L-1/T-1/CHE **Date: 30/03/2024**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **CHE 101** (Elementary Principles of Chemical Engineering)

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**.

Data Booklet for ChE 101/201 is to be supplied.

1. (a) Two hundred moles per hour of liquid n-hexane at 25°C and 10 bar is vaporized and heated to 400°C at constant pressure. Draw the hypothetical process path and estimate the rate at which heat (kW) must be supplied for two cases (i) Neglecting the effect of pressure on enthalpy (ii) Taking account the effect of pressure on enthalpy. Is the effect of pressure significant? Justify. **(16)**

(b) Values of the specific internal energy of Bromine at three conditions are given below:

State	T(K)	P(bar)	$\hat{V}$(L/mol)	$\hat{U}$(kJ/mol)
Liquid	300	0.310	0.0516	−28.24
Vapor	300	0.310	79.94	0.000
Vapor	340	1.33	20.92	1.38

(i) What reference conditions were used to generate the listed specific internal energies? **(3)**

(ii) Calculate $\Delta\hat{U}$ (kJ/mol) for a process in which bromine vapor at 300 K is condensed at constant pressure. Then calculate $\Delta\hat{H}$ (kJ/mol) for the same process. Finally, calculate ΔH (kJ) for 10.00 mol of bromine undergoing the process. **(8)**

(iii) Bromine vapor in a 10.00 liter container at 300 K and 0.205 bar is to be heated to 340 K. Calculate the heat (kJ) that must be transferred to the gas to achieve the desired temperature increase, assuming that $\hat{U}$ is independent of pressure. **(8)**

2. (a) Carbon monoxide and hydrogen react in a reactor to produce methanol. The single pass conversion of carbon monoxide in the reactor is 20%. The fresh feed consisting of 33 mole% carbon monoxide, 66.5% hydrogen and 0.5% methane (as inert) is mixed with a recycle stream and the combined stream is fed to the reactor. Methanol leaving the reactor is separated by condensation and the unconverted gases are recycled. To prevent the build up of methane and keep the methane concentration at the recycle stream at 3%, a portion of the recycle stream is purged. Taking 100 moles of fresh feed as a basis, calculate **(27)**

Contd P/2

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Contd... Q. No. 2(a)

(i) the moles of recycle stream

(ii) the moles of purge stream

(iii) the composition of the purge stream and

(iv) the moles of methanol produced

(v) the overall conversion of carbon monoxide

(b) A certain gasoline engine has an efficiency of 35%; that is, it converts 35% of the heat generated by burning a fuel into useful work.

(i) If the engine consumes 1 L/h of a gasoline with a heating value of 32,000 kJ/L, how much power does it provide? Express the answer both in kW and horsepower. **(4)**

(ii) To make the fuel environment friendly, suppose the fuel is mixed with ethanol to make it a fuel-mixture of 10% ethanol by volume. The heating value of ethanol is approximately 23,000 kJ/L. At what rate (L/h) does the fuel mixture have to be consumed to produce the same power as gasoline? **(4)**

3. (a) Liquified Petroleum Gas (LPG) containing 70 mole% butane and the balance propane is to be burned with 20% excess air. Before entering the furnace the air is preheated from 32°F to 600°F. If the feed rate of LPG is 150,000 SCFH [ft3/hr at Standard Temperature (32°F) and Pressure (1 atm)], at what rate (Btu/hr) must heat be transferred to the air? Write down assumption(s), if any. **(25)**

(b) Steam at 300°C and 7.00 bar absolute is expanded through a nozzle to 220°C and 2.5 bar. Negligible heat is transferred from the nozzle to its surroundings. The approach (inlet to nozzle) velocity of the steam is negligible. Use the open-system energy balance to calculate the exit steam velocity. **(10)**

4. (a) Superheated steam at 40 bar absolute and 500°C flows at a rate of 250 kg/min to an adiabatic turbine, where it expands to 5 bar. The turbine develops 1500 kW. From the turbine the steam flows to a heater, where it is reheated isobarically to its initial temperature. Neglect kinetic energy changes.

(i) Write an energy balance on the turbine and use it to determine the outlet stream temperature. **(6)**

(ii) Write an energy balance on the heater and use it to determine the required input (kW) to the steam. **(6)**

(iii) Verify that an overall energy balance on the two-unit process is satisfied. **(6)**

(iv) Suppose the turbine inlet and outlet pipes both have diameters of 0.5 meter. Show that it is reasonable to neglect the change in kinetic energy for this unit. **(6)**

Contd P/3

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

(i) Calculate the rate of heat transfer from the water to the methanol (kW). **(6)**

(ii) Calculate the required flow rate of the entering steam in m^3/min. **(5)**

SECTION – B

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

5. (a) The following empirical equation correlates the values of variables in a system in which solid particles are suspended in a flowing gas: **(15)**

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

Both $(\mu/\rho D)$ and $(d_p u\rho/\mu)$ are dimensionless groups; k_g is the coefficient that expresses the rate at which a particular species transfers from the gas to the solid particles; and the coefficients 2.00 and 0.600 are dimensionless constants obtained by fitting experimental data covering a wide range of values of the variables.

