1.

(a) $P(A, B, C), P(x, y, z)$	{ x/A, y/B, z/C }
(b) $Q(y, G(B, A), D), Q(G(x, x), y, D)$	Not unifiable because x cannot bind to both B and A
(c) $R(x, z, A)\ , R(A, z, y)$	{ x/y }
(d) $Older(Father(y), John), Older(Father(x), x)$	{ y/John }
(e) $Knows(y, y), Knows(Father(x), x)$	Not unifiable

2.

1. John likes all kinds of food.
2. Apples are food.
3. Chicken is food.
4. Anything someone eats and isn't killed by is food.
5. If you are killed by something, you are not alive.
6. Bill eats peanuts and is still alive. *
7. Sue eats everything Bill eats.

(a) First order logic:

1. $\forall x\ Food(x) \Rightarrow Likes(John, x)$
2. $Food(Apple)$
3. $Food(Chicken)$
4. $\forall y\big(\exists x\ Eats(x, y) \land \neg Kills(y, x)\big) \Rightarrow Food(y)$
   $= \forall x\ \forall y\ Eats(x, y) \land \neg Kills(y, x) \Rightarrow Food(y)$
5. $\forall x\ \forall y\ Kills(x, y) \Rightarrow \neg Alive(y)$
6. $Eats(Bill, Peanuts) \land Alive(Bill)$
7. $\forall x\ Eats(Bill, x) \Rightarrow Eats(Sue, x)$

(b) CNF:

1. $\forall x\ Food(x) \Rightarrow Likes(John, x)$
   = $\neg \boldsymbol{Food(a)} \lor \boldsymbol{Likes(John, a)}$
2. $\boldsymbol{Food(Apple)}$
3. $\boldsymbol{Food(Chicken)}$
4. $\forall x\ \forall y\ Eats(x, y) \land \neg Kills(y, x) \Rightarrow Food(y)$
   = $\neg(Eats(x, y) \land \neg Kills(y, x)) \lor Food(y)$
   = $\neg \boldsymbol{Eats(d, e)} \lor \boldsymbol{Kills(e, d)} \lor \boldsymbol{Food(e)}$
5. $\forall x\ \forall y\ Kills(x, y) \Rightarrow \neg Alive(y)$
   = $\neg \boldsymbol{Kills(f, g)} \lor \neg \boldsymbol{Alive(g)}$
6. $\boldsymbol{Eats(Bill, Peanuts)}$
7. $\boldsymbol{Alive(Bill)}$
8. $\forall x\ Eats(Bill, x) \Rightarrow Eats(Sue, x)$
   = $\neg \boldsymbol{Eats(Bill, h)} \lor \boldsymbol{Eats(Sue, h)}$

(c) Prove $\alpha = Likes(John, Peanuts)$

9. $\neg Likes(John, Peanuts)$	$\neg \alpha$
10. $\neg Food(Peanuts)$	Resolution of 1, 9 with binding list: { a/Peanuts }
11. $\neg Eats(d, Peanuts) \lor Kills(Peanuts, d)$	Resolution or 4, 10 with binding list: { e/Peanuts }
12. $\neg Eats(d, Peanuts) \lor \neg Alive(d)$	Resolution of 5, 11 with binding list: { f/Peanuts, g/d }
13. $\neg Eats(Bill, Peanuts)$	Resolution of 7, 12 with binding list: { d/Bill }
14. $\emptyset$	Resolution of 6, 13

Contradiction! $\therefore$ $Likes(John, Peanuts)$ is true.

(d) Use resolution to answer the question, "What food does Sue eat?"

9. $Eats(Sue, Peanuts)$	Unification of 6, 8 with binding list: { h/Peanuts }

$\therefore Sue\ eats\ peanuts.$

(e) Use resolution to answer (d) if, instead of the axiom marked with an asterisk above, we had:

1. $\neg Food(a) \vee Likes(John, a)$
2. $Food(Apple)$
3. $Food(Chicken)$
4. $\neg Eats(d, e) \vee Kills(e, d) \vee Food(e)$
5. $\neg Kills(f, g) \vee \neg Alive(g)$
6. $\neg Eats(Bill, h) \vee Eats(Sue, h)$

7. $\forall x \left(\forall y \neg Eats(x, y)\right) \Rightarrow Die(x)$
   = $\boldsymbol{Eats(i, j)} \vee \boldsymbol{Die(i)}$
8. $\forall x\, Die(x) \Rightarrow \neg Alive(x)$
   = $\neg \boldsymbol{Die(k)} \vee \neg \boldsymbol{Alive(k)}$
9. **$\boldsymbol{Alive(Bill)}$**

"What food does Sue eat?"

10. $\neg Die(Bill)$	Resolution of 8, 9 with binding list: { k/Bill }
11. $Eats(Bill, j)$	Resolution of 7, 10 with binding list: { i/Bill }
12. $Kills(j, Bill) \vee Food(j)$	Resolution of 4, 11 with binding list: { d/Bill, e/j }
13. $\neg Alive(Bill) \vee Food(j)$	Resolution of 5, 12 with binding list: { f/j, g/Bill }
14. $Food(j)$	Resolution of 9, 13 with binding list: {}
15. $Eats(Sue, j)$	Resolution of 6, 11 with binding list: { h/j }

$\therefore$ *Sue eats food but we cannot conclude which ones.*