2018-19
B. TECH. AUTUMN SEMESTER EXAMINATION
(CHMICAL / PETROLEUM STUDIES)
HIGHER MATHEMATICS
(AM-241)

Maximum Marks: 60
Credits: 04
Duration: Two Hours

Answer all questions.
Assume suitable data if missing.
Notations and symbols used have their usual meaning.

Q.No. Question CO M.M.

1(a) Find a unit vector normal to the surface \( x^2 + y^2 - z = 0 \) at the point \((1, -1, 2)\). (CO1) [03]

1(b) Find the directional derivative of \( \Phi = 3x^2y - y^3z^2 \) at the point \((1, -2, -1)\) in the direction perpendicular to the \(xy\) plane. (CO1) [06]

1(c) Find constants \(a, b, c\) so that

\[(i) \vec{F} = (x + 2y + az)i + (bx - 3y - z)j + (4x + cy + 2z)k \] is irrotational.

\[(ii) \vec{V} = (x + 3y)i + (y - 2z)j + (x + az)k \] is solenoidal

OR

1(c') Show that

\[(i) \nabla^2 \left(\frac{1}{r}\right) = 0 \]

\[(ii) \text{div}(\vec{r} \Phi) = 3\Phi + \vec{r}. \text{grad}\Phi \]

2(a) If \( \vec{A} = (3x^2 + 6y)i - 14yzj + 20xz^2k \), evaluate \( \int_C \vec{A}.d\vec{r} \) from \((0,0,0)\) to \((1,1,1)\) along the curve \(x = t, y = t^2, z = t^3\).

OR

2(a') Use Green’s theorem to evaluate \( \oint_C sinydx + x(1 + cosy)dy \)

where the region \(R\) is bounded by the circle \(C: x^2 + y^2 = a^2\).
2(b) Evaluate \( \int_S \vec{A} \cdot d\vec{S} \) where \( \vec{A} = 18z\hat{i} - 12\hat{j} + 3y\hat{k} \) and \( S \) is that part of the plane \( 2x + 6y + 6z = 12 \) which is located in the first octant.

3(a) Find

(i) \( L\{t^2 \cos 3t + e^{4t}\} \)

(ii) \( L^{-1}\left(\frac{5s + 3}{(s - 1)(s^2 + 2s + 5)}\right) \)

OR

3(a') Find

(i) Use convolution theorem to evaluate \( L^{-1}\left(\frac{2}{s(5s^2 + 4)}\right) \)

(ii) \( L\{U(t - 4)\sin(t - 4)\} \)

3(b) Use Laplace transform method to solve

\[ \frac{d^2y}{dt^2} + 3 \frac{dy}{dt} + 4y = \sin t, \quad y(0) = 1, y(1) = 2 \]

4(a) Use separation of variables method to solve heat equation \( \frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2} \)

subject to conditions:

\[ u(0, t) = u(3, t) = 0, \quad t > 0, \quad u(x, 0) = f(x) = \begin{cases} 0, & 0 < x < 1 \\ x, & 1 < x < 2 \\ 0, & 2 < x < 3 \end{cases} \]

4(b) Let \( u(x, y) = (A\cos ax + B\sin ax)(C\cosh ay + D\sinh ay) \) be a solution of the equation \( \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0 \). Find constants \( A, B, C \) and \( D \) so that \( u \) satisfies initial boundary conditions:

\[ u(0, y) = u(a, y) = 0, \quad 0 \leq y \leq b \]

\[ u(x, 0) = 0, \quad u(x, b) = \sin \frac{\pi}{a} x, \quad 0 \leq x \leq a \]

END
2018-19
B. TECH. AUTUMN SEMESTER EXAMINATION
(CHMICAL/PETROLEUM STUDIES)
HIGHER MATHEMATICS
(AMS-2410)

Maximum Marks: 60
Credits: 04
Duration: Two Hours

Answer all questions.
Assume suitable data if missing.
Notations and symbols used have their usual meaning.

