L-2/T-1/CHE **Date: 28/03/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2021-2022

Sub: **CHE 201** (Material and Energy Balance)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

A data booklet containing relevant data is attached.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

Q. No. 1 is Compulsory.

1. (a) As a Chemical Engineer why do you need to study combustion reactions? **(4)**

   (b) Explain how to estimate dew point temperature and bubble point temperature for component mixture with appropriate equations. **(6)**

   (c) Define (i) standard heat of reaction, (ii) standard heat of combustion, and (iii) standard heat of formation. **(6)**

   (d) Write a short note on differential and integral balance of a transient system. **(6)**

   (e) What is heating value of a fuel? How will you calculate lower heating value of a fuel from the higher heating value and vice-versa? Explain with a appropriate example. **(6)**

   (f) With the help of a neat sketches explain cooling with humidification and heating with humidification. Give appropriate examples of the two processes. **(7)**

2. (a) An ammonia solution at a high pressure is flash-vaporized at a rate of 200 lb_m/h. The solution contains 0.70 lb_m NH_3/lb_m, and its enthalpy relative to H_2O (l, 32°F) and NH_3 (l, –40°F) is –50 Btu/lb_m. Liquid and gas streams emerge from the unit at 1 atm and 80°F. Determine the mass flow rates and ammonia mass fractions of the vapor and the liquid product streams and the rate (Btu/h) at which heat must be transferred to the vaporizer. **(18)**

   (b) Saturated steam at 300°C is used to heat a counter-currently flowing stream of methanol vapor from 65°C to 260°C in an adiabatic heat exchanger. The flow rate of the methanol is 6500 L (STP) per minute, and the steam condenses and leaves the heat exchanger as liquid water at 90°C. **(17)**

   (i) Calculate the required flow rate of the entering steam in m^3/min.

   (ii) Calculate the rate of heat transfer from the water to the methanol (kW).

3. (a) The fresh feed to an ammonia production process contains nitrogen and hydrogen in stoichiometric proportion, along with an inert gas (I). The feed is combined with a recycle stream containing the same three species, and the combined stream is fed to a

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Contd.... for Q. No. 3(a)

reactor in which a low single-pass conversion of nitrogen is achieved. The reactor effluent flows to a condenser. A liquid stream containing essentially all of the ammonia formed in the reactor and a gas stream containing all the inerts and the unreacted nitrogen and hydrogen leave the condenser. The gas stream is split into two fractions with the same composition: one is removed from the process as a purge stream, and the other is the recycle stream combined with the fresh feed. *In every stream containing nitrogen and hydrogen, the two species are in stoichiometric proportion.* Let, the mole fraction of ienrts in the fresh feed is 1%, the single-pass conversion of nitrogen (and of hydrogen) in the reactor is 20%, and the fraction of the gas leaving the condenser that is purged (mol purged/mol total) is 0.1. Taking a basic of 1 mol fresh feed, draw and fully label a process flowchart and determine, **(25)**

(i) the total moles fed to the reactor

(ii) moles of ammonia produced, and

(iii) overall nitrogen conversion.

(b) A gas contains 80.0 wt% propane, 15.0 wt% butane, and the balance water. Calculate the molar composition of this gas on both wet and dry basis and the ratio of mol H_2O/mol dry gas. **(10)**

4. (a) Air at 50°C with a dew point of 4°C enters a textile dryer at a rate of 11.3 m^3/min and leaves saturated. The dryer operates adiabatically. Use the psychrometric chart to determine the absolute humidity and humid volume of the entering air, and then use the results to determine the flow rate of dry air (kg/min) at which water is evaporated in the dryer. **(17)**

(b) A continuous stirred-tank reactor is used to produce a compound R in the liquid-phase reaction A→ R. Feed enters the reactor at a rate of 1.15 L/s; the rate of product out-put 1.15 L/s; The concentration of the reactant i the feed is 10 mol A/L. The volume of the the tank contents is 10 L. The vessel may be considered perfectly mixed, so that the concentration of A in the product stream equals that in the tank. For this process the rate of consumption of A equals 0.0050 C_A mol/s-L of reaction volume. The tank is initially filled with a solution that contains 2.00 mol A/L, and the inlet and outlet flows then begin. **(18)**

(i) Write a differential balance on species A in the tank and provide an initial condition.

(ii) Solve the balance equation for $C_A(t)$.

(iii) Calculate, C_{AS}, the steady-state concentration of A in the tank (the value approached as $t \rightarrow \infty$).

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SECTION – B

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

5. The oxidation of NH_3 can result in the formation of the acid Nitrooxonium, H_2NO_3. NH_3 first interacts with O_2 to produce NO and H_2O, and in the presence of O_2, NO and H_2O combine to generate H_2NO_3. The block diagram of the process is shown in Fig. for Q. No. 5.

   (a) Describe the adiabatic reactor with proper definition. **(3)**

   (b) Estimate the percent of excess air. **(5)**

   (c) Evaluate the adiabatic reactor outlet temperature. **(20)**

   (d) To obtain pure H_2NO_3, create a block diagram beginning at the acid production reactor output. Suppose the solubility of H_2NO_3, H_2O, and N_2 is negligible. The boiling point of H_2NO_3 is 86°C. **(7)**

6. (a) Draw a P-xy diagram of a benzene-toluene system at 100°C temperature. **(12)**

   (b) The standard heat of reaction for the oxidation of ammonia is given below:

   $$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(v) \quad \Delta\hat{H}_r^0 = -904.7 kj/mol$$

   One hundred mol NH_3/s and 200 mol O_2/s at 25°C are fed into a reactor. 19.7 MW heat is transferred from the reactor to emerge the product gas at 300°C.