The value of k_g is needed to design a catalytic reactor. Since this coefficient is difficult to determine directly, values of the other variables are measured or estimated and k_g is calculated from the given correlation. The variables values are as follows:

$D_p = 5.00$ mm; $y = 0.100$ (dimensionless); $D = 0.100$ cm^2/s;

$\mu = 1.00 \times 10^{-5}$ $N.s/m^2$; $\rho = 1.00 \times 10^{-3}$ g/cm^3; $u = 10.0$ m/s

(i) What is the estimated value and units of k_g

(ii) Why might the true value of k_g in the reactor be significantly different from the value estimated?

(b) In a steady state process crystalline potassium chromate (K_2CrO_4) is recovered from an aqueous solution of this salt. 10 ton per hour of a solution that is 30% K_2CrO_4 by mass is joined by a recycle stream containing 35% K_2CrO_4, and combined stream is fed into an evaporator. The concentrated stream leaving the evaporator contains 50% K_2CrO_4; this stream is fed into a crystallizer in which it is cooled (causing crystals of K_2CrO_4 to come out of solution) and then filtered. The filter cake consists of K_2CrO_4 crystals and a solution that contain 35% K_2CrO_4 by mass; the crystals account for 95% of the total mass of the filter cake. The solution that passes through the filter also 35% K_2CrO_4 is the recycle stream. Calculate the rate of evaporation, the rate of production of crystalline K_2CrO_4, the feed rates that the evaporator and the crystallizer must be designed to handle and the recycle ratio. **(20)**

Contd P/4

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6. (a) The diagram of the shirt-cleaning process used by Floods of Suds One Day Laundry Services is given below: **(23)**

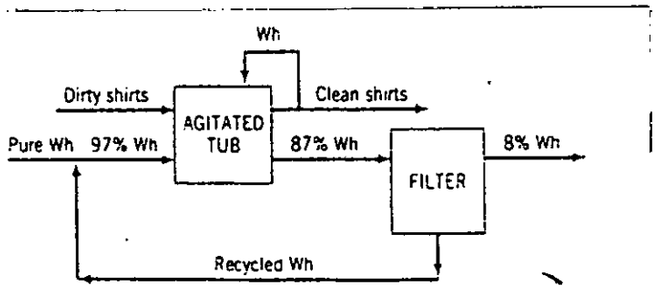

Figure for Question No. 6(a)

The shirts are soaked in an agitated tube containing Whizzo, the Wonder Detergent, then wrung out and sent to a rinse stage. The dirty Whizzo is sent to a filter in which most of the dirt is removed. The cleaned detergent is recycled back to join a stream of pure Whizzo, with the combined stream serving as the feed to the washtub

Data:

(i) Each 100 lb_m of dirty shirts contains 2 lb_m of dirt.

(ii) The washing removes 95% of the dirt in the dirty shirts.

(iii) For each 100 lb_m of dirty shirts, 25 lb_m of Whizzo leaves with the clean shirts of which 22 lb_m is wrung back into the tub.

(iv) The detergent that enters the tub contains 97% Whizzo and that which enters the filter contains 87%. The wet dirt that leaves the filter contains 8.0% Whizzo.

Calculate

(1) How much pure Whizzo must be supplied per 100 lb_m of dirty shirts?

(2) What is the composition of the recycled stream?

(b) An ideal gas mixture contains 35% helium, 20% methane, and 45% nitrogen by volume at 2.00 atm absolute pressure and 90°C temperature. Calculate **(12)**

(i) the mass fraction of methane

(ii) the average molecular weight of the gas

(iii) the density of the gas in kg/m^3

7. (a) An inclined manometer is a useful device for measuring small pressure differences. **(15)**

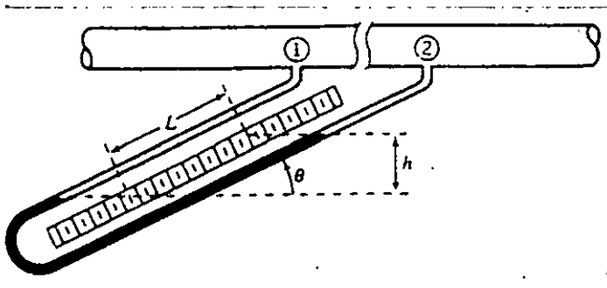

Figure for Question No. 7(a)

Contd P/5

CHE 101
Contd... Q. No. 7(a)

(i) Derive a formula for h in terms of L and θ

(ii) Suppose the manometer fluid is water, the process fluid is a gas, the inclination of the manometer is θ = 15° and a reading L = 8.7 cm is obtained. What is the pressure differences between points 1 and 2?

