Chemguide – answers

THE CONTACT PROCESS

1. a) $$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$$

Or if you want to make life more difficult:

$$4FeS_{2(s)} + 11O_{2(g)} \longrightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$$

b) $$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad \Delta H = -196 \text{ kJ mol}^{-1}$$

(You don't need the ΔH bit. It was quicker for me to copy this off the Chemguide page than to rewrite it without it. You *do* need the equilibrium sign.)

c) You need two equations here:

$$H_2SO_{4(l)} + SO_{3(g)} \longrightarrow H_2S_2O_{7(l)}$$

$$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$$

2. a) 1 : 1

b) 400 - 450°C

c) 1 - 2 atmospheres

d) V_2O_5 (or vanadium(V) oxide)

3. a) the proportion of sulphur dioxide to oxygen in the reaction mixture:

Equilibrium: The oxygen in the air is cheap, while the sulphur dioxide is more expensive and also a pollutant. It is therefore important to convert as much of it as possible into sulphur trioxide. According to Le Chatelier, increasing the concentration of something on the left-hand side of the equilibrium will shift the equilibrium to the right. Therefore it makes sense to increase the amount of oxygen above equation proportions.

Rates: There aren't any important rate considerations here.

Economics: You can't increase the proportion of oxygen too much, because that would clutter up the reactor with molecules that have nothing to react with. You could end up with a better percentage conversion, but a smaller total amount of sulphur trioxide formed in a given time. The 1 : 1 ratio is the best compromise.

(Note: You could have included this under the *Equilibrium* part of the answer. As long as you have made the comment somewhere, that's fine. That is true of all of these answers. I have just split things up into separate sections to help you to make sure you have covered everything.)

b) the choice of temperature:

Equilibrium: The production of sulphur trioxide is exothermic. According to Le Chatelier, if you lower the temperature the system would react by countering this by favouring the exothermic change. That means that a low temperature would give a higher percentage conversion into sulphur trioxide.

Rates: At a low temperature, the formation of sulphur trioxide is very slow. Increasing the temperature increases the rate at which equilibrium is reached. However, a high temperature means a lowering of the percentage yield of sulphur trioxide.

Economics: There are no extra factors to consider here. The temperature is chosen as a compromise to give the best possible yield of sulphur trioxide reasonably quickly.

b) the choice of pressure:

Equilibrium: A high pressure favours the reaction which produces fewer molecules. Fewer molecules produce a lower pressure. This is consistent with Le Chatelier's Principle – countering the change you have made. So in this case, to get the maximum percentage conversion to sulphur trioxide you would choose a high pressure.

Rates: High pressures bring molecules closer together and so increase collision rates, increasing the rate of reaction.

Economics: In this case, the position of equilibrium is already strongly to the right, and the reaction fast enough, at pressures of about 1 - 2 atmospheres. It isn't worth spending extra money to generate and contain any higher pressures.

c) the use of the catalyst:

Equilibrium: Catalysts have no effect on equilibrium.

Rates: The reaction producing sulphur trioxide is very slow in the absence of a catalyst.

Economics: Catalysts aren't used up during a reaction. The costs involving the catalyst are therefore relatively low, and the reaction would be much too slow without one.