

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **CHE 111** (Elements of Chemical Engineering)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

A data booklet containing all relevant data is to be supplied.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) The following empirical equation correlates the values of variables in a system in which solid particles are suspended in a flowing gas: (12)

$$\frac{k_g d_p y}{D} = 2.00 + 0.600 \left(\frac{\mu}{\rho D} \right)^{1/3} \left(\frac{d_p u \rho}{\mu} \right)^{1/2}$$

where, k_g is a rate in cm/s, d_p is particle diameter in mm, y is dimensionless, D is diffusivity in cm²/s, μ is viscosity in N.s/m², ρ is in density g/cm³, u is velocity in m/s.

Show that the equation is dimensionally homogeneous or consistent. What are the units of 2.00 and 0.600?

- (b) The reaction between ethylene and hydrogen bromide is carried out in a continuous reactor. The product stream is analyzed and found to contain 51.7 mole% C₂H₅Br and 17.3 mol% HBr. The feed to the reactor contains only ethylene and hydrogen bromide. Calculate the fractional conversion of the limiting reactant and the percentage by which the other reactant is in excess. (15)

- (c) Draw a schematic block diagram of an absorber and label it properly. How does it work? (8)

2. (a) A wastewater stream from a tannery contains 5 wt% chromium, Cr. The waste water stream is fed to a treatment unit that removes 95% of the chromium in the feed and recycles it to the tannery plant. The residual liquid stream leaving the treatment unit is sent to a waste lagoon. The treatment unit has a maximum capacity of 5000 kg/h wastewater. If the wastewater leaves the tannery at a rate higher than the capacity of the treatment unit, the excess (anything above 5000 kg/h) bypasses the unit and combines with the residual liquid leaving the unit, and the combined stream goes to the waste lagoon. Draw and label a complete flow chart of the process. If the wastewater leaves the tannery at a rate of 6000 kg/h, calculate the flow rate of the waste to the lagoon and the mass fraction of chromium in this stream. (18)

- (b) The product gas from a solid fuel combustion reaction has the following dry-basis molar composition. 72.0% CO₂, 2.5% CO, 0.06% SO₂ and the balance O₂. Pure oxygen is fed to the furnace in 20% excess of that required to burn the fuel completely. There is

Contd P/2

CHE 111

Contd ... Q. No. 2(b)

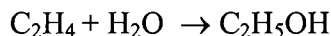
no oxygen in the fuel. Calculate the elemental composition (mole% of the various elements) of the fuel. (17)

3. (a) A storage tank containing oil (SG = 0.92) is 10.0 meters high and 15 meters in diameter. The tank is closed but the amount of oil it contains can be determined from the gauge pressure at the bottom. A pressure gauge connected to the bottom of the tank was calibrated with the top of the tank open to the atmosphere.

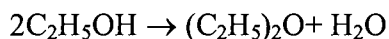
(i) The calibration curve is a plot of height of oil, $h(m)$, versus P_{gauge} (kPa). Find the equation of the calibration curve. What height of oil would lead to a gauge reading of 75 kPa? What would be the mass of oil in the tank corresponding to this height? (10)

(ii) An operator observes that the pressure gauge reading is 75 kPa and notes the corresponding liquid height from the calibration curve. What he did not know was that the absolute pressure above the liquid surface in the tank was 115 kPa when he read the gauge. What is the actual height of liquid in the tank? Assume atmospheric pressure is 101 kPa. (8)

(b) Ethanol is produced commercially by the hydration of ethylene: (17)



Some of the product is converted to diethyl ether in the side reaction



The feed to the reactor contains ethylene, steam and an inert gas. A sample of the reactor effluent gas is analyzed and found to contain 42 mole% ethylene, 3 mole% ethanol, 0.15 mole% ether, 10 mole% inerts and the balance water.

(i) Draw and label the process flow chart.

