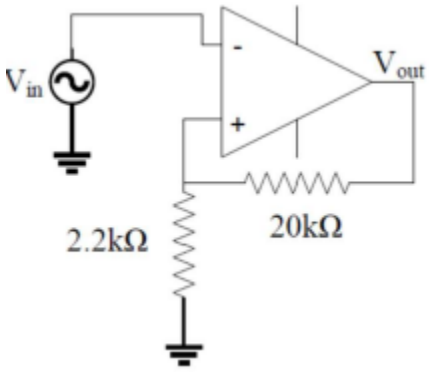
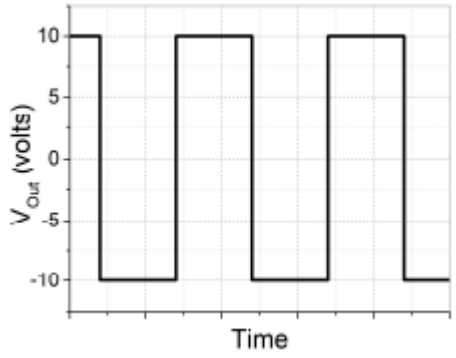
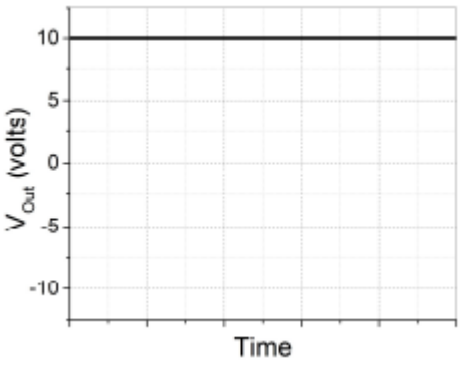
Q1) For the Op-Amp circuit shown below, choose the correct output waveform corresponding to the input V_{in} = 1.5 sin 20πt (in Volts). The saturation voltage for this circuit is V_{sat} = ±10 V.



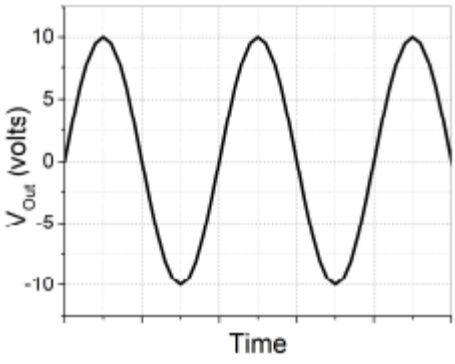
(A)



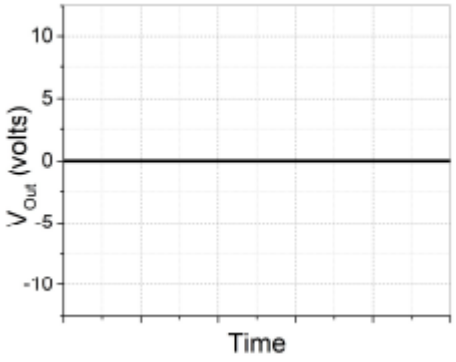
(B)



(C)



(D)



Q2) Match the order of β – decays given in the left column to appropriate clause in the right column. Here $X(I^{\pi})$ and $Y(I^{\pi})$ are nuclei with intrinsic spin I and parity π.

1. $X\left(\frac{1}{2}^{+}\right) \rightarrow Y\left(\frac{1}{2}^{+}\right)$	i)	First forbidden β-decay
2. $X\left(\frac{1}{2}^{-}\right) \rightarrow Y\left(\frac{5}{2}^{+}\right)$	ii)	Second forbidden β-decay
3. $X(3^{+}) \rightarrow Y(0^{+})$	iii)	Third forbidden β-decay
4. $X(4^{-}) \rightarrow Y(0^{+})$	iv)	Allowed β-decay

(A) 1 – i, 2 – ii, 3 – iii, 4 – iv
(B) 1 – iv, 2 – i, 3 – ii, 4 – iii
(C) 1 – i, 2 – iii, 3 – ii, 4 – iv
(D) 1 – iv, 2 – ii, 3 – iii, 4 – i

Q3) What is the maximum number of free independent real parameters specifying an n-dimensional orthogonal matrix?
(A) $n(n-2)$

