# 101 學年四技二專第四次聯合模擬考試
# 電機與電子群　專業科目（一）　詳解

101-4-03-4
101-4-04-4

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | C | B | C | A | C | A | D | C | A | D | B | C | A | C | B | D | B | D | C | C | C | A | B | D |
| 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| B | C | B | D | B | A | C | A | A | C | D | A | D | B | D | A | D | C | D | B | B | A | C | D | D |

**第一部份：基本電學**

1. 此物質帶有之電量為
$(8-4)\times(-1.602\times10^{-19})=-6.4\times10^{-19}$ 庫倫
$$V_{ba}=V_b-V_a=\frac{W_{ba}}{Q}=\frac{20\times10^{-19}}{4\times(-1.602\times10^{-19})}=-3.12\text{ V}$$
$V_b=V_{ba}+V_a=-3.12+5.12=2\text{ V}$

2. LED 燈泡需支出
$2.6\times(10\times10^{-3}\times30000)+300=1080$ 元
白熾燈泡需支出
$[(2.6\times60\times10^{-3}\times3000)+20]\times\dfrac{30000}{3000}=4880$ 元
使用 LED 燈泡共可省 $4880-1080=3800$ 元

3. 甲丙串 $\eta_{甲}\times0.9=\dfrac{360}{500}\rightarrow\eta_{甲}=\dfrac{360}{500\times0.9}=0.8$
乙丙串 $\eta_{乙}\times0.9=\dfrac{252}{400}\rightarrow\eta_{乙}=\dfrac{252}{400\times0.9}=0.7$
$P_{甲乙in}=\dfrac{112}{\eta_{甲}\times\eta_{乙}}=\dfrac{112}{0.8\times0.7}=200\text{ W}$

4. 電阻係數之單位方式常以下式表達
$\Omega\cdot m^2/m$ 或 $\Omega\cdot cm^2/m$ 或 $\Omega\cdot cm$ 或 $\Omega\cdot m$
或 歐姆·圓密爾/呎

5. $\because D=\dfrac{4}{\sqrt{\pi}}\text{ mm}=\dfrac{4}{\sqrt{\pi}}\times10^{-3}\text{ m}$
$A_a=A_b=\dfrac{1}{2}\times\dfrac{\pi}{4}D^2=\dfrac{\pi}{8}\times(\dfrac{4}{\sqrt{\pi}}\times10^{-3})^2=2\times10^{-6}\text{ m}^2$
$R_a=\rho\dfrac{\ell}{A}=2\times10^{-7}\times\dfrac{1}{2\times10^{-6}}=0.1\,\Omega$
$R_b=\rho\dfrac{\ell}{A}=1\times10^{-6}\times\dfrac{1}{2\times10^{-6}}=0.5\,\Omega$
$R=R_a\,//\,R_b=0.1//0.5=0.0833\,\Omega$

6. (1) S 未閉合前，由電壓分配定則求得
$V_1=100\times\dfrac{20}{20+80}=20\text{ V}$
(2) S 閉合時，$V_1+V_2=100$，$\because V_2=78$，$\therefore V_1=22\text{ V}$
故電流增加 $\Delta I=\dfrac{22\text{ V}-20\text{ V}}{20\,\Omega}=0.1\text{ A}$

7. $\begin{cases}(25\text{ m}-I_A)\times(R_1+R_2+R_3)=10\text{ m}\times R_A\\(50\text{ m}-I_A)\times(R_2+R_3)=10\text{ m}\times(R_A+R_1)\end{cases}$
$\begin{cases}(25\text{ m}-10\text{ m})\times(R_1+R_2+R_3)=10\text{ m}\times1\text{ k}\\(50\text{ m}-10\text{ m})\times(R_2+R_3)=10\text{ m}\times(1\text{ k}+R_1)\end{cases}$
化簡得 $R_1=333.3\,\Omega$

