Target IIT-JAM-2018

Test Series-1

Booklet Code: A

Thermodynamics + Solid State & Electronics + Mathematical Physics

Duration: 3:00 Hours | **PHYSICS-PH** | **Date: 31-12-2017**

Maximum Marks: 100

Read the following instructions carefully:

1 Attempt all the questions.

2. **Section-A** contains **30** Multiple Choice Questions (MCQ). Each question has 4 choices (a), (b), (c) and (d), for its answer, out of which **ONLY ONE** is correct. From **Q.1 to Q.10** carries 1 Marks and **Q.11 to Q.3**0 carries 2 Marks each.

3. **Section-B** contains **10** Multiple Select Questions(MSQ). Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which **ONE or MORE than ONE** is/are correct. For each correct answer you will be awarded **2 marks.**

4. Section-**C** contains **20** Numerical Answer Type (NAT) questions. From **Q.41 to Q.50** carries **1 Mark** each and **Q.51 to Q.60** carries **2 Marks** each. For each NAT type question, the value of answer in between 0 to 9.

5. In all sections, questions not attempted will result in zero mark. In Section–A (MCQ), wrong answer will result in negative marks. For all **1 mark** questions, **1/3 marks** will be deducted for each wrong answer. For all **2 marks** questions, **2/3 marks** will be deducted for each wrong answer. In Section–B (MSQ),there is no negative and no partial marking provision. There is no negative marking in Section –C (NAT) as well.

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Section-A : Multiple Choice Questions (MCQ)

Q.1 to Q.10: Carry 1 Mark each.

1. The volume of a first Brillouin zone of a simple cubic lattice of lattice constant a is

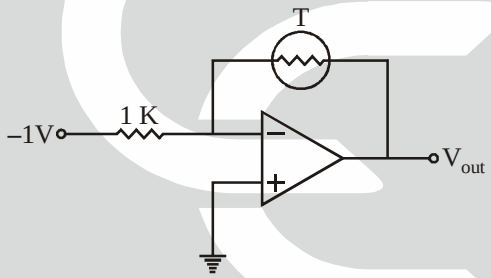
(a) a^3 (b) $(2\pi a)^3$ (c) $\left(\frac{2\pi}{a}\right)^3$ (d) $\left(\frac{4\pi}{a}\right)^3$

2. The simplified Boolean expression associated with the K map shown in Figure (X indicate 'don't care') is

CD \ AB	00	01	11	10
00	0	0	1	1
01	0	X	X	1
11	X	X	1	X
10	1	0	1	1

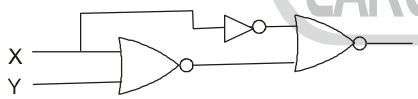
(a) $\bar{A} + \bar{B}C$ (b) $A + \bar{B}C$ (c) $ABC + A\bar{D}$ (d) $A + \bar{A}\bar{B}CD$

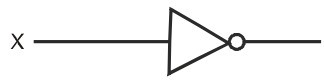
3. In the circuit given below, the thermistor has a resistance 3 kΩ at 25°C. Its resistance decreases by 150Ω per °C upon heating. The output voltage of the circuit at 30°C is

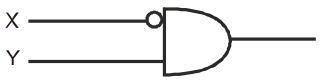


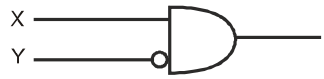
(a) –3.75 V (b) –2.25 V (c) 2.25 V (d) 3.75 V

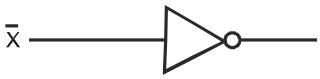
4. The logic circuit shown in the given figure can be minimized to



(a) 

(b) 

(c) 

(d) 

5. Find $\int_S \left(\vec{\nabla} \times \vec{V}\right) \cdot \hat{n} ds$ over the part of the surface $z = 9 - x^2 - 9y^2$ above the (x, y) plane if $\vec{V} = 2xy\hat{i} - x^2 z^2 \hat{k}$

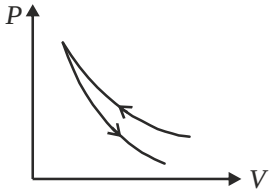
(a) 0 (b) 2π (c) π (d) $-\pi$

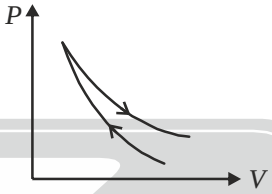
6. If a matrix A can be diagonalized using an orthogonal matrix, then the matrx A is
(a) symmetric (b) skew-symmetric (c) idempotent (d) none of these

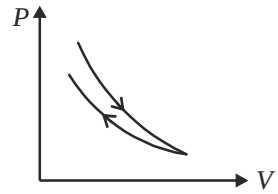
7. For what values of a and b, the differential equation $\left(y+x^3\right)dx+\left(ax+by^3\right)dy=0$ is exact
(a) $a=1, b=1$ (b) $a=1, b=-1$
(c) $a=2, b$ can have only positive value (d) a = 1, b can have any value.

