一、

(1) 每 6 个 FLOP，读 4 个浮点数，写 2 个浮点数，共访问 24 个字节。

运算密度 6/(6 * 4) = 1/4

(2)

```
        li          $VL,44          # perform the first 44 ops
        li          $r1,0           # initialize index
 loop:  lv          $v1,a_re+$r1    # load a_re
        lv          $v3,b_re+$r1    # load b_re
        mulvv.s     $v5,$v1,$v3     # a+re*b_re
        lv          $v2,a_im+$r1    # load a_im
        lv          $v4,b_im+$r1    # load b_im
        mulvv.s     $v6,$v2,$v4     # a+im*b_im
        subvv.s     $v5,$v5,$v6     # a+re*b_re - a+im*b_im
        sv          $v5,c_re+$r1    # store c_re
        mulvv.s     $v5,$v1,$v4     # a+re*b_im
        mulvv.s     $v6,$v2,$v3     # a+im*b_re
        addvv.s     $v5,$v5,$v6     # a+re*b_im + a+im*b_re
        sv          $v5,c_im+$r1    # store c_im
        bne         $r1,0,else      # check if first iteration
        addi        $r1,$r1,#44     # first iteration,
                                    increment by 44
        j loop                      # guaranteed next iteration
 else:  addi        $r1,$r1,#256    # not first iteration,
                                    increment by 256
 skip:  blt         $r1,1200,loop   # next iteration?
```

(3)

```
  1.    mulvv.s     lv        # a_re * b_re (assume already
                              # loaded), load a_im
  2.    lv          mulvv.s   # load b_im, a_im*b_im
  3.    subvv.s     sv        # subtract and store c _re
  4.    mulvv.s     lv        # a_re*b_im, load next a_re vector
  5.    mulvv.s     lv        # a_im*b_re, load next b_re vector
  6.    addvv.s     sv        # add and store c im
```

6 次

（4）第四题不算分，已经作答的忽略不计。

（5）

```
1. mulvv.s                      # a_re*b_re
2. mulvv.s                      # a_im*b_im
3. subvv.s  sv                  # subtract and store c_re
4. mulvv.s                      # a_re*b_im
5. mulvv.s  lv                  # a_im*b_re, load next a_re
6. addvv.s  sv   lv   lv   lv   # add, store c_im, load next b_re,a_im,b_im
```

6 次。尽管有三条存储器流水线和链接，但是分析出它的钟鸣后会发现没有变化，因此结果不会产生变化

二、

（1）1.5 × 16 × 16 = 384 GFLOPS/s

（2）维持吞吐量需要 12 bytes/FLOP × 384 GFLOPs/s = 4.6 TB/s 带宽，给定的存储器带宽不满足，所以吞吐量不能持续。

三、

（1）1.5 GHz × .80 × .85 × 0.70 × 10 cores × 32/4 = 57.12 GFLOPs/s

（2）

Option 1: 1.5 GHz × .80 × .85 × .70 × 10 cores × 32/2 = 114.24 GFLOPs/s (speedup = 114.24/57.12 = 2)

Option 2: 1.5 GHz × .80 × .85 × .70 × 15 cores × 32/4 = 85.68 GFLOPs/s (speedup = 85.68/57.12 = 1.5)

Option 3: 1.5 GHz × .80 × .95 × .70 × 10 cores × 32/4 = 63.84 GFLOPs/s (speedup = 63.84/57.12 = 1.11)

Option 3 is best