beams were heated to 200°C; their length was measured at various temperatures.
    B. Four equal length beams were obtained at room temperature. They were heated and cooled between the temperature range of 0°C and 200°C; their length was measured at various temperatures.
    C. Beams of four different materials with random lengths were obtained at 200°C. The beams were cooled until they reached the same length; this occurred at a temperature of 0°C.
    D. Beams of four different materials were measured to be of the same length at 0°C. They were heated to 200°C; their length was measured at various temperatures.

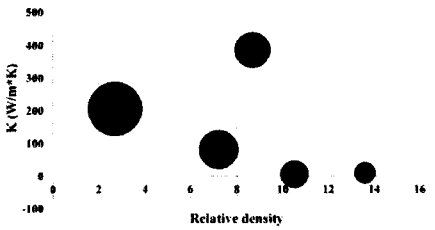
14. Which of the following statements is true when a fixed length of the material is heated from T_0 to T

    A. Metals always expand more than the non-metals
    B. Copper and polyvinyl chloride expand very similarly
    C. Wood expands more than steel till any temperature
    D. Polyethylene expands less than wood.

Answer questions 15 and 16 based on the data provided below.

The table below shows the relative densities of five different materials. The bubble chart plots the relative density, thermal conductivity and the specific heat of these materials.

	Material	Relative density
1.	Cu	8.68
2.	Fe	7.21
3.	Hg	13.56
4.	Ag	10.49
5.	Al	2.70



15. Which material has the maximum specific heat ?

A. Aluminium
B. Copper
C. Iron
D. Mercury

16. If the specific heat of silver is 234 J/Kg*K, what is the specific heat of iron in J/Kg*K ?

A. 167
B. 470
C. 1000
D. 234

Answer questions 17 - 18 based on the following information.

A 20 mW of collimated sunlight is focused on a crystal of thickness 0.5 mm. The diameter of the focused spot is 400 μm. The measured power of the transmitted sunlight is 15 mW. Reflection losses are negligible during the event.

17. What is the intensity of the sunlight in the units of W/cm^2 on the crystal ?

A. 15.9
B. 1.59
C. 0.45
D. 4.50

18. What is the percentage transmission loss from the Crystal

A. 15
B. 50
C. 20
D. 25

19. Humpty Dumpty sits on a wall every day while having evening snack. The wall sometimes breaks. A person sitting on the wall falls if the wall breaks. Which one of the statements given below is logically valid and can be inferred from the above sentences?

    A. Humpty Dumpty always falls while having supper
    B. When Humpty Dumpty does not sit on the wall, the wall does not break
    C. Humpty Dumpty never falls during evening snack
    D. Humpty Dumpty does fall sometimes while having evening snack.

20. What is the probability of getting a sum 9 from two throws of dice?

    A. 1/6
    B. 1/9
    C. 2/9
    D. 1/3

END OF PART – A

PART – B

21. A Carnot engine takes in 100 J of heat from a source at 400^0 K and gives up 80 J of heat to the sink. The temperature of the sink and thermal efficiency are respectively

A. 320^0 K, 20%
B. 500^0 K, 20%
C. 320^0 K, 40%
D. 200^0 K, 20%

22. It is more difficult to walk on ice than on a concrete road because

A. Ice is a soft material compared to concrete
B. There is little friction between the ice and feet pressing it
C. There is more friction between the ice and feet pressing it
D. Ice melts faster than concrete

23. The speed of light will be minimum while passing through

A. Water
B. Air
C. Vacuum
D. Glass

24. Hydrogen atom is excited from ground state to another state with principal quantum number equal to 4. Then the number of spectral lines in the emission spectra will be

A. 4
B. 6
C. 8
D. 10

25. When light enters from air to water, its

A. frequency increases and speed decreases
B. frequency and speed both decreases
C. frequency is same but the wavelength is larger
D. frequency is same but the wavelength is smaller

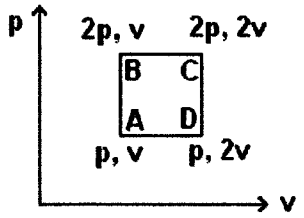
26. The numerical aperture of an optical fiber cable is 0.6 and the refractive index of the core is 1.55. Find the refractive index of the cladding.

A. 1.43
B. 1.46
C. 1.50
D. 1.53

27. Starting with same initial condition an ideal gas expands from volume V_1 to volume V_2. The work done in the first process (isothermal) is W_1, work done in the second process (isobaric) is W_2 and finally the work done in the third process (adiabatic) is W_3. Which of the following statements holds true?

A. $W_1 > W_2 > W_3$
B. $W_2 > W_1 > W_3$
C. $W_1 > W_3 = W_2$
D. $W_1 = W_2 > W_3$

28. An ideal monoatomic gas is taken in a cycle ABCD as shown in figure below. The work done in the whole process (cycle) is



A. pv
B. 2pv
C. 4pv
D. 0

29. A double slit arrangement produces interference fringes for sodium light that are 0.60^0 apart. Find the angular separation if the entire arrangements is immersed in water of refractive index 1.33.

