1. **(20 points)** These are trivial; the easiest way to calculate them is with a truth table: (a) true; (b) false; (c) false; and (d) false.

2. **(20 points)** The given entailment does hold:

   1 : \( P \)

   \( G : \neg(Q \Rightarrow P) = \neg(\neg Q \lor P) = Q \land \neg P \)

   \( G1 : Q; G2 : \neg P \)

   resolve 1, \( G2 \) to null

3. **(20 points)** Assume the following predicate terminology:

   - \( \text{took}(x, y, z) : \text{true when student } x \text{ took class } y \text{ in term } z. \)
   - \( \text{score}(x, y, z) : \text{true when student } x \text{ got a score of } z \text{ in class } y. \)
   - \( \text{passed}(x, y) : \text{true when student } x \text{ passed class } y. \)

   Then the various statements can be asserted as:

     \( \exists x : \text{took}(x, \text{French}, \text{Spring2001}). \)
   - You can also be pedantic about the plurality inherent in ‘some students’ and assert that there must be two different people \( x \) and \( y \), satisfying the above predicate.
   - Every student who took French passes it.
     \( \forall xy : \text{took}(x, \text{French}, y) \Rightarrow \text{passed}(x, \text{French}) \)
   - Obviously there is some relationship between score and passed, which we do not state explicitly (as it is not given).
   - Only one student took Greek in Spring 2001.
     \( \forall xy : (\text{took}(x, \text{Greek}, \text{Spring2001}) \land \text{took}(y, \text{Greek}, \text{Spring2001})) \Rightarrow (x = y) \)
   - The best score in Greek is always higher than the best score in French.
     \( \exists rm : \text{score}(m, \text{Greek}, x) \land (\forall yz : \text{score}(y, \text{Greek}, z) \Rightarrow (x \geq z)) \land (\forall ab : \text{score}(a, \text{French}, b) \Rightarrow (x > b)) \)

   Here we are assuming that this statement is true even across terms.

4. **(20 points)** Assume the following predicate terminology:

   - \( \text{Policy}(x) : \text{x is an insurance policy} \)
   - \( \text{Person}(x) : \text{x is a person} \)
   - \( \text{Expensive}(x) : \text{x is expensive} \)
   - \( \text{Smart}(x) : \text{x is smart} \)
   - \( \text{Buys}(x,y) : \text{x buys y} \)
   - \( \text{Sells}(x,y,z) : \text{x sells y to z} \)
Insured(x) :- x is insured

e) $\forall xy : \text{Buys}(x, y) \land \text{Person}(x) \land \text{Policy}(y) \Rightarrow \text{Smart}(x)$
f) $\forall xy : \text{Buys}(x, y) \land \text{Person}(x) \land \text{Policy}(y) \Rightarrow \neg \text{Expensive}(y)$
g) $\exists x \forall yz : \text{Sells}(x, y, z) \land \text{Person}(z) \land \text{Policy}(y) \Rightarrow \neg \text{Insured}(z)$

5. **(20 points)**

1 : $\forall x : \text{horse}(x) \Rightarrow \text{animal}(x)$

In clausal form, this becomes

$\neg \text{horse}(x) \lor \text{animal}(x)$

$G : \forall xy : (\text{horse}(x) \land \text{headof}(x, y)) \Rightarrow (\exists z : \text{animal}(z) \land \text{headof}(z, y))$

In clausal form and negated, this gives:

$G_1 : \text{horse}(H)$; $G_2 : \text{headof}(H, E)$; $G_3 : \neg \text{animal}(z) \lor \neg \text{headof}(z, E)$

resolve 1, $G_1$ to $\text{animal}(H)$

resolve $\text{animal}(H)$, $G_3$ to $\neg \text{headof}(H, E)$

resolve $\neg \text{headof}(H, E)$, $G_2$ to $\text{null}$