

**ENTRANCE EXAMINATION – 2017**  
**QUESTION PAPER BOOKLET**  
 (Ph.D. Admissions – January 2018 Session)  
**Ph.D. (PHYSICS)**

Marks: 80

Time: 2.00 hrs.

Hall Ticket No.:

**I.** Please enter your **Hall Ticket Number** on **Page 1** of this question paper and on the **OMR sheet** without fail

**II.** Read carefully the following instructions:

1. This Question paper has two parts: **PART-A** and **PART-B**
2. **PART-A** consists of 20 objective type questions related to Research Methodology.
3. **PART-B** consists of 20 objective type questions related to Physics.
4. All questions carry 2 marks each. **There is no negative marking.**
5. Answers are to be marked on the OMR answer sheet following the instructions provided there upon. An example is shown below:

100. ☐ A ☐ B ☐ C ☒

6. Only non-programmable scientific calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.
7. Hand over the OMR sheet at the end of the examination.
8. Space is provided at the end of the question paper booklet itself for rough work. This booklet can be taken by the candidate at the end of the examination.

This book contains 14 pages

**III.** Values of physical constants:

$$c = 3 \times 10^8 \text{ m/s}; h = 6.63 \times 10^{-34} \text{ J.s}; k_B = 1.38 \times 10^{-23} \text{ J/K}$$

$$e = 1.6 \times 10^{-19} \text{ C}; \mu_0 = 4\pi \times 10^{-7} \text{ Henry/m}; \epsilon_0 = 8.85 \times 10^{-12} \text{ Farad/m}$$

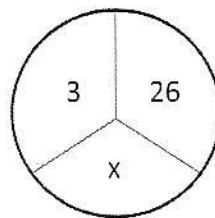
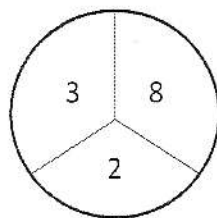
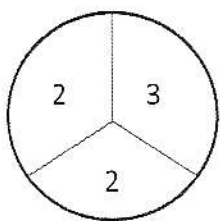
$$N_A = 6.023 \times 10^{23}; m_e = 9.11 \times 10^{-31} \text{ kg.}$$

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Blank sheets are provided for rough work at the end of this booklet

Part - A

1. The following data is from a random sample: 5, 1, 3, 3 standard deviation is
  - (A) 4
  - (B) 7
  - (C)  $\sqrt{7}$
  - (D) 2
  
2. "All Matter is made up of atoms  
Water is a form of matter  
Therefore water is made up of atoms"  
This type of reasoning is called
  - (A) Inductive
  - (B) Deductive
  - (C) Inducto-deductive
  - (D) Hypothetico-deductive
  
3. The binary number 1011 0110 is equal to the decimal number
  - (A) 180
  - (B) 64
  - (C) 182
  - (D) 132
  
4. The probability for an event occurring is given by the Poisson distribution defined by  $W(n) = \frac{\lambda^n}{n!} e^{-\lambda}$ . If  $\lambda$  is the mean number of events, the variance of the distribution is given by
  - (A)  $\lambda$
  - (B)  $\lambda/2$
  - (C)  $2\lambda$
  - (D) 0
  
5. Choose the appropriate letter that follows the sequence given below at "?"  
b, c, d, f, i, n, ?.....
  - (A) p
  - (B) v
  - (C) r
  - (D) Y

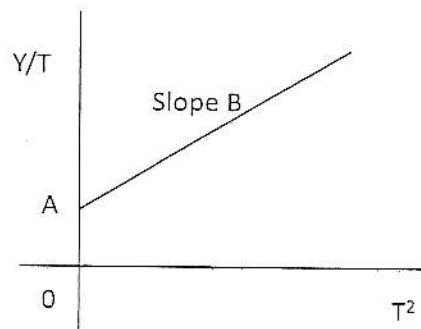
6. Fill in the missing number "x"