(ii) Calculate the molar composition of the reactor feed, the percentage conversion of ethylene, the fractional yield of ethanol and the selectivity of ethanol production relative to ether production.

(iii) If the percentage conversion of ethylene calculated in part (ii) is very low, what may be the reason for maintaining low conversion in the reactor. What additional processing are likely to take place downstream from the reactor.

4. (a) How many significant figures would the solution of each of the following problems has (i) $(5.74)(38.27)/0.001250$ (ii) $1.000 + 10.2$ (iii) $(1.76 \times 10^4)(0.12 \times 10)^{-6}$ (6)

(b) The fresh feed to an ammonia production process contains nitrogen and hydrogen in stoichiometric proportion, along with 1 mole% inert gas. The feed is combined with a recycle stream containing the same three species and the combined stream is fed to a reactor in which a single pass conversion of 15% is achieved. The reactor effluent flows

CHE 111**Contd ... Q. No. 4(b)**

to a condenser. A liquid stream containing essentially all of the ammonia formed in the reactor and a gas stream containing all inerts and the unreacted nitrogen and hydrogen leave the condenser. 5% of the gas stream leaving the condenser is removed as purge and the rest constitutes the recycle stream. (29)

- (i) Draw and label the flow chart of the process.
- (ii) Find the overall conversion of N_2 .
- (iii) Find the total feed flow rates to the reactor.
- (iv) Find the composition and the flow rate of the recycle stream.

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) A fuel gas containing 86% methane, 8% ethane, and 6% propane by volume flows to a furnace at a rate of $1450 \text{ m}^3/\text{h}$ at 15°C and 150 kPa (gauge), where it is burned with 8% excess air. Calculate the required flow rate of air in SCMH (standard cubic meters per hour). (18)

(b) A 5 m^3 tank is charged with 75 kg of propane gas at 25°C . Use the SRK equation of state to estimate the pressure in the tank; then calculate the percentage error that would result from the use of the ideal gas equation of state for the calculation.

The SRK equation of state is $P = \frac{RT}{\hat{V} - b} - \frac{aa}{\hat{V}(\hat{V} + b)}$ (17)

Where, $a = 0.42747 \frac{(RT_c)^2}{P_c}$

$$b = 0.08664 \frac{RT_c}{P_c}$$

$$m = 0.48508 + 1.55171\omega - 0.1561\omega^2$$

$$T_r = T/T_c$$

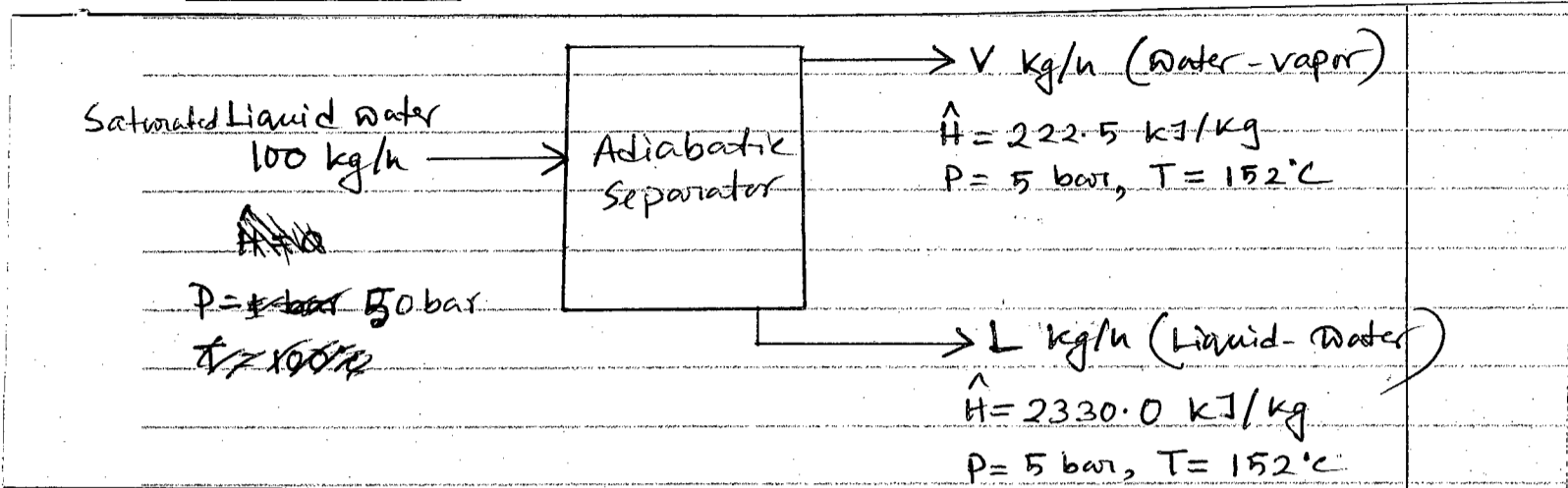
$$\alpha = \left[1 + m(1 - \sqrt{T_r})\right]^2$$