Q.No. | Question | CO | M.M.
--- | --- | --- | ---
1(a) | Show that \( \nabla \phi \) is a vector normal to the surface \( \phi(x, y, z) = c \) where \( c \) is a constant. | (CO1) | [03]
1(b) | Find the directional derivative of \( \phi = x^2y + 4xz^2 \) at the point \((1, -2, -1)\) in the direction normal to the surface \( x^2y + 2xz = 4 \) at the point \((2, -2, 3)\). | (CO1) | [06]
1(c) | Find constants \( a, b, c \) so that \( \vec{F} = (ax + 2y + 4z)i + (2x + by - z)j + (4x - y + cz)k \) is irrotational. Also find \( \phi \) so that \( \nabla \phi = \vec{F} \). | (CO1) | [06]
2(a) | Verify Green’s theorem in the plane for \( \oint_C (xy + y^2)dx + x^2 dy \) where \( C \) is the closed curve of the region bounded by \( y = x \) and \( y = x^2 \). | (CO2) | [07]
2(b) | Let \( V \) be the region defined by \( x^2 + y^2 + z^2 \leq 1 \). Use the divergence theorem to evaluate \( \iiint_V z^2 \, dV \). | (CO2) | [08]

OR

2(b') | Let \( V \) be the region bounded by the paraboloid \( z = x^2 + y^2 \) and the plane \( z = 1 \) and let \( S \) be the surface of the region. Evaluate \( \iint_S (yi + xj + z^2k) \cdot d\vec{S} \). | (CO2) | [08]
3(a) | Show that the two dimensional Laplacian operator \( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} = 4 \frac{\partial^2}{\partial z^2} \). | (CO3) | [07]

\text{contd} \ldots \text{a.}
in the complex plane. Use this result to find \( \left( \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} \right) |z + 2|^2 \)

**3(a')** If \( f(z) = u + iv \) is an analytic function and \( u - v = e^{-x}(\sin y + \cos y) \), find \( f(z) \) in terms of \( z \) subject to the condition that \( f(0) = 1 + i \)  

**3(b)** Using Cauchy integral formula, evaluate \( \int_C \frac{e^z}{(z-1)^3(z^2+1)} \, dz \) where \( C: |z - 1| = \frac{1}{2} \)  

**4(a)** Use separation of variables method to solve one dimensional heat equation \( \frac{\partial u}{\partial t} = 5 \frac{\partial^2 u}{\partial x^2} \) subject to conditions:

\[ u(0, t) = u(2, t) = 0, \quad u(x, 0) = f(x) = \begin{cases} 0, & 0 < x < 1 \\ x, & 1 < x < 2 \end{cases} \]

**4(a')** Reduce the initial boundary value problem

\[ \frac{\partial^2 u}{\partial t^2} = \frac{\partial^2 u}{\partial x^2} + 6x, \quad 0 < x < 2, \quad t > 0, \]

\[ u(0, t) = u(2, t) = 0, \quad t > 0 \]

\[ u(x, 0) = 0, \quad \frac{\partial u(x, 0)}{\partial t} = 0, \quad 0 < x < 2 \]

to the separable form \( U(x, t) \) by using the substitution \( u(x, t) = U(x, t) + g(x) \)

**4(b)** Solve wave equation \( \frac{\partial^2 u}{\partial t^2} = 25 \frac{\partial^2 u}{\partial x^2} \) by separation of variables method subject to conditions:

\[ u(0, t) = u(L, t) = 0, \quad t > 0 \]

\[ u(x, 0) = \frac{1}{4} x(L - x), \quad \frac{\partial u(x, 0)}{\partial t} = 0, \quad 0 < x < L \]

END
2018-19
B.TECH. (AUTUMN SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
BIOLOGY FOR ENGINEERS
CHA-2020

Maximum Marks: 60 Credits: 03 Duration: Two Hours

Answer all the questions. Assume suitable data if missing.

Q.No. Question M.M.

1(a) Explain Lineweaver Burk plot with the help of a neat diagram. Symbols used should be suitably defined. [06] (CO1)

OR

1(a') List down and explain important characteristics and practical significance of major groups of microorganisms. [CO1]

1(b) Production of single cell protein from hexadecane is described by the following reaction equation:

\[ C_{16}H_{34} + aO_2 + bNH_3 \rightarrow cCH_{1.66}O_{0.27}N_{0.20} + dCO_2 + eH_2O \]

Where \( CH_{1.66}O_{0.27}N_{0.20} \) represents the biomass. If Respiratory Quotient, \( RQ = \) your class serial number. Determine the stoichiometric coefficients. [09] (CO1)

2(a) Write down the salient features of Amino Acids. [CO2]

OR

2(a') What is the scope of biochemistry in the field of Genetic Engineering? [CO2]

