KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

SECOND YEAR FIRST SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BED (Science)

COURSE CODE: SCH 215

COURSE TITLE: INTRODUCTION   TO   KINETICS   AND
THERMODYNAMICS

DURATION: 2 HOURS

DATE: 4/02/2022   TIME: 2-4PM

QUESTION ONE (30 Marks)

(a) State the following laws **(3Marks)**
   i.   Boyle's law
   ii.   Charles law
   iii. Avogadro's law

(b) Gases are divided into ideal and real gases. State the two conditions under which real gases tend to obey ideal gas laws **(2Marks)**

(c) (i) Define heterogeneous catalysis **(1Mark)**

(ii) Give any two examples of heterogeneous catalysis **(2Marks)**

(d) Mercuric (II) chloride reacted with dichromate solution as shown in the equation below;

$$2HgCl_2 \text{ (aq)} + C_2O_4^{2-} \text{ (aq)} \rightarrow Hg_2Cl_2 \text{ (s)} + 2Cl^- \text{ (aq)} + 2CO_2 \text{ (g)}$$
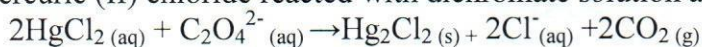
The table below shows the results involving different concentrations of reactants.

Experiment number	$[HgCl_2]$(M)	$[C_2O_4^{2-}]$(M)	Initial rate (mol/S)
1	0.096	0.13	2.1×10^{-7}
2	0.096	0.21	5.5×10^{-7}
3	0.171	0.21	9.8×10^{-7}

   i.   Determine the order of the reaction with respect to $HgCl_2$ and with respect to $C_2O_4^{2-}$ **(2Marks)**

   ii.   What is the overall order of the reaction? **(1Mark)**

   iii. Calculate the rate constant **(2Marks)**

(e) Using the information given in equations *a, b,* and *c* below, calculate the enthalpy of the following reaction **(3Marks)**

$C + 2H_2 \rightarrow CH_4$?? kJ/mol
$C + O_2 \rightarrow CO_2 \ \Delta H = -394 \ kJ/mol$ .... (a)
$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \ \Delta H = -245 \ kJ$ .... (b)
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O = -1187.8 kJ/mol$ ...... (c)
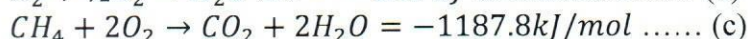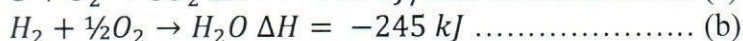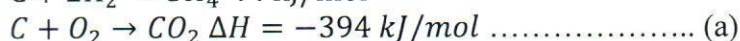
(f) State the first law of thermodynamics and write its mathematical expression **(3Marks)**

(g) Let us consider a first order reaction of the type

         A $\longrightarrow$ Products
Initial conc^n a   0
Final conc. $a - x$ x
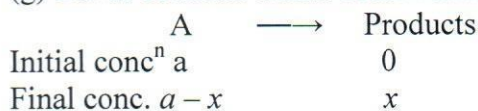
Show that its integrated rate law is given by $k = \frac{1}{t}\ln\left(\frac{a}{a-x}\right)$ **(4Marks)**

(h) (a) Define the following terms **(3Marks)**
   i.   Chemical kinetics
   ii.   Thermodynamics
   iii. Isothermal process

(i) Show that the half-life of a first order reaction of the form A $\rightarrow$ Products is

$t_{\frac{1}{2}} = \frac{0.693}{k}$ **(4Marks)**

QUESTION TWO (20 Marks)

(a) Using $E = q - W$ show that heat of an isothermal reversible process is

$q = nRTln\frac{V_2}{V_1}$ oR $nRTln\frac{P_1}{P_2}$ **(8Marks)**

(b) Consider a two-step reaction mechanism suggested below and use it to answer the questions that follows;

Step 1 Slow $NO_{2(g)} + NO_{2(g)} \rightarrow NO_{3(g)} + NO_{(g)}$

Step 2 Fast $CO_{(g)} + NO_{3(g)} \rightarrow CO_{2(g)} + NO_{2(g)}$

i) Derive the overall reaction **(2Marks)**

ii) Identifying the reaction intermediate **(1Mark)**

iii) Define the term reaction intermediate **(2Marks)**

iv) Identify the rate determining step **(2Marks)**

v) Derive the rate law for the above reaction **(1Mark)**

(c) The decomposition of carbon disulfide, CS_2, to carbon monosulfide, CS, and sulfur is first order with $k = 2.8 \times 10^{-7}$ s^{-1} at 100°C. What is the half-life of this reaction at 100°C?

(4marks)

QUESTION THREE (20 Marks)

(a) Describe the graphical method of determining rate constants **(10Marks)**

(b) Using $(E = q - W)$, show that work done by an isothermal reversible process is expressed as $W = -nRTln\frac{V_2}{V_1}$ **(5Marks)**

(c) State the five common characteristics of catalytic reactions **(5Marks)**

QUESTION FOUR (20 Marks)

(a) The gas-phase reaction between methane (CH_4) and diatomic sulphur (S_2) is given by the equation

$CH_4 (g) + 2S_2 (g) \longrightarrow CS_2 (g) + 2H_2S (g)$

At 550°C the rate constant for this reaction is 1.1 l mol^{-1} sec and at 625°C the rate constant is 6.4 l mol^{-1} sec. Calculate E_a for this reaction **(5Marks)**

(c)(i) What is isothermal reversible process **(2Marks)**

(ii) 2 dm^3 of hydrogen initially at stp are expanded isothermally to a volume of $4dm^3$. Calculate work done assuming ideal behaviour of hydrogen **(5Marks)**

(d) Derive the two numerical values of gas constant R using ideal gas equation $pv = nRT$ **(5Marks)**

(e) State the three thermodynamic systems **(3Marks)**

QUESTION FIVE (20 Marks)

(a) The following results were obtained from a study of the isomerization of cyclopropane to propene in the gas phase at 433°C

Time(hours)	0	2	5	10	20	30
% of Cyclopropane remaining	100	91	79	63	40	25

(i) Show that the reaction is a first order with respect to cyclopropane **(5Marks)**

(ii) Calculate the rate constant for the reaction **(2Marks)**

(b) State the three types of elementally reactions **(3Marks)**

(c) Describe the Michaelis-Menten mechanism **(10Marks)**