L-2/T-1/CHE Date : 07/01/2013

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

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

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**.

1. (a) Prove with a sample circuit that, in a three phase four wire Y-system, the current entering or leaving the neutral wire is zero. **(12)**

(b) Prove that, in a balanced system, total real power is given by **(11)**

$$P = \sqrt{3} V_L I_L \cos\theta_P$$

Here, the symbols have their usual meaning.

(c) Find line current, phase current, power per phase and total power for the following circuit. **(12)**

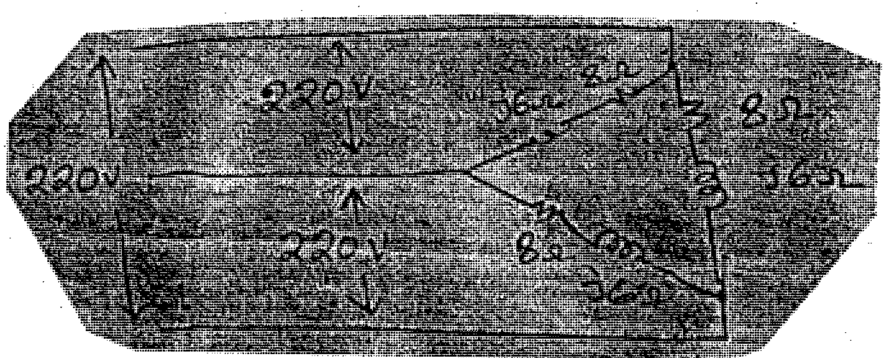

Fig for question 1. c)

2. (a) Explain with al least three different figures, how rotating magnetic field is created when 3-phase balanced voltage is applied at the stator of an induction motor. **(17)**

(b) A three phase, 230 V, 60 Hz, 100 hp, 6 pole induction motor operating at rated condition has an efficiency of 91% and draws a line current of 248 A. The core loss, stator copper loss and rotor copper loss are 1697 W, 2803 W and 1549 W respectively. Determine (i) Input power, (ii) Total loss, (iii) air gap power, (iv) shaft speed, (v) power factor, (vi) combined friction, windage and stray loss, (vii) shaft torque. **(18)**

3. (a) Data obtained from short circuit and open circuit tests of a 75 kVA, 4600-230 V, 60 Hz transformer are **(17)**

Open circuit test (low side data)	Short circuit test (high side data)
V_{OC} = 230 V	$V_{\text{~~OC~~}}$ [SC] = ~~230 V~~ [160.8 V]
I_{OC} = 13.04 A	$V_{\text{~~OC~~}}$ [SC] = 16.3 A
P_{OC} = 521 W	$V_{\text{~~OC~~}}$ [SC] = 1200 W

Contd P/2

EEE 267 (CHE)

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

Determine the equivalent resistance, equivalent reactance, core loss resistance and magnetizing reactance. **(9)**

(b) Sketch 'A brushless excitation scheme with pilot exciter' for a synchronous generator. **(9)**

(c) State all the ways of starting a synchronous motor. **(17)**

4. (a) Prove that, the speed of a series DC motor is given by

$$\omega = \frac{V_T}{\sqrt{KC\tau_{ind}}} - \frac{R_A + R_S}{KC}$$

Here, the symbols have their usual meanings.

(b) A separately excited DC generator is rated at 172 kW, 430 V, 400 A and 1800 rpm. Its magnetization curve is attached at Fig. for Q. 4(b). The machine has the following characteristics. **(18)**

$R_A = 0.05\ \Omega$ $\qquad$ $V_F = 430$ V

$R_F = 20\ \Omega$ $\qquad$ $N_F = 1000$ turns per pole

$R_{Adj} = 0$ to $300\ \Omega$

(i) If the variable resistor R_{Adj} in this generator's field circuit is adjusted to 63 Ω and the generator's prime mover is driving it at 1600 rpm, what is generator's no load terminal voltage?

(ii) What would its voltage be if a 360 A load were connected to its terminal?

(iii) What adjustment could be made to the generator to restore its terminal voltage to the value found in (i)?

(iv) How much field current would be needed to restore its terminal voltage to its no load value? What is the required value of R_{Adj} to accomplish this? Attach the supplied EA vs If graph with your answer script.

SECTION – B

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

5. (a) Why peak inverse voltage (PIV) is important for diode rectifier circuit? Determine the PIVs for half wave and full wave diode rectifiers. **(10)**

(b) Draw the waveshape of output voltage $V_o(t)$ of the circuit shown in Fig. 5(b)(i) for the input voltages $V_1(t)$ and $V_2(t)$ shown in Fig. 5(b)(ii). The cut-in voltage of the diode is 0.7 V. **(10)**

(c) Draw the wave shape of the output voltage $V_o(t)$ of the circuit shown in Fig. 5(c)(i) for the input voltage $V_s(t)$ shown in Fig. 5(c)(ii). The cut-in voltage of the diodes D_1 and D_2 is 0.7 V. **(15)**

Contd P/3

6. (a) Determine the value of R_1 such that the amplifier circuit shown in Fig. 6(a) operates in active region with $I_C = 1.25$ mA and $V_{CE} = 7.5$ V. Consider $\beta = 100$ and $V_{BE} = 0.7$ V. **(18)**

(b) Determine the operating point and region for the amplifier circuit shown in Fig. 6(b). Assume $\beta = 100$ and $V_{BE} = 0.7$ V at forward bias. What should we do to use the circuit as amplifier if it is not in active region? **(17)**

7. (a) Draw a circuit such that its input-output relationship follows the following equation. **(18)**

$$v_o = 5v_1 - 2v_2 - 4\frac{dv_1}{dt} + 10\int_0^t v_2\,dt$$

where v_1 and v_2 are inputs and v_o is output.

