Family Name:

Other Names:

Signature:

Student Number:

This PAPER is NOT to be retained by the STUDENT

The University Of New South Wales

C0MP4418 Practice Exam (Not Marked!)

Knowledge Representation and Reasoning

October 2018

Time allowed: **2 Hours plus 10 Minutes reading time**
Total number of questions: **27**
Total number of marks: **100**

Questions in PART A, must be answered on the generalised answer sheet provided.
Questions in PART B, PART C and PART D must be answered in the answer book(s) provided.
You must hand in this entire exam paper and ALL your answer booklets. Otherwise you will get zero marks for the exam and a possible charge of academic misconduct.
Ensure that you fill in all of the details on the front of this pink paper, generalised answer sheet, and answer booklet(s) and then SIGN everything. This exam paper is printed single-sided so that you can use the reverse side of each page for working. You must hand this paper back with your generalised answer sheet and answer booklets at the conclusion of the exam.

Do not use red pen or pencil in the answer booklets for this exam.

No examination materials permitted.
Calculators may **not** be used.
Questions are **not** worth equal marks.
Answer **all** questions.

Part A: Multiple Choice Questions

NOTE: Answer the questions in this section on the generalised answer sheet provided.

Note that each question has *five* alternatives. Once you have chosen an alternative, fill in the multiple-choice answer sheet by giving the letter (in square brackets e.g., "[B]") which corresponds to that alternative. Also, be careful that you fill each answer in on the correct row on the multiple-choice sheet (i.e., the row corresponding to the question number).

Each question in this section is worth **2 marks**. There is a **penalty** of $-\frac{1}{2}$ **mark** for answering a question in this section incorrectly. There is no penalty for not answering a question. In other words, you get no marks for a question if you do not attempt it and you lose half a mark for getting a question wrong.

DO NOT answer these questions in an **answer booklet** or this **question paper**!

Question 1

Which of the following propositional formulas is a tautology?

[A] $p \to (q \to p)$.
[B] p.
[C] $p \vee p$
[D] $(p \to q) \wedge (q \to p)$.
[E] $\neg\neg p$.

Question 2

How many positive literals can appear in a definite clause?

[A] At most one.
[B] At least one.
[C] At least one but no more than three.
[D] Exactly one.
[E] Zero or more.

Question 3

SLD resolution is most appropriate when the knowledge base consists entirely of?

[A] Arbitrary formulas.
[B] Arbitrary clauses.
[C] Horn clauses.
[D] Negative clauses.
[E] None of the above.

Question 4

Which of the following formal approaches to reasoning tries to capture commonsense reasoning?

[A] Default logic.
[B] First-order logic.
[C] Propositional logic.
[D] Resolution.
[E] None of the above.

Question 5

In Prolog, rules correspond to which type of formulas? Give the most approporiate answer.

[A] Arbitrary formulas.
[B] Arbitrary clauses.
[C] Definite clauses.
[D] Facts.
[E] Horn clauses.

Question 6

In first-order logic, how would you express that "something likes something"?

[A] $\exists x \exists y Likes(x, y)$
[B] $\exists x \forall y Likes(x, y)$
[C] $\forall x \exists y Likes(x, y)$
[D] $\forall x \forall y Likes(x, y)$
[E] None of the above.

Question 7

Which of the following is not required to convert a formual into conjunctive normal form?

[A] Drop universal quantifiers.
[B] Eliminate implication.
[C] Resolve two clauses with complementary literals.
[D] Skolemisation.
[E] Standardise variables.

Question 8

What is the idea behind Conflict-Driven Clause Learning?

[A] Add new literals that follow from the input CNF formula and the current partial interpretation.
[B] Add new clauses that follow from the input CNF formula and the current partial interpretation.
[C] Add new clauses to randomize the search tree.
[D] Add new clauses (in case of a conflict) that to avoid making similar assignments that lead to conflicts in future.
[E] Delete clauses that have low activity score.

Question 9

Which of the following statements about SAT and k-SAT is **false**?

[A] 4-SAT is not NP-complete.
[B] SAT is commonly believed to require exponential time.
[C] SAT is can be reduced to 3-SAT in polynomial time.
[D] 3-SAT and SAT are NP-complete.
[E] 2-SAT is in P and is hence known to be efficiently solvable.