$$\omega = 0.152$$

6. (a) You want to do a mass balance on the following separator system, yet you do not have enough material data. Instead you need to rely on an energy balance to help you along. Determine the split of liquid and vapor coming out of the evaporator. (12)

CHE 111

Contd ... Q. No. 6(a)



(b) A turbine discharge 200 kg/h of saturated steam at 10 bar absolute. It is desired to generate steam at 250°C and 10 bar by mixing the turbine discharge with a second stream of superheated steam of 300°C and 10 bar.

(23)

- (i) If 300 kg/h of the product steam is to be generated, how much heat must be added to the mixer?
- (ii) If instead the mixing is carried out adiabatically, at what rate is the product steam generated?

7. Sulfur dioxide is oxidized to sulfur trioxide in a small pilot-plant reactor. SO₂ and 100% excess air are fed to the reactor at 450°C. The reaction proceeds to a 65% SO₂ conversion, and the products emerge from the reactor at 550°C. The production rate of SO₃ is 100 kg/min. The reactor is surrounded by a water jacket into which water at 25°C is fed.

(35)

- (i) Calculate the feed rates of the SO₂ and air feed stream. Also, determine the extent of reaction, ξ (Kmol/s).
- (ii) Calculate the standard heat of the SO₂ oxidation reaction, $\Delta \hat{H}_r^\circ$ (kJ/mol)
- (iii) Prepare an inlet-outlet enthalpy table and do the energy balance to determine the heat (kW) that must be transferred from the reactor to the cooling water.

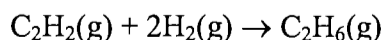
8. (a) An ideal gas mixture contains 35% Helium, 20% Methane and 45% Nitrogen by volume at 2 atm absolute pressure and 90°C. Calculate (i) the partial pressure of each component (ii) the mass fraction of methane (iii) the average molecular weight of the gas, and (iv) the density of the gas in kg/m³.

(20)

(b) Define the terms (i) standard heat of reaction (ii) Standard heat of formation, and (iii) Standard heat of combustion.

(6)

(c) Calculate the standard heat of acetylene hydrogenation reaction



Using (i) tabulated heats of formation and (ii) tabulated heats of combustion.

(9)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **MATH 123** (Integral Calculus and Differential equations)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE**.

