2021

PHYSICS — HONOURS

(2019-2020 Syllabus)

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) Show the difference between the current-voltage characteristics of an ideal and practical current source stating the reason for such difference.

(b) The band gap of a specimen of Ga-As is 1·98 eV. Calculate the wavelength of the electromagnetic wave radiated upon direct recombination of holes and electrons in the sample.

Given e = $1{\cdot}6 \times 10^{-19}$ C, h = $6{\cdot}626\times10^{-34}$ J.s.

(c) Write down the expression for conductivity of an intrinsic semiconductor in terms of mobility of its careers, explaining each term in the expression.

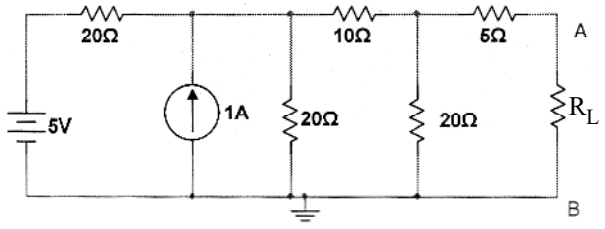
(d) What are the fundamental differences between a class-A and class-C amplifier?

(e) What is the significance of CMRR of an OPAMP?

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

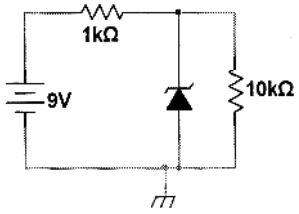
(g) Explain Barhhausen's criterion for self sustained oscillation.

2. (a) Determine the Thevenin's equivalent circuit between AB. Find the load current when $R_L = 10\,\Omega$.



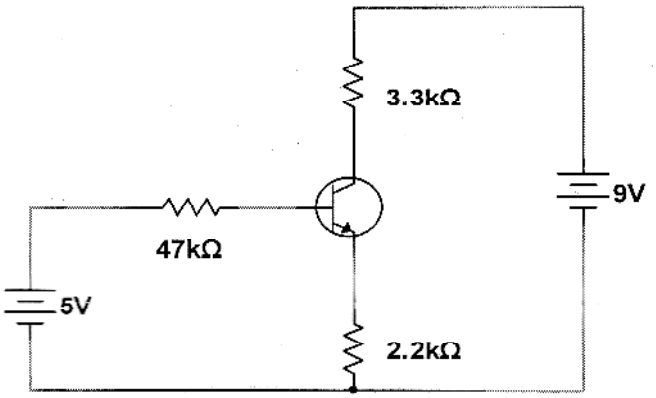
(b) Define cut-in voltage of a p-n junction diode. What are its typical values for Ge and Si diodes?

(c) In the given circuit, what are the currents flowing through the 1 kΩ and 10 kΩ resistances and the Zener diode? What happens when 10 kΩ resistance is replaced by a 1 kΩ resistance? (The breakdown voltage of the Zener diode is 6 V.) 4+2+4



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

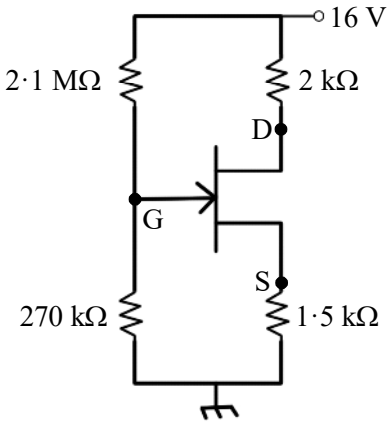
(b) For the given transistor circuit $V_{BE}(\text{sat}) = 0.85$ V and $V_{CE}(\text{sat}) = 0.22$ V. If $h_{FE} = 110$, is the transistor operating in the saturation region? Justify.



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

4. (a) Define the FET parameters and find a relation among them.

(b) Consider the following circuit of a small signal FET amplifier. Determine the bias voltages V_D, V_S, V_{DS}, V_{GS} of the circuit where $I_D = 2{\cdot}4$ mA.



(c) State the differences between depletion type and enhancement type MOSFET. Draw the $I_D - V_{GS}$ transfer characteristics of depletion type MOSFET. 3+3+(2+2)

5. (a) Explain with the help of a block diagram the working principle of a feedback amplifier. Find out the expression for voltage gain of a feedback amplifier.

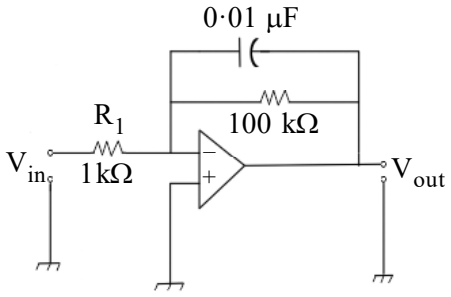
(b) Show that negative feedback improves the stability of gain of an amplifier.

