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VCE Chemistry ¾

AOS 2 Revision (Rates & Equilibrium) [2.0]

SAC 3

50 Marks. 12 Minutes Reading. 75 Minutes Writing.

Section A: Multiple Choice Questions (5 Marks)

Question 1 (1 mark)

Which of the following changes will definitely lead to a faster reaction rate?

A. Lower temperature, addition of a catalyst and higher concentrations.

B. Higher temperature, lower concentrations and the addition of a catalyst.

C. Greater surface area, higher temperatures and higher concentrations.

D. Greater surface area, lower temperatures and lower concentrations.

Question 2 (1 mark)

When a catalyst is added to a reaction:

A. An alternative reaction pathway is provided that requires a lower activation energy.

B. The activation energy is increased enabling more particles to react.

C. The kinetic energy of particles is increased, allowing more to collide successfully.

D. The activation energy is unchanged but a higher percentage of particles are above that level.

Question 3 (1 mark)

In the decomposition of NOCl, the reaction is:

$$2\text{NOCl(g)} \rightleftarrows 2\text{NO(g)} + \text{Cl}_2\text{(g)} \quad \text{K} = 1.2 \times 10^{-5}\ M \quad \text{at } 30°\text{C}.$$

In an equilibrium mixture at 30°C, the amount of:

A. Cl_2 is half the amount of NOCl.

B. NO will equal the amount of NOCl.

C. NO is far less than the amount of NOCl.

D. NO added to the amount of Cl_2 will give the amount of NOCl.

Question 4 (1 mark)

Given:

$$2A(g) \rightleftharpoons B(g) + C(g)\ \Delta H = +27kJ\ mol^{-1} \quad K_c = 3.2 \times 10^{-4}$$

Which of the following would be true if the temperature were increased from 25°C to 800°C?

1. The value of K_c would be smaller.

2. The value of K_c would be greater.

3. The concentration of A(g) would be increased.

4. The concentration of B(g) would be increased.

A. 1 & 3 only.

B. 3 only.

C. 2 & 4 only.

D. 4 only.

Question 5 (1 mark)

For the following system:

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

Dichromate ions are orange.

State the change in colour overall if dichromate ions are removed.

A. More intensely orange.

B. Less intensely orange.

C. Same intensity of orange.

D. Unable to determine from information.

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Section B: Short Answer Questions (45 Marks)

Question 6 (5 marks)

The reaction between nitrogen monoxide and chlorine is a reversible one:

$$2NO(g) + Cl_2(g) \rightleftarrows 2NOCl(aq)$$

In a 20.0 L reactor, the equilibrium amounts of the three chemicals are:

$$NO = 3.6\ mol \qquad Cl_2 = 2.8\ mol \qquad NOCl = 3.2\ mol$$

a. Calculate the value of K_c for this mixture. (2 marks)

b. In another 20.0 L equilibrium mixture at the same temperature, the concentration of NOCl is found to be 0.56 M and the concentration of Cl_2 is 0.40 M. Determine the amount of the NO present. (2 marks)

c. State the equilibrium constant value for the reverse reaction. (1 mark)

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Question 7 (8 marks)

A mixture of hydrogen gas and iodine gas is injected into a vessel that is then sealed. The mixture will establish an equilibrium system as described by the following equation:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \quad \Delta H = -300\ kJ\ mol^{-1}$$

a. State the optimum temperature conditions to maximise both rate of production of hydrogen iodide, and the equilibrium yield of hydrogen iodide. (1 mark)

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b. In an experiment, 3.00 mol of iodine and 2.00 mol of hydrogen were added to a 2.00 L reaction vessel. The amount of iodine present at equilibrium was 1.07 mol. A constant temperature was maintained in the reaction vessel throughout the experiment.

i. Write the expression for the equilibrium constant for this reaction. (1 mark)

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ii. Calculate the value of the equilibrium constant. (3 marks)