1. Workout the following integrals:

$$(a) \int \frac{dx}{(x-a)\sqrt{(x-a)(b-x)}}, \quad (b) \int \frac{x^2 dx}{(x \sin x + \cos x)^2} \quad (c) \int \frac{x dx}{(1+x)^{3/3} - (1+x)^{1/2}} \quad (11+12+12)$$

$$2. (a) \text{ Find a reduction formula for } I_n = \int x^n \cos mx dx \text{ and hence find } \int x^3 \cos 3x dx \quad (14)$$

(b) Evaluate:

$$\lim_{n \rightarrow \infty} \left[\left(2 + \frac{1}{n^2} \right)^{1/n^2} \left(2 + \frac{2^2}{n^2} \right)^{2/n^2} \left(2 + \frac{3^2}{n^2} \right)^{3/n^2} \dots \left(2 + \frac{n^2}{n^2} \right)^{n/n^2} \right] \quad (10)$$

$$(c) \text{ Evaluate: } \int_0^{\pi} \frac{x \tan x dx}{\sec x + \tan x} \quad (11)$$

$$3. (a) \text{ Prove that } \int_0^1 \frac{dx}{(1+x)(2+x)\sqrt{x(1-x)}} = \pi \left(\frac{1}{\sqrt{2}} - \frac{1}{\sqrt{6}} \right). \quad (12)$$

$$(b) \text{ Evaluate: } \int_1^{\infty} \frac{\tan^{-1} x}{1+x^2} dx \quad (10)$$

$$(c) \text{ Prove that } \int_0^1 \frac{x^2 dx}{\sqrt{1-x^4}} \times \int_0^1 \frac{dx}{\sqrt{1+x^4}} = \frac{\pi}{4\sqrt{2}}. \quad (13)$$

$$4. (a) \text{ Determine the area between the ellipses } x^2 + 2y^2 = a^2 \text{ and } 2x^2 + y^2 = a^2. \quad (14)$$

$$(b) \text{ Find the volume generated by revolving one loop of } y^2(a+x) = x^2(3a-x) \text{ about } x\text{-axis.} \quad (10)$$

$$(c) \text{ Find the area of the surface of revolution formed by revolving the curve } r = 2a \cos \theta \text{ about the initial line.} \quad (11)$$

MATH 123(CHE)**SECTION – B**

There are **FOUR** questions in this Section. Answer any **THREE** questions.

5. (a) Form the different equation of the family of curves $y = c(x - c)^2$ by eliminating the arbitrary constant c . (10)
- (b) Solve the different equation $\frac{dy}{dx} = (4x + y + 1)^2$. (12)
- (c) Solve $(3x - 2y + 1)dx - (6x - 4y + 1)dy = 0$. (13)
6. (a) Solve: $\frac{dy}{dx} + (2x \tan^{-1} y - x^3)(1 + y^2) = 0$ (10)
- (b) Test whether the following differential equation is exact or not and then solve $(x^2 + y^2 + 1)dx - 2xydy = 0$. (15)
- (c) Solve $\frac{dy}{dx} - 2y \tan x = y^2 \tan^2 x$. (10)
7. (a) Solve $(D^2 - 5D + 6)y = 4e^x + 5$. (11)
- (b) Solve $(D^2 + 4)y = x \sin x$. (12)
- (c) Solve the differential equation $x^2 \frac{d^2 y}{dx^2} - 2y = x^2 + \frac{1}{x}$. (12)
8. (a) Solve $y + x \frac{dy}{dx} = x^4 \left(\frac{dy}{dx} \right)^4$. (11)
- (b) Solve $[(x + 3)D^2 - (2x + 7)D + 2]y = (x + 3)^2 e^x$ by the method of factorization of the operator. (12)
- (c) Solve $(3x + 2)^2 \frac{d^2 y}{dx^2} + 3(3x + 2) \frac{dy}{dx} - 36y = 3x^2 + 4x + 1$. (12)
-

SECTION – A

There are **FOUR** questions in this Section. Answer Q. No. 1 and any **TWO** from the rest.

