EQUILIBRIUM CONSTANTS AND LE CHATELIER'S PRINCIPLE

1. The only thing that will change an equilibrium ***constant*** is a change of temperature - either a decrease or an increase.

   Learn that! You can then ignore any other statement in a list like the one in this question. This is quite common in multiple choice questions. If the question is asking about a change in an equilibrium constant, just look for the answer which talks about temperature - you don't even need to read the rest.

2. a)
$$K_c = \frac{[SO_3]^2}{[SO_2]^2\,[O_2]}$$

   b) K_C has to stay constant unless you change the temperature. If you increase the concentration of the oxygen on the bottom of the expression, the other terms will have to change in order for K_C to stay the same. That would mean decreasing the SO_2 concentration and increasing the SO_3 concentration until the value of K_C returns to its original value.

   So increasing the concentration of oxygen causes more SO_2 to turn into SO_3.

Q3 on next page

3. a) The partial pressure of one of the gases in a mixture is the pressure which it would exert if it alone occupied the whole container.

b) The mole fraction is the fraction found by dividing the number of moles of the ammonia in the mixture by the total number of moles of gases present.

c) For each gas, the partial pressure, P_A, is given by the equation

$$P_A = x_A \times P$$

where P is the total pressure of the mixture, and x_A is the mole fraction of gas A.

Substituting these values gives:

$$K_P = \frac{P_{NH_3}^2}{P_{N_2} \times P_{H_2}^3}$$

$$K_P = \frac{(x_{NH_3} \times P)^2}{(x_{N_2} \times P) \times (x_{H_2} \times P)^3}$$

$$K_P = \frac{x_{NH_3}^2 \times P^2}{x_{N_2} \times x_{H_2}^3 \times P^4}$$

$$K_P = \frac{x_{NH_3}^2}{x_{N_2} \times x_{H_2}^3 \times P^2}$$

d) If you increase the pressure, the bottom of this expression will increase, changing the value of K_P - but that's not allowed if the temperature stays the same. To compensate for this, the mole fraction of the ammonia must increase, and the mole fractions of the nitrogen and hydrogen must decrease. That means that the percentage of ammonia in the equilibrium mixture increases.

e) The value of K_P decreases as you increase the temperature. If you look at the first line involving K_P in the answer above, that must mean that the amount of ammonia in the equilibrium mixture has fallen, and the amounts of nitrogen and hydrogen have increased. So the percentage of ammonia in the equilibrium mixture falls with increasing temperature.

The forward reaction producing ammonia is exothermic (the enthalpy change is negative). According to Le Chatelier, increasing the temperature favours the reaction which would tend to reduce it again, and that is the endothermic back reaction. So at a higher temperature there would be a smaller percentage conversion into ammonia - which is consistent with what we have just found from the K_P expression.