$\boxed{8.2}$ The efficiency of the stop-and-wait ARQ is calculated according to the formula:

$$\eta = \frac{k}{n} \cdot \frac{P_a}{1+\frac{t_i r_c}{n}}$$

Here we have the block length $n = \frac{200}{K} + 16$ since in every block we have $\frac{200}{K}$ information bits and 16 bits introduced by the error-detecting code. Obviously $k = \frac{200}{K}$. The probability of acceptance P_a can be approximated by the probability for correctly received codeword $P_c = (1-p)^n = 0{,}98^n$. For the idle time t_i we have $t_i r_c = 20$ bits, where r_c is the transmission rate in bits/s. Finally the efficiency η as a function of K is

$$\eta = \frac{\frac{200}{K}}{\frac{200}{K}+16} \cdot \frac{0{,}98^{\frac{200}{K}+16}}{1+\frac{20}{\frac{200}{K}+16}} = \frac{50 \cdot 0{,}98^{\frac{200}{K}+16}}{50+9K}$$

Checking the values of η for small integer K's we have:

$K = 5 \quad : \eta \approx 0{,}1698$

$K = 6 \quad : \eta \approx 0{,}1775$

$K = 7 \quad : \eta \approx 0{,}1798$

$K = 8 \quad : \eta \approx 0{,}179$

This gives the maximum of η for $K = 7$.

8.7 For the ARQ scheme we have:

The coded BER: $P_b = \frac{1}{2(1+\gamma_0)} = \frac{1}{2\left(1+\frac{45}{56}10^{2,3}\right)} \approx 3,1.10^{-3}$

Probability of acceptance: $P_a \approx P_c = (1-P_b)^{56} \approx 0,84$

Efficiency: $\eta = \frac{k}{n} \cdot \frac{P_a}{1+\frac{t_i r_c}{n}} \approx 0,49737$

The message error probability (FER): $P_u \approx 1 - \sum_{i=0}^{4}\binom{n}{i}p^i(1-p)^{n-i} =$

$$= 1 - \sum_{i=0}^{4}\binom{56}{i}P_b^i(1-P_b)^{56-i} \approx 9,6.10^{-7}$$

according to eq. (8.12)

For the FEC system we have:

Efficiency: $\eta = \frac{k}{n} = \frac{15}{35} = \frac{3}{7} \approx 0,43$

The coded BER: $P_b = \frac{1}{2(1+\gamma_0)} = \frac{1}{2\left(1+\frac{3}{7}10^{2,3}\right)} \approx 5,8.10^{-3}$

The codeword error rate P_c:

$$P_c = \Pr\{wt(e) \geq 5\} = 1 - \sum_{i=0}^{4}\binom{35}{i}P_b^i(1-P_b)^{35-i} \approx 1,8.10^{-6}$$

Since a message consists of 3 codewords $\left(\frac{45}{15}=3\right)$ we have the message error probability

$$P_{Block} = 1-(1-P_c)^3 \approx 5,4.10^{-6}$$

$\boxed{8.5}$ The BER for DPSK in Rayleigh fading is

$$P_b = \frac{1}{2(1+\bar{\gamma}_b)} = \frac{1}{2(1+100)} = \frac{1}{202} \approx 5 \cdot 10^{-3}$$

The probability for being in "bad" state is $\frac{q_1}{q_1+q_2}$, where (eq. 6.1

$$P_b = \frac{q_1}{q_1+q_2} \cdot p_b + \frac{q_2}{q_1+q_2} \cdot p_g = \frac{q_1}{q_1+q_2} \cdot 0{,}05 \Rightarrow \frac{q_1}{q_1+q_2} = 10^{-1}.$$

a) The probability of acceptance is:

$$P_a \approx P_c = \text{Prob}\{\text{"bad state"}\} \cdot (1-p_b)^{100} + \text{Prob}\{\text{"good state"}\} (1-p_g)^{100} =$$
$$= 0{,}1 \, (1-0{,}05)^{100} + 0{,}9 \cdot 1 \approx 0{,}9$$

The efficiency for the selective-repeat scheme is

$$\eta = \frac{k}{n} \cdot P_a \approx \frac{100-16}{100} \cdot 0{,}9 = 0{,}756$$

b) The probability of acceptance in this case is

$$P_a \approx P_c = (1-P_b)^{100} \approx 0{,}6058$$

The efficiency is:

$$\eta = \frac{k}{n} \cdot P_a \approx 0{,}51$$

$\boxed{8.6}$ The BER for the Rayleigh channel is (see (6.16)):

$$p = \frac{g_1}{g_1+g_2} p_b + \frac{g_2}{g_1+g_2} \cdot p_g = \frac{10^{-3}}{10^{-3}+10^{-2}} \cdot 0{,}5 \approx 0{,}04545$$

a) If interleaving is used we can assume uncorrelated errors with probability $p \approx 0{,}04545$. We have

$$P_a \approx P_c = (1-p)^n = (1-p)^{k+20}$$

The efficiency η as a function of k is:

$$\eta = \frac{k}{n} \cdot P_a \approx \frac{k}{k+20} \cdot (1-p)^{k+20} = \frac{k}{k+20} \, 0{,}95455^{k+20}$$

The maximum of η is achieved for $k = 13$ and $\eta_{max} \approx 0{,}0849$
This give information data rate $\eta_{max} \cdot r = 0{,}0849 \cdot 10^5 \approx 8{,}5 \cdot 10^3$ bits/s

b) The probability of acceptance without using interleaving is
(see Example 8.2 on page 606)

$$P_a \approx \frac{\bar{\tau}_g}{\bar{\tau}_g + \bar{\tau}_b} \left(1 - \frac{n}{\bar{\tau}_g}\right) = \frac{q_2}{q_1+q_2} \left(1 - q_1(k+20)\right) =$$

$$= \frac{10}{11} \cdot \left(1 - \frac{k+20}{10^3}\right) = \frac{980-k}{11 \cdot 10^2}$$

The efficiency is

$$\eta = \frac{k}{n} P_a \approx \frac{k}{k+20} \cdot \frac{980-k}{11 \cdot 10^2} = \frac{(980-k)\,k}{1100\,(k+20)}$$

The maximum is achieved for $k = 122$ and $\eta_{max} \approx 0{,}67$
If we use the exact expression for the approximation of P_a from example 8.2 we get

$$\eta = \frac{k}{k+20} \cdot \frac{10}{11} \cdot \left(1 - \frac{1}{\bar{\tau}_g}\right)^{k+20} = \frac{10\,k}{11(k+20)} \cdot 0{,}999^{k+20}$$

and the maximum is achieved for $k = 132$ and $\eta_{max} \approx 0{,}678$