   (i) Explain the extent of reaction with the proper definition. **(3)**

   (ii) Perform the material balance calculation. **(5)**

   (iii) Evaluate the extent of reaction of NH_3 gas. **(15)**

7. Acetaldehyde is synthesized by the catalytic dehydrogenation of ethanol:

   $$C_2H_5OH \rightarrow CH_3CHO + H_2$$

   Fresh feed (pure ethanol) is blended with a recycle stream (95% ethanol and 5% acetaldehyde), and the combined stream is heated and vaporized, entering the reactor at 280°C. Gases leaving the reactor are cooled to –40°C to condense the acetaldehyde and unreacted ethanol. Off-gas from the condenser is sent to a scrubber, where the uncondensed organic compounds are removed and hydrogen is recovered as a byproduct. The condensate from the condenser which contains 45 mole% of ethanol is sent to a distillation column that produces a distillate containing 97 mole% acetaldehyde and a bottom product that constitutes the recycle blended with fresh feed to the process. The production rate of the distillate is 1000 kg/h. The pressure throughout the process may be taken as 1 atm absolute. (Use Raoult's law in the analysis of the condenser). The block diagram of the process is shown in Figure for Q. No. 7.

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Contd.... for Q. No. 7

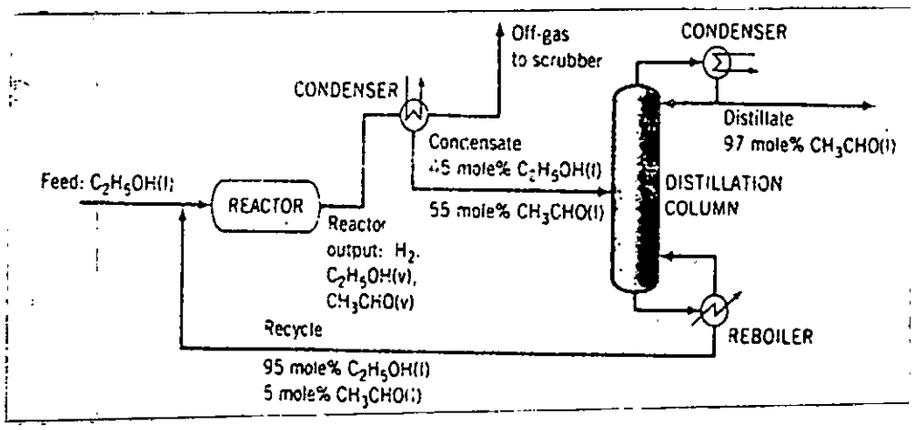

Figure for Q. No. 7

(a) Calculate the molar flow rates (kmol/h) of the fresh feed, the recycle stream, and, the hydrogen in the off gas. **(15)**

(b) Determine the volumetric flow rate (m^3/h) of the feed to the reactor. **(5)**

(c) Estimate the overall single-pass conversion of ethanol and rates (kmol/h) at which ethanol and acetaldehyde are sent to the scrubber. **(15)**

8. (a) A fuel gas is known to contain methane, ethane, and carbon monoxide. A sample of the gas is charged into an initially evacuated 2-litter vessel at 25°C and 2323 mm Hg absolute. The vessel is weighed before and after being charged and the mass difference is found to be 4.929 g. The higher heating value of the gas is determined in a calorimeter to be 841.0 kJ/mol. Calculate the molar composition of the gas. **(15)**

(b) A solution containing 100 lbm KNO_3/100 lbm H_2O at 80°C is fed to a cooling crystallizer operated at 25°C. Slurry from the crystallizer is fed to a filter where the crystals are separated from the solution.

(i) Determine the production rate of crystals (lbm crystals/lbm of feed) **(10)**

(ii) Estimate the solid-liquid mass ratio (lbm crystals/lbm feed) in the slurry leaving the crystallizer. **(10)**

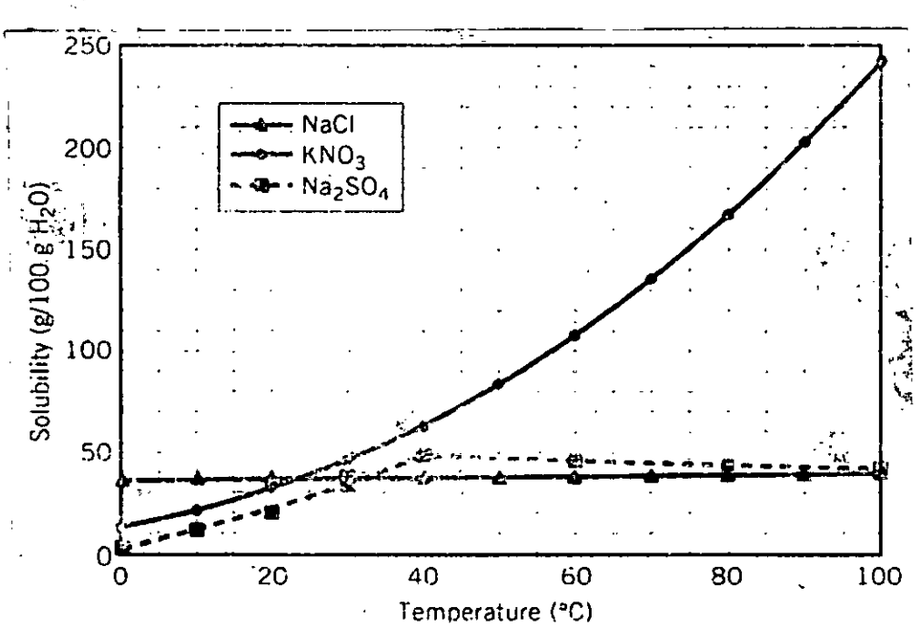

Fig. for Q. No. 8(b)

