L-2/T-1/CHE **Date : 17/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2014-2015

Sub : **MATH 221** (Vector analysis, Matrices and Laplace Transforms)

Full Marks: 280 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

Symbols used have their usual meaning.

1. (a) Prove by vector method that the line segment joining the middle points of the diagonals of a trapezium is parallel to each of the parallel sides and its length is half the difference of the lengths of the parallel sides. **(21⅔)**

   (b) Find a unit vector parallel to the plane containing the vectors $\mathbf{2i-j+2k}$ and $\mathbf{3i-2j-k}$ but perpendicular to $\mathbf{2i+5j-3k}$. **(10)**

   (c) Find $[\mathbf{a\times p\ b\times q\ c\times r}]+[\mathbf{a\times q\ b\times r\ c\times p}]+[\mathbf{a\times r\ b\times p\ c\times q}]$ **(15)**

2. (a) State and prove Frenet-Serret formulae. **(26)**

   (b) Find the work done in moving a particle from the point $(2,-1-3)$ to $(5,-1,1)$ applying forces of magnitudes 5, 3, 1 units acting in the directions of $\mathbf{6i+2j+3k}$, $\mathbf{3i-2j+6k}$ and $\mathbf{2i-3j-6k}$ respectively. **(20⅔)**

3. (a) Find the values of the constants *a, b, c* such that the directional derivative of $\phi = axy^2 + byz + cz^2x^3$ at (1, 2, –1) has a maximum magnitude 64 in the direction parallel to z-axis. **(21⅔)**

   (b) If **r** is the position vector of a particle of mass m relative to the origin of the coordinate system and **F** is the external force on the particle, then show that the moment **M** of **F** can be written as $\mathbf{M}=\dfrac{\mathbf{dH}}{\mathbf{dt}}$ where **H** = **r** × *m***v** and **v** is the velocity of the particle. **(15)**

   (c) Show that $\nabla(\mathbf{F}\cdot\mathbf{G})=\mathbf{F}\times(\nabla\times\mathbf{G})+\mathbf{G}\times(\nabla\times\mathbf{F})+(\mathbf{F}\cdot\nabla)\mathbf{G}+(\mathbf{G}\cdot\nabla)\mathbf{F}$. **(10)**

4. (a) State and verify Gauss divergence theorem $\mathbf{F}=(x^2-z^2)\mathbf{i}+2xy\mathbf{j}+(y^2+z)\mathbf{k}$ taken over the region bounded by the cylinder $y^2+z^2=9$ and the planes x = 0 and x = 3. **(26⅔)**

   (b) Evaluate $\int_C x^2y^3ds$ where *C* is the segment of the line *y* = *3x* in the xy-plane from $(-1,-3)$ to $(1,3)$ and *s* is corresponding arc length of the line segment. **(20)**

Contd P/2

MATH 221

SECTION – B

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

5. (a) Find the canonical matrix and hence find the rank of the matrix **(14)**

$$A=\begin{pmatrix}1 & 2 & 3 & 4 & 5\\ 2 & 3 & 4 & 5 & 6\\ 3 & 4 & 5 & 6 & 7\\ 8 & 9 & 10 & 11 & 12\end{pmatrix}$$

(b) Using only elementary row transformations find the inverse of the matrix **(12)**

$$A=\begin{pmatrix}1 & 2 & 3\\ 2 & 5 & 3\\ 1 & 0 & 8\end{pmatrix}$$

(c) Reduce the quadratic form **(20⅔)**

$$q=3x_1^2+5x_2^2+10x_3^2+12x_2x_3+8x_3x_1+2x_1x_2$$

to canonical form and write down the corresponding equations of transformation. Hence find a non-trivial set of values of x_1, x_2, x_3 which makes the form zero.

6. (a) Use matrix and Gaussian reduction method to solve the following system of linear equations: **(12)**

$$\begin{aligned}5x_1+3x_2+2x_3&=4\\ 3x_1+3x_2+2x_3&=2\\ x_2+x_3&=5\end{aligned}$$

(b) State Cayley Hamilton theorem. Use the theorem to find the inverse of the matrix **(14)**

$$A=\begin{pmatrix}1 & -1 & 1\\ 1 & 2 & 1\\ 1 & 0 & 3\end{pmatrix}$$

(c) Find the eigen-values and the corresponding eigen-vectors of the matrix **(20⅔)**

$$\begin{pmatrix}2 & 2 & -2\\ 2 & 3 & -1\\ -2 & -1 & 3\end{pmatrix}$$

7. (a) Derive a formula for finding the Laplace transform $L\{f(t)\}$ where $f(t)$ is a periodic function with period T. Hence find $L\{H(c,t)\}$ where $H(c,t)$ is a triangular wave function defined as **(16⅔)**

Contd P/3

MATH 221

Contd... Q. No. 7(a)

$$H(c,t)=\begin{cases} t\ ; & 0<t<c \\ 2c-t\ ; & c<t<2c \end{cases}$$

and $H(c,t+2c)=H(c,t)$

Also draw a graph of $H(c,t)$.

