UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF CHEMICAL SCIENCES
DEGREE: BACHELOR OF ENGINEERING TECHNOLOGY(METALLURGY)

MODULE CETM1B1
ENGINEERING CHEMISTRY 1B

CAMPUS **DFC**

SUPPLEMENTARY EXAMINATION

DATE: 10/01/2020 **SESSION: 08:00 – 11:00**

ASSESSOR **DR J RAMONTJA**

INTERNAL MODERATOR **MR PP MONAMA**

DURATION 3 HOURS **MARKS 120**

NUMBER OF PAGES: 8 PAGES, INCLUDING 2 ANNEXURES

INSTRUCTIONS:

ANSWER SECTION A (THE MULTIPLE CHOICE QUESTIONS) AND SECTION B (LONG QUESTIONS) IN THE SAME ANSWER SCRIPT.

FOR SECTION A, CLEARLY INDICATE THE QUESTION NUMBER AND THE LETTER CHOICE. FOR EXAMPLE 27 = E.

CONSULT THE DATA SHEET AND THE PERIODIC TABLE FOR ALL SUPPLEMENTARY INFORMATION.

ONLY ONE CALCULATOR PER STUDENT IS PERMITTED

GIVE ALL NUMERICAL ANSWERS TO THE CORRECT NUMBER OF SIGNIFICANT FIGURES AND WITH APPROPRIATE UNITS.

REQUIREMENTS: 1 ANSWER SCRIPT.

SECTION A

1. For the following reaction, $\Delta P(C_6H_{14})/\Delta t$ was found to be -6.2×10^{-3} atm/s.

$C_6H_{14}(g) \rightarrow C_6H_6(g) + 4H_2(g)$

Determine $\Delta P(H_2)/\Delta t$ for this reaction at the same time.

A. 6.2×10^{-3} atm/s
B. 1.6×10^{-3} atm/s
C. 2.5×10^{-2} atm/s
D. -1.6×10^{-3} atm/s
E. -2.5×10^{-2} atm/s

2. Which colligative property is based on mole fraction?

A. Freezing point depression
B. Boiling point elevation
C. Osmotic pressure
D. Vapor pressure lowering
E. Plasmolysis

3. Which of the following statements is **false**?

A. A catalyst increases the rate of the forward reaction, but does not alter the reverse rate.
B. A catalyst alters the mechanism of reaction.
C. A catalyst alters the activation energy.
D. A catalyst may be altered in the reaction, but is always regenerated.
E. A catalyst increases the rate of reaction, but is not consumed.

4. For the reaction represented below, the experimental rate law is given by rate = k $[(CH_3)_3CCl]$.

$(CH_3)_3CCl(aq) + OH^- \rightarrow (CH_3)_3COH(aq) + Cl^-$

If some solid sodium hydroxide were added to a solution in which $[(CH_3)_3CCl]$ = 0.01 M and [NaOH] = 0.10 M, which of the following would be *true*? (Assume the temperature and volume remains constant.)

A. Both the reaction rate and k would increase.
B. Both the reaction rate and k would decrease.
C. Both the reaction rate and k would remain the same.
D. The reaction rate would increase but k would remain the same.
E. The reaction rate would decrease but k would remain the same.

5. The pH of 0.0980 $mol.dm^{-3}$ solution of sodium carbonate is:

A. 8.37
B. 10.3
C. 11.6
D. 5.63
E. 9.24

6. Consider the reaction below:

$Cu(OH)_2(s) \rightleftharpoons Cu^{2+}(aq) + 2OH^-(aq)$

0.050 g of solid copper(II) hydroxide is added to 2.00 dm^3 of water in a glass container and the mixture is allowed to reach equilibrium. If thereafter the equilibrium mixture is made alkaline by adding 250 cm^3 of a 0.100 $mol.dm^{-3}$ solution of ammonia, then:

A. less solid copper(II) hydroxide will be left in the container
B. more solid copper(II) hydroxide will precipitate
C. the solubility of solid copper(II) hydroxide will reduce
D. less solid copper(II) hydroxide will dissolve than before
E. the concentration of free copper(II) ions will increase

7. Consider the following equilibria:

$CuS(s) \rightleftharpoons Cu^{2+}(aq) + S^{2-}(aq)$ K_1
$H_2S(aq) \rightleftharpoons H^+(aq) + HS^-(aq)$ K_2
$HS^-(aq) \rightleftharpoons H^+(aq) + S^{2-}(aq)$ K_3
$Cu^{2+}(aq) + H_2S(aq) \rightleftharpoons CuS(s) + 2H^+aq)$ K_4

Which one of the following is true?

