Q1:-

Part 1

$(\neg p \vee \neg t) \vee (\wedge \vee s)$ — C_1

$\neg q$ — C_2

u — C_3

t — C_4

$\neg u \vee p$ C_5

$\neg s$ — C_6

q — C_7

$\neg s$ — C_8

from C_2 & C_5 p — C_8

from C_2 & C_7 $\boxed{X}$

Argument is valid.

Part 2

$\neg p \vee \neg t \vee s$ — C_1

$\neg q \vee u \vee t$ — C_2

$\neg u \vee p$ — C_3

$\neg s$ — C_4

q — C_5

$\neg s$ — C_6

$u \vee t$ — C_7

$\neg p \vee \neg t$ — C_8

$\neg u \vee \neg t$ — C_9

$\boxed{X}$ — C_{10}

Valid argument

Part 3:

$\neg p \vee s \vee q$ — C_1

$\neg q$ — C_2

u — C_3

t — C_4

$\neg u \vee p$ — C_4

$\neg s$ — C_5

$\neg q \vee s$ — C_6

p — C_8

$s \vee q$ — C_9

s — C_{10}

using C_{10} & C_5 $\boxed{X}$

Argument is valid.

Part 4:

$\neg t$ — C_1

r — C_2

$\neg q$ — C_3

u — C_4

t — C_5

$\neg u \vee p$ — C_6

$\neg s$ — C_7

$\neg q$ — C_8

$\neg s$ — C_9

$\boxed{X}$ using C_1 & C_5

Argument is valid.

Part 5:- (3)

$\neg p \vee \neg t \vee r \vee s$ — C_1

$\neg q \vee t$ — C_2

$\neg u \vee p$ — C_3

$\neg s$ — C_4

s — C_5 using C_4 & C_5

$\neg s$ — C_6

$\boxed{\times}$

argument is valid.

Q2:-

Part 1:-

$\exists x \exists y \forall z \neg P(x,y,z)$

$= [(\neg P(1,1,1) \wedge \neg P(1,1,2) \wedge \neg P(1,1,3)) \vee (\neg P(1,2,1) \wedge \neg P(1,2,2) \wedge \neg P(1,2,3))$
$\vee (\neg P(1,3,1) \wedge \neg P(1,3,2) \wedge \neg P(1,3,3))] \vee [(\neg P(2,1,1) \wedge \neg P(2,1,2) \wedge \neg P(2,1,3))$
$\vee (\neg P(2,2,1) \wedge \neg P(2,2,2) \wedge \neg P(2,2,3)) \vee (\neg P(2,3,1) \wedge \neg P(2,3,2) \wedge \neg P(2,3,3))]$
$\vee [(\neg P(3,1,1) \wedge \neg P(3,1,2) \wedge \neg P(3,1,3)) \vee (\neg P(3,2,1) \wedge \neg P(3,2,2) \wedge \neg P(3,2,3))$
$\vee (\neg P(3,3,1) \wedge \neg P(3,3,2) \wedge \neg P(3,3,3))]$

(4)

Part 2:

$\forall x \exists y \exists z \neg P(x,y,z)$

$= [(\neg P(1,1,1) \vee \neg P(1,1,2) \vee \neg P(1,1,3))] \vee [\neg P(1,2,1) \vee \neg P(1,2,2) \vee \neg P(1,2,3)] \vee$
$[\neg P(1,3,1) \vee \neg P(1,3,2) \vee \neg P(1,3,3)] \wedge [(\neg P(2,1,1) \vee \neg P(2,1,2) \vee \neg P(2,1,3)) \vee$
$(\neg P(3,2,1) \vee \neg P(2,2,2) \vee \neg P(2,2,3)) \vee (\neg P(2,3,1) \vee \neg P(2,3,2) \vee \neg P(2,3,3))] \wedge$
$[\neg P(3,1,1) \vee \neg P(3,1,2) \vee \neg P(3,1,3)] \vee (\neg P(3,2,1) \vee \neg P(3,2,2) \vee \neg P(3,2,3)$
$\vee (\neg P(3,3,1) \vee \neg P(3,3,2) \vee \neg P(3,3,3))]$

