**AOS 2: Equilibrium structured questions**

**Experiment 1: The equilibrium law**

Theory says that for each reversible reaction there is an equilibrium law. When applied, this law leads to an equilibrium constant. The reaction between hydrogen and iodine gases is an example of a reversible reaction.

H2(g) + I2(g) ⬄ 2HI(g)

Three different mixtures of hydrogen and iodine gases are added to three different reactors at 731 °C. Some of the concentrations at equilibrium are shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Experiment** | [H2] | [I2] | **[HI]** |
| **1** | 0.0114 | 0.0120 | 0.0252 |
| **2** |  | 0.0200 | 0.0296 |
| **3** | 0.0770 | 0.0310 |  |
|  |  |  |  |

**Experiment 2: Simulation**

The reaction between nitrogen and hydrogen gases to form ammonia is a reversible one;



**Reactor 1**. A reactor is shown below. Samples of nitrogen and hydrogen are added to the reactor and allowed to react. Assume that each molecule shown stands for 1 mole of the gas.

N2 H2 H2 H2 H2

H2 H2

N2 H2 H2 N2

N2 N2 H2 H2 H2

 →

 t = 0

**Reactor 2**. A second reactor has a sample of ammonia gas added to it.

NH3 NH3  NH3

NH3 NH3

NH3 NH3

 →

**Experiment 3: Graphs of K**

The graph shown is for a reversible reaction.

 *% product*

Each line shows the yield of the reaction and how

it changes with an increase in temperature**.**

The other two lines show how an increase in pressure

impacts upon yield.

500 atm

300 atm

100 atm

*temperature*

**Experiment 4: Graphing**

Carbon monoxide and hydrogen can react to form methanol

CO(g) + 2H2(g) ⬄ CH3OH(g)

A sample of carbon monoxide and hydrogen is added to an empty reactor and allowed to react. Their concentrations are shown on the graph below

0.8

0.6

0.4

0.2

M

time

 1 2 3 4 5 mins

**Questions**

**Experiment 1**

**1**. Write an expression for K for this reaction.

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1 mark

**2**. Determine the values of the two measurements missing from the table.

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1 mark

**3**. Perhaps other expressions also lead to constants i.e. perhaps [H2][I2] is also constant

 [HI]

 Use the data provided to check whether this does in fact lead to a constant.

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2 marks

**Experiment 2: Simulation**

**Reactor 1**.

N2 H2 H2 H2 H2

H2 H2

N2 H2 H2 N2

N2 N2 H2 H2 H2

 →

 t = 0

**4. a**. The molecules in the reactor react and equilibrium is reached. Assuming whole

 numbers, draw in the blank box some combination of the concentrations that is

 stoichiometrically correct.

 **b**. Is there more than one possible answer? Explain your answer.

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2 + 2 = 4 marks

**Reactor 2**. A second reactor has a sample of ammonia gas added to it.

NH3 NH3  NH3

NH3 NH3

NH3 NH3

 →

**5. a.** Assuming whole numbers, draw in the blank box some combination of the

 concentrations that is stoichiometrically correct.

 **b**. How many possible answers are there? Explain your answer.

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2 + 2 = 4 marks

**Experiment 3: Graphs of K**

 *% product*

Each line shows the yield of the reaction and how

it changes with an increase in temperature**.**

The other two lines show how an increase in pressure

impacts upon yield.

500 atm

300 atm

100 atm

*temperature*

**6**. **a**. Is this reaction exothermic or endothermic? Explain your answer.

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 **b**. Would it be wise to run this reaction at very low temperatures to maximise the

 yield?

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1 + 1 = 2 marks

**7. a**. Does the yield increase or decrease when the pressure is increased?

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 **b**. What does this tell you about the reaction occurring?

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 **c**. Explain why high pressure is not always desirable?

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2 + 2 + 1 = 5 marks

**Experiment 4: Graphing**

A sample of carbon monoxide and hydrogen is added to an empty reactor and allowed to react. Their concentrations are shown on the graph below

0.8

0.6

0.4

0.2

M

time

 1 2 3 4 5 mins

**8. a**. Identify which line is the carbon monoxide and which is the hydrogen.

 **b**. Draw in the graph for the methanol

 **c**. Calculate a value for K

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1 + 1 + 1 = 3 marks

**9**. The volume of the container is halved at the 6 minute mark. Extend the 3 lines to show

 the likely response of the system

3 marks