(b) Find the following:

(i) $L^{-1}\left\{\ln\left(\dfrac{s+\sqrt{s^2+1}}{2s}\right)\right\}$ **(10)**

(ii) $L^{-1}\left\{\dfrac{s-1}{(s+3)(s^2+2s+2)}\right\}$ **(10)**

(iii) $L^{-1}\left\{\dfrac{s+2}{(s^2+4s+13)^{3/2}}\right\}$ **(10)**

8. (a) Solve the following differential equations using Laplace transformation:

(i) $Y''(t)+4Y'(t)+13Y(t)=\dfrac{1}{3}e^{-2t}\sin 3t$ where $Y(0)=1,\ \ Y'(0)=-2$. **(14⅔)**

(ii) $tY''(t)+Y'(t)+4tY(t)=0$; where $Y(0)=3,\ \ Y'(0)=0$. **(14)**

(b) Use Laplace transformation to evaluate the following integrals:

(i) $\int_0^\infty te^{-3t}\sin t\ dt;\ \ t>0$ **(6)**

(ii) $\int_0^\infty \dfrac{x\sin tx}{1+x^2}dx;\ \ t>0$ **(12)**

L-2/T-1/CHE **Date : 23/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2014-2015

Sub : **CHE 203** (Chemical Engineering Thermodynamics-I)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

Symbols denote their usual meanings. Assume reasonable values if additional data are required.

SECTION – A

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

1. (a) Derive the Maxwell relations. **(11)**

   (b) Show that **(12)**

$$dh = C_p dT + \left[V - T\left(\frac{\partial V}{\partial T}\right)_p \right] dP$$

   (c) Write a short account on Joule-Thomson co-efficient. **(12)**

2. (a) Describe the working of a Diesel cycle. **(9)**

   (Use simple schematics and write few sentences only, but include the main features)

   (b) Show that the thermal efficiency of an ideal Diesel cycle is given by **(17)**

$$\eta_{Th} = 1 - \frac{1}{r^{k-1}} \left[\frac{r_c^k - 1}{k(r_c - 1)} \right]$$

   (c) Suggest possible ways to improve the thermal efficiency of an ideal Diesel cycle. Justify your answer. **(9)**

3. (a) Why is it not practical to build a Carnot vapor power cycle engine? **(10)**

   (b) Describe briefly the working of the Rankine power cycle. **(10)**

   (c) Discuss the different ways of improving the efficiency of a simple Rankine power cycle. **(15)**

4. (a) Describe the working of a simple vapor-compression refrigeration cycle. (Use schematic diagram and proper thermodynamic diagram for your answer.) **(12)**

   (b) What is co-generation? With a simple schematic diagram describe the operation of a co-generation plant. Discuss the importance of co-generation in chemical process plants. **(11)**

   (c) Write a short account on combined gas-vapor power cycle. **(12)**

Contd P/2

CHE 203

SECTION – B

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

5. (a) Write down the statement of Zeroth law of thermodynamics. Explain how this law serves as a basis for the validity of temperature measurement. **(3+4=7)**

(b) Discuss briefly the forms in which energy can be transferred to or from a system. **(6)**

(c) What are the significance of "Compressibility Factor" and "Reference State" in thermodynamics? **(8)**

(d) Make a short comparison between Van der Walls and Beattie-Bridgeman equations of state. **(6)**

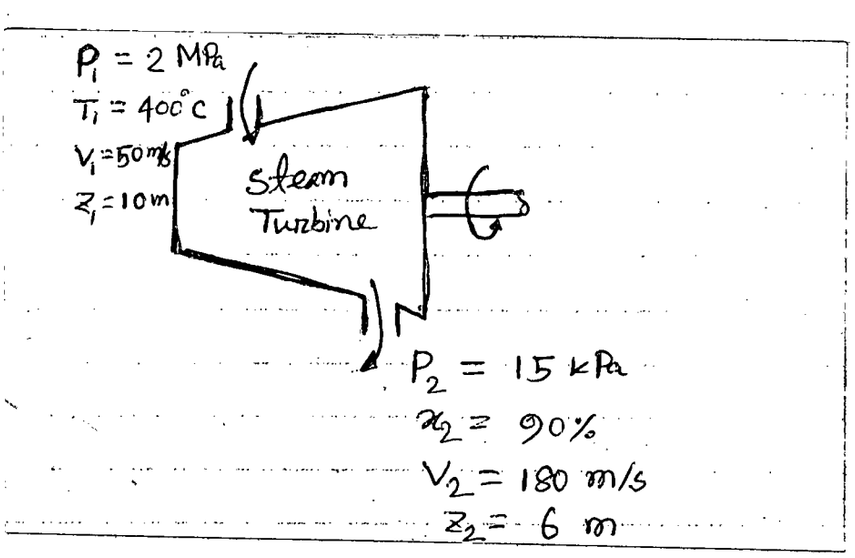
(e) Draw and explain P.T diagram for a typical pure substance. **(8)**

6. (a) Derive the general expression for work done in a polytropic process. **(10)**

(b) Prove that the enthalpy change of liquid can reasonably be determined by— **(5)**

$$\Delta h = C_{avg}\Delta T + V\Delta P$$

(c) The power output of an adiabatic steam turbine is 5 MW, and the inlet and the exit conditions of the steam are as indicated in the figure given below. **(20)**



(i) Compare the magnitudes of Δh, Δk_e, and ΔP_e.

(ii) Determine the work done per unit mass of the steam flowing through the turbine.