(b) Draw the waveshape of output voltage $v_o(t)$ of the differentiator circuit shown in Fig. 7(b)(i) for the input voltage shown in Fig. 7(b)(ii). Given that $R = 100$ kΩ and $C = 2$ μF. **(17)**

8. (a) What are the main functions of time base generator and triggering circuit in cathode ray tube oscilloscope? **(10)**

(b) Describe the operating principle of linear variable differential transformer (LVDT). **(15)**

(c) Describe one application of LVDT in measurement. **(10)**

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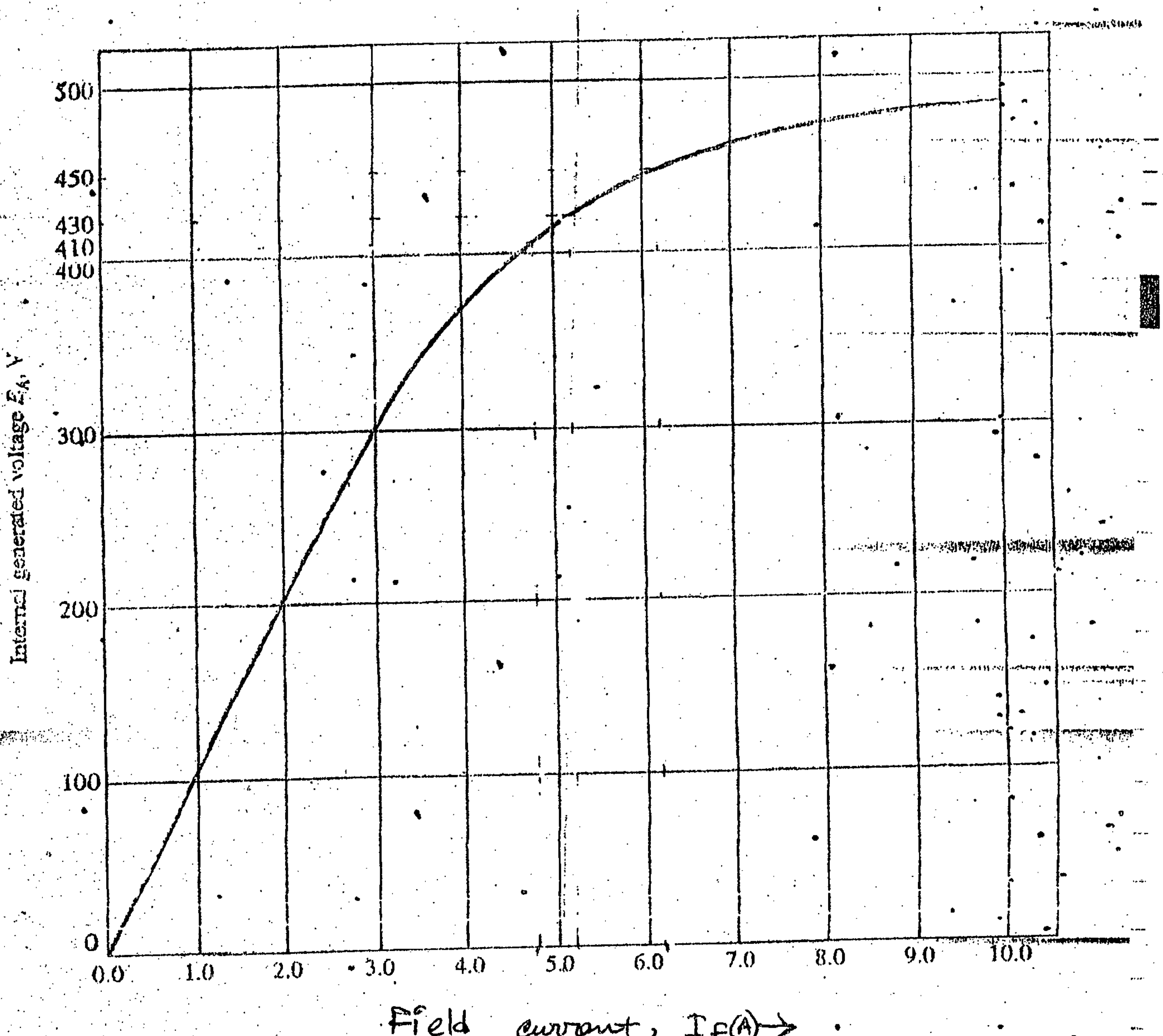

Fig. for question 4(b)

