RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, SEPTEMBER 2019

SECOND YEAR (BATCH 2018-21)

Date : 26/09/2020 **PHYSICS (Honours)**

Time : 11 am – 7 pm **Paper : IV** Full Marks : 100

GROUP - A

Answer **any four** questions from Question Nos. 1 – 7: [4×10]

1. a) Explain why a transistor should be biased? [2]

   b) Show that an emitter resistor with the fixed bias arrangement is able to stabilize the operating point of a transistor with the variation of temperature and gain. Why this circuit is not used? [5+1]

   c) Why voltage divider biasing arrangement is superior to others? [2]

2. a) Why CE amplifier is suitable for cascade connection? [2]

   b) Draw the circuit diagram of a two-stage RC coupled CE transistor amplifier. Determine the amplitude variation (magnitude) of voltage gain with frequency at mid and high frequency regions. [1+1.5+3.5]

   c) Why gain falls at high frequency region? [2]

3. a) When negative feedback is applied to an amplifier of gain 100, the overall gain reduces to 60. Find the fraction of output voltage feedback. [2]

   b) Describe the working of a Colpitts oscillator. Draw the small-signal ac equivalent circuit of the said oscillator. Obtain an expression for the frequency of oscillation and also obtain the condition for sustained oscillations. [5]

   c) A Wien bridge oscillator operating with a frequency of 1 kHz uses capacitors of value 100 pF. Find the value of the resistors used. If the amplifier gain is 10 find the ratio of resistances in the other arms. [3]

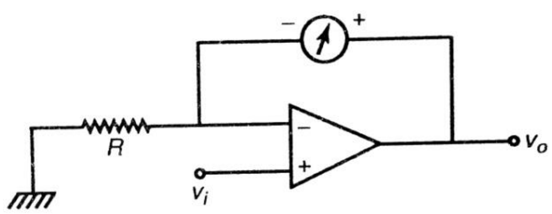
4. a) What do you mean by multivibrator? Mention specific applications of various kinds of multivibrator. [1+2]

   b) Design an astable multivibrator using two PNP type BJTs. State its principle of working. Draw the output characteristic of the multivibrator. [4]

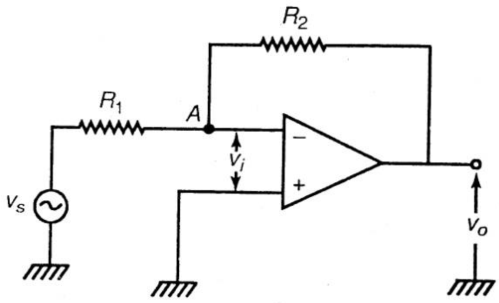
   c) State and explain Barkhausen criteria of oscillation. Compare oscillator and multivibrator. [1.5+1.5]

5. a) The moving coil meter shown in the following figure shows full scale deflection when a current of 0.1 mA passes through it. Find the value of R such that the full scale deflection is obtained with

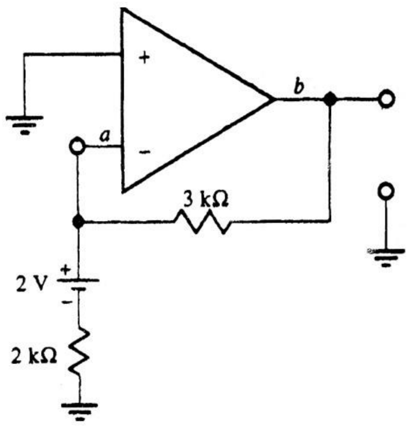
   $v_i = 1$ V. [2]