2(b) Fill in the blanks.

i) Auto oxidation of fats are known as .................

ii) Cephalins are the .............. of glycerol and fatty acids .

iii) Master molecule responsible for heredity is .................

iv) .................. protein carries iron in the plasma of blood?

v) .................. fats act as an insulator against loss of heat. [CO2]

cont'd .... 2.
2(c) Differentiate any two of the following:
   1. Homopolysaccharides and Heteropolysaccharides
   2. Essential Amino acids and Non essential Amino acids
   3. Simple proteins and Conjugated Proteins

3(a) With the help of a neat flow diagram describe the recombinant DNA technology. (CO3)

3(b) What are Genetically modified organisms? Explain in detail and write their applications also. (CO3)

3(b') What is transcription? Write the steps involved in the process of transcription. (CO3)

4(a) Describe in detail the industrial production of Vinegar with the help of a process flow diagram. Also mention various unit operations and processes used. (CO4)

4(b) Write the applications of Effective microorganisms in agriculture? (CO4)

4(b') Discuss the importance of biotechnology in the field of chemical industry. (CO4)

END
1(a) A slug is the mass of an object that will accelerate at a rate of 1 ft/s² when subjected to a force of 1 lb. Determine the conversion factor to convert slug into kg.

1(b) Barite mineral (BaSO₄) is processed by heat fusion with soda ash (Na₂CO₃) followed by leaching with water to produce BaCO₃. The overall reaction is:

\[ \text{Na}_2\text{CO}_3 + \text{BaSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{BaCO}_3 \]

Mol. wt: 106 233 142 197

The analysis shows the weight percent as: solid residue, 33.6% BaSO₄ and 66.4% BaCO₃; and soluble salts, 58.1% Na₂SO₄ and 41.9% Na₂CO₃. For the process, calculate:

(i) The composition of the mix before fusion
(ii) The percent excess reactant
(iii) The degree of completion

OR

1'(a) Two mercury manometers, one open-end and the other sealed-end, are attached to an air duct. The reading on the open-end manometer is 25 mm Hg and that on the sealed-end manometer is 800 mm Hg. Determine the absolute pressure in the duct, the gauge pressure in the duct, and the atmospheric pressure, all in mm Hg.

1'(b) A gas contains 10 mol% CO₂, 40 mol% CH₄, and 50 mol% C₂H₄. It is desired to distribute 14.2 kg of this gas per cylinder. Cylinders are to be designed so that the maximum pressure will not exceed 150 atm absolute when the temperature is 80 °C. Calculate the volume of the cylinder required by Kay’s method. The critical pressure and temperature and molecular weight of the gases are given in the following table.
<table>
<thead>
<tr>
<th>Gas</th>
<th>$T_c$ [K]</th>
<th>$P_c$ [atm]</th>
<th>$M$ [kg/kmol]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO$_2$</td>
<td>304.2</td>
<td>72.9</td>
<td>44.01</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>190.7</td>
<td>45.8</td>
<td>16.04</td>
</tr>
<tr>
<td>C$_2$H$_4$</td>
<td>283.1</td>
<td>50.5</td>
<td>28.05</td>
</tr>
</tbody>
</table>

Obtain the compressibility factor from figure given below

**Generalized compressibility chart at moderate pressure**

2(a) Define a batch, a semi batch, and a continuous process. Write down the form of material balance for these processes.

2(b) An evaporator is fed continuously with 40000 kg/h of a solution containing 12% NaOH, 12% NaCl, and 76% water by weight. During the evaporation, water is boiled off and NaCl precipitated as crystal and removed from the remaining liquor. The concentrated liquor leaving the evaporator contains 50% NaOH, 1% NaCl, and 49% water. Calculate the rate of water evaporated, rate of NaCl precipitated, and rate of concentrated liquor produced in kg/h.

OR

2 (b') A hydrocarbon gas is burned with air. The dry-basis product gas composition is 1.5 mole% CO, 6.0% CO$_2$, 8.20% O$_2$, and 64.3% N$_2$. There is no atomic oxygen in the fuel. Calculate the ratio of hydrogen to carbon in the fuel gas and speculate what the fuel might be. Also calculate the percent excess air fed to the reactor.

contd...
3(a) What are the different forms of energy that are possessed by the system and that is transferred through the system boundaries? Give a brief description.