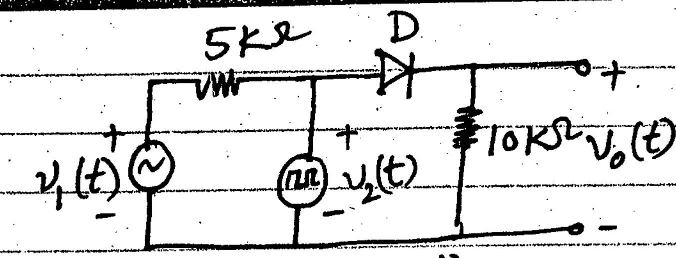

Fig. 5b(i)

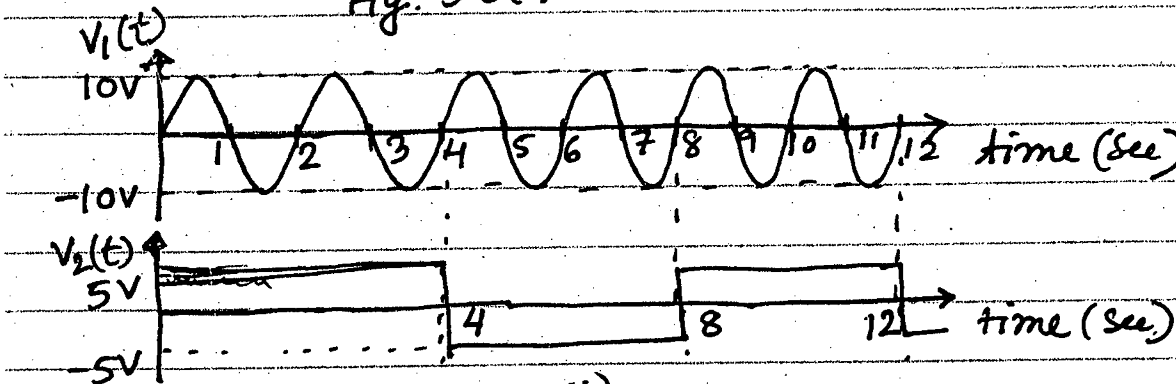

Fig 5b(ii)

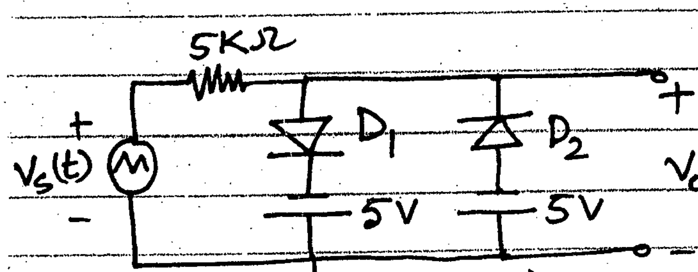

Fig 5c(i)

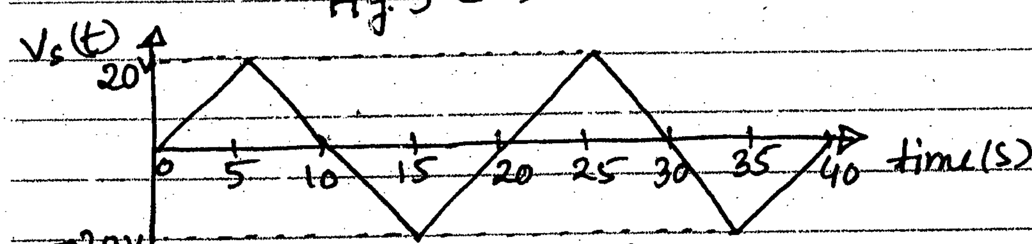

Fig 5c(ii)

L-2/T-1/ChE **Date : 17/12/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

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

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

A booklet containing all relevant data to be supplied.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Describe Raoult's law and Henry's law including their limitations. **(6)**

(b) What do you understand by vapor pressure of a substance? List three methods for estimating vapor pressure of a substance. **(5)**

(c) In the context of psychrometric chart describe the following: Wet bulb temperature, humid volume, Dew point, enthalpy deviation. **(10)**

(d) Define degrees of freedom, design variables and state variables. **(4)**

(e) What is transient system? Cite two examples. **(4)**

(f) What is Kopp's rule? **(3)**

(g) What is Gibb's phase rule? Apply the Gibb's phase rule for a system where NaCl crystals are suspended in an aqueous NaCl solution. **(3)**

2. (a) Concrete used in the construction of buildings, roads, dams, and bridges are made from *Portland cement*, a substance obtained by pulverizing the hard, granular residue (*clinker*) from the roasting of a mixture of clay and limestone and adding other materials to modify the setting properties of the cement and the mechanical properties of the concrete. **(17)**

The charge (inlet) to a Portland cement rotary kiln contains 17 wt% dried clay (72 wt% SiO_2, 16% Al_2O_3, 7% Fe_2O_3, 1.7% K_2O, 3.3% Na_2O) and 83 wt% limestone (95 wt% $CaCO_3$, 5% impurities). When the solid temperature reaches about 900 °C, calcinations of the limestone to lime (CaO) and carbon dioxide occurs. As the temperature continues to rise to about 1450 °C, the lime reacts with minerals to form such compounds as $3CaO.SiO_2$, $3CaO.Al_2O_3$ and $4CaO.Al_2O_3.Fe_2O_3$. The flow rate of CO_2 from the kiln is 1350 m^3/h at 1000 °C and 1 atm. Calculate the feed rates of clay and limestone (kg/h) and the weight percent of Fe_2O_3 in the final cement.

