UNIVERSITY OF JOHANNESBURG

CEM 1AC1 JUNE 2019 EXAMINATION

EXAMINERS:	**MR A. M. HAMESE**
MODERATOR:	**DR C. ARDERNE**
DATE:	**JUNE 2019**
TIME:	**3 HOURS**
MARKS:	**100**

INSTRUCTIONS:

1. This paper consists of 8 pages including A PERIODIC TABLE AND FUNDAMENTAL CONSTANTS.
2. There are a total of **5 QUESTIONS** in this examination paper.
3. Calculators are allowed but **no cell phones and/or tablets** may be used.
4. All answers **must** be reported to the correct number of significant figures, be in scientific notation and include the correct units.

QUESTION 1 **[20]**

1.1 Write a formula for the ionic compound that forms between the following elements: (a) Zinc and sulfur. (b) Rubidium and bromine. (2)

1.2 Name an element in the 3rd period of the periodic table with the following:

a) Three valence electrons. (1)

b) Four 3p electrons. (1)

1.3 A cube of gold that has the length of side of 1.00 cm has a density of 19.3 g/cm^3. A single gold atom has a mass of 197.0 amu.

(a) How many gold atoms are in the cube? (1)

(b) Determine the volume (in liters) of the gold cube that has the length of one side being 2.00 cm. (2)

1.4 Suppose an empty room is 340 cm wide by 3.60 m long by 26.0 dm high and has an air conditioner that exchanges air at a rate of 1200 dm^3.min^{-1}. How long (in hours) would it take the air conditioner to exchange all the air in the room?

(3)

1.5 Two samples of sodium chloride were decomposed into their constituent elements. One sample produced 6.98 g of sodium and 10.7 g of chlorine, and the other sample produced 11.2 g of sodium and 17.3 g of chlorine. Are these results consistent with the law of definite proportions? (4)

1.6 Bromine has two naturally occurring isotopes (Br-79 and Br-81) and has an atomic mass of 79.904 amu. The mass of Br-81 is 80.9163 amu, and its natural abundance is 49.31%. Calculate the mass and the natural abundance of Br-79.

(4)

1.7 Which of the following electron configurations is not allowed and why?

(2)

[redacted]

QUESTION 2 **[20]**

2.1 Based on periodic trends choose the larger atom or ion in each pair and explain the reason for your choice.

a) Ga or Br (2)

b) S or S^{2-} (2

c) In **(a)** which atom will have the highest 1st ionization energy and why? (2)

2.2 Give the name of the element having the following electron configuration:

a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$ (1)

b) Draw the orbital energy level diagram for the ground state of an atom of this element. Show electrons and label the orbitals. (2)

c) Is this atom paramagnetic or diamagnetic? (1)

2.3 Give the systematic name for the following compounds. In each case state whether they are molecular or ionic compounds.

a) $Pb(C_2H_3O_2)_2$ (2)

b) $NaBrO_4$ (2)

2.4 How many molecules are in 55.93 kg of $NaHCO_3$? (3)

2.5 According to VSEPR theory, what determines the geometry of a molecule? (1)

2.6 Give the correct electron and the molecular geometries of a molecule with five electron groups around a central atom: three bonding pairs and two lone pairs. (2)

QUESTION 3 **[20]**

3.1 Calculate the empirical formula for methyl butyrate (component of apple taste and smell), based on its elemental mass percent composition: C 58.80%, H 9.87%, O 31.33%. (5)

3.2 Are the following molecules polar or non-polar? Explain your choice by Lewis structure drawings with net dipole moment determinations.

(a) $AlCl_3$ (2)
(b) OCS (2)
(c) SF_6 (2)

3.3 Write a balanced chemical equation for the reaction of aqueous potassium hydroxide with aqueous iron(III)chloride to form solid iron(III)hydroxide and aqueous potassium chloride. (4)

3.4 Magnesium oxide can be made by heating magnesium metal in the presence of oxygen. The balanced equation for the reaction is:

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

When 10.1 g of Mg reacts with 10.5 g of O_2, 11.5 g of MgO is collected.

a) Determine the limiting reactant. (3)

b) Calculate the theoretical yield. (1)

c) Calculate the percentage yield. (1)

QUESTION 4 **[20]**

4.1 Identify the oxidizing agent and the reducing agent for the following reactions:

a) $4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$ (2)

b) $Mg(s) + Fe^{2+}(aq) \rightarrow Mg^{2+}(aq) + Fe(s)$ (2)

4.2 How does the density of a gas depend on temperature, pressure, and the molar mass of the gas? (3)

4.3 What is the total pressure exerted by a gaseous mixture that consists of 8.00 g of methane (CH_4) and 12.00 g of ethane (C_2H_6) in a 3.50 L container maintained at 35.20 °C. (4)