1. (a) Explain with reference to the context any one of the following: (8)
- (i) "But we can't possibly have a garden-party with a man dead just outside the front gate".
- (ii) "In the opinion of some of them the death penalty ought to be replaced everywhere by imprisonment for life."
- (b) Answer any one of the following: (10)
- (i) How did the lawyer in 'the Bet' become a changed man?
- (ii) How does Katherine Mansfield's story 'The Garden Party' make you aware of the class system in a society?
- (c) Answer any three of the following: (12)
- (i) Briefly describe the terms and conditions of the bet made between the banker and the lawyer.
- (ii) Why was Mrs. Matilda Loisel unhappy?
- (iii) "We must take measures to replace this jewel." Who under what circumstances said this?
- (iv) What impression do you get about Laura as pictured in 'The Garden Party'?
2. (a) Recast and correct any ten of the following sentences: (20)
- (i) The amount of horses on the range was small.
- (ii) They made less mistakes with the new calculating machine.
- (iii) We heard a sound somewheres in the distant woods.
- (iv) Walt Whitman occupys a most unique place in literature.
- (v) Joe and Stew is to help us.
- (vi) The jury is arguing among itself.
- (vii) Soup and salad are too light a lunch.
- (viii) Both of the mouse is underfed.
- (ix) Its a long way home.
- (x) If I were him, I should not accept the post.
- (xi) He is something better today.
- (xii) He didn't speak but once.

HUM 125 (ChE)

3. (a) Give meanings of any ten of the following words: (10)

Ailment, blandishment, castigate, diffidence, feud, hilarious, limpid, oblivion, phlegmatic, ratify, sporadic, tamper.

- (b) Make sentences with any ten of the following words: (10)

Applaud, brawl, condone, emulate, forbearance, holocaust, meddle, peek, ramble, sinuous, transcend, vicarious.

4. Write a précis of the following passage with a suitable title: (20)

The liberty of the individual is no gift of civilization. It was unlimited before there was any civilization, though then, it is true, it had for the most part no value, since the individual was scarcely in a position to defend it. The development of civilization imposes restrictions on it, and justice demands that no one shall escape those restrictions. What makes itself felt in a human community as a desire for freedom may be their revolt against some existing injustice, and so may prove favourable to a further development of civilization; it may remain compatible with civilization. But it may also spring from the remains of their original personality, which is still untamed by civilization. The urge for freedom, therefore, is directed against particular forms and demands of civilization or against civilization altogether. It does not seem as though any influence could induce a man to change his nature into a termite's. No doubt he will always defend his claim to individual liberty against the will of the group. A good part of the struggles of mankind centres round the single task of finding an expedient accommodation – one, that is, that will bring happiness – between this claim of the individual and the cultural claims of the group; and one of the problems that touches the fate of humanity is whether such an accommodation can be reached by means of some particular form of civilization or whether this conflict is irreconcilable.

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE** including Q. No. 5 as **COMPULSORY**.

5. (COMPULSORY) Read the following passage carefully and answer the questions that follow. (30)

There are a good number of reasons why students in Bangladesh fail in English. That is a foreign language is the main reason. In other words, students do not have the right approach to English. Very few of them are earnest in learning English. What most students seek is to jump are the hurdles of examinations. To them, learning is unpleasant and examination is fearful. Soundly, the teaching of a foreign language becomes very difficult when the learners are not been on the subject. In that situation, a teacher of

HUM 125(ChE)

Contd ... Q. No. 5

English can hardly follow a technique suitable for all. They fail to convince the learners that they must master the four skills (Listening, speaking, reading and writing) of language and that there is no easy way of learning a foreign language. In short, they fail to make language learning interesting. Moreover, textbooks for different classes are not suited to the stage and standard of the learners. Finally, the nature of the questions in the public examinations induces cramming rather than learning the language. The faulty nature of questions persuades the students to run after the so-called touch and pass system. It is high time we did something to save the students from the disgrace of failure.

