UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UCTATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: DTC 1043
COURSE	: PHYSICAL & ORGANIC CHEMISTRY
SEMESTER/SESSION	: 2 - 2022/2023
DURATION	: 3 HOURS

Instructions:

1. This booklet contains 4 questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 7 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) Volume is affected not just by pressure and temperature, but also by the amount of gas. State the Avogadro's hypothesis. (3 marks)

b) Outline Boyle's and Charles Law concepts. (6 marks)

c) At 25°C, a sample of N_2 gas under a pressure of 689 mmHg occupies 124 mL in a piston-cylinder arrangement before compression. If the gas is compressed to 65% of its original volume, find the new pressure (in atm) at 25°C. (5 marks)

d) 100 g of Argon gas occupies in a 500 L sealed container at 0.8976 atm. Calculate the temperature of Ar gas. (6 marks)
(Given atomic mass of Ar = 40g/mol; R = 0.082 L.atom/mol.K)

e) A gas occupies a volume at 720mL at 37°C and 640 mmHg pressure. By using combined gas law, calculate the volume that gas would occupy at 273K and 1 atm. (5 marks)

QUESTION 2

a) Justify the First Law of Thermodynamic. (3 marks)

b) 25200J of heat is supplied to the system while the system does 6000J of work. Calculate the change of internal energy, ΔU of the system. (4 marks)

c) A 15.5 g of chromium, heated to 100.0 °C, is dropped into 55.5 g of water at 16.5 °C. The final temperature of the metal and water is 18.9 °C. Find the specific heat capacity of chromium. (6 marks)
(Given specific heat capacity of water is 4.184 J g^{-1} K^{-1})

d) Given these reactions and their ΔH values: (7 marks)

$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2\ H_2O(l)$ $\quad \Delta H_f/kJ = -622.3$ kJ

$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$ $\quad \Delta H_f/kJ = -285.8$ kJ

$H_2(g) + O_2(g) \rightarrow H_2O_2(l)$ $\quad \Delta H_f/kJ = -187.8$ kJ

Calculate the value of ΔH_f for the reactions and state that the reaction either endothermic or exothermic.

$$N_2H_4(l) + 2\ H_2O_2(g) \rightarrow N_2(g) + 4\ H_2O(l)$$

e) Show how the equations: (5 marks)

$N_2O_4\ (g) \longrightarrow 2NO_2\ (g)$ $\quad \Delta Hf° = +\ 57.93$ kJ mol^{-1}

$2NO\ (g) + O_2\ (g) \longrightarrow 2NO_2\ (g)$ $\quad \Delta Hf° = -\ 113.14$ kJ mol^{-1}

can be manipulated to give ΔH_f for the following reaction:

$2\ NO\ (g) + O_2\ (g) \longrightarrow N_2O_4\ (g)$

QUESTION 3

a) For a reaction of, (3 marks)

Rate = k $[A]^2$ [B]

Solve the order of each reactant and the overall order of the reaction.

b) The following data were obtained for the reaction of NH_4^+ with NO_2^- ion at 55 °C.

$$NH_4^+(aq) + NO_2^-(aq) \rightarrow N_2(g) + 2\ H_2O(\ell)$$

Expt.	$[NH_4^+]$	$[NO_2^-]$	Initial rate (mol/L.s)
1	0.010	0.020	0.020
2	0.015	0.020	0.030
3	0.010	0.010	0.005

i) Find the order of the reaction with respect to $NH4^+$, NO_2^- and overall reaction. (7 marks)

ii) Write the rate expression for the reaction. (2 marks)

iii) Calculate the rate constant, k for the reaction. (4 marks)

c) Construct the molecular structure for each of the following.

