Q.1

1.1

$$R_1 = \rho_{\lambda_1} (lives)$$

$$R_2 = \rho_{\lambda_2} (lives \bowtie manages)$$

$$R_3 = R_1 \bowtie (R_1.manager\text{-}name = R_2.person\text{-}name$$
$$\land R_1.street = R_2.street$$
$$\land R_1.city = R_2.city) (R_2)$$

$$\boxed{Result = \Pi_{person\text{-}name} (R_3)}$$

1-2.

$$R_1 = \sigma_{company\text{-}name = "CITY BANK"} (works)$$

$$\boxed{Result = \Pi_{person\text{-}name, city} (lives \bowtie R_1)}$$

1.3.

$$R_1 = \sigma_{(company\text{-}name = "CITY BANK" \land salary > 52800)} (works)$$

$$\boxed{\begin{array}{l} Result = \\ \Pi_{person\text{-}name, street, city} (lives \bowtie R_1) \end{array}}$$

$$\boxed{Q.1}$$

1.4.

Result =

$$\Pi_{person\text{-}name} \left(lives \bowtie works \bowtie located\text{-}in \right)$$

1.5:

→ Assuming all person works in a company.

$$\Pi_{person\text{-}name} \left(\sigma_{company\text{-}name \neq \text{"CITY BANK"}} (works) \right)$$

→ If some person does not work !

$$R_1 = \Pi_{person\text{-}name} \left(\sigma_{company\text{-}name = \text{"CITY BANK"}} (works) \right)$$

$$\boxed{Result = \Pi_{person\text{-}name} (lives) - R_1}$$

$$\boxed{Q.2}$$

2.1)

```
SELECT company-name
FROM works GROUP BY company-name
HAVING sum(salary) ≤
        ALL ( SELECT SUM(salary)
               FROM WORKS
               GROUP BY company-name);
```

2.2)

```
SELECT C1. company-name FROM located-in C1
WHERE NOT EXISTS
((SELECT city FROM located-in
  WHERE company-name = 'CITYBANK')

EXCEPT

(SELECT CITY FROM located-in C2
  WHERE C1. company-name = C2. company-
                                    name));
```

Q2

2.3) Assuming all person work :

SELECT Person-name FROM works
    WHERE company-name < > 'CITY BANK';

However,
    if not all Person work for a company
    then Query would be

SELECT person-name FROM lives LEFT OUTER JOIN
    works ON lives. person-name = works. person-nam
    WHERE works. company-name < > 'CITY BANK';

2.4)
    SELECT person-name FROM works
    WHERE salary > (SELECT MAX (salary)
                     FROM works WHERE
                     company-name = 'CITY BANK');

Q.2

2.5)

    SELECT   person-name FROM works W1
    WHERE   salary > (SELECT Avg (salary)

                FROM works W2

                WHERE W1. company-name
                        = W2. company-name);

$$\boxed{Q.3}$$

3.1   Relation R :

$$P \rightarrow Q$$
$$R \rightarrow Q$$
$$S \rightarrow PQR$$
$$PR \rightarrow S$$

Step 1 :- Breaking RHS

(i) $P \rightarrow Q$ (ii) $R \rightarrow Q$ (iii) $S \rightarrow P$ (iv) $S \rightarrow Q$

(v) $S \rightarrow R$ (vi) $PR \rightarrow S$

Step 2 :- check essential dependency

(i) $P \rightarrow Q$, $(P)^+ = \{P, Q\}$

$\therefore (P)_Q^+ = \{P\}$.

$\therefore$ essential

(ii) $R \rightarrow Q$; $(R)^+ = \{R, Q\}$

$\therefore (R)_Q^+ = \{R\}$. → different than ab...

$\therefore$ essential

(iii) $S \rightarrow P$; $(S)^+ = \{P, Q, R, S\}$.

$(S)_P^+ = \{Q, R, S\}$ → different.

$\therefore$ essential

Q.3

3.1 (continued)

(iv) $S \to Q$: $(S)^+ = \{P, Q, R, S\}$

$(S)^+_a = \{P, Q, R, S\}$ $\to$ Redundant.

$\therefore$ Redundant.

(v) $S \to R$ $\therefore$ $(S)^+ = \{P, Q, R, S\}$.

$(S)^+_R = \{P, Q, S\}$ $\to$ different

$\therefore$ Essential

(vi) $PR \to S$ $\therefore$ $(PR)^+ = \{P, Q, R, S\}$

$\therefore$ $(PR)^+_S = \{P, Q, R\}$ $\to$ different

$\therefore$ Essential.

So we get following.

