11. (a) Since $m_l = 0$, $L_{\text{orb},z} = m_l h/2\pi = 0$.

(b) Since $m_l = 0$, $\mu_{\text{orb},z} = -m_l \mu_B = 0$.

(c) Since $m_l = 0$, then from Eq. 32-12, $U = -\mu_{\text{orb},z} B_{\text{ext}} = -m_l \mu_B B_{\text{ext}} = 0$.

(d) Regardless of the value of m_l, we find for the spin part

$$U = -\mu_{s,z} B = \pm \mu_B B = \pm \left(9.27 \times 10^{-24}\,\text{J/T}\right)(35\,\text{mT}) = \pm 3.2 \times 10^{-25}\ \text{J} .$$

(e) Now $m_l = -3$, so

$$L_{\text{orb},z} = \frac{m_l h}{2\pi} = \frac{(-3)\left(6.63 \times 10^{-27}\,\text{J}\cdot\text{s}\right)}{2\pi} = -3.16 \times 10^{-34}\ \text{J}\cdot\text{s}$$

and

$$\mu_{\text{orb},z} = -m_l \mu_B = -(-3)\left(9.27 \times 10^{-24}\,\text{J/T}\right) = 2.78 \times 10^{-23}\ \text{J/T} .$$

The potential energy associated with the electron's orbital magnetic moment is now

$$U = -\mu_{\text{orb},z} B_{\text{ext}} = -(2.78 \times 10^{-23}\,\text{J/T})(35 \times 10^{-3}\,\text{T}) = -9.73 \times 10^{-25}\ \text{J} ;$$

while the potential energy associated with the electron spin, being independent of m_l, remains the same: $\pm 3.2 \times 10^{-25}$ J.