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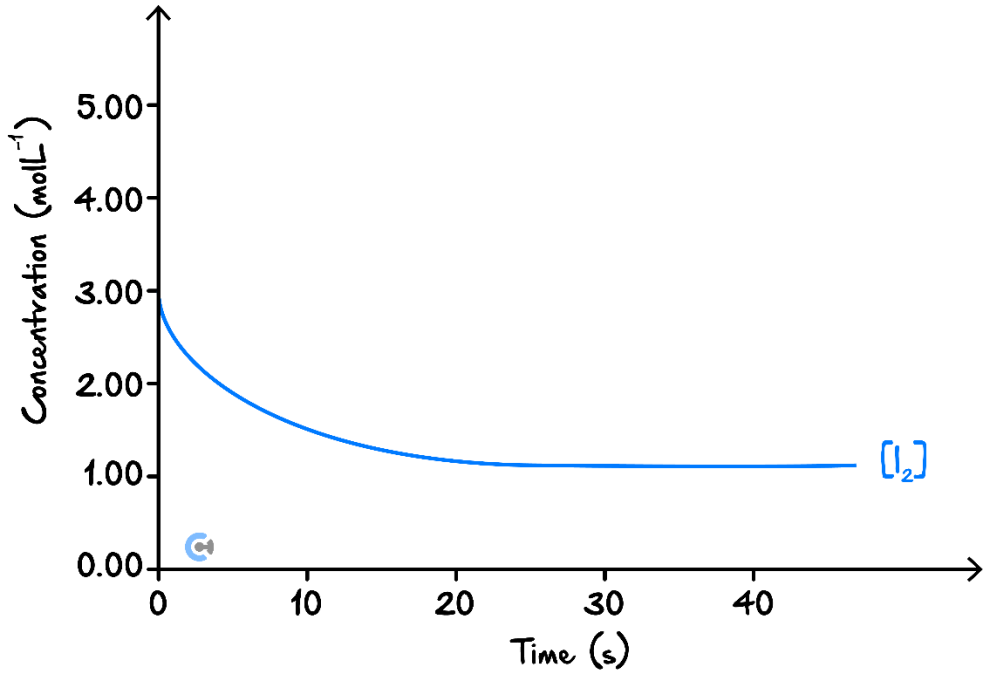
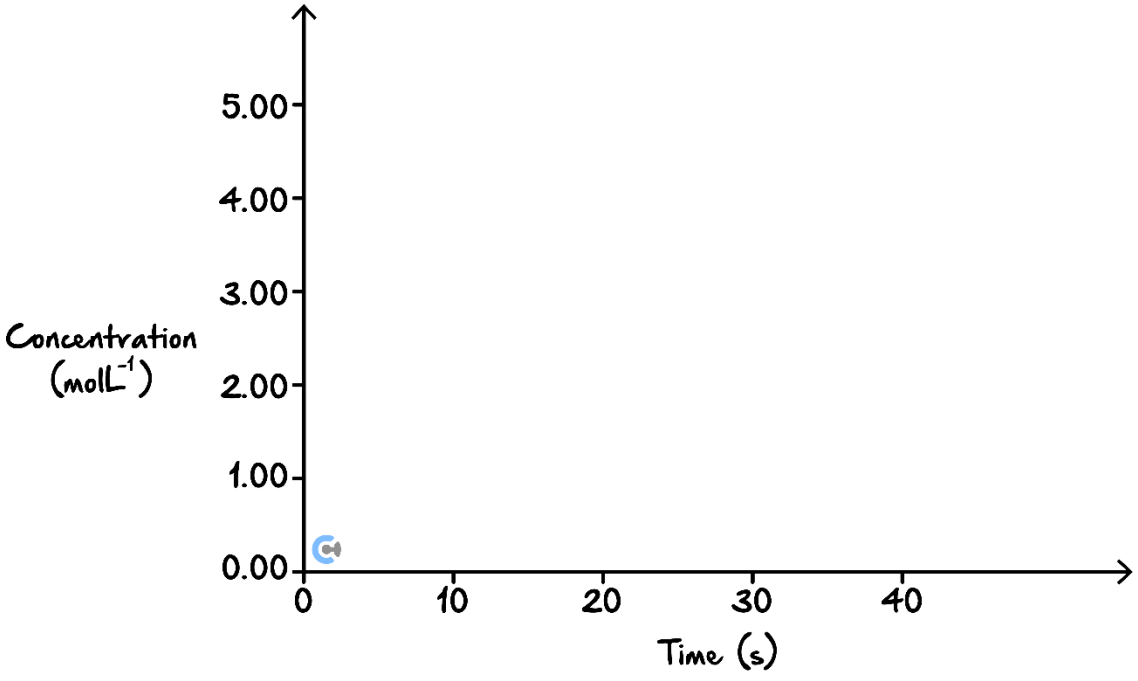
c.

