1. (70 pts total, 10 pts each) For each English sentence below, write the letter corresponding to its best or closest FOPC (FOL) sentence (wff, or well-formed formula). The first one is done for you, as an example.

1.a (example) D “Every butterfly likes some flower.”
A. \( \forall x \forall y \text{Butterfly}(x) \land \text{Flower}(y) \land \text{Likes}(x, y) \)
B. \( \forall x \exists y \text{Butterfly}(x) \land \text{Flower}(y) \land \text{Likes}(x, y) \)
C. \( \forall x \forall y \text{Butterfly}(x) \Rightarrow (\text{Flower}(y) \land \text{Likes}(x, y)) \)
D. \( \forall x \exists y \text{Butterfly}(x) \Rightarrow (\text{Flower}(y) \land \text{Likes}(x, y)) \)

1.b (10 pts) “All butterflies are insects.”
A. \( \forall x \text{Butterfly}(x) \land \text{Insect}(x) \)
B. \( \forall x \text{Butterfly}(x) \Rightarrow \text{Insect}(x) \)
C. \( \exists x \text{Butterfly}(x) \land \text{Insect}(x) \)
D. \( \exists x \text{Butterfly}(x) \Rightarrow \text{Insect}(x) \)

1.c (10 pts) “For every flower, there is a butterfly that likes that flower.”
A. \( \forall x \exists y \text{Flower}(x) \land \text{Butterfly}(y) \land \text{Likes}(y, x) \)
B. \( \forall x \exists y (\text{Flower}(x) \land \text{Butterfly}(y) \Rightarrow \text{Likes}(y, x)) \)
C. \( \forall x \exists y \text{Flower}(x) \Rightarrow (\text{Butterfly}(y) \land \text{Likes}(y, x)) \)
D. \( \exists x \forall y \text{Flower}(x) \land \text{Butterfly}(y) \land \text{Likes}(y, x) \)

1.d (10 pts) “Every butterfly likes every flower.”
A. \( \forall x \forall y (\text{Butterfly}(x) \land \text{Flower}(y) \Rightarrow \text{Likes}(x, y)) \)
B. \( \forall x \forall y \text{Butterfly}(x) \Rightarrow (\text{Flower}(y) \land \text{Likes}(x, y)) \)
C. \( \forall x \forall y \text{Butterfly}(x) \land \text{Flower}(y) \land \text{Likes}(x, y) \)
D. \( \exists x \text{Butterfly}(x) \Rightarrow (\text{In}(x, \text{Irvine}) \land \text{Pretty}(x)) \)

1.e (10 pts) “There is some butterfly in Irvine that is pretty.”
A. \( \exists x \text{Butterfly}(x) \land \text{In}(x, \text{Irvine}) \land \text{Pretty}(x) \)
B. \( \exists x \exists y \text{Butterfly}(x) \land \text{In}(x, \text{Irvine}) \land \text{Pretty}(x) \)
C. \( \forall x \exists y \text{Butterfly}(x) \land \text{In}(x, \text{Irvine}) \Rightarrow \text{Pretty}(x) \)
D. \( \exists x \text{Butterfly}(x) \Rightarrow (\text{In}(x, \text{Irvine}) \land \text{Pretty}(x)) \)

1.f (10 pts) “Every butterfly in Irvine is pretty.”
A. \( \forall x \text{Butterfly}(x) \land \text{In}(x, \text{Irvine}) \land \text{Pretty}(x) \)
B. \( \exists x \text{Butterfly}(x) \land \text{In}(x, \text{Irvine}) \land \text{Pretty}(x) \)
C. \( \forall x \exists y \text{Butterfly}(x) \land \text{In}(x, \text{Irvine}) \Rightarrow \text{Pretty}(x) \)
D. \( \exists x \text{Butterfly}(x) \Rightarrow (\text{In}(x, \text{Irvine}) \land \text{Pretty}(x)) \)

1.g (10 pts) “Every butterfly likes some flower.”
A. \( \forall x \exists y (\text{Butterfly}(x) \land \text{Flower}(y) \Rightarrow \text{Likes}(x, y)) \)
B. \( \forall x \exists y \text{Butterfly}(x) \land \text{Flower}(y) \land \text{Likes}(x, y) \)
C. \( \forall x \forall y \text{Butterfly}(x) \land \text{Flower}(y) \land \text{Likes}(x, y) \)
D. \( \forall x \exists y \text{Butterfly}(x) \Rightarrow (\text{Flower}(y) \land \text{Likes}(x, y)) \)

1.h (10 pts) “Some butterfly likes some flower.”
A. \( \exists x \exists y \text{Butterfly}(x) \land \text{Flower}(y) \land \text{Likes}(x, y) \)
B. \( \exists x \exists y (\text{Butterfly}(x) \land \text{Flower}(y) \Rightarrow \text{Likes}(x, y)) \)
C. \( \exists x \exists y \text{Butterfly}(x) \Rightarrow (\text{Flower}(y) \land \text{Likes}(x, y)) \)
D. \( \forall x \forall y \text{Butterfly}(x) \land \text{Flower}(y) \land \text{Likes}(x, y) \)

**** TURN PAGE OVER. QUIZ CONTINUES ON THE REVERSE. ****
2. (30 pts total, 10 pts each) BAYESIAN NETWORKS.
2.a. (10 pts) Write down the factored conditional probability expression corresponding to this Bayesian Network:

```
A
B
C
D
E
F
G
H
```


2.b. (10 pts) Draw the Bayesian Network corresponding to this factored conditional probability expression:

```
A
B
C
D
E
F
G
H
```


2.c. (10 pts) Shown below is the Bayesian network corresponding to the Burglar Alarm problem, i.e., P(J, M, A, B, E) = P(J | A) P(M | A) P(A | B, E) P(B) P(E). This is Fig. 14.2 in your R&N textbook.

(Burglary) (Earthquake) (Alarm) (John calls) (Mary calls)

```
B
E
A
J
M
```

P(B) .001
P(E) .002
P(A | B, E)

<table>
<thead>
<tr>
<th>B</th>
<th>E</th>
<th>P(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>t</td>
<td>.95</td>
</tr>
<tr>
<td>t</td>
<td>f</td>
<td>.94</td>
</tr>
<tr>
<td>f</td>
<td>t</td>
<td>.29</td>
</tr>
<tr>
<td>f</td>
<td>f</td>
<td>.001</td>
</tr>
</tbody>
</table>

write down an expression that will evaluate to P(J=f \land M=t \land A=t \land B=t \land E=f). Express your answer as a series of numbers (numerical probabilities) separated by multiplication symbols. You do not need to carry out the multiplication to produce a single number (probability). SHOW YOUR WORK, first as the symbolic conditional probabilities from the graphs, then as the corresponding numeric probabilities from the tables above.

P(J=f \land M=t \land A=t \land B=t \land E=f)

[put symbolic here] =

[put numeric here] =