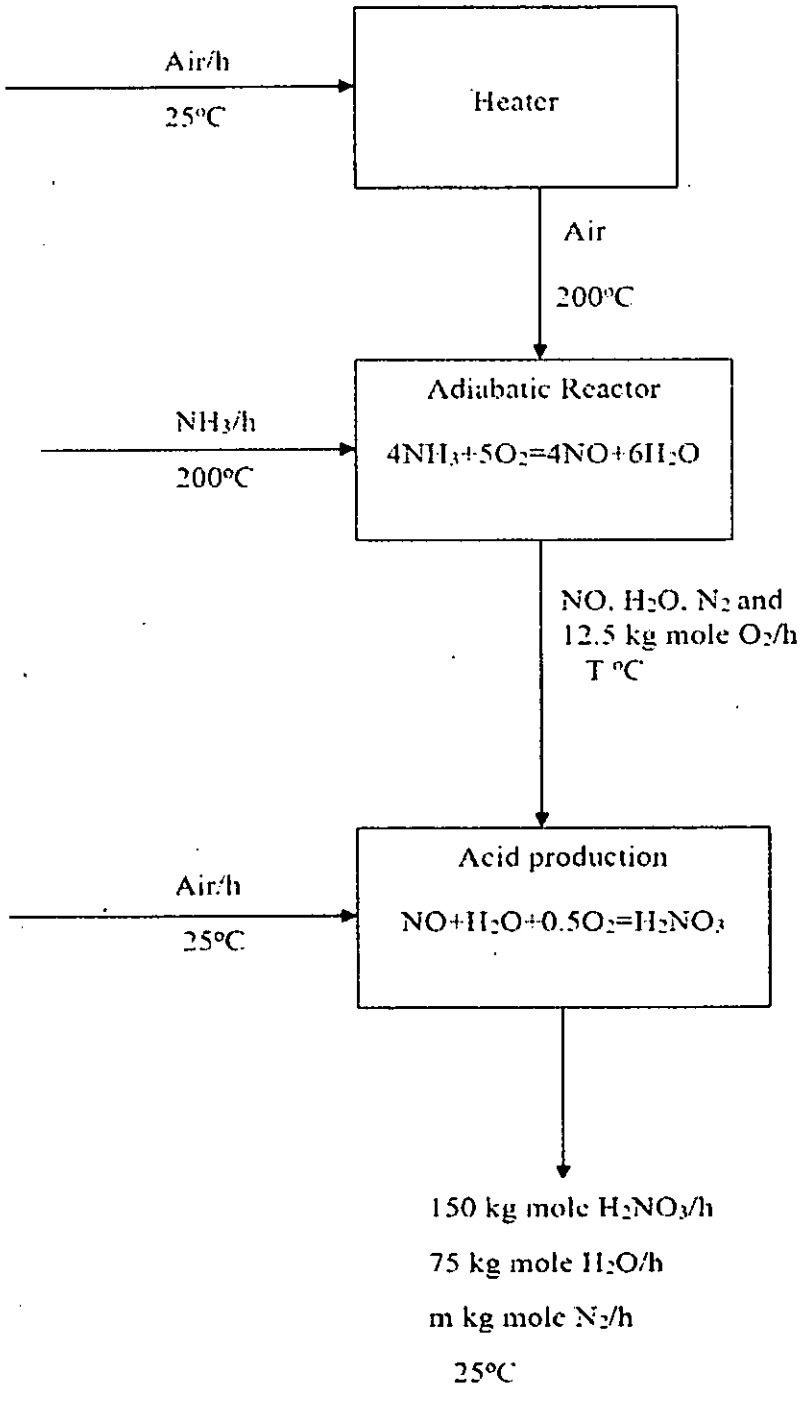

Figure for Question No. 5

L-2/T-1/CHE **Date: 04/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2021-2022

Sub: **CHEM 235** (Physical Chemistry II)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

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

1. (a) Define salt hydrolysis. With the concept of salt hydrolysis, choose the stronger acid between HX and HY if the corresponding 0.1 M solution of sodium salts NaX and NaY at 25°C have pH values 9.0 and 11.0, respectively. **(12)**

   (b) Show that the pH of a salt of weak acid and weak base is independent of the concentration of the salt, and hence establish the condition under which the solution is expected to be acidic, basic, and neutral. **(14)**

   (c) Calculate the pH of 0.1 M solution of ammonium ethanoate at 25°C (For NH_4^+, pk_a = 9.245 and for CH_3COOH, pk_a = 4.76). **(9)**

2. (a) How will you explain non-identity of an electrolyte solution in terms of activity coefficient and ionic strength? Consider two aqueous solutions of NaCl and $CaCl_2$ having the same concentration of 0.001 m. Which of the two solutions is expected to show more non-ideality? **(12)**

   (b) Show that the solubility of a sparingly soluble salt increases with increasing the ionic strength of an added electrolyte having no common ion. **(14)**

   (c) The solubility of silver iodate in pure water at 25°C is 1.77×10^{-4} $molL^{-1}$. Calculate the solubility in the pressure of 0.3252×10^{-2} $molL^{-1}$ of potassium nitrate. **(9)**

3. (a) The molar conductance of 0.1 M NaOH solution is 221 $ohm^{-1}cm^2mol^{-1}$. When equal volume of 0.1 M HCl solution is gradually added the molar conductance of the resulting solution is found to be 112 $ohm^{-1}cm^2mol^{-1}$. Sketch and explain the possible trend of the changes in specific conductance values during the course of addition of HCl solution, and find the specific conductance of NaCl and NaOH solutions. **(12)**

