

SECTION - AThere are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Write a short description to show the working principle of a gas-turbine operating on basic Bryton cycle. (8)
- (b) Draw the P-v and T-s diagram of the basic Bryton cycle and show that the air-standard thermal efficiency is given by (4+8)
- $$\eta = 1 - \frac{1}{r_p^{(k-1)/k}}$$
- (c) Discuss the modifications that are used over the basic cycle to improve the efficiency of gas-turbines. Elaborate your answer by using P-v and T-s diagrams. (15)
2. (a) Discuss the different ways of improving the efficiency of the basic Rankine cycle. Use T-s diagrams to elaborate your answer. (12)
- (b) Describe the "regenerative" and reheat Rankine cycles. (7+3)
- (c) What is combined gas-vapor power cycle? Why is the combined gas-vapor cycle more efficient than either of the cycles operated alone? (6)
- (d) What is cogeneration? Draw the schematics of a cogeneration plant with adjustable loads. (7)
3. (a) Derive Clapeyron equation. What is its main use? (10+3)
- (b) Starting from basic equations, i.e., Gibbs equation show that (10)
- $$C_p - C_v = T \left(\frac{\partial v}{\partial T} \right)_p \left(\frac{\partial P}{\partial T} \right)_v$$
- (c) Write a short note on Joule-Thomson co-efficient. (Include inversion temperature and maximum inversion temperature in your answer). (12)
4. (a) Describe the working of a simple vapor-compression refrigeration cycle. Use proper thermodynamic diagrams in your answer. (12)
- (b) What is cascade refrigeration system? Why is it used? (8)
- (c) In a cold country the inside temperature of a house is to be maintained at 27°C when the outside temperature is 5°C. This is done by transferring heat from a 500-kg iron block initially at 200°C. Determine the second law efficiency of the process. Assume specific heat of iron to be 0.45 kJ/kg.K. (15)

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SECTION – B

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

5. (a) Define (3×4=12)

- (i) Control volume
- (ii) Extensive properties
- (iii) Intensive properties
- (iv) State function

(b) A 20-kg aluminum block initially at 200°C is brought into contact with a 20-kg block of iron at 100°C in an insulated enclosure. Determine the final equilibrium temperature and the total entropy change of this process. Given that (9)

$$(C_p)_{Al} = 0.955 \text{ kJ/kg.K}$$

$$(C_p)_{iron} = 0.45 \text{ kJ/kg.K}$$

(c) Draw and explain P-V and P-T diagram for pure substance. (14)

6. (a) Write a few words to elaborate "the second law of thermodynamics indicates that energy has quality as well as quantity". (12)

(b) A reversible cycle executed by 1 mol of an ideal gas for which $C_p = (5/2)R$ and $C_v = (3/2)R$ consists of the following: (23)

- Starting at $T_1 = 700 \text{ K}$ and $P_1 = 1.5 \text{ bar}$, the gas is cooled at constant pressure to $T_2 = 350 \text{ K}$.
- From 350 K and 1.5 bar, the gas is compressed isothermally to pressure P_2 .
- The gas returns to its initial state along a path for which $PT = \text{constant}$.

What is the thermal efficiency of the cycle?

7. (a) Show that the constants appeared in Van-der-Waals Equation of state can be calculated from critical properties by (12)

$$a = \frac{27R^2 T_{Cr}^2}{64P_{Cr}} \quad \text{and} \quad b = \frac{RT_{Cr}}{8P_{Cr}}$$

(b) An ideal gas, $C_p = (5/2)R$ and $C_v = (3/2)R$, is changed from $P_1 = 1 \text{ bar}$ and $V_1^t = 12 \text{ m}^3$ to $P_2 = 12 \text{ bar}$ and $V_2^t = 1 \text{ m}^3$ by the following mechanically reversible processes: (23)

- (i) Isothermal compression
- (ii) Adiabatic compression followed by cooling at constant pressure
- (iii) Adiabatic compression followed by cooling at constant volume
- (iv) Heating at constant volume followed by cooling at constant pressure
- (v) Cooling at constant pressure followed by heating at constant volume

Calculate Q , W , ΔV^t and ΔH^t for each of these processes, and sketch the paths of all processes on a single PV diagram.

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8. (a) A polytropic process for ideal gas can be expressed as $PV^\delta = \text{constant}$. Starting from this equation, show that, if the system is changed from state 1 to state 2, heat added/removed can be expressed as:

(20)

$$Q = \frac{(\delta - \gamma)RT_1}{(\delta - 1)(\gamma - 1)} \left[\left(\frac{P_2}{P_1} \right)^{\frac{\delta-1}{\delta}} - 1 \right]$$

Assume constant heat capacities.

- (b) An insulated, electrically heated tank for hot water contains 190 kg of liquid water at 60°C is used when a power outage occurs. If water is withdrawn from the tank at a steady rate of $\dot{m} = 0.2$ kg/s, how long it will take for the temperature of the water in the tank to drop from 60° to 35°C? Assume that cold water enters to the tank at 10°C, and that heat losses from the tank are negligible. For liquid water, let, $C_v = C_p = C$, independent of T and P.

(15)

L-2/T-1/CHE

Date : 25/01/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2010-2011

Sub : CHE 201 (Materials and Energy Balance)

Full Marks: 210

Time : 3 Hours

The figures in the margin indicate full marks.

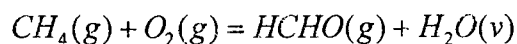
USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION - A

There are **FOUR** questions in this Section. Answer any **TWO** with Question No. 1.

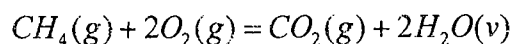
Question No. 1 is **COMPULSORY**.

