1) The 8086 accepts instructions with up to four parts, discuss.

2) Write the instructions that copy the word written in register DX to register AX and the word written in memory at address EF80h to register BX. What would happen if the XCHG command is used?

3) Outline the difference between a Jump instruction and a conditional Jump instruction.

4) What would be the result in register AL if the instruction SHL AL, CL, where AL contains 5Fh and CL contains 4h, is executed?

5) What would be the result in register AL if the instruction SHR AL, CL, where AL contains 8Ah and CL contains 3h, is executed? If the command SHR is replaced by SAR a different answer is obtained. Explain why this occurs giving the new result.

6) What would be the result in register AL if the instruction ROL AL, CL, where AL contains 2Ah and CL contains 5h, is executed? If ROL is replaced by RCL, what would be the new result?

7) What would be the result in register AL if the instruction ROR AL, CL, where AL contains 62h and CL contains 2h, is executed? If RCR is used instead of ROR, what would be the new result?

8) Write the instructions that would negate the current value in register AL and then mask the lowest two bits.

9) A relay connected to bit 5 of port 56h needs to be toggled after a small delay. Assuming that this delay is obtained by loading CX with 05FFh, write a small program that implements the above.

10) Write a program that performs the following mathematical operation, storing the result in AH: 9Fh + 25h – 4Ah.

11) A non-linear ph meter reads the ph of the liquid in volts (range 0 – 110) by means of a probe connected at port 5Fh. Write a program that converts this voltage to ph according to the formula given below and outputs the value on an LCD display at port 01E8h. \[ PH = \frac{(\text{volts} + 15) \times 5}{45}. \]

12) Write a program that tests bit 3 of an input signal coming from port 09h and outputs the word to port 09FBh if this bit is set or to port 0Ah if this bit is reset.
13) Write a program to find the lowest among 8 grades and write the result in register DL. The grades are: 89, 78, 84, 65, 54, 48, 68, and 59.

14) By using a suitable diagram, indicate how the following definitions will be written in the data segment:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAR_1</td>
<td>DB</td>
<td>?</td>
</tr>
<tr>
<td>VAR_2</td>
<td>DW</td>
<td>3452h</td>
</tr>
<tr>
<td>VAR_3</td>
<td>DB</td>
<td>11010110b</td>
</tr>
<tr>
<td>STR_1</td>
<td>DB</td>
<td>“TESTING”</td>
</tr>
<tr>
<td>VAR_4</td>
<td>DT</td>
<td>?</td>
</tr>
<tr>
<td>NUM_1</td>
<td>DB</td>
<td>3, 5, 6, 8</td>
</tr>
<tr>
<td>STR_2</td>
<td>DB</td>
<td>“OK”</td>
</tr>
<tr>
<td>VAR_5</td>
<td>DQ</td>
<td>?</td>
</tr>
</tbody>
</table>

15) Discuss the different types of addressing modes.

16) Write a program that reads a pattern from the input port 05h, increments this value by one, outputs the result to the output port 06h, and holds this value for 250ms. After this, it reads a second pattern from the input port 07h, decrements this value by one, outputs the result to port 08h, holds this value for 250ms, and loops through the whole program for a value set in CX (set CX to 0EA8h). (Use a procedure for the delay subroutine).

17) Assuming AL contains the BCD number 38 and BL contains the BCD number 45, an ADD AL, BL would give the wrong BCD result. Explain why the result is wrong and what instruction can be used to correct it.

18) Write a program that multiplies the ASCII numbers 5 and 6 producing an ASCII result. Explain the algorithm used in changing the hexadecimal answer into the ASCII equivalent.

19) Write a program that moves a 60 word block of data located at memory address DS: SOURCE_ARRAY to the memory address pointed to by ES: DESTINATION_ARRAY.

20) Write a program that reads a byte of data from port 45h and after processing this value, outputs the result to port 6Ah. The processing of the data consists in multiplying the value by four, decrements the result by 1, and ANDs the result with F Eh. The output is held for a certain time (for delay procedure take CX = 2435h) before repeating the sequence. During the program execution an interrupt on NMI can occur. When this happens the program outputs FFh to the output port to indicate an alarm and calls the delay procedure to keep this signal on for some time.
21) Explain line by line the function of the following programs:

a) CODE SEGMENT
ASSUME CS: CODE, DS: CODE, SS: CODE
ORG 0
START: MOV SP, OFFSET TOP_OF_STACK
TOP: IN AL, 0A2H
CMP AL, 54H
JA NEXT
ADD AL, 25H
NEXT: OUT 07H, AL
MOV CX, 0E45H
SELF: LOOP SELF
JMP TOP
DB 25 DUP (?)
TOP_OF_STACK: DB 0
CODE ENDS
END START

b) CODE SEGMENT
ASSUME CS: CODE, DS: CODE, SS: CODE
ORG 0
START: MOV SP, OFFSET TOP_OF_STACK
XOR AX, AX
MOV ES, AX
MOV WORD PTR ES:08H, OFFSET ISR_ROUT
MOV WORD PTR ES:0AH, 50H
MOV AL, 90H
OUT 7, AL
MOV AL, 1
TOP: OUT 3, AL
CALL DELAY
ROL AL, 1
JMP TOP
DELAY: PUSH AX
IN AL, 1
MOV CL, 0
MOV CH, AL
ONE: PUSH CX
MOV CX, 0F0CEH
SELF: LOOP SELF
POP CX
LOOP ONE
POP AX
RET
ISR_ROUT: PUSH AX
MOV AL, 0FFH
OUT 7, AL
CALL DELAY
POP AX
IRET
DB 25 DUP (?)
TOP_OF_STACK: DB 0
CODE ENDS
END START