   (b) Define ionic mobility. Show that the ionic mobility of an ion is directly proportional to its ion conductance. **(14)**

   (c) A potential of 5.60 V is applied to electrodes placed 9.8 cm apart. How far would an ammonium ion will move in 1 hour in a dilute solution of ammonium salt at 25°C? Given: $\lambda(NH_4^+ = 73.45\ cm^2mol^{-1})$ **(9)**

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4. (a) Consider a solution 10^{-3} M in $Cr_2O_7^{2-}$ and 10^{-2} M in Cr^{3+} in contact with a platinum foil at pH 2.0. Show the half cell arrangement, the corresponding half cell reaction, and find the electrode potential at 25°C. Justify whether $Cr_2O_7^{2-}$ will be a more powerful oxidizing agent at pH 3.0 (Given: $E°(Cr_2O_7^{2-}/Cr^{3+}) = 1.36$ V). **(12)**

(b) Explain how you can determine the activity coefficient of HCl solution used in the cell below and the standard electrode potential of Ag-AgCl(s) electrode. **(14)**

$$pt \mid H_2 \text{ (1 atm)} \mid HCl \text{ (m)} \mid AgCl(s) \mid Ag$$

(c) An electrochemical cell **(9)**

$$M(s) \mid MCl \text{ (aq, 1.0 m)} \mid AgCl(s) \mid Ag$$

where MCl is the chloride salt of the metal electrode M, yields a potential of 0.2053 V at 25°C. What is the mean activity coefficient, $\gamma_\pm$ of the electrolyte MCl? For $M(s) \mid M^+$ electrode $E° = 0.0254$ V.

SECTION – B

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

5. (a) Show that half-life for a second order reaction is inversely proportional to the rate constant. Obtain the unit of the third order rate constant from the rate expression. **(15)**

(b) 50% of a first order reaction is completed in 23 minutes. Calculate the time required to complete 90% of the reaction. **(10)**

(c) Describe the activated complex theory of bimolecular reactions. What are the advantages of this theory over collision theory? **(10)**

6. (a) Draw a well-labelled phase diagram of Mg-Zn system and discuss its salient features. **(15)**

(b) Explain why the fusion curve of ice has a negative slope whereas the sublimation curve has a positive slope in the phase diagram. **(10)**

(c) Explain briefly: (i) NH_4Cl in equilibrium with its dissociation product is a one component system, (ii) Sulphur system at any of its triple points is non-variant. **(10)**

7. (a) "A conjugated diene absorbs at a higher wavelength with higher value of extinction coefficient as compared to a diene in which double bonds are isolated" — explain using orbital concept. **(15)**

(b) The microwave spectrum of carbon monoxide consists of a series of lines separated by 1.15×10^{11} Hz. Calculate the bond length of CO. **(10)**

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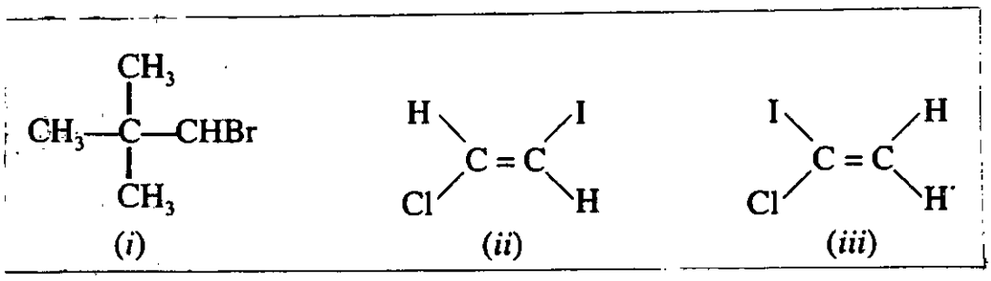
CHEM 235/CHE

Contd.... for Q. No. 7

(c) How does photodynamic therapy kill neighboring tumor cells? What prerequisites must a photosensitizer meet in order to be utilized in photodynamic therapy? **(15)**

8. (a) Mention two reference materials that are commonly used as internal standard. Why are they chosen? **(10)**

What will be the multiplicity of each kind of proton in the following molecules?



(b) Aromatic protons are more deshielded than ethylenic protons, although both the types of protons are attached to sp^2 hybridized carbon atom. Explain. **(10)**

(c) Calculate the wave number of stretching vibration of a carbon-carbon double bond (force constant, $k = 10 \times 10^5$ dynes cm^{-1}). **(10)**

L-2/T-1/CHE Date: 30/04/2023

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2021-2022

Sub: **HUM 103** (Economics)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Symbols indicate their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Define demand function. **(5)**

   (b) What are the factors that influence shifting of the demand curve? **(10)**

   (c) How would you derive the market demand curve of a commodity? Explain graphically. **(10)**

   (d) What are the exceptions to the law of demand? **(10)**

2. (a) Define income elasticity of demand and price elasticity of demand. **(10)**

   (b) Show that price elasticity of demand varies from zero to infinity along any straight line demand curve. Explain graphically. **(15)**

   (c) From the following table calculate elasticity of demand if you move from point B to C and explain what you understand from the result. **(10)**

POINT	P_X	Qy
A	500	120
B	600	150
C	700	180

3. (a) What are the methods for measuring national income? Explain any two of them. **(10)**

   (b) Discuss the problems of measuring national income in a developing country like Bangladesh. **(10)**

   (c) Given that **(15)**

$$C = 100 + 0.9\ Y_D$$

$$I = 200$$

$$G = 200$$

$$X = 150$$

$$M = 300$$

$$T = 0.15Y$$

$$TR = 300$$

Contd P/2

HUM 103/CHE

Contd.... for Q. No. 3(c)

(i) calculate equilibrium level of income and multiplier.

