Victorian Certificate of Education
2024

Name: _____

Teacher's name: _____

UNIT 3 CHEMISTRY

SAC 2: *Problem-solving, including calculations, using chemistry concepts and skills applied to real-world contexts.*

2024

QUESTION AND ANSWER BOOK

Structure of book

Number of questions	*Number of questions to be answered*	*Number of marks*
6	6	40
		Total 40

- Students are permitted to bring into the assessment room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the assessment room: blank sheets of paper and/or correction fluid/tape.

Materials supplied
- Question and answer book.
- Additional space is available at the end of the book if you need extra space to complete an answer.

Instructions
- Write your name in the space provided above on this page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the assessment room.

Instructions

Answer **all** questions in the spaces provided.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

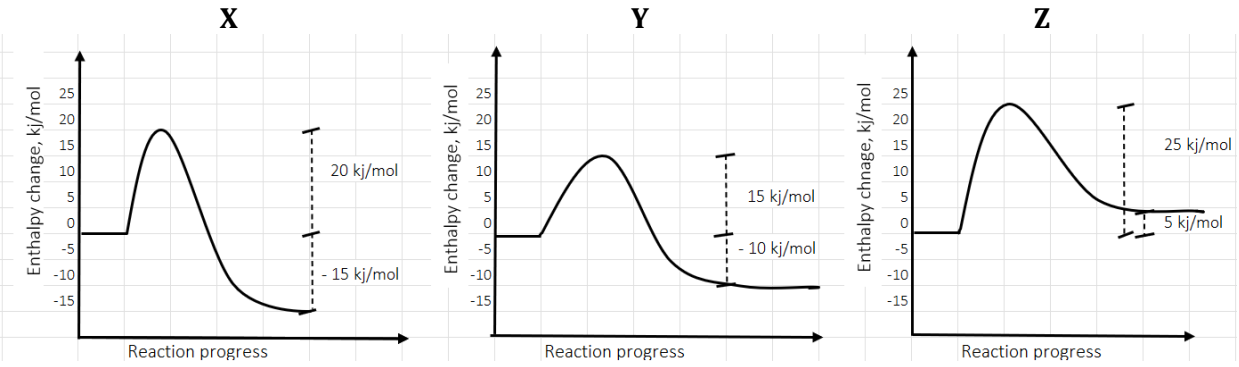
Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, H2(g), NaCl(s).

Unless otherwise indicated, the diagrams in this book are not drawn to scale.

Final answers must include correct units.

Question 1 (3 marks)

Below are the energy profiles for three reactions, X, Y and Z.



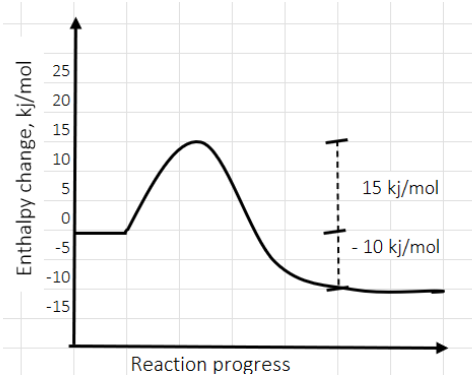
a. Rank the rate of the forward reactions from slowest to fastest. 1 mark

_____

b. Rank the rate of the reverse reactions from fastest to slowest. 1 mark

_____

c. Draw on the graph for reaction Y below to show how the reaction will progress when a catalyst is used. 1 mark



Question 2 (13 marks)

A mixture of 0.800 mol of $NO_{(g)}$, 0.400 mol of $H_{2(g)}$ and 0.800 mol of $H_2O_{(g)}$ was placed in a 4.00 L closed vessel to reach equilibrium. The reaction is:

$2NO_{(g)} + 2H_{2(g)} \rightleftarrows N_{2(g)} + 2H_2O_{(g)}$

When the system reached equilibrium, at a temperature T, ˚C, the concentration of $NO_{(g)}$ was 0.124 M.

a. Write the expression for the equilibrium constant, K. 1 mark

b. Calculate the equilibrium constant at temperature T˚C. 4 marks

c. Discuss the extent of the reaction with reference to the K value calculated in Question 2b. 2 marks

