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Part 1

Q1

$$\Pi_{flno,arrives}\left(\sigma_{to="HK"}(Flight)\right)$$

Q2

$$\Pi_{eid}\left(\Pi_{aid}\left(\sigma_{cruisingrange \geq 8000}(Aircraft)\right) \bowtie Certified\right)$$

Q3

The query cannot be expressed in standard relational algebra because there is no aggregate function in relational algebra. We cannot use relational algebra to sum queries.

Q4

$$\Pi_{aid}(Aircraft) - \Pi_{aid}\left(Aircraft \bowtie_{Aircraft.cruisingrange < A.cruisingrange} \rho(A, aircraft)\right)$$

Q5

$$\rho\left(NY\_to\_LA, \left(\sigma_{from="New\ York" \wedge to="Los\ Angeles"}(Flight)\right)\right)$$

$$\rho\left(Non\text{-}stop, Aircraft \bowtie_{Aircraft.cruisingrange > NY\_to\_LA.distance} NY\_to\_LA\right)$$

$$\rho(Airbus, \sigma_{amanufacturer="Airbus"}(Aircraft))$$

$$\rho(EID, \Pi_{eid}(\Pi_{aid}(Non\text{-}stop) \bowtie Certified) - \Pi_{eid}(\Pi_{aid}(Airbus) \bowtie Certified))$$

$$\Pi_{salary}(EID \bowtie Employee)$$

Part 2

Q1 The query cannot be expressed into relational algebra because there is no aggregate function in relational algebra. We cannot use relational algebra to sum queries.

Q2

$$\rho(\text{Eagle}, \sigma_{\text{predator}=\text{"eagle"}}(\text{Foodchain}))$$

$$\rho(\text{Leopard}, \sigma_{\text{predator}=\text{"leopard"}}(\text{Foodchain}))$$

$$\rho(\text{Tiger}, \sigma_{\text{predator}=\text{"tiger"}}(\text{Foodchain}))$$

$$\rho(\text{Food}, (\Pi_{\text{food}}(\text{Eagle}) \bowtie \Pi_{\text{food}}(\text{Leopard})) \cup (\Pi_{\text{food}}(\text{Eagle}) \bowtie \Pi_{\text{food}}(\text{Leopard})))$$

$$\Pi_{\text{category}}(\text{Creature} \bowtie_{\text{creature.name}=\text{Food.food}} \text{Food})$$

Q3

$$\rho(\text{Food}, \Pi_{\text{name}}(\sigma_{\text{category}=\text{"Amphibia"} \wedge \text{status}=\text{"Critically Endangered"}}(\text{Creature})))$$

$$\rho(\text{Predator}, \Pi_{\text{predator}}(\text{FoodChain} \bowtie_{\text{FoodChain.food}=\text{Food.food}} \text{Food}))$$

$$\rho(\text{Predator}(\text{predator} \rightarrow \text{food}), \text{Predator})$$

$$\Pi_{\text{predator, food}}(\text{FoodChain}) \div \text{Predator}$$

Q4

$$\Pi_{name,status}\left(Creature - \left(\Pi_{predator}\left(\sigma_{predator=food}(FoodChain)\right) \bowtie Creature\right)\right)$$

Q5 We cannot directly compute exactly three, but we can compute at least three. So the idea of this question is to compute queries of food with at least 3 predators and at least 4 predators. Then we take a set difference.
FC stands for FoodChain

$$\rho(FC1, (predator \to predator1, food \to food1), \Pi_{predator,food}(FoodChain))$$

$$\rho(FC2, (predator \to predator2, food \to food2), \Pi_{predator,food}(FoodChain))$$

$$\rho(FC3, (predator \to predator3, food \to food3), \Pi_{predator,food}(FoodChain))$$

$$\rho(FC4, (predator \to predator4, food \to food4), \Pi_{predator,food}(FoodChain))$$

$$\rho(AtLeast4, \sigma_{(food1=food2 \wedge food2=food3 \wedge food3=food4) \wedge (predator1 \neq predator2 \vee predator2 \neq predator3 \vee predator3 \neq predator4)}(FC1 \times FC2 \times FC3 \times FC4))$$

$$\rho(AtLeast3, \sigma_{(food1=food2 \wedge food2=food3) \wedge (predator1 \neq predator2 \vee predator2 \neq predator3)}(FC1 \times FC2 \times FC3))$$

$$\Pi_{food}(AtLeast3) - \Pi_{food}(Atleast4)$$