$P \to Q$
$R \to Q$
$S \to P$ $\Big\rangle$ $S \to PR$
$S \to R$
$PR \to S$

Step. 3 $\div$ Break LHS to single attribute

$PR \to S$; $(PR)^+ = \{P, Q, R, S\}$.

$(P)^+ = \{P, Q\}$, $(R)^+ = \{R, Q\}$.

$\boxed{\text{a.3}}$

Since $(P)^+$ & $(R)^+$ is different;
final Cenonical Cover is same as step 2

$$
\begin{array}{l}
\therefore \text{ final} \quad = \quad P \to Q \\
\qquad\qquad\qquad R \to Q \\
\qquad\qquad\qquad S \to PR \\
\qquad\qquad\qquad PR \to S
\end{array}
$$

3.2

$$R = (P, Q, R, S, T)$$

$$P \to Q$$

$$PQ \to R$$

$$S \to PQT .$$

Step (1)

$$P \to Q$$
$$PQ \to R$$
$$S \to P$$
$$S \to Q$$
$$S \to T$$

$$\boxed{Q.3}$$

Q.2) continued

Step (2)

$$P \rightarrow Q \quad ; \quad (P)^+ = \{P, Q, R\}. \; ; \; (P)^+_Q = \{P\}$$

$$PQ \rightarrow R \quad ; \quad (PQ)^+ = \{P, Q, R\} \; ; \; (PQ)^+_R = \{P, Q\}$$

$$S \rightarrow P \quad ; \quad (S)^+ = \{P, Q, R, S, T\} \; ;$$
$$\qquad\qquad\qquad\qquad\qquad (S)^+_P = \{S, Q, T\}$$

$$S \rightarrow Q \quad ; \quad (S)^+ = \{P, Q, R, S, T\} \; ; \; (S)^+_Q = \{P, Q, R, S, T\}.$$

Redundant

$$S \rightarrow T \quad ; \quad (S)^+ = \{P, Q, R, S, T\} \; ; \; (S)^+_T = \{P, Q, R, S\}.$$

So we get,
(1) $P \rightarrow Q$ (11) $PQ \rightarrow R$, (111) $S \rightarrow P$ (1V) $S \rightarrow T$.

Step (3)   for $PQ \rightarrow R$

$$(PQ)^+ = \{P, Q, R\}. \quad \Big\} \text{ Redundant}$$
$$(P)^+ = \{P, Q, R\}$$
$$(Q)^+ = \{Q\}.$$

| Q.3 |

P.2) continued

So, we get

(I) $P \to Q$ (ii) $P \to R$ (iii) $S \to P$ (iv) $S \to T$

> $\therefore$ final canonical cover
>
> $\quad = P \to QR$
>
> $\quad\quad S \to PT$

P.3)   Given $R =$ $Q \to P$

$\quad\quad\quad\quad\quad\quad\quad\quad PS \to QR$

$\quad\quad\quad\quad\quad\quad\quad\quad R \to PQS.$

Step (1)

(I) $Q \to P$ (II) $PS \to Q$ (III) $PS \to R$

(IV) $R \to P$ (V) $R \to Q$ (VI) $R \to S$

$$\boxed{Q \cdot 3}$$

3.3 - Continued

Step (II)

(I) $Q \rightarrow P$; $(Q)^+ = \{P, Q, \}$; $(Q)^+_P = \{Q\}$.

(II) $PS \rightarrow Q$; $(PS)^+ = \{P, S, Q, R\}$; $(PS)^+_Q = \{P, S, Q, R\}$

Redundant. So Remove

(III) $PS \rightarrow R$; $(PS)^+ = \{P, S, Q, R\}$; $(PS)^+_R = \{P, S, \}$.

(IV) $R \rightarrow P$; $(R)^+ = \{P, Q, R, S\}$; $(R)^+_P = \{P, Q, R, S\}$.

Redundant, So Remove

(V) $R \rightarrow Q$; $(R)^+ = \{P, Q, R, S\}$; $(R)^+_Q = $
                                                $\{R, S\}$.

(VI) $R \rightarrow S$; $(R)^+ = \{P, Q, R, S\}$. $(R)^+_S = \{P, Q, R\}$.

So after Removing

(I) $Q \rightarrow P$ (II) $PS \rightarrow R$ (III) $R \rightarrow Q$ (VI) $R \rightarrow S$

3.3 → continued

    Step (III)

      Remove LHS Redundancy

$$PS \to R$$

$$(PS)^+ = \{P, Q, R, S\}$$

$$(P)^+ = \{P\}$$

$$(S)^+ = \{S\}.$$

    ∴ No redundancy so cannot be Removed.

∴ final Canonical Cover =

$$Q \to P$$
$$PS \to R$$
$$R \to SQ$$