



RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. in Applied Sciences
First Year - Semester I Examination – May 2022

CHE 1201 – GENERAL CHEMISTRY

Time: Two (02) hours

Answer **question number 1 (compulsory) and any other three (03) questions**

Use of a non-programmable calculator is permitted.

Planck's constant (h) = 6.626×10^{-34} J s Velocity of light (c) = 2.99×10^8 m s⁻¹

Avogadro's number (N_A) = 6.02×10^{23} mol⁻¹

1. a) State the postulates of Bohr theory

(10 marks)

- b) i. Explain the de Broglie model of the hydrogen atom and state the mathematical condition required to fit the electron wave into Bohr orbit? Hence, show the quantization of angular momentum.
- ii. Define an orbital in quantum theory
- iii. Draw Ψ^2 and radial probability distribution versus distance plots for 1s, 2s and 3s orbitals of the hydrogen atom. How many radial nodes does each have?
- iv. The energies (E) of the electron in a hydrogenlike ion are given by

$$E_n = -(2.18 \times 10^{-18})Z^2 \left(\frac{1}{n^2} \right)$$

Where n is the principal quantum number and Z is the nuclear charge of the atom.
Calculate the ionization energy (in kJ mol⁻¹) of the He⁺ ion.

(60 marks)

- c) i. State Heisenberg's uncertainty principle.
- ii. What is photoelectric effect? Define threshold frequency and show its mathematical relation to kinetic energy of photoejected electrons.

(30 marks)

2. a) i. Compare and contrast between the valence bond theory and molecular orbital theory
 ii. What are hybrid orbitals?
 iii. Draw bonding and antibonding orbitals formed by linear and sideways overlap of two p-orbitals. Indicate the nodal plane in each case. (40 marks)
- b) N_2^+ ion can be prepared by bombarding the N_2 molecule with fast moving electrons.
 Draw the molecular orbital diagram of N_2^+ ion and compare the bond stability, magnetic properties, and bond length relative to N_2 molecule. (60 marks)
3. a) i. Draw a Lewis structure and resonance structures for A) S-N-O⁻ and B) O-C-S
 ii. Explain, which of the resonance structures of above two is most stable. (40 marks)
- b) Deduce the hybridization and the most stable geometry of the following species.
 i. ICl_2^- ii. XeF_4 iii. $[Fe(CN)_6]^{4-}$ (40 marks)
- c) Explain the following:
 i. AgF is soluble in water whereas AgI does not
 ii. Thermal stability of carbonates of alkaline earth metals increases down the group in the periodic table. (20 marks)
4. a) In general, the element hydrogen is placed in group IA in the periodic table. However, there are some rationales that it can be fitted into other groups as well. State the three positions in which hydrogen can be placed in the periodic table and give two justifications for each. (20 marks)
- b) Compare and contrast the molecular hydrides and the metallic hydrides. (20 marks)
- c) Alkali metal salts are consisted with strong ionic bonds. However, these salts are water soluble. Explain. (20 marks)
- d) Complete and balance the reactions below.
 i. $(CH_3)_3Ga(g) + AsH_3 \rightarrow$ *hint: a displacement reaction*
 ii. $Cl_2(g) + OH^-(aq) \rightarrow$ *hint: a disproportionation*
 iii. $CCl_4(l) + HF(g) \rightarrow$ (15 marks)
- e) Differentiate the structural geometries of trimethyl amine $N(CH_3)_3$ and trisilyl amine $N(SiH_3)_3$ with the use of orbital illustrations. Comment on the changes in properties of two molecules attributed to their geometries. (25 marks)

- 5 a) Boron is a group 3A element where carbon is a group 4A element in the periodic table. However, both of these elements form A_2H_6 type molecules where A = Boron / Carbon. With the help of orbital illustrations, describe the structure of these two molecules. (25 marks)
- b) F_2 shows lower bond dissociation energy compared to other members in the halogen family. Account for the observation. (20 marks)
- c) Account for the high reactivity of halogens. (20 marks)
- d) Second ionization energies of Cr and Cu are noticeably higher than those of the other transition metals in the period. Describe. (20 marks)
- e) Explain the following:
- Ti^{+4} is more stable than Ti^{+3} .
- Mn^{+2} is more stable than Mn^{+3} .
- $TiCl_3$ is more acidic than $TiCl_2$. (15 marks)

Periodic Table of the Elements																																																
1 H Hydrogen 1.008																	2 He Helium 4.003																															
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180																															
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.064	17 Cl Chlorine 35.453	18 Ar Argon 39.948																															
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80																															
37 Rb Rubidium 84.464	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.905	54 Xe Xenon 131.29																															
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanides		72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon 222.018																														
87 Fr Francium [223]	88 Ra Radium [226]	89-103 Actinides		104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [277]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [285]	111 Rg Roentgenium [272]	112 Cn Copernicium [285]	113 Uut Ununtrium [284]	114 Fl Flerovium [289]	115 Uup Ununpentium [288]	116 Lv Livermorium [293]	117 Uus Ununseptium [294]	118 Uuo Ununoctium [294]																														
<table><tr><td>57 La Lanthanum 138.905</td><td>58 Ce Cerium 140.12</td><td>59 Pr Praseodymium 140.908</td><td>60 Nd Neodymium 144.24</td><td>61 Pm Promethium [145]</td><td>62 Sm Samarium 150.36</td><td>63 Eu Europium 151.964</td><td>64 Gd Gadolinium 157.25</td><td>65 Tb Terbium 158.925</td><td>66 Dy Dysprosium 162.50</td><td>67 Ho Holmium 164.930</td><td>68 Er Erbium 167.26</td><td>69 Tm Thulium 168.934</td><td>70 Yb Ytterbium 173.04</td><td>71 Lu Lutetium 174.967</td></tr><tr><td>89 Ac Actinium 227.028</td><td>90 Th Thorium 232.038</td><td>91 Pa Protactinium 231.036</td><td>92 U Uranium 238.029</td><td>93 Np Neptunium 237.044</td><td>94 Pu Plutonium 244.064</td><td>95 Am Americium 243.061</td><td>96 Cm Curium 247.070</td><td>97 Bk Berkelium 247.070</td><td>98 Cf Californium 251.080</td><td>99 Es Einsteinium 252.083</td><td>100 Fm Fermium 257.095</td><td>101 Md Mendelevium 258.1</td><td>102 No Nobelium 259.101</td><td>103 Lr Lawrencium [262]</td></tr></table>																			57 La Lanthanum 138.905	58 Ce Cerium 140.12	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26	69 Tm Thulium 168.934	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.044	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium 252.083	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]
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