1. (a) When you will use the heat of reaction method, heat of formation method and heat of combustion method while performing energy balance on a reactive system? Explain with example. (9)
 - (b) Define the relationship between higher heating value (HHV) and lower heating value (LHV) of a combustion reaction. (3)
 - (c) Write short notes on (i) Adiabatic Flame temperature (2×3)
(ii) Detonation
(iii) Sequential Modular Simulation Process
 - (d) Explain that the amount of heat change associated with a process is independent on the reference state. (3)
 - (e) Write down the basic energy balance equations for both the open and closed system. Explain all the terms associated with the equations. (2+3)
 - (f) What are the reference states for deriving the Steam Table and Psychometric Chart of SI units? Give some points to support the reference states. (4)
 - (g) State and explain Hess's Law with an example. (5)
2. Methane is oxidized with air to produce formaldehyde in a continuous reactor as follows – (35)



Methane enters the reactor at 45°C and 20 percent excess air on the basis of this reaction enters the reactor 120°C.

A competing reaction is the combustion reaction of methane –



60 percent of the methane is consumed in the reactor and selectivity (the ratio of desired product to the undesired product) for formaldehyde is 3. Jacketed cooling system with

Contd P/2

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Contd ... Q. No. 2

cooling water is used to maintain constant temperature in the Reactor. Inlet and outlet temperatures of the cooling water are 20°C and 40°C. If 800 kg/hr water is required per 100 kmol/hr of CH₄ for the cooling purpose, then what should the temperature of the reactor?

Note:

- (a) The outlet gas stream from the reactor has the temperature as the reactor.
- (b) The heat produces in the reactor is completely absorbed by the cooling water, assume all the heat losses as negligible.
- (c) Use the following heat capacity and heat of formation data:

$$C_{p,H_2O(l)} = 4200 \text{ kJ/kg. } ^\circ\text{C}$$

$$C_{p,H_2O(g)} = 33.46 \times 10^{-3} + 0.688 \times 10^{-5} T \text{ kJ/mol. } ^\circ\text{C}$$

$$C_{p,CH_4(g)} = 34.31 \times 10^{-3} + 5.469 \times 10^{-5} T \text{ kJ/mol. } ^\circ\text{C}$$

$$C_{p,CO_2(g)} = 36.11 \times 10^{-3} + 4.233 \times 10^{-5} T \text{ kJ/mol. } ^\circ\text{C}$$

$$C_{p,O_2(g)} = 29.10 \times 10^{-3} + 1.158 \times 10^{-5} T \text{ kJ/mol. } ^\circ\text{C}$$

$$C_{p,N_2(g)} = 29.00 \times 10^{-3} + 0.2199 \times 10^{-5} T \text{ kJ/mol. } ^\circ\text{C}$$

$$C_{p,HCHO(g)} = 34.28 \times 10^{-3} + 4.268 \times 10^{-5} T \text{ kJ/mol. } ^\circ\text{C}$$

$$(\Delta H_f^\circ)_{H_2O} = -241.83 \text{ kJ/mol}$$

$$(\Delta H_f^\circ)_{CH_4} = -74.85 \text{ kJ/mol}$$

$$(\Delta H_f^\circ)_{CO_2} = -393.5 \text{ kJ/mol}$$

$$(\Delta H_f^\circ)_{HCHO} = -115.90 \text{ kJ/mol}$$

3. (a) A batch reactor wrapped in an electrical heating mantle is charged with a liquid reaction mixture. The reactor is well-stirred. The reactants must be heated from an initial temperature of 35°C to 270°C before the reaction can take place at a measurable rate. Use the data given below to determine the time required for this heating to take place –

(20)

| | | |
|-------------------------------------|---|--|
| Reactants | : | Mass = 2.00 kg |
| | | $C_v = 0.900 \text{ cal/(g.}^\circ\text{C)}$ |
| Reactor | : | Mass = 3.50 kg |
| | | $C_v = 1.200 \text{ cal/(g.}^\circ\text{C)}$ |
| Heating rate | : | $Q = 515.0 \text{ W}$ |
| Rate of energy added by the stirrer | : | 55.0 W |

Assume negligible reaction and no phase changes during this batch heating.

CHE 201**Contd ... Q. No. 3**

- (b) A 40 wt percent NH_3 solution at 120 psia is fed at a rate of 120 lb_m/h to a tank in which the pressure is 1 atm. The enthalpy of the feed solution relative to the reference conditions used to construct Figure for Q 3(b) is 150 Btu/lb_m . The vapor composition is to be 91 wt percent NH_3 . Determine the temperature of the stream leaving the tank, the mass fraction of NH_3 in the liquid product, the flow rates of the liquid and vapor product streams, and the rate at which heat must be transferred to the vaporizer. (8)
- (c) Write down the name of some modern software which help us in computer aided material and energy balance. Also write down short that how these software can help us in doing the balances. (2+5)
4. (a) Calculate the total enthalpy change to take 1 kg ice from -10°C to 150°C steam. Use the following information – (18)
- Trouton's rule for heat of vaporization (in kJ/mol) = $0.109 T_b(\text{K})$
 for heat of fusion (in kJ/mol) = $0.0025 T_m(\text{K})$
 $C_{p,\text{ice}} = 35.19 \times 10^{-3} \text{ kJ}/\text{mol}\cdot^\circ\text{C}$
 $C_{p,\text{water}} = 75.4 \times 10^{-3} \text{ kJ}/\text{mol}\cdot^\circ\text{C}$
 $C_{p,\text{steam}} = 33.46 \times 10^{-3} + 0.6880 \times 10^{-5} T + 0.7604 \times 10^{-8} T^2 - 3.593 \times 10^{-12} T^3 \text{ kJ}/\text{mol}\cdot^\circ\text{C}$
- (b) Air at 110°F and 45% relative humidity is cooled to 50°F at atmospheric pressure. Use the psychrometric chart to evaluate all the information at the initial condition of the air. Also calculate the fraction of the water that condenses and the rate at which heat must be removed to deliver $1000 \text{ ft}^3/\text{min}$ of humid air at the final condition. (17)

SECTION – B

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

A booklet containing all relevant data to be supplied.