(b) A liquid phase reaction with stoichiometry $A \rightarrow B$ follows a first order rate equation, $r_A = 0.0050\ C_A$ (mol A react/ L.s), where C_A is the reactant concentration in mol of A/L. Suppose the reaction is carried out in a continuous well-mixed stirred tank reactor. The liquid volume in the tank is 10.0 litres (L). The reactor tank is initially filled with a solution that contains 2 mol A/L. The inlet flow rate is 0.15 L/s and the inlet concentration is 10 mol A/L. The outlet flow rate is also 0.15 L/s. Draw the process flow diagram of the process, list the assumptions, write a differential balance equation on A, solve the balance equation to obtain an expression of $C_A(t)$ and sketch $C_A(t)$ showing the final steady state value of C_A. **(18)**

Contd P/2

ChE 201

3. (a) Hydrochloric acid is produced by absorbing gaseous HCl (Hydrogen chloride) in water. Calculate the heat that must be transferred to or from an absorption unit if HCl(g) at 90 °C and H_2O(l) at 30 °C are fed to produce 4000 kg/h of 16 wt% HCl(aq) at 50 °C. Given: Specific heat of 16 wt% HCL(aq) solution is 0.72 cal/g.°C. Show all steps clearly (include the input-output enthalpy table). **(20)**

(b) In the Daily Star, the latest weather report includes the following information: The temperature is 80 °F, barometric pressure is 29.9 inches Hg, and the relative humidity is 85%. Estimate the mole fraction of water in the air, the dew point (°F), the molal humidity, absolute humidity and percentage humidity. **(15)**

4. (a) A continuous rotary dryer is used to dry wet wood chips. The dryer operates at 1 atm pressure. The wet chips containing 42 wt% water enter the dryer at 20 °C and when leave the dryer the moisture content must be less than 10%. Hot dry air at 100 °C is fed to the dryer. The dry bulb temperature of the exiting air is found to be 38 °C and the wet bulb temperature is 30 °C. The air exits from the dryer at a rate of 14 m^3/kg of wet chips entering the dryer. **(18)**

   (i) Draw a block diagram of the process and completely label it.

   (ii) Calculate the moisture content of the exiting chips and check whether it meets the design specification, i.e., the moisture content is less than 10%.

   (iii) If the dryer is operating adiabatically, what is the exit temperature of the dry chips. Given: Specific heat of bone dry wood chips is 2 kJ/(kg °C), specific heat of liquid water is 4.18 kJ/(kg °C) and the molecular weight of air is 29. Show all steps clearly (include the input-output enthalpy table).

(b) Oil is extracted from soybeans using n-Hexane as a solvent. The solid residue from the extraction unit, which contains 0.78 kg liquid hexane/kg dry solids, is contacted in a dryer with nitrogen that enters at 85 °C. The solid leaves the dryer containing 0.05 kg liquid hexane/kg dry solids, and the gas leaves the dryer at 69 °C and 1.0 atm with a relative saturation of 85%. The gas is then fed to a condenser in which it is compressed to 5.0 atm and cooled to 30 °C, enabling some of the hexane to be recovered as condensate. Draw process flow diagram and calculate the fractional recovery of hexane (kg hexane condensed/kg hexane fed in wet solids). If needed, use Antoine's equation to calculate the vapor pressure of n-Hexane. **(17)**

Contd P/3

SECTION – B

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

5. (a) Methanol is produced by the reaction of carbon monoxide with hydrogen,

$$CO + 2H_2 \rightarrow CH_3OH \qquad \text{..........} \qquad (1)$$

The side reaction is: $CO + 3H_2 \rightarrow CH_4 + H_2O$ .... (2)

At a pressure of 6.9 MPa and a temperature of 574.6 K (301.5 °C), the conversion per pass is 12.5%. Of this amount, 87.5% is assumed to reach via eq.(1) and 12.5% via eq.(2). The stream leaving the reactor passes through a condenser-separator unit. The carbon monoxide and hydrogen leaving this unit are recycled. The methane leaves as a gas and the liquid mixture of methanol and water passes to a distillation column.