i. A graph of the decrease in the concentration of I_2 until equilibrium is effectively reached is given in the figure below. In the figure, draw clearly labelled graphs to show how the concentrations of H_2 and HI changed over the same period. (2 marks)



ii. Indicate in the figure below how the iodine concentration would have been changed if a catalyst had been added to the vessel as well. Assume all other conditions remained the same. (1 mark)



Question 8 (10 marks)

Phosgene gas is a known toxin used in chemical warfare. It is produced according to the equation below:

$$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$$

This gas ($COCl_2$) quickly decomposes when strongly heated to CO and Cl_2 gases.

a. According to the information given suggests whether the synthesis of phosgene is an exothermic or endothermic reaction. Justify your answer. (2 marks)

b. At a given temperature of 100°C the reaction below takes place:

$$COCl_2\ (g) \rightleftharpoons CO(g) + Cl_2\ (g)$$

If 0.100 mol of phosgene, $COCl_2$, is placed in a 2.00 L sealed vessel, calculate the concentration of carbon monoxide at equilibrium if at equilibrium 0.0250 mol of phosgene was detected. Fill out the information below. (4 marks)

$[\mathbf{CO}]_{equilibrium}$ = _____

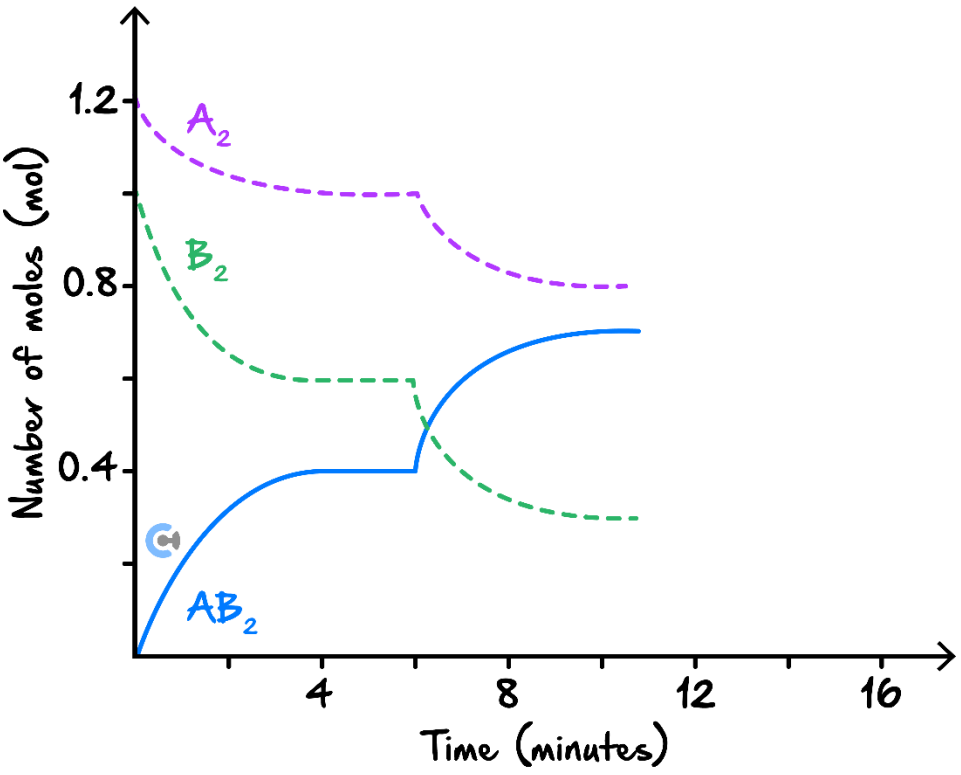
$\mathbf{K_C}$ = _____

c. Calculate the K_C value of this reaction based on your value obtained in **part b.** above. (2 marks)