OR

3(a') Air is being compressed from 2 atm and 460 °R (enthalpy 210.5 Btu/lbm) to 10 atm and 500 °R (enthalpy 219 Btu/lbm). The exit velocity of air is 200 ft/s. What is the horse power required for thr compressor if the load is 200 lbm air/h.

[Given: 1 Btu = 778 ft·lb, 1 HP = 2545 Btu/h]

3(b) Trichloroethylene, a widely used degreasing solvent for machine parts, is produced in a two-step reaction sequence:

\[ \text{C}_2\text{H}_4 (g) + 2\text{Cl}_2 (g) \rightarrow \text{C}_2\text{H}_2\text{Cl}_4 (l) + \text{H}_2 (g); \quad \Delta \text{H}^\circ = -326.2 \text{ kJ/mol} \]

\[ \text{C}_2\text{H}_2\text{Cl}_4 (l) \rightarrow \text{C}_2\text{HCl}_3 (l) + \text{HCl (g)} \]

The standard heat of formation of liquid trichloroethylene, ethylene, and hydrogen chloride gas are \(-276.2 \text{ kJ/mol}, 52.28 \text{ kJ/mol}, \) and \(-92.31 \text{ kJ/mol} \) respectively. Using Hess’s law, calculate the standard heat of formation of tetrachloroethane and the standard heat of reaction of second reaction and the reaction

\[ \text{C}_2\text{H}_4 (g) + 2\text{Cl}_2 (g) \rightarrow \text{C}_2\text{HCl}_3 (l) + \text{H}_2 (g) + \text{HCl (g)} \]

4(a) 150 kmol of an aqueous solution of phosphoric acid contains 5.0 mole% H₃PO₄. The solution is concentrated by adding pure phosphoric acid at a rate of 20.0 L/min.

(i) Write differential mole balance on phosphoric acid and provide the initial condition.

(ii) Solve the balance to obtain an expression for the number of moles of phosphoric acid. Use the result to derive an expression for the mole fraction of phosphoric acid in the solution. How long will it take to concentrate the solution to 15.0 mole% H₃PO₄?

4(b) A stream of air at 30 °C and 10% relative humidity is humidified in an adiabatic spray tower operating at a pressure 1 atm. The emerging air has a relative humidity of 40%.

(i) Determine the absolute humidity and the wet bulb temperature of the entering air.

(ii) Use the psychrometric chart to calculate the rate at which water must be added to humidify 1000 kg/h of the entering air and the temperature of the exiting air.

[3697/3694]
Psychrometric Chart, Ref: H2O (I, 0 °C, 1atm); Dry Air (0 °C, 1atm)
2018-19
B.TECH AUTUMN (III SEMESTER) EXAMINATION
CHEMICAL/PETROCHEMICAL ENGINEERING
FLUID MECHANICS
CHC-2030/PKC-2050/CH-213/PK-232

Maximum Marks: 60
Credits: 04
Duration: Two Hours

Answer all the questions.
Assume suitable data if missing.
Notations used have their usual meaning.

1(a) Define Newton's law of viscosity and discuss detail classification of fluid based on their rheological behaviour.

1(b) State and explain briefly the two axioms of rheology.

1(c) A large storage tank contains oil having a density of 917 kg/m³. The tank is 3.66 m tall and is vented to the atmosphere of 1 atm absolute at the top. The tank is filled with oil to a depth of 3.05 m and also contains 0.61 m of water in the bottom of tank. Calculate the pressure in Pascal 3.05 m from the top of the tank and at the bottom. Also calculate the gauge pressure at the tank bottom.

1(c') A closed tank A is filled with carbon tetrachloride having specific gravity 2.25 and has a small air space at its top as shown in Figure 1. A manometer is connected between the tank A and a water tank. If the pressure at point B in the water tank is 1.2 kg/cm², find the pressure in kN/m² in the closed air space at the top of tank A.

Figure 1
2(a) Identify the following problems as true and false with reasons:
   (i) One dimensional flow can take place in a curved passage. [CO2] [05]
   (ii) Local acceleration is zero in steady flow.
   (iii) A boundary layer may exist near a solid boundary only.
   (iv) Euler’s equation of motion is applicable for viscous flow.
   (v) Stream function is defined when the flow is continuous.

