

Equilibrium (Quantitative)

A Level only

Question Paper 1

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Equilibrium (Quantitative)
Paper	A Level only
Booklet	Question Paper 1

Time allowed: 42 minutes

Score: /31

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

Question 1

A mixture of N_2 and O_2 gases has a total pressure of 1.42 atm.
The mole fraction of N_2 is 0.700.

What is the partial pressure, in atm, of O_2 in the mixture?

A 0.211

B 0.426

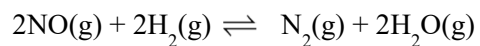
C 0.493

D 0.994

[1]

Question 2

NO(g), H₂(g), N₂(g) and H₂O(g) exist in equilibrium:



At room temperature and pressure, the equilibrium lies well to the right-hand side.

Which of the following could be the equilibrium constant for this equilibrium?

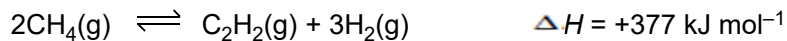
- A $1.54 \times 10^{-3} \text{ mol dm}^{-3}$
- B $6.50 \times 10^2 \text{ mol dm}^{-3}$ $1.54 \times$
- C $10^{-3} \text{ dm}^3 \text{ mol}^{-1}$
- D $6.50 \times 10^2 \text{ dm}^3 \text{ mol}^{-1}$

[1]

Question 3

Ethyne gas, C_2H_2 , is manufactured in large quantities for a variety of uses.

Much of this ethyne is manufactured from methane as shown in the equation below.



- (a) Write an expression for K_c for this equilibrium. [1]
- (b) A research chemist investigates how to improve the synthesis of ethyne from methane at a high temperature.
- The chemist adds CH_4 to a 4.00 dm^3 container.
 - The chemist heats the container and allows equilibrium to be reached at constant temperature. The total gas volume does not change.
 - The equilibrium mixture contains $9.36 \times 10^{-2} \text{ mol } CH_4$ and $0.168 \text{ mol } C_2H_2$.
- (i) Calculate the amount, in mol, of H_2 in the equilibrium mixture. [1]
- (ii) Calculate the equilibrium constant, K_c , at this temperature, including units. [3]
Give your answer to **three** significant figures.
- (iii) Calculate the amount, in mol, of CH_4 that the chemist originally added to the container. [1]

(c) The chemist repeats the experiment three times.

In each experiment the chemist makes **one** change but uses the **same** initial amount of CH_4 .

Complete the table to show the predicted effect of each change compared with the original experiment.

Only use the words **greater**, **smaller** or **same**.

Change	K_c	Equilibrium amount of $\text{C}_2\text{H}_2(\text{g})$ / mol	Initial rate
The container is heated at constant pressure			
A smaller container is used			
A catalyst is added to CH_4 at the start			

[3]

(d) In this manufacture of ethyne, hydrogen is also produced. To improve the atom economy of the process, it is important to make use of the hydrogen. For example, hydrogen can be used in the extraction of some metals from their ores.

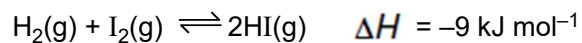
State **two** other large-scale uses of the hydrogen.

[1]

[Total: 10 Marks]

Question 4

Hydrogen and iodine react together in a reversible reaction:



A chemist mixes together 2.00×10^{-3} mol $\text{H}_2(\text{g})$ and 4.00×10^{-3} mol $\text{I}_2(\text{g})$ in a 1.00 dm^3 container. The chemist seals the container.

The mixture is heated and left to reach equilibrium.

At equilibrium, the mixture contains 3.00×10^{-4} mol of H_2 .

(a) Calculate the equilibrium constant, K_c , including units, if any, for this equilibrium.

Give your answer to **three** significant figures.

[5]

(b) The chemist repeats the experiment several times. In each experiment, the chemist makes one change.

(i) The chemist uses 3.00×10^{-3} mol $\text{H}_2(\text{g})$ instead of 2.00×10^{-3} mol $\text{H}_2(\text{g})$.

Predict whether the amounts of $\text{H}_2(\text{g})$, $\text{I}_2(\text{g})$ and $\text{HI}(\text{g})$ in the equilibrium mixture would be greater, smaller or the same as in the original experiment.

Answer by placing ticks in the appropriate boxes of the table below.

	$\text{H}_2(\text{g})$	$\text{I}_2(\text{g})$	$\text{HI}(\text{g})$
Greater			
Smaller			
The same			

[2]

(ii) The chemist heats the mixture to a higher temperature at constant pressure.

Explain whether the value of K_c would be greater, smaller or the same.

[1]

(iii) The chemist increases the pressure of the mixture at constant temperature.

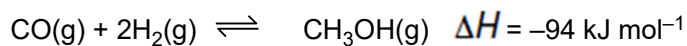
Explain whether the value of K_c would be greater, smaller or the same.

[1]

[Total 9 Marks]

Question 5

Methanol can be prepared industrially by reacting together carbon monoxide and hydrogen. This is a reversible reaction:



- A chemist mixes together 0.114 mol CO(g) and 0.152 mol H₂(g) in a container.
- The container is pressurised and then sealed. The total volume is 200 cm³.
- The mixture is heated to 500 K and left to reach equilibrium. The volume of the sealed container is kept at 200 cm³.
- The chemist analyses the equilibrium mixture and finds that 0.052 mol CH₃OH has formed.

(a) Calculate the value of K_c , including units, for the equilibrium at 500 K.

Give your answer to **three** significant figures.

[6]

- (b) The chemist repeats the experiment using the same initial amounts of CO and H₂. The same procedure is used but the mixture is heated in the 200 cm³ sealed container to a higher temperature than 500 K.

As the gas volume is kept at 200 cm³, the increased temperature also increases the pressure.

- Explain why it is difficult to predict how the yield of CH₃OH would change.
- Explain what happens to the value of K_c . [4]

[Total 10 Marks]