UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF CHEMISTRY

MODULE: CEM2A20 / CEM 02A2 (Intermediate Physical Chemistry)

CAMPUS: APK

EXAM Supplimentary Exam - 2019

DATE: June 2019 **TIME:**

ASSESSOR: **Dr. S. Sitha**

MODERATOR: **Prof. R. Meijboom**

DURATION: 3 Hours **Total Marks: 100**

NUMBER OF PAGES: 4 Pages (Including this page and a periodic table)

INSTRUCTIONS: Answer all the questions. Using of a non-graphing scientific calculator is allowed.

Important Equations & Physical Constants:

Trigonometric identities:	$Sin^2\theta = \frac{1-cos2\theta}{2}$	$\sin 2\theta = 2 \sin\theta \,.\, \cos\theta$ $2\text{Sin}\theta.\text{Sin}\phi = \text{Cos}(\theta-\phi) - \text{Cos}(\theta+\phi)$

Planck's Constant	h	6.626×10^{-34} J•S,	6.626×10^{-34} kg•m^2•S^{-1}
Universal Gas Constant	R	8.314 J• K^{-1}•mol^{-1}, 0.082 L•atm• K^{-1}•mol^{-1},	1.986 cal• K^{-1}•mol^{-1},

Question 1: (10 marks)

Consider a system containing 63.998 grams of O_2 (an ideal gas). This system then undergoes an isothermal reversible expansion process at 25 °C. During this process the volume changed from 15.0 litres to 50.0 L. Calculate the change in internal energy, work-done, heat exchanged and change in entropy during the process.

Question 2: (23 marks)

Consider a system containing 20.0 L of gaseous N_2 (an ideal gas) is at 10 atm pressure and 25 °C of temperature. The system undergoes an adiabatic reversible expansion process until the pressure got reduced to 1 atm. Calculate the work-done.

Question 3: (6 marks)

In a thermal fuel cell, a combustion reaction of propane is happening at standard temperature condition. Calculate change in the standard Gibbs' free energy for the reaction using the data shown below.

$\Delta_f G^0$ of $CO_2(g)$ = -394.36 kJ.mol^{-1}
$\Delta_f G^0$ of $H_2O(l)$ = -237.13 kJ.mol^{-1}
$\Delta_f G^0$ of $C_3H_8(g)$ = -23.49 kJ.mol^{-1}

Question 4: (7 marks)

When ammonia gas reacts with gaseous oxygen it produces gaseous nitric oxide and water vapor. If the change in internal energy for the reaction is 9080.0 J and the change in the entropy for the reaction is 35.7 JK^{-1} at 27 ºC, using Gibb's free energy equation, predict whether at 27 ºC, the reaction is spontaneous or not.

Question 5: (4 marks)

Calculate the change in Gibb's Free energy for the following reaction and predict whether the reaction is spontaneous under standard conditions or not?

$$4\ KClO_{3\ (s)} \rightarrow 3KClO_{4\ (s)} + KCl_{\ (s)}$$

Given:

	ΔH_f^0 (kJ/mol)	S^0(J/mol.K)
$KClO_{3\ (s)}$	-397.7	143.1
$KClO_{4\ (s)}$	-432.8	151.0
$KCl_{\ (s)}$	-436.7	82.6

Question 6: (17 marks)

A quantum mechanical particle is confined to move in one dimension between $x = 0$ and $x = L$.

(a) Write the mathematical expression for the wave function of the above particle in its ground state.

(b) Determine the value of the normalization constant, '***A***' and write the final normalized wave function.

(c) Using the normalized wave function as found in the part 2(a), find the probability that the particle will be found between $x = 0$ and $x = L/3$.

Question 7: (8 marks)

Show that the function e^{-3ikx} is eigenfunction of one dimensional kinetic energy operator. What is the eigen value?

Question 8: (25 marks)