8. 因 $4\times8=8\times4$，電橋平衡，電壓源 8 V 沒電流流出，故電路電流 $I=0\text{ A}$

9. 由 KCL 知 $4=\dfrac{V_a-(-24)}{12}+\dfrac{V_a-12}{6}$
化簡得 $V_a=16\text{ V}$，$I_{6\Omega}=\dfrac{V_a-12}{6}=\dfrac{16-12}{6}=\dfrac{2}{3}\text{ A}$

10. $\because V=\dfrac{KQ}{d}=\dfrac{KQ}{d^2}\times d=E\times d$，由公式導出知曲線下面積表示電位差
A 段電位差為 $\dfrac{1}{2}\times2\times5=5\text{ V}$
B 段電位差為 $2\times(10-5)=10\text{ V}$
C 段電位差為 $(2+4)\times(20-10)\times\dfrac{1}{2}=30\text{ V}$
D 段電位差為 $4\times(25-20)=20\text{ V}$
E 段電位差為 $(4+6)\times(30-25)\times\dfrac{1}{2}=25\text{ V}$
總電位差為 $5+10+30+20+25=90\text{ V}$

11. $\because H=\dfrac{NI}{\ell}=\dfrac{NI}{2\pi r}$，電場強度與距離成反比
$\because\dfrac{H_1}{H}=\dfrac{r}{r_1}$，$\therefore H_1=\dfrac{r}{r_1}\times H=\dfrac{10}{5}\times40=80\text{ AT/m}$

12. $\because F=I\ell B=\dfrac{\mu_0 II\ell}{2\pi a}$ 化簡得
$\therefore a=\dfrac{\mu_0 II}{2\pi B}=\dfrac{4\pi\times10^{-7}\times1}{2\pi\times4\times0^{-7}}=0.5\text{ m}$

13. $FF=\dfrac{有效值}{平均值}=\dfrac{\frac{1}{\sqrt{3}}最大值}{\frac{1}{2}最大值}=\dfrac{2}{\sqrt{3}}=1.15$

14. (A) $R_{TH}=\{R_0//[R_1+(R_2//R_3)]\}+R_4$
$=[60//(20+20//20)]+30=50\,\Omega$
$E_{TH}=I_0\times\{R_0//[R_1+(R_2//R_3)]\}$
$=1.5\times\{60//[20+(20//20)]\}=30\text{ V}$

$\tau = R_{TH} \times C = 50 \times 10 \times 10^{-6} = 0.5 \times 10^{-3}$ 秒

$\because t = 1\,ms = 2\,\tau$

$\therefore v_C(1\,ms) = E_{TH}(1-e^{-\frac{t}{\tau}}) = 30 \times (1-e^{-2})$

$= 30 \times (1-0.135) = 26\,V$

15. r.p.m = 每分鐘轉幾圈，頻率 = 每秒轉幾圈

頻率 $f = \dfrac{10{,}800\text{轉/分}}{60\text{秒/分}} = 180\text{轉/秒} = 180\,r.p.s = 180\,Hz$

時間 $t = 36$ 轉 $\times \dfrac{1}{180}$ 秒/轉 $= 0.2$ 秒

16. 考慮 $V_i$ 時，因 $\omega$ 非常大

故 $X_C = \dfrac{1}{\omega C} = 0\,\Omega$，C 視爲短路，由分壓得

$\therefore V_o' = 6\sin\omega t \times \dfrac{3\,k}{6\,k+3\,k} = 2\sin\omega t\,V$

考慮 6 V 時，因 $f = 0$，故 $X_C = \dfrac{1}{\omega C}$ 趨近無限大

電容 C 視爲開路，$\therefore V_o'' = 6\,V$

得 $V_o = V_o' + V_o'' = 6 + 2\sin\omega t\,V$

17. $\overline{Z} = R - jX_C = 30 - j40 = 50\angle -53°\,\Omega$

$\bar{I} = \dfrac{\overline{V}}{\overline{Z}} = \dfrac{100\angle 30°}{50\angle -53°} = 2\angle 83°\,A$

