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VCE Chemistry ¾

Rate-Yield Conflict [2.9]

Test Solutions

20 Marks. 1 Minute Reading. 17 Minutes Writing.

Results:

Test Questions	____________/ 15
Extension Questions	____________/ 5

Section A: Test Questions (15 Marks)

Question 1 (3 marks)

Tick whether the following statements are **true** or **false**.

	Statement	True	False
a.	Adding an inert gas to a system at equilibrium increases the overall pressure of the system and therefore the system will react by trying to decrease the pressure of the system.		✓
b.	A particular system is at equilibrium. If the vessel is heated up, to partially oppose this change, the system will always favour the forward, endothermic reaction.		✓
c.	If a concentration-time graph has no spikes/sudden changes after a change is made, the change which must have been made is a temperature change.	✓	
d.	If a catalyst is added to a system at equilibrium, it will not alter the position of equilibrium.	✓	
e.	A rate-yield conflict arises whenever the temperature of an equilibrium system is changed.		✓
f.	If the pressure of a gaseous system is increased, the rate of reaction will increase, irrespective of the effect on yield.	✓	

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Question 2 (12 marks)

Bromomethane, CH_3Br, is a toxic, odourless and colourless gas. It is used by quarantine authorities to kill insect pests.

A simplified reaction for its synthesis is:

$$CH_3OH(g) + HBr(g) \rightleftharpoons CH_3Br(g) + H_2O(g) \qquad \Delta H = -37.2\ kJ/mol \text{ at } 298\text{ K}$$

The manufacturer of this chemical investigates reaction conditions that could affect the time the process takes and the percentage yield.

a. Predict the effect of each change given below on the **rate** of production of bromomethane by circling your prediction (increase, no change or decrease). Briefly justify your choice.

i. Increasing temperature (at a constant volume). (2 marks)

Increase　　No change　　Decrease

Reasoning:

Increasing temperature (constant volume)
Increase
Reasoning: Increasing temperature increases the (average) kinetic energy of reactant molecules so:

- more collisions have energy greater than the activation energy
- the proportion of collisions that are successful (fruitful) increases.

ii. Increasing pressure (at a constant temperature). (2 marks)

Increase　　No change　　Decrease

Reasoning:

Increasing pressure (constant temperature)
Increase
Reasoning: Increasing the pressure increases the closeness (concentration) of the reactant molecules and so the frequency (number) of collisions increases.

b. Considering the system at equilibrium, predict the effect of each change given below on the percentage **yield** of bromomethane by circling your prediction (increase, no change or decrease). Briefly justify your choice.

i. Increasing pressure (at a constant temperature). (2 marks)

Increase No change Decrease

Reasoning:

Increasing pressure (constant temperature)
No change
Reasoning: The system cannot compensate for (partially oppose) the increase in pressure because there are the same number of particles (moles) on both sides of the equilibrium. The concentration fraction has not changed and the system remains at equilibrium.

ii. Continuously removing the product CH_3Br (at a constant volume and temperature). (2 marks)

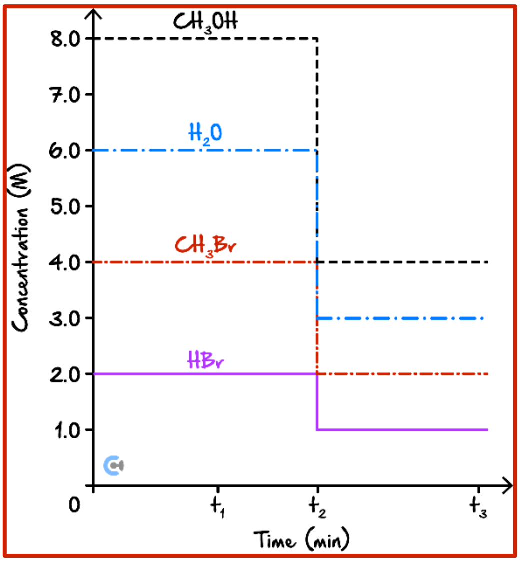
Increase No change Decrease

Reasoning:

Continuously removing the product CH_3Br (constant volume and temperature)
Increase
Reasoning: System moves to compensate for (partially oppose) the removal of product by favouring the forward reaction (production of CH_3Br) or removal of product reduces the rate of the reverse reaction and so the forward reaction is favoured.

c. The following concentration-time graph represents the system at equilibrium at time t_1.

