

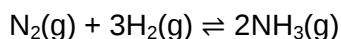
Name of the Student: _____

Max. Marks : 27 Marks

Time : 27 Minutes

Q1.

Nitrogen and hydrogen were mixed in a 1:3 mole ratio and left to reach equilibrium in a flask at a temperature of 550 K. The equation for the reaction between nitrogen and hydrogen is shown.



- (a) When equilibrium was reached, the total pressure in the flask was 150 kPa and the mole fraction of $\text{NH}_3(\text{g})$ in the mixture was 0.80

Calculate the partial pressure of each gas in this equilibrium mixture.

Partial pressure of nitrogen _____ kPa

Partial pressure of hydrogen _____ kPa

Partial pressure of ammonia _____ kPa

(3)

- (b) Give an expression for the equilibrium constant (K_p) for this reaction.

K_p

(1)

- (c) In a different equilibrium mixture, under different conditions, the partial pressures of the gases are shown in the table.

Gas	Partial pressure / kPa
N_2	1.20×10^2

H ₂	1.50×10^2
NH ₃	1.10×10^3

Calculate the value of the equilibrium constant (K_p) for this reaction and give its units.

K_p _____ Units _____

(2)

- (d) The enthalpy change for the reaction is -92 kJ mol^{-1}

State the effect, if any, of an increase in temperature on the value of K_p for this reaction.
Justify your answer.

Effect on K_p _____

Justification _____

(3)

(Total 9 marks)

Q2.

Which statement about K_p is correct for this reaction in the gas phase?



- A** The value of K_p is independent of pressure. ☐
- B** The value of K_p increases as pressure increases. ☐
- C** The value of K_p increases as temperature increases. ☐
- D** The value of K_p is independent of temperature. ☐

(Total 1 mark)

Q3.

An equilibrium mixture is prepared in a container of fixed volume.



The temperature of this mixture is decreased and the mixture is allowed to reach a new equilibrium.

Which is greater for the new equilibrium than for the original equilibrium?

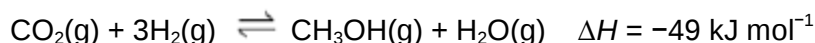
- | | | |
|----------|--|-----------------------|
| A | The mole fraction of carbon monoxide | ☐ |
| B | The partial pressure of chlorine | ☐ |
| C | The total pressure of the mixture | ☐ |
| D | The value of the equilibrium constant, K_p | ☐ |

(Total 1 mark)

Q4.

Many chemical processes release waste products into the atmosphere. Scientists are developing new solid catalysts to convert more efficiently these emissions into useful products, such as fuels. One example is a catalyst to convert these emissions into methanol. The catalyst is thought to work by breaking a H–H bond.

An equation for this formation of methanol is given below.



Some mean bond enthalpies are shown in the following table.

Bond	C=O	C–H	C–O	O–H
Mean bond enthalpy / kJ mol^{-1}	743	412	360	463

- (a) Use the enthalpy change for the reaction and data from the table to calculate a value for the H–H bond enthalpy.

H–H bond enthalpy = _____ kJ mol^{-1}

(3)

- (b) A data book value for the H–H bond enthalpy is 436 kJ mol^{-1} .

Suggest **one** reason why this value is different from your answer to part (a).

(1)

- (c) Suggest **one** environmental advantage of manufacturing methanol fuel by this reaction.

(1)

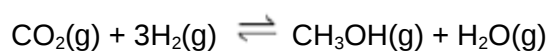
- (d) Use Le Chatelier's principle to justify why the reaction is carried out at a high pressure rather than at atmospheric pressure.

(3)

- (e) Suggest why the catalyst used in this process may become less efficient if the carbon dioxide and hydrogen contain impurities.

(1)

- (f) In a laboratory experiment to investigate the reaction shown in the equation below, 1.0 mol of carbon dioxide and 3.0 mol of hydrogen were sealed into a container. After the mixture had reached equilibrium, at a pressure of 500 kPa, the yield of methanol was 0.86 mol.



Calculate a value for K_p

Give your answer to the appropriate number of significant figures.

Give units with your answer.

$K_p =$ _____ Units = _____

(7)

(Total 16 marks)