(i) Draw and label the process flow diagram, **(5)**

(ii) Find the composition of the hot gaseous stream leaving the reactor in mol% and wt%, **(7)**

(iii) the methanol content, weight% of the liquid (methanol + water) stream, leaving the condenser-separator unit, **(4)**

(iv) the recycle ratio, expressed as kg of carbon monoxide and hydrogen recycled per kg of fresh feed gas, **(4)**

(v) the methane "off gas" expressed as a percentage by weight of the combined feed gas, and **(4)**

(vi) the volumetric flow rate of the gaseous combined feed to the reactor, measured at 338.5 K (65.5 °C) and 7 MPa for a yield of 1 kg/s of methanol, assuming the ideal gas behavior of the mixture. **(4)**

(b) What is the main purpose of recycling? When do we need purging? **(7)**

6. (a) In a commercial process, chlorine is manufactured by burning hydrogen chloride gas using air. The reaction taking place in the burner is: **(28)**

$$4\ HCl\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g) + 2\ Cl_2\ (g)$$

For good conversion, air is used in 35% excess of that theoretically required. Assume that oxidation is 80% complete and the dry air and hydrogen chloride gas enter the burner at 298 K (25 °C). Calculate:

(i) the composition of dry gases leaving the burner

(ii) the adiabatic reaction temperature of the product gas stream

(b) Write short notes: (i) Adiabatic Flame temperature (ii) Standard heat of formation. **(2×3.5=7)**

Contd P/4

7. Sulfer dioxide is oxidized to sulfer trioxide in a reactor. SO_2 and 100% excess air are fed to the reactor at 450 °C. The reaction proceeds to a 65% SO_2 conversion, and the products emerge from the reactor at 550 °C. The production rate of SO_3 is 1.00×10^2 kg/min. The reactor is surrounded by a water jacket into which water at 25 °C is fed.

   (a) Calculate the feed rates (standard cubic meters per second) of the SO_2 and air feed streams and the extent of reaction, $\dot{\xi}$ (Kmol/s). **(15)**

   (b) Calculate the heat (KW) that must be transferred from the reactor to the cooling water. **(12)**

   (c) Calculate the minimum flow rate of the cooling water if its temperature rise is to be kept below 15 °C. **(8)**

8. (a) Ethanol is produced commercially by the hydration of ethylene: **(20)**

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

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

$$2\ C_2H_5OH \rightarrow (C_2H_5)_2O + H_2O.$$

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 43 mole% ethylene, 2.5% ethanol, 0.14% ether, 9.3% inerts and the balance water.

   (i) Take a basis of 100 mol of effluent gas and do a degree of freedom analysis based on atomic species to prove that the system has zero degree of freedom.

   (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 diethyl ether production.

(b) The reaction between ethylene and hydrogen bromide to form ethyl bromide is carried out in a continuous reactor. The product stream is found to contain 51.7 mole% C_2H_5Br and 17.3% HBr. The feed to the reactor contains only ethylene and hydrogen bromide. Calculate the fractional conversion of the limiting reactant. If the molar flow rate of the feed stream is 165 mol/s, what is the extent of reaction? **(15)**

Fig for Q. 4(a)

