JNU MSc 2020

Q1. What is the decimal value of binary 1011.11?

(a) 14.50 (b) 11.75 (c) 16.25 (d) 9.25

Ans. : (b)

Q2. An ideal gas is kept at constant pressure 'P'. The root mean square speed V_{rms} of the gas is doubled by heating at constant volume. Calculate the pressure of the ideal gas after heating

(a) $2P$ (b) $4P$ (c) $6P$ (d) $8P$

Ans. : (b)

Q3. The convex surface of a plano-convex glass lens with curvature radius $40\,cm$ comes into contact with a glass plate. A certain ring observed in reflected light has a radius $2.5\,mm$. Watching the given ring, the lens was gradually removed from the plate by distance of $5\,\mu m$. What has the radius of that ring become equal to?

(a) $6.00\,mm$ (b) $4.50\,mm$ (c) $3.00\,mm$ (d) $1.50\,mm$

Ans. : (d)

Q4. How much heat must be absorbed by ice of mass $m = 700\,gm$ at $-15^0 C$ to take it to the liquid state at $10^0 C$?

Given parameters.

Specific heat of ice $\left(-15^0 C\right) = 2220\,J/kg.K$

(a) $233\,kJ$ Approx (b) $30\,kJ$ Approx

(c) $286\,kJ$ Approx (d) $256\,kJ$ Approx

Ans. : (c)

Q5. The resistance of a semiconductor decreases on heating. This is because:

(a) the material becomes harder on heating

(b) parallel channels of current flow become available

(c) more electrons become available for conduction

(d) the effective mass of an electron reduces on heating

Ans. : (c)

Case Study: Q6 to Q8

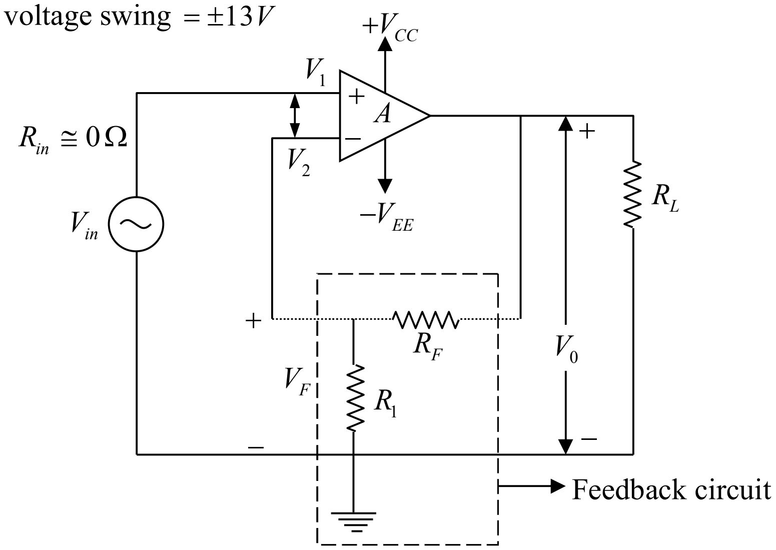
The $741C$ op-amp having the following parameters is connected as a non-inverting amplifier (figure 1) with $R_1 = 1k\Omega$ and $R_F = 20k\Omega$;

Open loop voltage gain $(A) = 2\times10^5$

Open loop resistance of the op-amp $= 2M\Omega$

Supply voltage $= \pm15V$

Output voltage swing $= \pm13V$



Q6. The value of closed loop voltage gain (A_F) is:

(a) 20.99 (b) 30.11 (c) 60.33 (d) 90.66

Ans. : (a)

Q7. What is the value input resistance of the op-amp with feedback (R_{iF})?

(a) $16.5M\Omega$ (b) $19.0G\Omega$ (c) $96G\Omega$ (d) $133G\Omega$

Ans. : (b)

Q8. Total output offset voltage with feedback (V_{OOT}) is:

(a) $\pm7.15mV$ (b) $\pm71.5mV$ (c) $\pm1.36mV$ (d) $\pm715mV$

Ans. : (c)

Q9. The eigenvalues of the orthogonal matrix $B = \frac{1}{6}\begin{bmatrix} 1 & 2 & 2 \\ 2 & 1 & -2 \\ 2 & -2 & 1 \end{bmatrix}$ is

(a) $4,4,-4$ (b) $3/2,3/2,-3/2$

(c) $2,2,-2$ (d) $1/2,1/2,-1/2$

Ans. : (d)

Q10. Let's take a carnot engine that operates between the boiling and freezing points of water. The engine performs $1200\,J$ of work per cycle in $0.5\sec$. Find the energy delivered as heat to the low temperature reservoir energy cycle.

