

### **Question 1**

The traffic light property “Once red, the light will never become immediately green” is considered to be:

- A. safety**
- B. liveness
- C. fairness
- D. None of the above

### **Question 2**

The traffic light property “once red, the light becomes green eventually” is considered to be:

- A. safety
- B. liveness**
- C. fairness
- D. None of the above

### **Question 3**

The traffic light property “Once red, the light becomes green after being yellow for some time between being red and being green” is considered to be:

- A. safety
- B. liveness**
- C. fairness
- D. None of the above

### **Question 4**

The traffic light property “If the light is red infinitely often, it should be yellow infinitely often” is considered to be:

- A. safety
- B. liveness
- C. fairness**
- D. None of the above

### **Question 5**

The following property “The resource must not be simultaneously accessed by a writer and a reader.” is considered to be:

- A. safety**
- B. liveness
- C. fairness
- D. None of the above

### Question 6

What pattern of behavior does the following temporal formula specify?

$$\square \left[ \begin{array}{l} \text{start} \rightarrow x \\ x \rightarrow \bigcirc(w \wedge y \wedge z) \\ z \rightarrow \bigcirc a \\ (w \wedge y \wedge z) \rightarrow \bigcirc b \\ (a \wedge b) \rightarrow \bigcirc x \end{array} \right]$$

- A. The program reproduces indefinitely the sequence  $\langle x, (w \wedge y \wedge z), (a \wedge b) \rangle$
- B. The program will terminate upon the occurrence of the sequence  $\langle x, (w \wedge y \wedge z), (a \wedge b) \rangle$
- C. The program reproduces indefinitely the sequence  $\langle x, (w \vee y \vee z), (a \vee b), x \rangle$
- D. The program reproduces indefinitely the sequence  $\langle x, (w \wedge y \wedge z), \langle a, b \rangle \rangle$
- E. None of the above

### Question 7

Are the following formulas logically equivalent?

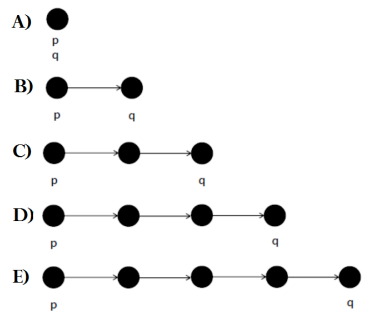
$\neg \square \neg (\text{process executes})$  and  $\Diamond (\text{process executes})$

- A. Yes
- B. No

### Question 8

Which of the following patterns visualizes the following formula?

$$p \rightarrow \bigcirc^3 q$$



**D**

### Question 9

Consider the following statement: “A procedure executes unless it throws an exception”  
Which of the following translations is correct?

- A) (procedure executes)  $\mathcal{R}$  (procedure throws exception)
- B) (procedure executes)  $\mathcal{U}$  (procedure throws exception)
- C) (procedure executes)  $\mathcal{S}$  (procedure throws exception)
- D) (procedure executes)  $\mathcal{W}$  (procedure throws exception)

**D.**

### Question 10

The boiler controller system is deadlock free. Which of the following translations is correct?

- A)  $\Box \Diamond \neg \text{deadlock}$
- B)  $\Diamond \neg \text{deadlock}$
- C)  $\Box \neg \text{deadlock}$
- D)  $\Diamond \Box \neg \text{deadlock}$

**C**

### Question 11

Consider the following formula:

$$\Diamond p \rightarrow \Box q \vee \neg r \mathcal{R} p$$

Which the formulas below is equivalent to the above formula?

- A)  $\Diamond p \rightarrow [(\Box q) \vee (\neg r \mathcal{R} p)]$
- B)  $\Diamond p \rightarrow [(\Box q \vee \neg r) \mathcal{R} p]$
- C)  $\Diamond p \rightarrow \Box (q \vee \neg r \mathcal{R} p)$
- D)  $(\Diamond p \rightarrow \Box q) \vee (\neg r \mathcal{R} p)$

**A**

### **Question 12**

Consider the following statement: “there are never two processes in their critical section at the same time”

Which of the following translations is correct?

