## EXERCISES 8.3

For Exercises 1–8, write the minimal sum-of-products form for the Karnaugh maps of the given figures.

1.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3$ | | | 1 | 1 |
| $x_3'$ | 1 | 1 | | 1 |

2.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3$ | 1 | | | 1 |
| $x_3'$ | | 1 | | |

3.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3$ | 1 | 1 | 1 | 1 |
| $x_3'$ | 1 | | | 1 |

4.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3$ | | | | |
| $x_3'$ | 1 | | 1 | 1 |

5.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3x_4$ | | 1 | | |
| $x_3x_4'$ | | 1 | 1 | 1 |
| $x_3'x_4'$ | 1 | 1 | 1 | |
| $x_3'x_4$ | | 1 | | |

6.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3x_4$ | | | | |
| $x_3x_4'$ | 1 | 1 | | 1 |
| $x_3'x_4'$ | 1 | | | 1 |
| $x_3'x_4$ | | | | |

7.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3x_4$ | | 1 | | |
| $x_3x_4'$ | | 1 | 1 | 1 |
| $x_3'x_4'$ | | | | |
| $x_3'x_4$ | | 1 | | |

8.

| | $x_1x_2$ | $x_1x_2'$ | $x_1'x_2'$ | $x_1'x_2$ |
|---|---|---|---|---|
| $x_3x_4$ | | | | 1 |
| $x_3x_4'$ | 1 | 1 | | |
| $x_3'x_4'$ | | 1 | 1 | |
| $x_3'x_4$ | | | 1 | |

For Exercises 9 and 10, use a Karnaugh map to find the minimal sum-of-products form for the truth functions shown.

9.

| $x_1$ | $x_2$ | $x_3$ | $f(x_1, x_2, x_3)$ |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 |

10.

| $x_1$ | $x_2$ | $x_3$ | $x_4$ | $f(x_1, x_2, x_3, x_4)$ |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 0 |

11. Use a Karnaugh map to find the minimal sum-of-products form for the truth function of Exercise 17, Section 8.2.

12. Use a Karnaugh map to find the minimal sum-of-products form for the truth function of Exercise 18, Section 8.2.

13. a. Use a Karnaugh map to find the minimal sum-of-products form for the truth function of Exercise 19, Section 8.2.
    b. Draw the logic network for the reduced expression of part (a).

14. a. Use a Karnaugh map to find the minimal sum-of-products form for the truth function of Exercise 20, Section 8.2.
    b. Draw the logic network for the reduced expression of part (a).

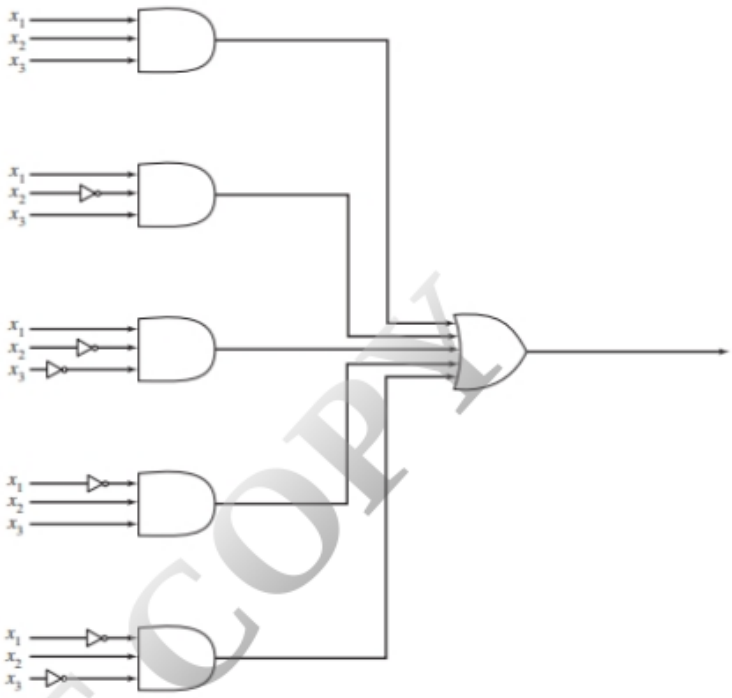
15. Use a Karnaugh map to find the minimal sum-of-products form for the following Boolean expression.

$$x_1'x_2'x_3x_4 + x_1x_2x_3'x_4 + x_1'x_2'x_3'x_4 + x_1x_2'x_3x_4' + x_1'x_2x_3x_4 + x_1'x_2x_3'x_4 + x_1'x_2'x_3x_4'$$

16. Use a Karnaugh map to find the minimal sum-of-products form for the following Boolean expression.

$$x_1'x_2'x_3'x_4' + x_1x_2x_3'x_4 + x_1'x_2'x_3'x_4 + x_1x_2x_3'x_4' + x_1'x_2x_3x_4 + x_1x_2'x_3'x_4'$$

17. Use a Karnaugh map to find a minimal sum-of-products expression for the network of three variables shown in the figure. Sketch the new network.




18. At Rats R Us, you found a standard sum-of-products form for the logic to control valves A and B (Exercise 39, Section 8.2). Now earn yourself a raise by using Karnaugh maps to minimize these expressions.

19. Use a Karnaugh map to find a minimal sum-of-products form for the truth function in the table. Don't-care conditions are shown by dashes.