(ii) if investment expenditure increases to 400, what will be the new equilibrium level of income?

(iii) if tax rate is increased to 20%, what will be the value of the new equilibrium level of income and multiplier?

4. (a) Show how market equilibrium is attained. Explain the market adjustment process using the concept of excess demand and excess supply. **(15)**

(b) The demand and supply function of brown eggs and white eggs are: **(20)**

Demand	Supply
$P_b = 220 - 4Q_b - 3Q_w$	$P_b = 300 + 3Q_b + 2Q_w$
$P_w = 1300 - 2Q_b - 3Q_w$	$P_w = 100 + 2Q_b + Q_w$

(i) What will be the price and quantities at equilibrium?

(ii) If supply functions changes to the following and the demand functions are unchanged, find the equilibrium point.

Supply
$P_b = 150 + Q_b + 4Q_w$
$P_w = 25 + Q_b + 3Q_w$

SECTION – B

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

5. Consider the production function, $Y = K^{2/3} L^{1/3}$, where Y denotes output, K capital and L labor. You are also given the price of labor, w = 5; price of capital, r = 10 and Total cost = 15000

(a) Find the equilibrium amount of labor, capital and output. **(20)**

(b) Draw an expansion path mathematically and graphically considering the equilibrium point you obtained in part "a" of question 5 as an initial point. **(15)**

6. (a) Drive average cost (AC) curve and marginal cost (MC) curve from total cost (TC) curve, and average product (AP) curve and marginal product (MP) curve from total product (TP) curve. **(20)**

(b) Show the relationships among different cost curves (AC, MC and TC) and product curves (AP, MP and TP), and between cost and product curves (AC, MC, TC and AP, MP and TP). **(15)**

Contd P/3

HUM 103/CHE

7. (a) Which market structures (perfectly competitive market or monopoly market) gives us more society's surplus (consumer surplus plus producer surplus) and less welfare loss (dead weight loss)? Use the following equations to answer your question. **(20)**

$TC = 60 + 15\,Q + 3Q^2$

$TR = 60\,Q - 3Q^2$

Where Q = Quantity of commodity, TC = Total cost, and TR = Total revenue

(b) Explain and show graphically super normal profit, loss and zero profit/normal profit in case of monopolistically competitive market. **(15)**

8. (a) Do you think that construction of the "Metro Rail" and "Padma Bridge" will help Bangladesh achieve Sustainable Development Goals (SDGs)? If yes, which goals and how? Explain. **(20)**

(b) Describe different steps of planning with an arbitrary example. **(15)**

L-2/T-1/CHE **Date: 06/05/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2021-2022

Sub: **MATH 225** (Different Equations and Laplace Transforms)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Symbols indicate their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Find the differential equation by eliminating arbitrary constants A and B from the equation $y = A\sin 2x + B\cos 2x + x\sin 2x$. **(10)**

   (b) Solve $(2x-5y+3)dx-(2x+4y-6)dy=0$. **(13)**

   (c) Solve $x(x^2-1)\frac{dy}{dx}+(2x^2-1)y=ax$. **(12)**

2. (a) Radium is known to decay at a rate proportional to the amount present. If the half life of radium is 1200 years, what percentages of radium will remain in a given sample after 7200 months? Also determine the number of years, after which only one-fifth of the original amount of radium would remain? **(12)**

   (b) Is the differential equation $y^2dx+(x^2-xy-y^2)dy=0$ exact? If not make it exact and solve. **(12)**

   (c) Solve $x\frac{d^2y}{dx^2}+x\left(\frac{dy}{dx}\right)^2-\frac{dy}{dx}=0$. **(11)**

3. (a) Solve $\frac{d^2y}{dx^2}-4\frac{dy}{dx}+4y=\sin 2x$, given that $y = 1/8$ and $\frac{dy}{dx}=4$ where $x = 0$. **(11)**

   (b) Find the general solution of the following higher order differential equation. **(12)**

   $$\frac{d^2y}{dx^2}-6\frac{dy}{dx}+13y=e^{2x}x^2.$$

   (c) Reduce the differential equation $x^2\frac{d^2y}{dx^2}-x\frac{dy}{dx}+4y=x^2\cos(\log x)$ into linear form with constant co-efficient and then solve. **(12)**

4. (a) Form a partial differential equation by eliminating the arbitrary function ϕ from $\phi(\tan x+\sin^{-1}y-\log z, e^x-2y^2+z^3)=0$. **(10)**

   (b) Apply Lagrange's auxiliary equation technique to solve: **(12)**

   $$(x-2z)p-(4zx+y)q=2x^2+y$$

   (c) Using Charpit's method find the complete and singular integrals of the following partial differential equation: **(13)**

   $$2xz-px^2-2qxy+pq=0.$$

Contd P/2

SECTION – B

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

5. Solve the following:

(a) $\left(D_x^2 - D_xD_y - 6D_y^2\right)z = e^{2y}\cos 3x$ **(11)**

(b) $\left(D_x^3 - 2D_x^2D_y - D_xD_y + 2D_y^2\right)z = e^{2x+y} + xy$ **(12)**

(c) $\left(D_x^2 - 4D_y^2\right)z = \frac{4x}{y^2} - \frac{y}{x^2}$ **(12)**

6. (a) Solve: $\left(x^2D_x^2 - 4xyD_xD_y + 4y^2D_y^2 + 6yD_y\right)z = x^3y^{-2}$ **(15)**

(b) Find

(i) $L\{\sin\sqrt{t}\}$ **(10)**

(ii) $L\{C_i(t)\}$ **(10)**

7. (a) Evaluate $\int_0^\infty \frac{e^{-t}\sin t}{t}\,dt$ using Laplace transform. **(15)**

(b) Solve the following differential equation by using Laplace transform: **(20)**

$$tY''(t) + (2t+3)Y'(t) + (t+3)Y(t) = 3e^{-t}$$

where $Y(0) = 2,\ Y'(0) = -1$.