- A)  $\Box (criti_1 \oplus criti_2)$
- B)  $\Box (\neg criti_1 \vee \neg criti_2)$
- C)  $(\Box \Diamond criti_1) \wedge (\Box \Diamond criti_2)$
- D)  $\Box (\neg criti_1 \wedge \neg criti_2)$

**B)**

### **Question 13**

Consider the following statement: “One server, either the main one or the backup one, will always be up”

Which of the following translations is correct?

- A)  $\Box ((\text{backup server up}) \oplus (\text{main server up}))$
- B)  $\Box ((\text{backup server up}) \vee (\text{main server up}))$
- C)  $\Box ((\text{backup server up}) \wedge (\text{main server up}))$

**A.**

### **Question 14**

Consider the following statement: “It is always the case that when smoke is detected, the alarm will go off at the immediately next moment in time.”.

Which of the following translations is correct?

- A)  $\Box ((\text{smoke detected}) \rightarrow \Diamond (\text{alarm off}))$
- B)  $\Box ((\text{smoke detected}) \rightarrow \bigcirc (\text{alarm off}))$
- C)  $\Diamond \Box ((\text{smoke detected}) \rightarrow (\text{alarm off}))$

**B**

### Question 15

In class we discussed the specification example of a 'Parent' allocating sweets to two children. What pattern of behavior does the following temporal formula specify?

$$\square \left[ \begin{array}{ll} \text{start} & \Rightarrow \text{req\_jack} \\ \text{start} & \Rightarrow \neg \text{wait} \\ \text{req\_jack} & \Rightarrow \bigcirc \text{wait} \\ \text{req\_jack} & \Rightarrow \bigcirc \neg \text{req\_jack} \\ \text{wait} & \Rightarrow \bigcirc \text{req\_jack} \\ \text{wait} & \Rightarrow \bigcirc \neg \text{wait} \end{array} \right]$$

- A. The program will terminate upon the occurrence of the sequence  $\langle \text{req\_jack} \wedge \neg \text{wait} \rangle, \langle (\neg \text{req\_jack} \wedge \text{wait}) \rangle$
- B. The program will terminate upon the occurrence of the sequence  $\langle \text{req\_jack} \vee \neg \text{wait} \rangle, \langle (\neg \text{req\_jack} \vee \text{wait}) \rangle$
- C. The program reproduces indefinitely the sequence  $\langle \text{req\_jack}, \neg \text{wait}, \text{req\_jack}, \text{wait} \rangle$
- D. The program reproduces indefinitely the sequence  $\langle \text{req\_jack} \wedge \neg \text{wait} \rangle, \langle (\neg \text{req\_jack} \wedge \text{wait}) \rangle$
- E. None of the above

### Question 16

In class we discussed the specification example of a 'Parent' allocating sweets to two children. What pattern of behavior does the following temporal formula specify?

$$\square \left[ \begin{array}{ll} \text{start} & \Rightarrow \text{req\_jill} \\ \text{req\_jill} & \Rightarrow \bigcirc \text{req\_jill} \end{array} \right]$$

- A. The program will terminate upon the occurrence of the sequence  $\langle \text{req\_jill}, \text{req\_jill} \rangle$
- B. The program will terminate upon the occurrence of  $\text{req\_jill}$
- C. The program will not terminate and  $\text{req\_jill}$  is true in every state
- D. None of the above

### Question 17

Jill will ask infinitely often.

Which of the following translations is correct?

- A)  $\diamond \text{asked\_jill}$
- B)  $\diamond \square \text{asked\_jill}$
- C)  $\square \text{asked\_jill}$
- D)  $\square \diamond \text{asked\_jill}$

**D**

### Question 18

Safety properties are satisfied by a system which does nothing:

**A. True**

B. False

### Question 19

Upon which scenario will the following program terminate?

$$\square \left[ \begin{array}{l} \text{start} \rightarrow a \\ \text{start} \rightarrow b \\ (a \wedge b) \rightarrow \bigcirc(c \vee d) \\ c \rightarrow \bigcirc c \\ d \rightarrow \bigcirc e \\ (c \wedge e) \rightarrow \bigcirc \bigcirc f \\ (c \wedge d) \rightarrow \bigcirc(g \mathcal{W} f) \end{array} \right]$$

A) The program will terminate upon the occurrence of the sequence

$\langle (a \wedge b), c \rangle$

**B) The program reproduces indefinitely the sequence**

$\langle (a \wedge b), d, e \rangle$

C) The program reproduces indefinitely the sequence

$\langle (a \wedge b), (c \vee d), (c \wedge e \wedge g), (c \wedge g), (c \wedge f), c \rangle$

D) None of the above

### Question 20

Once red, the light becomes green after being yellow for some time between being red and being green. Which of the following translations is correct?