A. 0.60^0
B. 0.30^0
C. 0.45^0
D. 0.90^0

30. A 50 cm^3 chamber is filled with Argon gas to a pressure of 20.3 Pa at a temperature of 0°C. A flash tube surrounding the gas energizes 2% of the atoms into the excited state having a mean life time of 1.4×10^{-8} sec. Assuming spontaneous emission is the only de-excitation process, at what rate photons are subsequently emitted by the gas?

A. 3.84×10^{23} photons/sec
B. 2.69×10^{23} photons/sec
C. 1.44×10^{23} photons/sec
D. 1.92×10^{23} photons/sec

31. Which of the following represents the radiation pressure in ascending order due to the electro magnetic radiation

A. Microwaves < X- rays < Gamma rays < Visible light
B. Gamma Rays > X-rays > Visible light > Microwaves
C. Microwaves < Visible light < X-rays < Gamma rays
D. X-rays < Visible light < Microwaves < Gamma rays

32. 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. 650 nm and 450 nm
B. 635 nm and 459 nm
C. 683 nm and 436 nm
D. 730 nm and 355 nm

33. For a spherical surface represented by $f(r, Z) = Z + \frac{r^2}{2R(Z)}$, the curvature and radius of curvature are, respectively,

A. $R(Z), \frac{1}{2R(Z)}$
B. $\frac{1}{R(Z)}, R(Z)$
C. $\frac{Z}{R(Z)}, R(Z)$
D. $R(Z), \frac{Z}{R(Z)}$

34. A particle of mass 'm' moving in 1-D infinite square well with a wave function at a time t=0 as $\psi(x, t=0) = A(a^2 - x^2)$. The average value of the energy is

A. $\frac{\hbar^2}{2ma^2}$
B. $\frac{5\hbar^2}{4ma^2}$
C. $\frac{\hbar^2}{4ma^2}$
D. $\frac{3\hbar^2}{2ma^2}$

35. Given the dispersion relation $\omega = ak^2$, what is the ratio of phase velocity to the group velocity?

A. 2:1
B. 3:2
C. 1:2
D. 1:1

36. The magnetic field associated with the electric field of a standing electromagnetic wave given by $E(x,t) = 2E_0 Sin(kx)Cos(\omega t)$ is

A. $2B_0$ Cos(kx) Sin(ωt)
B. $-2B_0$ Cos(kx) Sin(ωt)
C. B_0 Cos(2kx) Sin(ωt)
D. B_0 Cos(kx) Sin(2ωt)

37. The residue of $\frac{Sin\pi Z}{(Z-1)^2}$ at $Z = 1$ is

A. -π/4!
B. -π/2!
C. -π
D. -π/3!

38. At what distance from a long, straight wire carrying a current of 5.0 A is the magnetic field due to the wire equal to the strength of earth's field (approximately 5.0×10^{-5} T)?

A. 2 m
B. 2 cm
C. 3 m
D. 3 cm

39. If eigen values of a non-singular matrix A are 2, 3, 5, then the eigen values of A^{-1} are

A. 2, 3, 5
B. 1/2 , 1/3, 1/5
C. 1/2, 3, 5
D. 1/4, 2, 5

40. The nearest neighbour distance in the case of body centered cubic structure with side a is

A. $\frac{a\sqrt{3}}{2}$
B. $\frac{a\sqrt{2}}{2}$
C. $\frac{2\,a}{\sqrt{3}}$
D. $\frac{2\,a}{\sqrt{2}}$

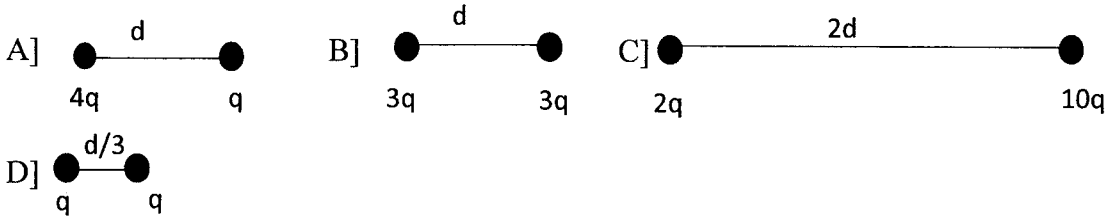
41. If the stiffness constants of elasticity $C_{11} = C_{12} = k$ for a cubic crystal, then bulk modulus is

A. $3k/2$
B. $2k/3$
C. $1/k$
D. k

42. The potential energy representing the interaction between two atoms is $u(r) = \frac{-2}{r^4} + \frac{3}{r^6}$, the equilibrium distance is

A. 1.5
B. $\sqrt{1.5}$
C. 2
D. $\sqrt{2}$

43. In each of these four scenarios listed below, the two charges remain fixed in place as shown. Rank the electric potential energies of the four system from the greatest to least



A. B = D > C > A
B. C > B > A> D
C. C > B = D >A
D. D> A = B > C

44. Let C be the curve $x = 1 - y^2$ from (0, -1) to (0, 1). The value of the integral $\int_c (y^3\,dx + x^2 dy)$ is

A. 4/15
B. 2/15
C. 15/2
D. 15/4

45. Let $L_{\pm} = L_x \pm iL_y$, then the commutator $[L_+, L_-] = ?$, where L is angular momentum

A. $2\hbar L_z$
B. $-i\hbar$
C. $\hbar L_y$
D. $\frac{1}{2}\hbar L_z$

46. Two light sources of intensity I and 4I are used in an interference experiment. Find intensity at the points where the waves from these two sources superimpose with the phase difference of 0 and π.