(iii) When you have to use inclined manometer instead of normal manometer, explain briefly.

(b) Briefly explain the basic principle of the Absorption Column, Distillation Column and Boiler with proper figure. **(20)**

8. A mixture containing 50.0 wt% acetone and 50.0 wt% water is to be separated into two streams- one enriched in acetone, the other in water. The separation process consists of the extraction of the acetone from the water into methyl isobutyl ketone (MIBK) works as a solvent, which dissolves acetone but is nearly immiscible with water. The description that follows introduces some of the terms commonly used in reference to liquid extraction processes. The process is shown schematically below. **(35)**

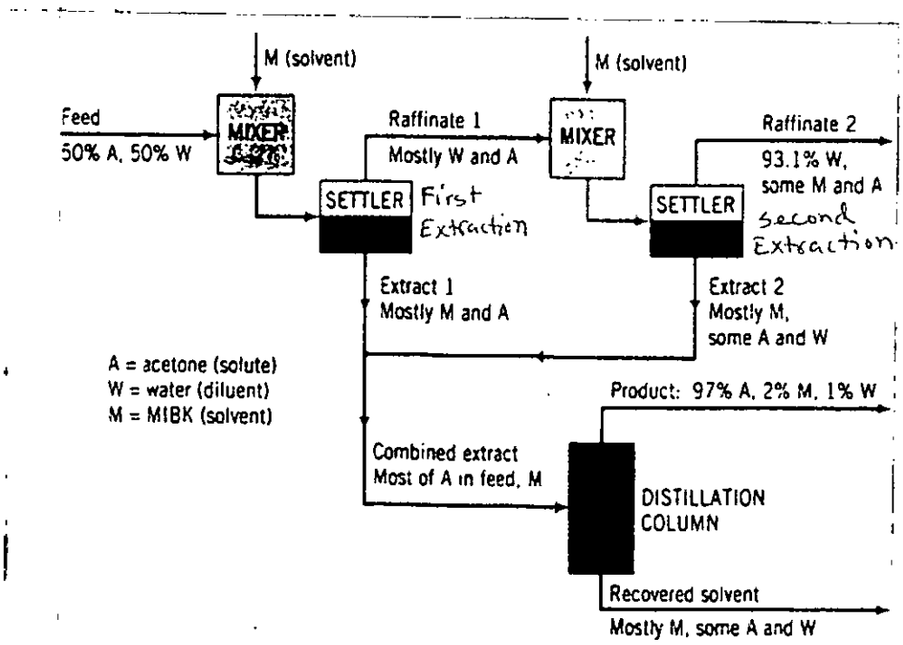

Figure for Question No. 8(a)

In a pilot plant study, for every 100 kg of acetone-water fed to the first extraction stage, 100 kg of MIBK is fed to the first stage and 75 kg of MIBK to the second stage. The extract from the first stage is found to contain 27.5% acetone. The second stage raffinate has a mass of 43.1 kg and contains 5.3% acetone, 1.6% MIBK, and 93.1% water, and the second stage extract contains 9.0% acetone, 88.0% MIBK and 3.0% water. The overhead product from the distillation column contains 2.0% MIBK, 1.0% water and balance acetone.

Taking a basis of calculation of 100 kg acetone-water feed, calculate the masses and compositions of (i) stage 1 raffinate (Raffinate 1) and extract (Extract 1), (ii) the combined extract and (iii) the distillation overhead and bottom products.

19/05/2024

L-1/T-1/CHE Date: ~~28/04/2024~~

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B.Sc. Engineering Examinations 2022-2023

Sub: **MATH 125 (Calculus)**

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

Symbols have their usual meaning.

1. (a) Define the continuity and differentiability of a function. **(5)**

(b) (i) If you are given at equation for the tangent line at the point $(a, f(a))$ on a curve $y = f(x)$, how would you go for finding $f(x)$? **(15)**

(ii) Given that the tangent line to the $f(x)$ graph of $y = f(x)$ at the point (2,5) has the equation $y = 3x - 1$, find $f'(2)$.

(iii) For the function $y = f(x)$ in part (ii) of Q 1(a), what is the instantaneous rate of change of y with respect to x at $x = 3$

(c) Evaluate: $\lim_{x \to 1} \sqrt{\left[\frac{\ln x}{x^4 - 1}\right]}$, using L' Hospital rule. **(15)**

2. (a) State Leibnitz's theorem. **(5)**

(b) If y = $\sin(m \sinh^{-1} x)$, then using the Leibnitz's theorem compute y_{n+2} and $(y_n)_0$. **(15)**

(c) (i) Find an interval [a, b] on which $f(x) = x^4 + x^3 - x^2 + x - 2$ satisfies the hypotheses of Rolle's Theorem.

