This information might be useful. For any instruction that might need it, assume the instruction is located in memory at 0x4000.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ADD	0	0	0	1	DR			SR1			0	0	0	SR2		
ADD	0	0	0	1	DR			SR1			1	imm5				
AND	0	1	0	1	DR			SR1			0	0	0	SR2		
AND	0	1	0	1	DR			SR1			1	imm5				
BR	0	0	0	0	n	z	p	PCoffset9								
LD	0	0	1	0	DR			PCoffset9								
LDI	1	0	1	0	DR			PCoffset9								
LDR	0	1	1	0	DR			BaseR			offset6					
LEA	1	1	1	0	DR			PCoffset9								
JSR	0	1	0	0	1	PCoffset11										
JSRR	0	1	0	0	0	0	0	BaseR			0					
TRAP	1	1	1	1	0	0	0	0	trapvect8							

1. Write LC3 code to push the number in register R0 on the stack.

2. Write LC3 code to pop a number off the stack, storing the value in register R0.

3. Suppose you're in a function. Why might you push register R7 onto the stack?

4. Suppose your function takes one argument (an integer). Assuming you're doing things in the manner shown in the textbook, how would you move that argument into register R0?

5. The JSR and RET instructions both do something with the PC and R7. Describe what that is.

6. Suppose the first 4 memory locations contain x2043, x4082, x4513, and xA432. You execute a TRAP #2 instruction at memory location x3FA0. What numbers are in the PC and register R7?

7. When doing I/O, why might an interrupt be better than a busy loop?

8. Describe briefly "memory-mapped I/O." How would you get a character from the keyboard, or send one to the screen? You should mention something about status registers....

9. Suppose you have a program that does it's math on the stack. The math operations work on the top two elements. If you run the following, what number is left on top of the stack?
   PUSH 4
   PUSH 3
   Multiply
   PUSH 7
   PUSH 1
   Add
   Multiply

10. There are LC3 instructions typically used for accessing things on the stack. In a function, how many local variables and arguments could you get to with just one instruction?

11. If you call a function, with one argument being an integer, and another argument being an array of integers, how are they handled differently?

12. You are running a program that will make a function call, sending in the numbers 14 and 11 to the function. The function itself has two local variables, which have the values 8 and 9. The instruction to call the function is at memory location xABCD, the function itself is at location xBA84, and the stack pointer (before starting the function call) is at xFFB6. Show what is in memory around the stack pointer, once you get into the function (in other words, show what's on the stack).

13. With a JSR instruction, how far from the current location can you jump?

14. Describe what happens with a JSRR instruction.

15. How many different trap functions can the LC3 have?

16. Floating point has one sign bit, 8 exponent bits, and 23 fraction bits. You can convert to a real number with $N = (-1)^S \times 1.\text{fraction} \times 2^{\text{exponent} - 127}$, for exponents in the range of 1 to 254. Show the bit pattern that would represent -6 5/8. Separate out the sections of bits, so that it's easy to read (as was done in the book).

17. Draw a NAND gate using N and P transistors.

18. Draw an R-S latch.

19. Sketch a gate-level 2-bit decoder circuit; this has two inputs, S_1 and S_2, and four output lines; the different combinations of input values for S_1 and S_2 cause one of the four output lines to turn on.

20. Convert the decimal number -57 to binary and hexadecimal (assuming 8 bit numbers).

21. Circuit functions can be written with a plus symbol for logical “or”, a multiply for logical “and”, and an exclamation point for logical “not”. Draw a simplified circuit for (A*!B*C)+(A*B*C).

22. For the truth table given, draw a Karnaugh map, and give a simple circuit that implements the function. If you had web access, you could just use the one off the Wikipedia page; for the exam, you have to use your brain. The “x” at the start of the first column is to keep the word processor from removing leading zeros...

ABCD		**ABCD**	
x0000	1	1000	1
x0001	0	1001	0
x0010	1	1010	1
x0011	0	1011	0
x0100	0	1100	0
x0101	0	1101	0
x0110	0	1110	0
x0111	0	1111	0

24. Write the bit pattern for an LC3 instruction which causes the program counter to jump forward 41 locations if the “negative” status register is set.

25. What do FSM, SEXT, MAR, and PC stand for? (1 point each).

26. Write a few lines of assembly language that results in R0 = R1 - R2.

27. (one point) We discussed an obscure item on a web site during the review session. What is that item?

28. (one point) How many years ago did the 4004 come out (or roughly what year was it)?

29. (one point) One of the flashing patterns for the lab kit was to count; the other was based on a car from a 80’s TV show. What was the name of the show?