(a) $1200\,J$ approx (b) $3377\,J$ approx

(c) $4477\,J$ approx (d) $3277\,J$ approx

Ans. : (d)

Q11. A steel wire of original diameter $20.0\,mm$ is subject to a tensile load up to fructure. Its diameter at fructure is $16.0\,mm$. Find its ductility.

(a) 40% (b) 36% (c) 32% (d) 28%

Ans. : (b)

Q12. A sphere of radius R carries polarization $\vec{P}(r)=k\vec{r}$, where k is constant and r is vector from centre. What would be the volume bound charge density of sphere?

(a) $3kr^2$ (b) $-3k$ (c) $-\frac{k}{r^2}$ (d) $\frac{\pi k}{4}R^4$

Ans. : (b)

Q13. If W_1 is the work done by an ideal gas at constant temperature 'T' to expand from a volume V_1 to a volume $2V_1$. Let W_2 be the work done by the same ideal gas at the same temperature to expand from V_2 to $4V_2$. Calculate the ratio W_2/W_1?

(a) 1 (b) 2 (c) 3 (d) 4

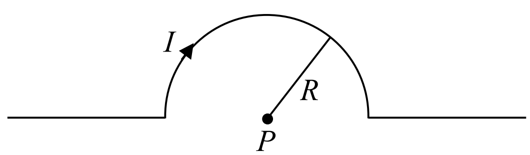
Ans. : (b)

Q14. Let's assume that water is flowing with speed of $12\,cm/\sec$ through a horizontally placed tube of radius $2\,cm$. Find the speed of water flow under similar conditions, in case the radius of tube is doubled

(a) $2\,cm/\sec$ (b) $3\,cm/\sec$ (c) $12\,cm/\sec$ (d) $6\,cm/\sec$

Ans. : (b)

Q15. Calculate magnetic field at centre P of a semi-circle carrying current I and radius R.



(a) $\frac{\mu_0 I}{2R}\left[\frac{1}{2}+\frac{1}{\pi}\right]$ (b) $\frac{\mu_0 I}{2\pi R}$ (c) $\frac{\mu_0 I}{4R}$ (d) $\frac{\mu_0 I}{\pi R}$

Ans. : (c)

Q16. In Michelson's interferometer the light source composed of two wavelengths $600\,nm$ and $600.6\,nm$. In the process of translational displacement of one of the mirrors the interference pattern vanished periodically. Find out the displacement of the mirror between two successive appearances of the sharpest pattern

(a) $30\,mm$ (b) $3\,mm$ (c) $0.3\,mm$ (d) $0.03\,mm$

Ans. : (c)

Q17. Ultraviolet light of wavelength $350\,nm$ and intensity $1.00\,W/m^2$ is directed at a potassium surface. Find the maximum kinetic energy of the photoelectrons. ($h = 6.62\times10^{-34}\,J\cdot s$ and work function of potassium $= 2.5\,eV$)

(a) $0.3\,eV$ (b) $1.0\,eV$ (c) $3.3\,eV$ (d) $7.1\,eV$

Ans. : (b)

Q18. Let's take a black total absorbing piece of cardboard of area $A = 2.00\,cm^2$, which intercepts light with an intensity of $24\,W/m^2$ from sunlight. Find the radiation pressure produced on the cardboard by the light.

(a) $3\times10^{8}\,N/m^2$ (b) $8\times10^{-8}\,N/m^2$

(c) $3\times10^{-8}\,N/m^2$ (d) $8\times10^{8}\,N/m^2$

Ans. : (b)

Q19. An ideal gas undergoes an isothermal expansion (at temperature T) from volume V_1 to V_2. The entropy change per mole is

(a) $R\left(\frac{V_2}{V_1}\right)$ (b) $R\left(\frac{V_1}{V_2}\right)$ (c) $R\ln\left(\frac{V_2}{V_1}\right)$ (d) $R\ln\left(\frac{V_1}{V_2}\right)$

Ans. : (c)

Q20. An electron gas is confined in a box of volume V. The number of electrons is N. The Fermi energy E_F at $T = 0\,K$ obeys:

(a) $E_F \propto \left(\frac{N}{V}\right)^{1/3}$ (b) $E_F \propto \left(\frac{N}{V}\right)^{2/3}$ (c) $E_F \propto \frac{N^{1/3}}{V^{2/3}}$ (d) $E_F \propto \frac{N^{2/3}}{V^{1/3}}$

Ans. : (b)

Q21. Consider an ideal gas at pressure P_1 and volume V_1 undergoing free expansion to volume $2V_1$. Then the gas is adiabatically expanded to a volume $16V_1$. Calculate the final pressure of the gas.