(ii) Generate the graph of $f(x)$, and use it to make rough estimates of all values of c in the interval obtained in part (i) that satisfy the conclusion of Rolle's Theorem.

(iii) Find the equation of the tangent line to the graph of $f(x)$ at the point $(c, f(c))$.

(iv) Confirm that tangent line is horizontal. **(15)**

3. (a) Explain extrema and concavity of a function. **(5)**

(b) Find the maximum and minimum values of the function $f(x) = (1 - x)^2 e^x$. **(15)**

Also comment on the concavity and find the point of inflection.

(c) In a certain chemical manufacturing process, the daily weight y of defective chemical output depends on the total weight x of all output according to the empirical formula $y = 0.01x + 0.00003x^2$, where x and y are in pounds. If the profit is \$100 per pound of non-defective chemical produced and the loss is \$20 per pound of defective chemical produced, how many pounds of chemical should be produced daily to maximize the total daily profit? **(15)**

Contd..... P/2

MATH 125 (CHE)

4. (a) Define homogenous function and discuss the Euler's theorem of homogenous function. **(5)**

(b) The voltage, V (in volts), across a circuit is given by Ohm's law, V = IR, where I is the current (in amperes) flowing through the circuit and R is the resistance (in ohms). If two circuits with resistances R_1 and R_2 are connected in parallel, them their combined resistance, R, is given by $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$. Suppose that the current is 3 amperes and is increasing at 10^{-2} ampere/s, R_1 is 2 ohms and is increasing at 0.4 ohm/s, R_2 is 5 ohms and decreasing at 0.7 ohm/s. Using chain rule of Partial derivatives estimate the rate at which the voltage is changing. **(15)**

(c) Find the angle of intersection of the curves $r=a(1+\cos\theta), r=b(1-\cos\theta)$, also find the pedal equation of the cardioid $r=a(1+\cos\theta)$. **(15)**

SECTION – B

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

Symbols have their usual meaning.

5. (a) Define rectangle and anti-derivative method for finding area with appropriate examples. **(5)**

(b) Find the following **(10+10=20)**

(i) $\int e^x \frac{2+\sin 2x}{1+\cos 2x}dx$,

(ii) $\int x(x-1)a^{x-2}dx.$

(c) Apply the concept of antiderivative to find the area $A(x)$ between the graph of $f(x)=2x+3$ and the interval [a, x] = [-1, x] and find the derivative $A'(x)$ of this area function. **(10)**

6. (a) State and prove Walli's formula. **(10)**

(b) Evaluate $\int_0^{\pi/2} \sin^7 x\,dx$ by using the Walli's formula. **(8)**

(c) Evaluate the improper integral $\int_1^{\infty} \frac{\sqrt{x}}{(1+x)^2}dx$. **(10)**

(d) Test the convergence of the integral $\int_0^{\infty} \frac{\sin x}{x}dx$ and hence evaluate it. **(7)**

Contd..... P/3

MATH 125 (CHE)

7. (a) Define First Eulerian Integral and Second Eulerian Integral. **(5)**

(b) Using Gamma function evaluate $\int_0^\infty x^m e^{-ax^n} dx$ when m, n and a are all positive constants. **(10)**

(c) Evaluate the integral by using the suitable properties of definite integral $\int_0^\pi x \ln(\sin x) dx$. **(10)**

(d) Find the area of the lower portion of the ellipse $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$ intercepted by the line $y = c$. **(10)**

8. (a) Write the formula for the volume by cylindrical shells about x-axis and y-axis. **(5)**

(b) Evaluate $\lim_{n\to\infty}\left\{\left(2+\frac{1^2}{n^2}\right)^{1/n^2}\left(2+\frac{2^2}{n^2}\right)^{2/n^2}\left(2+\frac{3^2}{n^2}\right)^{3/n^2} \ldots\ldots\ldots\left(2+\frac{n^2}{n^2}\right)^{n/n^2}\right\}$. **(10)**

(c) Derive the formula for finding the volume of a right pyramid whose altitude is h and whose base is a square with sides of length a. **(10)**

(d) Find the arc length of the loop of the curve, $r = \sin 4\theta$. **(10)**

L-1/T-1/CHE Date: ~~04/05/2024~~ 25/5/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **EEE 155** (Electrical Engineering Fundamentals)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

The corresponding Course Outcomes **(COs)** of each part of Questions 1 and 5 are mentioned on the right most column. The **COs** of the Course are mentioned at the end of the question paper.

SECTION – A

There are **FOUR** questions in this section. Answer to **Question no. 1 is Compulsory.**
Answer any **TWO** questions from Questions 2-4.

