

1. The equivalences follow by showing that the appropriate pairs of columns of this table agree.

p	$p \wedge T$	$p \vee F$	$p \wedge F$	$p \vee T$	$p \vee p$	$p \wedge p$
T	T	T	F	T	T	T
F	F	F	F	T	F	F

5.

p	q	r	$q \vee r$	$p \wedge (q \vee r)$	$p \wedge q$	$p \wedge r$	$(p \wedge q) \vee (p \wedge r)$
T	T	T	T	T	T	T	T
T	T	F	T	T	T	F	T
T	F	T	T	T	F	T	T
T	F	F	F	F	F	F	F
F	T	T	T	F	F	F	F
F	T	F	T	F	F	F	F
F	F	T	T	F	F	F	F
F	F	F	F	F	F	F	F

7. a) Jan is not rich, or Jan is not happy. b) Carlos will not bicycle tomorrow, and Carlos will not run tomorrow. c) Mei does not walk to class, and Mei does not take the bus to class. d) Ibrahim is not smart, or Ibrahim is not hard working.

11. a)

p	q	$p \wedge q$	$(p \wedge q) \rightarrow p$
T	T	T	T
T	F	F	T
F	T	F	T
F	F	F	T

b)

p	q	$p \vee q$	$p \rightarrow (p \vee q)$
T	T	T	T
T	F	T	T
F	T	T	T
F	F	F	T

c)

p	q	$\neg p$	$p \rightarrow q$	$\neg p \rightarrow (p \rightarrow q)$
T	T	F	T	T
T	F	F	F	T
F	T	T	T	T
F	F	T	T	T

d)

p	q	$p \wedge q$	$p \rightarrow q$	$(p \wedge q) \rightarrow (p \rightarrow q)$
T	T	T	T	T
T	F	F	F	T
F	T	F	T	T
F	F	F	T	T

e)

p	q	$p \rightarrow q$	$\neg(p \rightarrow q)$	$\neg(p \rightarrow q) \rightarrow p$
T	T	T	F	T
T	F	F	T	T
F	T	T	F	T
F	F	T	F	T

f)

p	q	$p \rightarrow q$	$\neg(p \rightarrow q)$	$\neg q$	$\neg(p \rightarrow q) \rightarrow \neg q$
T	T	T	F	F	T
T	F	F	T	T	T
F	T	T	F	F	T
F	F	T	F	T	T

logically equivalent. 67. For $(p \rightarrow r) \wedge (q \rightarrow r)$ to be false, one of the two conditional statements must be false, which happens exactly when r is false and at least one of p and q is true. But these are precisely the cases in which $p \vee q$ is true and r is false, which is precisely when $(p \vee q) \rightarrow r$ is false. Because the two propositions are false in exactly the same situations, they are logically equivalent. 24. For $(p \rightarrow q) \vee (q \rightarrow r)$ to

63. All nine 65. a) Satisfiable b) Not satisfiable c) Not satisfiable 67. a) $\left(\bigwedge_{i=1}^2 \bigvee_{j=1}^2 p(i, j) \right) \wedge \left(\bigwedge_{i=1}^2 \bigwedge_{j=1}^1 \bigwedge_{k=j+1}^2 \right)$