1. $\pi_{sname}(\pi_{sid}((\pi_{pid}\sigma_{color=\ red}\ Parts) \bowtie Catalog) \bowtie Suppliers)$

```
SELECT S.sname
FROM Suppliers S, Parts P, Catalog C
WHERE P.color='red' AND C.pid=P.pid AND C.sid=S.sid
```

2.

$$\pi_{sid}(\pi_{pid}(\sigma_{color=\ red\ \vee color=\ green}\ Parts) \bowtie catalog)$$

```
SELECT C.sid
FROM Catalog C JOIN Parts P ON P.pid = C.pid
WHERE                    (P.color = 'red' OR P.color = 'green')
```

3.

$\rho(R1, \pi_{sid}((\pi_{pid}\sigma_{color=\ red}\ Parts) \bowtie Catalog))$

$\rho(R2, \pi_{sid}\sigma_{address=\ 221Packer Street}\ Suppliers)$

$R1 \cup R2$

```
SELECT S.sid
FROM                    Suppliers S
WHERE                   S.address = '221 Packer street'
      OR S.sid IN ( SELECT C.sid
        FROM    Parts P JOIN Catalog C ON P.pid = C.pid
        WHERE   P.color='red' )
```

4.

$\rho(R1, \pi_{sid}((\pi_{pid}\, \sigma_{color= red}\ Parts) \bowtie Catalog))$

$\rho(R2, \pi_{sid}((\pi_{pid}\, \sigma_{color= green}\ Parts) \bowtie Catalog))$

$R1 \cap R$

```
SELECT C.sid
       FROM Parts P JOIN Catalog C ON P.pid = C.pid
          WHERE  P.color = 'red'
            AND EXISTS  ( SELECT P2.pid
                          FROM Parts P2, Catalog C2
                          WHERE P2.color = 'green' AND C2.sid = C.sid
                          AND P2.pid = C2.pid )
```

5.

$(\pi_{sid,pid}Catalog)/(\pi_{pid}Parts)$

```
SELECT C.sid
       FROM   Catalog C
          WHERE NOT EXISTS  (SELECT P.pid
                                  FROM Parts P
                                    WHERE NOT EXISTS  (SELECT C1.sid
                                                          FROM       Catalog C1
                                                          WHERE      C1.sid = C.sid
                                                                     AND C1.pid = P.pid))
```

6.

$(\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color= red}\ Parts)$

SQL

```
SELECT C.sid
FROM   Catalog C
WHERE   NOT EXISTS  (SELECT P.pid
                        FROM   Parts P
                            WHERE   P.color = 'red'
                            AND (NOT EXISTS (SELECT C1.sid
                                                FROM       Catalog C1
                                                  WHERE    C1.sid = C.sid AND
                                                           C1.pid = P.pid)))
```

7.

$(\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color= red\ \vee color= green}\ Parts)$

SQL

```
SELECT C.sid
            FROM Catalog C
                WHERE NOT EXISTS  (SELECT P.pid
                                       FROM Parts P
                                        WHERE  (P.color = 'red' OR P.color = 'green')
                                        AND (NOT EXISTS (SELECT C1.sid
                                                            FROM   Catalog C1
                                                             WHERE  C1.sid = C.sid AND
                                                            C1.pid = P.pid)))
```

8.

$\rho(R1, ((\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color= red}\ Parts)))$

$\rho(R2, ((\pi_{sid,pid}Catalog)/(\pi_{pid}\sigma_{color= green}\ Parts)))$

$R1 \cup R2$

```
SELECT C.sid
FROM   Catalog C
WHERE    (NOT EXISTS (SELECT P.pid
                      FROM Parts P
                       WHERE P.color = 'red' AND
                        (NOT EXISTS (SELECT C1.sid
                                     FROM Catalog C1
                                       WHERE C1.sid = C.sid AND
                                        C1.pid = P.pid))))
          OR ( NOT EXISTS  (SELECT P1.pid
                            FROM Parts P1
                             WHERE  P1.color = 'green' AND
                             (NOT EXISTS (SELECT C2.sid
                                          FROM Catalog C2
                                            WHERE   C2.sid = C.sid AND
                                                    C2.pid = P1.pid))))
```

9.

$\rho(R1, Catalog)$

$\rho(R2, Catalog)$

$\pi_{R1.sid,R2.sid}(\sigma_{R1.pid=R2.pid \wedge R1.sid/=R2.sid \wedge R1.cost>R2.cost}(R1 \times R2))$

SQL

```
SELECT C1.sid, C2.sid
FROM   Catalog C1 JOIN  Catalog C2 ON C1.pid = C2.pid
WHERE  C1.sid <> C2.sid
       AND  C1.cost > C2.cost
```

10.

$\rho(R1, Catalog)$

$\rho(R2, Catalog)$

$\pi_{R1.pid}\sigma_{R1.pid=R2.pid \wedge R1.sid/=R2.sid}(R1 \times R2)$

SQL

```
SELECT C.pid
FROM Catalog C
WHERE EXISTS (SELECT C1.sid
                FROM Catalog C1
                WHERE C1.pid = C.pid AND C1.sid <> C.sid )
```

11.

$\rho(R1, \pi_{sid}\sigma_{sname= Yosemite Sham} Suppliers)$

$\rho(R2, R1 \bowtie Catalog)$

$\rho(R3, R2)$

$\rho(R4(1 \rightarrow sid, 2 \rightarrow pid, 3 \rightarrow cost), \sigma_{R3.cost<R2.cost}(R3 \times R2))$

$\pi_{pid}(R2 - \pi_{sid,pid,cost}R4)$

```
SELECT C.pid
FROM   Catalog C, Suppliers S
WHERE S.sname = 'Yosemite Sham' AND C.sid = S.sid
      AND C.cost ≥ ALL (Select C2.cost
                        FROM   Catalog C2 JOIN Suppliers S2 ON C2.sid = S2.sid
                        WHERE S2.sname = 'Yosemite Sham')
```