5. (a) Air at 90°C and 1.00 atm (absolute) pressure contains 10 mole% water. A continuous stream of this air enters a compressor-condenser system, in which the temperature is lowered to 15.6°C and the pressure is raised to 3.00 atm. The air leaving the compressor-condenser system is then heated isobarically to 100°C . Calculate the fraction of water that is condensed from the air, the relative humidity of the air at 100°C and the ratio of m^3 of outlet air at 100°C to m^3 feed air at 90°C . (18)

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Contd ... Q. No. 5

(b) Table 5.1 shows the vapor pressure of ethylene glycol:

(17)

Table 5.1 Vapor Pressure Data for ethylene glycol

| | | | | | | |
|------------|------|-------|------|-------|-------|-------|
| T (°C) | 79.7 | 105.8 | 120 | 141.8 | 178.5 | 197.3 |
| p* (mm Hg) | 5.0 | 20.0 | 40.0 | 100.0 | 400.0 | 760.0 |

Using a semilog plot, find the Clausius-Clapeyron equation for estimating vapor pressure of ethylene glycol. Find the heat of vaporization of ethylene glycol in kJ/mol. *Semilog graph paper to be supplied*

6. (a) An equimolar mixture of benzene and toluene is separated into two product streams by distillation. A process flowchart is shown in Fig. Q. 6. The vapor leaving the top of the column, which contains 97 mole% benzene, is completely condensed and split into two equal fractions: one is taken off as the overhead product stream and the other (the reflux) is recycled to the top of the column. The overhead product stream contains 89.2% of the benzene fed to the column. The liquid leaving the bottom of the column is fed to a partial reboiler in which 45% of it is vaporized and fed to the bottom of the column. The residual liquid is the reboiler is taken off as the bottom product stream. The compositions of the streams leaving the reboiler is related by the equation:

(25)

$$\frac{y_B / (1 - y_B)}{x_B / (1 - x_B)} = 2.25$$

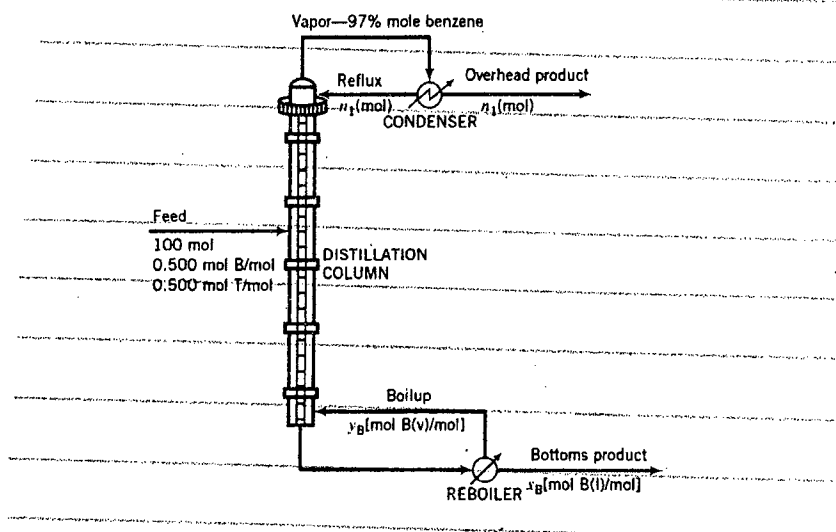


Fig Q6.: Distillation Column Schematic for Q6.

- (i) Draw and completely label a flowchart
- (ii) Calculate the percentage recovery of toluene in the bottom product (moles of toluene recovered/moles of toluene fed to the column).
- (iii) The mole fraction of toluene in the reboiler feed stream.

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Contd ... Q. No. 6

- (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. Determine the production rate of crystals (lbm crystals/lbm of feed) and the solid-liquid mass ratio (lbm crystals/lbm of liquid) in the slurry leaving the crystallizer. The solubility of KNO_3 is 40 g KNO_3 / 100 g H_2O at 25 °C. (10)
7. (a) A fuel oil is fed to a furnace and burned with 25% excess air. The oil contains 87.0 wt% C, 10% H, and 3% S. Assume complete combustion. The exhaust gas stream leaving the furnace is passed through a scrubber where most of the SO_2 is absorbed by an alkaline solution. Due to the capacity limitation of the scrubber, a part of the exhaust gas from the furnace must be bypassed directly to the stack. The scrubber removes 90% of the SO_2 in the gas fed to it and the combined stack gas contains 612 ppm SO_2 on a dry basis. Draw and completely label the flow chart. Calculate the fraction of the exhaust gas bypassed directly to the stack. (25)
- (b) Dry air is bubbled through 20 litres of water at a rate of 10 litres (STP) per min. The air leaving the liquid water is saturated with water at 25 °C and 1.5 atm. How long will it take for all water to vaporize? (10)
8. (a) The fresh feed to an ammonia production process contains nitrogen and hydrogen in stoichiometric proportion, along with 1 mole% inert gas. The feed is combined with a recycle stream containing the same three species and the combined stream is fed to a reactor in which a single pass conversion of 25% 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 leaves the condenser. 5% of the gas stream leaving the condenser is removed as purge and the rest constitutes the recycle stream. Find the overall conversion rate of nitrogen. (25)
- (b) A liquid mixture of 40% n-hexane and 60% n-heptane is in equilibrium with its associated vapor at 1 atm. Derive an expression for determining the bubble point temperature, T_{bp} . (10)
-