$\overline{V_C} = \bar{I} \times \overline{X_C} = 2\angle 83° \times 40\angle -90° = 80\angle -7°\,V$

18. $f_P = 2f = 120\,Hz$，$I = \dfrac{100}{50} = 2\,A$

$P_{max} = 2VI = 2 \times 100 \times 2 = 400\,W$，$P_{min} = 0\,W$

$P_{av} = VI = 100 \times 2 = 200\,W$

19. $\overline{S} = P - jQ = \overline{E}^* \times \bar{I} = 20\angle -15° \times 5\angle -15°$

$= 100\angle -30° = 50\sqrt{3} - j50\,VA$

20. $\overline{Z}_1 = R + j(X_L - X_C) = 40 + j(30-60)$

$= 40 - j30 = 50\angle -37°\,\Omega$

當 $f' = 2f \Rightarrow X'_L = 2X_L = 60\,\Omega$，$X'_C = \dfrac{1}{2}X_C = 30\,\Omega$

$\therefore \overline{Z}_2 = 40 + j(60-30) = 40 + j30 = 50\angle 37°\,\Omega$

$\therefore Z_1 = Z_2 \Rightarrow I_2 = I_1$

21. $\because X_L = 2\pi fL$，$\because X_L \propto f$，$\therefore \dfrac{X_{LO}}{X_L} = \dfrac{f_O}{f}$

$f_O = f \times \sqrt{\dfrac{X_C}{X_L}} = 120 \times \sqrt{\dfrac{60}{2160}} = 20\,Hz$

$X_{LO} = X_L \times \dfrac{f_O}{f} = 2160 \times \dfrac{20}{120} = 360\,\Omega$

$Q_S = \dfrac{X_{LO}}{R} = \dfrac{360}{30} = 12$

22. 因 $X_L = X_C = 20\,\Omega$ 電路達諧振現象，故流過兩元件之路支電流相等，又因相位相反，因此電流和爲零，故安培表顯示零

23. $X_L' = \dfrac{R^2 + X_L^2}{X_L} = \dfrac{3^2 + 30^2}{30} = 30.3\,\Omega$

$Q_p = \dfrac{X_L}{R} = \dfrac{30}{3} = 10 \geq 10$

$\therefore f_o = f \times \sqrt{\dfrac{X_C}{X_L'}} = 100 \times \sqrt{\dfrac{60}{30}} = 141.4\,Hz$

$\dfrac{R^2 + X_L^2}{X_L} = X_C$，$X_L = \sqrt{(\dfrac{L}{C} - R^2)}$

$f_o = \sqrt{(\dfrac{1}{(2\pi)^2 LC} - (\dfrac{R}{2\pi L})^2)}$，$f_o = f\sqrt{(\dfrac{X_C}{X_L} - (\dfrac{R}{X_L})^2)}\,Hz$

因在串並聯諧振電路 $f_o \neq f \times \sqrt{\dfrac{X_C}{X'_L}}$（$X'_L$ 內包含 R，無法與 f 成正比)，若 $Q_p = \dfrac{X_L}{R} \geq 10$，則 $f_o = f\sqrt{\dfrac{X_C}{X_L}}$

24. P 與 V 不變，則 $P = VI_1\cos\theta_1 = VI_2\cos\theta_2$

即 $100 \times 0.8 = I_2 \times 1$，$\because I_2 = 80\,A$

25. 負載不平衡時，且中性線斷，則負載小的兩端端電壓較大

## 第二部份：電子學

26. LSI 晶片上的元件數目爲 1000~10000 個

27. (A) 所謂 P 型半導體是在本質半導體中摻雜 3 價的元素
(B) P 型半導體中的多數載子爲電洞
(C) 當加以順向偏壓於 PN 接面時，空乏區增加，障壁電位下降
(D) 當 PN 接面加以逆向偏壓時，仍有少數載子的流動，稱之爲逆向飽和電流

