Ans 1.

$$n_p = n_i^2$$

$$p = N_A$$

$$\therefore n = \frac{n_i^2}{N_A} \quad \text{— (1).}$$

Ans 2.

For Si, $E_{g_0} = 1.21\,eV$ at room temp.

$$E_{g_T} = E_{g_0} - 3.6 \times 10^{-4} T$$

At $T = 300\,K$

$$E_{g_{300}} = 1.21 - 3.6 \times 10^{-4} \times 300$$

$$= 1.1\,eV \quad \text{— (1).}$$

Ans 3. Above the valence band — (1).

Ans 4. A difference Amp. amplifies the difference b/w the two i/p voltages but suppresses any voltage common to the two i/p's. — (1).

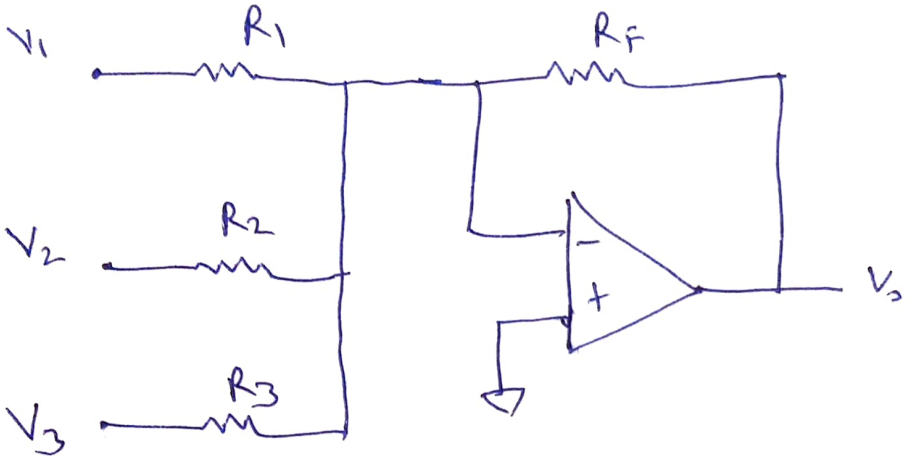
Ans 5.

$$B.W = 10 - 2.5$$

$$= 7.5\,kHz \quad \text{— (1).}$$

Ans 6.

$$V_o = -\left(\frac{R_F}{R_1} V_1 + \frac{R_F}{R_2} V_2 + \frac{R_F}{R_3} V_3\right)$$



— (0.5)

$$\frac{R_F}{R_1} = 6$$

$$\frac{R_F}{R_2} = 8$$

$$\frac{R_F}{R_3} = 4$$

$R_F = 120\,K\Omega$

$\therefore$ $R_1 = 20\,K\Omega$

$R_2 = 15\,K\Omega$

$R_3 = 30\,K\Omega$

— (0.5)

Ans 7. Low Pass Filter — (1)

Ans 8. All Pass Filter — (1)

Ans 9. True — (1)

Ans 10. Capacitor — (1)

Ans 11.

$$N_D = \frac{1}{2\times10^{8}} \times (5\times10^{22})$$

$$= 2.5 \times10^{14} \text{ atoms/cm}^{-3}$$

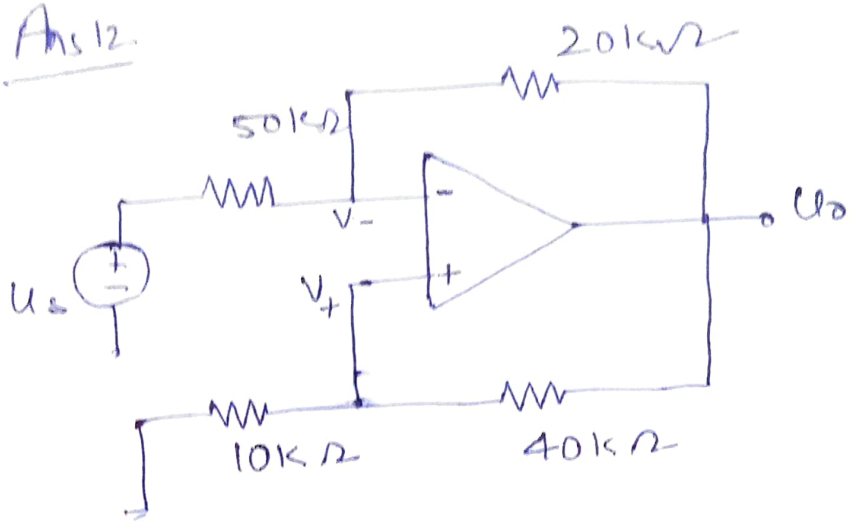
$$E_F - E_C = 0 = KT \ln\left(\frac{N_C}{N_D}\right)$$