A. $K_4 = K_2.K_3.K_1$
B. $K_4 = (K_2.K_3)/K_1$
C. $K_4 = K_1/(K_2.K_3)$
D. $K_4 = K_3/(K_1.K_2)$
E. $K_4 = K_2/(K_1.K_3)$

8. Which of the following types of mixtures exhibit the Tyndall effect?

A. True solutions and suspensions
B. True solutions and colloids;
C. Only true solutions
D. Only colloids;
E. Only suspensions

9. For the reaction $2AC_3(g) \rightleftharpoons A_2(g) + 3C_2(g)$, $K_c = 0.01659$. What will happen when 1.00 mol of $AC_3(g)$, 0.499 mol of $A_2(g)$ and 1.59 mol $C_2(g)$ are added to a 10.0 dm^3 container and allowed to equilibrate?

A. The amount of AC_3 will be halved.
B. More AC_3 will be formed.
C. More A_2 will be formed than C_2.
D. More C_2 will be formed than A_2.
E. The amount of A_2 formed will be double the amount of C_2 formed.

10. One difference between first-order and second-order reactions is that __________.

A. the half-life of a first-order reaction does not depend on $[A]_o$; the half-life of a second-order reaction does depend on $[A]_o$.
B. the rate of both first-order and second-order reactions do not depend on reactant concentrations
C. the rate of a first-order reaction depends on reactant concentrations; the rate of a second-order reaction does not depend on reactant concentrations
D. a first-order reaction can be catalyzed; a second-order reaction cannot be catalyzed
E. None of the above are true.

11. Consider the reaction below:
$Cu^{2+}(aq) + 4CN^{-}(aq) \rightleftharpoons Cu(CN)_4^{2-}(aq)$

A volume of 250 cm^3 of a 0.0325 mol dm^{-3} solution of copper (II) nitrate was mixed with 350 cm^3 of a 0.200 mol dm^{-3} solution of potassium cyanide in a single container. The resulting mixture was then allowed to reach equilibrium. If thereafter a volume of 150.0 cm^3 of a 0.00225 mol dm^{-3} solution of nitric acid was added to the equilibrium mixture, then

A. the concentration of $Cu(CN)_4^{2-}(aq)$ increased
B. the concentration of $Cu(CN)_4^{2-}(aq)$ remained unchanged
C. the concentration of $Cu^{2+}(aq)$ decreased
D. copper (II) nitrate precipitated from the solution
E. the concentration of $Cu^{2+}(aq)$ increased

12. Which transformation cannot take place at the anode of an electrochemical cell?

A. $H_2O \rightarrow H_2O_2$
B. $VO^{2+} \rightarrow VO_2^{+}$
C. $I_2 \rightarrow IO_3^{-}$
D. $CrO_4^{2-} \rightarrow Cr(OH)_3$
E. $[Fe(CN)_6]^{4-} \rightarrow [Fe(CN)_6]^{3-}$

13. The two electrodes $Al(s)/Al^{3+}(aq)$ (0.550 mol.dm^{-3}) and $Cu(s)/Cu^{2+}(aq)$ (0.00110 mol.dm^{-3}) were combined to produce a spontaneous electrochemical reaction. The cell potential for this reaction at 25.0^{o}C is**:**

A. +2.00 V
B. +2.08 V
C. +1.76 V
D. +1.91 V
E. –2.00 V

[13 x3 = 39]