(a) P_1 (b) $\frac{P_1}{4}$ (c) $\frac{P_1}{16}$ (d) $\frac{P_1}{64}$

Ans. : (d)

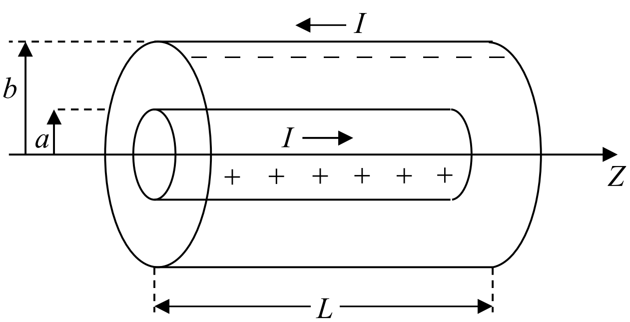
Q22. A gas of particles obeys the Maxwell-Boltzmann distribution. The value of the average speed $\langle v \rangle$ is :

(a) $\sqrt{3}\sqrt{\frac{kT}{m}}$ (b) $\sqrt{\frac{kT}{m}}$ (c) $\frac{2\sqrt{2}}{\sqrt{\pi}}\sqrt{\frac{kT}{m}}$ (d) $\frac{\sqrt{6}}{\pi}\sqrt{\frac{kT}{m}}$

Ans. : (c)

Case Study: Q23 to Q25

A long coaxial cable of length 'L' consists of an inner conductor (radius a) and outer conductor (radius b). The inner conductor carries a uniform charge per unit length λ and steady current I. The outer conductor has opposite charge and current as shown in following figure.



Q23. Find the total magnetic energy stored between the inner and outer conductor.

(a) $\frac{\mu_0 I^2}{4\pi}\ln\left(\frac{b}{a}\right)$ (b) $\frac{\mu_0^2 I^2 L}{2\pi}\ln\left(\frac{b}{a}\right)$

(c) $\frac{\mu_0 I^2 L}{4\pi}\ln\left(\frac{b}{a}\right)$ (d) $\frac{\mu_0^2 I^2}{4\pi}L$

Ans. : (c)

Q24. Find the electric field at any point r between the inner and outer conductor.

(a) $\frac{\lambda}{2\pi r L \in_0}$ (b) $\frac{\lambda}{2\pi r \in_0}$ (c) $\frac{\lambda}{4\pi \in_0 r^2}$ (d) $\frac{\pi \lambda a L}{4 \in_0 r^2}$

Ans. : (b)

Q25. Calculate the energy transported by these magnetic and electric fields per unit time, per unit area at the surface of inner conductor.

(a) $\frac{\lambda^2}{8\pi^2 a^2 \in_0}$ (b) $\frac{\mu_0 I \lambda}{4\pi_0^2 \in_0}$ (c) $\frac{\lambda}{I \mu_0^2 \in_0}$ (d) $\frac{I\lambda}{4\pi^2 a^2 \in_0}$

Ans. : (d)

Q26. For a magnet, C_h and C_M are the specific heats at constant magnetic field (h) and magnetization (M), respectively. Which of the following statements is correct?

(a) $C_h \geq C_M$

(b) $C_h = C_M$

(c) $C_h \leq C_M$

(d) C_h may be greater or less than C_M, depending on the material.

Ans. : (a)

Q27. In a one-dimensional infinite square well of length 'a', there are 6×10^9 electrons per meter. If all the lowest energy levels are filled, determine the energy of the most energetic electron.

($h = 4.136\times10^{-15}\, eV\cdot s, C = 3\times10^8\, m/s, m_e = 9.1\times10^{-31}\, kg$)

(a) $3.38\, eV$ (b) $13.25\, eV$ (c) $21.05\, eV$ (d) $27.28\, eV$

Ans. : (a)

Q28. Suppose a long wire of radius 'R' carries uniformly distributed current I. Find the magnetic field at point 'r' inside the wire.

(a) $\frac{\mu_0 I}{2\pi R}$ (b) $\frac{\mu_0 I}{2\pi r}$ (c) $\frac{\mu_0 I r^2}{2\pi R^2}$ (d) $\frac{\mu_0 I r}{2\pi R^2}$

Ans. : (d)

Q29. A source of sonic oscillations with frequency $1700\, Hz$ and a receiver is located on the same normal to a wall. Both the source and receiver are stationary, and the wall recedes from the source with velocity $6.0\, cm/s$. Find out the beat frequency registered by the receiver. The velocity of sound is $340\, m/s$.