$$3CO(g) + 3Cl_2(g) \rightleftharpoons 3COCl_2$$

d. Reactants *A* and *B* are placed in a 2.00 *L* sealed reaction vessel and allowed to reach equilibrium. The reaction is given below.

$$A_2(g) + 2B_2(g) \rightleftharpoons 2AB_2\ (g) \quad \Delta H = \text{positive } kJ/mol$$



What happened at the 6-minute mark? Justify your answer. (2 marks)

Question 9 (16 marks)

Hydrogen gas (H_2) reacts with gaseous iodine (I_2) reversibly at high temperature in the following reaction:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g); \quad \Delta H > 0$$

a. Write an expression for the equilibrium constant, K, of the above reaction. (1 mark)

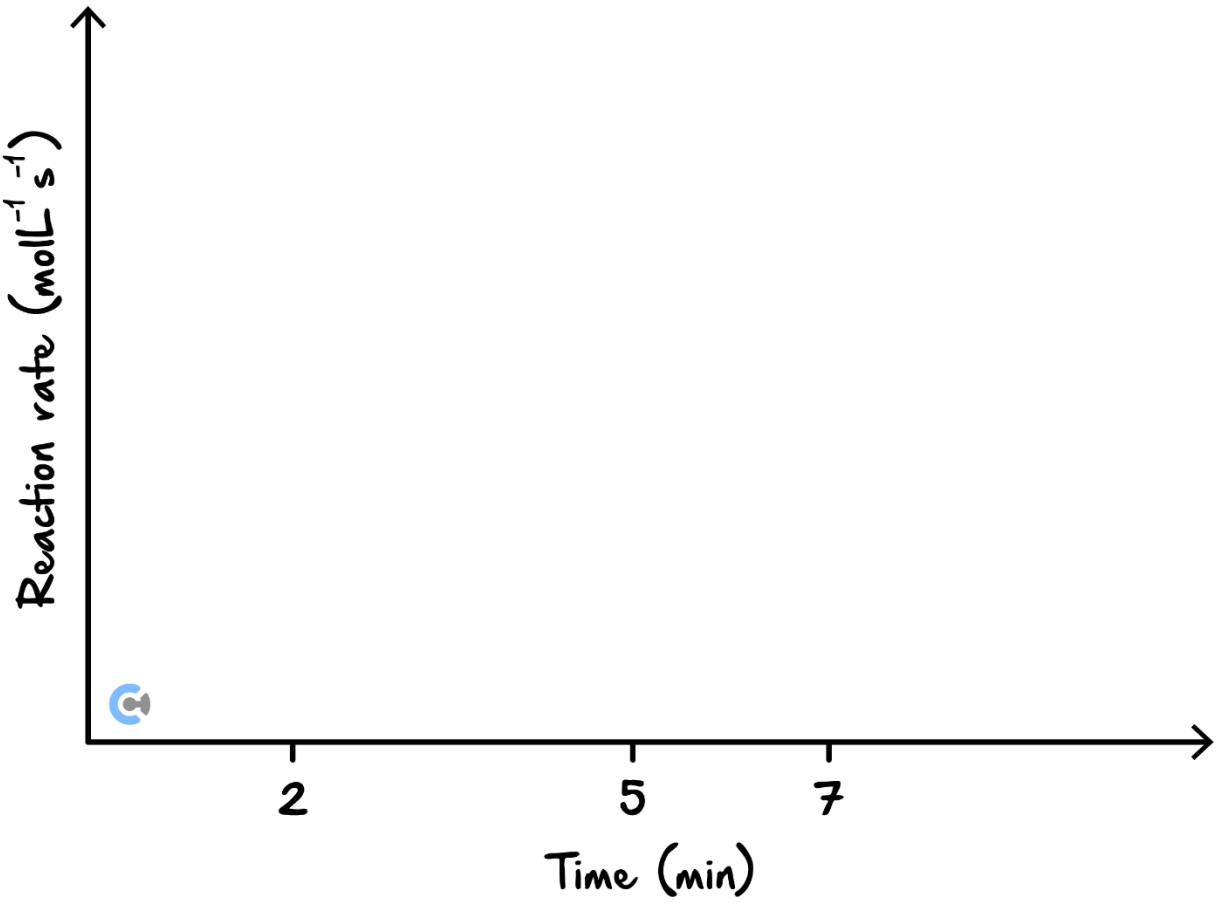
To a 1.00 L container at 698 K, Eddie adds 0.200 mol of H_2 and 0.200 mol of I_2. At equilibrium, which is established after 2 minutes, 0.316 mol of HI is present in the container.