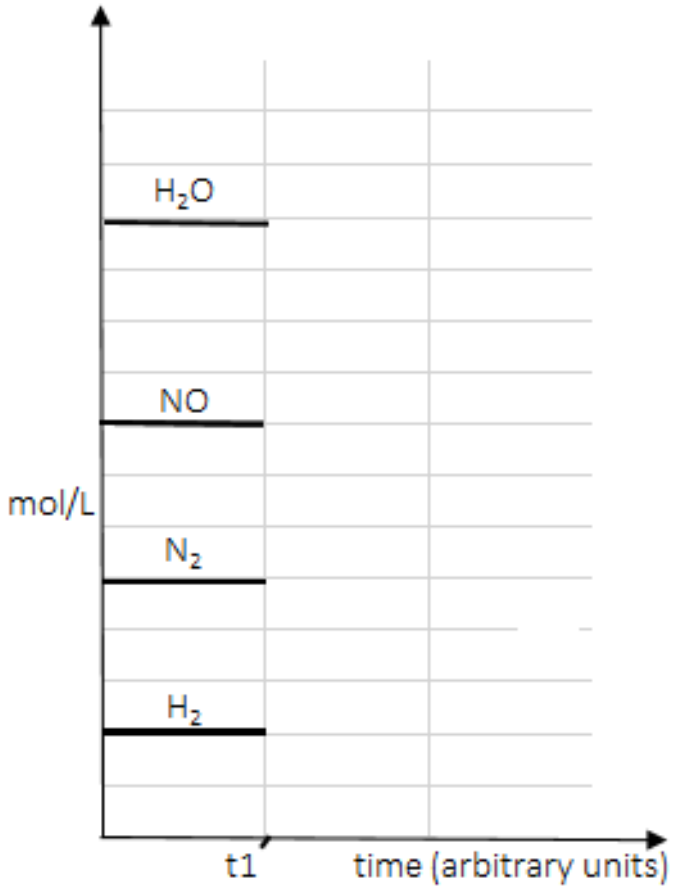
d. A change was made to the system so that it was no longer at equilibrium. Shortly after the change, at time t, the equilibrium quotient (Q) was found to be 200 M^{-1}. 2 marks

With reference to the K value calculated in Question 2b, explain what is required for the system to reach equilibrium.

e. What measure can be applied to the system to increase the yield of nitrogen production? 1 mark

f. The following figure shows the concentrations of all species at the first equilibrium. At time t_1, some N_2 is removed from the system. 3 marks

Continue the graphs to show the changes that occur for each species until a new equilibrium is re-established.



Question 3 (14 marks)

A nickel-plating experiment is designed to investigate the electrolytic conditions required for optimal product outcomes. A beaker containing 200 mL of green 1.00 M $NiSO_{4(aq)}$ solution is electrolysed using a carbon electrode. The second electrode is an object that is made of a material that needs to be nickel-plated. The object is not reactive.

a. Write the half equations for the oxidation and reduction reactions for this experiment. 2 marks

Oxidation:

Reduction:

b. For optimal plating, the $Ni^{2+}_{(aq)}$ concentration in solution needs to be maintained above 0.350 M. 5 marks

Assuming the cell operates consistently with a current of 3.00 A, and a voltage of 5 V, calculate the time, in seconds, before the initial 1.00 M $NiSO_4$(aq) solution would need replacing.

c. State two observations that could be noticed in the nickel-plating cell while it is operating. 2 marks

d. If the cell operates with a consistent current of 3.00 A, calculate the time, in seconds, for 2.00 g nickel to be plated on the object. 4 marks

e. Assuming that each object needs to have a plating of 2.00 g, identify one change that could be made to this experiment so that more objects can be fully plated without having to top up the electrolyte with $Ni^{2+}(aq)$. 1 mark

Question 4 (3 marks)

A trial investigates the effect of changes in the reaction conditions for the following reaction, which is carried out in a closed vessel.

$2SO_{2(g)} + O_{2(g)} \rightleftarrows 2SO_{3(g)} \qquad \Delta H < 0$

a. What are the observed effects on the rate of reaction, the equilibrium constant and the position of equilibrium when the volume of the vessel is halved at constant temperature? 1 mark

Change in reaction conditions	Rate of Reaction	Equilibrium Constant Value (K)	Position of Equilibrium Shifts
Halving the volume of the vessel			

b. What are the observed effects on the rate of reaction, the equilibrium constant and the position of equilibrium when the temperature is increased? 1 mark

Change in reaction conditions	Rate of Reaction	Equilibrium Constant Value (K)	Position of Equilibrium Shifts
Increasing the temperature			

c. What are the observed effects on the rate of reaction, the equilibrium constant and the effect on the position of equilibrium when a catalyst is used? 1 mark

Change in reaction conditions	Rate of Reaction	Equilibrium Constant Value (K)	Position of Equilibrium Shifts
Using a catalyst			

Question 5 (4 marks)

Cobalt dissolves in hydrochloric acid and forms coloured solutions, as shown in the reaction below.

$Co(H_2O)_6^{2+}_{(aq)} + 4Cl^-_{(aq)} \rightleftarrows CoCl_4^{2-}_{(aq)} + 6H_2O_{(l)}$ $\Delta H > 0$

pink *blue*

a. At equilibrium, and a particular temperature, the solution has a violet colour. 2 marks

What colour will be observed if the concentration of $Cl^-(aq)$ is increased? Justify your response with reference to Le Chatelier's Principle.

b. What colour will be observed when the system is cooled? Explain your answer. 2 marks

Question 6 (3 marks)

The Edison battery was developed by Thomas Edison in the 1900s. It uses iron and nickel electrodes and potassium hydroxide as the electrolyte. The overall reaction in the battery during discharge is:

$Fe_{(s)} + 2NiO(OH)_{(s)} + 2H_2O_{(l)} \rightarrow Fe(OH)_{2(s)} + 2Ni(OH)_{2(s)}$

a. Write the half equation for the reaction occurring at the cathode during discharge. 1 mark

b. Write the half equation for the reaction occurring at the cathode during recharge. 1 mark

c. During the recharge process, will the nickel electrode be the anode or the cathode? What polarity will it have? 1 mark

END OF QUESTION AND ANSWER BOOK

Extra space for responses

Clearly number all responses in this space.