1. (a) For the circuit in Fig. for Q. 1(a), Find I_0. **(20)** (CO2)

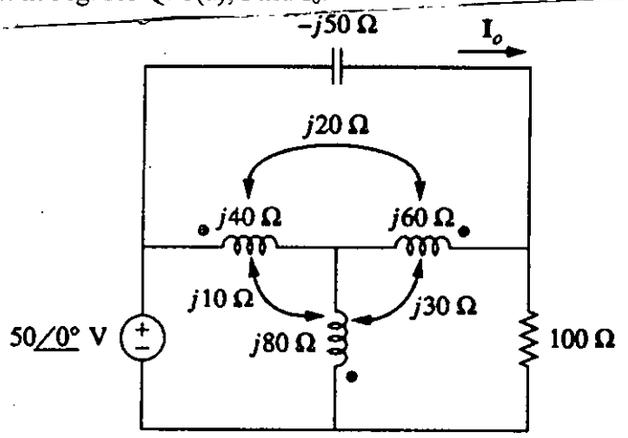

Fig. Q. 1(a)

(b) For the circuit in Fig. for Q. 1(b), determine the wattmeter reading. **(15)** (CO3)

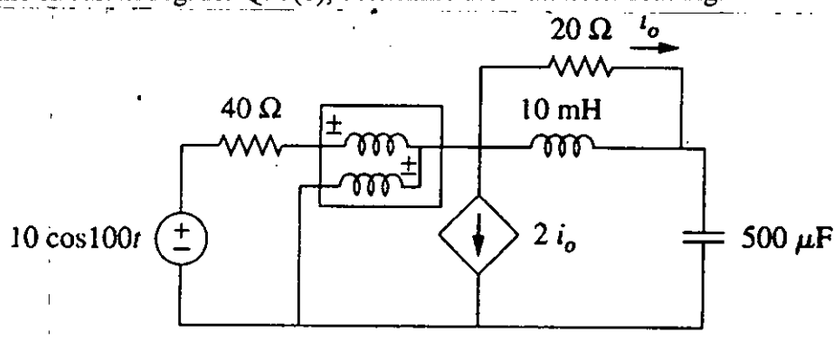

Fig for Q 1(b)

2. (a) For the current waveform shown in Fig. for Q 2(a), find the average power delivered to a 12 Ω resistor when the current flows through the resistor. **(15)**

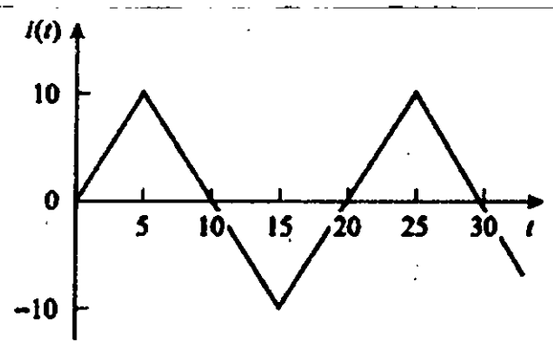

Fig for Q 2(a)

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

(b) For the circuit shown in Fig. for Q. 2(b), find V_s and the complex power supplied by the source. **(20)**

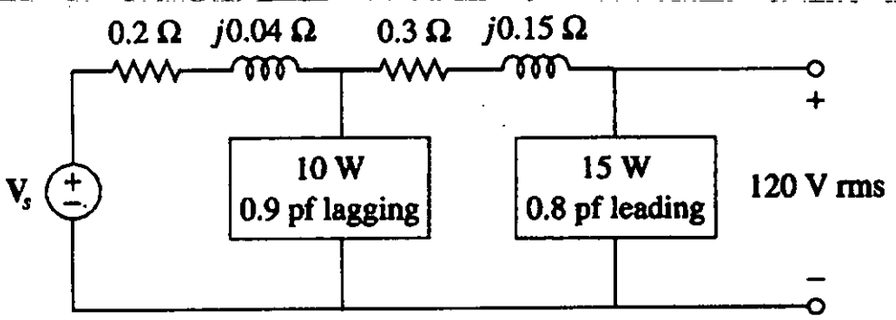

Fig for Q 2(b)

3. (a) For the Circuit shown in Fig. for Q. 3(a), find the value of Z_L that will absorb the maximum power and the value of the maximum power. **(20)**

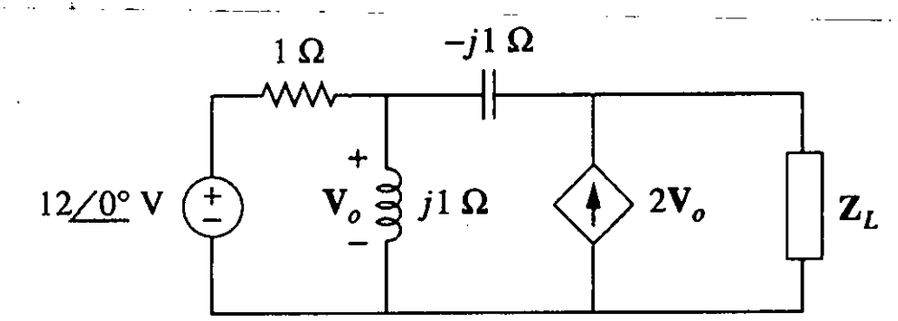

Fig for Q 3(a)