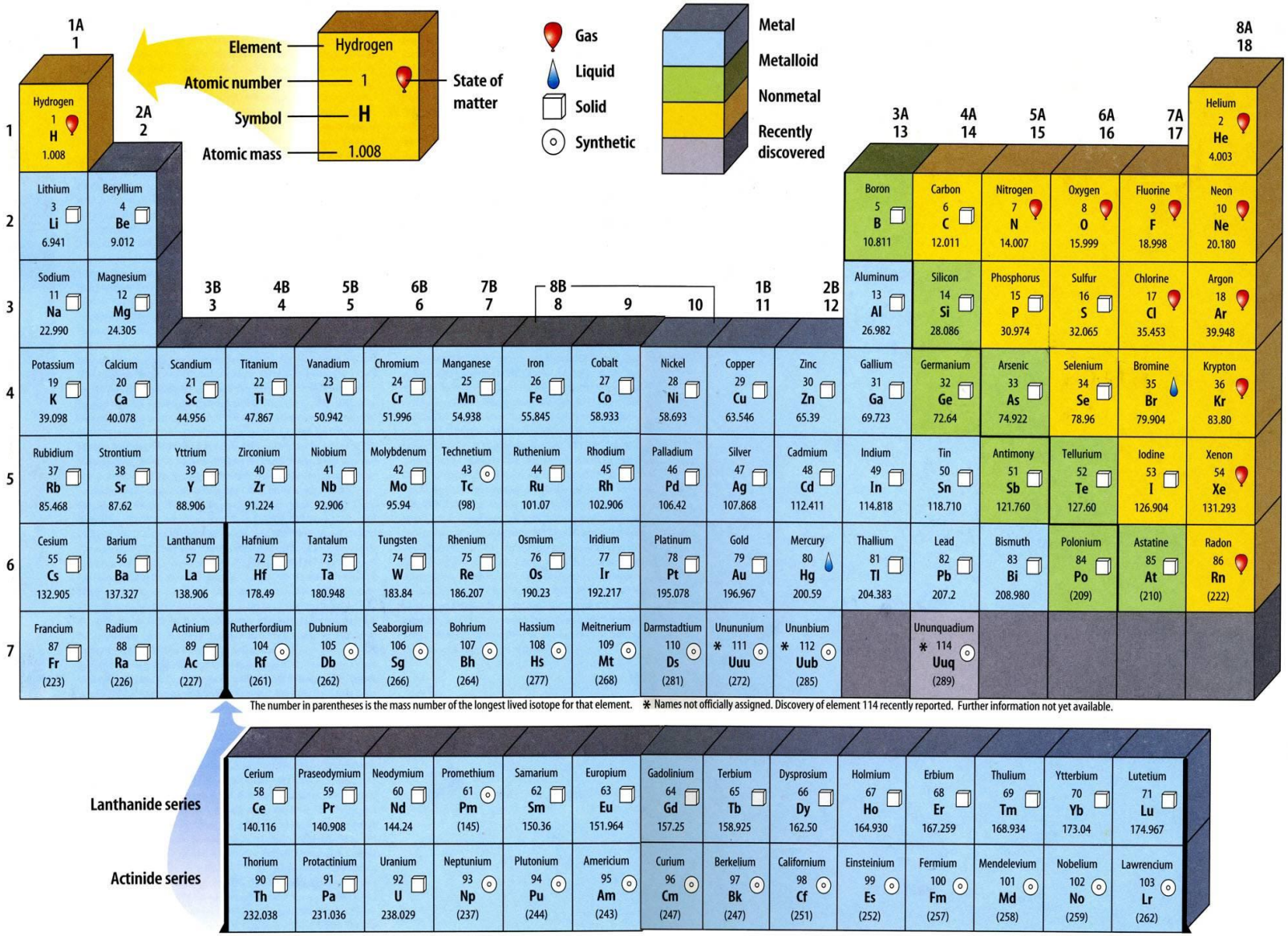
(a) In a gaseous reaction, the time for half change ($t_{1/2}$) for various initial partial pressures (P) are recorded as follows:

P(mm of Hg)	***500***	***600***	***800***	***1000***
$t_{1/2}$ (mins)	***268***	***223***	***168***	***134***

What is the trend for $t_{1/2}$ with respect to the increase in the initial partial pressures? Based on the trend, assign whether the reaction is either 0^{th} order or 1^{ST} order or 2^{ND} order and explain the reason behind your choice. Then using the appropriate $t_{1/2}$ equation for the above assigned order, calculate the values of 'k' at various partial pressures and confirm the above order of the reaction.

(b) For a first order reaction, the values of k, A and E_a are 1.155×10^{-3} sec^{-1}, 4.0×10^{13} sec^{-1} and 98.6 kJ mol^{-1}, respectively. Calculate the value of temperature.

(c) Show that in the case of a first order reaction, the time taken for the completion of 99.9% of the reaction is approximately 10 times of the half-life of the reaction.


