CSE322 Homework #1 Name___Answers_____

Read "The History of the 4004" by Faggin, F.; Hoff, M.E., Jr.; Mazor, S.; Shima, M.; IEEE Micro Volume: 16 Issue: 6 , Dec 1996 Page(s): 10 -20, and answer in the space provided the following Questions:

1. What was the original purpose for building the 4004? calculator
2. What was the size of a single data word in bits? __4__
3. Consider a 4004 system as pictured on page 11. How many types of chips were needed 4_____? How many total chips were used? ___1x4004+16x4001+16*4002+3x4003=36_also 23 was acceptable__
4. What was the maximum RAM (in bits) __1,280x4= 5120 x2_____ and ROM (in bits) __32K bits x2_____ could it support?
5. What kind of memory was used in "conventional" calculators of the day and why did the 4004 designers decide on a different style? shift registers. 4004 used DRAM because it could be used in arbitrary amounts and took less area.
6. What was the clock frequency either 1/1.35us = 740KHz or 1 MHz?
7. How many cycles did most instructions take (CPI) _8_____?
8. Given the above numbers about how many instructions per second could the chip execute? 1/8cycles*1.35us = 92.6Kips or 1/8x1us = 125Kips
9. List all the registers that the 4004 programmer could "see" or manipulate. PC, A, 16 Index Regs, stack, carry flag
10. How many transistors were on the 4004, what was the area of the 4004 chip, and thus how many transistors per square mm were implemented? 2,300 transistors in 12 sq, mm for 192 transistors/sq. mm
11. What chip followed the 4004 and how did it differ? 8008 had 8 bit register, could reach more memory, but took more support chips
12. Show in hexadecimal (with "English" annotations) a 4004 program to add 3 to the contents of register 5 and store the result in memory location 8.

Several solutions possible
D0 LDM 0 / load a 0 into acc - upper part of address
B0 XCH 0 / exchange acc & reg 0
D8 LDM 8 / load an 8 into acc
B1 SCH 1 / exchange acc and reg 1
21 SRC 0 / send register pair 000 to memory as address (an 8)
F0 CLC /clear the carry flag
D3 LDM 3 / load a 3 into the accumulator
85 ADD 5 / add register 5 to accumulator with carry
E0 WRM / write accumulator to previously selected RAM