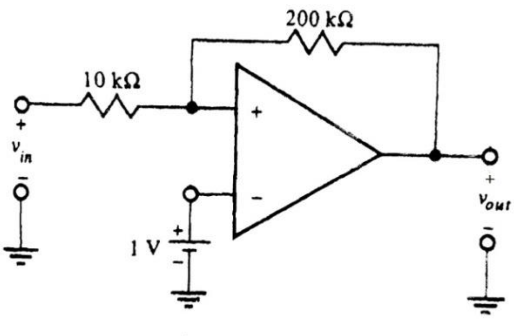
b) For the following circuit with R_1 = 1 kΩ, R_2 = 100 kΩ and OPAMP supply voltage ±10 V, find the gain and draw the output for the input signal $v_s = 0.2 sin 100\pi t$ volt. [3]



c) For the following circuit, determine the voltages at points *a* and *b* relative to ground. [2]



d) In the following comparator circuit the OPAMP has a voltage gain of 10^5 and it requires supply ±9 V. Determine the voltage that will cause the output to change from – 9 V to +9 V for increasing input and also find the voltage that will cause the output to change from +9 V to –9 V for decreasing input. [3]



6. a) Solve the following problems:

i. $(675.28)_9 = (?)_{10}$

ii. $(234)_5 + (424)_5 = (?)_5$

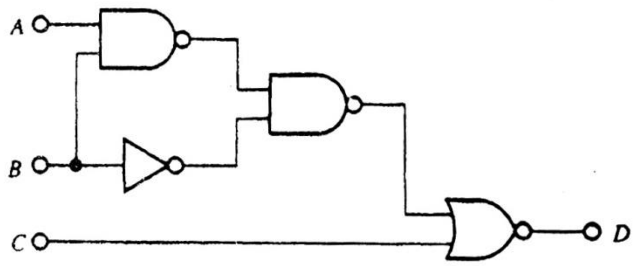
iii. $(5376.5)_8 = (?)_{16}$

iv. $(CAB)_{16} - (DAD)_{16} = (?)_{16}$, using r's complement method. Find sign-magnitude form of the result.

[0.5+0.5+0.5+1]

b) Draw a schematic circuit for NOT logic using diode logic or DL. Also Draw a schematic circuit for a 3-input NAND logic using transistor logic or TL and explain its working. [1+1+1.5]

c) For the following circuit obtain the corresponding truth table. Also find the most simplified Boolean expression relating output to the inputs. [2+2]



7. a) Explain the need of modulation and demodulation in radio communication. [1]

b) Describe the scheme of tone modulation producing DSB, with suitable modulator and demodulator circuit diagrams. [2+2]

c) Compare the power to be transferred during communication in DSB-SC and SSB-SC scheme. [2]

d) The modulation index for an FM wave is 10 and the highest modulation frequency is 10 kHz. Calculate the minimum bandwidth required for the detection of this FM wave. [3]

GROUP - B

Answer any Six questions from Unit – I and Unit - II [6×10]

8. a) Write down the expression of Lennard-Jones potential and explain the meaning of the two terms in it. Justify the validity of the ideal gas model at high temperature and at low pressure. [3+2]

b) During a hailstorm, hailstones with an average mass of 2 gm and a speed of 15 m/s strike a window pane at a 45^0 angle. The area of the window is 0.5 m^2 and the hailstones hit at a rate of 30 per second. What average pressure do they exert on the window? How does this compare to the pressure of the atmosphere? [4+1]

9. a) The position of a particle executing S. H. M is represented by $x = A\cos(\omega t)$, where ω is the angular frequency and A is the amplitude. Find the probability function P(x)dx for the position of the particle lying between x to x+dx. Find $< x >$ and $< x^2 >$. [2+1+2]

b) What do you mean by 'collision probability' of a gas molecule? Show that the probability of a gas molecule traversing a distance x without collision is $\exp(-x/l)$, where l is the mean free path of the gas. [1+4]

10. a) Write down the Maxwell's law of distribution of molecular speed in three dimension. Find out expressions for the most probable speed c_m and the number of molecules $n(c_m)$ having speed c_m. [2+2+2]

b) Depict the nature of speed distribution for two different temperatures T and 4T on the same graph. [2]

c) In gases the coefficient of viscosity increases with increasing temperature, whereas in liquids the coefficient of viscosity decreases with increasing temperature. Explain this behavior. [2]