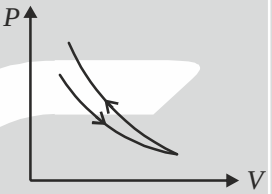
8. An insulated chamber is divided into two halves of volumes. The left half contains a real gas at temperature T_0 and the right half is evacuated. A small hole is opened between the two halves, allowing the gas to flow through and the system comes to equilibrium. No heat is exchanged with the walls. The final temperature of the system T_f is
(a) $T_0 < T_f$ (b) $T_0 > T_f$ (c) $T_0 = T_f$ (d) $T_0 = T_f / 2$

9. A monoatomic gas is compressed isothermally and then allowed to expand adiabatically. Which of the following P-V diagram is correct?

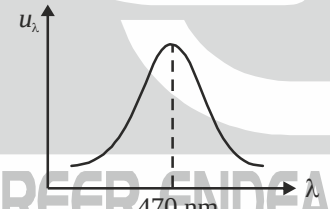
(a) 

(b) 

(c) 

(d) 

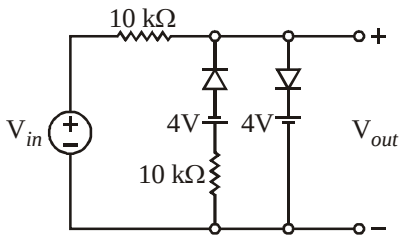
10. The spectral energy curve of the moon is found to be (Given : $\sigma = 5.670367(13)\times10^{-8}\ Wm^{-2}K^{-4}$)



where u_λ and λ have standard meanings. The approximate temperature of the moon's surface is
(a) $6.1\times10^5\ K$ (b) $6.1\times10^4\ K$ (c) $6.1\times10^3\ K$ (d) $6.1\times10^2\ K$

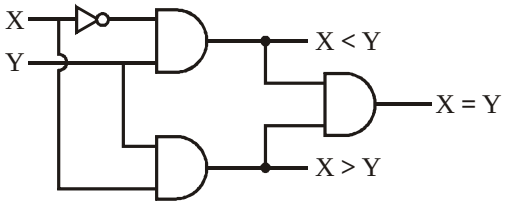
Q.11 to Q.30: Carry 2 Marks each.

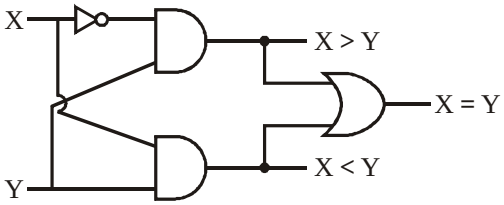
11. A voltage signal 10 sin ωt is applied to the circuit with ideal diodes, as shown in figure. The maximum, and minimum values of the output waveform V_{out} of the circuit are respectively.

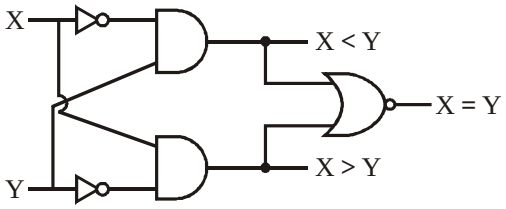


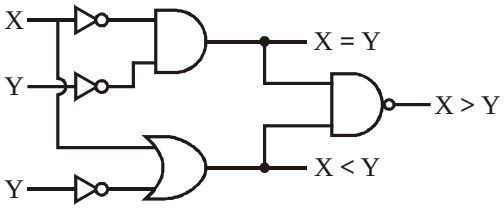
(a) +10 V and –10 V (b) +4 V and –4 V (c) +7 V and –4 V (d) +4 V and –7 V

