Oxford Cambridge and RSA

AS Level Chemistry A

H032/01 Breadth in chemistry

Question Set 21

1. This question is about ammonia, NH_3.

(a) In industry, ammonia is made from nitrogen and hydrogen. This is a reversible reaction, as shown in **equilibrium 24.1** below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1} \qquad \textbf{Equilibrium 24.1}$$

(i) Explain how le Chatelier's principle can be used to predict the conditions of temperature and pressure for a maximum **equilibrium** yield of ammonia

(1) a) i) decreasing the temperature would increase the yield of ammonia because the forward reaction is exothermic, so the equilibrium would move to the right in order to increase the temperature, according to Le Chatelier's principle (oppose the change in conditions). **[4]**

increasing the pressure would increase the yield of ammonia because there are less moles of gas on the right (2 moles on the right vs 4 moles on the left) so the equilibrium would move to the right in order to decrease the ressure i.e. o ose the chan e in conditions.

(ii) Using certain conditions, **equilibrium 24.1** has the equilibrium concentrations in the table.

Substance	Equilibrium concentration /mol dm^{-3}
$N_2(g)$	1.25
$H_2(g)$	2.75
$NH_3(g)$	0.862

Calculate the numerical value for K_c for **equilibrium 24.1** under these conditions.

Give your answer to an appropriate number of significant figures and in standard form.

[2]

ii) $K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3} \longrightarrow \dfrac{(mol\,dm^{-3})^2}{(mol\,dm^{-3})(mol\,dm^{-3})^3}$ cancelling out top and bottom $\rightarrow \dfrac{1}{(mol\,dm^{-3})^2}$

$(mol\,dm^{-3})^{-2}$

$K_c = \dfrac{(0.862)^2}{(1.25)(2.75)^3} = 0.0285829 = 2.86 \times 10^{-2}\ mol^{-2}\,dm^6$

(b) Ammonia is used to make nitric acid. The first stage of the reaction is shown below.

$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g) \qquad \Delta H = -908\,kJ\,mol^{-1}$

Standard enthalpy changes of formation, $\Delta_f H^\ominus$, are given in the table.

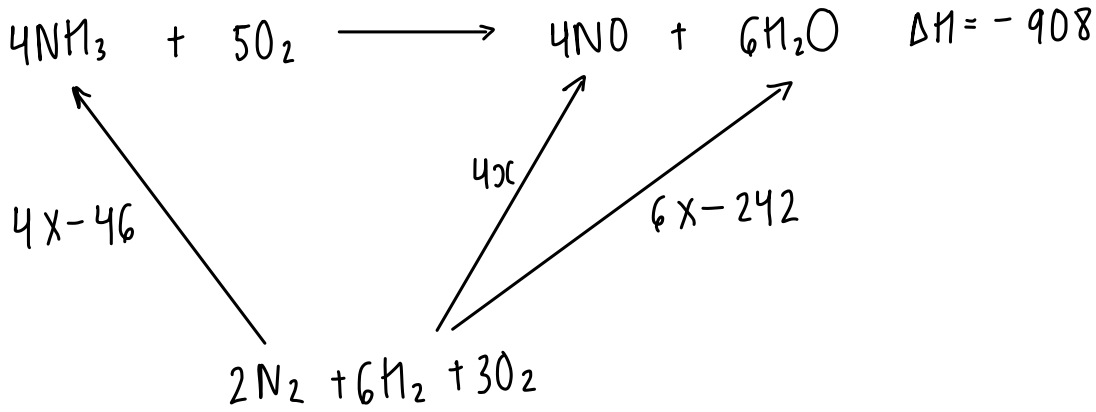
Substance	$\Delta_f H^\ominus$ / kJ mol^{-1}
$NH_3(g)$	−46
$O_2(g)$	0
$H_2O(g)$	−242

(i) State the conditions of temperature and pressure used for standard enthalpy measurements.

b) i) 298K and 1 atm pressure **[1]**

(ii) Calculate the standard enthalpy change of formation, in kJ mol^{-1}, for NO(g). Give your answer to a **whole number**. **[3]**

ii)



$-(4x - 46) + 4x + (6x - 242) = -908$

$4x = 360 \Rightarrow x = +90\ kJ\,mol^{-1}$

Total Marks for Question Set 21: 10

(1) a) i) decreasing the temperature would increase the yield of ammonia because the forward reaction is exothermic, so the equilibrium would move to the right in order to increase the temperature, according to Le Chatelier's principle (oppose the change in conditions).

increasing the pressure would increase the yield of ammonia because there are less moles of gas on the right (2 moles on the right vs 4 moles on the left) so the equilibrium would move to the right in order to decrease the pressure i.e. oppose the change in conditions.

ii) $K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3} \longrightarrow \dfrac{(\text{mol dm}^{-3})^2}{(\text{mol dm}^{-3})(\text{mol dm}^{-3})^3} \xrightarrow{\text{cancelling out top and bottom}} \dfrac{1}{(\text{mol dm}^{-3})^2}$

$(\text{mol dm}^{-3})^{-2}$

$K_c = \dfrac{(0.862)^2}{(1.25)(2.75)^3} = 0.0285829$

$= 2.86 \times 10^{-2}\ \text{mol}^{-2}\,\text{dm}^6$

ii)

$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O \quad \Delta H = -908$

$4x$

$4X - 46$

$6X - 242$

$2N_2 + 6H_2 + 3O_2$

$-(4X - 46) + 4x + (6X - 242) = -908$

$4x = 360 \Rightarrow$ **$x = +90\ \text{kJ mol}^{-1}$**