8. (a) Use convolution property to find **(15)**

$$L^{-1}\left\{\frac{s}{(s^2+4)^3}\right\}.$$

(b) Use Laplace transform to solve the following system: **(20)**

$$\frac{d^2X}{dt^2} + \frac{d^2Y}{dt^2} = e^{2t},\ 2\frac{dX}{dt} + \frac{d^2Y}{dt^2} = -e^{2t}$$

subject to $X(0) = 0,\ Y(0) = 0$ and $X'(0) = 0,\ Y'(0) = 0$.

L-2/T-1/CHE **Date: 11/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2021-2022

Sub: **EEE 267** (Electrical and Electronics Technology)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

All the symbols have their usual meanings. Assume reasonable values for missing data.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Explain the operation of the electronic circuit shown in Fig. for Q. No. 1(a) on the right side and sketch the output voltage (v_0) as a function of time (t) for the given sinusoid input voltage (v_i) in Fig. for Q. No. 1(a) on the left. (Consider Si diode) **(18)**

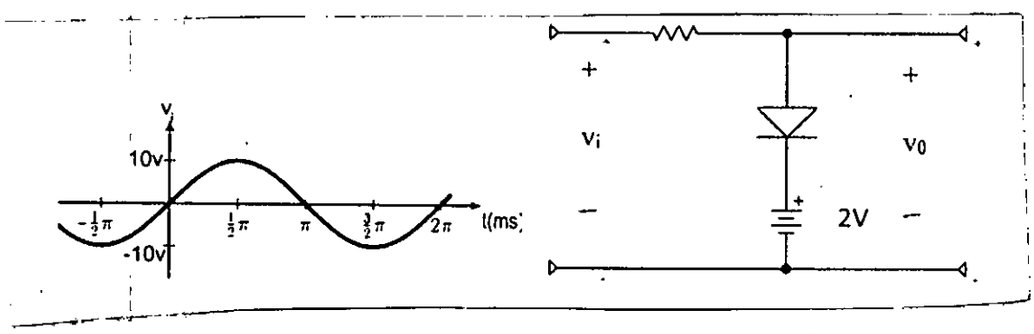


Fig. for Q. No. 1(a)

(b) Assuming ideal diodes in the circuit of Fig. for Q. No. 1(b), find the values of I_{D1} I_{D2} and v_0. **(17)**

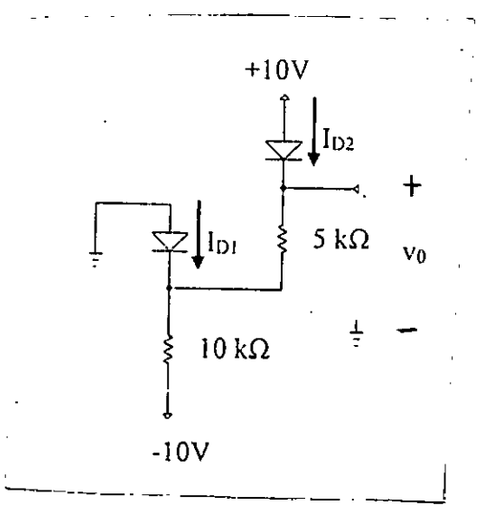


Fig. for Q. No. 1(b)

Contd P/2

EEE 267/CHE

2. (a) Analyze the circuit shown in Fig. for Q. No. 2(a) to determine the voltages at all nodes and current through all branches. Assume, $\beta = 100$. **(18)**

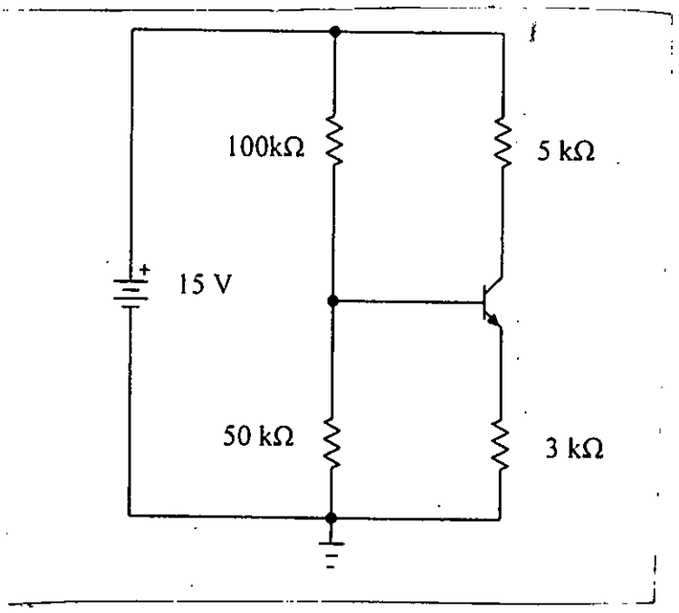


Fig. for. Q. No. 2(a)

(b) Design the circuit shown in Fig. for Q. No. 2(b) so that a current of 2 mA flows through the collector and a voltage of +5V appears at the collector. Assume, $\beta = 100$, $v_{BE} = 0.7\ V$ at $i_C = 1$ mA. Here, ±15 V dc power supplies are used. **(17)**

