RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc (General) Degree in Applied Sciences
First Year – Semester I Examination – September / October 2019

CHE 1201 – GENERAL CHEMISTRY

Time: Two (2) hours

1eV=1.602×10^{-19} J, Planck's constant = 6.626×10^{-34} J s, electron charge =1.602×10^{-19} C
Speed of light = 2.99×10^8 m s^{-1}
Use of nonprogrammable calculator is permitted

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1. a) Bohr's atomic model solves the limitations of Rutherford atomic model. Explain.

   (20 marks)

   b) For a hydrogen atom, show that
      i) Bohr radius (r) = $n^2 \times$ constant and
      ii) Total energy (E_T) in the nth orbital $= -\left(\frac{1}{n^2}\right) \times$ constant

   The force of attraction between charges (F) $= \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$, Centripetal force $(a) = \frac{mv^2}{r}$

   Potential and kinetic energy of an electron in an orbit are $-\frac{e^2}{4\pi\varepsilon_0 r}$, and $\frac{1}{2}mv^2$
   respectively.   (30 marks)

   c) Explain the origin of the emission spectrum of hydrogen   (10 marks)

   d) Johan Balmer obtained a good linear relationship as given below, between frequencies of
      each line in the emission spectrum of hydrogen and $\frac{1}{n^2}$.

   $$\nu = -4 \times 8.2202 \times 10^{14} \left(\frac{1}{n^2}\right) + 8.2202 \times 10^{14}$$

   Show that the wave number ($\bar{\nu}$) = $109680 \left(\frac{1}{2^2} - \frac{1}{n^2}\right) cm^{-1}$ (20 marks)

   e) Calculate the energy (kg mol^{-1}) required for the ionization of an electron from the ground
      state of the hydrogen atom.   (20 marks)

2. a) i. In the quantum-mechanical description, What is the physical significance of the square of the wave function, ψ^2? (10 marks)

   ii. Show the variation of ψ^2 as a function of distance (r) from the nucleus for 1s and 2s orbitals. (10 marks)

   iii. Write four quantum numbers for the last valence electron in a chlorine atom (10 marks)

   b) Write short notes on:

   i. (A) Ultraviolet catastrophe, (B) Wave-particle duality and (C) De-Broglie wavelength (30 marks)

   ii. Describe the Heisenberg's uncertainty principle? (10 marks)

   iii. The position of an alpha particle is known with a precision of 0.01 Å. What is the uncertainty involved in the simultaneous measurement of its momentum? (mass of alpha particle = 6.68×10^{-27} kg). (15 marks)

   C) A photoelectric surface has a work function of 4 eV. What is the maximum velocity of the photoelectrons emitted by light of frequency 10^{15} s^{-1} incident on the surface? (15 marks)

3. a) i. Draw possible Lewis structures for (i) ICl_4^- (ii) NO^+ and (iii) SO_4^{2-} and identify the electron geometry and the molecular geometry of each structure. (24 marks)

   ii. Identify the hybridization of the central atom of each structure (part i).

   b) i. The Lewis structure of O_2 fails to account for the paramagnatism of O_2, but molecular orbital theory correctly predicts its magnetism. Explain with appropriate molecular orbital diagrams. (20 marks)

   ii. Write down the molecular orbital electron configuration of O_2 molecule (04 marks)

   c) i. According to molecular orbital description, predict the bond order of O_2, O_2^+, and O_2^- (10 marks)

   ii. Arrange above oxygen species in order of increasing bond length (05 marks)

   d) Three possible Lewis structures for the thiocyanate ion, NCS$^-$, are

   i. $\left[N=C=S\right]^-$ ii. $\left[N\equiv C-S\right]^-$ iii. $\left[N-C\equiv S\right]^-$
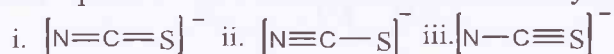
   A) Determine the formal charges in each structure. B) Based on the formal charges, which Lewis structure is the dominant one? Explain. (10 marks)

e) Draw all possible resonance forms for the following structure using appropriate arrow notation. Which resonance structure is most stable? and least stable? Draw the resonance hybrid indicating all partial charges.
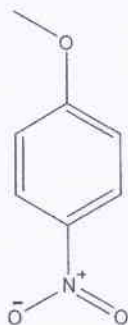
(15 marks)

4.   a) Explain the following:

   (i)   AgF is soluble in water while AgI is insoluble in water   (20 marks)

   (ii) H_3BO_3 is a very weak acid and direct titration with NaOH is not possible. However, in the presence of organic polyhydroxy compounds such as glycerol, mannitol etc, facilitates the acid–base titration.   (20 marks)

   b) Discuss the properties of trimethyl amine $(CH_3)_3$ N and trisilylamine $(SiH_3)_3$ N with respect to their molecular structures.   (20 marks)

   c) $SiCl_4$ rapidly hydrolyses in aqueous alkaline media whereas SiF_4 doesn't. Explain with appropriate reactions.   (20 marks)

   d) What would you observe if an aqueous solution of Na_2CO_3 is added to an aqueous solution of $AlCl_3$. Explain your answer.   (20 marks)

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