1. (10 points) a. (6 points) Draw a word-wide HEXADECIMAL content of memory cells corresponding to the following sequence of assembler directives:

```assembly
ORG $3700
A DS.W 2
P EQU 20
V1 DC.B 10,45
V2 DC.L $40302010
V3 DC.B P-2
V4 DS.L 3
```

<table>
<thead>
<tr>
<th>Address [Hex]</th>
<th>Content &lt;15:0&gt; [Hex]</th>
<th>Comment</th>
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b. (4 points) The Motorola 68000 microprocessor has:

(i) _____ sizes for data operations

(ii) _____ functioning as the stack pointer

(iii) register size is _____ bits

(iv) status bit N represents ___________. It is set when _______________________.

2. (1 point) ________________ is the hardest problem.

3. (1 point) ______________ occurs when a number can’t be represented in a computer.

4. (1 point) The addressing mode used when the contents of an address register specify the address of the operand is known as _________________________ addressing.

5. (15 points) Write a subroutine using 68K assembly that sums the elements of a word array. Assume that parameters for subroutine void sum_array(int *a, int n, int *sum), the starting address, array size, and the address of sum are prepared on the stack in the main program. Use registers for local variables in the subroutine.

6. (1 point) The addressing mode used when the operand appears in the instruction itself is known as _________________________ addressing.

7. (1 point) The Motorola 68000 instruction set is a ________ operand instruction set.

8. (20 points) For the given fraction of an assembly language program:

```
MOVE.L #1, D1
L2 MOVE.L -2(A6),D0
MULU.L D0,D1
ADDQ.W #1,-2(A6)
L1 ADDQ.W #1,D1
CMP.W #20,D1
BHI.S L2
RTS
```
a. (10 points) Find the total execution time of the given program on an 8 MHz 68000 microprocessor.

b. (5 points) Calculate the average CPI (number of clocks per instructions).

c. (5 points) Calculate the MIPS rate.

9. (25 points) Represent the state of the stack and values of SP and A6 during the execution of the following program:

```c
int power (long unsigned int *base, unsigned int *exponent,
          long unsigned int *product);
int main()
{
    long unsigned int a, b;
    unsigned int i;
    a = 2;
    i = 2;
    power(&a, &i, &b);
    return 0;
}
int power (long unsigned int *base, unsigned int *exponent,
          long unsigned int *product)
{
    unsigned int i = 1;
    *product = 1;
    while (i <= *exponent)
    {
        *product = *product * *base;
        i++;
    }
    return 0;
}
```
Code generated by the cross compiler is given below:

```
*5 int main()
* Variable a is at -4(A6)
* Variable b is at -8(A6)
* Variable i is at -10(A6)
LINK A6,#-10

MOVEQ.L #2,D1
MOVE.L D1,-4(A6)
MOVE #2,-10(A6)
PEA.L -8(A6)
PEA.L -10(A6)
PEA.L -4(A6)

JSR power
CLR D0
UNLK A6
RTS
```

```
*18 int power (long unsigned int *base,
unsigned int *exponent, long unsigned int *product)
* Parameter base is at 8(A6)
* Parameter exponent is at 12(A6)
* Parameter product is at 16(A6)
* Variable i is at -2(A6)
LINK A6,#-2
MOVE #1,-2(A6)

MOVEQ.L #1,D1
MOVEA.L 16(A6),A4
MOVE.L D1,(A4)
BRA L1
L2 MOVEA.L 16(A6),A4
MOVE.L (A4),D1
MOVEA.L 8(A6),A0
MULU.L (A0),D1
MOVE.L D1,(A4)
ADDQ #1,-2(A6)
L1 MOVEA.L 12(A6),A4
MOVE -2(A6),D1
CMP (A4),D1
BLS.S L2
CLR D0

UNLK A6
RTS
```
68000 Registers (all values are hex unless otherwise noted)

Main memory (all values are hex unless otherwise noted)

10. (30 points) What is the effect of applying each of the following 68000 instructions assuming the initial conditions shown? Represent modified internal registers, memory locations and condition codes.

(a) MOVE.B (A1)+, D0
CMPI.B #$5A, D0

(b) CMPM.W (A1)+, (A3)+
(c) CLR.L 5(A3, D6.W)

(d) BEQ #100

(e) AND.B 6(A4), $1001C

(f) BCHG.W #10, D3

(g) ROXR.B #4, D5

(h) ADD.W $FE(A2), (A3)+