1. (5 pts each, 30 pts total) Mark the following reasoning patterns as S (= sound, carries true premises to true conclusions) or U (= unsound, may carry true premises to false conclusions). Premises are shown above the line, conclusions below the line. Here, “ $\Rightarrow$ ” means “implies” and “ $\neg$ ” means “not.” The first one is done for you as an example.

a. __S__

$$\begin{array}{l} P \Rightarrow Q \\ P \\ \hline Q \end{array}$$

b. _____

$$\begin{array}{l} P \Rightarrow Q \\ Q \\ \hline P \end{array}$$

c. _____

$$\begin{array}{l} P \Rightarrow Q \\ \\ \hline P \text{ or } \neg Q \end{array}$$

d. _____

$$\begin{array}{l} P \Rightarrow \neg Q \\ Q \\ \hline \neg P \end{array}$$

e. _____

$$\begin{array}{l} P \Rightarrow Q \\ \neg Q \\ \hline \neg P \end{array}$$

f. _____

$$\begin{array}{l} P \Rightarrow Q \\ \\ \hline \neg P \text{ or } Q \end{array}$$

g. _____

$$\begin{array}{l} \neg P \Rightarrow Q \\ P \\ \hline \neg Q \end{array}$$

2. (5 pts each, 40 pts total) In each of the following, *KB* is a set of sentences, $\{\}$ is the empty set of sentences, and *S* is a single sentence. Recall |= means "entails" and |- means "derives," where |-i means "inference procedure i derives." Use these keys:

Snd = Sound.
Unsnd = Unsound.
C = Complete.
I = Incomplete.
V = Valid.
Sat = Satisfiable.
Unsat = Unsatisfiable.
N = None of the above.

For each blank below, write in the key above that best corresponds to the correct term.

(a) Suppose some inference procedure i has the property, that for some *KB* and some *S*, *KB* |= *S* but not *KB* |-i *S*. Then the inference procedure i is_______.

(b) Let *S* be given in advance. Suppose that for some KB_1, KB_1 |= *S*; but that for some other KB_2, KB_2 |= $\neg S$. Then *S* is _______.

(c) Suppose some inference procedure i has the property, that for any *KB* and any *S*, whenever *KB* |= *S* then *KB* |-i *S*. Then the inference procedure i is _______.

(d) Suppose inference procedure i has the property, that for some *KB* and some *S*, *KB* |-i *S* but not *KB* |= *S*. Then the inference procedure i is __________.

(e) Let *S* be given in advance. Suppose that $\{\}$ |= *S*. Then *S* is ________.

(f) Suppose some inference procedure i has the property, that for any *KB* and any *S*, whenever *KB* |-i *S* then *KB* |= *S*. Then the inference procedure i is _______.

(g) Suppose that *KB* |= *S*, then the sentence ($KB \Rightarrow S$) is _________.

(h) Suppose that *KB* |= *S*, then the sentence (*KB* and $\neg S$) is _______.

3. Consider the KB shown below.

a. (5 pts each, 15 pts total) Translate the following *KB* into Conjunctive Normal Form. The first one is done for you as an example (it was already in Conjunctive Normal Form ;-)).

A. $P \lor R$. ______ $P \lor R$ ______

B. $Q \Rightarrow S$. ____________________

C. $P \Rightarrow Q$. ____________________

D. $R \Rightarrow S$. ____________________

b. (15 pts total, -5 for each wrong step, but not negative. The order may vary, if proof is correct.) Write a complete resolution proof that $KB \models S$. Show the two clauses that you resolve in front of the symbol |-, and the resulting clause after |-. You may not require all of the lines provided. The sentence labeled "E." adds the negated goal. The first one is done for you as an example.

E. $\neg S$

(a) ___ $\neg S$ ______, ______ $\neg Q \lor S$ ______, |- ___ $\neg Q$ ______.

(b) ____________, ____________, |- ____________.

(c) ____________, ____________, |- ____________.

(d) ____________, ____________, |- ____________.

(e) ____________, ____________, |- ____________.

(f) ____________, ____________, |- ____________.

(g) ____________, ____________, |- ____________.

(h) ____________, ____________, |- ____________.

(i) ____________, ____________, |- ____________.

(add additional lines if you need them)