12. In the figures below, X and Y are one bit inputs. The circuit which corresponds to a one bit comparator is

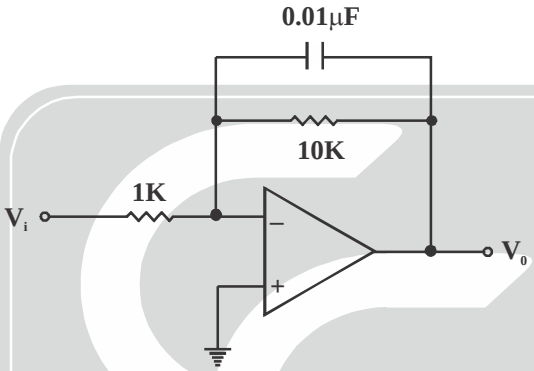
(a)


(b)


(c)


(d)


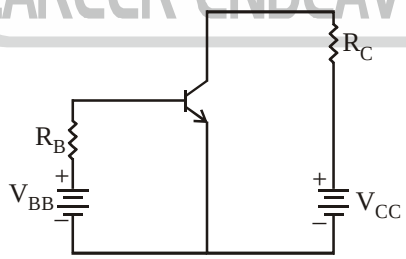
13. In the op-amp circuit shown in the figure, V_i is a sinusoidal input signal of frequency 10 Hz and V_0 is the output signal.

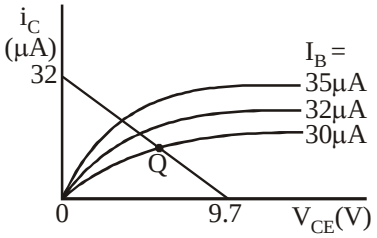


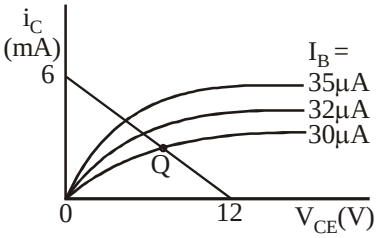
The magnitude of the gain and the phase shift, respectively, are close to the values

(a) $5\sqrt{2}$ and $\frac{\pi}{2}$ (b) $5\sqrt{2}$ and $\frac{-\pi}{2}$ (c) 10 and zero (d) 10 and π

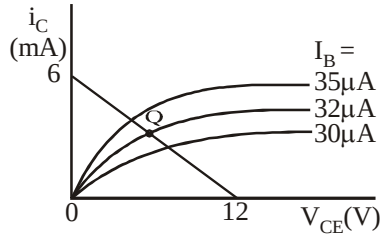
14. A silicon transistor with built-in voltage 0.7V is used in the circuit shown, with $V_{BB} = 9.7V$, $R_B = 300k\Omega$, $V_{CC} = 12V$ and $R_C = 2k\Omega$. Which of the following figures correctly represents the load line and the quiescent Q point?



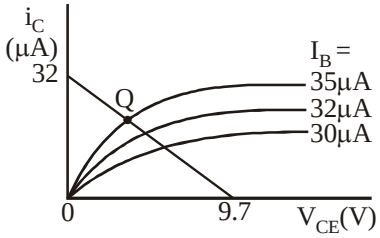
(a)


(b)


(c)



(d)



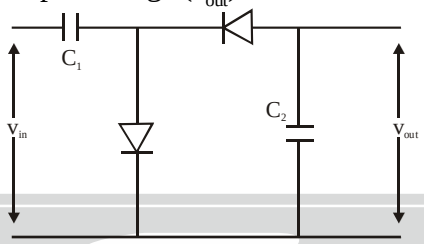
15. The following Boolean expression

$Y = A \bullet \bar{B} \bullet \bar{C} \bullet \bar{D} + \bar{A} \bullet B \bullet \bar{C} \bullet D + \bar{A} \bullet \bar{B} \bullet C \bullet D + \bar{A} \bullet \bar{B} \bullet \bar{C} \bullet D + \bar{A} \bullet B \bullet C \bullet D + A \bullet \bar{B} \bullet \bar{C} \bullet D$

can be simplified to

(a) $\bar{A} \bullet \bar{B} \bullet C + A \bullet \bar{D}$ (b) $\bar{A} \bullet B \bullet \bar{C} + A \bullet \bar{D}$ (c) $A \bullet \bar{B} \bullet \bar{C} + \bar{A} \bullet D$ (d) $A \bullet \bar{B} \bullet C + \bar{A} \bullet D$