(B) $(n-1)^2$
(C) $n(n-1)/2$
(D) $n(n+1)/2$

Q4) An excited state of Ca atom is $[Mg]3p^5 4s^2 3d^1$. The spectroscopic terms corresponding to the total orbital angular momentum are
(A) S, P, and D
(B) P, D, and F
(C) P and D
(D) S and P

Q5) On the surface of a spherical shell enclosing a charge free region, the electrostatic potential values are as follows: One quarter of the area has potential $\phi^<$, another quarter has potential $2\phi_0$ and the rest has potential $4\phi_0$. The potential at the centre of the shell is (You can use a property of the solution of Laplace's equation.)
(A) 11 / 4 ϕ_0
(B) 11 / 2 ϕ_0
(C) 7 / 3 ϕ_0
(D) 7 / 4 ϕ_0

Q6) A point charge q is performing simple harmonic oscillations of amplitude A at angular frequency ω. Using Larmor's formula, the power radiated by the charge is proportional to
(A) $q\omega^2A^2$
(B) $q\omega^4A^2$
(C) $q^2\omega^2A^2$
(D) $q^2\omega^4A^2$

Q7) Which of the following relationship between the internal energy U and the Helmholtz's free energy F is true?
(A) $$U = -T^2\left[\frac{\partial\left(\frac{F}{T}\right)}{\partial T}\right]_V$$
(B) $$U = +T^2\left[\frac{\partial\left(\frac{F}{T}\right)}{\partial T}\right]_V$$

(C) $U = +T\left[\frac{\partial F}{\partial T}\right]_V$

(D) $U = -T\left[\frac{\partial F}{\partial T}\right]_V$

Q8) If nucleons in a nucleus are considered to be confined in a three-dimensional cubical box, then the first four magic numbers are

(A) 2, 8, 20, 28
(B) 2, 8, 16, 24
(C) 2, 8, 14, 20
(D) 2, 10, 16, 28

Q9) Consider the ordinary differential equation

$$y'' - 2xy' + 4y = 0$$

and its solution $y(x) = a + bx + cx^2$**. Then**

(A) $a = 0$, $c = -2b \neq 0$
(B) $c = -2a \neq 0$, $b = 0$
(C) $b = -2a \neq 0$, $c = 0$
(D) $c = 2a \neq 0$, $b = 0$

Q10) For an Op-Amp based negative feedback, non-inverting amplifier, which of the following statements are true?

(A) Closed loop gain < Open loop gain
(B) Closed loop bandwidth < Open loop bandwidth
(C) Closed loop input impedance > Open loop input impedance
(D) Closed loop output impedance < Open loop output impedance

Q11) From the pairs of operators given below, identify the ones which commute. Here l **and** j **correspond to the orbital angular momentum and the total angular momentum, respectively.**

(A) l^2, j^2
(B) j^2, j_z
(C) j^2, l_z
(D) l_z, j_z

Q12) For normal Zeeman lines observed $\parallel$ **and** $\perp$ **to the magnetic field applied to an atom, which of the following statements are true?**

(A) Only π-lines are observed $\parallel$ to the field

(B) σ-lines $\perp$ to the field are plane polarised
(C) π-lines $\perp$ to the field are plane polarised
(D) Only σ-lines are observed $\parallel$ to the field

Q13) For a bipolar junction transistor, which of the following statements are true?
(A) Doping concentration of emitter region is more than that in collector and base region
(B) Only electrons participate in current conduction
(C) The current gain β depends on temperature
(D) Collector current is less than the emitter current

Q14) Electric field is measured along the axis of a uniformly charged disc of radius 25 cm. At a distance d from the centre, the field differs by 10% from that of an infinite plane having the same charge density. The value of d is _____cm.
(Round off to one decimal place)

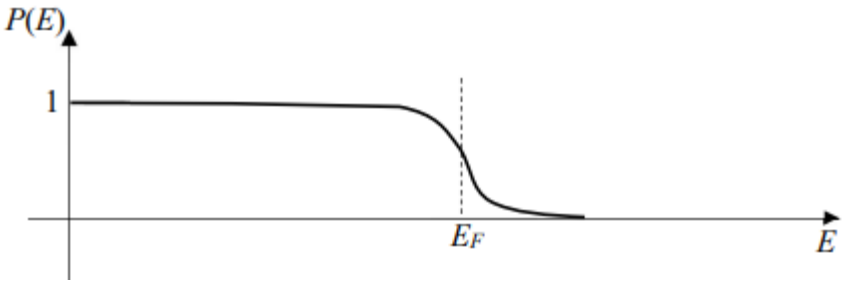
Q15) In a solid, a Raman line observed at 300 cm^{-1} has intensity of Stokes line four times that of the anti-Stokes line. The temperature of the sample is _____K.
(Round off to the nearest integer) (1 $cm^{-1} \equiv 1.44$ K)