Contd P/3

CHE 203

7. (a) Write short technical notes on **(5×4=20)**

   (i) Perpetual-motion machine

   (ii) Carnot cycle

   (iii) Heat pump

   (iv) Quality of energy

   (v) Thermodynamic temperature scale.

   (b) A heat pump is used to meet the heating requirements of a house and maintain it at 20°C. On a day when the outdoor air temperature drops to –2°C, the house is estimated to lose heat at a rate of 80,000 kJ/h. If the heat pump under these conditions has a COP of 2.5, determine (i) the power consumed by the heat pump and (ii) the rate at which heat is absorbed from the cold outdoor air. **(15)**

8. (a) How is it possible to save work by using multistage compression with intercooling? Explain graphically. **(10)**

   (b) Derive the T ds relations of— **(8)**

   (i) $T\,ds = du + P\,dV$

   (ii) $T\,ds = dh - V\,dP$

   (c) A dealer advertises that he has just received a shipment of electric resistance heaters for residential buildings that have an efficiency of 100 percent. Assuming an indoor temperature of 21°C and outdoor temperature of 10°C, determine the second-law efficiency of these heaters. **(7)**

   (d) A heat engine receives heat from a source at 1200 K at a rate of 500 kJ/s and rejects the waste heat to a medium at 300 K. The power output of the heat engine is 180 kW. Determine the reversible power and the irreversibility rate for this process. **(10)**

L-2/T-1/CHE **Date : 27/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2014-2015

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

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

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. **Compulsory:** (a) Explain the terms dew point temperature and bubble point temperature with appropriate equations. **(6)**

   (b) Which property depicts the air's ability to hold water and show how? **(4)**

   (c) Describe the two approaches for computer aided process design. **(5)**

   (d) What is the heating value of a fuel? How will you calculate lower heating value of a fuel from its higher heating value and vice-versa. **(5)**

   (e) In the context of psychrometric chart, define humid volume and enthalpy deviation. **(6)**

   (f) What is heat of solution? Explain briefly. **(4)**

   (g) Write a short note on differential and integral balance of a transient system. **(5)**

2. (a) n-Hexane is burned with excess air. An analysis of the product gas yields the following dry basis molar composition: 82.1% N_2, 6.9% CO_2, 2.1% CO, 8.6% O_2 and 0.265% C_6H_{14}. The stack gas emerges at 760 mm Hg. Calculate the percentage conversion of hexane, the percentage excess air fed to the burner, and the dew point of the stack gas, taking water to be the only condensable species. **(25)**

   (b) Aqueous sulfuric acid solutions containing 15.0 wt% H_2SO_4 and 80.0 wt% H_2SO_4 are mixed to form a 60.0 wt% product solution. The 15% solution was in a laboratory in which the temperature was 77°F. The 80% solution had just been taken from a storage cabinet in an air-conditioned stockroom and was at a temperature of 60°F when the mixing occured. **(10)**

   (i) The mass of the 15% solution is 2.30 lbm. What mass of 60% solution should be weighed out?

   (ii) Use Figure for Question 2(b) to estimate the product solution temperature if the mixing is adiabatic

Contd P/2

CHE 201

3. (a) A vapor mixture containing 30 mol% benzene and 70% toluene at 1 atm is cooled isobarically in a closed container from an initial temperature of 115°C. Use the Txy diagram of Figure for Question 3(a) to answer the following questions, **(17)**

   (i) At what temperature does the first drop of condensate form? What is its composition?

   (ii) At one point during the process the system temperature is 100°C. Determine the mole tractions of benzene in the vapor and liquid phases at this point and calculate the ratio (mole vapor/mole liquid).

   (iii) At what temperature does the last drop of condensate form? What is its composition?

   (b) An open vessel containing 0.205 lbm of liquid water is placed in an empty room 5 ft wide, 4 ft deep and 7 ft high, which initially contains dry air at 90°F. All the water evaporates without changing the room temperature. What will be the final relative humidity, wet-bulb temperature, humid volume, dew point temperature, and specific enthalpy of the room air. Take the molecules weight of dry air to be 29, and for simplicity assume the mass of dry air in the room stays constant at its initial value. **(18)**

4. (a) In the manufacture of nitric acid, ammonia and preheated air are mixed to form a gas containing 10 mole% NH_3 at 600°C. The ammonia is then catalytically oxidized to form NO_2, which is absorbed in water to form HNO_3. If ammonia enters the gas blending unit at 25°C at a rate of 520 kg/h and heat is lost from the mixture to its surroundings at a rate of 7.00 kW, determine the temperature to which the air must be preheated. **(18)**

   (b) The following two reactions occur in an ethylene oxide production process: **(17)**

$$2C_2H_4 + O_2 \rightarrow 2C_2H_4O$$
$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

   A stream containing equimolar amounts of ethylene and oxygen is joined by a recycle stream containing pure ethylene, and the combined stream is fed to the reactor. The reactor effluent goes to a multiple unit separation process that has three outlet streams. The first stream, which is sold, is pure ethylene oxide; and the second, which is discarded, contains all the carbon di-oxide, oxygen, water and 5% of the unreacted ethylene having the reactor; and the third stream which is the recycle stream, contains the remaining unreacted ethylene. Perform a degrees of freedom analysis for the process and specify the design variables that must be known to solve the problem completely.

