ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

Semester Final Examination — Winter Semester, A.Y. 2017-2018
Course Code: Chem 4121 — Time: 3 hours
Course Title: Engineering Chemistry — Full Marks: 150

There are **8 (Eight)** Questions. Answer any **6 (Six)** of them.
Use the graph paper wherever necessary. Marks in the Margin indicate the full marks.

1 a) List the various factors that affect the rate of reactions? Elaborate the effect of temperature on the rate of reaction with the aid of Boltzmann distribution curve. 8

b) Derive an equation for rate constant of a second order reaction. Show that half-life of second order reaction is inversely proportional to the initial concentration of reactant. 9

c) The decomposition of nitrogen dioxide, 8

$$2NO_2(g) \Rightarrow 2NO(g) + O_2(g)$$

has a rate constant of 0.498 M/s at 319°C and a rate constant of 1.81 M/s at 354°C. What are the values of the activation energy and the frequency factor for this reaction? What is the rate constant at 420°C?

2 a) What is standard cell electromotive force (emf)? Derive Nernst equation. 8

b) What is corrosion? What are the factor accelerating the rate of corrosion? How corrosion can be controlled? 9

c) Consider a cell constructed of the following two half-reactions. 8

$$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \quad E_{Zn2+(aq)|Zn(s)} = -0.76\ V$$

$$2Ag^+(aq) + 2e^- \rightarrow 2Ag(s) \quad E_{Ag+(aq)|Ag(s)} = 0.80\ V$$

(i) Write down the possible cell notations for the above cell.
(ii) Calculate the standard cell potential. Describe whether the cell reaction will occur spontaneously or not.
(iii) Write down the half-cell reaction and total cell reaction.
(iv) If concentration of Zn^{2+} and Ag^+ are 1.00×10^{-6}M and 0.010M, calculate the cell potential at 25°C temperature.

3 a) What is osmotic pressure? Derive van't Hoff equation of osmotic pressure. How molecular mass of solute can be determined by measuring osmotic pressure of solution? 8

b) What is colligative property of a dilute solution? Derive an expression relating depression of freezing point of a solution and molar mass of solute with the help of vapour pressure- temperature diagram. 10

c) The melting point of pure Naphthalene is 82.2°C and its freezing-point-depression constant is 6.85 °C/m. (i) 2.0 g of a compound was dissolved in 20.0 g of Naphthalene. The solution melted at 77.52°C. What is the molecular mass of the compound? (ii) If the empirical formula of the compound is CH, what is the molecular formula? 7

4 a) Define pH. Derive Henderson-Hasselbalch equation for calculating the pH of a buffer solution. 8

b) State and explain Kohlrausch's law. Write at least three application of Kohlrausch's law. 9

c) The equivalent conductance of a 0.014 N solution of chloro-acetic acid is 109.0 $ohm^{-1}\ cm^2$. At infinite dilution, the ion conductance of chloro-acetic acetate and hydrogen ion are 40.2 and 349.8 $ohm^{-1}\ cm^2$, respectively. Calculate (a) degree of dissociation and (b) dissociation constant of the acid. 8

5 a) Derive an expression applying Bohr atom model for the calculation of energy and wavelength of radiation obtained in the emission of spectrum of hydrogen. 12

b) State and explains Pauli exclusion principle. State whether each of the following sets of quantum numbers is permissible for an electron in an atom. If a set is not permissible, explain why. 8

(i) $n = 1, l = 0, m_l = 0, m_s = +\frac{1}{2}$

(ii) $n = 3, l = 1, m_l = =2, m_s = =-\frac{1}{2}$

(iii) $n = 2, l = 1, m_l = 0, m_s = +\frac{1}{2}$

(iv) $n = 2, l = 0, m_l = 0, m_s = 1$

c) What is de-Broglie equation? Show that de-Broglie equation is applicable only for microscopic particle like electron. Electron has a mass = 9.10×10^{-28} g and moves with a velocity 2.188×10^{-8} cm/sec, $h = 6.625 \times 10^{-27}$ J.S. 5

6 a) What is hydrogen bond? Discuss different types of hydrogen bond with suitable examples. 5

b) Describe the main features of Valence-Shell Electron-Pair Repulsion (VSEPR) model for predicting the shape of molecules (two, three and four electron pairs). Predict the shape of the following molecules according to VSEPR model (i) SiF_4, (ii) SF_4, (iii) XeF_4, and (iv) IF_5. 12

c) Describe molecular orbital theory (MOT). With the aid of MOT describe whether **NO** is formed or not. State the bond order and magnetic properties of **NO**. 8

7 a) State and explain first law of thermodynamic. Prove that at constant pressure $\mathbf{dH = q_P}$. 13

b) What is electron affinity? What are the factors affecting electron affinity of the molecule? Briefly discuss them. 12

c) (i) Show the electronic configuration of oxygen (**O**) and phosphorus (**P**) atoms according to Hund's rule.
(ii) Find out the position of iron (**Si**) and nickel (**Ni**) atoms in the periodic table from the electronic configuration.