Q16) Water at 300 K can be brought to 320 K using one of the following processes.
Process 1: Water is brought in equilibrium with a reservoir at 320 K directly.
Process 2: Water is first brought in equilibrium with a reservoir at 310 K and then with the reservoir at 320 K.
Process 3: Water is first brought in equilibrium with a reservoir at 350 K and then with the reservoir at 320 K.
The corresponding changes in the entropy of the universe for these processes are ΔS_1, ΔS_2 and ΔS_3 respectively. Then

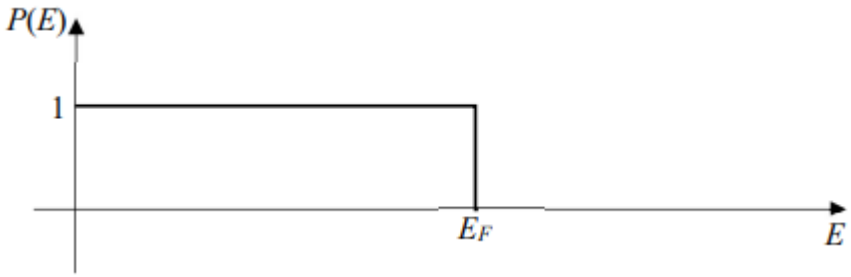
(A) $\Delta S_2 > \Delta S_1 > \Delta S_3$
(B) $\Delta S_3 > \Delta S_1 > \Delta S_2$
(C) $\Delta S_3 > \Delta S_2 > \Delta S_1$
(D) $\Delta S_1 > \Delta S_2 > \Delta S_3$

Q17) At T = 0 K, which of the following diagram represents the occupation probability $P(E)$ of energy states of electrons in a BCS type superconductor?

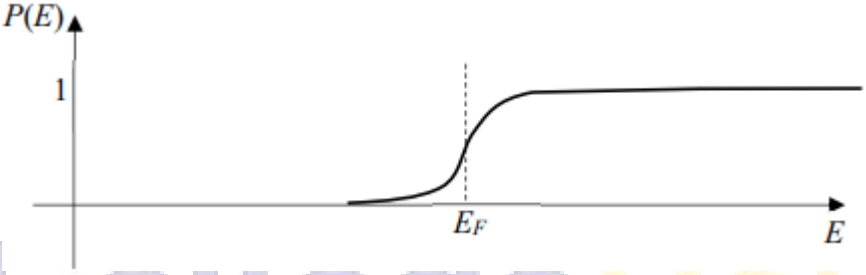
(A)



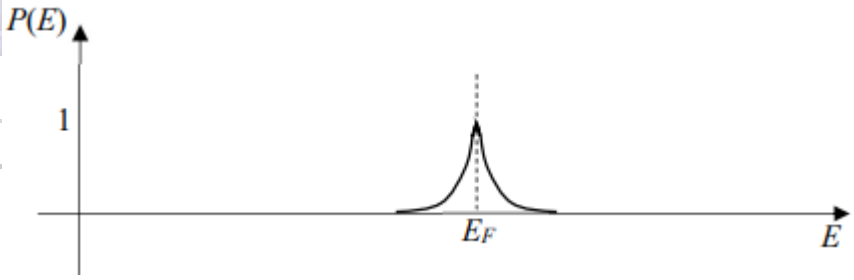
(B)



(C)



(D)



Q18) In a Hall effect experiment on an intrinsic semiconductor, which of the following statements are correct?

(A) Hall voltage is always zero

(B) Hall voltage is negative if the effective mass of holes is larger than those of electrons

(C) Hall coefficient can be used to estimate the carrier concentration in the semiconductor

(D) Hall voltage depends on the mobility of the carriers

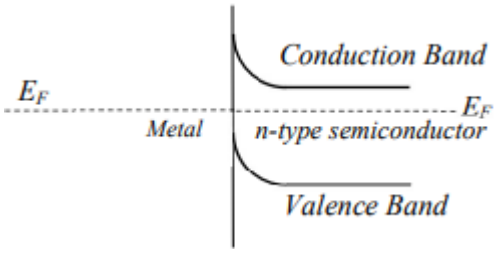
Q19) A system with time independent Hamiltonian $H(q, p)$ has two constants of motion $f(q, p)$ and $g(q, p)$. Then which of the following Poisson brackets are always zero?