Contd P/3

CHE 201

SECTION – B

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

A data booklet is supplied.

5. (a) Seawater containing 3.50 wt% salt passes through a series of 10 evaporators. Equal quantities of water is evaporated in each of the 10 units and then condensed and combined to obtain a product stream of fresh water. The concentrated salt solution, i.e., brine leaving each evaporator but the tenth is fed to the next evaporator. The brine leaving the tenth evaporator contains 5.50 wt% salt. Draw a flow chart of the process showing the first, fifth, and tenth evaporators. Label all the streams entering and leaving these three evaporators. Calculate the fractional yield of fresh water from the process (kg H_2O recovered/kg H_2O in process feed) and the weight fraction of salt in the solution leaving the fifth evaporator. **(20)**

(b) A natural gas contains 90% methane and 10% ethane by volume. The combustion reactions are: **(15)**

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(v)} \quad : \Delta\hat{H}_C^o = -802\ kJ/mol$$

$$C_2H_{6(g)} + \frac{7}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(v)} \quad : \Delta\hat{H}_C^o = -1428\ kJ/mol$$

Calculate the higher heating value in Btu/lb_m of the natural gas.

6. A process consisting of an absorption tower and a stripping tower is used to separate the components of the gas containing 30.0 mole% CO_2 and the balance methane. A stream of this gas is fed to the bottom of the absorber. A liquid containing 0.500 mole% of dissolved CO_2 and the balance methanol is recycled from the bottom of the stripper and fed to the top of the absorber. The product gas leaving the top of the absorber contains 1.00 mole% CO_2 and essentially all of the methane fed to the unit. The CO_2 rich liquid solvent leaving the bottom of the absorber is fed to the top of the stripper and a stream of N_2 gas is fed to the bottom of the stripper. Ninety percent of CO_2 in the liquid feed to the stripper comes out of solution in the column and the N_2 and CO_2 stream leaving the column passes out to the atmosphere through a stack. The liquid stream leaving the stripper is the 0.500% CO_2 solution recycled to the absorber.

(a) In your own word describe the overall objective of this two-unit process and functions of the absorber and stripper in the process. **(6)**

(b) Draw and label the flow chart of the process. **(6)**

(c) Taking a basis of 100 mol/h of gas fed to the absorber, calculate the fractional CO_2 removal in the absorber (moles absorbed/mole in gas feed) and the molar flow rate and composition of the liquid stream feed to the stripper. **(23)**

Contd P/4

CHE 201

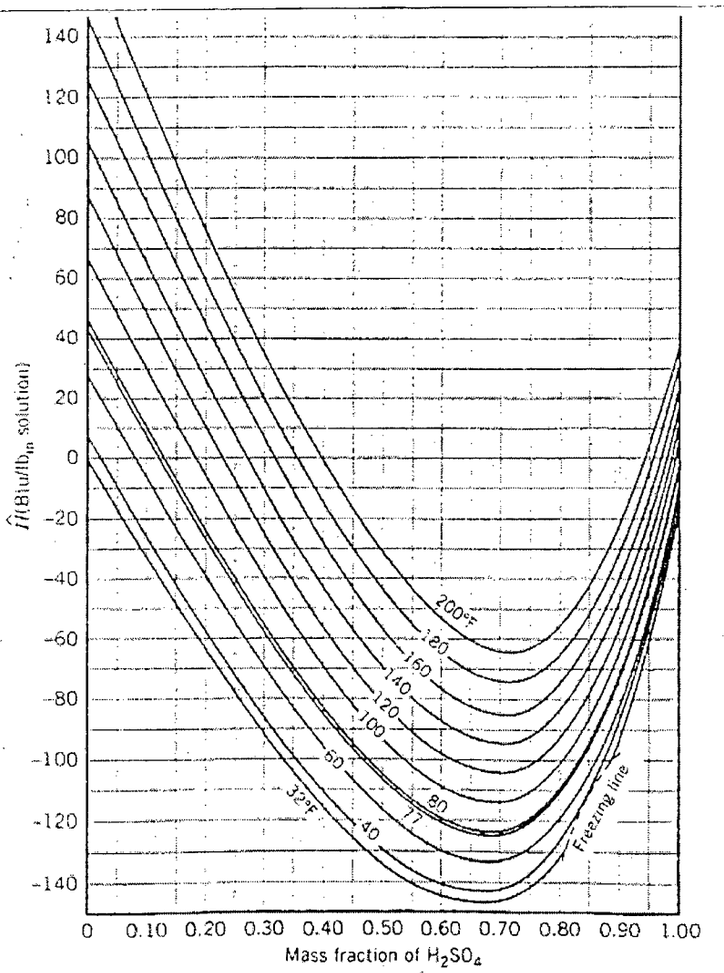
7. In a small pilot plant reactor, sulfur dioxide is oxidized to sulfur trioxide. Sulfur dioxide and 100% excess air are fed to the reactor at 400°C. The reaction proceeds to 75% SO_2 conversion, and the products emerge at 500°C. The production rate of SO_3 is 100 kg/min. The reactor is surrounded by a water jacket into which water at 25°C is fed. Calculate the heat in kW that must be transferred from the reactor to the cooling water. Find the minimum flow rate of cooling water if its temperature rise is to be kept below 20°C. **(30+5)**