30. $\because C = \dfrac{\in A}{d}$，$\therefore C \propto \dfrac{1}{d}$，當外加逆向電壓增加時，空乏區寬度將增加，空乏區形成之電容值隨之減少

31. $I_{S(T2)} = I_{S(T1)} \times 2^{\frac{T_2 - T_1}{10}}$

$I_{S(40°C)} = 5n \times 2^{\frac{40-20}{10}} = 5n \times 2^2 = 20\,nA$

32. $V_{DC} = \dfrac{118+102}{2} = 110\,V$，$V_{r(rms)} = \dfrac{118-102}{2\sqrt{2}} = 5.65\,V$

$r\% = \dfrac{5.65}{110} \times 100\% = 5.14\%$

33. $V_o(t)_{(max)} = (V_{i(max)} - 4) \times \dfrac{5\,k}{3\,k + 5\,k}$

$= (28-4) \times \dfrac{5}{8} = +15\,V$

34. 當二極體導通時，1 kΩ 上的最大壓降爲：

$V_{1\,k\Omega} = 3 - 0.7 = 2.3\,V$

則導通時的最大電流爲：

$I = \dfrac{V_i - V_D}{R} = \dfrac{V_{1\,k\Omega}}{R} = \dfrac{2.3}{1 \times 10^3} = 2.3\,mA$

最小電流即爲二極體不導通時，亦即 0 mA

35. 次級線圈之有效値電壓電壓爲

$V_{2(rms)} = V_{1(rms)} \times \frac{N_1}{N_2} = 150\sqrt{2} \times \frac{1}{10} = 15\sqrt{2}$ V

$V_i$ 經半波整流及濾波後得

$V_C = \sqrt{2} V_{2(rms)} = \sqrt{2} \times 15\sqrt{2} = 30$ V

又當輸入於正半波時 $D_2$ off，$D_3$ on

$V_o = 30 \times \frac{1\text{ k}}{2\text{ k} + 1\text{ k}} = 10\text{ (V)}$，$V_o < 12$ V

$D_3$，off，故 $V_o = 10$ (V)

36. $Z_i = R_{B1} // r_\pi = 120\text{ k} // 1\text{ k} ≒ 1\text{ k}\Omega$

$Z_O = R_{B2} // R_C = 120\text{ k} // 2.5\text{ k} ≒ 2.5\text{ k}\Omega = R_C$

$A_V = \frac{V_o}{V_i} = -\frac{R_{B2} // R_C}{r_e} = -\frac{R_C}{r_e} = -\frac{2.5\text{ k}}{10} = -250$

$A_i = |A_i| \times \frac{Z_i}{R_{iO}} = 250 \times \frac{1\text{ k}}{2.5\text{ k}} = 100$

37. $R_{iS} = R_S + (R_B // r_\pi) = 5\text{ k} + (300\text{ k} // 1\text{ k}) ≒ 6\text{ k}\Omega$

38. $V_o = V_Z + V_{BE} = 6.3 + 0.7 = 7$ V

$I = \frac{V_i - V_o}{R_S} = \frac{12 - 7}{10} = 0.5$ A

39. (1) $V_a = V_{CC} \times \frac{R_2}{R_1 + R_2} = 12 \times \frac{4\text{ k}}{2\text{ k} + 4\text{ k}} = 8 > V_Z = 6\text{ (V)}$

∴稽納二極體可正常工作

(2) 因 $V_+$ 爲虛接地 $I_f = \frac{V_Z}{R_2} = \frac{6}{4\text{ k}} = 1.5\text{ (mA)}$

(3) $I_Z = I_1 - I_f = \frac{V_{CC} - V_Z}{R_1} - I_f = \frac{12 - 6}{2\text{ k}} - 1.5 = 1.5\text{ (mA)}$

40. 總電壓增益

$A_{VT} = A_{V1} \times A_{V2} \times A_{V3} \cdots\cdots A_{Vn} = 20\log(A_V)^n\text{ (dB)}$