(A) $\{H, f+g\}$

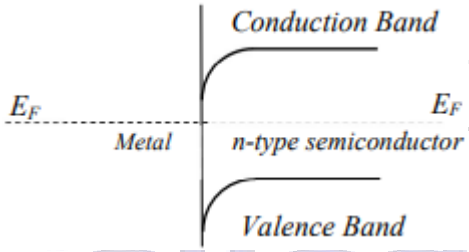
(B) $\{H, \{f, g\}\}$
(C) $\{H + f, g\}$
(D) $\{H, H + fg\}$

Q20) A junction is formed between a metal on the left and an *n*-type semiconductor on the right. Before forming the junction, the Fermi level E_F of the metal lies below that of the semiconductor. Then which of the following schematics are correct for the bands and the I-V characteristics of the junction?

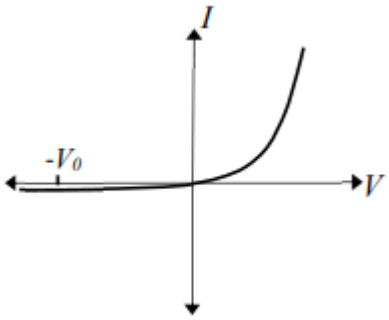
(A)



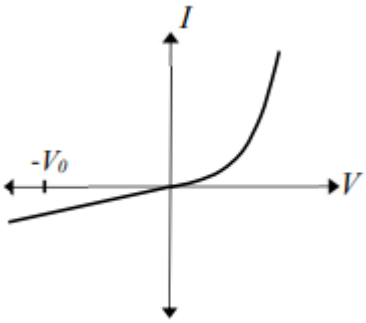
(B)



(C)



(D)



Q21) If the peak output voltage of a full wave rectifier is 10 V, its d.c. voltage is
(A) 10.0 V
(B) 7.07 V
(C) 6.36 V
(D) 3.18 V

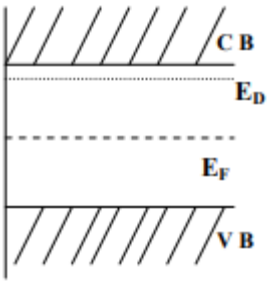
Q22) Which one of the following sets corresponds to fundamental particles?
(A) proton, electron and neutron
(B) proton, electron and photon
(C) electron, photon and neutrino
(D) quark, electron and meson

Q23) In case of a Geiger-Muller (GM) counter, which one of the following statements is CORRECT?
(A) Multiplication factor of the detector is of the order of 10^{10}
(B) Type of the particles detected can be identified
(C) Energy of the particles detected can be distinguished
(D) Operating voltage of the detector is few tens of Volts

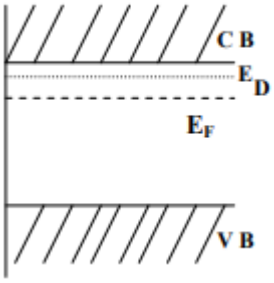
Q24) A plane electromagnetic wave travelling in free space is incident normally on a glass plate of refractive index 3/2. If there is no absorption by the glass, its reflectivity is
(A) 4%
(B) 16%
(C) 20%
(D) 50%

Q25) Identify the CORRECT energy band diagram for Silicon doped with Arsenic. Here CB, VB, E_D and E_F are conduction band, valence band, impurity level and Fermi level, respectively.