(b) For the circuit shown in Fig. for Q. 3(b), if $v_s(t) = V_m \sin \omega t$ and $v_0(t) = A\sin(\omega t + \varphi)$, derive the expression for A and φ. **(15)**

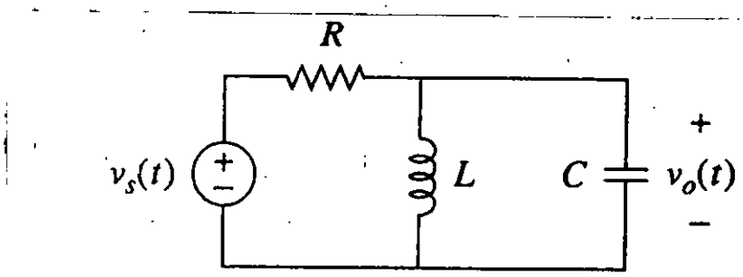

Fig for Q 3(b)

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4. (a) For the circuit shown in Fig. for Q. 4(a), find i_0 using superposition. **(20)**

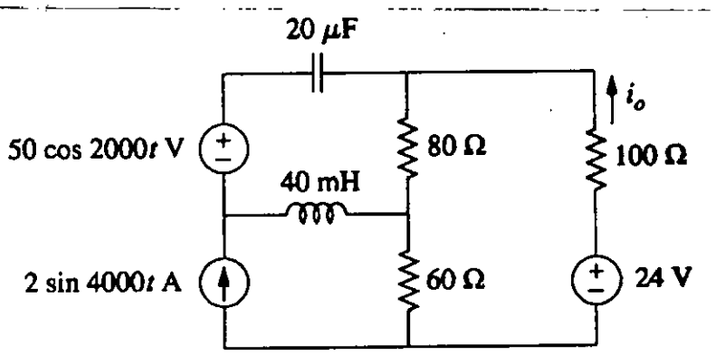

Fig for Q 4(a)

(b) For the circuit shown in Fig. for Q. 4(b), find the current I using mesh analysis **(15)**

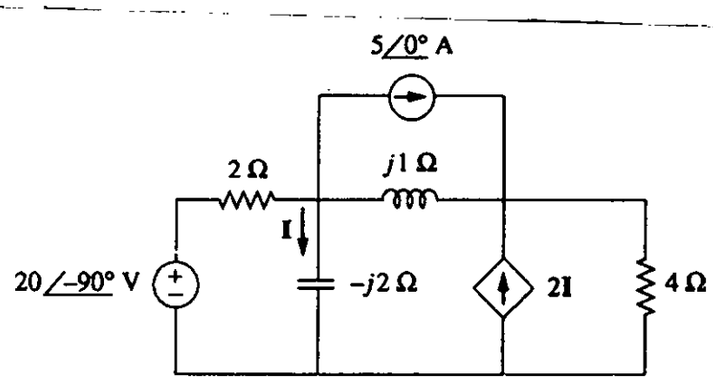

Fig for Q 4(b)

SECTION – B

There are **FOUR** questions in this section. Answer to **Question no. 5 (five) is Compulsory.**

Answer any **TWO** questions from Questions 6-8.

5. (a) Determine the voltage V_{DC} as indicated in Fig. for Q. No. 5(a) to establish a flux of 10^{-4} *Wb* in the section of the core with the air gap. Given, N = 200. Necessary B-H curves are attached to the question paper. **(18)** (CO2)

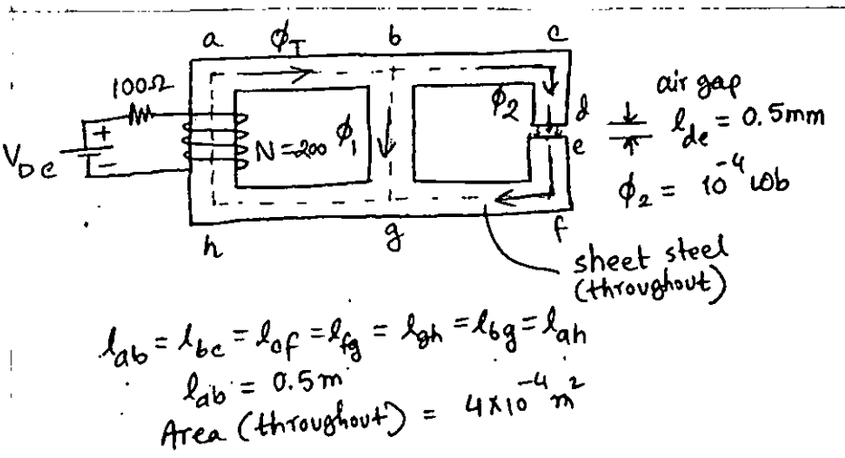

Figure for Question no. 5(a)

