1. (20 %) Answer the following questions:
   (a) What are the contents of the PC (program counter) upon RESET of the 8051?
       **ANS: 0000**
   (b) What are the contents of the SP register upon RESET of the 8051?
       **ANS: 07**
   (c) For 8051 family members with on-chip ROM such as the 8751 and the 89C51, pin $\overline{EA}$ is connected to ________ ($V_{cc}$, GND).
       **ANS: $V_{cc}$**
   (d) Including reset, how many interrupts does the 8051 have?
       **ANS: 6**
   (e) RST is an ________ (input/output) pin. The RST pin is normally ______ (low, high) and needs a ________ (low, high) signal to be activated.
       **ANS: Input/Low/High**
   (f) The registers of Timer 0 are accessed as ______ and ______.
       **ANS: TH0 and TL0**
   (g) In the 8051, how many pins are designed as I/O port pins?
       **ANS: 32 I/O pins**

2. (10 %) Assuming that XTAL = 20MHz, program Timer 1 to generate a time delay of 100ms.

   **ANS:**

   ```
   MOV R3, #0AH
   MOV TL1, #0E6H
   MOV TH1, #0BEH
   SETB TR1
   HERE: JNB TF1, HERE
   CLR TF1
   DJNZ R3, HERE
   CLR TR1
   ```
3. (10 %) Write an 8051 program to transfer serially the letter “Z” continuously at a 1,200 baud rate.

**ANS:**

```asm
MOV TMOD, #20H
MOV TH1, #-24H
MOV SCON, #50H
SETB TR1
AGAIN: MOV A, 'Z'
MOV SBUF, A
HERE: JNB TI, HERE
CLR TI
SJMP AGAIN
```

4. (5 %) Find the TMOD value for both Timer 0 and Timer 1, mode 2, software start/stop (gate = 0), with the clock coming from the 8051’s crystal.

**ANS: 00100010b**

5. (5 %) Assuming that XTAL = 16 MHZ, indicate when the TF0 flag is raised for the following program.

```asm
MOV TMOD, #01
MOV TL0, #12H
MOV TH0, #1CH
SETB TR0
```

**ANS:**

FFFF - 1C12 = E3EDH(dex) = 58349(Dec)

and 58349 x 0.75 μs = 43.761 ms

6. (10 %) Find the baud rate for the following if XTAL = 16 MHz and SMOD = 1.
   (a) MOV TH1, #-10  
   (b) MOV TH1, #-25

**ANS:**

16MHz/12 = 1.333 MHz and 1.333MHz/16 = 83333 Hz
(a) 83333/10 = 8333
(b) 83333/25 = 3333
7. (10 %) Program Timer 0 to be an event counter. Use mode 2 and display the binary count on P2 continuously. Set the initial count to 20.

ANS:

![Program Code](image1)

8. (10 %) Write an 8051 program to transfer serially the letter “Z” continuously at a 1,200 baud rate.

ANS:

![Program Code](image2)

9. (5 %) Explain what happens if a low-priority interrupt is activated while the 8051 is serving a higher-priority interrupt.

ANS: The microcontroller finishes the higher priority first and then the lower priority interrupt is served.

會先優先執行高順位的中斷，才去執行低順位的中斷
10. (5 %) Explain the difference between the low-level and edge-triggered interrupts.

ANS: The edge trigger occurs on the negative edge of the pulse applied to the external pins of P3.2 and P3.3. No new interrupt is recognized until the RETI instruction is executed. The level triggered interrupt occurs when a low level pulse is applied to these pins. Within 4 clock cycles, the pulse must become high, or before the execution of the RETI in order to prevent multiple interrupts from the same pulse.

11. (5 %) Assume that Timer 1 is programmed for mode 1, TH0 = FFH, TL1 = F8H, and the IE bit for Timer 1 is enabled. Explain how the interrupt is activated.

ANS: It counts up from FFF8h to FFFFh and when the rollover from FFFF to 0000 occurs, the interrupt is activated. Then the microcontroller jumps to ROM address 001B to execute the interrupt service routine.

12. (5 %) Sketch the waveform of letter h (0x68) when it is transmitted via the UART interface using the format of one start bit, eight data bits, and one stop bit.

ANS: 0x68 = 1101000

![Waveform of letter h](image)