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CS161 HW#5

1.
a) Show that P -> !Q and Q->!P are equivalent

P	!Q	P->!Q	Q	!P	Q->!P
T	T	T	F	F	T
T	F	F	T	F	F
F	T	T	F	T	T
F	F	T	T	T	T

b) Show that P <-> !Q and ((P ^ !Q) v (!P^Q)) are equivalent

P	!Q	P->!Q	P<-!Q	P<->!Q
T	T	T	T	T
T	F	F	T	F
F	T	T	F	F
F	F	T	T	T

P	!Q	P^!Q	!P	Q	!P^Q	((P ^ !Q) v (!P^Q))
T	T	T	F	F	F	T
T	F	F	F	T	F	F
F	T	F	T	F	F	F
F	F	F	T	T	T	T

2.
a) (Smoke -> Fire) -> (!Smoke -> !Fire)

Let S = Smoke and F = Fire

S	F	S->F	!S	!F	!S->!F	(S->F)->(!S->!F)
T	T	T	F	F	T	T
T	F	F	F	T	T	T
F	T	T	T	F	F	F
F	F	T	T	T	T	T

Neither because the truth table shows that (Smoke -> Fire) -> (!Smoke -> !Fire) does not hold for every world so it not valid. However, it is satisfiable since the statements holds for at least one world. Thus, the answer is neither.

b) (Smoke -> Fire) -> ((Smoke v Heat) ->Fire)

S	F	H	S->F	SvH	(S v H) -> F	(S->F)->((S v H) -> F)
T	T	T	T	T	T	T
T	T	F	T	T	T	T
T	F	T	F	T	F	T
T	F	F	F	T	F	T
F	T	T	T	T	T	T
F	T	F	T	F	T	T
F	F	T	T	T	F	F
F	F	F	T	F	T	T

Neither because the truth table shows that the statement does not hold for every world so it is not valid. However, it is satisfiable since the statements holds for at least one world. Thus, the answer is neither.

c) ((Smoke^Heat)->Fire) <=> ((Smoke->Fire)v(Heat->Fire))

S	H	F	(S^H)->F	(S->F)	(H->F)	(S->F) v (H->F)	(S^H)->F ⇔ ((S->F)v(H->F)
T	T	T	T	T	T	T	T
T	T	F	F	F	F	F	T
T	F	T	T	T	T	T	T
T	F	F	T	F	T	T	T
F	T	T	T	T	T	T	T
F	T	F	T	T	F	T	T
F	F	T	T	T	T	T	T

This is valid since the statement holds for all worlds (i.e it is True for every set of values).

3.

If the unicorn is mythical, then it is immortal, but if it is not mythical, then it is a mortal mammal. If the unicorn is either immortal or a mammal, then it is horned. The unicorn is magical if it is horned.

Let M = mythical, I = immortal, Mam = mammal, Mag = Magical, and H = Horned

a) Represent information using propositional logic knowledge base

1. M -> I (If the unicorn is mythical, then it is immortal)
2. !M -> (!I^Mam) (If the unicorn is not mythical, then it is mortal and a mammal)
3. (I v Mam) -> H (If the unicorn is either immortal or a mammal, then it is horned)
4. H -> Mag (If the unicorn is horned, then it is magical)

b) Convert knowledge base into CNF

1. !M v I (From 1.)
2a. M v !I (From 2.)
2b. M v Mam (From 2.)
3a. !I v H (From 3.) note: !(I v Mam) -> H = (!I^!Mam)vH
3b. !Mam v H (From 3.)
4. !H v Mag (From 4.)

c)

i) Can you use the knowledge base to prove that the Unicorn is mythical?

Let alpha = !M and let's add alpha to our knowledge base. If we get a contradiction, then our unicorn is mythical

5. !M
6. !I (From 2a. And 5.)
7. Mam (From. 2b. and 5.)
8. H (From 3b. and 7.)

We cannot reach a contradiction, so we cannot say whether the unicorn is mythical based on our knowledge base.

ii) Can you use the knowledge base to prove that the Unicorn is Horned?

Let alpha = !H and let's add alpha to our knowledge base. If we get a contradiction, then our unicorn is horned

5. !H
6. !Mam (From 3b. And 5.)
7. !I (From. 3a. and 5.)
8. M (From 7. And 2a.)
9. Mam (From 8 and 2b.)
10. Contradiction (From 6. And 9.)

Since we've reached a contradiction, we can say the unicorn is horned based on our knowledge base.

iii) Can you use the knowledge base to prove that the Unicorn is Magical?

Let alpha = !Mag and let's add alpha to our knowledge base. If we get a contradiction, then our unicorn is magcal

5. !Mag
6. !H (From 4. And 5.) (This gives us a contradiction as seen in ii))

7. !Mam (From 3b. And 6.)
8. !I (From. 3a. and 6.)
9. M (From 8. And 2a.)
10. Mam (From 8 and 2b.)
11. Contradiction (From 7. And 9.)

Since we've reached a contradiction, we can say the unicorn is magical based on our knowledge base.