1) (a) $Q_\Omega(s,w) = \sum_a \pi_{w,\theta}(a|s) \, Q_U(s,w,a)$

$Q_U(s,w,a) = r(s,a) + \gamma \sum_{s'} P(s'|s,a) \, U(w,s')$

$$\frac{\partial Q_\Omega(s,w)}{\partial \theta} = \sum_a \frac{\partial}{\partial \theta} \left[\pi_{w,\theta}(a|s) \, Q_U(s,w,a) \right]$$

$$= \sum_a \pi_{w,\theta}(a|s) \frac{\partial}{\partial \theta} Q_U(s,w,a)$$
$$+ Q_U(s,w,a) \frac{\partial}{\partial \theta} \pi_{w,\theta}(a|s)$$

$$\frac{\partial}{\partial \theta} Q_U(s,w,a) = \frac{\partial}{\partial \theta} \left[r(s,a) + \gamma \sum_{s'} P(s'|s,a) \, U(w,s') \right]$$

$$= 0 + \gamma \sum_{s'} P(s'|s,a) \frac{\partial U(w,s')}{\partial \theta}$$

$$= \gamma \sum_{s'} P(s'|s,a) \frac{\partial U(w,s')}{\partial \theta}$$

$$\therefore \frac{\partial Q_\Omega(s,w)}{\partial \theta} = \sum_a \left[\pi_{w,\theta}(a|s) \cdot \gamma \sum_{s'} P(s'|s,a) \frac{\partial U(w,s')}{\partial \theta} \right.$$
$$\left. + Q_U(s,w,a) \frac{\partial}{\partial \theta} \pi_{w,\theta}(a|s) \right]$$

(b)
$$\frac{\partial U(w,s')}{\partial \theta} = \frac{\partial}{\partial \theta} \left[(1 - \beta_{w,v}(s')) \, Q_\Omega(s',w) \right.$$
$$\left. + \beta_{w,v}(s') \, V_\Omega(s') \right]$$

$$= \frac{\partial}{\partial \theta} \left[Q_\Omega(s', \omega) - \beta_{\omega, \nu}(s') Q_\Omega(s', \omega) \right.$$
$$\left. + \beta_{\omega, \nu}(s') V_\Omega(s') \right]$$

$$= \frac{\partial}{\partial \theta} Q_\Omega(s', \omega) - \beta_{\omega, \nu}(s') \frac{\partial}{\partial \theta} Q_\Omega(s', \omega) + \beta_{\omega, \nu}(s') \frac{\partial V_\Omega(s')}{\partial \theta}$$

2) (c)