Q1

7.7 Consider a vocabulary with only four propositions, A, B, C, and D. How many models are there for the following sentences?

a. $B \vee C$.

b. $\neg A \vee \neg B \vee \neg C \vee \neg D$.

c. $(A \Rightarrow B) \wedge A \wedge \neg B \wedge C \wedge D$.

There are 16 cases in the truth table for 4 propositions.

a. When B and C are false, the sentence is false(4 cases), other 12 are true
b. When A,B,C,D are false, the sentence is false(1 cases), other 15 are true
c. When the first conjunct is false, the last four conjuncts is false. So 16 cases are both true.

Q2

2. Design a knowledge-based expert agent for a Street crossing guard robot. Describe [20 points]

- What kinds of objects in the world the robot will need to be aware of
- How these objects can be organized into an ontology (a short description or sketch of a taxonomic tree will suffice)
- What kinds of events in the world the robot needs to model to achieve its goals

Street crossing guard

Goal: Get all pedestrians across the street safely, without them getting hit by vehicles (but without stopping traffic entirely).

Sensors: The robot is aware of objects at either end of the crosswalk and objects that are about to enter the intersection from any direction.

The robot will need to be aware of vehicles and traffic lights.
When pedestrians are going go across the street, first the agent should be aware of the traffic lights. When the traffic light is green, the pedestrians could go. Then, agent should be aware of vehicles or other objects about to enter, and let pedestrians stop to wait for them. Finally, the pedestrians could go across the street safely.
The robot needs to achieve traffic lights with red and green, and traffic jams and when sensors aware of objects about to enter.

Q3

3. Translate the following English sentences into propositional logic [15 points]

i. A and B are both true.
ii. If A is true, then B must be true as well.
iii. If a student studies for a test, they will do well on it. We can also tell that if a student did well on a test, then they must have studied for it.
iv. If a student is completely dry and it is raining outside, it is because they have an umbrella or a hoodie and it is not raining heavily.
v. If a student doesn't hand in the homework late or incomplete, this doesn't necessarily imply that they will not lose points.

i. $A \wedge B$

ii. $A \rightarrow B$

iii. Study for a test $\leftrightarrow$ do well on test

iv. (Umbrella or a hoodie) ∧ (not raining heavily) → (Student is dry) ∧ (raining)

v. hand in the homework late or incomplete → Lose points

Q4

4. Simplify and translate this *propositional logic* sentence into English

$A \vee (A \wedge B) \Longleftrightarrow \neg(A \wedge B \wedge C)$

$$
\begin{aligned}
& A \vee (A \wedge B) \Longleftrightarrow \neg (A \wedge B \wedge C) \\
\equiv\ & (A \vee A) \wedge (A \vee B) \Longleftrightarrow \neg (A \wedge B \wedge C) \\
\equiv\ & A \wedge (A \vee B) \Longleftrightarrow \neg (A \wedge B \wedge C) \\
\equiv\ & A \Longleftrightarrow \neg (A \wedge B \wedge C) \\
\equiv\ & (A \rightarrow \neg (A \wedge B \wedge C)) \wedge (\neg (A \wedge B \wedge C) \rightarrow A) \\
\equiv\ & (\neg A \wedge \neg (A \wedge B \wedge C)) \wedge ((A \wedge B \wedge C) \wedge A) \\
\equiv\ & \neg (A \vee (A \wedge B \wedge C)) \wedge (A \wedge B \wedge C) \\
\equiv\ & \neg A \wedge (A \wedge B \wedge C) \\
\equiv\ & A \rightarrow A \wedge B \wedge C
\end{aligned}
$$

If A, then A and B and C

Q5

5. Translate the following English sentences into *first order logic* [10 points]

vi. Some students pass English but not Math.

vii. Every student is registered in a class and enrolled at a university.

viii. If someone is an aunt or uncle, then someone must be their niece or nephew.

ix. The old that is strong does not wither.

vi. $\exists x\ \text{Student}(x) \rightarrow \text{Pass}(x, \text{English}) \wedge \text{Fail}(x, \text{Math})$

vii. $\forall x\ \text{Student}(x) \rightarrow \text{Register}(x, \text{class}) \wedge \text{Enroll}(x, \text{University})$

viii. $\exists x . \exists y, \text{Anut or Uncle}(x) \rightarrow \text{Niece or Nephew}(x, y)$

ix. $\exists x\ \text{Strong}(x) \wedge \text{Old}(x) \rightarrow \neg \text{Wither}(x)$