\( \text{1) } \quad \text{Cl080000}_\text{hex} \)

\[
\begin{array}{c}
\text{b.e. = 130} \\
\text{frac = 0.0001} \\
\Rightarrow \text{exp = 130 - 127 = 3}
\end{array}
\]

\[
\Rightarrow -1.0001 \times 2^3 = -1000.1_2 = [-8.5]
\]

\( \text{C120000}_\text{hex} \)

\[
\begin{array}{c}
\text{b.e. = 130} \\
\text{frac = 0.01} \\
\Rightarrow \text{exp = 130 - 127 = 3}
\end{array}
\]

\[
\Rightarrow -1.01 \times 2^3 = -101_2 = \boxed{-10}
\]

\[
\Rightarrow \text{product = } (-8.5)(-10) = 85
\]

\[
85 = 64 + 16 + 4 + 1 = 1010101_2
\]

\[
= 1.010101 \times 2^6
\]

\[
\begin{array}{c}
\text{frac} \\
\text{b.e. = 6127 = 133} \\
\text{sign bit = 0}
\end{array}
\]

\[
\Rightarrow \text{0 10000101 01010100} \ldots
\]

\[
\begin{array}{c}
4 \quad 2 \quad A \quad A
\end{array}
\]

\[
\Rightarrow \boxed{42AA00000}
\]
2 (a) (must show work)

\[
\begin{align*}
&LDI \ r0, \ #85 \\
&ADD \ r1, \ r0, \ r0 \\
&AND \ r2, \ r1, \ r0 \\
&HLT
\end{align*}
\]

(in the 1st instruction, it's also ok to say: LDI r0, \#0x55 or some other way to indicate hex 55)

(b) (must show work)

---

Instruction #: 1 \hspace{1cm} PC=00000004
Condition codes: \(C=x\) \(V=x\) \(Z=x\) \(N=x\)
R[0]: 00000005 00000000 00000000 00000000

Instruction #: 2 \hspace{1cm} PC=00000008
Condition codes: \(C=0\) \(V=0\) \(Z=0\) \(N=0\)
R[0]: 00000005 00000000 00000000 00000000

Instruction #: 3 \hspace{1cm} PC=0000000c
Condition codes: \(C=0\) \(V=0\) \(Z=0\) \(N=0\)
R[0]: 00000005 00000000 00000000 00000000

Instruction #: 4 \hspace{1cm} PC=00000010
Condition codes: \(C=0\) \(V=0\) \(Z=0\) \(N=0\)
R[0]: 00000005 00000000 00000000 00000000

(it's ok to use either upper- or lower-case letters for hex values, registers or instruction names)
add r14, r15, r16 ; instruction 1
sub r16, r17, r15 ; instruction 2
or r14, r16, r17 ; instruction 3

(a) flow dependence from instruction 2 to instruction 3 through r16

instruction 1 is anti-dependent on instruction 2 through r16

instructions 1 and 3 are output dependent through r14

(b)

<table>
<thead>
<tr>
<th></th>
<th>IF</th>
<th>ID</th>
<th>EX</th>
<th>MEM</th>
<th>WB</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>add</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>sub</td>
<td>add</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>or</td>
<td>sub</td>
<td>add</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>or</td>
<td>sub</td>
<td>add</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>or</td>
<td>sub</td>
<td>add</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>or</td>
<td>sub</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>or</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(no bubbles are inserted because of the forwarding logic in the pipelined VeSPA implementation). Thus:

instruction 1 will be in the WB stage during cycle 25
instruction 2 will be in the WB stage during cycle 26
instruction 3 will be in the WB stage during cycle 27
4.

Page size of 32k bytes

$\Rightarrow$ 15-bit page offset

$\Rightarrow$ 40 - 15 = 25-bit virtual page #

$\Rightarrow$ # of page table entries is $2^{25}$

Each entry is 32 bits = 4 bytes

$\Rightarrow$ Total size of page table is:

$(2^{25})(2^3 \text{ bytes}) = 2^{27} \text{ bytes}$

$= 2^7 \text{ Mbytes}$

$= 128 \text{ Mbytes}$

(either one is OK)
5-miss, 10-miss, 2-miss, 12-miss, 5-hit, 18-miss, 2-hit, 5-hit, 10-miss, 7-miss, 26-miss, 20-miss, 12-hit, 28-miss

Final cache contents are shown below:

<table>
<thead>
<tr>
<th>set</th>
<th>address</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10 18 10</td>
</tr>
<tr>
<td></td>
<td>2 26</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>12 20 28</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
(a) predicts all T's
⇒ 6 correct, 4 wrong
accuracy = 60%

(b) predicts all N's
⇒ 4 correct, 6 wrong
accuracy = 40%

(c)
\[
\begin{align*}
\text{predict} &= T N T T N T T T N N N \\
\text{actual} &= N T T N T T T N N T \\
& \quad \times \times \checkmark \times \times \checkmark \times \checkmark \times \checkmark \times \\
⇒ \quad 4 \text{ correct, } 6 \text{ wrong}
\end{align*}
\]
accuracy = 40%

(d) state = 2 3 4 1 2 1 1 1 1 2 3
\[
\begin{align*}
\text{predict} &= T N N T T T T T T N \\
\text{actual} &= N T T N T T T N N T \\
& \quad \times \times \times \checkmark \checkmark \checkmark \times \times \times \\
⇒ \quad 3 \text{ correct, } 7 \text{ wrong}
\end{align*}
\]
accuracy = 30%
(must show work)

10 \( x = 3 \), \( y = 4 \), \( z = 12 \)
20 \( x = 4 \), \( y = 4 \), \( z = -16 \)
30 \( x = 5 \), \( y = 4 \), \( z = -12 \)