- (A) 3  
(B) 7  
(C) 6  
(D) 9
7. **G**, **F** and **H** are children of **A**. **D** is brother of **E**. **G** is son of **R**. **E** is daughter of **F**. **R** is wife of **A**. Who is **D**'s Uncle?
- (A) H  
(B) A  
(C) G  
(D) R
8. If **MEDICINE** maps into **KAJCLCMA** in a language, what will be **CINEMA** likely to be among the following
- (A) LEMANT  
(B) LCM AKP  
(C) LENCMP  
(D) LCNAKT
9. Every time a ball falls to ground, it bounces back to half the height it fell from. If a ball is dropped from a height of 1024 cm, the maximum height from the ground to which it can rise after the **tenth bounce** is
- (A) 102.4 cm  
(B) 1.24 cm  
(C) 1 cm  
(D) 2 cm
10. Of a set of three numbers, the average of the first and second is greater than the average of the second and third by 20. What is the difference between the first and third of the three numbers?
- (A) 20  
(B) 40  
(C) 30  
(D) 10

11. If a function  $Y$  varies with temperature  $T$  as shown in figure, then  $Y(T)$  is given by

- (A)  $AT + BT^3$   
 (B)  $AT + B e^{-k_B T/E}$   
 (C)  $AT + BT^2$   
 (D)  $AT^2 + BT^3$



12. If the resistance per cm length of a heater wire is  $1\Omega$ , to make a heater of  $25W$  with a current source as  $0.5A$ , what should be the total length of the wire?

- (A) 50 cm  
 (B) 25 cm  
 (C) 2.5 cm  
 (D) 100 cm

13. A cylindrical wooden box of  $1\text{ m}^3$  is to be filled with marbles of  $2\text{cc}$  volume each, how many marbles can be accommodated in the box

- (A) 10  
 (B) 100  
 (C) 500  
 (D) 50

14. If the percentage of error in measuring the distance is  $0.5\%$  and that in measuring the time is  $0.5\%$ , what will be the percentage of error in measuring the acceleration of a freely falling body?

- (A)  $1.0\%$   
 (B)  $1.5\%$   
 (C)  $2.0\%$   
 (D)  $0.5\%$

15.  $30\%$  of the people read newspaper  $X$ ,  $50\%$  read newspaper  $Y$ , and  $20\%$  read both the papers. What percentage of the people read neither of the newspapers?

- (A) 10  
 (B) 20  
 (C) 30  
 (D) 40

16. A train travelling at a speed of 45 km/hr and is of 130 m long can cross a bridge in 30 seconds. Then the length of the bridge is
- (A) 200 m
  - (B) 225 m
  - (C) 245 m
  - (D) 250 m
17. Which one of the following is a prime number?
- (A) 1009
  - (B) 4199
  - (C) 2401
  - (D) 1221
18. A father said to his son, "I was as old as you are at the present at the time of your birth". If the father's age is 38 years now, the son's age five years back was
- (A) 14 years
  - (B) 19 years
  - (C) 33 years
  - (D) 38 years
19.  $N$  is a sum of squares of three numbers (from a set of whole numbers including zero), which are either all even or all odd. Fill in the missing number ( $x$ ) in the series of values of  $N$  given below in increasing order  
3, 4, 8, 11, 12, 16, 19,  $x$
- (A) 26
  - (B) 24
  - (C) 22
  - (D) 20
20. Arrange the words given below in a meaningful sequence  
i) Introduction, ii) conclusion, iii) Presentation, iv) Abstract, v) Discussion
- (A) i, iii, iv, v, ii
  - (B) iv, i, iii, v, ii
  - (C) i, ii, iii, iv, v
  - (D) iii, i, iv, v, ii

Part - B

21. For a single particle with mass ' $m$ ' which is a function of time ' $t$ ', the differential equation satisfied by the kinetic energy ' $T$ ' is given by