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Contd ... Q. No. 5(b)

(b) Calculate the maximum power that can be dissipated by the resistance **R** in the circuit of Figure for Question No. 5(b). **(17)** (CO1)

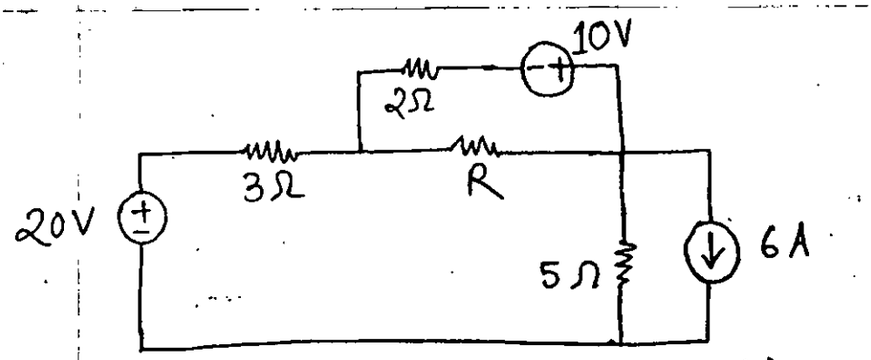

Figure for Questim no 5(b)

6. (a) Sketch a circuit that satisfies the following mesh equations. You are only allowed to use 10 Ω and 2 Ω resistances in your circuit. Identify the mesh currents in your circuit. **(17)**

$$24i_1 - 5i_2 - 2i_3 = 10$$
$$-5i_1 + 55i_2 - 10i_3 = -5$$
$$-2i_1 - 10i_2 + 16i_3 = 0$$

(b) Apply source transformation to find v_x from the circuit in Figure for Question no. 6(b). **(18)**

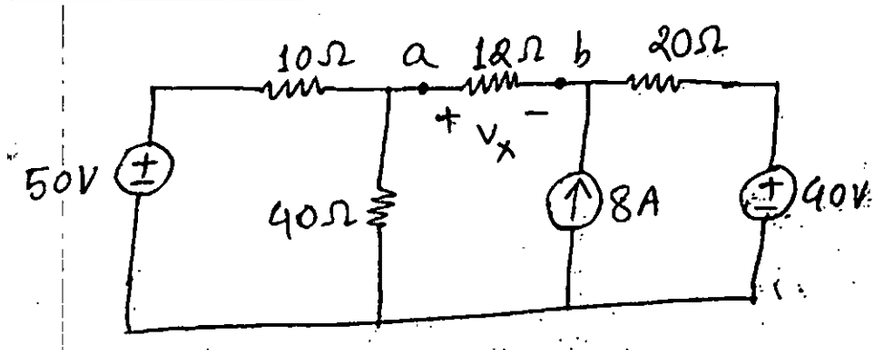

Figure for Question no. 6(b)

7. (a) Determine the voltage v_0 in the circuit of Figure for Question no. 7(a) using nodal analysis. **(17)**

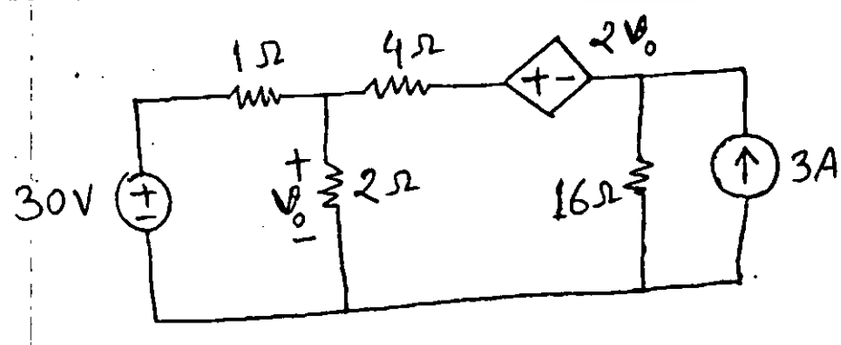

Figure for Question no. 7(a)

EEE 155

Contd ... Q. No. 7(b)

(b) Use the superposition principle to determine v_0 and i_0 from the circuit given in Figure for Question no. 7(b). **(18)**

