**Exercise: I/O**

**Reference answer**

1. B
2. A
3. C
4. The total memory space can be addressed is 2^10 = 1024 words

The memory space can be used for I/O controller is 1024-1000=24 words

Each controller uses 4 words (4 registers, one word per register), so the number of I/O controller can be supported in at most 24/4=6

We estimate the total time spent on data access with each technique:

* Programmed I/O: Each time when program accesses the data, it may wait for 0~4 ms for the device to be available, on average the waiting time is 2ms. The time to transfer 1MB data is 1ms.  
  So on average the data access time for the 1MB data is 2+1=3ms.

The total data access time is 3ms\*10=30ms

* Interrupt-driven I/O: the overhead for interrupt service is 0.5ms, the total amount of time to transfer 1MB data is 1ms, so the total data access time for the 1MB data is 1+0.5=1.5ms.

The total data access time is 1.5ms\*10=15ms

* DMA: the total time to transfer the data between CPU and device of 1KB data is (0.0012+0.0008) = 0.002ms, so transferring 10MB data is 20ms in total. So the total data access time is 20ms plus the DMA configuration overhead 10ms, which is 30ms in total.

Therefore, the interrupt-driven I/O is the best for this program.