At time t_2, a change was made to the system:



i. State what change was made. (1 mark)

Volume was doubled/pressure halved.

ii. On the graph above, sketch how the concentrations of all species would change after time t_2, until equilibrium is re-established at time t_3. (1 mark)

d. State what could be done to the system in order to increase its K_c value. Justify your answer. (2 marks)

Decrease the temperature. (1)
The system would partially oppose this by trying to increase the temperature by favouring the forwards exothermic reaction, so [products] increases and [reactants] decreases, increasing K_c overall. (2)

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Section B: Extension Questions (5 Marks)

Question 3 (5 marks)

The combustion of hydrogen is a vital one for society, as explored throughout your VCE Chemistry studies this year. In fact, when steam is produced, the system establishes an equilibrium:

$$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$$

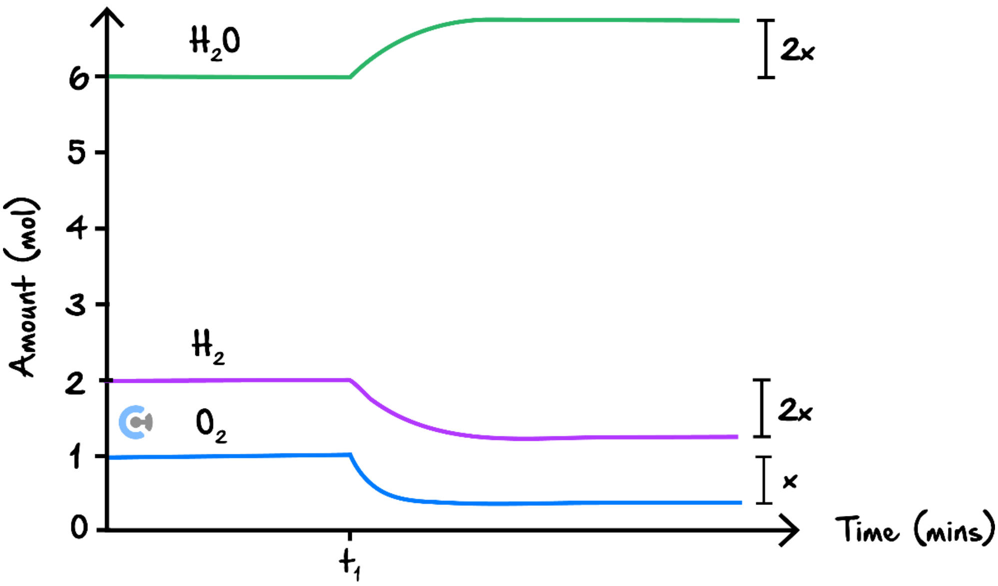
a. Propose what can be done to this system at equilibrium, such that the yield of greenhouse gases is reduced, whilst simultaneously altering the K_c value for the system. Justify your reasoning. (2 marks)

Increase temperature: System will try to lower the temperature by favouring the endothermic reaction, which is the reverse reaction as the forwards one is combustion (exothermic), thus lowering the yield of $H_2O(g)$.
Only T change can alter K_c value so removal/addition of species is not a valid response.

b. Hence, explain why a catalyst is not typically utilised in industry for this particular reaction whenever the aim is to minimise the production of steam. (1 mark)

Because high temperature is favoured for yield purposes, which is also optimal for the rate of reaction (no rate-yield conflict), so no need for a catalyst to increase the rate.

c. The following mol-time graph depicts the **amounts** of each of the three species originally at equilibrium, and how they are impacted after a change is made at time t_1.



i. State the two possible changes which could have been made at time t_1 to produce the graph above. (1 mark)

1. Decrease in temperature.

2. Increase in pressure/decrease in volume.

ii. If both changes mentioned in part **c.i**. were implemented **together** at time t_1, outline the optimal temperature and pressure conditions that would be used in industry, assuming the goal was to produce as much steam as possible, as fast as possible. (1 mark)

There would be a rate-yield conflict for temperature only which must be addressed in industry: therefore, use moderate temperatures, but maintain high pressure (both conditions need to be correctly addressed for the mark).

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