**Seat No.: Enrolment No.** 

## **GUJARAT TECHNOLOGICAL UNIVERSITY**

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

**Subject Code: 2140505 Date: 30/05/2017**

**Subject Name: Chemical Engineering Maths**

**Time: 10:30 AM to 01:30 PM Total Marks: 70** 

**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. 14
	- **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  $\frac{d^2 y}{2} + y^2$  $\frac{d^2y}{dx^2} + y^2 \frac{dy}{dx} + y = 0$  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. **03**
	- **(b)** Describe the term error propagation with example. **04**
	- (c) Solve following equations using Newton Raphson technique starting with  $x_0 = [0.5 \ 0.5]$ . Perform two iterations. **07**

$$
f_1(x_1, x_2) = 4 - 8x_1 + 4x_2 - 2x_1^3
$$
  

$$
f_2(x_1, x_2) = 1 - 4x_1 + 3x_2 + x_2^2
$$

## **OR**

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

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:  $\ln P^{sat} = A - \frac{B}{T+C}$ , 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. **03**

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

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

Compute f for  $Re = 1000$ , using Newton-Raphson method with initial f<sub>0</sub>= 0.01. Perform one iteration.

**(c)**

Solve 1 2 3 1 2 1  $\sin x = 2$ 0 1 1  $|x_1|$  4  $\begin{vmatrix} 1 & 2 & 1 \end{vmatrix}$   $\begin{vmatrix} x_2 \\ x_3 \end{vmatrix} = \begin{vmatrix} 2 \\ 1 \end{vmatrix}$  $\begin{bmatrix} 0 & 1 & 1 \end{bmatrix}$   $\begin{bmatrix} x_3 \end{bmatrix}$   $\begin{bmatrix} 4 \end{bmatrix}$ using Gauss-Seidel technique.

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. **03**

2 1 0  $\|$  x  $\|$  1

 $\begin{bmatrix} 2 & 1 & 0 \end{bmatrix} \begin{bmatrix} x \\ 1 \end{bmatrix}$ 

**(b)** Solve the following three equations for  $P_1$ ,  $P_2$  and  $P_3$  using Gauss Elimination method. **04**

> $0.01$   $0.95$   $0.10$  || P | 400 0.99 0.05 0  $\mu$  P  $_i = 400$

 $\begin{bmatrix} 0.01 & 0.95 & 0.10 \end{bmatrix} \begin{bmatrix} P_1 \end{bmatrix}$   $\begin{bmatrix} 400 \end{bmatrix}$  $\begin{vmatrix} 0.99 & 0.05 & 0 \end{vmatrix}$   $\begin{vmatrix} 1 \\ 1 \end{vmatrix}$   $P_2$  =  $\begin{vmatrix} 400 \\ 1 \end{vmatrix}$ 





- **Q.4 (a)** Suggest method to plot the variables y and x, given in the following equation, so that data **03** fitting the equation will fall on straight line.
	- $(\alpha 1)$  $y = \frac{\alpha x}{1 + x (\alpha - 1)}$  $= \frac{\alpha x}{1 + x (\alpha -$
	- **(b)** Obtain the density of a 26% solution of phosphoric acid in water at 20°C, using Lagrange's interpolation formula. Can we perform the same calculation using Newton's forward difference interpolation formula? Yes OR No? **04**



**(c)** For certain component following data are available: **07**

2

**07**



Using Newton's forward difference interpolation method, predict the kinematic viscosity at 2.5  $^{\circ}C$ .

## **OR**

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

T. °C		$0 \mid 10 \mid$	20	30 40 50 60 70		80	90	100
$\frac{KJ}{\frac{1}{2}}$ k g 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  $^{\circ}$ C to 90  $^{\circ}$ C using Simpson's  $1/3^{r\bar{d}}$  rule.

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

**0**



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

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

**Q.5 (a)** Consider general linear 2<sup>nd</sup> order partial differential equation given below.

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

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  $3<sup>rd</sup>$  order ordinary differential equation using Euler method. At time, t = 0, initial guess values are  $x_{1} = 2$ ,  $x_{2} = 16$ ,  $x_{3} = 4$ . Use time interval from 0 to 1 second, with step size h = 0.5 sec. **04**

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

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

 $\frac{dv}{dt}$  = 0.0107 h - 0.00205 v<sup>2</sup>  $\frac{1}{dt}$  = 0.0107 n –  $\frac{dh}{dt} = 0.311 - 0.0624$  v  $\frac{1}{\text{dt}}$  = 0.311 –

where, v is velocity (ft/Sec) and  $h = h$ eight of liquid in tank(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

3

**03**

**07**

**03**

**04**

- **Q.5 (a)** Describe Milne's predictor-corrector method. **03**
	- **(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  $\frac{dC}{dt} = \frac{1.5 - 4.5 \text{ C}}{1.5 - 4.5 \text{ C}}$ **d t 3**  $=\frac{1.5-4.5 \text{ C}}{4.5}$  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>.

**\*\*\*\*\*\*\*\*\*\*\*\*\***

**07**