8. (a) Coke can be converted into CO (a fuel gas) in the reaction **(25)**

$$C_{(s)} + CO_{2(g)} \rightarrow 2CO_{(g)}$$

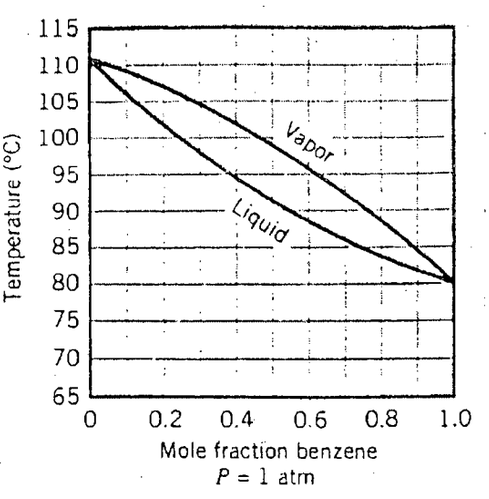
A coke that contains 84% carbon by mass and the balance noncombustible ash is fed to a reactor with a stoichiometric amount of CO_2. The coke is fed at 77°F and the CO_2 enters at 400°F. Heat is transferred to the reactor in the amount of 6000 Btu/lbm of coke fed. The gaseous products and the solid reactor effluent (the ash and unburned carbon) leave the reactor at 1830°F.The heat capacity of the solid is 0.24 Btu/(lbm.°F). Calculate the percentage conversion of the carbon in the coke.

(b) A 12.0 m^3 tank is being filled with water at a rate of 0.05 m^3/s. At a moment when tank contains 1.2 m^3 of water, a bottom leak develops and gets progressively worse with time. The rate of leakage is 0.002 t (m^3/s), where t is the time in second from the moment leak begins. Obtain an expression of V(t) and draw a plot of V(t) versus time. **(10)**



Enthalpy-concentration chart for H_2SO_4–H_2O. (Redrawn from the data of W. D. Ross, *Chem. Eng. Progr.*, 43:314, 1952.)

Figure for Question 2. (b)



(*a*) *Txy* diagram

Figure for Question 3. (a)

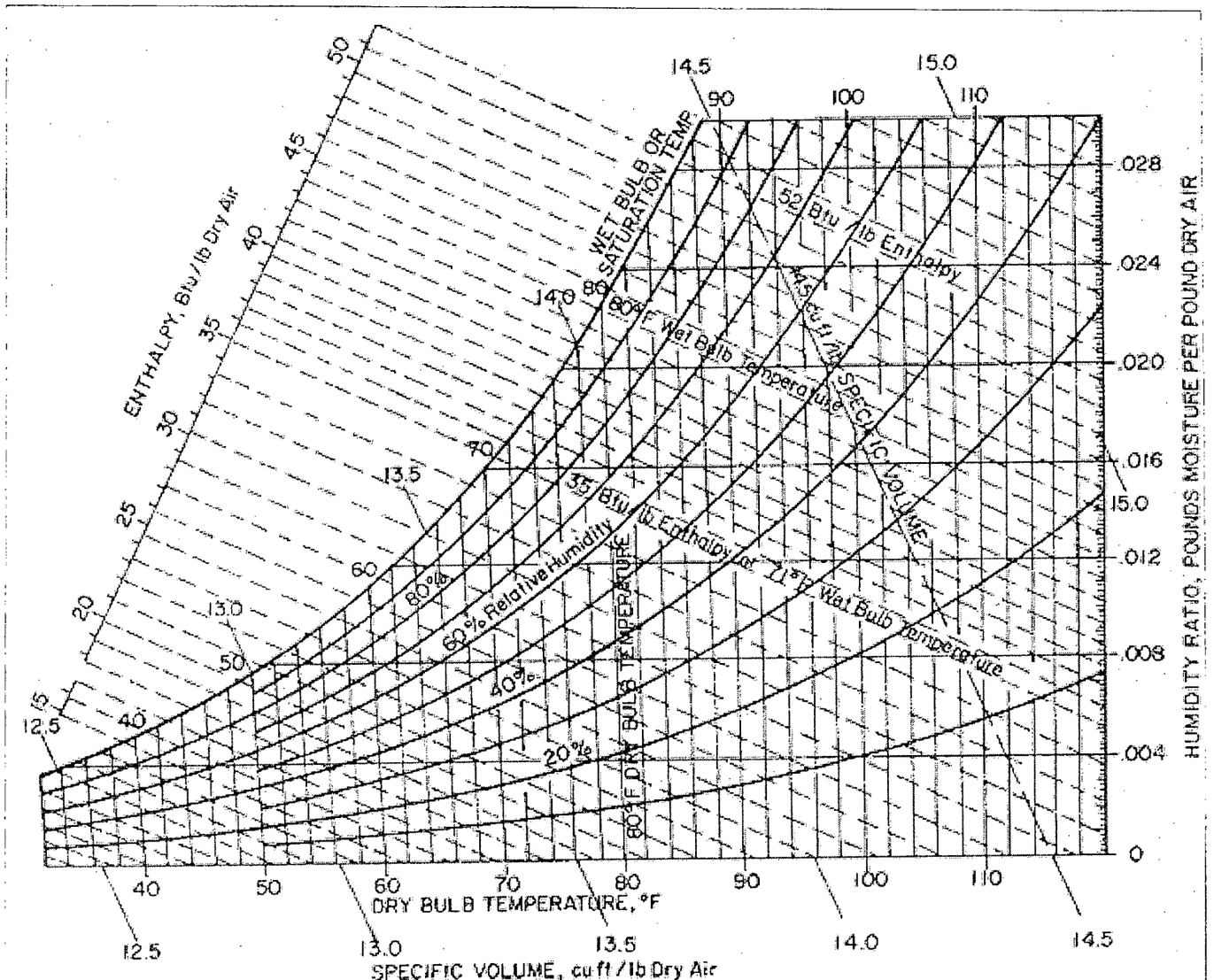


Figure for Question 3. (b)

