2022

PHYSICS — HONOURS

(Syllabus : 2019-2020)

Paper : CC-9

[Analog Electronics]

Full Marks : 50

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Answer ***question no.* 1** and ***any four*** questions from the rest.

1. Answer ***any five*** questions : 2×5

(a) State and explain Thevenin's theorem.

(b) Can barrier potential be measured by a voltmeter?

(c) Why is the emitter current always greater than the collector current in normal biasing BJT?

(d) Mention the utilities of emitter bypass capacitor and coupling capacitor from collector in self biased configuration of BJT.

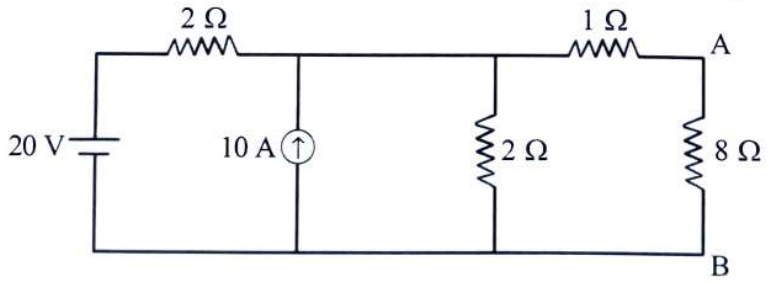
(e) What are the advantages of negative feedback in voltage amplifier?

(f) Draw the circuit diagram of a bridge rectifier.

(g) What is slew rate of an OPAMP?

2. (a) State and explain Norton's theorem.

(b) Solve the circuit shown below for the current in the branch AB using Norton's theorem.



(c) State Maximum Power transfer theorem. (2+1)+5+2

3. (a) Find the expression for the ripple factor of a half-wave rectifier.

(b) Explain with a circuit diagram, the use of Zener diode as a reference diode.

(c) Explain the principle of operation of an LED. Why is silicon not preferred as an LED material? 3+4+(2+1)

Please Turn Over

4. (a) What are the factors that affect the bias stability of a transistor? Define stability factor with respect to change of any one of them.

   (b) A transistor is operating in CE configuration. A 560 Ω resistor is joined between the collector and power supply and a voltage drop of 0.6V occurs across it. If $\alpha = 0.97$, calculate the base current.

   (c) Using *h* parameters, obtain an expression for input resistance of a CE amplifier. (2+1)+4+3

5. (a) What is a load line? Define Q-point with respect to load line.

   (b) State the differences between depletion type and enhancement type MOSFET. Draw $I_D - V_{GS}$ transfer characteristics of depletion type MOSFET.

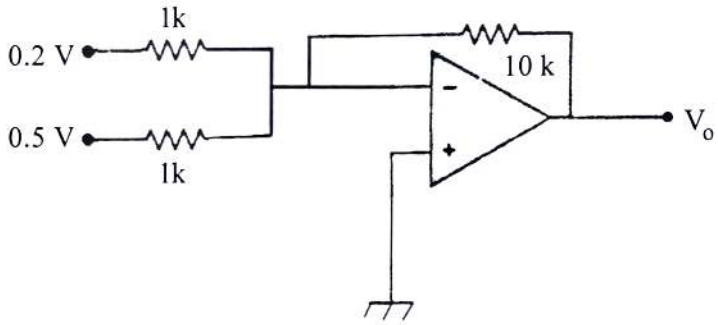
   (c) When V_{GS} of a JFET changes from –3.1 V to –3 V, the drain current changes from 1 mA to 1.3 mA. What is the value of transconductance?

   (d) What are the different ways of sampling the output signal in a feedback amplifier? Name the four feedback topologies. (1+1)+(2+2)+2+2

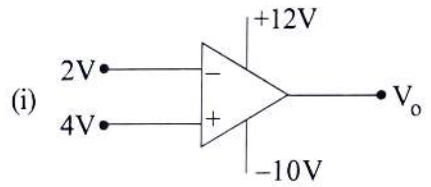
6. (a) Calculate the voltage gain of an inverting OPAMP.

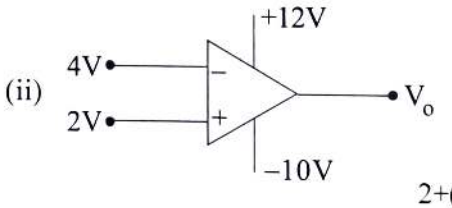
   (b) What do you mean by CMRR? Deduce the expression for CMRR of OPAMP.

