Question - 01

Nitrogen dioxide decomposes at a high temperature.

$$2\ NO_2(g) \rightleftharpoons 2\ NO(g) + O_2(g) \qquad \Delta H = +113\ kJ\ mol^{-1}$$

(a) A 0.317 mol sample of nitrogen dioxide is placed in a sealed flask and heated at a constant temperature until equilibrium is reached.

At equilibrium, the flask contains 0.120 mol of oxygen.

Calculate the mole fraction of each substance at equilibrium.

Mole fraction of NO_2 _____

Mole fraction of NO _____

Mole fraction of O_2 _____

(3)

(b) The total pressure in the flask in part (a) is 120 kPa at equilibrium.

Calculate the partial pressure, in kPa, of NO_2

If you were unable to answer part (a) you should assume that the mole fraction of NO_2 is 0.380. This is **not** the correct answer.

Partial pressure _____ kPa

(1)

(c) The table below shows the mole fractions of the three gases in a different equilibrium mixture.

$$2\ NO_2(g) \rightleftharpoons 2\ NO(g) + O_2(g) \qquad \Delta H = +113\ kJ\ mol^{-1}$$

Gas	Mole fraction
NO_2	0.310
NO	0.460
O_2	0.230

For this equilibrium mixture, $K_p = 59.7$ kPa

Give an expression for K_p for this reaction.

Use your expression and the data in the table to calculate the total pressure, in kPa, in the flask.

K_p

Total pressure _____ kPa

(3)

(d) The equilibrium mixture in part (c) is compressed into a smaller volume.

Deduce the effect, if any, of this change on the equilibrium yield of oxygen and on the value of K_p

Effect on yield of oxygen _____

Effect on K_p _____

(2)

(e) The equilibrium mixture in part (c) is allowed to reach equilibrium at a lower temperature.

Explain why the equilibrium yield of oxygen decreases.

_____

_____

_____

_____

(2)

(a) M1 0.176

M2 0.549

M3 0.275

Allow answers to 2 significant figures

3

(b) 21.1 (kPa)

*Allow answer to question **(a)** x 120 and answer in kPa*

Allow 21.6 (kPa)

Answer using given value of 0.380 mol = 45.6(kPa)

1

(c) M1 $K_p = \frac{p(NO)^2 p(O_2)}{p(NO_2)^2}$

M2 $= \frac{K_p \times \text{mol frac } (NO_2)^2}{\text{mol frac } (NO)^2 \times \text{mol frac } (O_2)}$ OR $\frac{59.7 \times (0.31)^2}{(0.46)^2 \times (0.23)}$

M3 = 117.9 (kPa) or 118 (kPa)

*Do **not** allow square brackets*

Rearrangement

3

(d) Decrease

No change

2

(e) M1 Reaction is endothermic OR exothermic in backwards direction

M2 Equilibrium shifts/moves in backwards direction/to the left to raise the temp/oppose the decrease in temp

2