Part 3:

$\forall x \forall y \exists z \neg P(x,y,z)$

$= [(\neg P(1,1,1) \vee \neg P(1,1,2) \vee \neg P(1,1,3)) \wedge (\neg P(1,2,1) \vee \neg P(1,2,2) \vee \neg P(1,2,3))$
$\wedge (\neg P(1,3,1) \vee \neg P(1,3,2) \vee \neg P(1,3,3)] \wedge [(\neg P(2,1,1) \vee \neg P(2,1,2) \vee \neg P(2,1,3)) \wedge$
$((\neg P(2,2,1) \vee \neg P(2,2,2)) \vee \neg P(2,2,3)) \wedge (\neg P(2,3,1) \vee \neg P(3,3,2) \vee \neg P(2,3,3))]$
$\wedge [(\neg P(3,1,1) \vee \neg P(3,1,2) \vee \neg P(3,1,3)] \wedge (\neg P(3,2,1) \wedge \neg P(3,2,2) \vee \neg P(3,2,3))$
$\wedge (\neg P(3,3,1) \vee \neg P(3,3,2) \vee \neg P(3,3,3))]$

Part 4:

~~$\forall x \forall y \exists z \neg P$~~ $\neg \exists x \neg \exists y \neg \forall z P(x,y,z)$

$= [(\neg P(1,1,1) \vee \neg P(1,1,2) \vee \neg P(1,1,3)) \vee (\neg P(1,2,1) \vee \neg P(1,2,2) \vee \neg P(1,2,3)) \vee$
$(\neg P(1,3,1) \vee \neg P(1,3,2) \vee \neg P(1,3,3))] \wedge [(\neg P(1,1,1) \vee \neg P(1,1,2) \vee \neg P(1,1,3)) \vee$
$(\neg P(1,2,1) \vee \neg P(1,1,2) \vee \neg P(1,2,3)) \vee (\neg P(1,3,1) \vee \neg P(1,3,2) \vee \neg P(1,3,3))] \vee$
$[(\neg P(1,1,1) \vee \neg P(1,1,2) \vee \neg P(1,1,3) \vee (\neg P(1,2,1) \vee \neg P(1,2,2) \vee \neg P(1,2,3)) \vee$
$(\neg P(1,3,1) \vee \neg P(1,3,2) \vee \neg P(1,3,3)]$

Part 5:-

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$$\neg\exists x \neg\exists y \, \forall z \, P(x,y,z)$$

$$= \{[(P(1,1,1) \wedge P(1,1,2) \wedge P(1,1,3)) \vee (P(1,2,1) \wedge P(1,2,2) \wedge P(1,2,3)) \vee$$

$$P(1,3,1) \wedge P(1,3,2) \wedge P(1,3,1)] \wedge [(P(1,1,1) \wedge P(1,1,2) \wedge P(1,1,3)) \vee$$

$$P(1,2,1) \wedge P(1,2,2) \wedge P(1,2,3)) \vee P(1,3,1) \wedge P(1,3,2) \wedge P(1,3,3)] \wedge$$

$$[(P(1,1,1) \wedge P(1,1,2) \wedge P(1,1,3)) \vee (P(1,2,1) \wedge P(1,2,2) \wedge P(1,2,3))$$

$$\vee (P(1,3,1) \wedge P(1,3,2) \wedge P(1,3,3))]\}$$

Q3:- **Part 1:** Knights speak the truth

- Knaves speak the truth

i) $P \wedge Q$

ii) $\neg P$

Case 1:-

Knights, Knights

i) $T \wedge T = T$ $\quad P = T \quad \neg P = F$

ii) $F \neq T$ $\quad q = T \quad \neg q = F$

Case does not hold.

