

# Knowledge Representation and Reasoning: Questions

## Multiple Choice Questions

**Question - 1: What is the primary aim of Knowledge Representation and Reasoning?**

- a. To enable computers to process vast amounts of data efficiently.
- b. To develop advanced machine learning algorithms.
- c. To understand the nature of intelligence and cognition to simulate human-like abilities in computers.
- d. To create complex robotic systems for automation.

**Question - 2: Which type of reasoning is described as “jumping to conclusions based on some default assumptions” when information is insufficient, potentially leading to unsound conclusions that may need to be withdrawn?**

- a. Deductive reasoning
- b. Abductive reasoning
- c. Epistemic reasoning
- d. Default reasoning

**Question - 3: In propositional logic, what is an “atom”?**

- a. A logical connective like 'and' or 'or'.
- b. A formula composed of multiple propositions.
- c. The smallest unit to which a truth value (true/false) can be assigned.
- d. A symbol representing a numerical value.

**Question - 4: Which of the following connectives is considered a unary propositional connective?**

- a. Conjunction ( $\wedge$ )
- b. Implication ( $\rightarrow$ )
- c. Disjunction ( $\vee$ )
- d. Negation ( $\neg$ )

**Question - 5: A propositional formula  $F$  is a tautology if:**

- a. At least one interpretation satisfies  $F$ .
- b.  $F$  can be reduced to a Conjunctive Normal Form (CNF).
- c. Every interpretation satisfies  $F$ .
- d. Its negation ( $\neg F$ ) is satisfiable.

**Question - 6: What does it mean for a propositional formula  $F$  to be satisfiable?**

- a.  $F$  is true for all possible interpretations.
- b. There exists at least one interpretation that satisfies  $F$ .
- c.  $F$  contains no logical connectives.
- d.  $F$  can be reduced to an empty clause.

**Question - 7: Which of the following is equivalent to saying that  $F$  entails  $G$  ( $F \models G$ )?**

- a.  $F \wedge G$  is a tautology.
- b.  $F \leftrightarrow G$  is satisfiable.
- c.  $(F \wedge \neg G)$  is unsatisfiable.
- d.  $\neg F \vee G$  is a contradiction.

**Question - 8: What is the total number of subformulas that can be formed for the propositional formula**

$$\neg(\mathbf{p} \wedge \mathbf{q}) \vee (\mathbf{r} \rightarrow \neg \mathbf{p})$$

- a. 8
- b. 10
- c. 7
- d. 9

**Question - 9: What is a key characteristic of a Herbrand interpretation for a given signature  $\sigma$  (containing at least one object constant)?**

- a. Its universe is any non-empty set of individuals.
- b. Its universe is the set of all ground (variable-free) terms of  $\sigma$ , and every ground term is interpreted as itself.
- c. It always makes all quantified formulas true.
- d. It must contain at least one function constant of arity greater than 0.

**Question - 10: Which of the following statements about SAT solvers is correct?**

- a. SAT solvers only accept formulas in Disjunctive Normal Form (DNF).
- b. SAT solvers decide satisfiability of propositional formulas, often using DPLL.
- c. SAT solvers can only handle problems with at most 100 variables.
- d. SAT solvers are inefficient and rarely used in practice.

**Question - 11: Every atom,  $\top$ ,  $\perp$ , and any recursive combination of formulas with connectives are considered valid formulas in propositional logic.**

- a. True
- b. False

**Question - 12: Which of the following statements is a tautology?**

- a.  $(p \rightarrow q) \wedge (p \wedge \neg q)$
- b.  $(p \rightarrow q) \rightarrow (\neg p \vee q)$
- c.  $(p \rightarrow (q \rightarrow p))$
- d.  $\neg p \vee p$

**Question - 13: Which of the following is a key limitation of propositional logic that First-Order Logic overcomes?**

- a. Inability to represent negation
- b. Inability to express relations between individuals and relations
- c. Inability to use logical connectives such as  $\wedge$  and  $\vee$
- d. Inability to reason with truth values

**Question - 14: Which of the following is a valid term in FOL?**

- a.  $\forall x P(x)$
- b.  $P(x) \wedge Q(y)$
- c.  $\text{father}(\text{john})$

**Question - 15: What is the Herbrand Universe of a signature  $\sigma$ ?**

- a. The set of all formulas in  $\sigma$ .
- b. The set of all predicates in  $\sigma$ .
- c. The set of all ground terms of  $\sigma$ .
- d. The set of all interpretations over  $\sigma$ .

**Question - 16:** Which of the following is an example of a terminological axiom in FOL?

- a.  $\forall x (\text{Teenager}(x) \rightarrow \neg \text{Adult}(x))$
- b.  $\text{Child}(\text{John})$
- c.  $\text{Affects}(\text{JRA}, \text{Mary})$
- d.  $\neg \text{Affects}(\text{JRA}, \text{Mary})$

**Question - 17:** What are some of the free occurrences of a variable in the formula below?

$$\forall x (\mathbf{P(x)} \rightarrow \mathbf{Q(x, y)}) \wedge \exists y \mathbf{R(y, z)}$$

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- a. 4, 7
- b. 2, 3
- c. 1, 6, 7
- d. None of the above

## Long Answer Questions

1. Construct the parse tree for the following propositional logic formula:

$$(((\neg \mathbf{p} \vee \mathbf{q}) \wedge (\mathbf{r} \rightarrow \mathbf{s})) \rightarrow ((\mathbf{t} \wedge \neg \mathbf{u}) \vee \mathbf{v}))$$

2. Draw a parse tree of the following formula and specify bound and free variables.

$$(\forall x (\mathbf{P(x)} \vee \mathbf{Q(x)})) \rightarrow (\exists y \mathbf{R(x, y)})$$

3. Starting with an empty set  $U$  of literals, apply unit propagation to the formula below. Show how  $F$  and  $U$  (the set of unit clauses) change in each iteration and say what is the interpretation of  $\mathbf{p}, \mathbf{q}$  and  $\mathbf{r}$ .

$$\mathbf{r} \wedge (\neg \mathbf{q} \vee \neg \mathbf{r}) \wedge (\mathbf{p} \vee \mathbf{q} \vee \neg \mathbf{r}) \wedge (\neg \mathbf{p} \vee \mathbf{r})$$