2) $p, q$ canonical

$$\dot{p} = -\frac{\partial H}{\partial q} \qquad \dot{q} = \frac{\partial H}{\partial p}$$

$$[Q_i, Q_j]_{p,q} = [P_i, P_j]_{p,q} = 0$$

$$[Q_i, P_j]_{q,p} = \delta_{ij}$$

show that $\dfrac{dQ}{dt} = \dfrac{\partial H}{\partial P} \qquad \dfrac{dP}{dt} = -\dfrac{\partial H}{\partial Q}$

$$\frac{dQ_i}{dt} = \frac{\partial Q_i}{\partial q_j}\frac{dq_j}{dt} + \frac{\partial Q_i}{\partial p_j}\frac{dp_j}{dt}$$

$$= \frac{\partial Q_i}{\partial q_j}\frac{\partial H}{\partial p_j} - \frac{\partial Q_i}{\partial p_j}\frac{\partial H}{\partial q_j}$$

$$= \frac{\partial Q_i}{\partial q_j}\left(\frac{\partial H}{\partial P_e}\frac{\partial P_e}{\partial p_j} + \frac{\partial H}{\partial Q_e}\frac{\partial Q_e}{\partial p_j}\right)$$

$$- \frac{\partial Q_i}{\partial p_j}\left(\frac{\partial H}{\partial P_e}\frac{\partial P_e}{\partial q_j} + \frac{\partial H}{\partial Q_e}\frac{\partial Q_e}{\partial q_j}\right)$$

$$= \frac{\partial H}{\partial P_e}[P_e, Q_i] + \frac{\partial H}{\partial Q_e}[Q_e, Q_i]$$

$$= \frac{\partial H}{\partial P_e}$$

$$\frac{dP_i}{dt} = \frac{\partial P_i}{\partial q_j}\frac{dq_j}{dt} + \frac{\partial P_i}{\partial p_j}\frac{\partial p_j}{\partial t}$$

$$= \frac{\partial P_i}{\partial q_j}\frac{\partial H}{\partial p_j} + \frac{\partial P_i}{\partial p_j}(-)\frac{\partial H}{\partial q_j}$$

$$= \frac{\partial P_i}{\partial q_j}\left(\frac{\partial H}{\partial Q_e}\frac{\partial Q_e}{\partial p_j} + \frac{\partial H}{\partial P_e}\frac{\partial P_e}{\partial p_j}\right) - \frac{\partial P_i}{\partial p_j}\left(\frac{\partial H}{\partial Q_e}\frac{\partial Q_e}{\partial q_j} + \frac{\partial H}{\partial P_e}\frac{\partial P_e}{\partial q_j}\right)$$

$$= \frac{\partial H}{\partial Q_e}[Q_e, P_i] = -\frac{\partial H}{\partial Q_i}$$