16. A sinusoidal input voltage v_{in} of frequency ω is fed to the circuit shown in the figure, where $C_1 >> C_2$. If v_{in} is the peak value of the input voltage, then output voltage (v_{out}) is:



(a) $2v_{in}$ (b) $2v_0 \sin \omega t$ (c) $\sqrt{2}v_{in}$ (d) $\frac{v_{in}}{2} \sin \omega t$

17. Find the flux of vector field $\vec{V}$ through the hemispherical bowl of radius one with its base on x-y plane and the origin at the centre of the base. The vector field is $\vec{V} = \left(r \sin \theta \hat{r} + \hat{\theta} + \hat{\phi} \right)$

(a) $\frac{\pi}{2}$ (b) $-\frac{\pi}{2}$ (c) $-\frac{\pi^2}{2}$ (d) $\frac{\pi^2}{2}$

18. Eigenvectors of a 3×3 matrix A corresponding to the eigenvalues 1, 1, 3 are $[1, 0, -1]^T$, $[0, 1, -1]^T$ and $[1, 1, 0]^T$ respectively. Then the matrix A is

(a) $\begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ (b) $\begin{bmatrix} 2 & -1 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 2 \end{bmatrix}$ (c) $\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & -1 \\ 1 & 0 & 1 \end{bmatrix}$ (d) none

19. The first few terms of Taylor expansion of function $f(x) = e^x \cos x$ about $x = 0$ is

(a) $1 + \frac{x^2}{2!} - \frac{x^3}{3!} - \ldots\ldots\ldots\ldots$ (b) $1 + x - \frac{x^3}{3} - \frac{x^4}{6} \ldots\ldots\ldots\ldots$

(c) $1 - x - \frac{x^3}{3} + \frac{x^4}{6} \ldots\ldots\ldots\ldots$ (d) $x - \frac{x^3}{3} - \frac{x^4}{6} \ldots\ldots\ldots\ldots$

20. A compressor designed to compress air is used instead to compress helium. Assuming the compression is adiabatic and the starting pressure is the same for both the ideal gas, which of the following is correct

(a) The air compressor overcools
(b) The air compressor overheats
(c) The air compressor neither overcools nor overheats
(d) The air compressor first overheats and then overcools

21. Two identical bodies have internal energy $U = NCT$, with a constant C. The values of N and C are the same for each body. The initial temperatures of the bodies are T_1 and T_2, and they are used as a source of work by connecting them to a Carnot heat engine and bringing them to a common final temperature. The work delivered is

(a) $\frac{NC(T_1+T_2)}{2}$ (b) $\frac{NC(T_1-T_2)}{2}$ (c) $NC\left(\sqrt{T_1}-\sqrt{T_2}\right)^2$ (d) $NC\left(\sqrt{T_1}+\sqrt{T_2}\right)^2$

22. If $A=\begin{pmatrix} 0 & 0 & \alpha \\ 0 & -\alpha & 0 \\ \alpha & 0 & 0 \end{pmatrix}$, then eigenvalues of A are

(a) $-2\alpha, \alpha, 0$ (b) $\alpha, -\alpha, -\alpha$ (c) $\alpha, \alpha, -\alpha$ (d) $-\alpha, 0, 0$

23. The value of $(1+i)^{24}$ is equal to

(a) 2^{12} (b) 2^{24} (c) $\left(\sqrt{2}\right)^{12}$ (d) $\left(\sqrt{2}\right)^{6}$

24. The value of $\oint_C \vec{F}\cdot d\vec{r}$, where '$C$' is the curve bounded by $x^2+y^2 \geq 4$, $x^2+y^2 \leq 16$, $x \geq 0$ and $\vec{F} = -y\hat{i} + x\hat{j} + z\hat{k}$, is

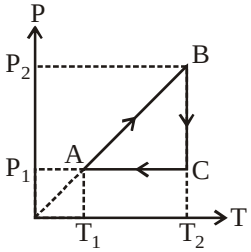
(a) -12π (b) 12π (c) 10π (d) -10π

25. For a fcc lattice, the Miller indices for the first Bragg's peak (smallest Bragg angle) are
(a) (200) (b) (111) (c) (110) (d) (100)

26. The glancing angle for first order diffraction maximum is 60° for X-rays of wavelength 10.0 Å incident on the (100) plane at a simple cubic crystal. The interplanar distance is
(a) 2.88Å (b) 5.77Å (c) 8.64Å (d) 11.52Å

