<u>Quiz-1 (2023)</u>

Time: 50 min

Course: PH209

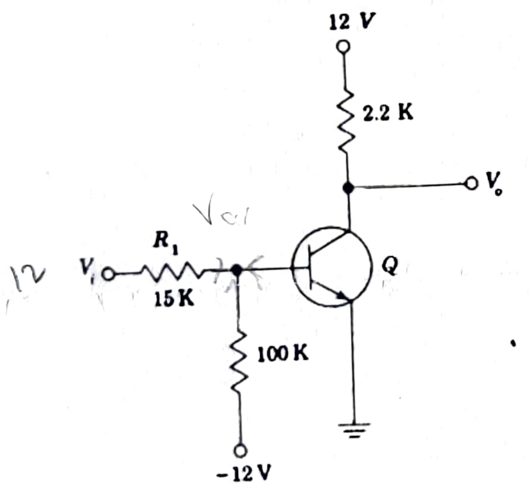
1. a) Draw the energy band diagram of a PNP transistor (including Fermi level) when it is in an active region and give the justification of your drawing. [Mark 2]

   b) Explain how the emitter resistance of a CE amplifier can stabilize a quiescent operating point. [Marks 2]

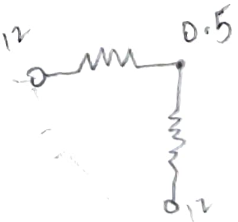
2. For the silicon transistor given in the figure below, the minimum value of $\beta = 30$

   (a) For V_i=12 V find the state of the transistor (in which region it is operating), and find V_o

   (b) Suppose the 15k resistance is replaced with another resistance R_1, find the minimum value of R_1 for which the transistor is in the active region. [Marks 6]



$12 - V_{CB} - 0.7$



$\frac{V_B - 12}{15} = \frac{-12 - V_B}{100}$

$20 V_B - 240 = 36 + 3 V_B$

P | N | P

$17 V_B = 276$

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PH 205

Quiz 1 (2023)

Full marks: 10 **Time: 45 minutes**

Tick the correct answer choice on the question paper itself. Correct answer will carry 1 mark, whereas incorrect answer will carry (-1/2) mark. Use back page/ extra sheet for rough work.

1. The lattice constant of Ge is 5.64 Å at room temperature. The number density of Ge atoms (per cubic centimeter) in a Ge crystal is :
(a) 1.1×10^{22}, (b) 2.2×10^{22} (c) 4.4×10^{22}, (d) 8.8×10^{22} −0.5

2. If the effective mass of electron in GaAs is $0.07m_0$ and dielectric constant of GaAs is 13.2, using *Hydrogen atom model*, the donor energy level (in meV unit) in GaAs is :
(a) 4.46 meV, (b) 5.46 meV (c) 8.92meV, (d) 10.92 meV 1

3. At room temperature (300 K), the displacement of the Fermi level E_{Fi} from the middle of the band gap ($E_g/2$) in intrinsic Si is given by (take kT=26 meV, $m_e^*=1.1m_0$ and $m_h^*=0.56m_0$)
(a) -6.6 meV, (b) -13.1 meV (c) -26.2 meV, (d) -19.5 meV 1

4. The intrinsic carrier concentration (n_i) of InAs (band gap E_g=0.35eV) at 300 K is given as $1\text{x}10^{15}$/cc. In this material, the n_i at 600 K will be approximately (note: $n_i=AT^{3/2}\exp(-E_g/2kT)$):
(a) 4.1×10^{17}/cc (b) 8.2×10^{17}/cc (b) 4.1×10^{16}/cc (d) 8.2×10^{16}/cc 1

5. Hall effect cannot be used for which of the following?
(a) Determining whether the semiconductor is p or n type.
(b) Determining the carrier concentration.
(c) Determining both the mobility and the conductivity −0.5
(d) Determining the bandgap of the material

6. The diffusion coefficient of electron in a material at room temperature (300 K) is given as 110 cm²/s. The electron mobility in the material is approximately, μ
(a) 8500 cm²/V-s (b) 4230 cm²/V-s (b) 1350 cm²/V-s (d) 450 cm²/V-s 1

7. The energy (E) dependence of electronic density of states, *N(E)*, in a 2-dimensional semiconductor is proportional to
(a) $E^{-1/2}$ (b) $E^{1/2}$ (c) E^0 (d) E^2 1

8. **In the Kronig-Penny model for the bandstructure calculation, which of the following is/are incorrect:**
(a) This model uses a periodic potential
(b) This model uses Bloch's theorem
(c) This model predicts allowed and forbidden energy bands in a solid 1
(d) This model is applicable only for semiconductors

9. The bandgap of a semiconductor is found to be 3.40 eV. The associated wavelength falls in the
(a) UV region, (b) Visible region, (c) Infrared region, (d) X-ray region 1

10. For modulation doping, which of the following is incorrect:
(a) It enables to achieve very high carrier mobility
(b) It enables to overcome carrier freeze out phenomena
(c) It requires semiconductor heterostructures 1
(d) It requires wide bandgap semiconductors

06+02
=08

Quiz-I/ PH207/Full Marks:10/Time: 35 minutes/ September 7 2023

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1. An adiabatic chamber with rigid walls consists of two compartments, one containing a gas and the other complete vacuum. The partition between the two is suddenly removed. Is the work done during an infinitesimal portion of this process equal to pdV, p, V the pressure and volume, respectively? [2]

Yes, the work done is equal to $W = pdv$. This is because pressure is an extrinsic property and does not change when half of the setup is added or removed. Since volume is an intrinsic property there will be a change dV. Hence the W.D would by PdV.

