Directions: Make sure to show any necessary work to receive full credit. If you need extra space please use the back of the sheet with appropriate labeling.

1. Use the space below to create a world where all of the following statements are true.

(a) Dodec(a) \land Cube(b)
(b) FrontOf(b, a) \land LeftOf(d, b) \land BackOf(f, d) \land RightOf(a, f)
(c) Tet(c) \land Tet(e) \land LeftOf(c, d)
(d) \neg LeftOf(c, e) \land \neg LeftOf(e, c)
(e) Between(d, b, c) \land \neg Between(d, c, a)
(f) \neg Cube(b) \lor (Cube(d) \land BackOf(d, b))
(g) (Small(c) \land FrontOf(c, b)) \lor Cube(d)
(h) Larger(f, a) \land Larger(a, b)
(i) \neg (Smaller(c, a) \lor Smaller(a, c))
(j) Larger(d, b) \land Larger(f, d) \land \neg (Larger(e, d) \lor Larger(d, e))
2. What is an atomic sentence?

3. State the definition of a literal.

4. State the definition for what it means for two sentences, say $P$ and $Q$, to be tautologically equivalent (a.k.a. TT-equivalent).

5. State DeMorgan’s Laws. (Full credit for both statements.)
   
   i)  
   
   ii) 

6. How many predicates are there in $\text{Set}$ (the FOL of Set Theory)? What are they? Give an example of an atomic sentence in $\text{Set}$ which is not a literal.

7. Given a fixed first-order FOL state the definition for what it means for the sentence $S$ to be a logical consequence of the sentence $T$. 
8. Consider the following values for sentences in the language of Tarski’s World:

1: $P$ is a tautology.
2: $P$ is a logical necessity.
3: $P$ is a logical possibility.
4: $P$ is TT-possibility.
5: $P$ is not a truth table possibility.

For each of the following TW-sentences determine the least value for which the sentence makes the value true. Circle each of your responses.

(a) $\text{Cube}(a) \lor \text{Dodec}(a) \lor \text{Tet}(a)$.

(b) $\text{Large}(a) \land \text{Large}(b) \land \text{Adjoins}(a, b)$.

(c) $a = b$.

(d) $\text{SameSize}(a, b) \land \text{SameShape}(b, a) \land a = b$.

(e) $\text{Dodec}(a) \lor \neg \text{Dodec}(b)$.

(f) $\text{Small}(a) \land \neg(\text{Small}(a) \lor \text{Tet}(a))$
9. Prove that the following two sentences are tautologically equivalent.

\[ P \land (Q \lor R) \quad \text{and} \quad (P \land Q) \lor (P \land R) \]

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<th>$P \land (Q \lor R)$</th>
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