CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN AGRICULTURAL EDUCATION AND EXTENSION

CHEM 102: GENERAL INORGANIC AND PHYSICAL CHEMISTRY

STREAMS: BSC **TIME: 2 HOURS**

DAY/DATE: WEDNESDAY 16/12/2020 **8.30 A.M. – 10.30 A.M.**

INSTRUCTIONS

- **Answer question ONE and any other TWO questions.**

QUESTION ONE (30 MARKS)

a) Define the following terms (2 marks)
   i. Isotopes
   ii. Mass number

b) Copper is made of two isotopes. Copper-63 is 69.17% abundant and it has a mass of 62.9296 amu. Copper-65 is 30.83% abundant and it has a mass of 64.9278 amu. Calculate the weighted average mass of the two isotopes. (2 marks)

c) A sample of gas has an initial volume of 158 mL at a pressure of 735 mm Hg and a temperature of 34^{o}C. If the gas is compressed to a volume of 108 mL and heated to a temperature of 85^{o}C, calculate its final pressure in millimeters of mercury. (3 marks)

d) Consider the following species; Na;Ni; F^-
   i. Write the ground state electronic configuration for each of the species (3 marks)
   ii. Write the orbital diagram for Na andNi (2 marks)

e) State the four quantum numbers and describe their significance. (4 marks)

f) Nitrogen dioxide (NO) is a component of urban smog that forms from gases in car exhaust. Determine the number of molecules present in 8.92 g of nitrogen dioxide. (3 marks)

g) Anabolic steroids are sometimes used illegally by athletes to increase muscle strength. A forensic chemist analyzes some tablets suspected of being a popular steroid. He determines that the substance in the tablets contains only C, H, and O and has a molar mass of 300.42 g/mol. When a 1.200-g sample is studied by combustion analysis, 3.516 g of CO_2 and 1.007 g of H_2O are collected. Determine the empirical and molecular formulae of the substance in the tablets. (6 marks)

h) Briefly discuss the covalent bonding. (2marks)

i) Calculate the pH of sodium hydroxide solution in which $[OH^-] = 3.5 \times 10^{-3}$ M. (3 marks)

QUESTION TWO (20 MARKS)

a) The reaction N_2O_4 (g) ⇌ $2NO_2$ (g) is endothermic, with ΔH = +56.9 KJ. Explain how the amount of NO_2 at equilibrium will be affected by; (4 marks)

(i) By adding N_2O_4
(ii) Lowering the pressure by increasing the volume of the container.
(iii) Raising the temperature
(iv) Adding a catalyst to the system

b) For the reaction CO (g) + H_2O (g) ⇌ CO_2 (g) + H_2 (g), the equilibrium constant (Kc) at 800K is 4.24. Calculate the equilibrium concentrations of CO_2, H_2, CO and H_2O at 800 K, if only CO and H_2O are present initially at concentrations of 0.10 M each. (5 marks)

c) Identify the acid, base, conjugate acid and the conjugate base in the following reaction.(2 marks)
HI (g) + NH_3 (g) ⇌NH_4^+(aq) + I^-(aq)

d) Given that $K_W = 1.0 \times 10^{-14}$, calculate at 25°C;

i. the $[H^+]$ and pH of a tap water sample in which $[OH^-] = 2.0 \times 10^{-7}$ (3 marks)
ii. the $[H^+]$ and $[OH^-]$ of human blood at pH 7.40. (3 marks)
iii. the pOH of a solution in which $[H^+] = (5.0)[OH^-]$. (3 marks)

QUESTION THREE (20 MARKS)

a(i) Draw Lewis structures of the following molecules/ions (i) H_2S (ii) SO_3 (iii) CO_2 (iv) BF_3 (v) NO_3^- (5 marks)

(ii) Determine the molecular geometry of (i) CO_2 (ii) H_2S (iii) BF_3 (3 marks)

(iii) Draw the resonance structures for NO_3^- (1 mark)

b) State the postulates of Bohr's model of an atom. (3 marks)

c) Calculate the wavelength in nanometers of a transition in a hydrogen atom from n=5 to n=2 ($R_H = 1.097\times 10^{-2}$ nm^{-1}) (2 marks)

d) Explain briefly how the following properties of the elements vary across a period and down a group in the periodic table (6 marks)

i. Atomic radius
ii. Ionization energy
iii. Electronegativity

QUESTION FOUR (20 MARKS)

a) Derive the ideal gas law, explaining each term as used in the equation. (3 marks)

b) A student collected a sample of a gas in a 220 ml gas bulb until its pressure reached575 torr at a temperature of 25.0°C. Its mass was found to be 0.299g. What is the molecular mass of the gas? {1atm=760 torr, 1ml=10^{-3}L, R=0.0821 L atm $mol^{-1}K^{-1}$} (3 marks)