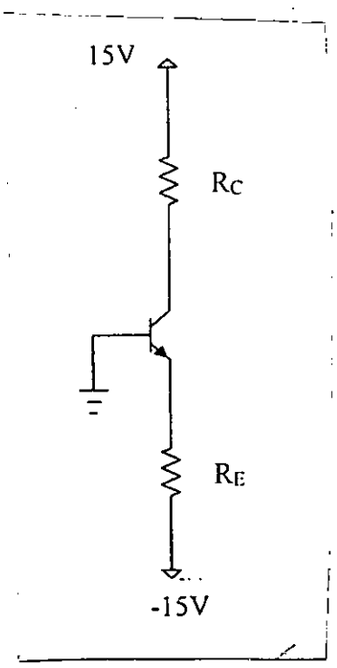


Fig. for Q. No. 2(b)

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3. (a) Determine the values of R_D and R_S in the circuit shown in Fig. for Q. No. 3(a), so that the transistor operates at $I_D = 0.4$ mA and $V_D = +0.5$ V. The NMOS transistor has $V_t = 0.7$ V, $\mu_n C_{ox} = 100\ \mu A/V^2$, $L = 1\ \mu m$, and $W = 32\ \mu m$. Neglect the channel-length modulation effect. **(18)**

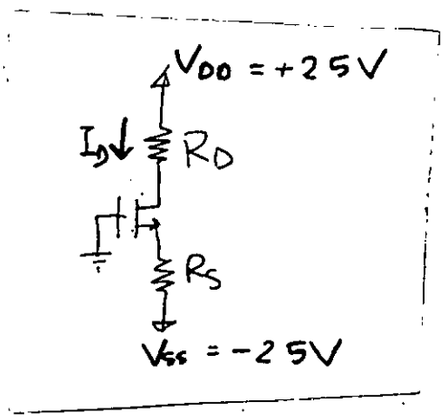

Fig. for Q. No. 3(a)

(b) Design the circuit of Fig. for Q. No. 3(b) so that the MOSFET operates in the saturation region with $I_D = 0.5$ mA and $V_D = +3$ V. Let the enhancement-type PMOS FET have $V_{tp} = -1$ V and $k_p(W/L) = 1$ mA/V^2. Assume $\lambda = 0$. What is the largest value that R_D can have while maintaining the operation in the saturation-region? **(17)**

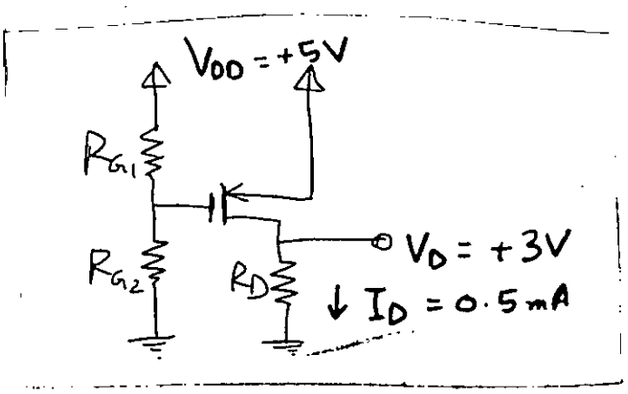

Fig. for Q. No. 3(b)

4. (a) A balanced Y-connected load with a phase impedance of 40 + j25 Ω is supplied by a balanced, positive sequence Δ-connected sources with a line voltage of 210 V. Calculate the phase currents. Use V_{ab} as reference. **(17)**

(b) Identify the circuit of Fig. for Q. No. 4(b). For the input voltage, $E_1 = 2$ V, $E_2 = 3$ V, and $E_3 = 2$ V p-p 5 Hz sinusoidal signal, calculate and sketch the output voltage (V_o) as a function of time (t). **(18)**

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Contd.... for Q. No. 4(b)

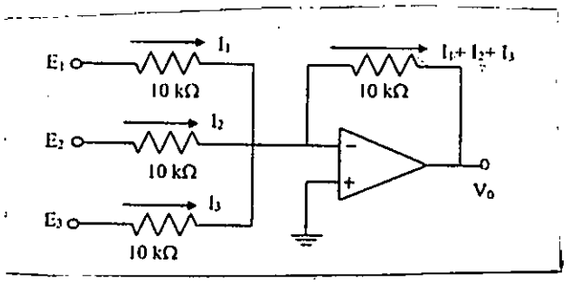

Fig. for Q. No. 4(b)

SECTION – B

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

5. (a) Describe step by step (cause and effect summary) how speed of a DC shunt motor can be increased using Armature Voltage Control method? Show necessary equation and circuit diagram. **(10)**

(b) Derive the torque-speed characteristics of a shunt DC motor. Draw a conceptual torque-speed plot. **(10)**

(c) A 1000 rpm shunt DC motor with the shunt field current $I_F = 0.6\ A$ and armature resistance, $R_A = 0.5\ \Omega$ is supplied with a DC voltage of $V_T = 180$ V. **(15)**

(i) What is the field resistance R_F and induced torque τ_{ind}?

(ii) If the shunt current is increased by 16%, what should be the new field resistance R_F and induced torque τ_{ind}? [magnetization curve is shown in Fig. for Q. 5(a).