6

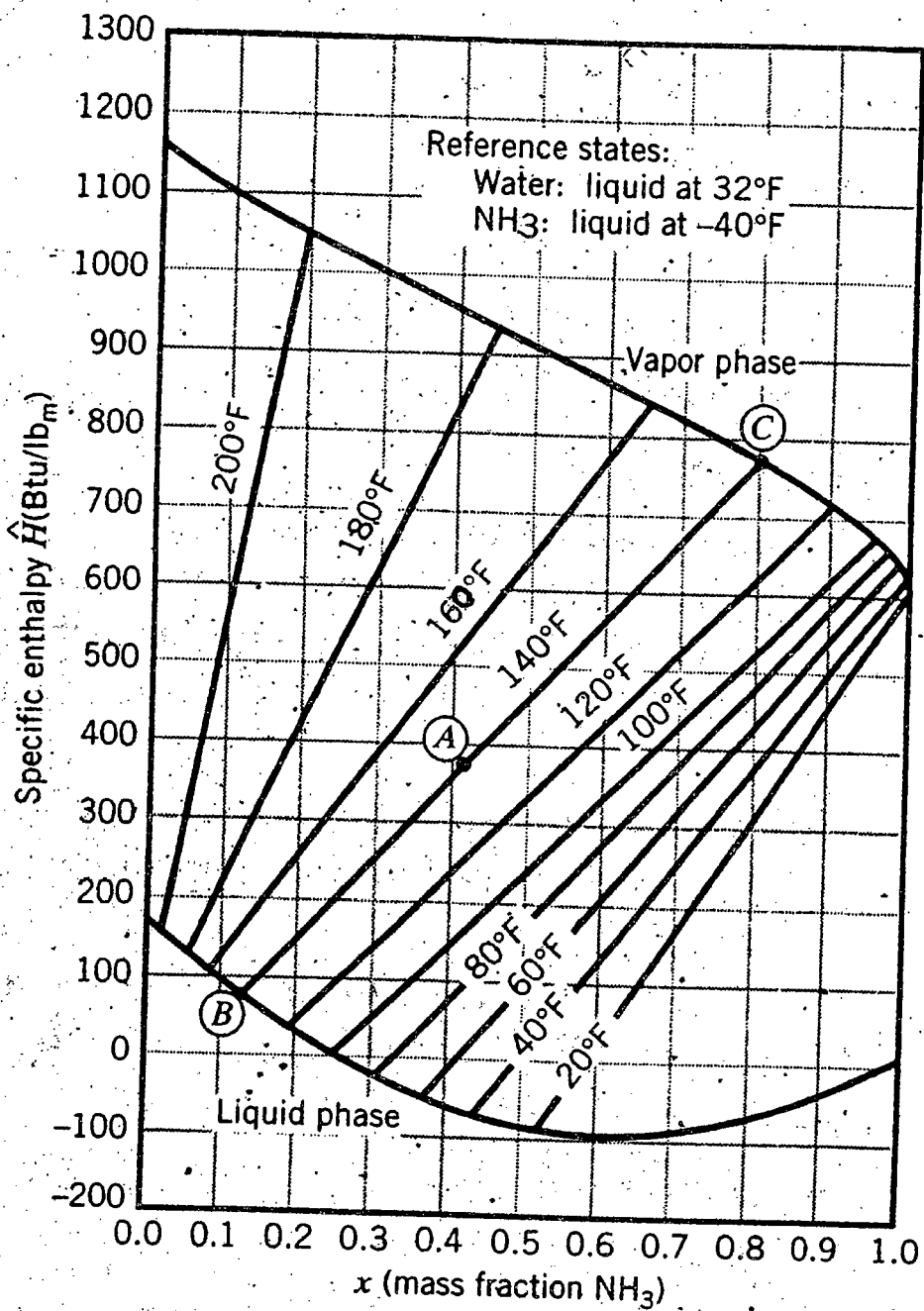
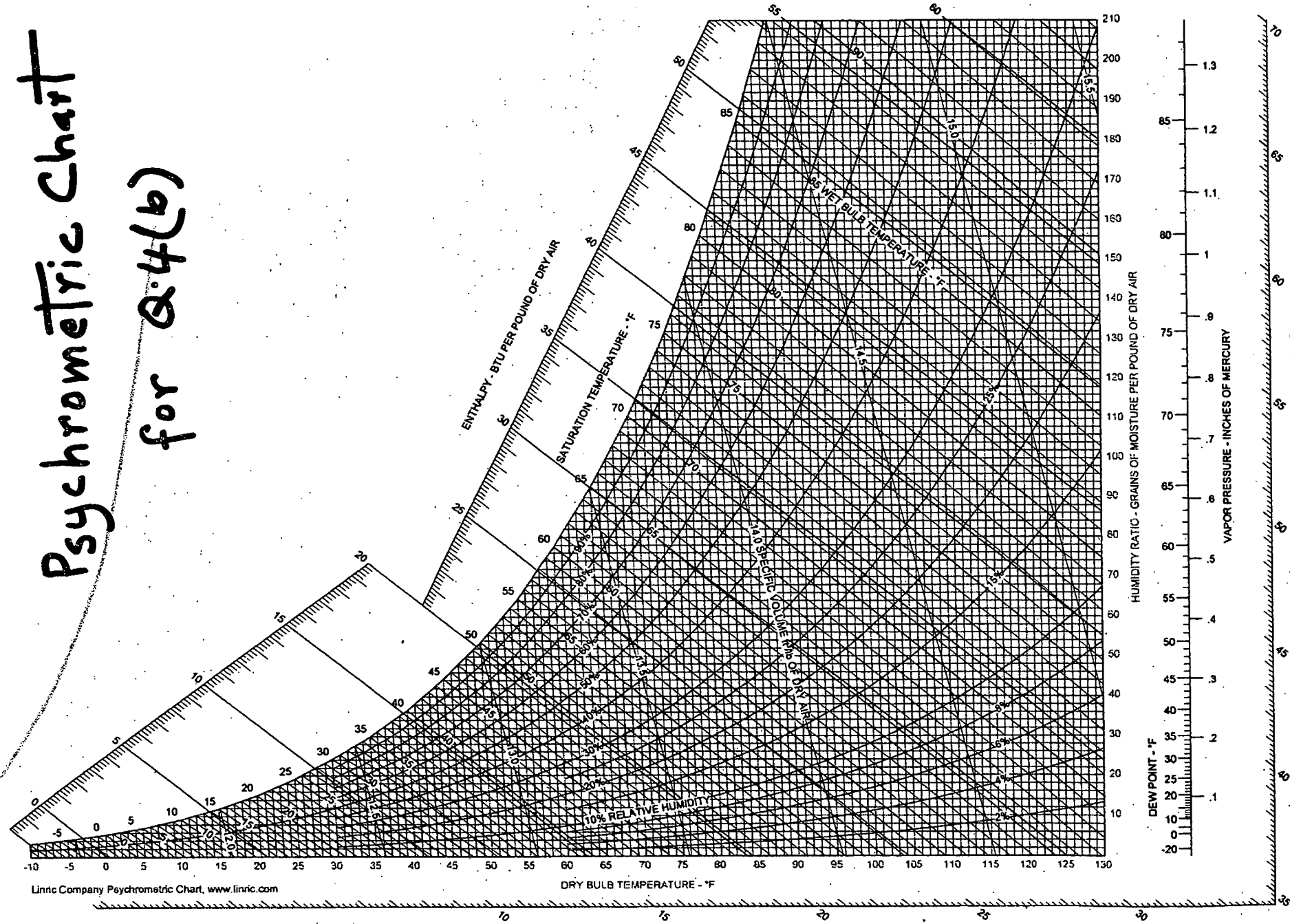