SECTION B

QUESTION 1

1.1 The decomposition of SO_2Cl_2 is a first-order reaction:

$$SO_2Cl_2\ (g) \rightarrow SO_2\ (g) + Cl_2\ (g)$$

The rate constant for the reaction is 2.8×10^{-3} min^{-1} at 600 K. If the initial concentration of SO_2Cl_2 is 1.24×10^{-3} M, how long will it take for concentration to drop to 0.31×10^{-3} M? (6)

1.2 A 0.500 L sample of an aqueous solution containing 10.0 g of hemoglobin has an osmotic pressure of 5.9 torr at 22 °C. What is the molar mass of hemoglobin? (6)

1.3 Consider the following multistep reaction mechanism:

Step 1: $Cl_2(g) \rightarrow 2Cl(g)$

Step 2: $N_2O(g) + Cl(g) \rightarrow N_2(g) + ClO(g)$

Step 3: $ClO(g) + ClO(g) \rightarrow Cl_2(g) + O_2(g)$

1.3.1 Write the overall reaction and the rate law of this reaction. (5)
1.3.2 Identify the intermediate(s) and the catalyst(s) in the above reaction mechanism. Motivate your answers. (5)
1.3.3 What is the molecularity of each of the above elementary processes? (3)

[25]

QUESTION 2

Given the following reaction:

$$COF_2(g) \rightleftharpoons CO(g) + F_2(g)$$

An amount of 7.40 mol of COF_2 is initially placed into a 15.0 dm^3 flexible container at 823 K. At the initial equilibrium the pressure in the container was found to be 3.53×10^6 Pa.
The pressure was then changed and the reaction was allowed to reach a new equilibrium. At this new equilibrium, the moles of CO were 40.00% less than those observed at initial equilibrium.
Calculate the total pressure in the container at the new equilibrium.

[20]

QUESTION 3

A mixture is first made of 240 cm^3 of a 0.412 $mol.dm^{-3}$ solution of silver nitrate and **y** cm^3 of a 2.00 $mol.dm^{-3}$ solution of ammonia. Thereafter, 280 cm^3 of a 0.0116 $mol.dm^{-3}$ solution of sodium chloride is added to this mixture and the resulting solution is diluted to 2.50 dm^3. Calculate the value of **y** that *will just prevent the precipitation* of silver chloride.

[14]

QUESTION 4

The minerals of a 50.0 kg ore sample from a South African mine in Northwest were dissolved by acid leaching to make up a solution whose volume was 25.0 dm^3. When this solution was analysed it was found to contain 0.200 $mol.dm^{-3}$ of Cd^{2+}(*aq*) ions and 0.150 $mol.dm^{-3}$ of Ni^{2+}(*aq*) ions. The solution was then subjected to electrolysis at 25.0^oC. Calculate the mass percentage **purity** of the metal that plated last.

[18]

QUESTION 5

5.1 Calculate the cell potential of the following cell:

$$\text{Fe} \;\Big|\; \begin{array}{l} Fe(CN)_6^{4-}\ (0.200\ mol.dm^{-3}) \\ CN^-\ (0.100\ mol.dm^{-3}) \end{array} \;\Big|\Big|\; H^+\ (\text{pH of } 6.00) \;\Big|\; H_2\ (Pt)$$

[14]

DATA SHEET

Avogadro's number: N = 6.02×10^{23}

$0^{o}C = 273.15$ K

Standard pressure = 1 atm = 101.325 kPa = 760 mmHg = 760 torr = 1.01325 bar

R = 8.31451 L.kPa .K^{-1}.mol^{-1}
= 8.31451 J.K^{-1}.mol^{-1}
= 8.31451×10^{-2} L.bar .K^{-1}.mol^{-1}
= 8.20578×10^{-2} L.atm .K^{-1}.mol^{-1}
= 62.364 L.torr .K^{-1}.mol^{-1}

F = 9.6485×10^{4} C.mol^{-1}

V = J.C^{-1}

Equilibrium constants (T = 25.0°C)

K_{b1} (Sodium carbonate) = 1.79×10^{-4}

K_{b2} (Sodium carbonate) = 2.33×10^{-8}

K_{sp} (copper(II)hydroxide) = 2.2×10^{-20}

K_{sp} (Silver chloride, AgCl) = 1.80×10^{-10}

K_f ($Ag(NH_3)_2^{+}$) = 1.70×10^{7}

K_f ($Fe(CN)_6^{4-}$) = 1.00×10^{35}

Standard reduction potentials (T = 25.0 °C)