L-2/T-1/CHE **Date : 31/01/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2014-2015

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

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) Define molecular spectroscopy. What is Born-oppenheimer approximation? Show Diagrammatically that each electronic energy state is associated with a series of vibrational energy levels and each vibrational energy level is associated with series of rotational energy level. **(3+4+5=12)**

   (b) Derive Beer-Lambert law. How can the law be applied for the quantitative determination of metal ions in solution? **(9+5=14)**

   (c) What do you mean by charge transfer absorbtion? Show that pink color of MnO_4^- is due to the charge transfer transition rather d-d transition. **(6+3=9)**

2. (a) 'A reaction of fourth order or higher order is improbable' — Explain with the help of collision theory. **(8)**

   (b) How can the graphical method based on integrated rate expression be used to determine the order of a reaction? **(7)**

   (c) What is a consecutive reaction? For the following consecutive reaction, **(12)**

   (i) Write down the rate with respect to A, B and C

   (ii) Draw the reaction profile when $k_1 >> k_2$ and $k_2 >> k_1$.

   $$A \xrightarrow{k_1} B \xrightarrow{k_2} C$$

   (d) Write down the quantitative relation between reaction rate and temperature. The rate constants of some reactions double with every 10-degree rise in temperature. Assume that a reaction takes place at 295 K and 305 K. What must the activation energy be for the rate constant to double as described? **(8)**

3. (a) What are the main differences between physical adsorption and chemisorption? **(8)**

   (b) The deviation of Langmuir Isotherm are quite common due to multilayer adsorption by most solid. How does BET theory extend. Langmuir theory to treat multilayer adsorption? How can this theory be applied for the determination of specific surface area? Why the measurement of surface area is important in the field of nanomaterials? **(7+6+3=16)**

Contd P/2

CHEM 235

Contd... Q. No. 3

(c) How can adsorption theory of catalysis be applied to explain the function of **(5+6=11)**

(i) Catalytic poison

(ii) Catalytic promoters

4. (a) What are the number of component in the following equilibrium? Justify your answer. Does the number of component change upon the addition of little HCl or NH_3 in the system in (ii)? **(9)**

(i) $CaCO_3 \rightleftharpoons CaO(s) + CO_2(g)$

(ii) $NH_4Cl(s) \rightleftharpoons HCl(g) + NH_3(g)$

(b) Sulfur exists in two solid modifications. What are the possible two phase and three phase equilibrium possible for sulfur system including the metastable one? Draw the phase diagram of sulfur system and show how a metastable equilibrium is formed. **(4+4+4=12)**

(c) What is freeze drying or critical drying? Draw the phase diagram of water and show the principle of freeze drying. **(7)**

(d) What is congruent melting point? Show with a suitable phase diagram. **(7)**

SECTION – B

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

5. (a) Define the term "specific conductance" and "equivalent conductance". Explain how equivalent conductance of strong and weak electrolytes vary with concentration. **(12)**

(b) State and explain the law of independent migration of ions. How can you determine the $\wedge_0$ value of CH_3COOH with the help of this law? **(8)**

(c) What is ionic mobility? With suitable examples explain the effect of hydration on the mobility of ions. **(8)**

(d) 0.5 N solution of a salt placed between two platinum electrodes 3.0 cm apart and of area of cross section 6.0 sq cm has a resistance of 25 ohms. Calculate the equivalent conductance of the solution. **(7)**

6. (a) What do you mean by "thermodynamic ionization constant"? Describe how you can determine the value of thermodynamic ionization constant of a weak electrolyte. **(15)**

(b) Define activity and activity coefficient. Establish the relationship between the activity and molality of the electrolyte of general formula M_xA_y. **(12)**

(c) Calculate the mean ionic molality of 0.5 m solution of sodium sulphate. **(8)**

Contd P/3

CHEM 235

7. (a) Define transport number. Show that the transport number of an ion is directly proportional to its absolute velocity. **(15)**

(b) What is meant by the term "hydrolysis"? Derive expressions for hydrolysis constant and pH of solution of a salt of a weak acid and a strong base. **(13)**

(c) Calculate the hydrolysis constant of sodium acetate and its degree of hydrolysis in 0.1 M solution at 25°C [Assume reasonable values if necessary]. **(7)**

8. (a) Define "standard hydrogen electrode". Why is platinum used in such electrodes? Explain how you can determine the standard electrode potential of $Z_n \mid Z_n^{2+}$. **(15)**

(b) Show the effect of ionic concentration on the electrode potential, and hence justify that the formula of mercurous chloride is Hg_2Cl_2 not HgCl. **(13)**

