

2915/205  
PHYSICAL CHEMISTRY II  
Oct./Nov. 2022  
Time: 3 hours



THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ANALYTICAL CHEMISTRY

MODULE II

PHYSICAL CHEMISTRY II

3 hours

**INSTRUCTIONS TO CANDIDATES**

*You should have the following for this examination:*

*Answer booklet;*

*Non-programmable scientific calculator.*

*This paper consists of TWO sections; A and B.*

*Answer ALL the questions in section A and any THREE questions from section B.*

*Each question in section A carries 4 marks while each question in section B carries 20 marks.*

*Maximum marks for each part of a question are indicated.*

*Candidates should answer the questions in English.*

**This question paper consists of 5 printed pages.**

**Candidates must check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.**

SECTION A (40 marks)

Answer ALL the questions in this section.

1. (a) Define the term compressibility factor. (2 marks)
- (b) Nitrogen gas, diffuses 1.25 times faster than a hydrocarbon gas Y. Calculate the relative mass of the hydrocarbon. (2 marks)
2. (a) Define the term dynamic equilibrium. (2 marks)
- (b) Explain why a dynamic equilibrium is not desired in an industrial set-up. (2 marks)
3. Using appropriate equations, explain the meaning of the following terms:
- (a) catalytic poison; (2 marks)
- (b) negative catalyst. (2 marks)
4. Consider the following reaction:
- $$2H_2O_{2(aq)} \rightarrow 2H_2O_{(aq)} + O_{2(g)}$$
- If the  $t_{\frac{1}{2}} = 100$  seconds, calculate the time it takes for the reaction to be 75% complete. (4 marks)
5. Given the reaction below
- $$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$
- The amount of  $H_2$ ,  $I_2$  and  $HI$  are 0.2 g, 9.2525 g and 44.8 g respectively at equilibrium and constant temperature. Calculate the equilibrium constant of the reaction. (4 marks)
6. Calculate the Van der Waals constant 'a' if  $b = 0$ , pressure is 0.5 atm,  $n = 1$  mole of gas, temperature is  $0^\circ C$  and  $V = 0.112 \text{ cm}^3$ . (4 marks)
7. (a) Given the following equation.
- $$H_2 + I_2 \rightleftharpoons 2HI_{(g)} \quad K_c = 57.0 \text{ at } 700 \text{ K.}$$
- If the value of  $[H_2] = 0.10 \text{ dm}^3$ ,  $[I_2] = 0.20 \text{ dm}^3$  and  $[HI] = 0.40 \text{ dm}^3$ . With reason, state the direction of the reaction. (3 marks)
- (b) State what it means in a chemical reaction when the value of  $K_c$  is very small. (1 mark)

8. Draw a clearly labelled phase diagram for  $CO_2$ . (4 marks)

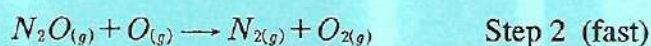
9. Methane, is produced when ethanal is thermally decomposed as below.



Draw an energy profile diagram for a catalysed and uncatalysed reaction (4 marks)

10. For the reaction  $2N_2O_{(g)} \rightarrow 2N_{2(g)} + O_{2(g)}$  where Rate law =  $k[N_2O]^2$ .

The mechanism:



(a) Explain which of the two equations is the rate determining step. (2 marks)

(b) Determine the molecularly of the reaction. (2 marks)

### SECTION B (60 marks)

Answer Question 11 and any **THREE** questions from this section.

11. (a) State the ideal gas law and explain each component. (3 marks)

(b) A mixture of 0.39 g of ethoxyethene (ether) and 0.67 g of trichloromethane was vapourized in a closed vessel at  $100^\circ C$ . Calculate:

(i) number of moles of each component;  $(CH_3CH_2)_{off}$  (5 marks)

(ii) pressure of the components; (4 marks)

(iii) partial pressure of the components; (4 marks)

(iv) total pressure at  $100^\circ C$ . (3 marks)

(C = 12, H = 1, Cl = 35.5, O = 16, R = 8.3142)

(c) State the meaning of the term partial pressure. (1 mark)

12. A eutetic mixture of naphthalene-biphenyl forms a mixture at  $41^{\circ}\text{C}$  at a composition of 0.47 mole fraction of naphthalene. The melting points of various composition of naphthalene-biphenyl system is as follows:

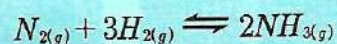
Mole fraction of naphthalene	0.125	0.275	0.625	0.800
Melting point in $^{\circ}\text{C}$	64.5	56.0	58.0	72.5

- (a) Using the data above and information given, plot a phase diagram of a eutetic mixture of naphthalene-biphenyl system. (12 marks)
- (b) Show that for a first order reaction the half life is independent of the masses of the reagents. (8 marks)
13. (a) Explain the meaning of the term steam distillation. (2 marks)
- (b) Explain the principle of steam distillation. (4 marks)
- (c) State four conditions necessary for steam distillation. (4 marks)
- (d) Draw a set-up for the apparatus used to perform steam distillation in a laboratory. (6 marks)
- (e) Write the Arrhenius equation and identify all the symbols. (4 marks)
14. The table below shows the variation of pressure-volume with pressure.

Pressure	PV in atm cm <sup>3</sup>	
	H <sub>2</sub> at 0 $^{\circ}$ C	CO <sub>2</sub> at 40 $^{\circ}$ C
1	1.0	1.0
50	1.033	0.741
100	1.064	0.270
200	1.134	0.409
400	1.277	0.718
800	1.566	1.299

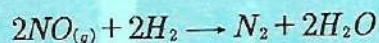
- (i) Plot a graph of PV against P for both Hydrogen and Carbon(IV)oxide on the same axis. (12 marks)
- (ii) Draw the ideal gas curve, on the graph. (1 mark)
- (iii) Explain the shape of the curves. (3 marks)
- (b) Explain the reasons why Van der Waal modified the ideal gas equation. (4 marks)

15. (a) Consider the equation below



At equilibrium, 600°C and 10 atm, the percentage of ammonia in the mixture is 15%.  
Calculate the numerical value of  $K_p$ . (8 marks)

- (b) The following data was obtained for the reaction below.



Experiment	Initial [NO]	Initial [ $N_2$ ]	Rate mol L/S
1	0.210	0.100	0.0339
2	0.210	0.200	0.0678
3	0.210	0.300	0.1020
4	0.420	0.100	0.1360
5	0.630	0.100	0.3050

- (i) Using the table, determine the order of the reaction w.r.t:
- I. NO (4 marks)
- II.  $H_2$  (3 marks)
- (ii) Determine the rate law equation. (2 marks)
- (iii) Calculate the numerical value of  $K$ . (3 marks)

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