Answer the following questions:

- (a) What are the problems of learners of English in Bangladesh?
 - (b) What are defects of the text books and the nature of the questions?
 - (c) Why can't the teachers make their classes effective?
 - (d) Give meanings of the following as used in the passage (any five):
earnest; hurdle; a good number of; very few; most of them; keen on; so-called;
 - (e) What is the main idea of the passage?
 - (f) "The faulty nature of questions persuades the students to run after the so-called touch and pass system" – Explain the idea in brief.
6. (a) Suppose you are the chief engineer of a chemical engineering firm. Draft a letter ordering some chemicals from a supplier. Invent the details regarding the chemicals you are ordering. **(10)**
- (b) Give phonetic transcriptions of the following words: (Any five) **(10)**
measure; pleasant; school; scholar; wait; English;
7. (a) Write a dialogue between two friends about what they are planning for the year 2017. **(10)**
- (b) Write a short essay on any one of the following topics: **(10)**
- (i) The uses and abuses of the internet.
 - (ii) The need for inter-religious and inter-cultural harmony in today's World.
 - (iii) Rag Day celebration and Bangladeshi culture.
8. (a) Transform the following sentences as directed: (Any five) **(10)**
- (i) The dying phoenix must destroy itself before it can be reborn. (Compound)
 - (ii) Seeing a snake, the boy began to run. (Complex)
 - (iii) Make haste or else you will be late. (Simple)
 - (iv) He is so poor that he cannot lead a decent life. (Simple)
 - (v) The examination was too difficult for us to pass (Complex)
 - (vi) I know that faithful man (Complex)
 - (vii) If you take exercise regularly, you can be fit. (Compound)

HUM 125(ChE)

Contd ... Q. No. 8

(b) Write short notes on any two of the following:

(10)

- (i) Thesis statement
 - (ii) Diphthongs
 - (iii) Back Matter of a report.
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2015-2016

Sub : **CHEM 131** (Physical Chemistry I)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – AThere are **FOUR** questions in this Section. Answer any **THREE**.

Assume reasonable values for any missing data. Symbols used here bear usual meaning.

1. (a) Explain the law of chemical equilibrium. Briefly discuss the characteristics of chemical equilibrium. (11)
- (b) Derive an expression for the variation of equilibrium constant with temperature. How can this expression provide information about exothermic and endothermic nature of chemical reactions? (12)
- (c) At 2155°C and 1 atm pressure $\text{H}_2\text{O}(\text{g})$ is decomposed into $\text{H}_2(\text{g})$ and $\text{O}_2(\text{g})$ in accordance with the equation. (12)

$$2\text{H}_2\text{O}(\text{g}) = 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$$

Derive an expression for K_p . If $\text{H}_2\text{O}(\text{g})$ is 1.18% decomposed for the above process, find the value of K_p .
2. (a) Define entropy. Prove that all spontaneous processes are accompanied by an increase in entropy. (11)
- (b) Deduce an expression for the entropy of mixing of two ideal gases. Under what condition will the entropy of mixing be maximum? (12)
- (c) Obtain an expression for entropy change of an ideal gas when the temperature changes from T_1 to T_2 and volume from V_1 to V_2 . Simplify the expression for an isothermal process. Use the simplified expression to calculate the entropy change involved in the isothermal reversible expansion of 5 moles of an ideal gas from a volume of 10 L to a volume of 100 L at 300 K. (12)
3. (a) What you mean by the term “free energy”? Establish the condition under which free energy change of a system can be used as a criterion for spontaneity of a process. (11)
- (b) Derive the Clausius-Clapeyron equation and discuss its uses. (12)
- (c) Considering ideal behavior derive expressions for ΔV , ΔG , and ΔH for mixing of n_1 moles of an ideal gas with n_2 moles of another. Use the expressions to calculate ΔV , ΔG and ΔH of mixing 1.6 moles of argon at 1 atm and 25°C with 2.6 moles of nitrogen at 1 atm and 25°C (Assume ideal behavior). (12)