Figure 8.5-2 Enthalpy-concentration diagram for the ammonia-water system at 1 atm. (From G. G. Brown et al., *Unit Operations*, ©1950, Figure 551. Reprinted by permission of John Wiley & Sons.)

Figure for Question # 3(b)

7

Psychrometric Chart for Q:4(b)



BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 20010-2011

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

The questions are of equal value.

1. (a) Determine the current I_{D2} and the voltage V_0 in the circuit shown in Fig. 1(a). Assume constant voltage drop modes for the diodes $D1$ and $D2$ with cut-in voltage, $V_v = 0.70$ V.
(b) Fig. 1(b) (i) shows a circuit diagram of a clipper circuit. The applied sinusoidal voltage $v_s(t)$ is $10 \sin(2000 \pi t)$ volt, the waveforms of the input ($v_s(t)$) and output ($v_0(t)$) voltages are shown in Fig. 1(b) (ii) superimposed on each other. Now, calculate the value of DC voltage source $V1$ and $V2$ shown in Fig. 1(b)(i). (Assume constant voltage drop models for the given diodes with cut-in voltage, $v_v = 0.70$ v) Also determine the value of t_{D1} and t_{D2} as shown in Fig. 1(b) (ii).
2. (a) Draw the voltage transfer curve (V_0 vs V_I) for the circuit shown in Fig. 2(a). Consider $\beta = 120$.
(b) Calculate the voltage V_0 in the circuit shown in Fig. 2(b) . Consider $\beta = 75$.
3. (a) Design the common-base circuit as shown in Fig. 3(a) such that $I_{EQ} = 0.25$ mA and $V_{ECQ} = 2.0$ V. Consider $\beta = 75$.
(b) Derive the input-output relationship of Op-Amp based inverting and non-inverting amplifiers.
4. (a) Design a circuit in such a way that the input-output relationship of the circuit satisfies the following equation:

$$v_0 = 3v_1 - 6v_2 + 2v_3 - 2 \int_0^t v_1 dt + 3 \frac{dv_2}{dt}$$

where, v_1, v_2, v_3 are inputs and v_0 is output.

- (b) Fig. 4(b) (i) shows an inverting integrator. Consider $R = 100$ k Ω and $C = 1$ μ f. The waveform of input voltage ($v_s(t)$) of the integration is shown in Fig. 4(b)(ii). Draw the waveform of the output voltage ($v_0(t)$) of the integrator.

EEE 267(ChE)

SECTION - B

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

The figures in the margin indicate full marks.

5. (a) A separately excited DC generator with a field current of 2.5 A. When running at 1200 rpm, supplies 200 A at 125 V to a load circuit of constant resistance. Given that the armature resistance is 0.04Ω and total drop at brushes is 2 V. Determine the generated voltage. Now the speed is increased to 1600 rpm and the field current is reduced to 80%. The relation between the field current (I_f) in A and produced field flux (ϕ) in wb can be expressed as $\phi = 1 - e^{-I_f}$. Calculate changed generated voltage. Also determine the changed current in load circuit. (18)

- (b) A DC shunt generator delivers 195 A at terminal potential drop of 250 V. The armature resistance and shunt field resistance are 0.02Ω and 50Ω respectively. The iron and friction losses equal 950 W. Find (i) Cu losses, (ii) output of the prime mover/motor (iii) commercial, mechanical and electrical efficiencies. (17)

6. (a) A 4-pole, 240 V, wave connected shunt motor gives 11.19 kW when running at 1000 rpm and drawing armature and field currents of 50 A and 1.0 A respectively. It has 540 conductors. Its armature resistance is 0.1Ω . Assuming a drop of 1v per brush. Find (i) total torque, (ii) shaft torque (iii) useful flux/pole (iv) rotational losses and (v) efficiency. (18)

- (b) Compare the characteristics; torque vs. armature current, speed vs. armature current, speed vs torque of a DC shunt and series motors. (17)

7. (a) A 50 hp, 460 V DC shunt motor running light takes a current of 4 A and runs at a speed of 660 rpm. The resistance of the armature circuit is 0.3Ω and that of the shunt field circuit is 270Ω . (18)

Determine when the motor is running at full load- (i) the current input (ii) the speed and (iii) armature current at which efficiency is maximum.

