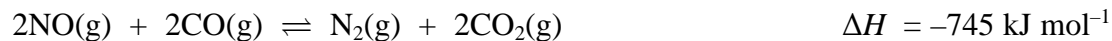


1 (a) In the catalytic converter of a car engine's exhaust system, the following reaction occurs.



The temperature in a catalytic converter is high.

- (i) State the effect, if any, on the position of equilibrium if the temperature is lowered. Give a reason for your answer.

(2)

Effect

Reason

- (ii) The gases from the engine are **not** cooled before entering the converter. Explain why this is so.

(2)

- (iii) State the effect, if any, on the position of equilibrium if the pressure on the reacting gases is increased. Give a reason for your answer.

(2)

Effect

Reason

(b) Nitrogen monoxide, NO, is formed when nitrate ions,  $\text{NO}_3^-$ , in acidic solution are reduced by silver metal.

(i) Calculate the oxidation number of nitrogen in NO and in  $\text{NO}_3^-$ .

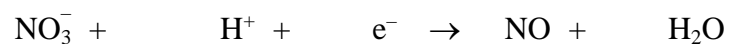
(2)

**In NO**

**In  $\text{NO}_3^-$**

(ii) Balance the half-equation for the reduction of nitrate ions,  $\text{NO}_3^-$ , in acidic solution.

(1)



(iii) Write the half-equation for the oxidation of silver metal, Ag, to silver ions,  $\text{Ag}^+$ .

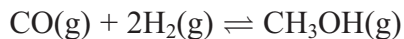
(1)

(iv) Hence deduce the full ionic equation for the reaction between silver metal and nitrate ions in acidic solution. State symbols are **not** required.

(2)

**(Total for Question = 12 marks)**

2 The exothermic reaction between carbon monoxide and hydrogen can be used industrially to make methanol. The process is carried out at 250 °C and between 50 and 100 atm.



(a) Explain why increasing the pressure increases the yield of methanol. Give **one** disadvantage of increasing the pressure.

(2)

.....

.....

.....

.....

(b) The reaction gives a greater equilibrium yield at 100 °C than at 250 °C.

(i) Explain, in terms of the entropy change of the surroundings and the total entropy change of the reaction, why this is so.

A calculation is **not** required.

(2)

.....

.....

.....

.....

(ii) Explain why the reaction is, nevertheless, carried out at 250 °C.

(1)

.....

.....

(c) Given that the reaction is an equilibrium, suggest **two** ways in which the atom economy of this process could be maximised without changing the temperature or pressure.

(2)

.....

.....

(Total for Question 7 marks)