CHEMISTRY/BIOCHEMISTRY

Answer all questions
Use of calculator is not permitted

Time: 2 Hours   Full Marks: 100

1. a) When electron in the excited hydrogen atom is promoted from second to fifth Bohr orbit,
   find the ratio of the velocities of the electron in the said orbits. [Given: first Bohr radius, a_o]   3

   b) For the reaction $A + B \longrightarrow C + D + q$ cal , $\Delta S = +ve$. Explain in terms of ΔG that the forward reaction is
   possible at any temperature.   3

   c) The initial rate and rate constant (প্রারম্ভিক বিক্রিয়া হার ও হার ধ্রুবক) of a first order reaction are v_x $molL^{-1}s^{-1}$ and k_x s^{-1}
   respectively at 25 ^{o}C. Write the rate and rate constant at $t_{1/2}$ at 25 ^{o}C.   2

   d) $y(T/R)$ and $h\nu/k_B$ have same unit. Find the SI unit of y.   2

   e) Balance the equation by ion-electron method: 3
   $Zn + NO_3^- + OH^- \rightarrow ZnO_2^{2-} + NH_3 + H_2O$

   f) Represent in the same graph, the plots of density (d) vs. $1/T$ at constant p for H_2 and He, assuming ideal
   behaviour and compare their slopes.   3

   g) An element of periodic group 16 emits 2α and 3β particles successively. Find the periodic group of the daughter
   element.   2

   h) Which two of the following are isostructural with CO_2? N_2O, NO_2, C_2H_2, O_3 2

   i) Write the structure of 3-ethenyl-1,5-heptadiene.   2

   j) For propane, write the maximum number of $C - C$ bonds and $C - H$ bonds that would lie on the same plane. 2

   k) An optically active (আলোকসক্রিয়) hydrocarbon (C_7H_{14}) shows *cis / trans* isomerism. Give its structure.   2

   l) Draw the structure of a hydrocarbon (C_4H_4) in which two carbons are sp hybridized and all hydrogens are
   equivalent.   2

   m) A mixture of phthalimide and benzophenone cannot be separated by which of the following?   2
   i) NaOH   ii) HCl   iii) NaHCO$_3$

2. a) The degree of dissociation(বিয়োজন মাত্রা) of AB_2 is x at temp T for the reaction $2AB_2 (g) == 2 AB (g) + B_2 (g)$.
   Assuming $x \ll 1$, show that, $x = (2K_p/ p)^{1/3}$ [p = total pressure K_p = equilibrium constant (সাম্য ধ্রুবক)].   5

   b) 2 litres of an ideal gas at a pressure of 10 atm expands isothermally(স-মাষ্ণ অবস্থায়) into a vacuum until its total
   volume is 10 litres. Calculate q and w.   5

   c) Freezing point (হিমাঙ্ক) of an aqueous solution containing 0.0855 g of a nonvolatile nonelectrolytic (অনুদায়ী,
   তড়িৎঅবি-শ্লষ্য) solute $C_{n+1}H_{2n}O_n$ in 25 g water at 1 atm pressure is–0.0185 ^{o}C. Find out the molecular formula of
   the solute. [K_f for water = 1.85 ^{o}Cm^{-1}]   5

   d) From the kinetic study of a reaction at 25 ^{o}C, the slope and the intercept (নতি ও -ছ্দিতাংশ) of the plot of log(rate)
   vs log(concentration) were found to be +2 and −3 respectively (concentration was expressed in $molL^{-1}$ and
   time in s). Find the order and the rate constant of the reaction at 25 ^{o}C.   5

   e) i) 250 mL of 10^{-4} M hemoglobin solution contains 1.7 g hemoglobin. What is the molar mass of the protein?
   ii) A certain ion A^{n+} is oxidized successively to AO_4^{2-} and AO_4^- by a powerful oxidizing agent (জারকদ্রব্য). If the
   number of moles of the oxidizing agent required in two successive steps of oxidation for equimolar quantities of
   the reductants are in the ratio 4:1, find the value of n.   2+3

3. a) Write the formulae of the compounds **A** to **E** in the following reactions: 5

   A (**M**SO$_4$.**x**H$_2$O) + **B** + **C** $\longrightarrow$ **M**CO$_3$ + **D** + H$_2$O
   [eq. wt. = 86]

   D + **E** $\xrightarrow{\Delta}$ **C** + **M**SO$_4$ + H$_2$O

   MCO$_3$ $\xrightarrow{\Delta}$ **B** + **E**
   (1 g)   (224 mL at STP)

   CuO + **C** $\xrightarrow{\Delta}$ Cu + N$_2$ + H$_2$O

   b) Convert showing intermediate structures (গঠনসং-কত):   2+3
   i) $CH_3CH=CHBr \longrightarrow CH_3CH=CHD$ (in two steps)
   ii) Benzene $\longrightarrow$ Phenylacetylene (using the reagents: NaNH$_2$, anhyd. AlCl$_3$, PCl$_5$, CH$_3$COCl)

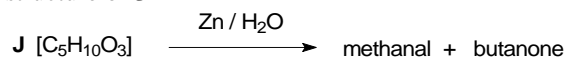c) Give the structures of **H, I, J, K** and **L** in the following reactions: 5

$$\textbf{H} \quad \xrightarrow{\text{ozonolysis}} \quad \textbf{I} \quad + \quad \textbf{J}$$