- (b) A 75 kVA, 4800-240 V, 60 Hz, single phase transformer has the following parameters, (expressed in ohms): (17)

| | | |
|--------------------|--------------------|-----------------------|
| $R_{LS} = 0.006;$ | $R_{HS} = 2.488;$ | $R_{fe, HS} = 44,202$ |
| $X_{LS} = 0.0121;$ | $X_{HS} = 4.8384;$ | $X_{H, HS} = 7798.6$ |

The transformer is operating in the step-down mode, delivering one-half rated load at the rated voltage and 0.96 power factor lagging. Determine (i) the equivalent impedance of the transformer referred to the high side, (ii) the input impedance of the combined transformer and load (iii) the actual input voltage at the high side.

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8. (a) The equivalent low voltage side parameters of a 250 kVA, 480 V / 4160 V, 60Hz transformer are $R_{eq, l_s} = 0.0092 \Omega$ and $X_{eq, l_s} = 0.0433 \Omega$. The transformer is operating in the step-up mode, and is delivering half of the rated current at rated voltage to a 0.9 of leading load. Determine the voltage regulation. (17)

(b) Data obtained from short circuit and open circuit tests of a 75 kVA, 4600/230 V, 60 Hz transformer are, (18)

| Open circuit test (Low-side data) | Short circuit test (High-side data) |
|--------------------------------------|--|
| $V_{oc} = 230 \text{ V}$ | $V_{sc} = 160,8 \text{ V}$ |
| $I_{oc} = 13.04 \text{ A}$ | $I_{sc} = 16.3 \text{ A}$ |
| $P_{oc} = 521 \text{ W}$ | $P_{sc} = 1200 \text{ W}$ |

Determine (i) the magnetizing reactance and core loss resistance referred to the low-side.
(ii) the per unit resistance, reactance and per unit impedance of the transformer winding.

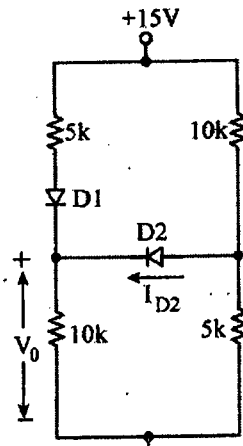


Fig. 1(a)

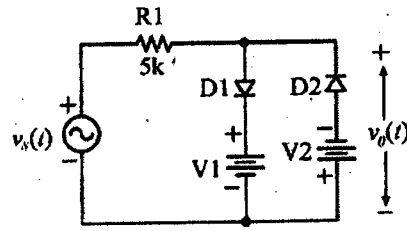


Fig. 1(b)(i)

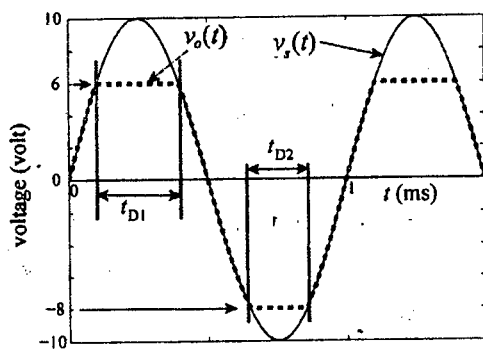


Fig. 1(b)(ii)

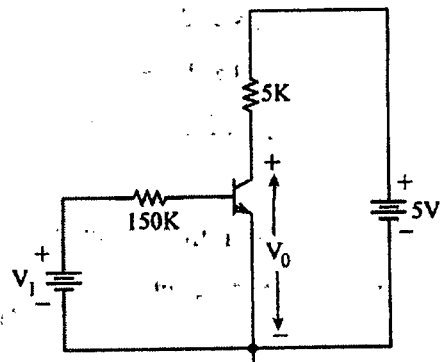


Fig. 2(a)

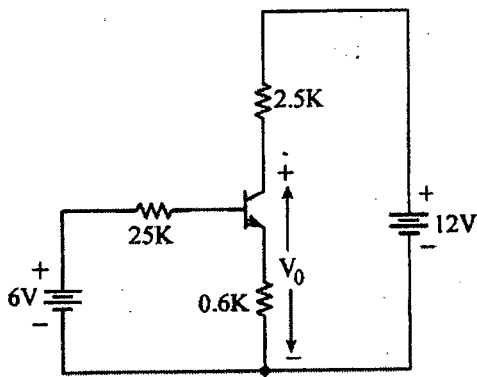


Fig. 2(b)

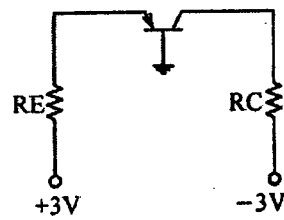


Fig. 3(a)

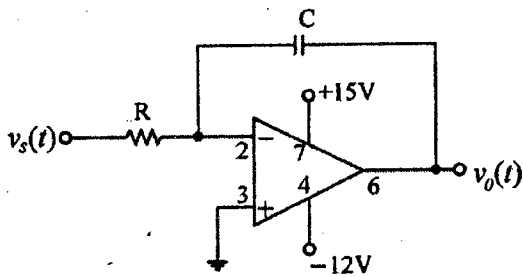


Fig. 4(b)(i)

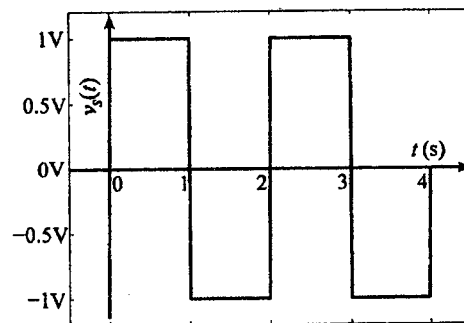


Fig. 4(b)(ii)