(a) $0.6\, Hz$ (b) $1.2\, Hz$ (c) $1.8\, Hz$ (d) $2.4\, Hz$

Ans. : (a)

Q30. Determine $\vec{\nabla}\left(\frac{\vec{r}}{r^n}\right), n > 0$ and $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

(a) $\frac{3-n}{r^{\frac{n}{2}}}$ (b) $\frac{3-n}{r^n}$ (c) $\frac{n-3}{r}$ (d) $\frac{n-3}{r^{\frac{n}{2}}}$

Ans. : (b)

Q31. A $24V$, $600\,mW$ zener diode is to be used for providing a $24V$ stabilized supply to a variable load. If input voltage is $32V$, calculate the series resistance R required and diode current when load resistance is $12000\,\Omega$.

(a) $320\,\Omega$ and $23\,mA$ (b) $650\,\Omega$ and $15\,mA$

(c) $900\,\Omega$ and $2\,mA$ (d) $1200\,\Omega$ and $8\,mA$

Ans. : (a)

Q32. What will be the cohesive energy of copper (FCC), given the bond energy between two copper atoms is $56.8\,kJ/mol$?

(a) $92.6\,kJ/mol$ (b) $112.5\,kJ/mol$

(c) $340.8\,kJ/mol$ (d) $693.2\,kJ/mol$

Ans. : (c)

Q33. A physical pendulum performs small oscillations about the horizontal axis with frequency $\omega_1 = 15.0\sec^{-1}$. When a small mass $m = 100$ gram is fixed to the pendulum at a distance $I = 20\,cm$ below the axis, the oscillation frequency becomes equal to $\omega_2 = 10.0\sec^{-1}$. Find out the moment of inertia (I) of the pendulum relative to the oscillation axis. (where acceleration of gravity $g = 10\,m/\sec^2$

(a) $0.80\,gram\cdot m^2$ (b) $1.60\,gram\cdot m^2$

(c) $2.40\,gram\cdot m^2$ (d) $3.20\,gram\cdot m^2$

Ans. : (b)

Q34. Consider the phase diagram of water in the pressure-temperature plane. Which of the following statements is **false**?

(a) It is possible to directly convert water vapour to ice.

(b) It is possible to convert water vapour to water without a phase transition.

(c) The triple point corresponds to the coexistence of three phases.

(d) All phase transitions are characterized by a latent heat.

Ans. : (d)

Q35. An electric field in free space is given by $\vec{E} = 100\cos\left(10^8 t + kx\right)\hat{e}_y$. Find the wavelength of propagating wave.

(a) 10^8 (b) 2π (c) $\frac{1}{3}$ (d) 6π

Ans. : (d)

Q36. Calculate the maximum frequency of vibration in a one-dimensional lattice of identical atoms of mass $9.0\times10^{-26}\,kg$. If force constant of nearest neighbour interaction is $100\,N/m$.

(a) $10.61\times10^{10}\,Hz$ (b) $10.61\times10^{12}\,Hz$

(c) $10.61\times10^{14}\,Hz$ (d) $10.61\times10^{16}\,Hz$

Ans. : (b)

Q37. The wave functions of electrons in a one-dimensional potential box of dimension is given by $\psi_n = A\sin\left(\frac{n\pi}{a}\right)x$, where $n = 1, 2, 3, ...$

The value of A by normalizing the wave function to unity is:

(a) $\sqrt{\frac{4}{a}}$ (b) $\sqrt{\frac{2}{a}}$ (c) $\sqrt{\frac{a}{4}}$ (d) $\sqrt{\frac{a}{2}}$

Ans. : (b)

Q38. Find the unit normal to the surface defined by $xy^3z^2 = 4$ at $(-1,-1,2)$.

(a) $-4i-12j+4k$ (b) $\frac{-1}{\sqrt{11}}\left(\hat{i}+3\hat{j}-\hat{k}\right)$

(c) $4i+4j+4k$ (d) $i+3j+k$

Ans. : (b)

Q39. A material whose K absorption edge is $0.15\overset{0}{\mathrm{A}}$ is irradiated with $0.08\overset{0}{\mathrm{A}}$ X-rays. What is the maximum kinetic energy of photoelectrons that are emitted from the K shell ?

(a) $11.3\,keV$ (b) $25.3\,keV$ (c) $72.3\,keV$ (d) $81.3\,keV$

Ans. : (c)

Q40. If $x = \sqrt{-1}$, what is the value of x^{2x} ?