27. The Miller indices of a plane, which cuts off intercepts in the ratio 1a : 3b : –2c along the three axes, where a, b, c are primitives, are
(a) $(63\bar{2})$ (b) $(6\bar{2}3)$ (c) $(2\bar{3}6)$ (d) $(62\bar{3})$

28. Figure shows a process ABCA performed on an ideal gas of n moles

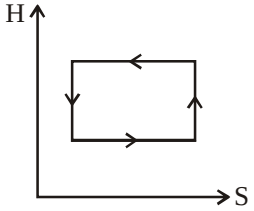


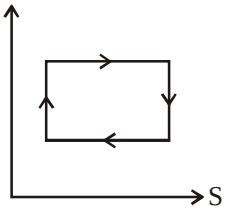
The net heat given to the system is

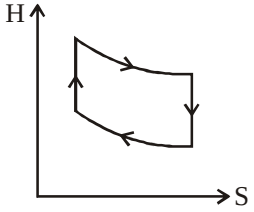
(a) $nRT_2\ell n\left(\frac{P_1}{P_2}\right)+nR(T_2-T_1)$ (b) $nRT_2\ell n\left(\frac{P_1}{P_2}\right)+nR(T_1-T_2)$

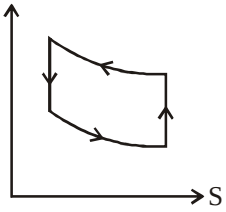
(c) $nRT_2\ell n\left(\frac{P_2}{P_1}\right)+nR(T_2-T_1)$ (d) $nRT_2\ell n\left(\frac{P_2}{P_1}\right)+nR(T_1-T_2)$

29. A Carnot engine is made to operate as a refrigerator with an ideal gas as a working substance. The representation of Carnot cycle of it as an enthalpy (H) – entropy (S) diagram is

(a) 

(b) 

(c) 

(d) 

30. The vander Waals' gas equation for a mole is

$$\left(P+\frac{a}{V^2}\right)(V-b)=RT$$

The value of C_P–C_V where C_P and C_V are the molar specific heat capacity at constant pressure and volume respectively when $V \to \infty$ is

(a) zero (b) $2R$ (c) R (d) $R/2$

Section-B : Multiple Select Questions (MSQ)

Q.31 to Q.40: Carry 2 Marks each.

31. If $A=\begin{pmatrix}1 & 3 & 0\\ 0 & -1 & 1\\ 0 & 0 & 2\end{pmatrix}$ and $B=\begin{pmatrix}\pi/2 & 1 & 3\\ 0 & \pi & 0\\ 0 & 0 & \pi/4\end{pmatrix}$, then choose the correct options is/are

(a) A and B both are diagonalizable (b) A is diagonalizable but not A

(c) Eigenvalues of both A and B are real distinct (d) Eigenvalue of only A is real and distinct

32. Consider the fourier expansion of

$$f(x)=\begin{cases}\pi+x & -\pi<x<0\\ 0 & 0\le x<\pi\end{cases}$$

then which of the following statements is/are incorrect.

(a) Fourier expansion of $f(x)$ is $\frac{\pi}{4}+\frac{2}{\pi}\left[\frac{\cos x}{1^2}+\frac{\cos 3x}{3^2}+.....\right]-\left[\frac{\sin x}{1}+\frac{\sin 2x}{2}+.....\right]$

(b) Fourier expansion of $f(x)$ is $\frac{\pi}{2}+\frac{2}{\pi}\left[\frac{\cos x}{1}+\frac{\cos 3x}{3}+.....\right]-\left[\frac{\sin x}{1}+\frac{\sin 2x}{2}+.....\right]$

(c) At $x = 0$ fourier expansion converges to π

(d) At $x = 0$ fourier expansion converges to $\frac{\pi}{2}$

33. Consider the differential equation, $y''+9y=\cos 3x$, then which of the following statements is/are correct.

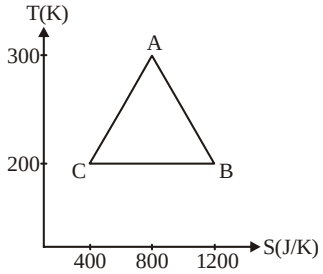
(a) particular integral of differential equation is $\frac{1}{6}x\sin 3x$

(b) particular integral of differential equation is $\frac{1}{6}\sin 3x$

(c) Roots of the auxiliary equation are complex conjugate

(d) Roots of the auxiliary equation are real numbers

34. A reversible engine cycle is shown in figure (T-S diagram). Find out the incorrect statement(s)-



(a) The efficiency of engine is $\frac{1}{5}$.