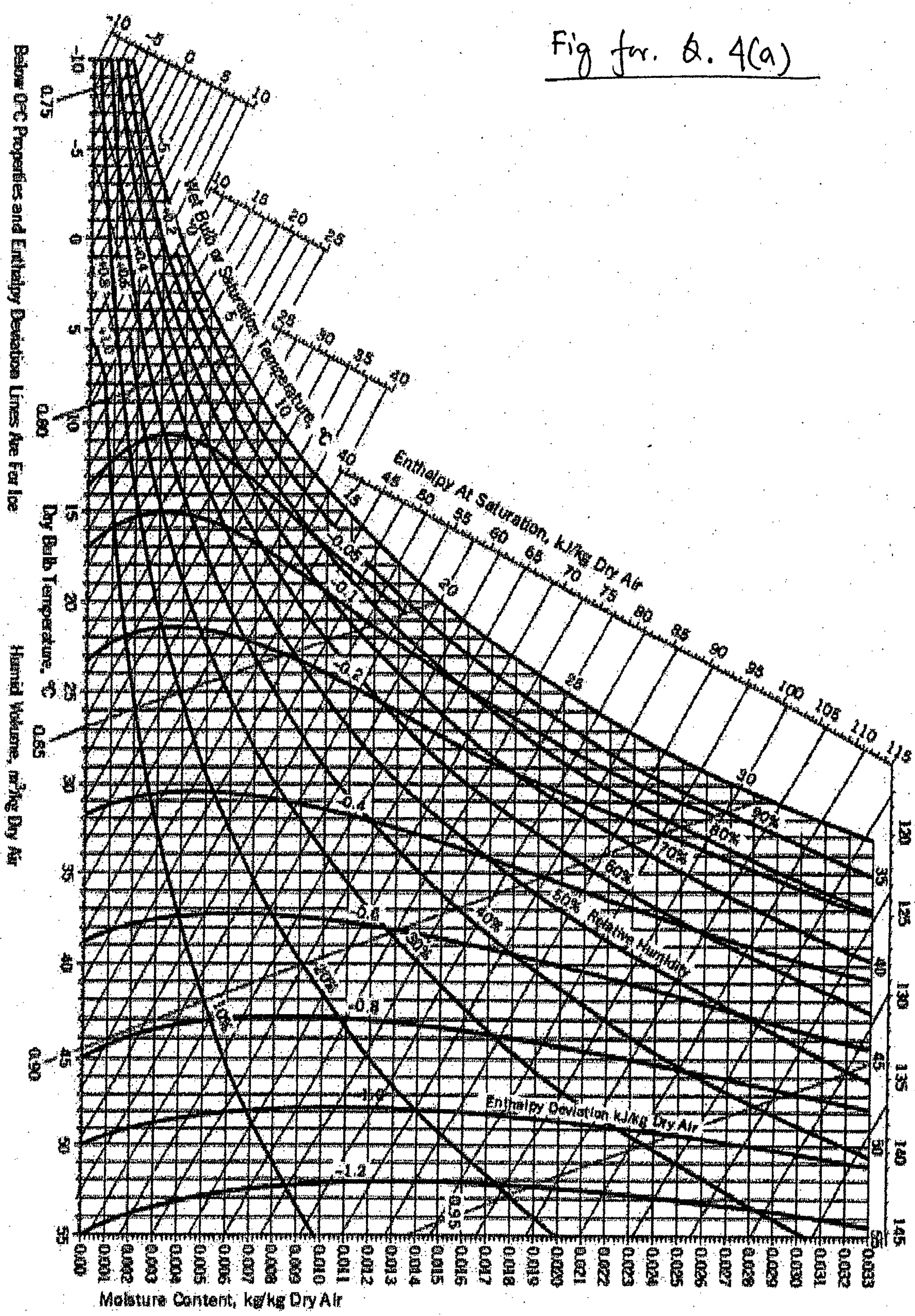

Figure 8.4-1 Psychrometric chart—SI units. Reference states: H_2O (L, 0°C, 1 atm), dry air (0°C, 1 atm). (Reprinted with permission of Carrier Corporation.)

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L-2/T-1/CHE **Date : 31/12/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

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

Full Marks : 280 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Prove that the area of the triangle formed by joining the mid-point of one of the non-parallel sides of a trapezium to the extremities of the opposite side is half of that of the trapezium. **(20)**

(b) If **a**, **b**, **c** are non-coplanar vectors then prove that the following four points are coplanar: **($16\frac{2}{3}$)**

$$-\mathbf{a} + 4\mathbf{b} - 3\mathbf{c},\quad 3\mathbf{a} + 2\mathbf{b} - 5\mathbf{c},\quad -3\mathbf{a} + 8\mathbf{b} - 5\mathbf{c},\quad -3\mathbf{a} + 2\mathbf{b} + \mathbf{c}$$

(c) Give the geometrical interpretation of the scalar triple product. **(10)**

2. (a) State and prove Frenet-Serret formulae. **($21\frac{2}{3}$)**

(b) If $\underline{P} = \mathbf{A}\cos kt + \mathbf{B}\sin kt$, where **A** and **B** are constant vectors and k, a constant scalar, show that $\frac{d}{dt}\left(\underline{P} \times \frac{d\underline{P}}{dt}\right) = 0$. **(10)**

(c) Find $\nabla^2(r^n\mathbf{r})$ where **r** is the position vector. **(15)**

3. (a) Find the angle of intersection at the point (–3, 0, –5) of the spheres **(15)**

$$x^2 + y^2 + z^2 + 6x - 5y + 2z + 27 = 0 \text{ and } x^2 + y^2 + z^2 - 29 = 0.$$

(b) Show that the gradient of a scalar function f is a vector along the normal to the level surface whose magnitude is the greatest rate of change of f. **($16\frac{2}{3}$)**

(c) Find curl of **F** where $\mathbf{F} = (x^2 - y^2 + 2xz)\mathbf{i} + (xz - xy + yz)\mathbf{j} + (z^2 + x^2)\mathbf{k}$. Also show that the vectors given by curl **F** at the points P(1, 2, –3) and Q(2, 3, 12) are orthogonal. **(15)**

4. (a) State and verify Green's theorem in the plane for $\int_C (2x - y^3)dx - xydy$ where C is the boundary of the region enclosed by $x^2 + y^2 = 1$ and $x^2 + y^2 = 3$. **($26\frac{2}{3}$)**

(b) Evaluate $\iiint_V (2x + y)dV$ where V is the closed region bounded by the cylinder $z = 4 - x^2$ and the planes x = 0, y = 0, y = 2 and z = 0. **(20)**

Contd P/2

MATH 221

SECTION – B

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

5. (a) Find the inverse of the matrix A, where $A = \begin{pmatrix} 1 & 0 & 2 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & -1 & 3 & 0 \\ 2 & 1 & 1 & -1 \end{pmatrix}$. **(23)**

(b) Solve the following system of equations by converting it to matrix form: **(23⅔)**

$$-x - 2y - 3z = 0$$
$$w + x + 4y + 4z = 7$$
$$w + 3x + 7y + 9z = 4$$
$$-w - 2x - 4y - 6z = 6$$

6. (a) For the matrix, $A = \begin{pmatrix} -1 & 4 & -2 \\ -3 & 4 & 0 \\ -3 & 1 & 3 \end{pmatrix}$, find an invertible matrix P such that $P^{-1}AP$ is a diagonal matrix. **(23)**

(b) Reduce the quadratic form $q = x_1^2 + 5x_3^2 + 8x_2x_3 + 6x_3x_1 + 4x_1x_2$ to canonical form and find the rank, index and signature of the form. **(23⅔)**