11. a) State the classical equipartition theorem of energy. Comment on its validity criterion. [2]

b) Find the total kinetic energy (K.E) associated with the chaotic motion of one mole of an ideal monatomic gas at absolute temperature T. How does this K.E vary with temperature if pressure is maintained constant? [2+1]

c) Plot isotherms according to van der Waals equation of state and identify critical isotherm. What is the value of latent heat associated with the liquid-vapour phase transition at critical point? Indicate those regions of the van der Waals isotherm which represent metastable states. [3+2]

12. a) Distinguish between conduction and convection of heat. [2]

b) One end of a long insulated bar is periodically heated at one end according to the temperature variation $\theta=\theta_o\sin(\omega t)$, where ω is the angular frequency of the harmonic variation of the temperature with time t. θ_o is a constant. Show that temperature wave through the bar is dispersive in nature and find its group velocity. [5]

c) The roof of a room is made of concrete whose diffusivity is 4×10^{-4} $m^2 hour^{-1}$. Why does the inside of the room at about 2 pm remain comfortable, even though heat waves from the sun (with a period of 24 hours) heat the roof up to a temperature as high as 50^oC. [Thickness of roof ~ 0.127 m] [3]

UNIT – II

13. a) Write the significance and limitations of first law of thermodynamics [1+2]

b) An ideal gas is allowed to undergo adiabatic expansion so that its temperature drops from 320 K to 286 K and the pressure changes from 1.4×10^5 Pa to 1.0×10^5 Pa. Determine its atomicity. [3]

c) An ideal gas undergoes a process in which its internal energy U is related to its volume V as $U = a\ V^b$, where a, b are constants. Show that the work done by the gas and the quantity of heat transferred to it to increase its internal energy by ΔU are respectively (i) $\Delta U(\gamma - 1)/b$ and (ii) $(\Delta U/b)\{1 + (\gamma - 1)b\}$, where γ is the ratio of specific heats. [2+2]

14. a) What is the change of entropy in the gas, the surroundings and the universe during (i) a reversible isothermal expansion and (ii) a Joule expansion of the gas. [2+1]

b) Two identical bodies of constant heat capacity C_p have the same initial temperature T_i. If a refrigerator working between the two bodies cools down one of them to temperature T_2, show that the minimum work required to do this is $W_{min} = C_P\ (T_i^2/T_2 + T_2 - 2T_i)$. [4]

c) 1 kg of water at room temperature 0^0C is brought into contact with a heat reservoir at 100^0C. Calculate the entropy change of the water and reservoir when the temperature of water reached 100^0C. What is the entropy change of the universe? [3]

15. a) Establish the condition of equilibrium of a thermodynamic system undergoing isothermal-isobaric transformation [3]

b) For 1 mole of van der Waals gas undergoing a reversible isothermal expansion from a volume V_1 to V_2, show that the heat transferred Q is given by $Q = RTln\{(V_2 - b)/(V_1 - b)\}$ (Symbols have their usual meaning). [4]

c) Find Gibb's free energy (G), Entropy (S), and Enthalpy (H) for a thermodynamic system having an equation of state: $pV = A(T) + B(T)\,p + C(T)\,p^2 + ...$ where $A(T)$, $B(T)$, and $C(T)$ are determined from experiment (Symbols have their usual meaning). [3]

16. a) Establish the principle of increase of entropy. [3]

b) If $A = (\partial p/\partial T)_V$ and $B = (\partial p/\partial T)_S$ then prove that $A/B = 1 - 1/\gamma$, where γ is the ratio of two specific heats. [3]

c) Using Maxwell's thermodynamic relations, calculate the heat transferred when the pressure on 10 gm of water at 0^0C is increased reversibly by 1000 atmosphere. Is heat absorbed or given out? The coefficient of volume expansion of water, $\alpha = -6.7 \times 10^{-5}\ {}^0C^{-1}$ and 1 atmosphere $= 10^5\, dynes\ cm^{-2}$. [4]

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