Case 2:- Knight, Knave

i) $T \wedge F \neq T$ $\quad P = T \quad \neg P = F$

$q = F \quad \neg q = \cancel{T}$

case does not hold.

Case 3:- Knave, Knight $\quad P = F \quad \neg P = T$

i) $F \wedge T \neq T$ $\quad q = T \quad \neg q = F$

case does not hold.

Case 4:- Knave, Knave $\quad P = F \quad \neg P = T$

i) $F \wedge F \neq T$ $\quad q = F \quad \neg q = T$

Case does not hold.

Hence, we cannot tell that which one is a knight and which one is knave.

Part 2: Knights speak the truth
Knaves speak the lie

Case 1:- Knight, Knight

$p = T \quad \neg p = F$
$q = T \quad \neg q = F$

i) $p \wedge q = T \rightarrow T \wedge T = T$
ii) $\neg p = T \rightarrow F \neq T$

case does not hold.

Case 2:- Knight, Knave

$p = T \quad \neg p = F$
$q = F \quad \neg q = T$

i) $T \wedge F \neq T$

case does not hold

case 3: Knave, knight

$p = F \quad \neg p = T$
$q = T \quad \neg q = F$

i) $F \wedge T = F$
ii) $T = T$

case holds.

Case 4: Knave, Knave

$p = F \quad \neg p = T$
$q = F \quad \neg q = T$

i) $F \wedge F = F$
ii) $T \neq F$

Case does not hold.

Hence,
A is a knave
B is a ~~kn~~ knight.

Part 3: Knights tells lies ⑧

Knaves tell lies

Case 1: Knight, Knight $p = T \quad \neg p = F$

$q = T \quad \neg q = F$

i) $T \wedge T \neq F$

case does not hold

Case 2: Knight, Knave

i) $T \wedge F = F$ $p = T \quad \neg p = F$

ii) $F = F$ $q = F \quad \neg q = T$

case holds

Case 3:

Knave, Knight

i) $F \wedge T = F$ $p = F \quad \neg p = T$

ii) $T \neq F$ $q = T \quad \neg q = F$

case does not hold.

Case 4:

Knave, Knave

i) $F \wedge F = F$ $p = F \quad \neg p = T$

ii) $T \neq F$. $q = F \quad \neg q = T$

case does not hold

Hence, A is a knight

B is a knave.

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Part 4: Knights tell lies

Knaves ~~tell~~ speaks truth

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Case 1:

Knight, Knight $\quad P = T \quad \neg P = F$

$\quad q = T \quad \neg q = F$

i) $T \wedge T \neq F$

case does not hold.

Case 2: Knight, Knave $\quad P = T \quad \neg P = F$

$\quad q = F \quad \neg q = T$

i) $T \wedge F = F$

ii) $F \neq T$

case does not hold.

Case 3: Knave, Knight

$\quad P = F \quad \neg P = T$

$\quad q = T \quad \neg q = F$

i) $F \wedge F \neq T$

case does not hold

Case 4: Knave, Knave

$\quad P = F \quad \neg P = T$

$\quad q = F \quad \neg q = T$

i) $F \wedge F \neq T$

case does not hold

Hence,

we canot determine who is who.

Part 5:

Knight speaks the truth
Knave's tell lies

(10)

Case 1:- Knight, Knight

$P = T$ $\quad \neg P = F$
$q = T$ $\quad \neg q = F$

i) $T \wedge T = T$

ii) $F \neq T$

case does not hold

Case 2:- Knight, knave

$P = T$ $\quad \neg P = F$
$q = F$ $\quad \neg q = T$

i) $T \wedge F \neq T$

case does not hold

Case 3:- Knave, knight

i) $F \wedge T = F$

ii) $T = T$

$P = F$ $\quad \neg P = T$
$q = T$ $\quad \neg q = F$

case holds

Case 4:- knave, knave

$P = F$ $\quad \neg P = T$
$q = F$ $\quad \neg q = T$

i) $F = F$

ii) $T \neq F$

case does not hold

Hence,
A is a knave
B is a knight

Q4:

Part 1:

Implication:- $\neg q \to \neg p \vee \neg q$

Inverse:- $q \to (p \wedge q)$

Converse:- $\neg p \vee \neg q \to \neg q$

Contrapositive: $(p \wedge q) \to q$

Part 2:

Implication:: $q \to (p \wedge q)$

Inverse: $\neg q \to (\neg p \vee \neg q)$

converse: $(p \wedge q) \to q$

Contrapositive: $\neg p \vee \neg q \to \neg q$

Part 3:

Implication:- $\neg p \vee \neg q \to \neg q$

Inverse:- $(p \wedge q) \to q$

converse:- $\neg q \to (\neg p \vee \neg q)$

Contrapositive:- $q \to (p \wedge q)$

Part 4:

Implication:- $\neg q \to (p \vee \neg q)$

Inverse:- $q \to (\neg p \wedge q)$

Converse:- $(p \vee \neg q) \to \neg q$

Contrapositive: $(\neg p \wedge q) \to q$

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Part 5:-

Implication: $(p \vee \neg q) \to q$

Inverse :- $(\neg p \wedge q) \to q$

Converse :- $q \to (p \vee \neg q)$

Contrapositive :- $q \to \neg p \wedge q$

Q5:-

Part 1:-

$(R_1 \cup R_2)^{-1} = \{(1,1)(2,1),(1,2),(1,3),(2,3)\}$

$\overline{R_1 \cup R_2} \Rightarrow \{(2,2)\}$

Part 2:-

$(R_1 \cap R_2)^{-1} = \{(1,2)\}$

$(\overline{R_1 \cap R_2}) = \{(1,1)(1,2)(2,2)(3,1)(3,2)\}$

Part 3:-

$(R_1 - R_2)^{-1} = \{(2,1)(2,3)\}$

$\{\overline{R_1 - R_2}\} = \{(1,1)(2,1)(2,2)(3,1)\}$

Part 4:-

$(R_2 - R_1)^{-1}$ $\{(1,1),(1,3)\}$

$(\overline{R_2 - R_1}) = \{(1,2)(2,1)(2,2)(3,2)\}$

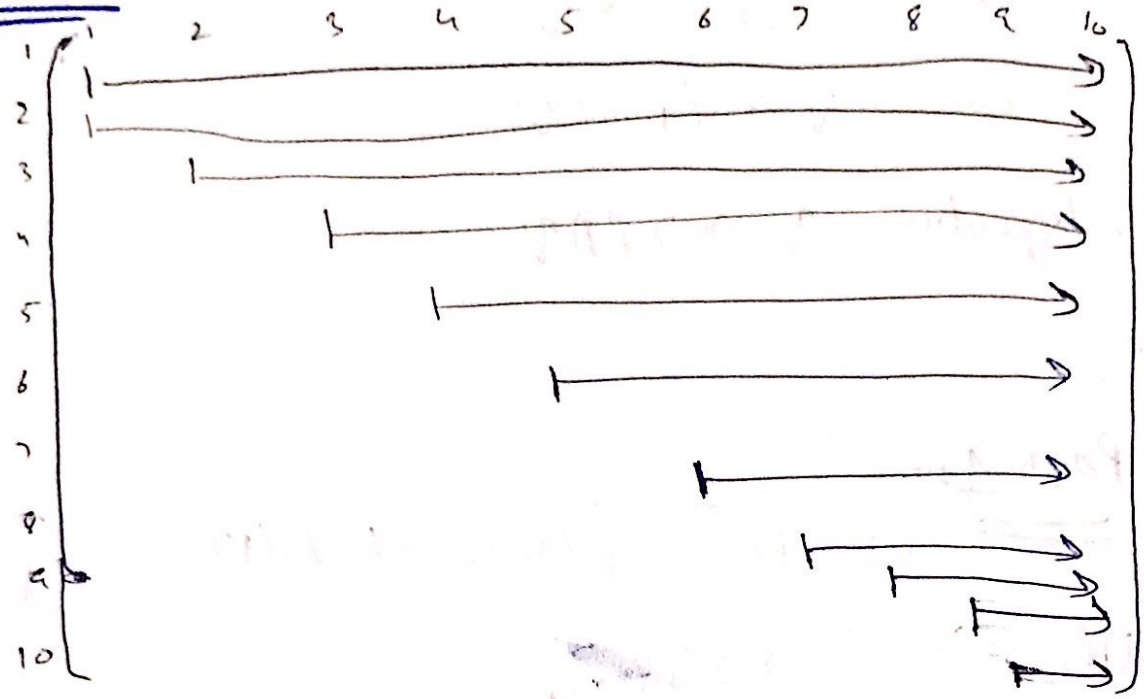
Part 5:-

$((R_1)^{-1})^{-1} = \{(1,2)(2,1)(3,2)\}$