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

Ans. : (d)

Q41. The resistivity of Si at $300\,K$ is 3.16×10^{3} ohm-m. The mobility of electrons and holes in Si are $0.14\,m^2/V\text{-sec}$ and $0.06\,m^2/V\text{-sec}$ respectively. The intrinsic carrier density is:

(a) $0.05\times10^{19}/m^3$ (b) $1.00\times10^{16}/m^3$

(c) $4.01\times10^{13}/m^3$ (d) $6.02\times10^{12}/m^3$

Ans. : (b)

Q42. In a Compton experiment an electron attains a kinetic energy of $0.200\,MeV$ when an X-ray of energy $0.500\,MeV$ strikes it. Determine the wavelength of the scattered photon if the electron is initially at rest.

($h = 4.136\times10^{-15}\,eV\cdot s$)

(a) $9\times10^{-12}\,A$

(b) $21\times10^{-9}\,A$

(c) $43\times10^{-9}\,A$

(d) $41\times10^{-9}\,A$

Ans. : (d)

Q43. In a photoelectric experiment, light of wavelength $700\,nm$ is incident on a metal of work function $2\,eV$. The maximum kinetic energy of emitted photoelectrons is :

(a) $1\,eV$

(b) $0.66\,eV$

(c) $0.33\,eV$

(d) There is no photo-emission

Ans. : (d)

Q44. Suppose in a sphere, the electric field inside at some point r is found to be $\vec{E} = kr^2\hat{r}$, where k is constant. Find the charge density ρ.

(a) $2k\in_0 r$

(b) $4k\in_0 r^2$

(c) $4k\in_0 r$

(d) $\frac{3k}{4\pi}\frac{1}{r}$

Ans. : (c)

Q45. In a pure macroscopic, perfect crystal the major contribution to thermal resistance at normal temperature is from:

(a) Boundary scattering

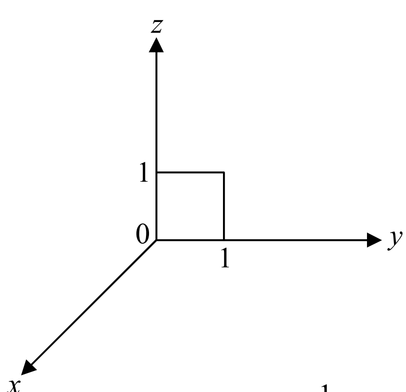
(b) Umklapp process

(c) Impurity scattering

(d) Harmonic vibration of lattice atom

Ans. : (b)

Q46. Suppose there is a vector $\vec{v} = 4yz\hat{y} + (3xy + 2z^2)\hat{z}$. Calculate $\int(\vec{\nabla}\times\vec{v})\cdot d\vec{a}$ for given square surface area in figure. The $d\vec{a}$ is elementary surface area with directing along $+x$ axis.



(a) -2

(b) $3x-2$

(c) $-\frac{1}{2}$

(d) -7

Ans. : (a)

Q47. Boolean function $Y=(A+B)\left(A'(B'+C')\right)'+A'(B+C)$. What is the simplified form of Y ?

(a) $A+B+C$ (b) $(A'+B'+C')$

(c) $(AB+BC+AC)$ (d) ABC

Ans. : (a)

Q48. The Laplace transform of $\cos^2 t$ is

(a) $\frac{1}{2}\left[\frac{s^2}{s^2+4}+\frac{1}{2}\right]$ (b) $\frac{1}{2}\left[\frac{s^2}{s^2+4}+\frac{1}{s}\right]$

(c) $\left[\frac{2}{s^2+4}+\frac{1}{2}\right]$ (d) $\left[\frac{s^2}{s^2+4}+\frac{1}{s}\right]$

Ans. : (b)

Q49. Let's take three vectors

$$\vec{A}=6\hat{i}+4\hat{j}+\hat{k}$$

$$\vec{B}=\hat{i}+4\hat{j}+2\hat{k}$$

$$\vec{C}=7\hat{i}+X\hat{j}+3\hat{k}$$

Find the value of 'X' when these vectors are co-planar.

(a) 7 (b) 8 (c) 6 (d) 9

Ans. : (b)

Q50. Find the electric field inside a solid sphere which carries a charge density proportional to the distance from its origin, $\rho=kr$ where k is constant.

(a) $\frac{\pi k r^4}{\epsilon_0}$ (b) $\frac{kr^2}{4\epsilon_0}$ (c) $\frac{kr^2}{3\epsilon_0}$ (d) $\frac{k}{4\pi\epsilon_0 r}$

Ans. : (b)