Part 1

Q1
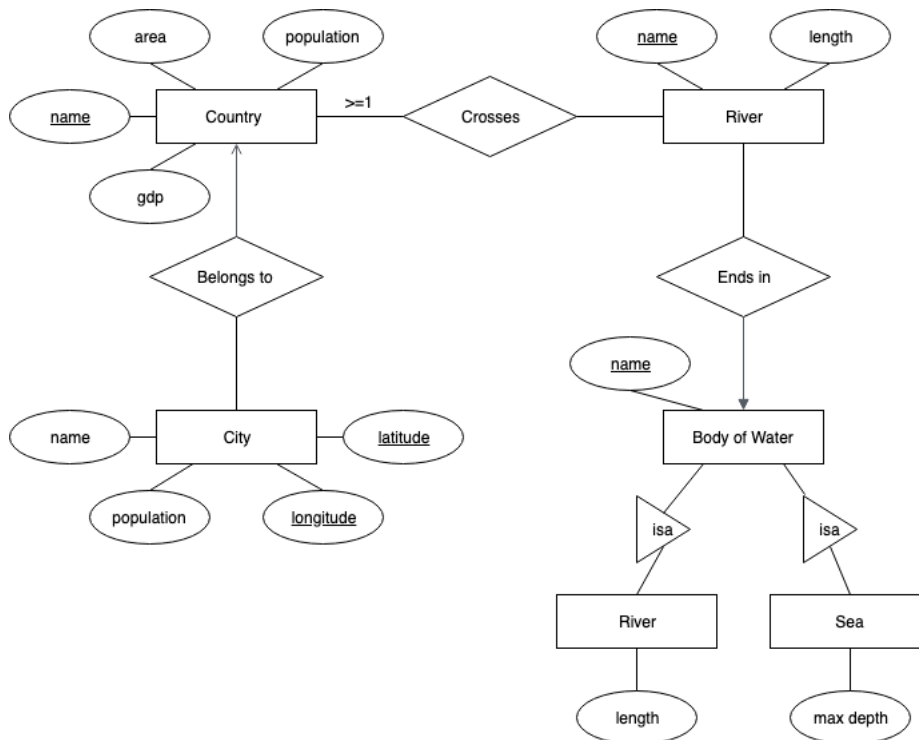

Q2

E/R represented by SQL

```
-- create entities and N-1 relationships
CREATE TABLE InsuranceCo(
  name VARCHAR(255) PRIMARY KEY,
  phone INT
);

CREATE TABLE Person(
  ssn INT PRIMARY KEY,
  name VARCHAR(255)
);

CREATE TABLE Driver(
  ssn INT PRIMARY KEY REFERENCES Person(ssn),
  driverID INT
);

CREATE TABLE NonProfessionalDriver(
```

```
  ssn INT PRIMARY KEY REFERENCES Driver(ssn)
);

CREATE TABLE ProfessionalDriver(
  ssn INT PRIMARY KEY REFERENCES Driver(ssn),
  medicalHistory VARCHAR(255)
);

CREATE TABLE Vehicle(
  licensePlate VARCHAR(255) PRIMARY KEY,
  year INT,
  maxLiability REAL,
  insuranceCoName VARCHAR(255) REFERENCES InsuranceCo(name),
  ownedBy INT REFERENCES Person(ssn),
  UNIQUE(licensePlate, insuranceCoName),
  UNIQUE(licensePlate, ownedBy)
);

CREATE TABLE Car(
  licensePlate VARCHAR(255) PRIMARY KEY REFERENCES Vechicle(LicensePlate),
  make VARCHAR(255)
);

CREATE TABLE Truck(
  licensePlate VARCHAR(255) PRIMARY KEY REFERENCES Vehicle(LicensePlate),
  capacity INT,
  operatedBy INT REFERENCES ProfessionalDriver(ssn),
  UNIQUE(licensePlate, operatedBy)
);

-- create N-N relationship
CREATE TABLE Drives(
  driver INT REFERENCES NonProfessionalDriver(ssn),
  car VARCHAR(255) REFERENCES Car(licensePlate)
);
```

Parts that represent "Insures" relationship

```
maxLiability REAL,
insuranceCoName VARCHAR(255) REFERENCES InsuranceCo(name),
UNIQUE(licensePlate, insuranceCoName)
```

"Insures" relationship is represented in table "Vehicle", since entity Vehicle to entity InsuranceCo is a many to one relation, there is no need to create another table for this relationship. "Unique" vehicle's license plate and insurance company to make sure given vehicle, it is insured by at most one company.

"Drives" and "Operates" have different scheme, since "Drives" is many to many and "Operates" is many to one. i.e. given a car, it can be driven by multiple non professional drivers, and given each non professional driver can drive multiple cars. Given a truck, it can be operated by at most one professional driver, and each professional driver can operate multiple trucks.

Q3

R(A,B,C,D,E)
Choose D first , since D is not a key $D^+ = (D, B) \neq R$, so in the first iteration, R can be decomposed into R1(D,B), R2(D,A,C,E)
Violation exists in R2 since $(CE)^+ = (C, E, A) \neq R2$
No violation exists in R1
In the second iteration, decompose R2 into R21(C,E,A) and R22(C,E,B)
Now no violations exist in R1, R21, R22, we can say R1(D,B) R21(C,E,A) R22(C,E,B) are BCNF of R(A,B,C,D,E).

S(A,B,C,D,E)
Choose A first, since $A^+ = (A, E) \neq S$, so in the first iteration, S can be decomposed into S1(A,E), S2(A,B,C,D)
Violation exists in S2 $(B, C)^+ = (A, B, C) \neq S2$
No violation exists in S1
In the second iteration, decompose S2 into S21(A,B,C) and S22(B,C,D)
Now no violations exist in S1, S21, S22, we can say S1(A,E), S21(A,B,C), S22(B,C,D) are BCNF of S(A,B,C,D,E).

Q4

R(A,B,C,D)
All sets of attributes are closed: {} empty set of FD
The only closed sets are {} and $\{ABCD\}$: $\{A \to B, B \to C, C \to D, D \to A\}$
The only closed sets are $\{\}, \{A, B\}$ and $\{ABCD\}$: $\{A \to B, B \to A, C \to ABD, D \to ABC\}$