5. For $\theta = 90^0$, Eq. (21) gives

$\bar{\lambda} = \lambda + h/m_e c = 5.00 \times 10^{-11}$ m + 2.4×10^{-12} m

$= \boxed{5.24 \times 10^{-11} \text{ m}}$

The energy lost by the photon is

$$\frac{hc}{\lambda} - \frac{hc}{\bar{\lambda}} = 6.63 \times 10^{-34} \text{ J·s} \times 3 \times 10^8 \text{ m/s} \left(\frac{1}{5.00} - \frac{1}{5.24} \right) \times 10^{11}/\text{m}$$

$$= 1.8 \times 10^{-16} \text{ J} = \boxed{1.1 \text{ keV}}$$

The energy gained by the electron is the same.

8. The formula for Compton scattering by a proton is the same as that for an electron, but the electron mass must be replaced by the proton mass. Accordingly, the final energy of the photon is

$$\frac{hc}{\bar{\lambda}} = \frac{hc}{\lambda + (1 - \cos\theta)h/m_p c} = \frac{1}{1/E_1 + (1 - \cos\theta)/m_p c^2}$$

$$= \frac{1}{1/20 \text{ MeV} + (1 - \cos 30^0)/938 \text{ MeV}} = \boxed{19.9 \text{ MeV}}$$

26. Obviously, each boson will have an energy of 270 GeV. Hence the kinetic energy of each is 270 GeV - 80 GeV = $\boxed{190 \text{ GeV}}$

The momentum is $p = \sqrt{E^2/c^2 - m^2c^2} = \sqrt{270^2 - 80^2}$ GeV/c = 258 GeV/c

and the speed is $v = c^2\, p/E = 258/270\ c = \boxed{0.96\ c}$

27. According to Eq. (38), the threshold energy is

$$E_1 = \frac{1}{2 \times 0.938 \text{ GeV}} [(80 \text{ GeV} + 80 \text{ GeV})^2 - 0.938^2 \text{ GeV}^2 - 0.938^2 \text{ GeV}^2]$$

$$= \boxed{14 \text{ TeV}}$$