(b) Heat taken by the engine is 10^5 J.

(c) Work done by the engine is 4×10^4 J

(d) The efficiency of engine is $\frac{1}{3}$.

35. A body of constant heat capacity C_P and a temperature T_i is put into contact with a reservoir at temperature T_f. If $T_i > T_f$, which of the following is/are correct?

(a) The final temperature of the reservoir is T_i.

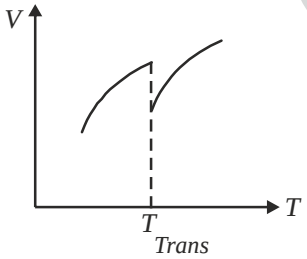
(b) The change in the entropy of the body is $C_P\ell n\left(\frac{T_f}{T_i}\right)$

(c) The change in the entropy of the universe is $C_P\left[\frac{T_i}{T_f}-1+\ell n\left(\frac{T_f}{T_i}\right)\right]$

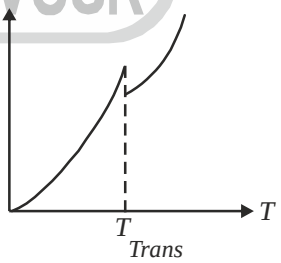
(d) The change in the entropy of the universe is $C_P\left[-\frac{T_i}{T_f}+1+\ell n\left(\frac{T_f}{T_i}\right)\right]$

36. A student was observing various properties of second-order phase transition and oberved the following four graphs

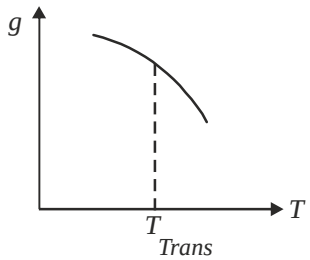
(I)



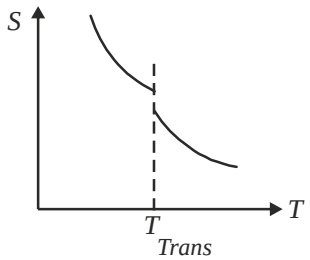
(II)



(III)



(IV)



Which of the following graph/graphs did he measure wrong?

(a) I (b) II (c) III (d) IV

37. Choose the correct statement from the following

(a) If (423) are the Miller indices of a plane, then intercepts made by the plane in the crystallographic axes are $3a$, $6b$ and $4c$ respectively

(b) The miller indices of plane parallel to z-axis are (110)

(c) If a plane intercepts $a, \frac{b}{2}, 3c$ in a simple cubic unit cell. The miller indices are (361).

(d) The miller indices of a set of parallel planes which makes intercepts in the ratio $3a : 4b$ on the X and Y axes are parallel to z-axis are (430)

38. Choose the correct statement(s) from the following

(a) The first Brillouin zone and simple cubic in a region bounded by $k_x = \pm\frac{\pi}{a}, k_y = \pm\frac{\pi}{a}$

(b) The Bragg's law in reciprocal lattice is given by $\left(\vec{k} + \frac{\vec{G}}{2}\right)\cdot\vec{G} = 0$

(c) The second Brillouin zone of simple cubic is a region bounded by $\pm k_x, \pm k_y = -\frac{\pi}{a}$

(d) The second Brillouin zone of simple cubic is a region bound by $\pm k_x, \pm k_y = -\frac{2\pi}{a}$

39. The incorrect statement(s) from the following is/are

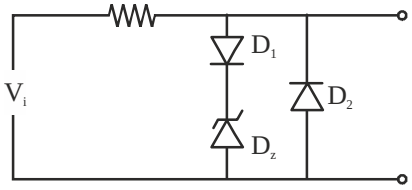
(a) the coordination number of NaCl structure is 6

(b) The number of molecules per unit cell in NaCl lattice is 8

(c) The distance between nearest Na^+ and Cl^- ions in a unit cell of NaCl of lattice constant 'a' is $\frac{a}{\sqrt{2}}$

(d) The distance between nearest like ions in a unit cell of NaCl of lattice constant 'a' is $\frac{a}{2}$

40. Consider a circuit shown in figure. The diodes D_1 and D_2 are made of silicon and the voltage drop across each of them is 0.7V in the forward bias condition. D_z is the zener diode of the breakdown voltage 6.8V. If the input voltage $V_i = 10\sin 100\pi t V$, which of the following statements is/are correct.