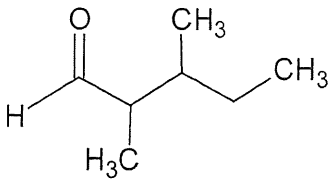
i) 4-methyl-2-pentanol (3 marks)

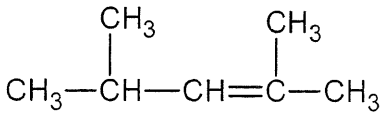
ii) 3-methyl-2-hexanone (3 marks)

iii) 4-chloro-2-hydroxyheptanal (3 marks)

QUESTION 4

a) Interpret the molecular structure below and name the compounds.

i)  (3 marks)

ii)  (3 marks)

b) Define galvanic cell. (2 marks)

c) Explain a salt bridge. (2 marks)

d) For the following voltaic cell reaction (at standard condition, Zn and Cu as the electrodes in their respective ionic solution):

i) Construct the schematic diagram for the voltaic cell. (4 marks)

ii) Write two half-cell reactions that takes place at anode and cathode. (3 marks)

iii) State the total cell reaction. (3 marks)

e) Calculate the cell potential (Ecell) of this reaction at 25°C.

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ $E°=0.4594$ (5 marks)

The concentration are $[Zn^{2+}] = 0.020$ M, $[Cu^{2+}]= 0.004$ M

----------End of question----------

APPENDIX I

THE PERIODIC TABLE

Legend: H — SYMBOL; 1 — ATOMIC NUMBER; 1.008 — ATOMIC WEIGHT; Hydrogen — NAME

( ) = ESTIMATES

	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	H 1 1.008 Hydrogen																	He 2 4.00 Helium
2	Li 3 6.94 Lithium	Be 4 9.01 Beryllium											B 5 10.81 Boron	C 6 12.01 Carbon	N 7 14.01 Nitrogen	O 8 16.00 Oxygen	F 9 19.00 Fluorine	Ne 10 20.18 Neon
3	Na 11 22.99 Sodium	Mg 12 24.31 Magnesium											Al 13 26.98 Aluminum	Si 14 28.09 Silicon	P 15 30.97 Phosphorus	S 16 32.07 Sulfur	Cl 17 35.45 Chlorine	Ar 18 39.95 Argon
4	K 19 39.10 Potassium	Ca 20 40.08 Calcium	Sc 21 44.96 Scandium	Ti 22 47.88 Titanium	V 23 50.94 Vanadium	Cr 24 52.00 Chromium	Mn 25 54.94 Manganese	Fe 26 55.85 Iron	Co 27 58.93 Cobalt	Ni 28 58.69 Nickel	Cu 29 63.55 Copper	Zn 30 65.39 Zinc	Ga 31 69.72 Gallium	Ge 32 72.61 Germanium	As 33 74.92 Arsenic	Se 34 78.96 Selenium	Br 35 79.90 Bromine	Kr 36 83.80 Krypton
5	Rb 37 85.47 Rubidium	Sr 38 87.62 Strontium	Y 39 88.91 Yttrium	Zr 40 91.22 Zirconium	Nb 41 92.91 Niobium	Mo 42 95.94 Molybdenum	Tc 43 (97.9) Technetium	Ru 44 101.07 Ruthenium	Rh 45 102.91 Rhodium	Pd 46 106.42 Palladium	Ag 47 107.87 Silver	Cd 48 112.41 Cadmium	In 49 114.82 Indium	Sn 50 118.71 Tin	Sb 51 121.76 Antimony	Te 52 127.60 Tellurium	I 53 126.90 Iodine	Xe 54 131.29 Xenon
6	Cs 55 132.91 Cesium	Ba 56 137.33 Barium	La 57 138.91 Lanthanum	Hf 72 178.49 Hafnium	Ta 73 180.95 Tantalum	W 74 183.85 Tungsten	Re 75 186.21 Rhenium	Os 76 190.2 Osmium	Ir 77 192.22 Iridium	Pt 78 195.08 Platinum	Au 79 196.97 Gold	Hg 80 200.59 Mercury	Tl 81 204.38 Thallium	Pb 82 207.2 Lead	Bi 83 208.98 Bismuth	Po 84 (209) Polonium	At 85 (210) Astatine	Rn 86 (222) Radon
7	Fr 87 223.02 Francium	Ra 88 226.03 Radium	Ac 89 227.03 Actinium	Rf 104 (261) Rutherfordium	Db 105 (262) Dubnium	Sg 106 (263) Seaborgium	Bh 107 (262) Bohrium	Hs 108 (265) Hassium	Mt 109 (266) Meitnerium	Unnamed Discovery 110 Nov. 1994	Unnamed Discovery 111 Nov. 1994	Unnamed Discovery 112 1996		Unnamed Discovery 114 1999		Unnamed Discovery 116 1999		Unnamed Discovery 118 1999
	ALKALI METALS	ALKALI EARTH METALS															HALOGENS	NOBLE GASES