E^o red (Al^{3+}/ Al) = –1.66 V

E^o red (Cd^{2+}/ Cd) = –0.403 V

E^o red (Co^{2+}/ Co) = –0.277 V

E^o red (Ni^{2+}/ Ni) = –0.280 V

E^o red (H^{+}/ H_2) = 0.00 V

E^o red (Cu^{2+}/ Cu) = +0.337 V

E^o red (Zn^{2+}/ Zn) = –0.763 V

E^o red (Fe^{2+}/ Fe) = –0.440 V

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Department of Chemical Sciences

Atomic Number | 2 **He** *4.0026* | Atomic Weight

1 **H** *1.0079*																	2 **He** *4.0026*
3 **Li** *6.941*	4 **Be** *9.0122*											5 **B** *10.811*	6 **C** *12.011*	7 **N** *14.007*	8 **O** *15.999*	9 **F** *18.998*	10 **Ne** *20.179*
11 **Na** *22.990*	12 **Mg** *24.305*											13 **Al** *26.982*	14 **Si** *28.086*	15 **P** *30.974*	16 **S** *32.064*	17 **Cl** *35.453*	18 **Ar** *39.948*
19 **K** *39.098*	20 **Ca** *40.078*	21 **Sc** *44.956*	22 **Ti** *47.88*	23 **V** *50.942*	24 **Cr** *51.996*	25 **Mn** *54.938*	26 **Fe** *55.847*	27 **Co** *58.933*	28 **Ni** *58.69*	29 **Cu** *63.546*	30 **Zn** *65.39*	31 **Ga** *69.723*	32 **Ge** *72.61*	33 **As** *74.922*	34 **Se** *78.96*	35 **Br** *79.904*	36 **Kr** *83.80*
37 **Rb** *85.47*	38 **Sr** *87.62*	39 **Y** *88.906*	40 **Zr** *91.224*	41 **Nb** *92.906*	42 **Mo** *95.94*	43 **Tc** *(98)*	44 **Ru** *101.07*	45 **Rh** *102.91*	46 **Pd** *106.42*	47 **Ag** *107.87*	48 **Cd** *112.41*	49 **In** *114.82*	50 **Sn** *118.71*	51 **Sb** *121.75*	52 **Te** *127.60*	53 **I** *126.90*	54 **Xe** *131.29*
55 **Cs** *132.91*	56 **Ba** *137.33*	57 **La** *138.91*	72 **Hf** *178.49*	73 **Ta** *180.95*	74 **W** *183.85*	75 **Re** *186.2*	76 **Os** *190.2*	77 **Ir** *192.22*	78 **Pt** *195.08*	79 **Au** *196.97*	80 **Hg** *200.59*	81 **Tl** *204.38*	82 **Pb** *207.2*	83 **Bi** *208.98*	84 **Po** *(209)*	85 **At** *(210)*	86 **Rn** *(222)*
87 **Fr** *(223)*	88 **Ra** *226.03*	89 **Ac** *227.03*															

58 **Ce** *140.12*	59 **Pr** *140.91*	60 **Nd** *144.24*	61 **Pm** *146.92*	62 **Sm** *150.36*	63 **Eu** *151.97*	64 **Gd** *157.25*	65 **Tb** *158.93*	66 **Dy** *162.50*	67 **Ho** *164.93*	68 **Er** *167.26*	69 **Tm** *168.93*	70 **Yb** *173.04*	71 **Lu** *174.97*
90 **Th** *232.04*	91 **Pa** *231.04*	92 **U** *238.03*	93 **Np** *237.05*	94 **Pu** *(244)*	95 **Am** *(234)*	96 **Cm** *(247)*	97 **Bk** *247*	98 **Cf** *(251)*	99 **Es** *(252)*	100 **Fm** *(257)*	101 **Md** *(258)*	102 **No** *(259)*	103 **Lr** *(260)*