Question 10

How many stable models can an ASP program have?

[A] Exactly zero.
[B] Exactly one.
[C] One or more.
[D] Zero or one.
[E] Zero or more.

Question 11

ASP offers several extensions of normal logic programs. Which of the following extensions is **not** supported by ASP?

[A] Integrity constraints, i.e., rules of the form $\leftarrow B_1, \dots, B_m, \text{not} C_1, \dots, \text{not} C_n$.
[B] Choice rules, i.e., rules of the form $\{A_1, \dots, A_k\} \leftarrow B_1, \dots, B_m, \text{not} C_1, \dots, \text{not} C_n$.
[C] Rules with a negated head, i.e., rules of the form $\text{not} A \leftarrow B_1, \dots, B_m, \text{not} C_1, \dots, \text{not} C_n$.
[D] Disjunctive rules, i.e., rules of the form $A_1; \dots; A_k \leftarrow B_1, \dots, B_m, \text{not} C_1, \dots, \text{not} C_n$.
[E] Fist-order quantification, i.e., rules of the form
$Q_1 x_1 \dots Q_k x_k \big(A(\vec{x}) \leftarrow B_1(\vec{x}), \dots, B_m(\vec{x}), \text{not} C_1(\vec{x}), \dots, \text{not} C_n(\vec{x})\big)$. where $Q_i \in \{\exists, \forall\}$

Question 12

Consider the CNF formula $\phi = (\bar{p} \lor q \lor \bar{t}) \land (r \lor t) \land (\bar{t} \lor p) \land (s \lor \bar{r})$ and $I = \{\bar{s}\}$. When I is closed under unit propagation using the watched-literal scheme, which literals are added to I in which order?

[A] That depends on the watched literals in this case.
[B] No literals are added.
[C] The following literals are added: $\bar{r}, t, p, q$
[D] The following literals are added: $\bar{r}, p$
[E] The following literals are added: $\bar{r}$

Question 13

Which of the following sentences is valid for arbitrary ϕ?

[A] $\neg\mathbf{K}\phi \to \mathbf{K}\neg\mathbf{K}\phi$
[B] $\mathbf{K}\phi \lor \mathbf{K}\neg\phi$
[C] $\neg\mathbf{K}\phi \to \mathbf{K}\neg\phi$
[D] $\mathbf{K}\phi \to \neg\mathbf{K}\neg\phi$
[E] $\neg(\mathbf{K}\phi \land \mathbf{K}\neg\phi)$

Question 14

What does the frame problem refer to?

[A] Representing the positive effects of actions.
[B] Representing the negative effects of actions.
[C] Representing what is not changed by actions.
[D] Representing the minor preconditions of an action.
[E] Representing the indirect effects of an action.

Question 15

Which statement is true?
[A] A Condorcet winner always exists.
[B] The Borda winner is the Condorcet winner.
[C] The plurality winner is the Condorcet winner.
[D] The Condorcet winner is the Borda winner.
[E] None of the above.

Question 16

Which statement is false?

[A] Probabilistic Serial mechanism is strategyproof.
[B] When allocating more than one item per agent, sequential allocation is not strategyproof.
[C] Random serial dictatorship is strategyproof.
[D] Random dictatorship is strategyproof.
[E] None.

Question 17

Which of the cooperative game solutions always lies within the least core?

[A] Core.
[B] Nucleolus.
[C] ϵ-core.
[D] Shapley value.
[E] None of the above.

Question 18

In the game theory problem of the Prisoner's Dilemma, what is the Nash Equilibria

[A] A mixed Nash Equilibria of each player choosing to defect with probability 1/2.
[B] A pure Nash Equilibria of both players co-operating.
[C] A pure Nash Equilibria of both players defecting.
[D] A pure Nash Equilibria of one player defecting and the other co-operating.
[E] There is no Nash Equilibria.

Question 19

Consider the following profile with 10 voters and 3 candidates. E.g., there are 4 voters with preference A $\succ$ B $\succ$ C.