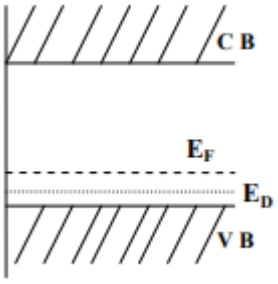
(A)



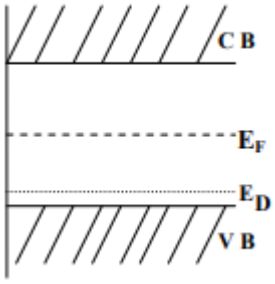
(B)



(C)



(D)



Q26) The first Stokes line of a rotational Raman spectrum is observed at 12.96 cm^{-1}. Considering the rigid rotor approximation, the rotational constant is given by

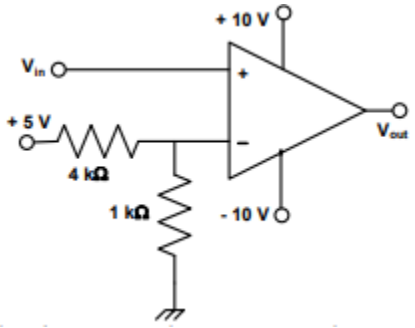
(A) 6.48 cm^{-1}

(B) 3.24 cm^{-1}

(C) 2.16 cm^{-1}

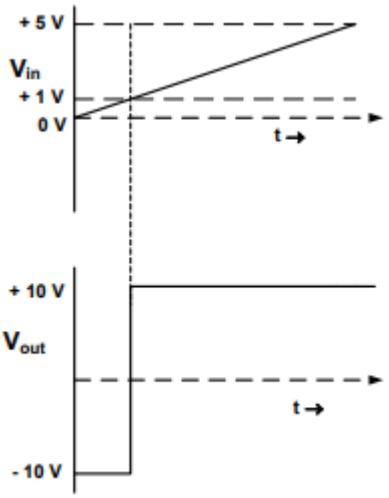
(D) 1.62 cm^{-1}

Q27) Consider the following OP-AMP circuit.

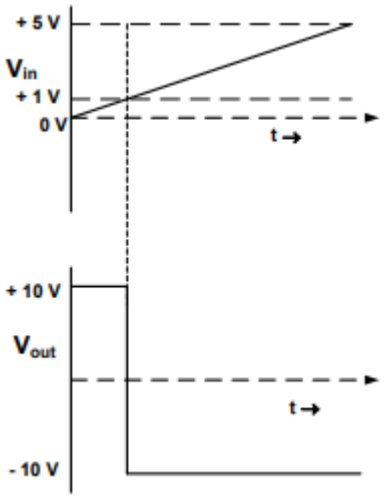


Which one of the following correctly represents the output V_{out} corresponding to the input V_{in}?

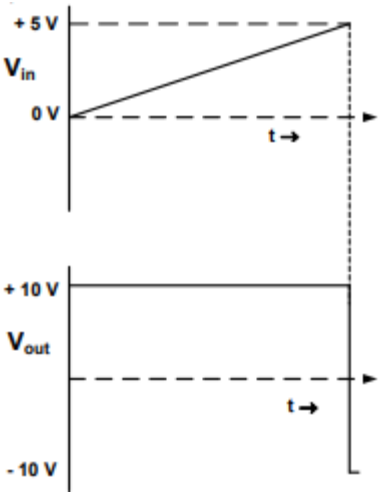
(A)



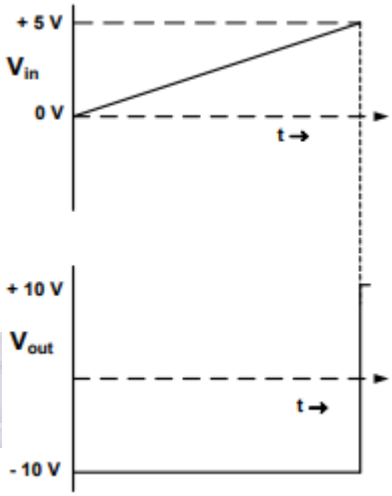
(B)



(C)



(D)



Q28) Deuteron has only one bound state with spin parity 1^+, isospin 0 and electric quadrupole moment 0.286 efm^2. These data suggest that the nuclear forces are having

(A) only spin and isospin dependence
(B) no spin dependence and no tensor components
(C) spin dependence but no tensor components
(D) spin dependence along with tensor components

Q29) Which one of the following CANNOT be explained by considering a harmonic approximation for the lattice vibrations in solids?

(A) Debye's T^3 Law
(B) Dulong Petit's law
(C) Optical Branches in Lattices
(D) Thermal Expansion

Q30) Choose the CORRECT statement from the following.

(A) Neutron interacts through electromagnetic interaction

(B) Electron does not interact through weak interaction

(C) Neutrino interacts through weak and electromagnetic interaction

(D) Quark interacts through strong interaction but not through weak interaction