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

1. (a) Prove vectorially that the medians of a triangle meet in a point which is a trisection of the medians. (15)
- (b) Prove that (vectorially) $\sin(A+B) = \sin A \cos B + \cos A \sin B$. (15)
- (c) If $(\underline{a} \times \underline{b}) + (\underline{b} \times \underline{c}) = (\underline{a} \times \underline{c})$ then prove that (16 $\frac{2}{3}$)
- (i) $(\underline{a} \times \underline{b})$, $(\underline{b} \times \underline{c})$ and $(\underline{c} \times \underline{a})$ are parallel.
- (ii) if \underline{a} , \underline{b} , and \underline{c} have the same initial point, then their terminal points are collinear.
2. (a) Show that the acceleration \underline{a} of a particle which travels along a space curve with velocity \underline{v} is given by (16 $\frac{2}{3}$)
- $$\underline{a} = \frac{dv}{dt} \underline{T} + \frac{v^2}{p} \underline{N},$$
- where \underline{T} is the unit tangent vector to the space curve, \underline{N} is its unit principal normal. p is the radius of curvature and v is the speed of the particle.
- (b) Find the equations of the tangent plane and normal line to the surface $z = x^2 + y^2$ at the point $(2, -1, 5)$. (15)
- (c) Is $\underline{F} = (y^2 + 2xz^2 - 1)\underline{i} + 2xy\underline{j} + 2x^2z\underline{k}$ irrotational? If so, find \underline{u} such that $\underline{F} = \nabla \cdot \underline{u}$. (115)
3. (a) Evaluate $\int_c \underline{r} \times d\underline{r}$ and $\int_c \underline{r} ds$ from the point $(a, 0, 0)$ to the point $(a, 0, 2\pi b)$ on the circular helix $\underline{r} = a \cos t \underline{i} + a \sin t \underline{j} + bt \underline{k}$. (26 $\frac{2}{3}$)
- (b) Evaluate $\iint_S \underline{A} \cdot \underline{\hat{n}} dS$ over the entire surface of the region above the XY plane bounded by the cone $z^2 = x^2 + y^2$ and the plane $z = 4$, if $\underline{A} = 4xz \underline{i} + xyz^2 \underline{j} + 3z \underline{k}$. (20)
4. (a) Let $\underline{F} = 2xz\underline{i} - x\underline{j} + y^2\underline{k}$, evaluate $\iiint_V \underline{F} dV$, where V is the region bounded by the surface $x = 0$, $y = 0$, $y = 6$, $z = x^2$, $z = 4$. (20)
- (b) State Stoke's theorem. Verify Stoke's theorem for $\underline{F} = (2y + z)\underline{i} + (x - z)\underline{j} + (y - x)\underline{k}$ taken over the triangle ABC cut from the plane $x + y + z = 1$ by the coordinate planes. (26 $\frac{2}{3}$)

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SECTION - B

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

- 5. (a) Find the inverse of the matrix A, where (17)

$$A = \begin{pmatrix} -11 & 2 & 2 \\ -4 & 0 & 1 \\ 6 & -1 & -1 \end{pmatrix}$$

by using only row transformation.

- (b) State and prove Cayley-Hamilton theorem. (15)

- (c) Find the minimum polynomial $x(\lambda)$ for the matrix A when (14 $\frac{2}{3}$)

$$A = \begin{pmatrix} 2 & 7 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & -2 & 4 \end{pmatrix}$$

- 6. (a) For which values of 'a' will the following system have no solution? Exactly one solution? Infinitely many solution? (15)

$$x + 2y - 3z = 4$$

$$3x - y + 5z = 2$$

$$4x + y + (a^2 - 14)z = a + 2$$

- (b) Consider the quadratic form $q(x, y) = 3x^2 + 2xy - y^2$ and the linear substitution $x = s - 3t, y = 2s + t$

- (i) Rewrite $q(x, t)$ in matrix notation, and find the matrix A representing $q(x, y)$ (5)

- (ii) Rewrite the linear substitution using matrix notation, and find the matrix P corresponding to the substitution. (5)

- (iii) Find $q(s, t)$ using direct substitution. (4)

- (iv) Find $q(s, t)$ using matrix notation. (4)

- (c) Find the eigenvalues and corresponding eigen-vectors of the matrix (13 $\frac{2}{3}$)

$$A = \begin{pmatrix} 3 & -4 \\ 2 & -6 \end{pmatrix}$$

- 7. (a) Let $F(t) = \begin{cases} 3t & , 0 < t < 2 \\ 6 & , 2 < t < 4 \end{cases}$ where F(t) has period 4. Draw the graph of F(t). Find $\alpha\{F(t)\}$. (15)

- (b) Find $\alpha\left\{\frac{\cos\sqrt{t}}{\sqrt{t}}\right\}$ (16 $\frac{2}{3}$)

- (c) Evaluate $\int_0^\infty \sin x^2 dx$

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8. (a) Find $\mathcal{L}^{-1} \{e^{-\sqrt{s}}\}$ (15)

(b) Using Laplace transformation solve: (15)

$$\frac{dx}{dt} = 2x - 3y$$

$$\frac{dy}{dt} = y - 2x$$

subject to $X(0) = 8, Y(0) = 3$

(c) An inductor of 2 henrys, a resistor of 16 ohms and a capacitor of 0.02 farads are connected in series with an e.m.f of $E = 120 \sin 3t$ (volts). At $t = 0$ the charge on the capacitor and current in the circuit are zero. Using Laplace Transformation find the charge and current at any time $t > 0$.

(16 $\frac{2}{3}$)

Mojam

L-2/T-1/CHE

Date : 27/02/2012

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-1 B. Sc. Engineering Examinations 2010-2011

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**.