LANTHANIDES	Ce 58 140.12 Cerium	Pr 59 140.91 Praseodymium	Nd 60 144.24 Neodymium	Pm 61 (145) Promethium	Sm 62 150.36 Samarium	Eu 63 152.97 Europium	Gd 64 157.25 Gadolinium	Tb 65 158.93 Terbium	Dy 66 162.50 Dysprosium	Ho 67 164.93 Holmium	Er 68 167.26 Erbium	Tm 69 168.93 Thulium	Yb 70 173.04 Ytterbium	Lu 71 174.97 Lutetium
ACTINIDES	Th 90 232.04 Thorium	Pa 91 231.04 Protactinium	U 92 238.03 Uranium	Np 93 237.05 Neptunium	Pu 94 (240) Plutonium	Am 95 243.06 Americium	Cm 96 (247) Curium	Bk 97 (248) Berkelium	Cf 98 (251) Californium	Es 99 252.08 Einsteinium	Fm 100 257.10 Fermium	Md 101 (257) Mendelevium	No 102 259.10 Nobelium	Lr 103 262.11 Lawrencium

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APPENDIX II

Ideal Gas Law

$PV = nRT$

Heat capacity

$E = mc\Delta T$

Titration

$M_1V_1 = M_2V_2$

Summary of the Kinetics of Zero-Order, First-Order and Second-Order Reactions

Order	Rate Law	Concentration-Time Equation	Half-Life
0	rate = k	$[A] - [A]_0 = -kt$	$t_{1/2} = \frac{[A]_0}{2k}$
1	rate = k [A]	$\ln[A] - \ln[A]_0 = -kt$	$t_{1/2} = \frac{\ln 2}{k}$
2	rate = k [A]^2	$\frac{1}{[A]} - \frac{1}{[A]_0} = kt$	$t_{1/2} = \frac{1}{k[A]_0}$

TABLE 19.1 Standard Electrode (Reduction) Potentials in Aqueous Solution at 25°C*

Cathode (Reduction) Half-Reaction	Standard Potential, $E°$ (V)
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	−3.04
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	−2.71
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	−2.38
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	−1.66
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	−0.83
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76
$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s)$	−0.74
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	−0.41
$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$	−0.40
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	−0.23
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	−0.14
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	−0.13
$Fe^{3+}(aq) + 3e^- \rightleftharpoons Fe(s)$	−0.04
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	0.15
$Cu^{2+}(aq) + e^- \rightleftharpoons Cu^+(aq)$	0.16
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	0.34
$IO^-(aq) + H_2O(l) + 2e^- \rightleftharpoons I^-(aq) + 2OH^-(aq)$	0.49
$Cu^+(aq) + e^- \rightleftharpoons Cu(s)$	0.52
$I_2(s) + 2e^- \rightleftharpoons 2I^-(aq)$	0.54
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	0.77
$Hg_2^{2+}(aq) + 2e^- \rightleftharpoons 2Hg(l)$	0.80
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	0.80
$Hg^{2+}(aq) + 2e^- \rightleftharpoons Hg(l)$	0.85
$ClO^-(aq) + H_2O(l) + 2e^- \rightleftharpoons Cl^-(aq) + 2OH^-(aq)$	0.90
$2Hg^{2+}(aq) + 2e^- \rightleftharpoons Hg_2^{2+}(aq)$	0.90
$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightleftharpoons NO(g) + 2H_2O(l)$	0.96
$Br_2(l) + 2e^- \rightleftharpoons 2Br^-(aq)$	1.07
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	1.23
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightleftharpoons 2Cr^{3+}(aq) + 7H_2O(l)$	1.33
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	1.36
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	1.49
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	1.78
$S_2O_8^{2-}(aq) + 2e^- \rightleftharpoons 2SO_4^{2-}(aq)$	2.01
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	2.87