Enrolment No	
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Date: 30/05/2017

**Total Marks: 70** 

## **GUJARAT TECHNOLOGICAL UNIVERSITY**

**BE - SEMESTER-IV (NEW) - EXAMINATION - SUMMER 2017** 

Subject Code: 2140505

Subject Name: Chemical Engineering Maths

Time: 10:30 AM to 01:30 PM

Instructions:

- 1. Attempt all questions.
- 2. Make suitable assumptions wherever necessary.
- **3.** Figures to the right indicate full marks.
- **Q.1** Answer the following questions.
  - **1** Round the numbers 3.645 and 3.655 to three significant figure.
  - 2 Define Relative error
  - **3** Define upper triangular matrix.
  - 4 List out iterative methods to solve linear algebraic equations.
  - 5 Differentiate between open methods and bracketing methods to solve non linear algebraic equations.
  - **6** What are the limitations of Newton Raphson method.
  - 7 Define Coefficient of determination( $r^2$ ).
  - **8** For perfect fit, what is value of correlation coefficien (r)?
  - **9** List out the interpolation methods, which can be used when data points are available at unequal interval.
  - 10 Define trapezoidal rule for numerical integration.
  - 11 If number of equal spacing even than we can use Simpson's 3/8 rule. True/False?

12 Reduce  $\frac{d^2 y}{dx^2} + y^2 \frac{dy}{dx} + y = 0$  to set of 1<sup>st</sup> order differential equations.

**13** Write down Runge Kutta 4<sup>th</sup> order formula to solve following two ordinary differential equations.

$$\frac{dy}{dx} = f_1(x, y, z) \quad and \quad \frac{dz}{dx} = f_2(x, y, z)$$

- 14 List out methods, which can be used to convert partial differential equations in to algebraic equations.
- Q.2 (a) Describe different types of errors.
  - (b) Describe the term error propagation with example.
  - (c) Solve following equations using Newton Raphson technique starting with  $x_0 = [0.5 \ 0.5]$ . 07 Perform two iterations.

$$f_{1}(\mathbf{x}_{1}, \mathbf{x}_{2}) = 4 - 8\mathbf{x}_{1} + 4\mathbf{x}_{2} - 2\mathbf{x}_{1}^{3}$$
$$f_{2}(\mathbf{x}_{1}, \mathbf{x}_{2}) = 1 - 4\mathbf{x}_{1} + 3\mathbf{x}_{2} + \mathbf{x}_{2}^{2}$$

## OR

(c) Calculate the bubble point temperature for binary mixture benzene(1) and toluene(2) at 1 atm 07

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pressure and  $x_1 = 0.4$ , using Secant method. Carry out one iteration. **Data Given:**Two initial guess temperatures are:  $T_i = 353$  K and  $T_{i-1} = 360$  K.

 $f_{T} = x_{1} P_{1}^{sat} + x_{2} P_{2}^{sat} - P = 0$ Antoine equation : ln P<sup>sat</sup> = A -  $\frac{B}{T+C}$ , P is in kPa and T is in K. A B C Antoine constants : Benzene 14.1603 2948.78 -44.5633 Toluene 14.2515 3242.38 -47.1806

- Q.3 (a) Describe bisection method.
  - (b) For turbulent flow of a fluid in a hydraulically smooth pipe, Prandtl's universal resistance law 04 relates the friction factor, f, and the Reynolds number, Re, according to following relationship:

$$\frac{1}{\sqrt{f}} = -0.4 + 4 \log_{10} \left( \text{Re } \sqrt{f} \right)$$

Compute f for Re = 1000, using Newton-Raphson method with initial  $f_0$ = 0.01. Perform one iteration.

(c) Solve  $\begin{bmatrix} 2 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ 1 & 2 & 1 \end{bmatrix} \begin{bmatrix} 1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$  using Gauss-Seidel technique.  $\begin{bmatrix} 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_3 \end{bmatrix} = \begin{bmatrix} 4 \end{bmatrix}$ 

Carry out two iteration, starting with  $x^{(1)} = \begin{bmatrix} 1 & 2 & 1 \end{bmatrix}^T$ .

## OR

- **Q.3** (a) Describe Gauss-Jordan elimination method.
  - (b) Solve the following three equations for  $P_1$ ,  $P_2$  and  $P_3$  using Gauss Elimination method.

