

CHUKA



UNIVERSITY

UNIVERSITY EXAMINATIONS

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN
CHEMISTRY

CHEM 120: PHYSICAL CHEMISTRY 1

STREAMS:

TIME: 2 HOURS

DAY/DATE: TUESDAY 23/03/2021

11.30 A.M – 1.30 P.M

INSTRUCTIONS:

Answer question one and any other two questions

USEFUL DATA

$$1 \text{ cal} = 4.184 \text{ J}$$

$$1 \text{ atm} = 101.325 \text{ kPa} = 760 \text{ Torr}$$

$$1 \text{ L atm} = 101.325 \text{ J}$$

$$\theta \text{ } ^\circ\text{C} = T \text{ } ^\circ\text{K} - 273.15 / 0 \text{ } ^\circ\text{C} = 273$$

$$1 \text{ J} = 1 \text{ kg m}^2 \text{ s}^{-2} = 1 \text{ AVS}$$

$$1 \text{ N} = 1 \text{ kg m s}^{-2}$$

$$1 \text{ Pa} = 1 \text{ N m}^{-2} = 1 \text{ kg m}^{-1} \text{ s}^{-2} = 1 \text{ J m}^{-3}$$

$$C = 3.0 \times 10^8 \text{ m}^5$$

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1} = 8.314 \times 10^{-2} \text{ L bar K}^{-1} \text{ mol}^{-1}$$

$$R = 8.20574 \times 10^{-2} \text{ L atm K}^{-1} \text{ mol}^{-1}$$

$$R = 6.23637 \times 10^1 \text{ L Torr K}^{-1} \text{ mol}^{-1}$$

$$h = 6.62608 \times 10^{-34} \text{ J s}$$

$$F = NA e = 9.64853 \times 10^4 \text{ (mol}^{-1}\text{)}$$

$$h = \frac{h}{2\pi} = 1.05457 \times 10^{-34} \text{ JS}$$

$$K = 1.38065 \times 10^{-23} \text{ J K}^{-1}$$

$$e = 1.602176 \times 10^{-19} \text{ C}$$

$$1 \text{ m}^3 = 10^3 \text{ dm}^3$$

QUESTION ONE (30 MARKS)

1.(a)(i) Briefly discuss how kinetic theory explains the existence of a minimum temperature, ok. [3

marks]

(ii) Write short notes on how kinetic theory explains the greater effusion rate of a gas with a low formula mass compared to one with a higher formula mass. [3 marks]

(iii) Calculate the density of moist air in gm litre^{-1} of moist air at 298.15k and 1 bar pressure when dry air contains 79% nitrogen and 21% oxygen by volume. The relative humidity of moist air is 60%. The aqueous tension at 298.15k is 0.032 bar { $R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$ 1 atm = 1.01325 bar } [3 marks]

(b) (i) From an economic point of view, why would an industrial corporation want to know about the factors that affect the rate of a reaction. [5 marks]

(ii) The reaction iodine with hypochlorite ion OCl^- (which is found in liquid bleach) follows the equation : $\text{OCl}^- + \text{I}^- \rightarrow \text{OI}^- + \text{Cl}^-$

It is a rapid reaction that gives the following rate data

Initial concentration

$$\text{mol L}^{-1}$$

$$\text{OCl}^-$$

$$[\text{I}^-]$$

$$\text{Rate of formation of } \text{Cl}^- (\text{mol L}^{-1} \text{ s}^{-1})$$

1.7×10^{-3}	1.7×10^{-3}	1.75×10^4
3.4×10^{-3}	1.7×10^{-3}	3.5×10^4
1.7×10^{-3}	3.4×10^{-3}	3.50×10^4

- (I) Determine the rate law for the reaction. [2½ marks]
 (II) Calculate the value of the rate constant with its correct units.

(c) The reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ is endothermic, with $\Delta H^\circ = +56.9 \text{ kJ}$. How will the amount of NO_2 at equilibrium be affected by:

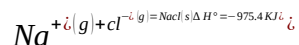
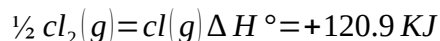
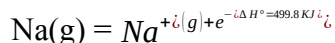
- (i) Adding $N_2O_4(g)$ [1 mark]
 (ii) Lowering the pressure by increasing the volume of the container. [1 mark]
 (iii) Raising the temperature. [1½ marks]
 (iv) Adding a catalyst to the system? [1½ marks]
 (v) Which of the above changes will alter the value of K_c [½ mark]

(d) 25ml of a 0.15M solution of the ammonia solution ($K_b = 1.75 \times 10^{-5}$) is titrated with 0.3 M H_2SO_4 . Calculate the pH at the ;

- (i) Start of titration [2 marks]
 (ii) After addition of 4ml, 6.25 ml and 10ml of titrant. [5 marks]

QUESTION TWO (20 MARKS)

2.(a) (i) Calculate the electron affinity of chlorine from the following data at 298K.