$$\Rightarrow N_C = N_D = 2.5\times10^{20} \text{ m}^{-3} \quad — (1)$$

$$T = \left(\frac{2.5\times10^{20}}{4.82\times10^{21}}\right)^{2/3}$$

$$T = 0.14 \text{ K} \quad — (1)$$

Ans 12



Output voltage is $u_o = A_o[V_+ - V_-]$

where $V_+ = \frac{10k}{10k+40k} u_o = \frac{u_o}{5}$

$$V_- = \left[\frac{50k}{50k+20k} u_o + \frac{20k}{20k+50k} u_s\right]$$

$$V_- = \left[\frac{5}{7} u_o + \frac{2}{7} u_s\right]$$

so $$u_o = A_o\left[\frac{u_o}{5} - \frac{5}{7} u_o - \frac{2}{7} u_s\right]$$

$$u_o = A_o\left[\frac{-18}{35} u_o - \frac{2}{7} u_s\right]$$

$$u_o\left[1 + A_o \frac{18}{35}\right] = -\frac{2}{7} u_s \cdot A_o$$

$$\frac{u_o}{u_s} = \frac{-\frac{2}{7} A_o}{1 + A_o \frac{18}{35}}$$

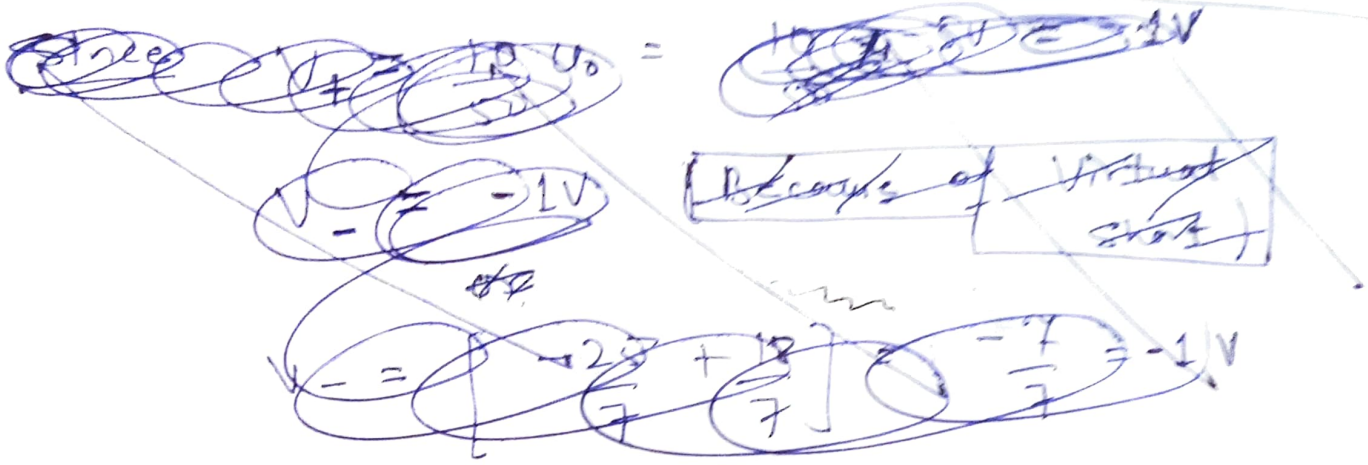
In opamp A_o is very very large, so

$$\left(1 + A_o \frac{18}{35}\right) \simeq A_o \frac{18}{35}$$

$$\frac{U_0}{U_S} = -\frac{2}{7} \times \frac{35}{18} = -\frac{5}{9}$$ — (1 mark)

If $U_S = 9V$

$U_0 = -5V$ — (1 mark)



Ans 13.

$$N_D - N_A = (12-8)\times 10^{11}$$

$$= 4\times 10^{11}\ cm^{-3} \quad \text{at } 100^\circ C.$$ — (1)

At 300K, from charge neutrality :-

$$n_0 - p_0 = N_D - N_A$$

$$n_0 - p_0 = 4\times 10^{11}$$

$$n_0 \cdot p_0 = (1.5\times 10^{10})^2$$

$$(n_0 + p_0)^2 = (n_0 - p_0)^2 + 4 n_i^2$$

$$= (4\times 10^{11})^2 + 9\times 10^{20}$$

$$= 1.609 \times 10^{23}$$

$$n_0 + p_0 = 4.011 \times 10^{11}$$

$$n_0 - p_0 = 4\times 10^{11}$$

$$\Rightarrow \quad n_0 = 4.006 \times 10^{11}\ cm^{-3}$$ — (1)

$$p_0 = \frac{n_i^2}{n_0}$$

$$= \frac{(1.5\times 10^{10})^2}{4\times 10^{11}}$$

$$= 5.62 \times 10^{8}\ cm^{-3}$$ — (1)

A.c N.

$$Z_2 = \frac{R_2 \times \frac{1}{sC_2}}{R_2 + \frac{1}{sC_2}} = \frac{R_2}{1 + sC_2R_2}$$

$$Z_1 = \frac{R_1}{1 + sC_1R_1}$$

$$H(j\omega) = \frac{-\frac{R_2}{1 + j\omega C_2R_2}}{\frac{R_1}{1 + j\omega C_1R_1}}$$

$$= -\frac{R_2}{R_1} \cdot \frac{(1 + j\omega C_1R_1)}{(1 + j\omega (C_2R_2)} \quad \text{— (1)}$$

Pole $p_1 = -\frac{1}{C_2R_2}$

Zero $z_1 = \frac{-1}{C_1R_1}$

Low freq gain = 40 dB.

$$20 \log |H(j\omega)| = 40$$

$$\Rightarrow \frac{R_2}{R_1} = 100$$

Let $R_1 = 1K\Omega$

$R_2 = 100K\Omega$ — (1)

Geometric Mean $= \sqrt{f_{p_1} \cdot z_{p_1}}$

$$1000 = \frac{1}{\sqrt{R_1 C_1 R_2 C_2}}$$

Assume $C_1 = C_2 = C$

$$R_1 \cdot C \cdot 10 = \frac{1}{1Khz}$$

$$R_1 C = \frac{1}{10\,Khz}$$

$$C = \frac{1}{10 R_1}$$

$$\boxed{C = 0.1\,\mu F}$$ — (1)