   (c) Determine the output voltage of the following circuit :



   (d) Find out the output voltage of the following two circuits :





2+(1+2)+3+(1+1)

7. (a) Draw the circuit digram of a series regulated power supply with two transistors taking reference voltage from a reverse biased Zener diode.

   (b) Draw the circuit diagram of a Wien Bridge Oscillator. Prove that the gain of the amplifier used in Wien Bridge Oscillator must be greater than 3 for sustained oscillation.

   (c) Draw the circuit diagram of a monostable multivibrator and explain briefly its operation. 3+4+3

(Syllabus : 2018-2019)

[Elements of Modern Physics]

Full Marks : 50

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Candidates are required to give their answers in their own words as far as practicable.

Answer ***question no.*** **1** and ***any four*** questions from the rest.

1. Answer ***any five*** questions : 2×5

(a) Show the shape of the energy distribution curve for Black Body radiation at two different temperatures.

(b) What is the minimum energy of a photon so that it can convert into an electron-positron pair?

(c) Normalize the wave function $\psi(x) = A \cos mx, -\pi \leq x \leq \pi$, where m is an integer.

(d) Explain why does the average nuclear binding energy in the range $30 < A < 170$ remain almost constant.

(e) Why does U^{235} and not U^{238} undergo fission with thermal neutrons?

(f) Differentiate between spontaneous and stimulated emission.

(g) Why 4-level LASERS are better than 3-level LASERS?

2. (a) What is Compton Effect? Show that $h\nu' = \frac{h\nu}{1+\epsilon(1-\cos\theta)}$, where $h\nu'$ and $h\nu$ are energies of scattered and incident photons respectively, and $\epsilon = \frac{h\nu}{m_0 c^2}$; m_0 is the rest mass of electron, θ = scattering angle of photon.

(b) If energy of incident photon is 1.22 MeV and that of scattered one is 0.511 MeV, find scattering angle of photon.

(c) Define group velocity. Show that group velocity of a wave packet is equal to the velocity of a particle. (1+4)+2+(1+2)

3. (a) What are meant by degenerate and non-degenerate energy levels?

(b) If $\hat{p}$ be the linear momentum operator associated with the position coordinate operator $\hat{q}$, find out the expression of the operator $\hat{p}\hat{q} - \hat{q}\hat{p}$.

(c) Show that the operator $i\frac{\partial}{\partial x}$ is Hermitian.

(d) Under what condition $e^{\hat{A}} . e^{\hat{B}} = e^{\hat{A}+\hat{B}}$ if $\hat{A}$ and $\hat{B}$ are two linear operators? 2+3+2+3

Please Turn Over

4. (a) What are the properties of a 'well-behaved' wave function? Which of the following wave functions can be regarded as well behaved and why?

(i) $\psi(x) = Ae^{-x^2}$

(ii) $\psi(x) = Axe^{x^2}$, A is a constant (The range of values of x is $-\infty < x < \infty$).

(b) Using the definition of expectation value of an observable, show that $\frac{d}{dt}\langle x\rangle = \frac{\langle p_x\rangle}{m}$, where the symbols have their usual meanings.

(c) Evaluate the commutator bracket $[L_x, L_y]$. (2+1+1)+3+3

5. (a) Explain the asymmetry energy term in the semi-empirical mass formula.

(b) Calculate the binding energy per nucleon for ${}_8O^{16}$. Given that M $({}_1H^1) = 1.007825\ u$, M $({}_0n^1) = 1.008665\ u$, M $({}_8O^{16}) = 15.994915\ u$ and $1u = 931.5$ MeV.

(c) Calculate the distance of closest approach of a proton with 2 MeV kinetic energy to a gold ($z = 79$) nucleus. Given, $\frac{1}{4\pi\epsilon_0} = 9\times10^9$. 3+3+4

6. (a) Using the single particle shell model predict the ground state spin and parity of ${}^{19}_{10}Ne$ and ${}^{20}_{10}Ne$ nuclei.

(b) Draw a typical β-ray spectrum. Why was it necessary to postulate the existence of a new type of particle to explain this spectrum?

(c) What is the role of a moderator in a nuclear reactor? Define multiplication factor in the context of chain reaction. 3+(1+3)+(2+1)

7. (a) What do you mean by 'population inversion'?

(b) Find the ratio of the rate of spontaneous and stimulated emission in terms of frequency and temperature. Hence, explain why the ordinary light is incoherent.

(c) Draw the energy level diagram of ruby laser and show the lasing transition. 2+(4+2)+2