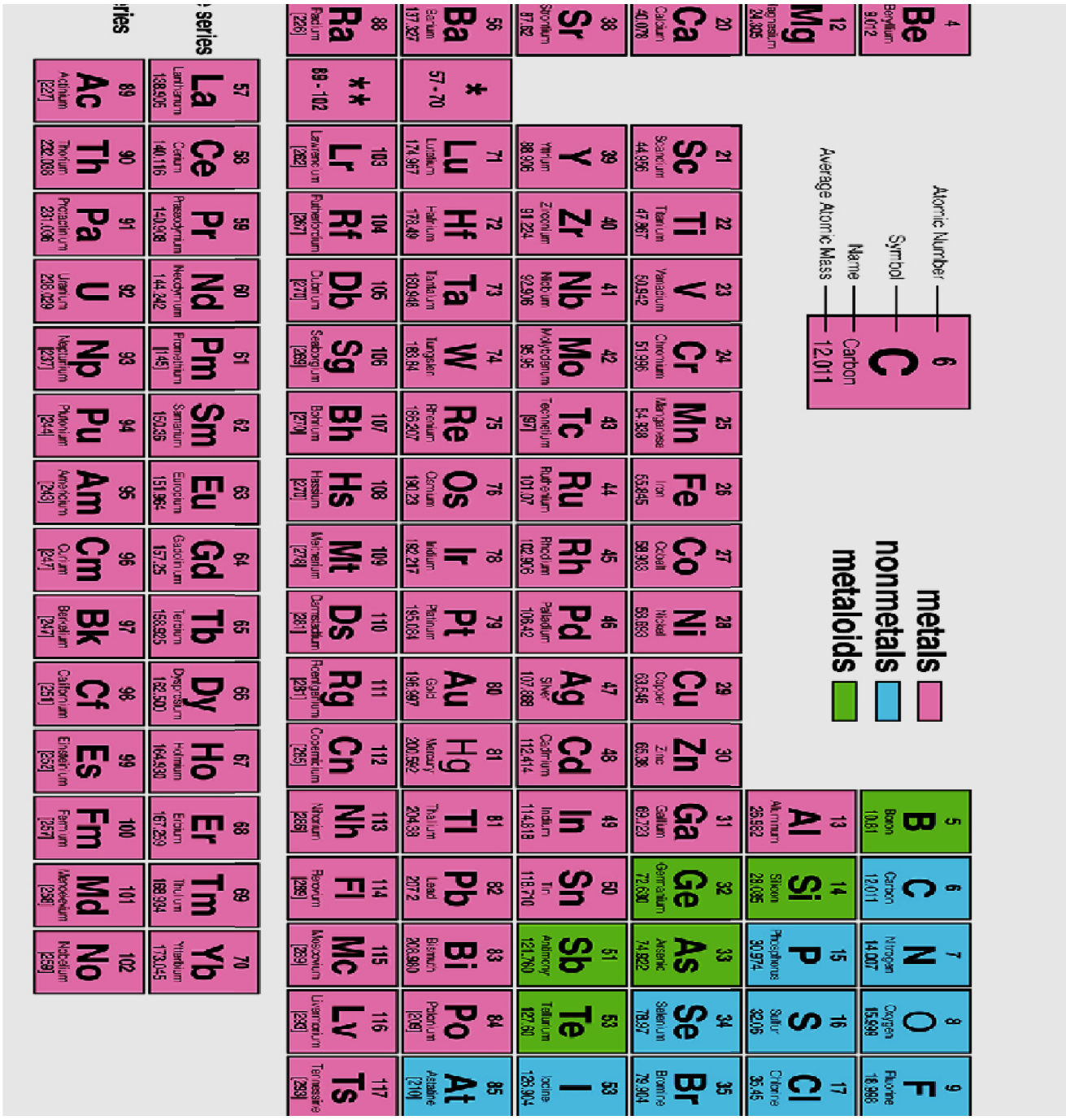
c) Explain how the real gases deviate from the ideal gasses in obeying the ideal gas law. (4 marks)

d) (i) Differentiate between molarity and molality (2 marks)