Element
Hydrogen
Atomic number
1
Symbol
H
Atomic mass
1.008
State of matter
Gas
Liquid
Solid
Synthetic
Metal
Metalloid
Nonmetal
Recently discovered
1A 1
2A 2
3A 13
4A 14
5A 15
6A 16
7A 17
8A 18
3B 3
4B 4
5B 5
6B 6
7B 7
8B 8
9
10
1B 11
2B 12
Hydrogen 1 H 1.008
Helium 2 He 4.003
Lithium 3 Li 6.941
Beryllium 4 Be 9.012
Boron 5 B 10.811
Carbon 6 C 12.011
Nitrogen 7 N 14.007
Oxygen 8 O 15.999
Fluorine 9 F 18.998
Neon 10 Ne 20.180
Sodium 11 Na 22.990
Magnesium 12 Mg 24.305
Aluminum 13 Al 26.982
Silicon 14 Si 28.086
Phosphorus 15 P 30.974
Sulfur 16 S 32.065
Chlorine 17 Cl 35.453
Argon 18 Ar 39.948
Potassium 19 K 39.098
Calcium 20 Ca 40.078
Scandium 21 Sc 44.956
Titanium 22 Ti 47.867
Vanadium 23 V 50.942
Chromium 24 Cr 51.996
Manganese 25 Mn 54.938
Iron 26 Fe 55.845
Cobalt 27 Co 58.933
Nickel 28 Ni 58.693
Copper 29 Cu 63.546
Zinc 30 Zn 65.39
Gallium 31 Ga 69.723
Germanium 32 Ge 72.64
Arsenic 33 As 74.922
Selenium 34 Se 78.96
Bromine 35 Br 79.904
Krypton 36 Kr 83.80
Rubidium 37 Rb 85.468
Strontium 38 Sr 87.62
Yttrium 39 Y 88.906
Zirconium 40 Zr 91.224
Niobium 41 Nb 92.906
Molybdenum 42 Mo 95.94
Technetium 43 Tc (98)
Ruthenium 44 Ru 101.07
Rhodium 45 Rh 102.906
Palladium 46 Pd 106.42
Silver 47 Ag 107.868
Cadmium 48 Cd 112.411
Indium 49 In 114.818
Tin 50 Sn 118.710
Antimony 51 Sb 121.760
Tellurium 52 Te 127.60
Iodine 53 I 126.904
Xenon 54 Xe 131.293
Cesium 55 Cs 132.905
Barium 56 Ba 137.327
Lanthanum 57 La 138.906
Hafnium 72 Hf 178.49
Tantalum 73 Ta 180.948
Tungsten 74 W 183.84
Rhenium 75 Re 186.207
Osmium 76 Os 190.23
Iridium 77 Ir 192.217
Platinum 78 Pt 195.078
Gold 79 Au 196.967
Mercury 80 Hg 200.59
Thallium 81 Tl 204.383
Lead 82 Pb 207.2
Bismuth 83 Bi 208.980
Polonium 84 Po (209)
Astatine 85 At (210)
Radon 86 Rn (222)
Francium 87 Fr (223)
Radium 88 Ra (226)
Actinium 89 Ac (227)
Rutherfordium 104 Rf (261)
Dubnium 105 Db (262)
Seaborgium 106 Sg (266)
Bohrium 107 Bh (264)
Hassium 108 Hs (277)
Meitnerium 109 Mt (268)
Darmstadtium 110 Ds (281)
* Ununnunium 111 Uuu (272)
* Ununbium 112 Uub (285)
* Ununquadium 114 Uuq (289)
The number in parentheses is the mass number of the longest lived isotope for that element.
* Names not officially assigned. Discovery of element 114 recently reported. Further information not yet available.
Lanthanide series
Cerium 58 Ce 140.116
Praseodymium 59 Pr 140.908
Neodymium 60 Nd 144.24
Promethium 61 Pm (145)
Samarium 62 Sm 150.36
Europium 63 Eu 151.964
Gadolinium 64 Gd 157.25
Terbium 65 Tb 158.925
Dysprosium 66 Dy 162.50
Holmium 67 Ho 164.930
Erbium 68 Er 167.259
Thulium 69 Tm 168.934
Ytterbium 70 Yb 173.04
Lutetium 71 Lu 174.967
Actinide series
Thorium 90 Th 232.038
Protactinium 91 Pa 231.036
Uranium 92 U 238.029
Neptunium 93 Np (237)
Plutonium 94 Pu (244)
Americium 95 Am (243)
Curium 96 Cm (247)
Berkelium 97 Bk (247)
Californium 98 Cf (251)
Einsteinium 99 Es (252)
Fermium 100 Fm (257)
Mendelevium 101 Md (258)
Nobelium 102 No (259)
Lawrencium 103 Lr (262)