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4. (a) Derive the Gibbs-Duhem equation and hence show that the Chemical Potentials of components in a mixture do not change independently. **(11)**
- (b) Starting with the ideal gas equation, establish the relation $\mu = \mu^\circ + RT \ln a$. **(12)**
- (c) Show that $dG = Vdp - SdT$ and hence deduce an expression for the change in free energy for a process under isothermal condition. Use the expression to calculate the free energy change when 44 g of CO_2 are allowed to expand from 1 atm to 1/10 atm at 27°C isothermally and reversibly (Assume ideal behavior). **(12)**

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) How the concept of solubility of gas in water can be applied to explain **(5+5=10)**
- (i) The formation of scale in boiler due to the presence of Ca^{2+} ions in water.
- (ii) 'The bends' – the decompression sickness of scuba drivers.
- (b) Explain that the relative solubilities of ionic solids in water can be decided from the knowledge of hydration enthalpy and lattice energy. **(8)**
- (c) 'X' is a solute distributed between two immiscible solvent 'A' and 'B'. If 'X' undergoes association in solvent 'B', show that the distribution coefficient is not $\frac{[X_A]}{[X_B]}$ but $\frac{[X_A]}{n[X_B]}$, where $[X_A]$ and $[X_B]$ are the concentrations of 'X' in solvent 'A' and solvent 'B' respectively. Write down the significance of 'n' in the expression. **(12)**
- (d) A commercial bleach solution contains 3.62 mass% NaOCl in water. Calculate (i) the mole fraction (ii) the molality of NaOCl in solution. **(5)**
6. (a) Define 'ideal solution' and give a molecular interpretation of ideal behaviour of a solution. Draw a graphical relation between the vapor pressure as function of mole fraction for an ideal solution of component 'A' and 'B'. What are the relations if the solution is non-ideal? Give the molecular interpretation of such non-ideal behaviour. **(5+3+3+8=19)**
- (b) What happens when two partially miscible liquid pair is heated? Draw such a typical diagram of temperature vs. composition for a partially miscible liquid pair and write down the significance of the line separating the solution and the immiscible layer. **(10)**
- (c) The solubility of methylamine at 18°C in water is 8.49 times greater than in chloroform. What percentage of the substance remains in 1000 mL of chloroform solution of methylamine if it is extracted (i) Four times with 200 mL of water each time and (ii) twice with 400 mL of water each time? **(6)**

CHEM 131(CHE)

7. (a) Apply the concepts of free energy and partial molar free energy to find out the condition for equilibrium of a solution if the system composed of several phases each of which may contain a number of components. (10)
- (b) Derive a relationship between osmotic pressure and vapor pressure of a solution. From the relation prove that osmotic pressure is independent on the nature of the solute. (10)
- (c) A non-volatile non-electrolyte substance 'F' is added to a pure solvent. What will happen to the boiling point of the solvent? Show that (10)
- (i) the change in the boiling point is not dependent on the chemical nature of 'F'
- (ii) the change in boiling point of the solution can be applied for the determination of molar mass of 'F'
- (d) A solution of polystyrene in benzene contains 10 g/L. The equilibrium height of the column of solution (density 0.88 g/cm³) in the osmometer corrected for capillary rise is 11.6 cm at 25°C. What is the molar mass of polystyrene, assuming the solution is ideal? (5)
8. (a) Write down suitable chemical reactions to prepare the colloidal solution of (8)
- (i) gold (ii) Fe (OH)₃
- (b) Peptization is the process of formation of colloidal particles from precipitation. Explain that the process is nothing but formation of charge on the surface of particles. Explain the mechanism. (8)
- (c) Explain the experimental principle to determine the particle size distribution by dynamic light scattering method. (10)
- (d) Draw the electrical double layer model of charge in colloidal particles. How zeta potential can be measured from such diagram? Why Zeta potential is important for nanomaterials. (4+2+3=9)
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SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Explain the statement “Charge is Consumed”. (10)
 (b) Deduce an expression for the electric field, \vec{E} , for points on the axis of a circular ring of charge, q , of radius, ‘ a ’, at a distance x from its centre. (17)
 (c) Two point charges of magnitude $+2 \times 10^{-7} \text{C}$ and $+8.5 \times 10^{-8} \text{C}$ are 12 cm apart. (i) What electric field does each produce at the site of the other? (ii) What force acts on each? (8)