1. (a) What is derivative spectra? Illustrate the derivative spectra of the pure and mixture samples and discuss how these spectra are utilized in the quantitative analysis of the samples. (2+6+2=10)
(b) Distinguish between 'chromophore' and 'auxochrome'. Explain the effects of auxochrome in the absorption and intensity shifts of a spectrum. (4+6=10)
(c) Define the following spectroscopic terms: (3+7+5=15)
(i) A, (ii) T and (iii) ϵ
Derive the spectroscopic law and thus establish a relation between A and ϵ .
The transmittance of a 0.1 M $CuSO_4(aq)$ solution at 600 ^{nm}mm was measured as 0.30 in a 5.0 mm cell. Calculate the absorbance and molar absorption coefficient of $Cu^{+2}(aq)$ solution at that wave length. Also find, what is the transmittance through a 1.0 mm cell.
2. (a) Suggest a reaction mechanism of the following reaction: $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$ and prove that its experimental rate law is: rate = k $[N_2O_5]$. (10)
(b) Discuss 'collision theory' and 'transition state theory' of reaction rate and also depict the energy profiles associated with the change from reactant to product. (10)
(c) Explain Arrhenius equation. Describe how 'energy of activation' for a reaction can be obtained using Arrhenius concept. The half-life of a first order reaction are 69.3 and 34.7 min at 27° and 37°C respectively. Find energy of activation of the reaction. (10+5=15)
3. (a) Distinguish between homogeneous and heterogeneous catalysis with suitable examples. Discuss the importance of heterogeneous catalysis in the industrial processes. (6+4=10)
(b) What are 'promoter' and 'catalytic poisoning'? Discuss their role with mechanism in catalysis. (4+6=10)
(c) Discuss the important 'characteristics' and 'adsorption theory' of catalysis. Show the steps involved in the hydrogenation of ethane in presence of a Ni catalyst. (5+5+5=15)

Contd P/2

CHEM 235

4. (a) Equal volume of $AgNO_3$ ($2 \times 10^{-5} \text{ mol/L}$) and $NaCl$ ($2 \times 10^{-5} \text{ mol/L}$) solutions are mixed together. Comment on the precipitation of $AgCl$. (6)

Given: $K_{SP}(AgCl) = 1.10 \times 10^{-10} \text{ mol}^2 \text{ L}^{-2}$.

- (b) What is hydrolysis? Discuss the nature of solutions produced after neutralization of different classes of acids and bases. Deduce the equation for the calculation of p^H of the solution produced after neutralization of weak acid with a weak base. (20)

- (c) Calculate the p^H of the resulting solutions when 10 mL of 1 M HCl is added to (i) 1000 mL of water and (ii) 1000 mL of a solution mixture containing 0.1 M acetic acid and 0.1 M sodium acetate. Comment on the buffer action in case of solution (ii). (9)

K_a (acetic acid) = $1.75 \times 10^{-5} \text{ mol L}^{-1}$.

SECTION - B

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

5. (a) Explain why: (5×5=25)

- AC source is used for conductance measurement of electrolytes in solution.
- The ionic size of alkali metal ions follow the order: $Li^+ < Na^+ < K^+$, their ionic mobilities also follow the same order.
- Specific conductance increases but equivalent conductance decreases with an increase in electrolyte concentration.
- In conductometric titration of silver nitrate against KCl , the conductance values remain almost constant up to the equivalence point and then sharply increase with further increases in the volume of KCl solution.
- The activity coefficient of strong electrolytes initially decreases and then increases with increasing the molality of the solution.

- (b) State and explain Kohlrausch law. Find out the Λ_0 value of CH_3COOH from the following data with the help of this law. (4+6=10)

$$\Lambda_0 (NaCl) = 126.4 \text{ ohm}^{-1} \text{ cm}^2 \text{ equiv}^{-1}$$

$$\Lambda_0 (HCl) = 426.1 \text{ ohm}^{-1} \text{ cm}^2 \text{ equiv}^{-1}$$

$$\Lambda_0 (CH_3COONa) = 91.0 \text{ ohm}^{-1} \text{ cm}^2 \text{ equiv}^{-1}$$

6. (a) What is a condensed system? Explain the reduced phase rule for such a system. (8)

- (b) Draw the phase diagram of a two-component system where two components are completely miscible with each other in the liquid state and there is no chemical interaction between them. Discuss the features of the phase diagram including the eutectic point. (5+10=15)

CHEM 235

Contd ... Q. No. 6

(c) Construct the phase diagram for Zn and Mg system using the following data: **(12)**

- (i) Melting point of Mg 665°C
- (ii) Melting point of Zn 500°C
- (iii) One eutectic point at 350°C with 20 mole % of Zn and another at 430°C with 92 mole % of Zn.
- (iv) A solid compound $MnZn_2$ is formed which melts at 540°C.

Explain the different regions of the phase diagram mentioning the eutectic and congruent melting point.

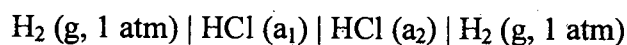
7. (a) Define transport number. Prove that the transport numbers of ions are directly proportional to their absolute velocities in solution. **(3+14=17)**

(b) What is electromotive force (emf)? Discuss the principle of direct reading potentiometer for emf measurement based on Poggendorff compensation method. **(10)**

(c) What is a gas electrode? Discuss the construction of a hydrogen gas electrode and show how the electrode potential of hydrogen gas electrode is related to the p^H of a solution. **(8)**

8. (a) What are concentration cells? Cite examples. **(6)**

(b) What type of cell is the following one? **(12)**



Deduce the cell emf equation which relates the molalities, activity coefficients and transport number.

(c) Discuss how the solubility product of a difficultly soluble salt is determined by emf measurement. Calculate the solubility product of AgBr at 25°C. **(10)**

Given: $E_{Ag}^0 = -0.7991 \text{ V}$ and $E_{Ag-AgBr}^0 = 0.0711 \text{ V}$ at 25°C. Using reasonable values for any missing data.

(d) Mention very briefly how the end point is determined in case of pH-metric titration of an acid with a base. **(7)**