	$\begin{bmatrix} 0.01 & 0.95 & 0.10 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \end{bmatrix} = \begin{bmatrix} 400 \\ 400 \end{bmatrix}$ $\begin{bmatrix} 0.99 & 0.05 & 0 \\ 0 & 0 & 0.90 \end{bmatrix} \begin{bmatrix} P_2 \\ P_2 \end{bmatrix} = \begin{bmatrix} 200 \\ 200 \end{bmatrix}$	
(c)	Heat transfer coefficient (h) is related to the velocity (u) of flowing fluid through a pipe by $h = a u^{b}$ . Determine the values of <b>a</b> and <b>b</b> from the following data using least square technique.	07

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Q.4	<b>(a)</b>	Suggest method	to plot the va	riables y a	and x, g	given in	the following	ng equation	, so that data	03
		fitting the equation	on will fall on s	straight lin	e.					

u, m/s 0.305 0.914 1.524 2.134 h, W/(m<sup>2</sup> K) 852 2100 3208 4258

(b) Obtain the density of a 26% solution of phosphoric acid in water at 20°C, using Lagrange's **04** interpolation formula. Can we perform the same calculation using Newton's forward difference interpolation formula? Yes OR No?

 $y = \frac{\alpha x}{1 + x (\alpha - 1)}$ 

y, Density	1.0764	1.1134	1.2160	1.3350
<b>x</b> , % H <sub>3</sub> PO <sub>4</sub>	14	20	35	50

(c) For certain component following data are available:

 $\frac{2.743}{5228}$ 

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Kinematic viscosity, cm <sup>2</sup> /s	0.0179	0.0156	0.0138	0.0124	0.0112
Temperature, °C	0	4	8	12	16

Using Newton's forward difference interpolation method, predict the kinematic viscosity at 2.5 °C.

## OR

Q.4 (a) The variation of the specific heat Cp with temperature T for a substance is tabulated below:

T, °C	0	10	20	30	40	50	60	70	80	90	100
Cp, $\frac{kJ}{kg K}$	2.11	2.25	2.39	2.54	2.69	2.83	2.95	3.08	3.22	3.38	3.52

Estimate the heat required to raise the temperature of 1 kg of substance from 30 °C to 90 °C using Simpson's  $1/3^{rd}$  rule.

- (b)  $_{6}$  Using Trapezoidal rule evaluate the integral  $\int x^{2} e^{x} dx$  with h = 1.
- (c) Water is flowing through a pipe line 6 cm in diameter. The local velocities (u) at various radial 07 positions (r) are given below:

u, cm/s	2	1.94	1.78	1.5	1.11	0.61	0
r, cm	0	0.5	1	1.5	2	2.5	3

Estimate the average velocity  $\overline{u}$ , using Simpson's  $1/3^{rd}$  rule.

The average velocity is given by:  $\overline{u} = \frac{2}{R^2} \int_{0}^{R} u r dr$ , where R = 3 cm

**Q.5** (a) Consider general linear  $2^{nd}$  order partial differential equation given below.

$$a\frac{\partial^{2}C}{\partial r^{2}} + b\frac{\partial^{2}C}{\partial r \partial z} + d\frac{\partial^{2}C}{\partial z^{2}} + e\frac{\partial C}{\partial r} + f\frac{\partial C}{\partial z} + gC = h$$

where, a, b, d, e, f, g and h are functions of r, z and their derivatives. How to check, whether given partial differential equation is parabolic, hyperbolic or elliptic?

(b) Solve the following  $3^{rd}$  order ordinary differential equation using Euler method. At time, t = 0, initial **04** guess values are  $x_{1_0} = 2$ ,  $x_{2_0} = 16$ ,  $x_{3_0} = 4$ . Use time interval from 0 to 1 second, with step size h = 0.5 sec.

$$\frac{d^{3}x}{dt^{3}} + 4\frac{d^{2}x}{dt^{2}} - 2\frac{dx}{dt} + 16x = 21$$

(c) Gravity flow tank can be described by following two ordinary differential equation:

 $\frac{dv}{dt} = 0.0107 h - 0.00205 v^{2}$  $\frac{dh}{dt} = 0.311 - 0.0624 v$ 

where, v is velocity (ft/Sec) and h = height of liquid in tan k(ft)

Integrate above equation between time t = 0 to t = 60 sec with  $\Delta t = 20$  sec using Euler method. At time t = 0 sec,  $v_0 = 3.4$  ft/sec and  $h_0 = 2.05$  ft

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- Q.5 (a) Describe Milne's predictor-corrector method.
  - (b) Explain procedure to solve following heat conduction equation using finite difference 04 technique.

$$k \frac{\partial^2 T}{\partial x^2} = \frac{\partial T}{\partial t}$$

(c) Solve  $\frac{dC}{dt} = \frac{1.5 - 4.5 C}{3}$  using Runge-Kutta 4<sup>th</sup> order method.

**Data given:** Time interval from t = 0 min to t = 1 min, with step size h = 0.5 min. At time t = 0 min,  $C_0 = 1$  mol/m<sup>3</sup>.

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