(ii) Using the data (all values in KJ mol^{-1} at 298K) given below. Calculate the bond enthalpies of c-c and C- H bonds.

$$\Delta H^\circ(\text{combustion}) C_2H_6 = -1556.45$$

$$\Delta H^\circ(\text{combustion}) C_2H_6 = -2217.52$$

$$\Delta H^\circ C(S) \rightarrow C(g) = +719.65$$

$$\Delta H^\circ H \rightarrow +436.0$$

$$\Delta H^\circ F H_2O(L) \rightarrow -285.8$$

$$\Delta H^\circ CO_{2(g)} \rightarrow -393.30$$

[5 marks]

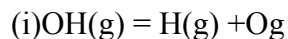
(b) From the data at 298K

$$\frac{1}{2}H_2(g) + \frac{1}{2}O_2(g) = OH(g) \quad \Delta H^\circ = 42.09 \text{ KJ mol}^{-1}$$

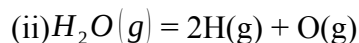
$$H_2(g) + \frac{1}{2}O_2(g) = H_2O(g) \quad \Delta H^\circ = 241.83 \text{ KJ mol}^{-1}$$

$$H_2(g) = 2H(g) \quad \Delta H^\circ = 435.94 \text{ KJ mol}^{-1}$$

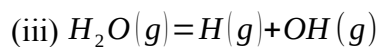
$$O_2(g) + 2O(g) \quad \Delta H^\circ = 495.04 \text{ KJ mol}^{-1}$$

Compute ΔH° for reaction

[1½ marks]

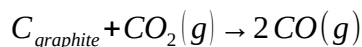


[1½ marks]



[1½ marks]

(c) CO_2 reacts with graphite to form CO. Based on the following data given below, calculate ΔE (change in internal energy for the reaction)

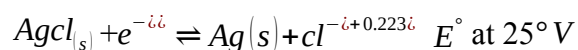


ΔH (enthalpy change) at 25°C and 1.0 bar pressure = 172.46KJ. Density of graphite = 2.25g cm^{-3} {R=8.314J $mol^{-1} K^{-1}$, 1 bar = 10^5 pa, 1 pa = $1NM^{-2} = 1kg m^{-1} s^{-2} = 1Jm^{-3}$ }

[4½ marks]

(d)(i) Calculate the potential of the electrochemical cell shown above. [1½ marks]

(ii) Calculate the concentration of Fe^{3+} in an electrochemical cell similar to that shown above, if the concentration of HCl in the left hand cell is 1.0M, the concentration of $FeCl_2$ in the right hand cell is 0.0151M and the measured potential is +0.546V.



QUESTION THREE (20 MARKS)

3.(a) (i) Write short notes on the following:

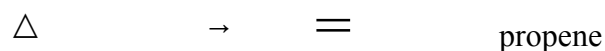
(I) Indicator errors in determination of end point of a titration using visual indicator. [6 marks]

(II) Selection of pH indicator for a particular titration. [2 marks]

(ii) Discuss Buffer capacity. [3 marks]

(iii) Calculate the buffer capacity of a buffer solution containing 0.4M NH_3 and 0.2M NH_4Cl [$pK_b = 4.76$] [3 marks]

(b) For the isomerization of cyclopropane to propene.



Cyclopropane



The following data were obtained

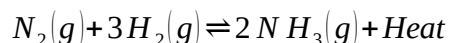
T/°C	477	523	577	623
K_s^{-1}	0.00018	0.0027	0.030	0.26

Calculate without using graph;

- (i) Frequency factor. [5 marks]
- (ii) The activation energy. [$\frac{1}{2}$ mark]
- (iii) Fraction of molecules with minimum energy for reaction at temperature 523°C. [$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$] [$\frac{1}{2}$ mark]

QUESTION FOUR (20 MARKS)

4.(a) (i) For the reaction



Write expression for K_c and K_p and show how they are related when the initial moles of $N_2(g)$ and $H_2(g)$ were different. [6 marks]

(ii) 16.4g potassium iodine was dissolved in 500 cm^3 of water and about 1.0g of iodine was dissolved in 100 cm^3 of benzene. The two solutions were then mixed and allowed to stand subsequent titrations showed 10 cm^3 of the benzene layer was equivalent of 5.1 cm^3 of m/10 sodium thiosulphate while 50 cm^3 of the aqueous layer was equivalent to 2.9 cm^3 of m/10 thiosulphate. The distribution coefficient between benzene and water is 130. Calculate the value of equilibrium reaction $KI + I_2 + KI_3$

[I = 126.9043, O = 15.9994, K = 39.0989, S = 32.066J]

(b) (i) Comment on the following statement: "Gases cannot be liquefied unless their temperature are lowered to values equal to or below their critical temperature. [12 marks]

(ii) The compressibility factor z for N_2 at -50°C and 800—atm pressure is 1.95 and at 100°C and 200 atm it is 1.10. A certain mass of nitrogen occupied a volume of 1.0 litre at -50°C and 800 atm. Calculate the volume occupied by the same quality of nitrogen at 100°C and 200 atm.

[1½ marks]

(c) In an experiment to determine the percentage of gaseous mixture at 25°C , a gas cylinder was evacuated and a gas Y was let in until the pressure was one atmosphere. The cylinder was then weighted and compressed inert gas X was forced in until W grams had been added. If the volume of the cylinder was 82 litres, calculate the;

(i) Mass of gas x that gives a mixture of composition 20 mole percent Y and 80 mole percent X given the molar mass of X is 20g. [3 marks]

(ii) Total pressure of the final of mixture. [1½ marks]
