$\phi(A,B,C,D,E) = m_0 + m_2 + m_4 + m_6 + m_9 + m_{10} + m_{13} + m_{14} + m_{15} + m_{16} + m_{17} + m_{21} + m_{26} + m_{28} + m_{30} + m_{31}$  Classifying and setting min terms:

| min terms              | patterns |
|------------------------|----------|
| IIITII CELIII2         |          |
| m <sub>∅</sub>         | 00000    |
| m <sub>2</sub>         | 00010    |
| <b>m</b> 4             | 00100    |
| <b>m</b> <sub>6</sub>  | 00110    |
| <b>m</b> 9             | 01001    |
| m <sub>10</sub>        | 01010    |
| m <sub>13</sub>        | 01101    |
| m <sub>14</sub>        | 01110    |
| m <sub>15</sub>        | 01111    |
| m <sub>16</sub>        | 10000    |
| m <sub>17</sub>        | 10001    |
| m <sub>21</sub>        | 10101    |
| <b>m</b> <sub>26</sub> | 11010    |
| m <sub>28</sub>        | 11100    |
| m <sub>30</sub>        | 11110    |
| <b>m</b> <sub>31</sub> | 11111    |

## Now classifying them:

| min                    | nattanna |                      | Min toom                        | nattann   | ·            | Min tonn                 | nattar | · |
|------------------------|----------|----------------------|---------------------------------|-----------|--------------|--------------------------|--------|---|
| min                    | patterns | u                    | Min term                        | pattern   | u            | Min term                 | patter | u |
| terms                  |          | S                    |                                 |           | S            |                          | n      | S |
|                        |          | e .                  |                                 |           | e            |                          |        | e |
|                        |          | d                    |                                 |           | d            |                          |        | d |
| m <sub>0</sub>         | 00000    | $ $                  |                                 | 000_0     | ✓            |                          |        | X |
| m                      | 00010    | ,                    | $m_{0,2}$                       | 00_00     |              |                          |        |   |
| m <sub>2</sub>         | 00010    | $\checkmark$         | $m_{0,4}$                       | _0000     | ✓            | $m_{0,2,4,6}$            | 000    |   |
| m <sub>4</sub>         | 00100    | <b>√</b>             | M <sub>0,16</sub>               |           | Χ            |                          |        |   |
|                        |          | <b>'</b>             |                                 |           |              |                          |        |   |
| <b>m</b> <sub>6</sub>  | 00110    | ✓                    |                                 | 00_10     | ✓            |                          |        | X |
|                        | 04.004   |                      | <b>m</b> 2,6                    | 0_010     | <u> </u>     |                          |        |   |
| <b>m</b> 9             | 01001    | ✓                    | M <sub>2,10</sub>               | 001_0     | ✓            |                          |        |   |
| m <sub>10</sub>        | 01010    | <b>√</b>             | M <sub>4,6</sub>                | 1000_     | <b>/</b>     | m <sub>2,6,10,14</sub>   | 0 10   |   |
| 11170                  | 01010    | <b>'</b>             | M <sub>16,17</sub>              | _         | <b>'</b>     | , , , ,                  |        |   |
| m <sub>13</sub>        | 01101    | <b>√</b>             | 20,27                           |           | Χ            |                          |        |   |
|                        |          |                      |                                 |           | <u> </u>     |                          |        |   |
| m <sub>14</sub>        | 01110    | ✓                    |                                 | 0_110     | ✓            |                          |        | X |
|                        | 2444     | _                    | M <sub>6,14</sub>               | 01_01     |              |                          |        |   |
| <b>m</b> <sub>15</sub> | 01111    | $ $ $\checkmark$ $ $ | <b>M</b> 9,13                   | 01_10     | X            |                          |        |   |
| m <sub>16</sub>        | 10000    | <b>√</b>             | M <sub>10</sub> , <sub>14</sub> | 1010      | <b>/</b>     |                          | 1 10   |   |
| 11176                  | 10000    | <b>V</b>             | M <sub>10,26</sub>              | <br>10_01 | <b>'</b>     | m <sub>10,14,26,30</sub> |        |   |
| M <sub>17</sub>        | 10001    | <b>√</b>             | m <sub>17,21</sub>              |           | <b>√</b>     |                          |        |   |
|                        |          | Ů                    | 17,21                           |           |              |                          |        |   |
| m <sub>21</sub>        | 10101    | ✓                    |                                 |           | X            |                          |        |   |
|                        | 44040    |                      |                                 | 011 1     |              |                          |        |   |
| <b>m</b> <sub>26</sub> | 11010    | ✓                    | M <sub>13,15</sub>              | 011_1     | X            |                          |        | X |
| m <sub>28</sub>        | 11100    | /                    | M <sub>14,15</sub>              | 0111_     | /            |                          |        |   |
| 11128                  | 11100    | ✓                    | M <sub>14,30</sub>              | _1110     | <b>√</b>     |                          |        |   |
|                        |          |                      | $m_{28,30}$                     | 111_0     | $\checkmark$ | M <sub>14,15,30,31</sub> | _111_  |   |
| m <sub>30</sub>        | 11110    | ✓                    | $m_{26,30}$                     | 11_10     | X            |                          |        |   |
|                        |          |                      |                                 |           | <b>√</b>     |                          |        |   |
| m <sub>31</sub>        | 11111    | <b>√</b>             | M <sub>15,31</sub>              | 1111      | <b>√</b>     |                          |        |   |
| 11121                  |          | <b>'</b>             |                                 | 1111_     |              |                          |        |   |
|                        |          |                      | M <sub>30,31</sub>              |           | $\checkmark$ |                          |        |   |

