4) Suppose you have a cache memory with 64KB, direct-mapped cache with 4 words (32 bytes) blocks. Indicate for the address fields (showing bit positions), given that 32 bit address is used.

a) Locate the byte offset bits of the address and give the number of byte offset bits.
b) Locate the word offset bits of the address and give the number of word offset bits.
c) Locate the index bits of the address and give the number of index bits.
d) Locate the tag bits of the address and give the number of tag bits.

a) 4words → 32 bytes ⇒ 1 word = 8 bytes
1 word → ?

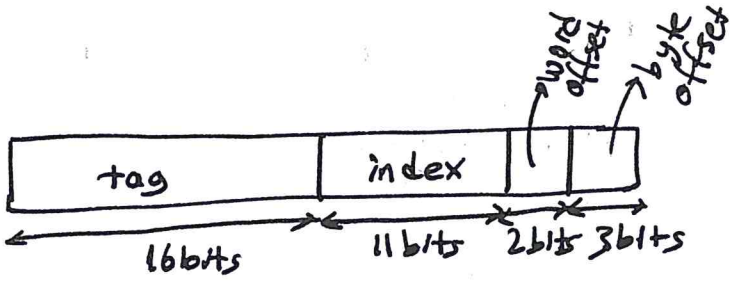
$\log_2 8 = 3$ ⇒ 3 bits for the byte offset

b) 1 block → 4 words

$\log_2 4 = 2$ ⇒ 2 bits for the word offset

c) $\log_2\left(\frac{64\,kB}{32\,B}\right) = \log_2\left(\frac{2^{16}\,B}{2^5\,B}\right)$ = 11 bits for the index

d) $32 - (3+2+11) = 16$ bits for the tag



B) Here is a series of byte address references in decimal

4, 16, 32, 20, 80, 68, 76, 224, 36, 44, 16, 172, 20, 24, 36, 68

Assuming a direct-mapped cache initially empty, label each reference in the list as a hit or miss. Show the final contents of the cache.

tag: 16 bit, decimal
index: 11 bit, decimal
word: 2 bit, binary
byte: 3 bit, binary

	reference	tag	index	block offset: word	block offset: byte	
(a)	4	0	0	00	100	miss
(b)	16	0	0	10	000	hit
(c)	32	0	1	00	000	miss
(d)	20	0	0	10	100	hit
(e)	80	0	2	10	000	miss
(f)	68	0	2	00	100	hit
(g)	76	0	2	01	100	hit
(h)	224	0	7	00	000	miss
(i)	36	0	1	00	100	hit
(j)	44	0	1	01	100	hit
(k)	16	0	0	10	000	hit
(l)	172	0	5	01	100	miss
(m)	20	0	0	10	100	hit
(n)	24	0	0	11	000	hit
(o)	36	0	1	00	100	hit
(p)	68	0	2	00	100	hit

initial

	V	tag	addresses
0	0	x	x...x
1	0	x	x...x
2	0	x	x...x
3	0	x	x...x
4	0	x	x...x
5	0	x	x...x
6	0	x	x...x
7	0	x	x...x
⋮	⋮	⋮	⋮

(a), (b)

	V	tag	addresses
0	1	0	0...31
1	0	x	x...x
2	0	x	x...x
3	0	x	x...x
4	0	x	x...x
5	0	x	x...x
6	0	x	x...x
7	0	x	x...x
⋮	⋮	⋮	⋮

(c), (d)

	V	tag	addresses
0	1	0	0...31
1	1	0	32...63
2	0	x	x...x
3	0	x	x...x
4	0	x	x...x
5	0	x	x...x
6	0	x	x...x
7	0	x	x...x
⋮	⋮	⋮	⋮

(e), (f), (g)

	V	tag	addresses
0	1	0	0...31
1	1	0	32...63
2	1	0	64...95
3	0	x	x...x
4	0	x	x...x
5	0	x	x...x
6	0	x	x...x
7	0	x	x...x
⋮	⋮	⋮	⋮

(h), (i), (j), (k)

	V	tag	addresses
0	1	0	0...31
1	1	0	32...63
2	1	0	64...95
3	0	x	x...x
4	0	x	x...x
5	0	x	x...x
6	0	x	x...x
7	1	0	224...255
⋮	⋮	⋮	⋮

(l), (m), (n), (o), (p)

	V	tag	addresses
0	1	0	0...31
1	1	0	32...63
2	1	0	64...95
3	0	x	x...x
4	0	x	x...x
5	1	0	160...191
6	0	x	x...x
7	1	0	224...255
⋮	⋮	⋮	⋮

final

	V	tag	addresses
0	1	0	0...31
1	1	0	32...63
2	1	0	64...95
3	0	x	x...x
4	0	x	x...x
5	1	0	160...191
6	0	x	x...x
7	1	0	224...255
⋮	⋮	⋮	⋮

Total of 16 references ⇒ 11 Hit, 5 miss