Part A

1. Define Unification and explain why it is important in predicate logic inference.

Unification is the process of finding substitutes for two logical expressions to be identical. It is crucial as it enables inference rules in generalized statements. It is important in predicate logic inference because it matches a rule's pattern to concrete facts so it can be applied.

2. Differentiate between Forward Chaining and Backward Chaining. Provide one practical application of each.

Forward Chaining starts with known facts and applies inference rules repeatedly to derive new facts until the goal is achieved. Backward Chaining on the other hand starts with the goal and works backwards gathering rules, creating subgoals and asking for facts until it establishes known facts. An example of Forward Chaining is teaching AI by providing it with rules to reach the desired result from a set of data. An example of Backwards Chaining is AI in Business suggesting actions to reach a given financial goal

3. What is Generalized Modus Ponens (GMP)? Give an example in predicate logic.

It is a generalized Propositional Modus Ponens that uses unification and substitution. It is also the rule of inference in predicate logic. An example of GMP is…

Rule: $\forall x\,(Food(x) \rightarrow Delicious(x))$; Fact: Food(Pizza); GMP: Delicious(Pizza)

4. Explain in your own words what Resolution is and why it is powerful in automated theorem proving

Resolution is the method of negating the conclusions, taking the statements into clausal forms, repeatedly applying resolution rules with unification, then deriving a contradiction and then concluding into the final statements. It is essential in automated theorem proving due to its uniformity which allows theorem provers to implement one core mechanism that searches for proofs.

Part B

1. "All humans are mortal."
"Socrates is a human."
→ Prove that Socrates is mortal.

Premise:

- $\forall x\,(Human(x) \rightarrow Mortal(x))$
- Human(Socrates)

Universal Instantiation (UI): Human(Socrates) → Mortal(Socrates)
Modus Ponens (MP): Mortal(Socrates)

2. "Every student who studies passes the exam."
"Juan is a student and he studies."
→ Prove that Juan passes the exam.

Premise:

- $\forall x\,((Student(x) \land Studies(x)) \rightarrow PassesExam(x))$
- Student(Juan)
- Studies(Juan)

UI: (Student(Juan) ∧ Studies(Juan)) → PassesExam(Juan)
  (Student(Juan) ∧ Studies(Juan)

Modus Ponens: PassesExam(Juan)

3. “If a person is a teacher, then they advise some students.”
“Mark is a teacher.”
→ Prove that Mark advises at least one student.

Premise:

- $\forall x\ (Teacher(x) \rightarrow \exists y\ (Student(y) \land Advises(x,y)))$
- Teacher(Mark)

UI: $Teacher(Mark) \rightarrow \exists y\ (Student(y) \land Advises(Mark,y))$

Modus Ponens: $\exists y\ (Student(y) \land Advises(Mark,y))$