

1. a)

$$T_S(\emptyset) \uparrow 0 = \{R\}$$

$$T_S(\emptyset) \uparrow 1 = \{R, Q_1\}$$

$$T_S(\emptyset) \uparrow 2 = \{R, Q_1, P_1\}$$

$$T_S(\emptyset) \uparrow 3 = \{R, Q_1, P_1, S_1\}$$

$$T_S(\emptyset) \uparrow 4 = \{R, Q_1, P_1, S_1\}$$

Siis $M_S = \{R, Q_1, P_1, S_1\}$.

b)

R	$[R]$
Q_1	$[Q_1 \leftarrow R]$
P_1	$[P_1 \leftarrow Q_1]$
S_1	$[S_1 \leftarrow P_1 \wedge Q_1]$

c)

$$T_S(\emptyset) \uparrow 0 = \{Q(a)\}$$

$$T_S(\emptyset) \uparrow 1 = \{Q(g^i(a))\}_{i=0}^1$$

$$T_S(\emptyset) \uparrow 2 = \{Q(g^i(a))\}_{i=0}^2$$

$$\vdots$$

$$T_S(\emptyset) \uparrow n = \{Q(g^i(a))\}_{i=0}^n$$

$$\vdots$$

$$T_S(\emptyset) \uparrow \omega = \{Q(g^i(a))\}_{i=0}^\infty$$

2. a) Klausuulijoukon S Herbrand-instantiaatio S_H on:

$$\begin{aligned} & \{ d(1) \leftarrow a(1), b(1); d(2) \leftarrow a(2), b(2); \\ & d(3) \leftarrow a(3), b(3); d(4) \leftarrow a(4), b(4); \\ & e(1, 1) \leftarrow d(1), d(1); e(1, 2) \leftarrow d(1), d(2); \\ & e(1, 3) \leftarrow d(1), d(3); e(1, 4) \leftarrow d(1), d(4); \\ & e(2, 1) \leftarrow d(2), d(1); e(2, 2) \leftarrow d(2), d(2); \\ & e(2, 3) \leftarrow d(2), d(3); e(2, 4) \leftarrow d(2), d(4); \\ & e(3, 1) \leftarrow d(3), d(1); e(3, 2) \leftarrow d(3), d(2); \\ & e(3, 3) \leftarrow d(3), d(3); e(3, 4) \leftarrow d(3), d(4); \\ & e(4, 1) \leftarrow d(4), d(1); e(4, 2) \leftarrow d(4), d(2); \\ & e(4, 3) \leftarrow d(4), d(3); e(4, 4) \leftarrow d(4), d(4); \\ & a(1); a(2); b(2); b(3); c(4) \} \end{aligned}$$

b) Ja sen minimimalli:

$$\begin{aligned} T_{S_H}(\emptyset) \uparrow 0 &= \{a(1), a(2), b(2), b(3), c(4)\} \\ T_{S_H}(\emptyset) \uparrow 1 &= \{d(2), a(1), a(2), b(2), b(3), c(4)\} \\ T_{S_H}(\emptyset) \uparrow 3 &= \{e(2, 2), d(2), a(1), a(2), b(2), b(3), c(4)\} \end{aligned}$$

c) Pienin instantiaatio G saadaan S_H :sta jättämällä pois kaikki säännöt, joiden vartalossa esiintyy totutumattomia atomeita:

$$\begin{aligned} G = \{ & d(2) \leftarrow a(2), b(2), e(2, 2) \leftarrow d(2), d(2); \\ & a(1); a(2); b(2); b(3); c(4) \} \end{aligned}$$