b. Determine the percentage yield of HI in this reaction. (2 marks)

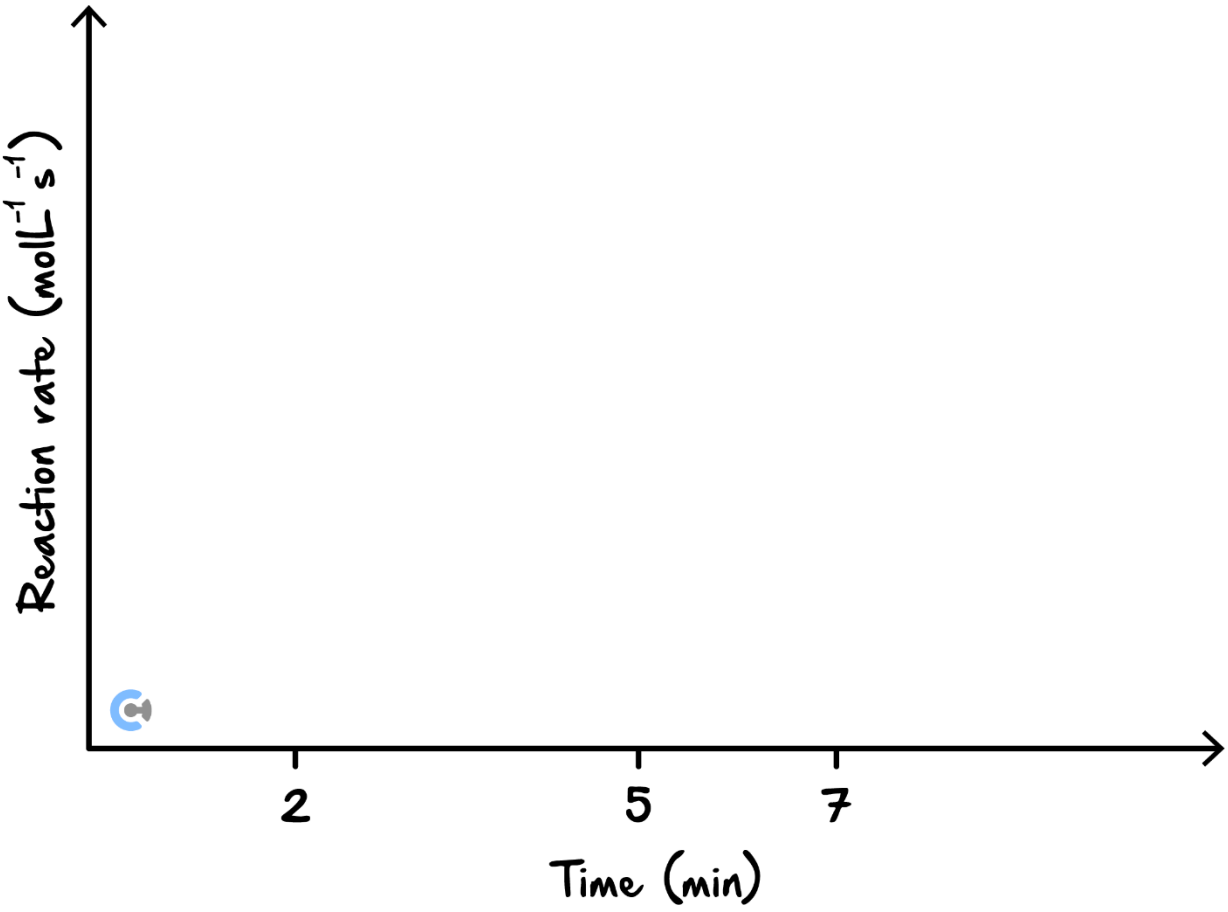
c. Determine the value of K. (2 marks)