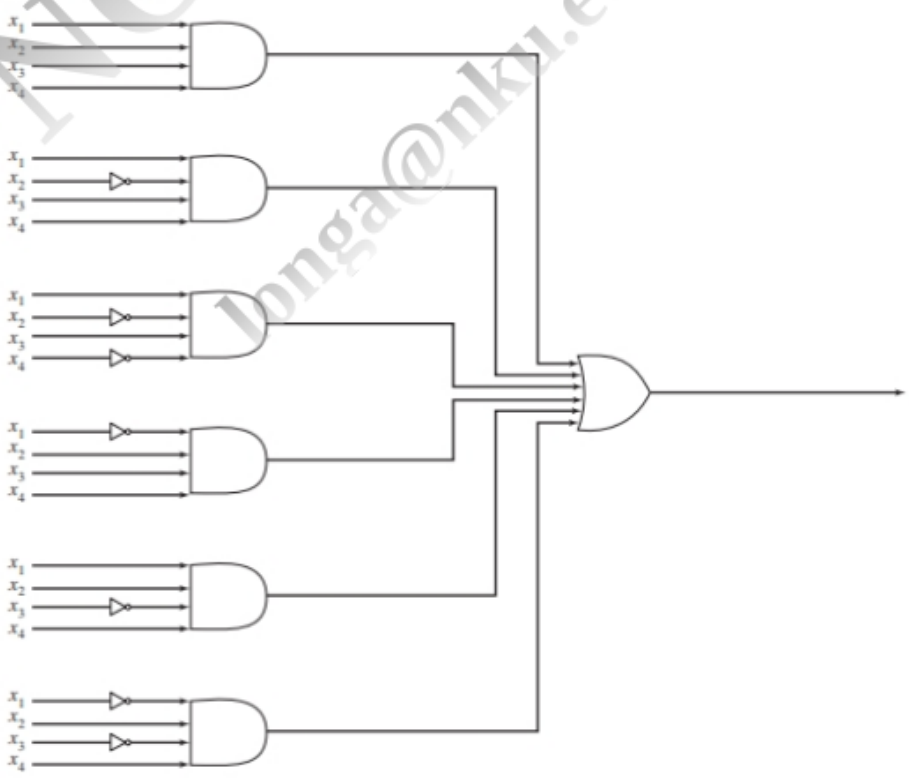
| $x_1$ | $x_2$ | $x_3$ | $x_4$ | $f(x_1, x_2, x_3, x_4)$ |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 | – |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | – |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 | – |
| 0 | 0 | 0 | 0 | 0 |

20. Use a Karnaugh map to find a minimal sum-of-products form for the truth function in the table. Don't-care conditions are shown by dashes.

| $x_1$ | $x_2$ | $x_3$ | $x_4$ | $f(x_1, x_2, x_3, x_4)$ |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 | – |
| 1 | 0 | 1 | 1 | – |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 | – |
| 0 | 0 | 0 | 0 | 0 |

21. Use the Quine–McCluskey procedure to find a minimal sum-of-products form for the truth function illustrated by the map for Exercise 3.

22. Use the Quine–McCluskey procedure to find a minimal sum-of-products form for the network in the figure. Sketch the new network.



For Exercises 23 and 24, use the Quine–McCluskey procedure to find the minimal sum-of-products form for the truth functions in the given tables.

23.

| $x_1$ | $x_2$ | $x_3$ | $x_4$ | $f(x_1, x_2, x_3, x_4)$ |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 0 | 1 |

24.

| $x_1$ | $x_2$ | $x_3$ | $x_4$ | $f(x_1, x_2, x_3, x_4)$ |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 0 | 0 | 1 |

In Exercises 25–28, use the Quine–McCluskey procedure to find the minimal sum-of-products form for the Boolean expressions.

25. $x_1x_2'x_3x_4' + x_1'x_2'x_3x_4 + x_1'x_2x_3x_4 + x_1'x_2'x_3'x_4' + x_1'x_2x_3'x_4' + x_1'x_2'x_3'x_4$

26. $x_1x_2x_3x_4 + x_1x_2'x_3x_4 + x_1x_2x_3x_4' + x_1x_2'x_3x_4' + x_1'x_2x_3x_4' + x_1x_2x_3'x_4' + x_1'x_2x_3'x_4' + x_1x_2x_3'x_4 + x_1'x_2x_3'x_4$

27. $x_1x_2x_3x_4 + x_1x_2x_3x_4' + x_1'x_2x_3x_4' + x_1x_2x_3'x_4' + x_1'x_2'x_3'x_4' + x_1'x_2x_3'x_4' + x_1x'_2x_3'x_4 + x_1'x_2'x_3'x_4 + x_1x_2x_3'x_4$

28. $x_1'x_2x_3'x_4x_5' + x_1'x_2x_3x_4'x_5 + x_1x_2x_3x_4x_5 + x_1'x_2'x_3x_4'x_5 + x_1x_2'x_3x_4x_5 + x_1'x_2'x_3'x_4'x_5 + x_1'x_2x_3'x_4'x_5 + x_1x_2x_3'x_4'x_5' + x_1x_2x_3'x_4x_5 + x_1'x_2'x_3'x_4x_5'$

29. Use the Quine–McCluskey procedure to find a minimal sum-of-products form for the truth function illustrated by the map in Figure 8.34.