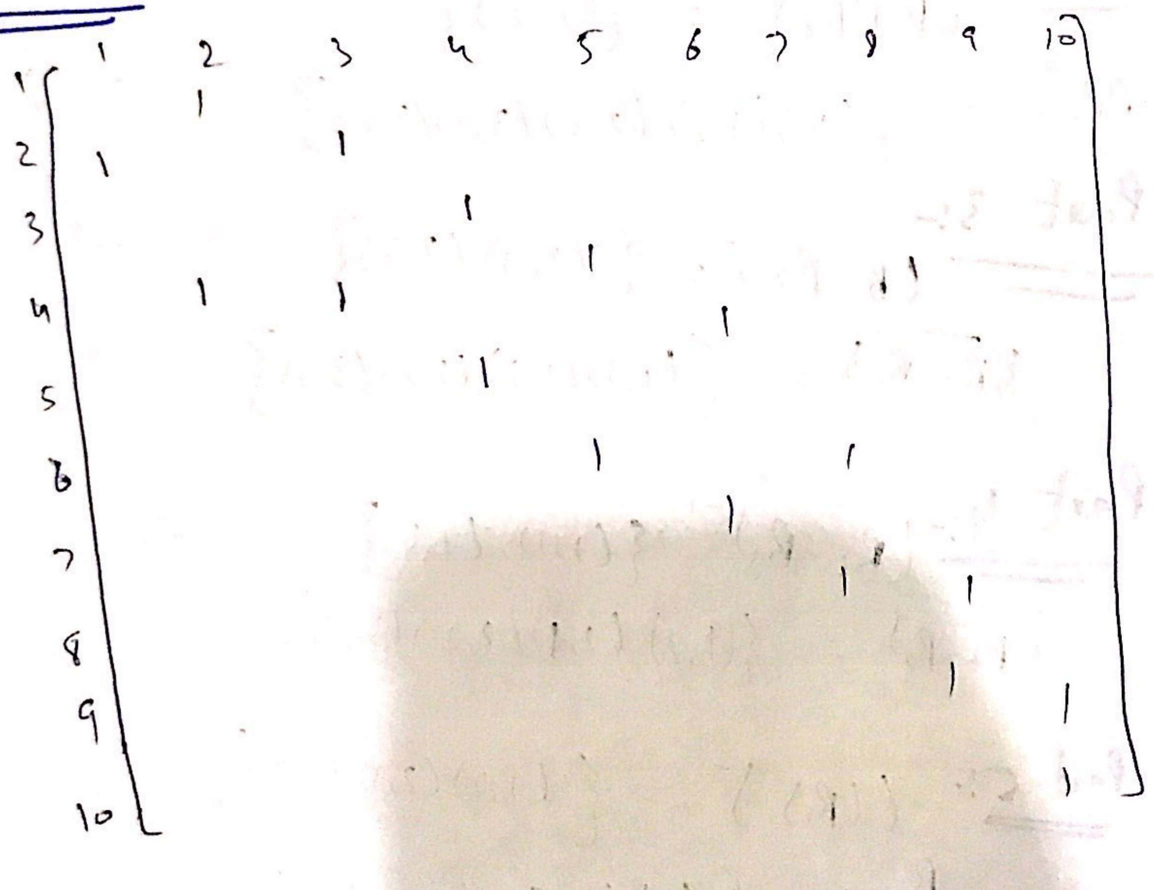
$R_1^{-1} = \{(1,1)(2,2),(3,1),(3,2)\}$

Q6:-

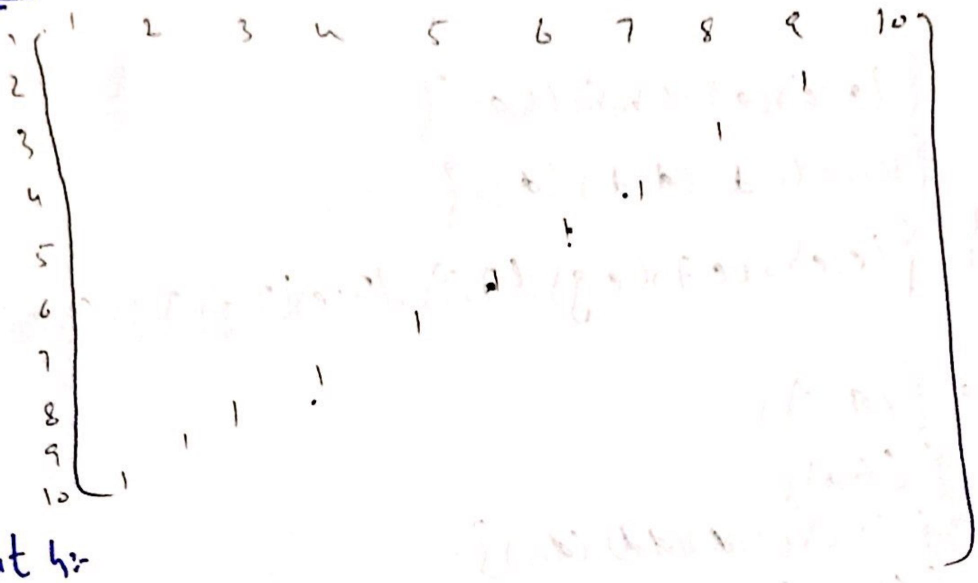
Part 1:-



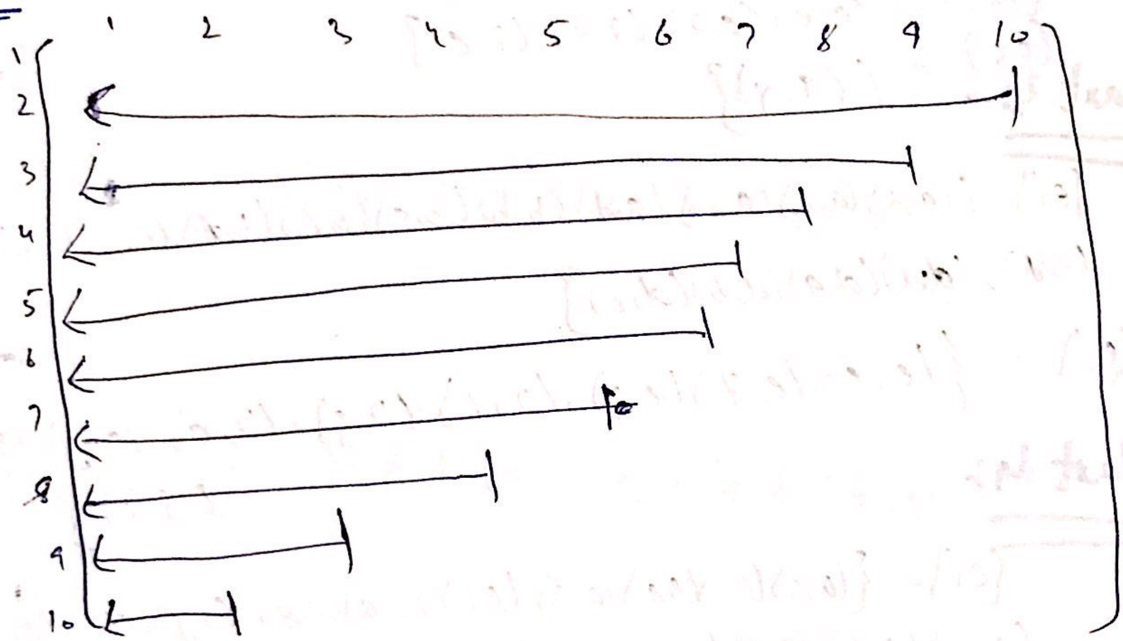
Part 2:-



Part 3:-



Part 4:-



Part 5:-

Q 7:-

Part 1:-

$[e_1] = \{(a,a)(a,b)(b,b)(b,a)\}$

$[e_2] = \{(c,c)(c,d)(d,d)(d,c)\}$

$[e_3] = \{(e,e),(e,f)(e,g),(f,f),(f,e)(f,g)(g,g)(g,e)(g,f)\}$

Part 2:-

$[e_1] = \{(a,a)\}$

$[e_2] = \{(b,b)\}$

$[e_3] = \{(c,c)(c,d)(d,d)(d,c)\}$

$[e_4] = \{(e,e)(e,f)(f,f)(f,e)\}$

$[e_5] = \{(g,g)\}$

Part 3:-

$[e_1] = \{(a,a)(a,b)(a,c)(a,d)(b,b)(b,a)(b,c)(b,d)(c,a)(c,b)(c,c)$
$(c,d),(d,d)(d,a)(d,b)(d,c)\}$

$(e_2) = \{(e,e),(e,f)(e,g),(f,f)(f,g),(f,e),(g,g)(g,e)$
$(g,f)\}$