4.4 A 0.384 g mass of gas is collected in a flask of volume 250 cm^3. The pressure in the flask at 25 °C is 120 kPa. Is the gas O_2 or N_2? Show you calculation. (4)

4.5 To what volume should you dilute 125 ml of an 8.00 M $CuCl_2$ solution so that 50.0 ml of the diluted solution contains 8.33 g of $CuCl_2$? (5)

QUESTION 5 **[20]**

5.1 A gas mixture contains 1.25 g N_2 and 0.85 g O_2 in a 1.55 L container at 18℃ . Calculate the mole fraction and the partial pressure of each component in the gas mixture. (6)

5.2 If a 3.5 ml sample of 6.8 M HCl is added to 105 ml of water,what is the final concentration of HCl? (2)

5.3 Consider the titration of a 35.0 ml sample of 0.175 M HBr with 0.200M KOH. Calculate the following:

(a) The initial pH (2)

(b) The volume of added base required to reach the equivalence point. (5)

5.4 Consider the reaction: $2N_2(g) + O_2(g) \leftrightarrow 2N_2O(g)$

An equilibrium mixture of this reaction at a certain temperature was found to have $[N_2]$ = 3.6 M, $[O_2]$ = 4.1 M, and $[N_2O] = 3.3 \times 10^{-18}$ M. What is the value of the equilibrium constant (K_c) at this temperature? (3)

5.5 Name the hybridization scheme that corresponds to the following electron geometry:

(a) Tetrahedral (b) Trigonal bipyramidal (2)

The Periodic Table

Period	1	2	3	4	5	6	7	8	9	10	11	12	13/III	14/IV	15/V	16/VI	17/VII	18/VIII
								1 H 1.008										2 He 4.003
2	3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
6	55 Cs 132.9	56 Ba 137.3	La-Lu	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po 210.0	85 At 210.0	86 Rn 222.0
7	87 Fr 223.0	88 Ra 226.0	Ac-Lr	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	......								
	s block		d block										p block					

Lanthanides	57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm 144.9	62 Sm 150.4	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
Actinides	89 Ac 227.0	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.0	94 Pu 239.1	95 Am 243.1	96 Cm 247.1	97 Bk 247.1	98 Cf 252.1	99 Es 252.1	100 Fm 257.1	101 Md 256.1	102 No 259.1	103 Lr 260.1
	f block														

FUNDAMENTAL CONSTANTS AND CONVERSION FACTORS

Avogadro's number (N_A) = 6.022 x 10^{23} mol^{-1}

Gas Constant (R) = 8.314 J K^{-1} mol^{-1} (8.314 kPa dm^3 K^{-1} mol^{-1})

= 0.082 dm^3 atm K^{-1} mol^{-1}

= 0.082 L atm K^{-1} mol^{-1}

Molar gas volume = 22.4 dm^3 mol^{-1} at STP (0 °C and 1 atm pressure)

1 atm = 760 mm Hg = 760 torr = 101.3 kPa

1 bar = 1 x 10^5 Pa (100 kPa)

Electronegativity → H 2.1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Li 1.0	**Be** 1.5											**B** 2.0	**C** 2.5	**N** 3.0	**O** 3.5	**F** 4.0
Na 0.9	**Mg** 1.2											**Al** 1.5	**Si** 1.8	**P** 2.1	**S** 2.5	**Cl** 3.0
K 0.8	**Ca** 1.0	**Sc** 1.3	**Ti** 1.5	**V** 1.6	**Cr** 1.6	**Mn** 1.5	**Fe** 1.8	**Co** 1.8	**Ni** 1.8	**Cu** 1.9	**Zn** 1.6	**Ga** 1.6	**Ge** 1.8	**As** 2.0	**Se** 2.4	**Br** 2.8
Rb 0.8	**Sr** 1.0	**Y** 1.2	**Zr** 1.4	**Nb** 1.6	**Mo** 1.8	**Tc** 1.9	**Ru** 2.2	**Rh** 2.2	**Pd** 2.2	**Ag** 1.9	**Cd** 1.7	**In** 1.7	**Sn** 1.8	**Sb** 1.9	**Te** 2.1	**I** 2.5
Cs 0.7	**Ba** 0.9	**La-Lu** 1.1-1.2	**Hf** 1.3	**Ta** 1.5	**W** 1.7	**Re** 1.9	**Os** 2.2	**Ir** 2.2	**Pt** 2.2	**Au** 2.4	**Hg** 1.9	**Tl** 1.8	**Pb** 1.8	**Bi** 1.9	**Po** 2.0	**At** 2.2
Fr 0.7	**Ra** 0.9	**Ac-No** 1.1-1.7														