$C_{16}H_{14}$

I $\xrightarrow{\text{Cannizzaro reaction}}$ Benzyl alcohol + **K**

J $\xrightarrow{\text{Cannizzaro reaction}}$ **L**
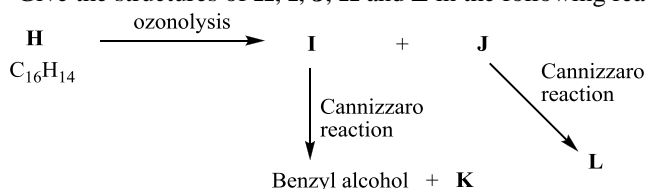
d) i) Write the structures of **X, Y** and **Z**

$$\textbf{X} \xrightarrow{\text{dil. HCl}} \textbf{Y} + \text{methanol} \quad ; \quad \textbf{Y} \xrightarrow{\text{50\% NaOH}} \textbf{Z} + \text{benzoic acid}$$

ii) Write the structure of **J**

$$\textbf{J} \; [C_5H_{10}O_3] \xrightarrow{Zn / H_2O} \text{methanal} + \text{butanone}$$

3+2

e) A sample of xylene on mononitration gives a single compound **E**, which on strong oxidation is converted to **F**. Compound **F** contains same amount of carbon and oxygen by weight. Suggest structures of **E** and **F**. Aqueous solution of **F** obtained from 0.1 mole of **E** requires 6.4 g of NaOH for complete neutralization (সম্পূর্ণ প্রশমিত কর-ত). Calculate % yield for the oxidation step. 5

4. a) Choose **A, B, C** or **D** as the correct answer: 1×10

i) The ratio of energies of photons having wavelengths (তরঙ্গদৈর্ঘ্য) 2000 Å and 4000 Å is
   (**A**) 1 : 4   (**B**) 4 : 1   (**C**) 1 : 2   (**D**) 2 : 1

ii) The solubility of As_2S_3 is x moles/litre. Its solubility product(দ্রাব্যতা গুণফল) is
   (**A**) $6x^2$ (**B**) $64x^4$ (**C**) $108x^5$ (**D**) $36x^5$

iii) Which of the following ions has the highest ionic radius?
   (**A**) Na^+ (**B**) O^{2-} (**C**) F^- (**D**) N^{3-}

iv) Concentrated nitric acid can be stored in a container made up of
   (**A**) Cu   (**B**) Ag   (**C**) Mg   (**D**) Al

v) An ideal gas will have maximum density when
   (**A**) P = 0.5 atm T = 600 K   **B**) P = 2 atm T = 150 K   (**C**) P = 1 atm T = 300 K   (**D**) P = 1 atm T = 500 K

vi) The maximum number of 3d electrons having spin quantum number s = + ½ is
   (**A**) 10   (**B**) 5   (**C**) 2   (**D**) 1

vii) Which of the following atoms would be paramagnetic?
   (**A**) Ca   (**B**) Be   (**C**) Zn   (**D**) N

viii) For a certain reaction E^o is positive. This means that
   (**A**) $\Delta G^o > 0$, K <1   (**B**) $\Delta G^o > 1$, K <1   (**C**) $\Delta G^o < 0$, K >1   (**D**) $\Delta G^o < 0$, K <1

ix) Which of the following would decrease the pH of 25 cm^3 of a 0.01 M HCl solution?
   (**A**) addition of 25 cm^3 of a 0.2 M HCl solution   (**B**) addition of Mg
   (**C**) addition of 25 cm^3 of a 0.005 M HCl solution   (**D**) none of these

x) Identify the process where nitrogen is oxidised
   (**A**) $NO_3^- \rightarrow NO$ (**B**) $NO_3^- \rightarrow NH_4^+$ (**C**) $NH_4^+ \rightarrow N_2$ (**D**) $NH_3 \rightarrow NH_4^+$

b) Each question below has two correct answers. Write the two correct choices from **P, Q, R, S**.
   (*no credit for single choice*): 2×5

i) The set of four quantum numbers of a single p electron having n + 1 ≤ 4 may be
   (**P**) (3, 1, +2, - ½)   (**Q**) (2, 1, -1, + ½)   (**R**) (3, 1, 0, - ½)   (**S**) (2, 1, -2, + ½)

ii) The quantities having unit of length are /
   (**P**) h/mv (**Q**) $h\nu/k$ (**R**) $\sqrt{kT/m}$ (**S**) $\sqrt[3]{nRT/p}$

iii) Given, $E^o_{Ag^+/Ag} = 0.80$ V and $E^o_{Zn^{2+}/Zn} = {}^-0.76$ V at 25 °C.

   For the cell reaction, $2 Ag^+ (aq) + Zn (s) \rightleftharpoons 2 Ag (s) + Zn^{2+} (aq)$

   (**P**) $E^o_{cell} = 1.56$ V   (**Q**) $E^o_{cell} = - 3.12$ V   (**R**) $\Delta G^o = 1.56 \times 96500$ J   (**S**) $\Delta G^o = - 3.12 \times 96500$ J

iv) Which of the following pairs are isoelectronic (সমই-লকট্রণীয়)?
   (**P**) $(ClO_4^-, H_2PO_4^-)$ (**Q**) $(S_2O_3^{2-}, H_2PO_2^-)$ (**R**) (HSO_4^-, PO_4^{3-}) (**S**) (S^{2-}, NO_2^-)

v) For an ideal gas the number of molecules per unit volume is proportional to p/T. The proportionality constant is   (**P**) N_A/R (**Q**) $1/k$ (**R**) M/R   (**S**) R/N_A