X

2. Why the room having a refrigerator is usually warmer than other rooms? Explain using direction of heat flow. [2]

Room having refrigerator is warmer than other rooms because the work is done on the by the refrigerator to cool the internal air. using a compressor As a result of this heat is produced which is soaked in a heat reservoir and then exhausted using a fan this air is hotter and since it is exhausted it makes the room warmer

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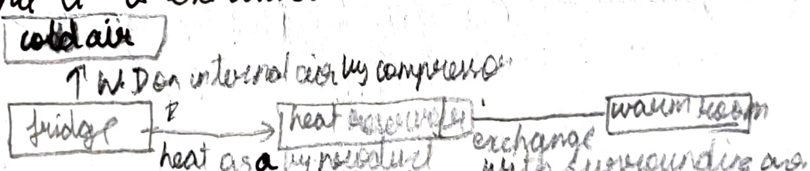
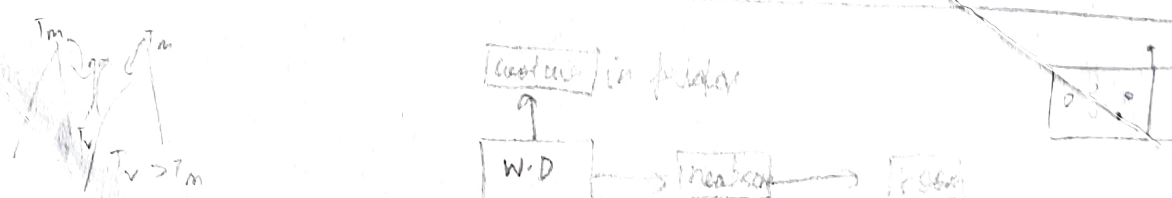


3. Consider a valley with temperature T_v. Cold air from surrounding mountain tops (temperature $T_m < T_v$) blows into the valley and gets trapped there. Does T_v increase, decrease or remain same? Explain. [2]

According to me T_v remains the same. This is because the trapped air T_v is at a higher temperature. When cold air surround the moutains blow into the valley, they displace the warmer air because warm air has a lower density it rises up and interacts with the colder air and till the colder air reaches the valley it gains energy and the temperatures of T_m increases to roughly T_v.

X



4. 10 litres of a monatomic ideal gas ($\gamma = \frac{5}{3}$) at atmospheric pressure is first compressed isothermally to a volume of 1 litre and then expanded adiabatically to 10 litres. Does the internal energy change in this process? Is a net work done on or done by the system? [2+2]

$V = 10L$ $T =$ constant.

$P = P_0$ ($P_0 =$ atmp. pressure.)

$\gamma = \frac{5}{3}$

In first step.

$P_1 V_1 = P_2 V_2 \Rightarrow P_2 = 10 P_0$ $\gamma = \frac{5}{3}$.

W.D =

In second step:

$P_2 V_2^{\gamma} = P_3 V_3^{\gamma}$

$P_3 = P_2 \times \left(\frac{V_2}{V_3}\right)^{\gamma} = 10 P_0 \times \left(\frac{1}{10}\right)^{5/3} = 15 P_0$.

Yes, there will be change in internal energy.

$\Delta U = \Delta U_1 - \Delta U_2 \; P_0 10 \left[\frac{1}{1^{2/3}} - \frac{1}{10^{2/3}}\right] - 15 \left[\frac{1}{10^{2/3}} - \frac{1}{1^{2/3}}\right]$.

$= -11.76 J$.

Now since ~~ΔU~~ = using first law of thermodynamic.

~~ΔQ = ΔU + W.D~~ $\Delta Q = \Delta U + WD$.

we can see that

$W.D_I = -\int P dV$

$nRT [\cancel{1-10}] \ln \frac{1}{10}$

$= -\cancel{9P} + nRT \ln 10$

$\Delta U = - W.D.$

$\boxed{W.D = 11.76 J}$

Hence ~~is~~ work is done on the system.

$\therefore$ The change in internal energy is $-11.76 J$ & the work is done on the system & is equal to W.D = 11.76 J.

2 × 2

$P5 \left[\frac{1}{10^{2/3}} - \frac{1}{1}\right]$.

$\therefore \Delta U_1 + \Delta U_2 = -11.76 J$.

$\gamma - 1 = \frac{2}{3}$

$T_1 V_1^{\gamma} = T_2 V_2^{\gamma}$

$P_1 V_1^{2/3} = P_2 V_2^{2/3}$

$\Rightarrow U = 10 \left[\frac{2}{V_1^{2/3}} - \frac{1}{V_2^{2/3}}\right]$.

~~U = Q - WD~~.

$P [$