4	3	3
A	B	C
B	C	A
C	A	B

What are the Borda scores for each candidate?

[A] A:10, B:11, C:7.
[B] A:10, B:8, C:7.
[C] A:11, B:9, C:8.
[D] A:11, B:10, C:9.
[E] None of the above.

Question 20

The top trading cycles algorithm does not satisfy which of the properties?

[A] Individual rationality.
[B] Core stability.
[C] Strategyproofness.
[D] Envy-freeness.
[E] Pareto optimality.

Part B: Introduction to KRR, Formal Logic and Reasoning

NOTE: Answer the questions in this section in the answer book provided.

Make your answers as clear and easy to understand as possible. Confusing or illegible solutions will lose marks.

Question 21

(8 marks)

Determine whether the following hold:

- $p \to q, q \to r \vdash p \to r$
- $p \to q \models \neg q \to \neg p$
- $\models p \leftrightarrow \neg\neg p$
- $p \vee \neg p \vdash$

Question 22

(6 marks)

Consider the following two sentences:

[A] All birds except emu's fly

[B] Tweety is a bird that doesn't fly

Write a formula in first-order logic expressing each of the given facts. Call them A and B. Show semantically whether these two formulas are sufficient to determine whether Tweety is an emu or not.

Question 23

(6 marks)

Determine whether the following is a valid inference in first-order logic using resolution:
$\forall x.(P(x) \to Q(x)), \forall x.(\neg R(x) \to \neg Q(x)) \vdash \forall x.(\neg R(x) \to \neg P(x))$

Part C: Non-monotonic reasoning, reasoning about knowledge, reasoning about actions

NOTE: Answer the questions in this section in the answer book provided.

Make your answers as clear and easy to understand as possible. Confusing or illegible solutions will lose marks.

Question 24

(10 marks)

Determine all stable models of the following ASP program P:

$$\begin{aligned}
a &\leftarrow c, \text{not } b. \\
b &\leftarrow c, \text{not } a. \\
c &\leftarrow \text{not } a. \\
c &\leftarrow \text{not } b.
\end{aligned}$$

Use the following table for your solution:

S	P^S	Stable?
$\{a, b, c\}$		
$\{a, b\}$		
$\{a, c\}$		
$\{b, c\}$		
$\{a\}$		
$\{b\}$		
$\{c\}$		
$\{\}$		

Question 25

(10 marks)

Consider the following scenario: a robot can put items into a single storage box and take them out of it. In the Logic of Actions, we can represent this scenario using

- a predicate $\text{InBox}(x)$ that represents whether or not x is in the storage box;
- an action $\text{putIn}(x)$ that puts object x into the storage box;
- an action $\text{takeOut}(x)$ that takes object x out of the storage box.

[A] Write a successor-state axiom for $\text{InBox}(x)$.

[B] Determine $\mathcal{R}([\text{takeOut}(\text{Book})]\neg\text{InBox}(\text{Book}))$.

Part D: Decision Making

NOTE: Answer the questions in this section in the file answer book provided.

Make your answers as clear and easy to understand as possible. Confusing or illegible solutions will lose marks. Provide justifications where needed but irrelevant text detracting from the answer will lose marks.

Question 26

(10 marks)

Consider the following school choice problem with four students 1, 2, 3, 4 and four schools a, b, c, and d with each school having exactly one seat. The preferences of the students are as follows.

$$1 : b \succ a \succ c \succ d$$
$$2 : a \succ b \succ c \succ d$$
$$3 : a \succ b \succ c \succ d$$
$$4 : d \succ b \succ c \succ a$$

The preferences of the schools are as follows.

$$a : 1 \succ 3 \succ 2 \succ 4$$
$$b : 2 \succ 1 \succ 3 \succ 4$$
$$c : 2 \succ 1 \succ 3 \succ 4$$
$$d : 4 \succ 1 \succ 3 \succ 2$$

Find the outcome matching of the student proposing deferred acceptance algorithm and explain how you found the matching. Prove or disprove that the resultant matching is Pareto optimal for the students.

Question 27

(10 marks)

Compute all the Nash equilibria of the following two player game and explain how you computed them.

	D	E
A	2,3	8,5
B	6,6	4,2