1. 10 pts. each   Write the negation of each statement.

   (a) All cosmologists think big.

   (b) Some logicians can not tie their shoelaces.

   (c) None of the lights are on.

2. 10 pts. each   Let

$$p: \text{ Captain Kirk is beaming down to the planet.}$$
$$q: \text{ The Red Shirts are doomed.}$$
$$r: \text{ The dilithium crystals are cracked.}$$

   Write the following statements in words.

   (a) $\neg p \leftrightarrow \neg q$

   (b) $p \rightarrow (q \lor \neg r)$.

3. 10 pts. each   Let

$$p: \text{ Harley Quinn was paroled last week.}$$
$$q: \text{ The Clock King's time is up.}$$
$$r: \text{ Batman is on vacation.}$$
$$s: \text{ The Mad Hatter is off his meds.}$$

   Write the following in symbolic form.

   (a) If Batman is not on vacation, then Harley Quinn was paroled last week or the Clock King's time is up.

   (b) The Clock King's time is up if and only if Batman is on vacation or Harley Quinn was paroled last week.

   (c) It is false that the Mad Hatter is not off his meds and Harley Quinn was not paroled last week.

   (d) Harley Quinn was paroled last week and Batman is on vacation, or the Clock King's time is up and the Mad Hatter is off his meds.

4. 10 pts. each   Make a truth table for each statement.

   (a) $\neg(q \lor \neg p)$

   (b) $\neg p \land (q \lor r)$

   (c) $(\neg q \rightarrow p) \leftrightarrow \neg q$

5. 10 pts.   Use a truth table to determine whether the statements $\neg(p \rightarrow \neg q)$ and $p \land q$ are equivalent.

6. [10 pts.] Use one of DeMorgan's laws to write an equivalent statement for the sentence: "It is not the case that entropy always increases in an open thermodynamic system or radiocarbon dating is not reliable."

7. [10 pts.] Use the fact that $p \rightarrow q$ is equivalent to $\neg p \lor q$ to rewrite the statement "If the store is out of Mint Milano cookies, then I am going to pitch a fit."

8. [10 pts.] Write the contrapositive and also the converse of the statement "If the sky is not cloudy, then it is not raining."

9. [20 pts.] Write each statement below in symbols. Then use truth tables or established logical equivalencies to determine which of the three statements are equivalent.

   i. The package was sent by Federal Express, or the package was not sent by UPS but the package arrived on time.
   ii. The package arrived on time, if and only if it was sent by Federal Express or it was not sent by UPS.
   iii. If the package was not sent by Federal Express, then the package was not sent by UPS but the package arrived on time.