41. $I_B = \frac{10 - 0.6}{100\text{ k}} = 0.094 = 94\ \mu$A

$I_C = \beta \times I_C = 49 \times 94\ \mu \cong 4.61$ mA

$V_C = I_C \times R_C = -4.61\text{ m} \times 1.2\text{ k} \cong -5.472$ V

42. $V_{GS} = V_G - V_S = -3 - 0 = -3$ V

$I_D = I_{DSS}(1 - \frac{V_{GS}}{V_P})^2 = 9\text{ m}(1 - \frac{-3}{-4.5})^2$

$= 9\text{ m} \times \frac{1}{9} = 1$ mA

$V_{DS} = V_{DD} - I_D R_D = 12 - 1\text{ m} \times 3\text{ k} = 9$ V

43. $P_o\text{(dBm)} = 10\log(\frac{P_o}{P_1}) = 10\log(\frac{P_o}{10\text{ mW}}) = -20$ dBm

$P_o = 10\text{ mW} \times 10^{-2} = 0.1$ mW

44. $V_G = V_{DD} \times \frac{R_{G2}}{R_{G1} + R_{G2}} = 24 \times \frac{1\text{ M}}{3\text{ M} + 1\text{ M}} = 6$ V

$V_{GS} = V_G - V_S = 6 - 0 = 6$ V

$I_D = K(V_{GS} - V_t)^2 = 0.3\text{ m}(6 - 2)^2 = 4.8$ mA

$V_{DS} = V_{DD} - I_D R_D = 24 - 2\text{ k} \times 4.8\text{ m} = 14.4$ V

45. $V_- = 12 \times \frac{6\text{ k}}{6\text{ k} + 6\text{ k}} = 6$ V，$V_+ = 12 \times \frac{6\text{ k}}{6\text{ k} + 3\text{ k}} = 8$ V

因 $V_+ > V_-$，OPA 之輸出爲 $+V_{sat}$

故 $LED_1$ 亮，$LED_2$ 暗

46. 輸出端 $V_o$ 的正飽和電壓及負飽和電壓與 $V_{ref}$ 無關

47. 當 $R_2 = 6\text{ k}\Omega$，$V_+ = 12 \times \frac{6\text{ k}}{3\text{ k} + 6\text{ k}} = 8$ V

又 $V_- = 6$ V，$V_+ > V_-$，∴ $V_o = +V_{sat} = 10$ V

48. ∵ $V_{PP} = 6$ V，∵ $V_{rms} = \frac{V_{PP}}{2\sqrt{2}} = \frac{6}{2\sqrt{2}} = \frac{3}{\sqrt{2}}$ V

由圖知∵ $V(t) = 10 + 3\sin\omega t$ V，∴ $V_{av} = 10$ V

∴ $V_{rms} = \sqrt{10^2 + (\frac{3}{\sqrt{2}})^2} = \sqrt{A^2 + (B)^2}$

得 $A = 10$ V、$B = \frac{3}{\sqrt{2}}$

$2A + 6\sqrt{2}B = 2 \times 10 + 6\sqrt{2} \times \frac{3}{\sqrt{2}} = 38$

49. 假設全通

則 $V_o = \dfrac{\frac{4 - 0.6}{2\text{ k}} + \frac{12 - 0.6}{1\text{ k}} + \frac{2 - 0.6}{2\text{ k}} + 0}{\frac{1}{2\text{ k}} + \frac{1}{1\text{ k}} + \frac{1}{2\text{ k}} + \frac{1}{1\text{ k}}} = 4.6$ V

(與題目不符合，即假設全通爲錯誤！)

故只有 12 V 端導線通，∵ $\Sigma I_i = \Sigma I_o$

$\Rightarrow \frac{12 - 0.6 - V_o}{1\text{ k}} = \frac{V_o}{1\text{ k}} \Rightarrow$ 化簡得 $V_o = 5.7$ (V)

50. 韋恩電橋振盪器之正回授電路決定振盪頻率，負回授電路決定增益