**A.**

1. What is swapping?

Swapping is exchanging pages between one page from hard disk and a one from the RAM.

2. What is a page table? What does it do?

A table contains a record of each page associated with its mapping of real physical address. Provides a mapping between virtual address and physical address.

3. In your own words explain what virtual memory is.

Due to Shortage of physical memory, each application has its virtual memory space that part of the disk, and when program needs pages to be on physical memory it swaps those pages between physical and virtual memories.

4. What does the MMU do?

Memory Management Unit, that maps pages between physical and virtual memories using page table.

5. What does the TLB (associative memory) do?

Caching for the pages that frequently used to be retrieved relatively faster to physical memory.

6. What is the relationship of the TLB to the MMU?

TLB Caches pages that frequently used to be retrieved relatively faster to physical memory by MMU.

**B. Page 248 - 1, 4, 6, 8, 11(a), 12, 16, 18.**

4. First fit takes 20 KB, 10 KB, 18 KB. Best fit takes 12 KB, 10 KB, and 9 KB. Worst fit takes 20 KB, 18 KB, and 15 KB. Next fit takes 20 KB, 18 KB, and 9 KB.

6. They built an MMU and inserted it between the 8086 and the bus. Thus all 8086 physical addresses went into the MMU as virtual addresses, the MMU then mapped them onto physical addresses, which went to the bus.

8. (nv) is the total virtual address space for all the processes combined, however an amount (r) can be in RAM, so the amount of disk storage required is (nv − r). This amount is more than the needed in practice.

11.

a. There’s no need to load the whole page table in memory and only load the level that may have the searched address.

12. 20-bits are used for the virtual page numbers, leaving 12 over for the offset (4-KB page). So, 20-bits for the virtual page means 220 pages.

16. The R bit is never needed in the TLB. because the page has been referenced.

18. 2^48 / 2^13 = 2^35