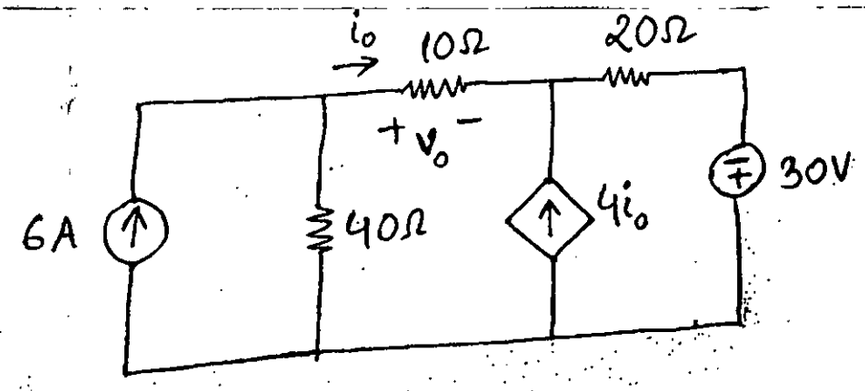

Figure for Question no. 7(b)

8. (a) Consider the circuit given in Figure for Question no. 8(a). Derive the value of the load resistance R_L in terms of R_1 and R_2 that will result in maximum power transfer to the load. **[Do not use the Thevenin's theorem or maximum power transfer theorem to simplify calculations. Derive the necessary equations from first principles.]** **(17)**

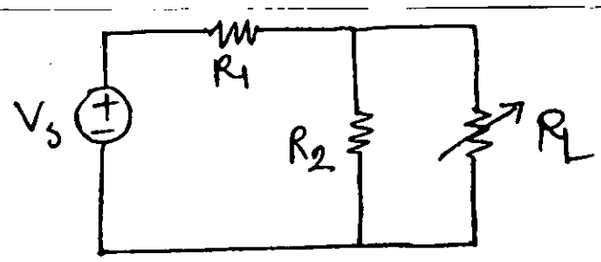

Figure for Question no. 8(a)

(b) The 60W light bulb in the circuit of Figure for Question no. 8(b) is rated at 120V. Calculate the source voltage V_S to operate the light bulb at the rated conditions. **(18)**

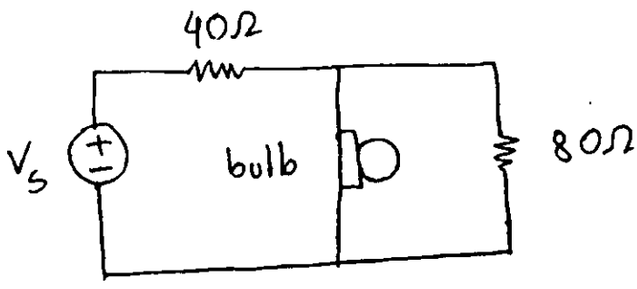

Figure for Question no. 8(b)

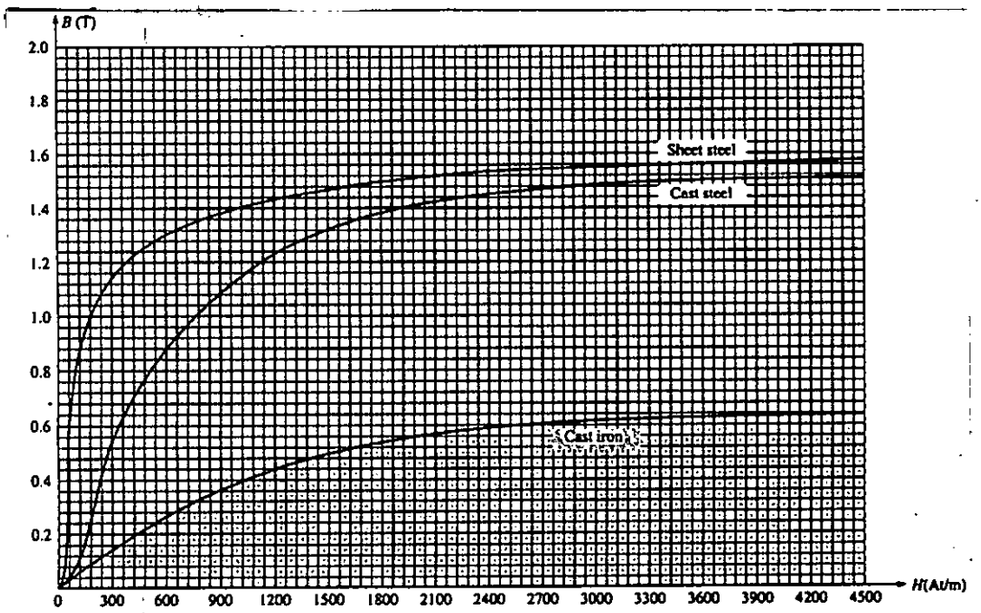

Figure : B-H curve for Question no. 5(a)