Part 4:-

$[e_1] = \{(a,a)(a,c)(a,e)(a,g)(c,c)(c,a)(c,e)(c,g)(e,e)(e,a)$
$(e,c)(e,g)(g,g)(g,c)(g,e)\}$

$[e_2] = \{(b,b)(b,d)(d,d)(d,b)\}$

$[e_3] = \{(f,f)\}$

Part 5:-

$[e_1] = \{(a,a)\}$

$[e_2] = \{(b,b)\}$

$[e_3] = \{(c,c)(c,d)(c,e)(c,f)(c,g)(d,d),(d,c)(d,e)$
$(d,f)(d,g)(e,e)(e,c)(e,d)(e,f)(e,g)(f,f)(f,c)(f,d)(f,e)$
$(f,g),(g,g)(g,c)(g,d)(g,e)(g,f)$

CQ 8:-

Part 1:-

R = {(a,a)(b,b)(c,c)(d,d)(e,e)(a,e)(a,b)(a,c)(a,d)(e,b)(e,c)(e,d)}

Part 2:-

R = {(a,a)(b,b)(c,c)(d,d)(e,e)(a,c)(b,c)(a,d)(e,e)(b,d)(b,e)
(c,d)(c,e)}

Part 3:-

R = {(a,a)(b,b)(c,c)(d,d)(a,c)(b,c)(a,d)(b,d)(c,d)}

Part 4:-

R = {(a,a)(b,b)(c,c)(d,d)(a,b)(a,c)(a,d)(b,d)(c,d)}

Part 5:-

R = {(a,a),(b,b)(c,c)(d,d)(a,b)(a,c)(a,d)(b,c)(b,d)}