(c) Can a solution of 1 M copper sulphate be stored in a vessel made of nickel? Justify your answer. Given that $E^{\circ}_{Ni/Ni^{2+}} = 0.25\,V$ and $E^{\circ}_{Cu/Cu^{2+}} = -0.34\,V$. **(7)**

L-2/T-1/CHE **Date : 06/02/2016**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2014-2015

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

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) What is an infinite bus? Mention some common prime movers used in electricity generation. **(2+3=5)**

(b) Why are synchronous generators operated in parallel? Why does the oncoming generator (to be paralleled) need to have a higher frequency than the running system? What are the other conditions required for paralleling alternators? **(4+3+3=10)**

(c) A power system comprising of two synchronous generators connected in parallel is shown in Fig. for Q. 1(c). **(6+6+8=20)**

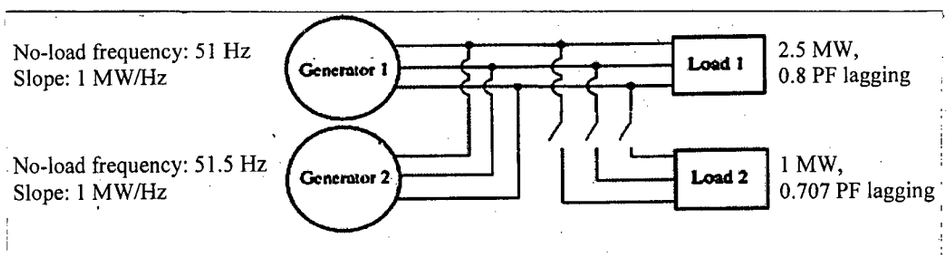


Fig. for Q. 1(c)

(i) If only load-1 is connected, determine the frequency at which the system is operating and also the power drawn from each generator.

(ii) Determine the system frequency and also power supplied by each generator when both loads are connected.

(iii) After load-2 is connected, what action can an operator take to restore the system frequency to its previous value, so that power sharing between the two generators remains unaffected? Explain with house diagram and show necessary calculations.

2. (a) Prove that, a set of three-phase currents flowing through a three-phase winding produces a rotating magnetic field of constant magnitude. **(12)**

(b) Draw the V-curve of a synchronous motor and explain its significance of power factor improvement. **(8)**

Contd P/2

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Contd... Q. No. 2

(c) A 400-V, 100-kW, 50-Hz, four-pole, Y-connected synchronous motor has a rated power factor of 0.85 leading. At full load, the efficiency is 90 percent. The armature resistance is 0.10 Ω. Find the following quantities for this machine when it is operated at rated condition. **(15)**

(i) Shaft speed

(ii) Input power

(iii) $\overline{E}_A$

(iv) $\overline{I}_A$

(v) P_{cu}

(vi) $P_{mech} + P_{core} + P_{stray}$

3. (a) Draw the torque-speed characteristic curve for an induction motor and a synchronous motor. Why cannot an induction motor operate at synchronous speed? **(6+4=10)**

(b) Why a single-phase induction motor is unable to start itself? Draw the schematic diagram of a single phase induction motor with a phase splitter. **(6+4=10)**

(c) A two-pole, 50-Hz induction motor supplies 15 kW to a load at a speed of 2940 rpm. Ignoring mechanical losses, calculate the following for this machine. **(15)**

(i) What is the slip of an induction motor?

(ii) What is the induced torque under this condition?

(iii) What will the operating speed of the motor be if its torque is doubled?

4. (a) What is commutation of a dc machine? Why is commutation necessary in a DC motor? **(2+8=10)**

(b) Describe the causes for failure in voltage build up in a DC shunt generator. What are the solutions for this problem? **(15)**

(c) A 230-V DC shunt motor has an armature resistance of 0.5 Ω and a field resistance of 115 Ω. At no-load, the motor takes a current of 5 A and the motor rotates at a speed of 1150 rpm. If the input power is 11 kW at rated condition, determine the rotational speed at rated condition. **(10)**

SECTION – B

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

5. (a) A balanced Δ-Y system consists of Δ connected source feeding a balanced Y connected load. Derive the expressions for line currents. Draw phasors of voltage and currents of the system. **(15)**

(b) A Y-connected source is connected to a load as shown in Fig. for Q. 5(b). Line voltage of the source is given to be 220 V (rms). **(20)**

(i) Find line currents and voltages across load terminals.

(ii) Find the power absorbed by the connected load.

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6. (a) The following test data are obtained from open-circuit and short-circuit tests of 25 kVA, 6900-230 V, 50 Hz single phase, step-down transformer **(20)**

$V_{OC} = 230$ V	$V_{SC} = 513$ V
$I_{OC} = 5.4$ A	$I_{SC} = 3.62$ A
$P_{OC} = 260$ W	$P_{SC} = 465$ W

(i) Determine all transformer model parameters using test data.

(ii) Calculate voltage regulation and efficiency, if the transformer delivers 10 kW at 0.8 pf lagging at rated secondary voltage.

(b) The hysteresis and eddy current losses for a 75 kVA, 480 V - 240 V, 50 Hz transformer are 215 W and 115 W respectively. The magnetizing current is 2.5% of rated primary current. The transformer is operating in the step-up mode. **(15)**

Determine

(i) excitation current and its components.