A. 4I,I
B. 9I,3I
C. 9I,I
D. 3I,9I

47. If one interchanges the spatial coordinates of two electrons in a state of total spin '0' (zero), the following holds true

A. The wave function changes sign
B. The wave function is unchanged
C. The wave function gets modified to a different function
D. The wave function becomes zero

48. The fine structure of atomic spectral lines arises due to

A. Electron spin-orbit coupling
B. Interaction between electron and nucleus
C. Nuclear spin
D. Electronic transitions

49. A particle and its anti-particle

A. Can always annihilate into two photons
B. Must have different mass from each other
C. Must have same mass
D. Must have same electric and magnetic properties

50. For a conservative system the following is true

A. $\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = 0$
B. $\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{q}_i}\right) - \frac{\partial L}{\partial q_i} = 0$
C. $\frac{d}{dt}\left(\frac{\partial L}{\partial q_i}\right) - \frac{\partial L}{\partial \dot{q}_i} = 0$
D. $\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial q_i}\right) - \frac{\partial L}{\partial \dot{q}_i} = 0$

51. An experiment involving lasers, requires the systematic control of the amount of polarized light falling on the sample, while all other parameters remaining the same. This can be achieved by which of the following

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

52. What is the temperature of a black sphere of diameter 10 cm which is emitting a total of 100 W thermal radiation. ($\sigma = 5.67 \times 10^{-8}\ W/m^2K^4$)

A. 328.1 K
B. 391.4 K
C. 411.7 K
D. 486.2 K

53. What is the common mode rejection ratio of a differential amplifier with A= 200 and A_{cm}= 0.5?

A. -200
B. -400
C. -100
D. -2.5×10^{-3}

54. What is the AC output V_{out} of an Op Amp (between collector to GND) , If A= 1000, $V_{non\text{-}inverting}$= 3 mV and $V_{inverting}$= 2 mV :

A. 1 V
B. 5 V
C. 10V
D. 15V

55. One end of the cu-constant thermocouple is used for measuring the temperature of an oven at 200 ^{0}C with the other end placed in ice (0 ^{0}C). The reading of the voltmeter shows 2 μV. Thermocouple signal is fed to the double ended input and single ended output differential amplifier for controlling the temperature. If gain of Op-amp is 10^5 , what is the output voltage ?

A. 0.02 V
B. 0.2 V
C. 2 .5V
D. 0.5 V

56. The Fourier transform of a decaying exponential exp(-*at*) for all positive values of *t* is

A. Complex Gaussian
B. Laplacian
C. Delta Function
D. Complex Lorentzian

57. The equivalent component of an optical beam splitter with R:T = 50:50 in the microwave domain is

A. Directional Coupler
B. Magic Tee
C. Horn Antenna
D. Waveguide

58. Which of these magnetic fields can exist?

I) $\vec{B}(\vec{r}) = e^{-y^2}\,\vec{x}$ II) $\vec{B}(\vec{r}) = e^{-x^2}\,\vec{x}$

III) $\vec{B}(\vec{r}) = Sin(kr)\,\vec{r}$ IV) $\vec{B}(\vec{r}) = r\,\vec{\theta}$

A. I and IV
B. III and II
C. I and III
D. III, II and IV

59. A pendulum of constant mass 'm' and length 'l' is oscillating with a rigid support. If the position of the bob (x,y) is given as $(l\sin\theta,\ -l\cos\theta)$, the Euler-Lagrange equation and the total energy respectively are

A. $\frac{g}{l}\cos\theta$ and $\frac{m}{2}l^2\dot{\theta}^2 + mgl\,(1-\sin\theta)$
B. $-\frac{g}{l}\sin\theta$ and $\frac{m}{2}l^2\dot{\theta}^2 + mgl\,(1-\cos\theta)$
C. $-\frac{g}{l}\cos\theta$ and $\frac{m}{2}l^2\dot{\theta}^2 + mgl\,(1-\cos\theta)$
D. $\frac{g}{l}\sin\theta$ and $\frac{m}{2}l^2\dot{\theta}^2 + mgl\,(1-\sin\theta)$

60. Which of the following methods converges quickly to the solution, while finding the roots of equations of the form f(x) = 0.

A. The Bisection method
B. The method of false position
C. Newton – Raphson method
D. The iteration method

END OF PART – B