2. (a) State and explain Biot-Savart law. (10)
 (b) Applying Biot-Savart law, obtain an expression for the magnetic field induction \vec{B} , at a distance, ‘ r ’, from a long straight wire carrying a current, i . (17)
 (c) A solenoid is 5.0 m long and 2.0 cm in mean diameter. It has 5 layers of windings of 750 turns each and carries a current of 5.0 A. What is \vec{B} at its centre? ($\mu_0 = 4\pi \times 10^{-7} \text{wb/A-m}$) (8)

3. (a) Define electric potential and potential difference. (10)
 (b) Show that the electric field strength at a point in an electric field is equal to the negative gradient of potential at the same point. (17)
 (c) Three charges $-5 \times 10^{-8} \text{C}$, $+2 \times 10^{-8} \text{C}$ and $+3 \times 10^{-8} \text{C}$ are placed at the three corners of an equilateral triangle; the length of any side of it is 10 cm. Calculate the potential energy of the system. (8)

4. (a) What is binding energy per nucleon? Briefly explain the binding energy curve. (10)
 (b) Define half life and average life time of a radioactive substance. Show that the average lifetime of a radioactive material is reciprocal to the disintegration constant. From this show that $T_{\text{average}} = 1.44 T_{1/2}$. Where symbols have their usual meaning. (17)
 (c) A counter rate meter is used to measure the activity of a radioactive material. At a certain instant the count rate was recorded as 4750 counts per minute. Five minutes later, the count rate recorded was 2700 counts per minute. Compute (8)
 - (i) the decay constant and
 - (ii) the half life of the sample.

PHY 155(CHE)

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) What is time dilation and length contraction? Give an example of each. (10)
- (b) Derive an expression for the relativistic kinetic energy of a particle and show that the relationship between the energy and momentum of a particle is $E^2 = p^2c^2 + m_0c^4$. where the symbols have their usual meaning. (17)
- (c) A particle has a kinetic energy of 62 MeV and a momentum of 335 MeV/c. Find its mass (in MeV/c²) and speed (as a function of C). (8)
6. (a) Discuss the wave particle duality. What are threshold frequency and stopping potential in photoelectric effect? (12)
- (b) Describe Einstein's photoelectric effect. What is work function? How do you determine the work function graphically? (15)
- (c) A surface having work function 1.5 eV is illuminated by light of wavelength 4000 Å. Calculate (i) the maximum kinetic energy of the ejected electrons and (ii) the stopping potential. (8)
7. (a) What does Bravais lattice stand for? Categorize Bravais lattice in three dimensional space. (15)
- (b) Copper (Cu) crystallizes in face centered cubic form. Atomic mass of Cu is 63.546 a.m.u. and density is 8.96 g/cm³. Calculate the lattice constant of Cu-crystal. (5)
- (c) Discuss intrinsic and extrinsic semiconductors in the light of Band theory of solid. Why does resistance of a semiconductor reduce with the increase of temperature? (15)
8. (a) Derive Bragg's law of x-ray diffraction. What are the advantages of using x-ray diffraction techniques for analyzing the structure of solids? Write down the names of some x-ray diffraction techniques. (18)
- (b) Determine the wavelength of an x-ray beam reflected from the 2nd (110) plane of a cubic crystal through an angle 21.56°. The interplaner spacing between two (110) parallel planes is 4.14 Å. (5)
- (c) Write short note on Van der Waals bonds. Prove that Van der Waals force is proportional to r^{-7} , where r is the distance between two molecules. (12)
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