(c) What do you understand by Regulated Power Supply? Draw a block diagram of a series regulated power supply mentioning each block clearly. 4+3+(1+2)

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

(b) An OPAMP has a differential gain $A_d = 120$. The input voltages applied to the inverting and non-inverting terminals are 1·0 mV and 0·9 mV respectively. Calculate the output voltage for CMRR = 100.

(c) Determine the lower frequency limit (critical frequency) for the integrator circuit shown below. 2+4+4



7. (a) Draw the circuit diagram of a Hartley Oscillator.

(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 an astable multivibrator using transistor and explain the principle of action showing the collector voltage waveforms. 2+4+4

2021

PHYSICS — HONOURS

(2018-19 Syllabus)

Paper : CC-9

(Modern Physics)

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) Calculate the value of Compton wavelength of an electron.

(b) Show that momentum operator is hermitian provided $\psi(x) \to 0$ as $x \to \pm\infty$.

(c) Find the eigenvalues and eigenfunctions of the angular momentum operator $\hat{L}_z = i\hbar\frac{\partial}{\partial\phi}$.

(d) Write the coulomb term in the semi-empirical mass formula. What does it account for?

(e) Find out the parity of $_{16}Si^{33}$.

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

(g) What is population inversion in LASER?

2. (a) How does the energy distribution curve for black body radiation change with temperature?

(b) Using Plank's radiation law for $\rho(\lambda)$, prove that $\lambda_m T = \frac{hc}{4.965k_B}$.

(c) A 0.75 MeV photon is scattered by a free electron at rest at an angle 60º. Find the energy of the recoil electron.

(d) The photoelectric work-function W for lithium is 2.3eV. Find the threshold wavelength for the photoelectric effect. (Given h = 6.62×10^{-34}J sec) 2+2+3+3

3. (a) Calculate the probability current density and $\langle x^2 \rangle$ for the wave function

$$\Psi(x) = \left(\frac{a}{\sqrt{\pi}}\right)^{1/2} \exp\left(-\frac{1}{2}a^2x^2 + ikx\right),$$

where a and k are constants.

(b) A particle is represented by a wave function $\Psi(x) = \left(\frac{\sqrt{2}}{\pi}\right)^{\frac{1}{2}} \frac{x + ix}{1 + ix^2}$. Find the position probability density. Where is the particle most likely to be found? (3+3)+(2+2)

4. (a) A particle is moving along a line between $x = 0$ and $x = a$ where

$$V(x) = \begin{cases} 0 & 0 < x < a \\ \infty & \text{otherwise} \end{cases}$$

The nth stationary state is given by $\Psi_n(x) = A \sin \frac{n\pi x}{a}$.

(i) Find A.

(ii) Calculate $\langle x \rangle$ and $\langle p \rangle$ for this state.

(b) Let $\hat{a}_+ = \frac{1}{\sqrt{2}}\left(\hat{x} + i\hat{p}\right)$ and $\hat{a}_- = \frac{1}{\sqrt{2}}\left(\hat{x} - i\hat{p}\right)$. Calculate $\left[\hat{a}_+ , \hat{a}_-\right]$.

(c) Calculate $\left[\hat{x} , \hat{L}_y\right]$. {2+(2+2)}+2+2

5. (a) Derive an expression for the 'surface energy' of a uniformly charged liquid drop. Write the surface energy term in semi-empirical mass formula. State the assumptions needed.

(b) Write the nuclear 'magic numbers'. Why are they so called? (3+1+2)+(2+2)

6. (a) The binding energy of $_3Li^7$ and $_2He^4$ are 39.2 MeV and 28.24 MeV respectively. Which of them is more stable?

(b) What is the implication of Geiger–Nuttal law in relation with alpha decay?

(c) Show that impossibility of an electron being in the nucleus is a consequence of the uncertainty principle.

(d) Calculate the binding energy per nucleon for the deuteron.

Given $m_n = 1.675 \times 10^{-27}\ Kg$; $m_p = 1.672 \times 10^{-27}\ Kg$;

$M_D = 3.343 \times 10^{-27}\ Kg$; $c = 3 \times 10^8\ ms^{-1}$. 2+2+3+3

7. (a) What are the differences between spontaneous and stimulated emission?

(b) Establish the relation between Einstein's A and B coefficients.

(c) Explain the energy level diagram of He-Ne laser. 2+4+4