Question 1 (9 points)
The donations relation was defined based on the following SQL statement:

```
CREATE TABLE  donations
        (recipientName  CHAR(20)  NOT NULL,
        donorOrganization CHAR(20)  NOT NULL,
        organizationType CHAR(20),
        amount REAL,
        PRIMARY KEY  (recipientName, donorOrganization)
)
```

For each of the following relational calculus queries, determine if there exists an equivalent relational algebra statement. If you answer is positive, give such a statement; otherwise, just state that no such statement exists. (You may get part marks if you write down in English the correct meaning of each query.)

a) $\{ <N> | \exists x, y (<N, x, tobacco, -> \in donations$ and $<N, y, tobacco, -> \in donations$ and $x \neq y) \}$

b) $\{ <N> | \forall x (<-, x, tobacco, -> \in donations \Rightarrow <N, x, tobacco, -> \in donations) \}$

c) $\{ <N> | \exists x (<N, -, tobacco, x> \in donations$ and $\forall y (<-, -, tobacco, y> \in donations \Rightarrow x \geq y) \}$

d) $\{ <N> | \forall x, y ((<N, -, x, -> \in donations$ and $<N, -, y, -> \in donations) \Rightarrow x \neq y)$
$\}$(Remove from the exam. See bulletin board.)

Question 2 (8 points)
Based on the donations relation defined above, determine whether each of the following four pairs of SQL statements is equivalent. If the pair is equivalent, just say yes and no explanation is needed. If you do not think the pair is equivalent, construct an instance of the donations relation to illustrate the difference between the pair of statements.

a)

        select distinct recipientName from donations A
        where not exists
          (select B.donorOrganization from donations B
          where recipientName = "Campbell"

          and A.donorOrganization $\neq$ B.donorOrganization)

   vs

        select distinct recipientName from donations A
        where not exists
          ((select donorOrganization from donations
           where recipientName = "Campbell")
           except
          (select donorOrganization from donations B
          where B.recipientName = A.recipientName))

b)

        (select distinct recipientName from donations
         where amount $\geq$ 500)
         union
        (select distinct recipientName from donations
         where amount < 500)
   vs

        select distinct recipientName from donations

c)
        select distinct recipientName from donations A, donations B
        where A.amount $\geq$ 1000
        and A.recipientName = B.recipientName

        and A.donorOrganization $\neq$ B.donorOrganization

  vs

        select distinct recipientName from donations
          where amount $\geq$ 1000
          group by recipientName
          having count(donorOrganization) $\geq$ 2

d)
        select distinct recipientName from donations
        where recipientName not in
          (select recipientName from donations
           where organizationType = tobacco)

  vs

        select distinct recipientName from donations A
        where exists
          (select * from donations B
           where B.recipientName = A.recipientName
           and organizationType $\neq$ tobacco)

--- The End ---