

$$\begin{aligned}(2) \quad (fg)^{(3)} &= \{(fg)''\}' \\ &= (f''g + 2f'g' + fg'')' \\ &= f^{(3)}g + f''g' + 2f''g' + 2f'g'' + f'g'' + fg^{(3)} \\ &= f^{(3)}g + 3f''g' + 3f'g'' + fg^{(3)}\end{aligned}$$