7. (a) If $L\{F(t)\} = f(s)$ and $G(t) = \begin{cases} F(t-a), & t > a \\ 0, & t < a \end{cases}$ then show that $L\{G(t)\} = e^{-as} f(s)$

and hence find $L\{F(t)\}$ where $F(t) = \begin{cases} \cos\left(t - \frac{2\pi}{3}\right), & t > \frac{2\pi}{3} \\ 0, & t < \frac{2\pi}{3} \end{cases}$. **(15)**

(b) Find $L\{\sin\sqrt{t}\}$. **(16)**

(c) Evaluate $\int_0^\infty \frac{e^{-3t} - e^{-6t}}{t}\,dt$. **(15⅔)**

8. (a) Find $L^{-1}\left\{\frac{s}{\left(s^2 + a^2\right)^2}\right\}$. **(15)**

(b) Use Laplace transform to solve $tY'' + Y' + 4tY = 0$, $Y(0) = 3$, $Y'(0) = 0$. **(16)**

(c) A particle of mass 2 grams moves on the X axis and is attracted towards origin O with a force numerically equal to 8X. If it is initially at rest at X = 10, find its position at any subsequent time assuming a damping force numerically equal to 8 times the instantaneous velocity acts. **(15⅔)**

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L-2/T-1/ChE

Date : 24/12/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

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) Discuss how the thermodynamic dissociation constant of a weak base, BOH is determined. Use Debye-Hückel limiting law of activity coefficient in the determination. **(10)**

   (b) What are solubility and solubility product? Deduce a relationship between them in case of a sparingly soluble salt A_xB_y. **(4)**

   (c) How is single electrode potential determined? Describe the construction and working principle of a secondary reference electrode. **(8)**

   (d) What is a standard cell and why is it used? Show the construction of a commonly used standard cell. **(7)**

   (e) Calculate the pH of a 0.01 M solution of acetic acid in which the dissociation is 12.5%. Also calculate the hydroxyl ion concentration. **(6)**

2. (a) What are the advantages of using amalgam electrodes over metal-metalion electrodes? Discuss, with an example, the working principle of an amalgam electrode. **(8)**

   (b) What is liquid junction potential? Show, with the help of a concentration cell with transference, that in case of equal transport numbers of positive and negative ions make the liquid junction potential negligible or zero. **(15)**

   (c) Discuss how the emf of a chemical cell without transference is used to determine the mean activity coefficient of ions. **(12)**

3. (a) Show a setup for performing a pH-metric titration. Discuss how the accurate neutralization point is fixed by this pH-metric method. **(12)**

   (b) How are electrochemical cells classified? Cite examples. **(6)**

   (c) Write the electrode and cell reactions and calculate the emf of the following cell at 25°C. **(8)**

   $$Zn|Zn^{++}(m=0.5)||Cd^{++}(m=0.1)|Cd$$

   Given: ionic activity coefficients are 0.376 and 0.137 for Zn^{++} and Cd^{++} respectively. $E^{\circ}_{cell} = 0.359$ V

   (d) Show the construction of a lead storage cell. Discuss its discharging and recharging processes. **(9)**

Contd P/2

ChE 235

4. (a) What are the different types of molecular spectra? **(6)**

(b) Derive an expression for the vibrational energy of a diatomic molecule considering it as a simple harmonic oscillator. **(9)**

(c) Derive the Beer-Lambert law. What is the physical significance of the molar absorption coefficient? **(12)**

(d) The percentage of transmittance of aqueous solution of disodium fumarate at 250 nm and 25°C is 19.2% for 5.0×10^{-4} mol L^{-1} solution in a 1 cm cell. Calculate the absorbance and molar absorption coefficient. **(8)**

SECTION – B

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

5. (a) Discuss the following theories concerning the mechanism of electrolytic conduction and electrolysis: (i) Grothuss theory (ii) Faraday theory (iii) Clausius theory and (iv) Arrhenius theory. **(14)**

(b) Define equivalent conductance and degree of dissociation. **(4)**

(c) A gram equivalent of acetic acid in 1000 litres solution has a specific conductivity of 4.1×10^{-5} ohm^{-1} cm^{-1}. Its equivalent conductivity at infinite dilution is 350 $mhos.cm^{-2}$. Calculate the equivalent conductance and the degree of dissociation of the given solution. **(10)**

(d) Show by calculation that ionic product of water and dissociation constant of water do not have the same value. **(7)**

[Sp. conductance of water at 25°C is 0.58×10^{-7} $ohm^{-1}.cm^{-1}$ and its density is 0.997 g/cm^3].

