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, “ ⇒” means “implies” and “ ¬ ” means “not.” The first one is done for you as an example.

P ⇒ Q

Q

P

P ⇒ Q

P

Q

a. S b. U

P ⇒ ¬Q

Q

¬P

P ⇒ Q

P or ¬Q

c. U d. S

P ⇒ Q

¬Q

¬ P

P ⇒ Q

¬P or Q

e. S f. S

¬P ⇒ Q

P

¬Q

g. U

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 I .

(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 |= ¬*S*. Then *S* is Sat .

(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 C .

(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 Unsnd .

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

(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 Snd .

(g) Suppose that *KB* |= *S*, then the sentence (*KB* ⇒ *S*) is V .

(h) Suppose that *KB* |= *S*, then the sentence (*KB* and ¬*S*) is Unsat .

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* *∨ R*. *P* ∨ *R*

**B.** *Q* ⇒ *S*. ¬*Q* ∨ *S*

**C.** *P* ⇒ *Q*. ¬*P* ∨ *Q*

**D.** *R* ⇒ *S*. ¬*R* ∨ *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* |= *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.** ¬ *S*

(a) ¬ *S* , ¬ *Q∨ S* , *|-* ¬ *Q* .

(b) ¬ *Q* , ¬*P* ∨ *Q* , *|-*  ¬*P* .

(c) ¬*P* , *P* ∨ *R* , *|-*  *R* .

(d) *R* , ¬*R* ∨ *S*  , *|-*  *S* .

(e) *S* , ¬ *S* , *|-*  .

Other proofs are fine if correct. For example, at step (d) above you could have resolved with ¬*S:*

(d) ¬ *S* , ¬*R* ∨ *S* , *|-*  ¬*R* .

(e) ¬*R* , *R* , *|-*  .