A)  $\square (red \rightarrow (red \mathcal{U} yellow) \mathcal{U} green)$

B)  $\square (red \rightarrow (red \mathcal{U} yellow) \mathcal{W} green)$

C)  $\square (red \rightarrow (red \mathcal{R} yellow) \mathcal{W} green)$

**A)**

The following paragraph refers to Questions 20, 21, 22:

The behavior of a program is expressed by the following pattern:

$$\square \left[ \begin{array}{l} \text{start} \rightarrow p \\ \text{start} \rightarrow \neg q \\ \text{start} \rightarrow \neg \text{send\_msg} \\ p \rightarrow \bigcirc \neg p \\ p \rightarrow \bigcirc \neg \text{send\_msg} \\ p \rightarrow \bigcirc q \\ q \rightarrow \bigcirc p \\ q \rightarrow \bigcirc \text{send\_msg} \end{array} \right]$$

### Question 21

The behavior indicates the following with respect to  $p$  and  $q$  (where the execution path numbers moments starting from zero):

- A) The program will terminate and  $p$  is true in every odd-numbered state while  $q$  is true in every even-numbered state.
- B) The program will not terminate and  $p$  is true in every odd-numbered state while  $q$  is true in every even-numbered state.
- C) The program will not terminate and  $p$  is true in every even-numbered state while  $q$  is true in every odd-numbered state.
- D) The program will terminate and  $p$  is true in every even-numbered state while  $q$  is true in every odd-numbered state.

### Question 22

Which of the following statements is true:

- A)  $\square \diamond \text{send\_msg}$ .
- B)  $\square (\text{send\_msg} \rightarrow \diamond \text{send\_msg})$ .
- C)  $p \rightarrow \bigcirc \bigcirc \text{send\_msg}$ .
- D) All of the above.
- E) None of the above.

**D**

### Question 23

The behavior indicates the following with respect to  $\text{send msg}$ :

- A) (a)  $\text{send msg}$  is true whenever  $p$  is true.
- B) (b)  $\text{send msg}$  is true in all even-numbered states (including zero).
- C) (c)  $\text{send msg}$  is true in all even-numbered states (excluding zero).
- D) (d)  $\text{send msg}$  is true in all odd-numbered states.

### Question 24

Invariantly always, when the *Control Level* message happens and the water quantity is more than the safe limit *Max*, the water quantity eventually will be in the safe range between max and minimum.

Which of the following translations is correct?

- A)  $\square (\text{Control Level} \wedge \text{quantity} \geq \text{Max}) \rightarrow \bigcirc (\text{quantity} \geq \text{Min} \wedge \text{quantity} \leq \text{Max})$
- B)  $\square (\text{Control Level} \wedge \text{quantity} \geq \text{Max}) \rightarrow \Diamond (\text{quantity} \geq \text{Min} \wedge \text{quantity} \leq \text{Max})$
- C)  $\square \Diamond (\text{Control Level} \wedge \text{quantity} \geq \text{Max}) \rightarrow (\text{quantity} \geq \text{Min} \wedge \text{quantity} \leq \text{Max})$
- D)  $(\text{Control Level} \wedge \text{quantity} \geq \text{Max}) \rightarrow (\text{quantity} \geq \text{Min} \wedge \text{quantity} \leq \text{Max})$
- E) None of the above

**E**

### Question 25

Invariantly always, the water quantity in the boiler is below the minimum safe limit *Min* at the time when the pump is opened. Which of the following translations is correct?

- A)  $\square (\text{OpenPump} \rightarrow \text{quantity} \leq \text{Min})$
  - B)  $\square \Diamond (\text{OpenPump} \rightarrow \text{quantity} \leq \text{Min})$
  - C)  $\text{OpenPump} \rightarrow \Diamond \text{quantity} \leq \text{Min}$
  - D)  $\square (\text{OpenPump} \rightarrow \bigcirc \text{quantity} \leq \text{Min})$
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**A**