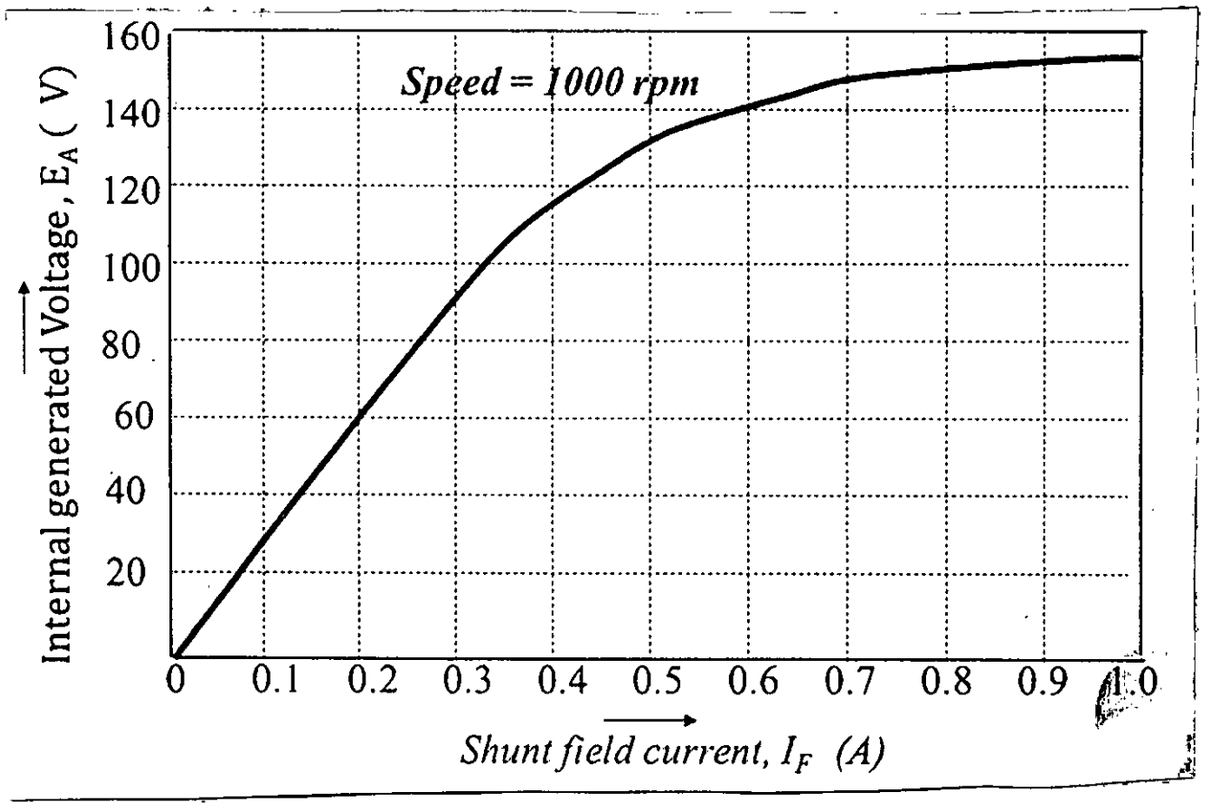

Fig. for Q. 5(a).

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6. (a) A 1000 VA 230 V/115 V transformer has been tested to determine its equivalent circuit. The results of the tests are shown Table for Q. 6(a). **(25)**

Table for Q. 6(a)

Open Circuit Test		Short Circuit Test	
V_{OC}	230 V	V_{SC}	19.1 V
I_{OC}	0.45 A	I_{SC}	8.7 A
P_{OC}	30 W	P_{SC}	42.3 W

(i) Find the equivalent circuit of this transformer referred to the low-voltage side of the transformer.

(ii) Find the transformer's voltage regulation at rated condition and 0.8 PF leading.

(iii) Determine the transformer's efficiency at rated condition and 0.8 PF leading.

(b) Referring to the equivalent circuit of a transformer, explain the following terms with necessary diagram and equation: **(10)**

(i) Copper Losses

(ii) Leakage Flux

(iii) Hysteresis Losses

(iv) Eddy Current Losses

7. (a) A 480 V, 100 kW, two-pole, three-phase, 60 Hz synchronous generator's prime mover has a no-load speed of 3630 rpm and a full-load speed of 3537 rpm. It is operating in parallel with a 480 V, 75 kW, four-pole, 60 Hz synchronous generator whose prime mover has a no-load speed of 1800 rpm and a full-load speed of 1785 rpm. The loads supplied by the two generators is 100 kW at 0.85 PF lagging, **(20)**

(i) Calculate the speed droops of generator-1 and generator-2.

(ii) Find the operating frequency and the power being supplied from each the generator to the power system.

(iii) Draw the House diagram for the case of (ii) with proper labelling.

(iv) If terminal voltage V_T is 460 V, what must the generator's operators do to correct for the low terminal voltage?

(b) A 480-V, 50-Hz, Y-connected, six-pole synchronous generator has a per-phase synchronous reactance of 1.0 Ω. Its full-load armature current is 60 A at 0.8 PF lagging. This generator has friction and windage losses of 1.5 kW and core losses of 1.0 kW at full load. The generator is loaded with the rated current at 0.8 PF lagging. [Assume that Armature resistance is negligible] **(15)**

(i) Calculate the terminal voltage of this generator,

(ii) Calculate the generator efficiency.

Contd P/6

8. (a) A 450 V, 50 Hz, four-pole, Y-connected induction motor has the following per phase impedances referred to the stator circuit: **(20)**

$$R_1 = 0.6\,\Omega \qquad R_2 = 0.4\,\Omega$$
$$X_1 = 1.2\,\Omega \qquad X_2 = 0.4\,\Omega$$
$$X_M = 30\,\Omega$$

The total rotational losses are 1 kW and are assumed to be constant. The core loss is lumped in with the rotational losses. For a rotor slip of 1.5 percent at the rated voltage and rated frequency. Find the motor's

(i) efficiency, and

(ii) maximum torque and the speed at which maximum torque occurs.

(b) Describe three possible reasons for the failure to voltage build-up during starting of a DC shunt generator with necessary diagram and equation. **(15)**