(A)  $\frac{dT}{dt} = F \cdot v$

(B)  $\frac{d(mT)}{dt} = F \cdot v$

(C)  $\frac{d(mT)}{dt} = F \cdot p$

(D)  $\frac{dT}{dt} = \frac{1}{m} F \cdot v$

22. The Lagrangian of a particle in an electric field ( $E$ ) is given by

$$L = \frac{1}{2} m \dot{r}^2 - qEz; \text{ The conserved quantities are:}$$

- (A) Energy and angular momentum
- (B) Energy, angular momentum and distance
- (C) Energy and linear momentum in all directions
- (D) Energy and linear momentum in  $x$  and  $y$  directions

23. Two operators  $b$  and  $b^\dagger$  satisfy the commutation relation:  $[b, b^\dagger] = 1$ . Two new operators are defined as :  $\bar{b} = e^{-S} b e^S$  and  $\bar{b}^\dagger = e^S b e^{-S}$ , where  $S$  is anti-Hermitian. The commutator  $[\bar{b}, \bar{b}^\dagger]$  is equal to

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

24. Commutator of two Hermitian operators is

- (A) Hermitian
- (B) Anti-Hermitian
- (C) Unitary
- (D) Anti-Unitary

25. A harmonic oscillator with energy levels  $E_n = \left(n + \frac{1}{2}\right) \hbar\omega$  is in thermal contact with a heat bath at temperature  $T$ . What is the ratio of the probability of the oscillator being in the first excited state to the probability of it being in the ground state?
- (A)  $e^{-\hbar\omega/k_B T}$   
 (B)  $e^{-2\hbar\omega/k_B T}$   
 (C)  $\frac{1}{2}$   
 (D)  $e^{-\hbar\omega/2k_B T}$
26. Which of the following is minimum in equilibrium of a thermodynamic system for fixed  $N$ ,  $V$ ,  $T$  ( $N$  = total number of particles,  $V$  = volume,  $T$  = temperature)?
- (A) Gibbs free energy  
 (B) Helmholtz free energy  
 (C) Enthalpy  
 (D) Entropy
27. An electron and a proton are injected into a uniform magnetic field perpendicular to it with the same momentum. Which of the following is true?
- (A) Radius of curvature is less for the electron  
 (B) Radius of curvature is more for the electron  
 (C) Radius of curvature is the same for both  
 (D) Both move in straight lines
28. Which of the following *cannot* cause a magnetic field?
- (A) A steady electric current  
 (B) A steady electric field  
 (C) A time-varying electric current  
 (D) A time-varying electric field
29. If the surface current density in the  $xy$ - plane is given by  $\mathbf{J}(x, y) = (\mathbf{i} x^2 + \mathbf{j} y^2)$ , where  $x, y$  are functions of time, then the charge density will change with time at the rate of
- (A)  $2(x+y)$   
 (B)  $(x-y)$   
 (C)  $-(x-y)$   
 (D)  $-2(x+y)$



30. Which of the following are the eigen values of the matrix  $\begin{pmatrix} 2 & i \\ -i & 2 \end{pmatrix}$

- (A)  $1-i, 1+i$
- (B)  $1, 3$
- (C)  $2, 2$
- (D)  $i, -i$

31. If  $\delta^3(r)$  is Dirac delta function in 3 dimensions,  $\nabla^2 \left( \frac{1}{r} \right)$  is equal to

- (A)  $-4\delta^3(r)$
- (B)  $-\delta^3(r)$
- (C)  $-4\pi\delta^3(r)$
- (D)  $-\pi\delta^3(r)$

32. Given one electron per atom contributes to electrical conductivity ( $\sigma$ ) of  $4.1 \times 10^7 (\Omega\text{m})^{-1}$  at 300 K for gold (Au) of atomic weight 196.967 and density  $19.3 \text{ g/cm}^3$ , then the mobility of electrons in  $\text{cm}^2/\text{Vs}$  at 300 K in Au is close to

- (A) 1.76
- (B) 4.52
- (C) 20.8
- (D) 43.4

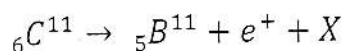
33. Consider a 2-dimensional lattice defined by translation vectors  $\mathbf{t}_1$  and  $\mathbf{t}_2$ . Which of the following statements is true concerning the direction  $[hk]$  and the plane  $(hk)$ ?