From the table we can conclude 10 prime implicants

$$M_{0,16} = (\neg B \land \neg C \land \neg D \land \neg E)$$

$$m_{16,17} = (A^{-3}B^{-3}C^{-3}D)$$

$$M_{9,13} = (\neg A \land B \land \neg D \land E)$$

$$M_{17,21} = (A ^ ¬B ^ ¬D ^ E)$$

$$m_{13,15} = (\neg A \land B \land C \land E)$$

$$m_{28,30} = (A^B^C^7E)$$

$$m_{0,2,4,6} = (\neg A \land \neg B \land \neg E)$$

$$m_{2,6,10,14} = (\neg A \land D \land \neg E)$$

$$m_{10,14,26,30} = (B^D^T)$$

$$m_{14,15,30,34} = (B ^ C ^ D)$$

| MINTERMS                  | m <sub>0</sub> | m <sub>2</sub> | m <sub>4</sub> | m <sub>6</sub> | <b>m</b> <sub>9</sub> | m <sub>10</sub> | <b>m</b> 13 | m <sub>14</sub> | m <sub>15</sub> | m <sub>16</sub> | m <sub>17</sub> | m <sub>21</sub> | <b>m</b> <sub>26</sub> | m <sub>28</sub> | m <sub>30</sub> | m <sub>31</sub> | Е        |
|---------------------------|----------------|----------------|----------------|----------------|-----------------------|-----------------|-------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------------|-----------------|-----------------|-----------------|----------|
| M0,16                     | ✓              |                |                |                |                       |                 |             |                 |                 | <b>√</b>        |                 |                 |                        |                 |                 |                 |          |
| M <sub>16,17</sub>        |                |                |                |                |                       |                 |             |                 |                 | <b>√</b>        | <b>√</b>        |                 |                        |                 |                 |                 |          |
| M9,13                     |                |                |                |                | <b>√</b>              |                 | <b>√</b>    |                 |                 |                 |                 |                 |                        |                 |                 |                 | <b>√</b> |
| M <sub>17,21</sub>        |                |                |                |                |                       |                 |             |                 |                 |                 | <b>√</b>        | <b>√</b>        |                        |                 |                 |                 | <b>√</b> |
| M <sub>13,15</sub>        |                |                |                |                |                       |                 | <b>√</b>    |                 | <b>√</b>        |                 |                 |                 |                        |                 |                 |                 |          |
| M <sub>28,30</sub>        |                |                |                |                |                       |                 |             |                 |                 |                 |                 |                 |                        | <b>√</b>        | <b>√</b>        |                 | <b>√</b> |
| M0,2,4,6                  | <b>√</b>       | <b>√</b>       | <b>√</b>       | <b>√</b>       |                       |                 |             |                 |                 |                 |                 |                 |                        |                 |                 |                 | <b>√</b> |
| M <sub>2,6,10,14</sub>    |                | <b>√</b>       |                | <b>√</b>       |                       | <b>√</b>        |             | <b>√</b>        |                 |                 |                 |                 |                        |                 |                 |                 |          |
| M <sub>10,14,26,30</sub>  |                |                |                |                |                       | <b>√</b>        |             | <b>√</b>        |                 |                 |                 |                 | <b>√</b>               |                 | <b>√</b>        |                 | ✓        |
| M <sub>14</sub> ,15,30,34 |                |                |                |                |                       |                 |             |                 |                 |                 | <b>√</b>        | <b>√</b>        |                        |                 |                 |                 | <b>√</b> |
|                           | <b>√</b>       | <b>√</b>       | <b>√</b>       | <b>√</b>       | <b>√</b>              | <b>√</b>        | <b>√</b>    | <b>√</b>        | <b>√</b>        | <b>√</b>        | <b>√</b>        | <b>√</b>        | <b>√</b>               | <b>√</b>        | <b>√</b>        | <b>√</b>        |          |

Essential prime implicants are:

 $(m_{9,13}, m_{17,21}, m_{28,30}, m_{0,2,4,6}, m_{10,14,26,30}, m_{14,15,30,34})$  and  $(m_{0,16} \text{ or } m_{16,17})$ 

## c) solution:

$$\phi = (\neg B \land \neg C \land \neg D \land \neg E) \land (\neg A \land B \land \neg D \land E) \land (A \land \neg B \land \neg D \land E) \land (A \land B \land C \land \neg E)$$

$$\land (\neg A \land \neg B \land \neg E) \land (B \land D \land \neg E) \land (B \land C \land D)$$

<u>OR</u>

$$\phi = (A \land \neg B \land \neg C \land \neg D) \land (\neg A \land B \land \neg D \land E) \land (A \land \neg B \land \neg D \land E) \land (A \land B \land C \land \neg E)$$

$$\land (\neg A \land \neg B \land \neg E) \land (B \land D \land \neg E) \land (B \land C \land D)$$