1.

$$\begin{aligned} 8M &= 2^3 * 20^{20} \\ &= 2^{23} \text{ words} \\ 64K &= 2^6 * 2^{10} \\ &= 2^{16} \text{ words} \end{aligned}$$

a)

$$\begin{aligned} \text{block size} &= 32 = 2^5 \text{ words} \\ \text{frames in cache} &= \frac{2^{16}}{2^5} \\ &= 2^{11} = 11 \text{ bits for block frame \#} \end{aligned}$$

23 bits		
TAG	BlockFrame #	Offset
7 bits	11 bits	5 bits

b)

23 bits	
TAG	Offset
$23 - m$ bits	m bits

c)

$$\begin{aligned} \text{number of BF's} &= \frac{2^{16}}{2^6} \\ &= 2^{10} \\ \text{number of sets} &= \frac{\text{number of BF's}}{\text{set size}} \\ &= \frac{2^{10}}{2^2} \\ &= 2^8 \end{aligned}$$

23 bits		
TAG	Set #	Offset
9 bits	8 bits	6 bits

2.

$$
\begin{aligned}
\text{BF's in cache} &= 8 \\
&= 2^3 \\
\text{BF offset} &= 16 \\
&= 2^4 \\
\text{address size} &= 2^4 * 2^6 \\
&= 2^{10}
\end{aligned}
$$

a)

10 bits		
TAG	BF #	Offset
$10-3-4=3$ bits	3 bits	4 bits

b)

0x37A = 1101111010 since we have tag 110 in frame 7 we know that this word will be in cache because the block 110111 is in cache.

c)

0x22C = 1000101100 since we have tag 100 in frame 2 we know that this word will be in cache because the block 100010 is in cache.

c)

0x1B9 = 0110111001 since we have tag 010 in frame 3 we know that this word will not be in cache because the block 011011 is not in cache.

3.

$$
\begin{aligned}
\text{number of BF's} &= 8 \\
&= 2^3 \\
\text{number of sets} &= \frac{\text{number of BF's}}{\text{set size}} \\
&= \frac{2^3}{2^1} \\
&= 2^2
\end{aligned}
$$

a)

10 bits		
TAG	Set #	Offset
$10-2-4=4$ bits	2 bits	4 bits

b)

0x37A = 1101111010 since we have tag 1101 in a set 3 spot we know that this word will be in cache because the block 110111 is in cache.

c)

0x22C = 1000101100 since we have tag 1000 in a set 2 spot we know that this word will be in cache because the block 100010 is in cache.

c)

0x1B9 = 0110111001 since we have tag 0110 in a set 3 spot we know that this word will be in cache because the block 011011 is in cache.

4.

$1M = 2^{20}$words/address size$4K \quad = 2^2 * 2^{10} = 2^{12}$words/cache sizeBF's in cache $= \frac{2^{12}}{2^4} = 2^8$

a)

20 bits		
TAG	BF #	Offset
$20 - 8 - 4 = 8$ bits	8 bits	4 bits

0x949DA = 10010100100111011010

cache frame = 10011101 = 157

tag = 10010100 = 148

b)

number of sets $= 64 = 2^6$

20 bits		
TAG	Set #	Offset
$20 - 6 - 4 = 10$ bits	6 bits	4 bits

0x949DA = 10010100100111011010

cache tag = 10 bits

tag = 1001010010 = 252_8

c)

TAG = $20 - 4$ bits = 16 bits TAG = 0x949D

5.

$$\text{Main Mem Words/ address bits} = 2^5 * 2^{10} = 2^{15}$$
$$\text{BF's in cache} = \frac{2^2 * 2^{10} \text{ words}}{2^3 \text{ block size}}$$
$$= 2^9$$

a)

2^9 comparators are needed because there are 2^9 block frames in cache

b)

the size of the tag field is $15 - 3 = 12$ because the address is 15 bits long and the offset for a block size of 8 is 3.

c)

1 comparator would be needed and the tag size would be $15 - 3 - 9 = 3$ since 9 of the bits will be used to notate block frame number

6.

$$\text{Main Mem words} = 2^3 * 2^{10} * 2^3$$
$$= 2^16$$

a)

the number of bits in a main memory address is 16 because there are 2^16 words in main memory

b)

0xCA49 = 1100101001001001 so the 3 bit offset would be 001.

c)

since there are 512 BF's in cache there must be 10 bits that specify BF # $16 - 10 - 3 = 3$ so the tag is 3 bits so the block frame number is $0101001001 = 329$ there should be 1 hardware comparitor and it should be width 3 because the tag is 3 bits.

d)

if there are 512 BF's and 4 frames per set there are 128 sets in cache. so there should be 6 bits in the set number, $16 - 6 - 3 = 7$ so the tag is 7 bits. the set number would be $001001 = 9$. there would need to be 4 comparators, since the set size is 4, and the width should be 7 since the tag is 7 bits.