- (A) Direction  $[hk]$  is always perpendicular to the plane  $(hk)$ .
- (B) Direction  $[hk]$  is never perpendicular to the plane  $(hk)$ .
- (C) The direction  $[hk]$  is perpendicular to the plane  $(hk)$  only when  $\mathbf{t}_1$  and  $\mathbf{t}_2$  form a square lattice.
- (D) The direction  $[hk]$  is perpendicular to the plane  $(hk)$  only when  $\mathbf{t}_1$  and  $\mathbf{t}_2$  form an oblique lattice.

34. If magnetic moment ( $\mu$ ) of 4 Bohr magnetons is measured on Fe ions in a compound, the valence state of Fe (Atomic no. 26) ion in that compound, (neglect orbital contribution to  $\mu$ ), is

- (A)  $\text{Fe}^-$
- (B)  $\text{Fe}^+$
- (C)  $\text{Fe}^{2+}$
- (D)  $\text{Fe}^{3+}$

35. In the nuclear process



$X$  stand for

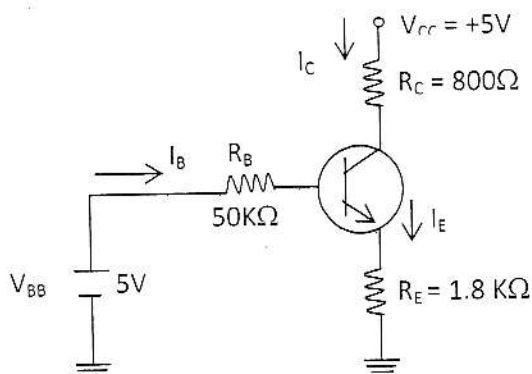
- (A) neutron
- (B) neutrino
- (C) antineutrino
- (D) photon

36. A radioactive isotope has a half-life of 20 days. What is the time required for the activity of the isotope to fall to  $1/8^{\text{th}}$  of its original value

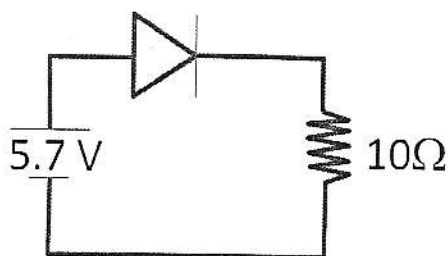
- (A) 40 days
- (B) 160 days
- (C) 60 days
- (D) 80 days

37. Consider the transistor circuit given in the figure below, which has a resistance included between emitter and ground. Amplification factor  $\beta = 50$ . The transistor is operating in which part of the load line?

- (A) saturation region
- (B) active region
- (C) cut-off region
- (D) indeterminate



38. Find the resistance of the silicon diode in the circuit given below



- (A)  $0.7\ \Omega$
  - (B)  $1.4\ \text{k}\Omega$
  - (C)  $1.4\ \Omega$
  - (D)  $2.8\ \Omega$
39. A rod of Copper and another rod of Germanium of identical dimensions are cooled from room temperature to  $80\text{ K}$ . Their resistance ( $R$ ) with temperature ( $T$ ) varies with decreasing  $T$  as
- (A)  $R$  of both increases with  $T$
  - (B)  $R$  of  $\text{Cu}$  increases while that of  $\text{Ge}$  decreases with  $T$
  - (C)  $R$  of  $\text{Cu}$  decreases while that of  $\text{Ge}$  increases with  $T$
  - (D)  $R$  of both decreases with  $T$
40. A beam of polarized light is traveling horizontally along the  $x$ -axis. The beam has its electric field oscillating up and down along the  $y$ -axis. How many polarizing filters would you need to change the direction of polarization so that the electric field oscillates along the  $x$ -axis?
- (A) this cannot be done
  - (B) one filter
  - (C) two filters, oriented at  $90^\circ$  to each other
  - (D) two filters, oriented at  $180^\circ$  to each other

\_\_\_\_End\_\_\_\_