(a) The maximum output voltage is 7.5 V

(b) The maximum output voltage is 10 V

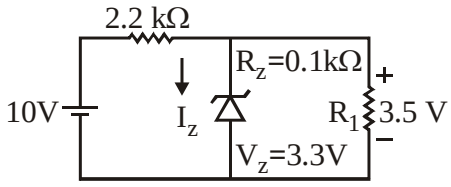
(c) The minimum output voltage is –10 V

(d) The minimum output voltage is –0.7 V

Section-C : Numerical Answer Type (NAT)

Q.41 to Q.50: Carry 1 Mark each.

41. The current through the Zener diode in figure is _____mA



42. The area of the part of the cone $z^2 = 3\left(x^2 + y^2\right)$ (above *x*-*y* plane) which is inside the sphere $x^2 + y^2 + z^2 = 16$, is _____$\times \pi$.

43. If $A = \pi\begin{pmatrix} 2 & 4 \\ 1 & -1 \end{pmatrix}$ and $B = \begin{pmatrix} \pi/2 & 0 \\ 0 & \pi/4 \end{pmatrix}$, then the value of $\det\left(2\sin A \sin B\right)$ is _____

44. If the solution of the differential equation, $y' = 4xy + xy^3 = 0$ has the form $y = \left(ce^{4x^2} - \frac{1}{4}\right)^n$, then the value of *n* is _____

45. If ω is a cube roots of unity and $\left(1+\omega\right)^7 = A + B\omega$, then the value of product (AB) is equal to _____

46. An ideal monoatomic gas initially at t_1 =10ºC is reversibly and adiabatically expands to 10 times its initial volume. The final temperature is _____ºC (nearest integer)

47. The change in entropy in heating a mole of silver at constant volume from 0ºC to 30ºC. (C_V for silver is 5.85 cal/ºC-mol) is _____cal/K (to two place decimal)

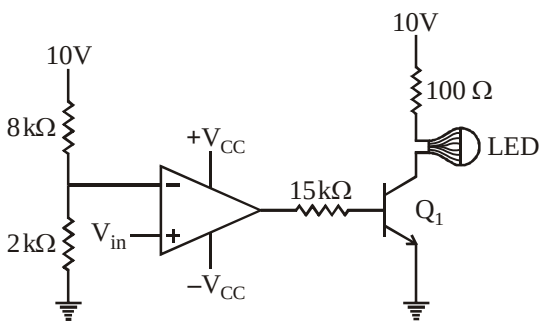
48. The number of ways in which two spin half particles are distributed in three energy levels is _____

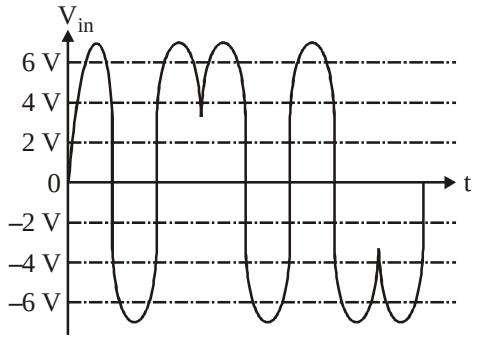
49. Copper crystal has a face-centered cubic structure. The atomic radius of copper atom is 1.28Å. If the atomic mass of the copper is 63.5, the density of copper metal is _____$\times 10^3$ kg/m^3.

50. If the six distinguishable particles are distributed over three non-degenerate levels of energies 0, ε and 2ε, the total energy of the microstates for which the probability is maximum is $n\varepsilon$. The value of n is _____

Q.51 to Q.60: Carry 2 Marks each.

51. The following signal V_{in} of peak voltage 8V is applied to the non-inverting terminal of an ideal op-amp. The transistor has $V_{BE} = 0.7\,V$, $\beta = 100$; $V_{LED} = 1.5\,V$, $V_{CC} = 10\,V$ and $-V_{CC} = 10\,V$.