(ii) core-loss resistance and magnetizing reactance

(iii) no-load power factor

(iv) Input reactive power and input apparent power at no-load.

7. (a) For the circuit shown in Fig. for Q. 7(a), the input voltage at primary side is a sinusoid with an amplitude of 240 V. The turns ratio of the transformer is 10:1 and $R_L = 3R$. Sketch the output waveform considering the diodes are ideal. **(20)**

If a capacitor is connected in parallel with an R_L. How will the output voltage change? Explain.

(b) For the network shown in Fig. for Q. 7(b) determine the range of R_L and I_L that will keep V_L at 10 V. **(15)**

8. (a) For the circuit shown in Fig. for Q. 8(a) determine all node voltages and branch currents considering $V_B = 4$ V. **(20)**

Determine the maximum voltage to which V_B can be raised keeping the transistor in the active mode.

(b) For the Figure shown in Fig. for Q. 8(b) **(15)**

$$K'_n\left(\frac{W_n}{L_n}\right) = K'_p\left(\frac{W_p}{L_p}\right) = 1\text{mA/V}^2 \text{ and } |V_{tn}| = |V_{tp}| = 1\text{V}$$

Sketch the output waveform if the square wave shown in the figure is input.

Contd P/4

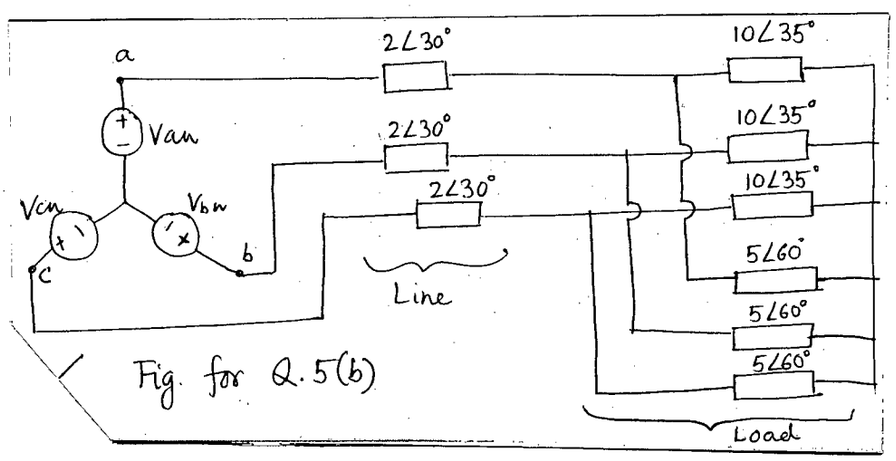

Fig. for Q.5(b)

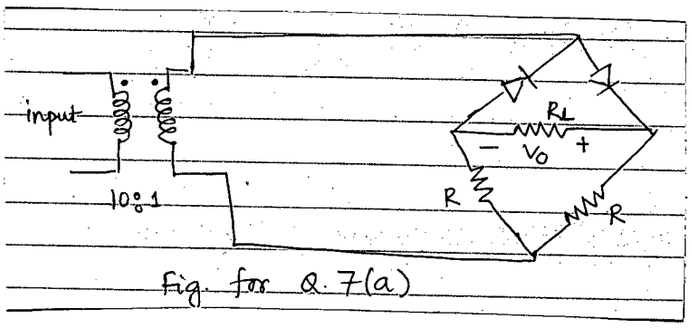

Fig. for Q.7(a)

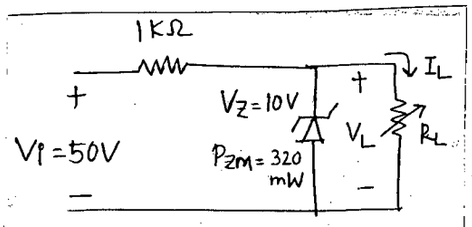

Fig. for Q.7(b)

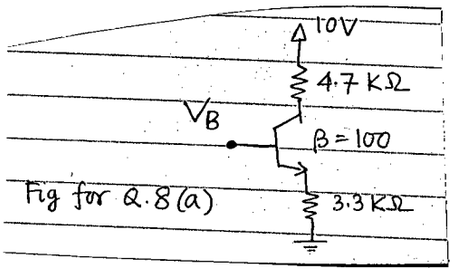

Fig for Q.8(a)

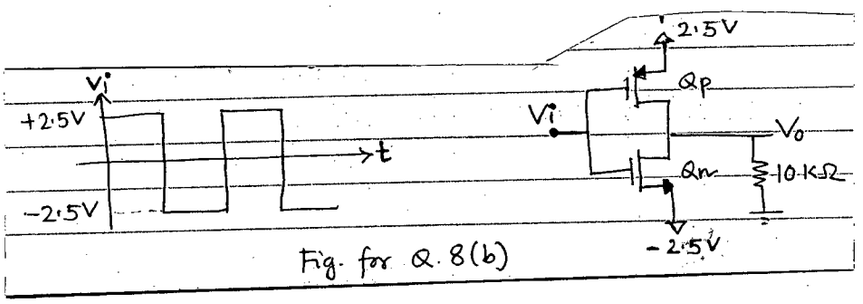

Fig. for Q.8(b)