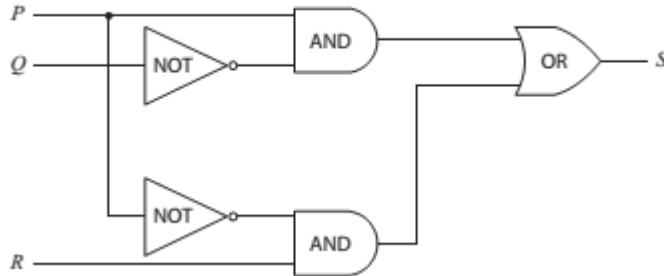


pp. 76, Exercise Set 2.4

12.  $(P \vee Q) \vee \sim (Q \wedge R)$

17.



33. a.

$$\begin{aligned}
 (P \mid Q) \mid (P \mid Q) &\equiv \sim [(P \mid Q) \wedge (P \mid Q)] && \text{by definition of } \mid \\
 &\equiv \sim (P \mid Q) && \text{by the idempotent law for } \wedge \\
 &\equiv \sim [\sim (P \wedge Q)] && \text{by definition of } \mid \\
 &\equiv P \wedge Q && \text{by the double negative law.}
 \end{aligned}$$

b.

$$\begin{aligned}
 P \wedge (\sim Q \vee R) &\equiv (P \mid (\sim Q \vee R)) \mid (P \mid (\sim Q \vee R)) \\
 &\equiv (P \mid [(\sim Q \mid \sim Q) \mid (R \mid R)]) \mid (P \mid [(\sim Q \mid \sim Q) \mid (R \mid R)]) && \text{by part (a)} \\
 &\equiv (P \mid [((Q \mid Q) \mid (Q \mid Q)) \mid (R \mid R)]) \mid (P \mid [((Q \mid Q) \mid (Q \mid Q)) \mid (R \mid R)]) && \text{by Example 2.4.7(b)} \\
 &\equiv (P \mid [((Q \mid Q) \mid (Q \mid Q)) \mid (R \mid R)]) \mid (P \mid [((Q \mid Q) \mid (Q \mid Q)) \mid (R \mid R)]) && \text{by Example 2.4.7(a)}
 \end{aligned}$$

34. b.

$$\begin{aligned}
 P \vee Q &\equiv \sim (\sim (P \vee Q)) && \text{by the double negative law} \\
 &\equiv \sim (P \downarrow Q) && \text{by definition of } \downarrow \\
 &\equiv (P \downarrow Q) \downarrow (P \downarrow Q) && \text{by part (a).}
 \end{aligned}$$

c.

$$\begin{aligned}
 P \wedge Q &\equiv \sim (\sim P \vee \sim Q) && \text{by De Morgan's law and the double negative law} \\
 &\equiv \sim P \downarrow \sim Q && \text{by definition of } \downarrow \\
 &\equiv (P \downarrow P) \downarrow (Q \downarrow Q) && \text{by part (a).}
 \end{aligned}$$

d.

$$\begin{aligned}
 P \rightarrow Q &\equiv \sim P \vee Q && \text{by Exercise 13(a) of Section 2.2} \\
 &\equiv (\sim P \downarrow Q) \downarrow (\sim P \downarrow Q) && \text{by part (b)} \\
 &\equiv ((P \downarrow P) \downarrow Q) \downarrow ((P \downarrow P) \downarrow Q) && \text{by part (a).}
 \end{aligned}$$

e.

$$\begin{aligned}
 P \leftrightarrow Q &\equiv (P \rightarrow Q) \wedge (Q \rightarrow P) \\
 &\equiv (((P \downarrow P) \downarrow Q) \downarrow ((P \downarrow P) \downarrow Q)) \wedge (((Q \downarrow Q) \downarrow P) \downarrow ((Q \downarrow Q) \downarrow P)) && \text{by the truth table on page 46 of the text} \\
 &\equiv (((P \downarrow P) \downarrow Q) \downarrow ((P \downarrow P) \downarrow Q)) \downarrow (((Q \downarrow Q) \downarrow P) \downarrow ((Q \downarrow Q) \downarrow P)) && \text{by part (d)} \\
 &\equiv (((P \downarrow P) \downarrow Q) \downarrow ((P \downarrow P) \downarrow Q)) \downarrow (((Q \downarrow Q) \downarrow P) \downarrow ((Q \downarrow Q) \downarrow P)) && \text{by part (c)}
 \end{aligned}$$