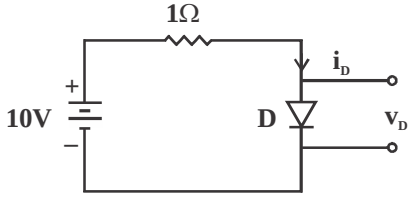




The number of times the LED glows is _____

52. A diode D as shown in the circuit as an i–v relation which can be proximated by

$$i_D = \begin{cases} v_D^2 + 2v_D, & \text{for } v_D > 0 \\ 0, & \text{for } v_D \le 0 \end{cases}$$



The value of v_D in the circuit is _____V

53. If x, y, z are cartesian coordinate and r, θ, ϕ are spherical co-ordinate and J is Jacobian transforming the variables from cartesian to spherical, and we have

$\frac{\partial(x,y,z)}{\partial(r,\theta,\phi)} = |J|$ then $|J|_{r=2,\,\theta=\frac{\pi}{2}}$ is equal to _____

54. If the fourier expansion of $f(x) \forall\, x \in [a,b]$ is given by $f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos\frac{2\pi nx}{b-a} + \sum_{n=1}^{\infty} b_n \sin\frac{2\pi nx}{b-a}$,

then the value of a_2, if $f(x) = \delta\left(x^2 - \frac{\pi^2}{4}\right), x \in [-\pi, \pi]$ is _____$\times \frac{1}{\pi^2}$

55. In the fourier expansion of $f(x) = x,\ -\pi \le x \le \pi$, with $f(x+2\pi) = f(x)$, the ratio of coefficients of 4th overtone to 6th overtone is _____

56. 20 grams of ice at 0ºC are dropped into a beaker containing 120 grams of water at 70ºC. The final temperature of the mixture neglecting the heat capacity of the beaker is _____ºC (to two place decimal), where heat of fusion of ice is 80 cal/g.

57. The equation of state for a gas is $\left(P + \frac{a}{V^3}\right)V^2 = bRT$, a and b are constants. If the variation of the internal energy U with volume V at constant temperature T is $\left(\frac{\partial U}{\partial V}\right)_T = \frac{a}{V^x}$. The value of x is _____(answer should be integer).

58. For lithium, the fermi energy is 4.7 eV and the density of electrons is 4.6×10^{28} /m^3. The electron density for a metal with fermi energy 2.35 eV, is _____$\times10^{28}$ /m^3.

59. If a substance at its boiling point is in equilibrium in liquid and vapour phase such that the volume in the vapour phase is very large as compared to that in liquid phase. If the vapour is considered to be an ideal gas, the vapour pressure at the boiling point varies with boiling point as

$$P = \text{constant} \exp\left(-\frac{a}{T^{2n}}\right)$$

where a is same constant. The value of n is _____

60. If the specific heat of a linear triatomic molecule at very high temperature T is x times $k_B T$, the value of x is _____

***** END OF QUESTION PAPER *****

Space for Rough Work

IIT-JAM PHYSICA-PH

TEST SERIES - 1

Date : 31-12-2017

Booklet: A

(Thermodynamics + Solid State & Electronics + Mathematical Physics)

ANSWER KEY

Section-A : Multiple Choice Questions (MCQ)

1. (c)	**2.** (b)	**3.** (c)	**4.** (d)	**5.** (a)
6. (a)	**7.** (d)	**8.** (b)	**9.** (a)	**10.** (c)
11. (d)	**12.** (c)	**13.** (d)	**14.** (b)	**15.** (c)
16. (a)	**17.** (d)	**18.** (a)	**19.** (b)	**20.** (b)
21. (c)	**22.** (b)	**23.** (a)	**24.** (b)	**25.** (b)
26. (b)	**27.** (d)	**28.** (d)	**29.** (a)	**30.** (c)

Section-B : Multiple Select Questions (MSQ)

31. (a),(c)	**32.** (b),(c)	**33.** (a),(c)	**34.** (b),(d)
35. (b),(c)	**36.** (a),(d)	**37.** (a),(b),(c),(d)	**38.** (a),(b),(d)
39. (c),(d)	**40.** (a), (d)		

Section-C : Numerical Answer Type (NAT)

41. (2)	**42.** (8)	**43.** (0)	**44.** (–0.5)
45. (1)	**46.** (–214 to –210)	**47.** (0.60 to 0.62)	**48.** (6)
49. (8.8 to 9.0)	**50.** (6)	**51.** (3)	**52.** (2)
53. (4)	**54.** (–2)	**55.** (1.4)	**56.** (47 to 50)
57. (3)	**58.** (1.62 to 1.65)	**59.** (0.5)	**60.** (4.4 to 4.7)