6. (a) State phase rule and explain the terms present in it. **(8)**

(b) Derive phase rule in a simplified way. **(10)**

(c) Draw the phase diagram of phosphorous and explain its main features with the help of phase rule. **(17)**

7. (a) Draw the cooling curves i.e., temperature-time curves for two components (molten-solid) system and describe them in brief. **(9)**

(b) Construct a phase diagram for the condensed system of A (Na_2SO_4) and B (H_2O). [The possible solid phases are: ice (m.p. = 0°C), $Na_2SO_4.10H_2O$ (decomposition temperature = 32.4°C), $Na_2SO_4.7H_2O$ (decomposition temperature = 25.5°C) and Na_2SO_4] **(9)**

Contd P/3

ChE 235

Contd Q. No. 7

(c) Define 'order' of a reaction. How can you determine the order of a reaction from differential rate equation? **(7)**

(d) Write down the steps involved in the thermal decomposition of acetaldehyde and hence show that the over all order of the reaction is $+1\frac{1}{2}$. **(10)**

8. (a) State the basic assumption of Langmuir adsorption isotherm. **(6)**

(b) Derive Langmuir adsorption equation and hence show that the Freundlich isotherm is a special case of the Langmuir adsorption isotherm. **(10+10)**

(c) A film containing 5.14×10^{-5} g of hexadecyl alcohol spread on water was compressed into a monomolecular layer occupying an area 15.0×17.9 cm^2. The density of the alcohol is 0.818 $g.cm^{-3}$. Calculate (i) the cross sectional area of the molecule and (ii) its length. **(9)**

L-2/T-1/ChE

Date : 19/11/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2011-2012

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.

SECTION – A

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

1. (a) Define exergy. State and explain the decrease of exergy principle. **(3+5)**

(b) Carbon steel balls (ρ = 7833 kg/m^3 and C_p = 0.465 kJ/kg.°C) of 12 mm diameter are annealed by heating them first to 950°C in a furnace and then allowing them to cool slowly to 100°C in ambient air at 30°C. If 1500 balls are to be annealed per hour, determine the rate of exergy destruction due to heat loss from the balls to the air. **(27)**

2. (a) Starting from basic principles, show that **(10)**

$$ds = \frac{Cp}{T}dT - \left(\frac{\partial V}{\partial T}\right)_P dP$$

(b) Describe the working of a simple vapor-compression refrigeration cycle. Use proper thermodynamic diagrams to explain how refrigeration is obtained in the above cycle. **(13)**

(c) Write a short account on how to select the right refrigerant for a given situation. **(12)**

3. (a) Describe the ideal Rankin cycle with simple schematic and thermodynamic diagrams. **(12)**

(b) Discuss the main deviations of actual vapor power cycles from idealized ones. **(8)**

(c) Discuss the different ways of improving the efficiency of the basic Rankin cycle. Use thermodynamic diagrams to elaborate your answer. **(15)**

4. (a) What are the "cold air-standard" assumptions. **(6)**

(b) Derive an expression for the thermal efficiency of an air-standard Otto cycle. **(12)**

(c) Write a short account on combined gas-vapor power cycle. **(9)**

(d) What is co-generation? Discuss its importance in chemical plants. **(8)**

SECTION – B

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

5. (a) Write the significance of 'Zeroth Law of Thermodynamics'. **(5)**

(b) Distinguish between state and path functions. **(5)**

(c) What are the forms in which energy can be transferred to or from a system? **(3)**

(d) What is the significance of compressibility factor? What do you understand by the 'Principle of Corresponding States'? **(3+3)**

(e) Draw and explain T-V diagram of a pure substance and P-V diagram of a substance that contracts on freezing. **(8+8)**

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6. (a) There are several equations of state to represent the P-V-T behavior of substances. Discuss the applicability and limitations of the following equations of state: **(4×5=20)**

   (i) Ideal-gas equation of state
   (ii) Vander Waals equation of state
   (iii) Beattie-Bridgeman equation of state
   (iv) Benedict-Webb-Rubin equation of state
   (v) Virial equation of state.

   (b) A piston-cylinder device initially contains 0.07 m^3 of nitrogen gas at 130 kPa and 180°C. The nitrogen is now expanded to a pressure of 80 kPa polytropically with a polytropic exponent whose value is equal to the specific heat ratio (called isentropic expansion). Determine the final temperature and the boundary work done during this process. It is provided that $C_p = 1.039$ kJ/kg.k and $C_v = 0.743$ kJ/kg.k for N_2. **(15)**

7. (a) Steam flows steadily through an adiabatic turbine. The inlet condition of the steam are 6 MPa, 400°C, and 80 m/s, and the exit conditions are 40 kPa, 92 percent quality, and 50 m/s. The mass flow rate of the steam is 20 kg/s. Determine (i) the change in kinetic energy, (ii) the power output, and (iii) the turbine inlet area. **(20)**

   (b) What do you understand by multistage compression with intercooling? Show graphically and explain the work saving in a two-stage compression with intercooling. How should the compression or pressure ratio across each stage of the compressor be chosen to minimize the overall compression work. **(15)**

8. (a) Write a short note on: **(5×4=20)**

   (i) Perpetual-motion machine
   (ii) Heat pumps
   (iii) Thermodynamic temperature scale
   (iv) Carnot cycle.

   (b) A Carnot refrigeration cycle is executed in a closed system in the saturated liquid-vapor mixture region using 0.85 kg of refrigerant-134a as the working fluid. The maximum and the minimum temperatures in the cycle are 25 and –8°C, respectively. It is known that the refrigerant is saturated liquid at the end of the heat rejection process, and the net work input to the cycle is 20 kJ. Determine the friction of the mass of the refrigerant that vaporizes during the heat addition process, and the pressure at the end of the heat rejection process. It is provided that the enthalpy of vaporization of refrigerant-134a at –8°C is 204.52 kJ/kg. **(15)**