8 a) Define phase, degree of freedom, and component. Derive phase rule. 13

b) Discuss different types of organic reaction with suitable examples. 12

4 a) What do you mean by colligative property? Prove that lowering of vapour pressure of dilute solution containing non-volatile solute is a colligative property. 8

b) Derive an expression relating depression of freezing point of a solution and molar mass of solute with the help of vapour pressure- temperature diagram. 10

c) Glycol ($C_nH_{2n}(OH)_2$) is a derivative of a hydrocarbon. A solution containging 1.821 g glycol per dm^{-3} has osmotic pressure 51.8 cm (Hg) at 10^0C. Calculate the molecular mass, and also determine the molecular formula of the glycol. 7

5 a) Describe the main features of Valence-Shell Electron-Pair Repulsion (VSEPR) model for predicting the shape of molecules (two, three and four electron pairs). Predict the shape of the following molecules according to VSEPR model (i) ICl_3, (ii) SO_2, (iii) XeF_4, and (iv) IF_5. 12

b) What is hybridization? How the shaped of the molecules can be predicted from different types of hybridization? 8

c) What is ionic bond? Discuss Fajan's rule for explaining covalent character of ionic compound. 5

6 a) What is de-Broglie equation? Show that de-Broglie equation is applicable only for microscopic particle like electron. Electron has a mass = 9.10×10^{-28} g and moves with a velocity 2.188×10^{-8} cm/sec, $h = 6.625 \times 10^{-27}$ J.S. 6

b) Derive an expression applying Bohr atom model for the calculation of energy and wavelength of radiation obtained in the emission of spectrum of hydrogen. 12

c) Calculate the shortest wavelength of the electromagnetic radiation emitted by the hydrogen atom in undergoing a transition from the $n = 6$ level. Calculate the energy of the emitted photon. 7

7 a) State and explain first law of thermodynamics. Prove that at constant pressure $\mathbf{dH = q_p}$. 8

b) What is ionization energy? What are the factors affecting ionization energy? Briefly discuss them. 9

c) Consider the combustion (burning) of methane, CH_4, in oxygen. 8

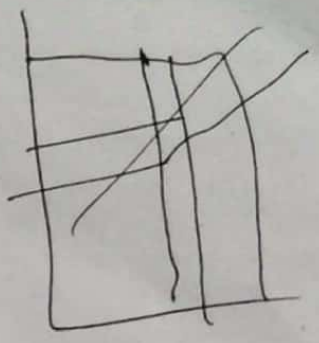
$$CH_4(g) + 2O_2(g) \Rightarrow CO_2(g) + 2H_2O(l)$$

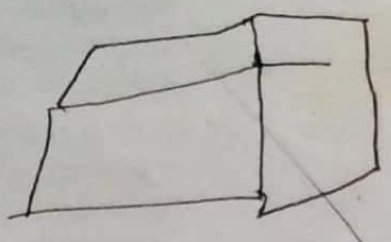
The heat of reaction at 25^0C and 1.00 atm is -890.2 kJ. What is the change in volume when 1.00 mol CH_4 reacts with 2.00 mol O_2? (You can ignore the volume of liquid water, which is insignificant compared with volumes of gases.) What is w for this change? Calculate. ΔU for the change indicated by the chemical equation.

8 a) Deduce phase rule. 9

b) What is the difference between thermotropic and lyotropic liquid crystals? Write the application of liquid crystals. 8

c) Discuss different types of organic reactions with suitable examples. 8





Solution

B.Sc. Eng. /1st Semester (EE) 17 May 2019

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There are **8 (Eight)** Questions. Answer any **6 (Six)** of them.
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1 a) Define Cell and Battery. Describe the working principle of alkaline dry cell along with diagram. 8

b) What is corrosion? What are the factors accelerating the rate of corrosion? How corrosion can be controlled? 9

c) A cell is constructed by connecting a chromium and an iron electrode. The standard electrode potentials are given below. 8

$$E^0_{Cr^{3+}(aq)|Cr(s)} = 0.75\ V \quad E^0_{Fe^{2+}(aq)|Fe(s)} = -0.45\ V$$

(i) Calculate the standard cell potential. Write down the half-cell reaction and total cell reaction.

(ii) If concentration of Cr^{3+} and Fe^{2+} are 0.10M and 0.01M, calculate the cell potential at 25°C temperature.

2 a) Define order of the reaction. Describe differential method for the determination of reaction order. 9

b) Deduce an expression showing the effect of temperature on chemical equilibrium constant. 8

c) The experimental data for the decomposition of NO_2 is given below 8

$$2NO_2(g) \Rightarrow 2NO(g) + O_2(g)$$

Time (min)	Conc. (M)
0	0.0165
10	0.0124
20	0.0093
30	0.0071
40	0.0053
50	0.0039
60	0.0029

(i) Find out the order of the reaction.

(ii) Calculate the rate constant for the decomposition of NO_2.

3 a) What is equivalent conductance? How the equivalent conductance changes with variation of concentration of solution? 8

b) State and explain Kohlrausch's law. Write at least three application of Kohlrausch's law. 10

c) Paracetamol has a pK_a of 3.5. (i) Calculate the ratio of ionized/unionized of the drug in the stomach where pH is 1. (ii) Calculate the ratio of ionized/unionized in the intestine where pH is 6. (iii)Based on these calculations- where is aspirin absorbed within the body? 7