Another 0.200 mol of H_2 was added to the container after 5 minutes, after the system had already reached equilibrium. At 7 minutes, the system re-established equilibrium.

d. On the axes below, draw a **concentration-time** graph for each gas over the 7 minutes. (3 marks)



e. On the axes below, draw a **reaction rate–time** graph of the forward and back reactions over the 7 minutes. (3 marks)



f. The volume of the container was quickly expanded to 2 *L* at 7 minutes.

i. In which direction will the equilibrium shift? Circle your answer. (1 mark)

Forwards Backwards No change

ii. Explain your answer to **part (f) (i)** using Le Chatelier's principle. (2 marks)

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Bronson, keen to replicate this experiment, added 0.200 mol of H_2 and 0.200 mol of I_2 to a rigid 1.00 L container at a different temperature. However, he only got a yield of 0.240 mol of HI at equilibrium.

g. Determine the difference between the conditions used by Eddie and Bronson in their reaction of hydrogen with iodine. Explain your answer. (2 marks)

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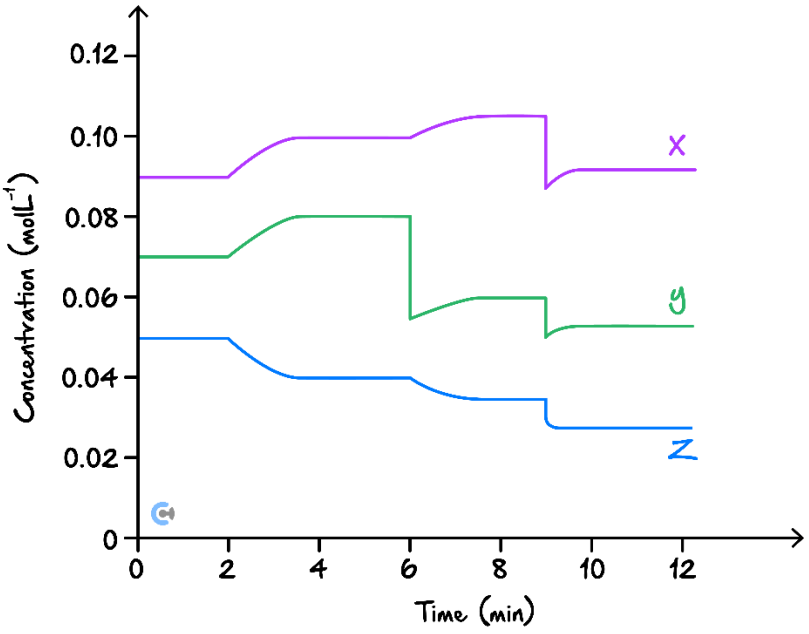
Question 10 (6 marks)

The gases X, Y and Z are components of an equilibrium reaction shown by the following equation:

$$\mathrm{X(g) + Y(g) \rightleftharpoons Z(g)} \qquad \Delta H = -108\ kJ\ mol^{-1}$$

The graph below shows the variation in concentration of the components of an equilibrium mixture in a closed vessel of fixed, unchangeable volume with time.



a. Complete the table below to identify the changes made to the equilibrium system at the specified times, and explain why the system responded as shown. (4 marks)

Time of Change	Description of change	Why the equilibrium system responded as shown
2 minutes		
9 minutes		

b. State the amount of different values of K_c are evident in the graph above? Explain your choice. (2 marks)

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