(ii) Calculate the concentration of a solution formed by diluting 0.850 L of a 5.0 M glucose solution to 1.80L. (2 marks)

(iii) If 0.025 gram of $Pb(NO_3)_2$ is dissolved in 100 grams of H_2O, calculate the concentration of the resulting solution, in parts per million (2 marks)

e) Calculate the pH of 0.10 M acetic acid(CH_3COOH which can be simplified to HAc). Given that the dissociation constant for acetic acid is, Ka = 1.8 x 10^{-5} (4 marks)


Atomic Number
Symbol
Name
Average Atomic Mass
6
C
Carbon
12.011
metals
nonmetals
metaloids
4 Be Beryllium 9.012
12 Mg Magnesium 24.305
20 Ca Calcium 40.078
38 Sr Strontium 87.62
56 Ba Barium 137.327
88 Ra Radium [226]
21 Sc Scandium 44.956
39 Y Yttrium 88.906
57 La Lanthanum 138.905
89 Ac Actinium [227]
22 Ti Titanium 47.867
40 Zr Zirconium 91.224
72 Hf Hafnium 178.49
104 Rf Rutherfordium [267]
58 Ce Cerium 140.116
90 Th Thorium 232.038
23 V Vanadium 50.942
41 Nb Niobium 92.906
73 Ta Tantalum 180.948
105 Db Dubnium [270]
59 Pr Praseodymium 140.908
91 Pa Protactinium 231.036
60 Nd Neodymium 144.242
92 U Uranium 238.029
24 Cr Chromium 51.996
42 Mo Molybdenum 95.96
74 W Tungsten 183.84
106 Sg Seaborgium [269]
61 Pm Promethium [145]
93 Np Neptunium [237]
25 Mn Manganese 54.938
43 Tc Technetium [97]
75 Re Rhenium 186.207
107 Bh Bohrium [270]
62 Sm Samarium 150.36
94 Pu Plutonium [244]
26 Fe Iron 55.845
44 Ru Ruthenium 101.07
76 Os Osmium 190.23
108 Hs Hassium [277]
63 Eu Europium 151.964
95 Am Americium [243]
27 Co Cobalt 58.933
45 Rh Rhodium 102.906
77 Ir Iridium 192.217
109 Mt Meitnerium [278]
64 Gd Gadolinium 157.25
96 Cm Curium [247]
28 Ni Nickel 58.693
46 Pd Palladium 106.42
78 Pt Platinum 195.084
110 Ds Darmstadtium [281]
65 Tb Terbium 158.925
97 Bk Berkelium [247]
29 Cu Copper 63.546
47 Ag Silver 107.868
79 Au Gold 196.967
111 Rg Roentgenium [281]
66 Dy Dysprosium 162.500
98 Cf Californium [251]
30 Zn Zinc 65.38
48 Cd Cadmium 112.414
80 Hg Mercury 200.592
112 Cn Copernicium [285]
67 Ho Holmium 164.930
99 Es Einsteinium [252]
5 B Boron 10.81
13 Al Aluminum 26.982
31 Ga Gallium 69.723
49 In Indium 114.818
81 Tl Thallium 204.33
113 Nh Nihonium [286]
68 Er Erbium 167.259
100 Fm Fermium [257]
6 C Carbon 12.011
14 Si Silicon 28.085
32 Ge Germanium 72.630
50 Sn Tin 118.710
82 Pb Lead 207.2
114 Fl Flerovium [289]
69 Tm Thulium 168.934
101 Md Mendelevium [258]
7 N Nitrogen 14.007
15 P Phosphorus 30.974
33 As Arsenic 74.922
51 Sb Antimony 121.760
83 Bi Bismuth 208.980
115 Mc Moscovium [289]
70 Yb Ytterbium 173.045
102 No Nobelium [259]
8 O Oxygen 15.999
16 S Sulfur 32.06
34 Se Selenium 78.97
52 Te Tellurium 127.60
84 Po Polonium [209]
116 Lv Livermorium [293]
9 F Fluorine 18.998
17 Cl Chlorine 35.45
35 Br Bromine 79.904
53 I Iodine 126.904
85 At Astatine [210]
117 Ts Tennessine [293]