2(b) A pipeline carrying oil of specific gravity 0.8 changes in diameter from 300 mm at a
position A to 500 mm diameter to a position B which is 5 m at a higher level. If the
pressures at A and B are 19.62 N/cm² and 14.91 N/cm² respectively and discharge is
150 litres/s, determine the loss of head and direction of flow? [CO2] [10]

OR

2'(a) Derive differential linear momentum balance equation and simplify it to obtain
     Navier’s stokes equation. [CO2] [10]

2'(b) A flow field is characterised by \( \Psi = x^3y \). Determine the velocity potential \( \phi \) for the
     flow if the flow is irrotational. [CO2] [05]

3(a) State Buckingham’s Pi theorem. Why this theorem is considered superior over the
     Rayleigh’s method for dimensional analysis? [CO3] [06]

OR

3(a') Define and write the significance of the following dimensionless numbers:
     (i) Reynolds number    (ii) Euler’s number    (iii) Mach number [CO3]

3(b) The pressure drop in an aeroplane model of size 1/40 of its prototype is 80 N/cm².
     The model is tested in water. Find the corresponding pressure drop in the prototype.
     Take density of air=1.24 kg/m³, viscosity of water =0.01 poise and viscosity of
     air=0.00018 poise. [CO3] [09]

4(a) Write a short note on any two of the following:
     (i) Pipes and tubing used in chemical industry.
     (ii) Rotameter and Orificemeter
     (iii) Characteristics of Centrifugal pumps [CO4]

4(b) A vertical venturimeter has an area ratio of 5 and has a throat diameter of 10 cm.
     When oil of specific gravity 0.8 flows through it, the mercury in the differential
gauge indicates a difference in height of 12 cm. Find the discharge through the
     venturimeter. Take \( C_d=0.98 \) [CO4] [09]
2018-19
B. TECH. (AUTUMN SEMESTER) EXAMINATION
PETROCHEMICAL/CHEMICAL ENGINEERING
FLUID- PARTICLE OPERATIONS
PKC-2090/PK-233/CHC-2040/CH-214

Maximum Marks: 60  Credits: 04  Duration: Two Hours

Answer all questions.
Assume suitable data if missing.
Notations and symbols used have their usual meaning.
Use of Graph paper is allowed.

Q.No.  Question  CO  M.M.
1(a) Comment TRUE or FALSE on the following statements and justify your answer:

(i) Sphericity of cube = 0.806.
(ii) In the case of separation of mixture of finer particles, dry-sieving is more accurate than wet-sieving.
(iii) In solid particle separation, “Effectiveness of a screen” is maximum means recovery is more and rejection is less.
(iv) Solid mass stored in a bin and if K (coefficient of flow ability) > 1 then side-discharge of solid should be preferred.

1(b) Derive the Janssen’s equation for the hold up pressure of the solid mass on the floor of the storage bin. Prove that once the hold up of solid is very large in a Bin, the further addition of solids will not materially change the total pressure on the bin floor.

OR

1(b’) Differentiate between Idlers and Take-ups in belt conveyor. Explain the mechanism of working of flight conveyors with proper diagram.

2(a) Answer the following:

(i) Differentiate between free-crushing and choke-crushing

contd... 2.
(ii) Statement: ‘A ball mill should always be operated below critical speed’. Is this statement TRUE or False (justify your answer)?

(iii) Briefly describe the Kicks’ law of crushing.

2(b) According to the Bond’s Law, the power required to crush 100 ton/h of a material is 179.8 KW when 80% of the feed passes through a 51 mm screen and 80% of the product passes through a 3.2 mm screen. Calculate the power required for the same feed at 100 ton/h to be crushed to a product such that 80% is to pass through a 1.6 mm screen.

2(c) With the help of proper sketches of Hammer-mills and Impactors, discuss the differences in their operation and applications.

OR

2(c') Explain the working of “Fluid Energy Mills” with proper sketch.

3(a) Answer any TWO:

(i) Statement: ‘Hindered settling velocity is more than the free settling velocity’. Is this statement TRUE or False (justify your answer)?

(ii) Differentiate between radial-flow and axial-flow impellers.

(iii) Briefly describe the working of Elutriators.

3(b) In the classification of spherical particles of different sizes, derive the “equal-falling” criteria for laminar and turbulent flow zone.

OR

3(b') Calculate the maximum velocity at which silica particles of 0.04 mm diameter (sp. gravity = 2.65) fall through still water (viscosity = 0.001 kg/ms) that fills a 50 mm ID glass cylinder, if the slurry is so dilute that free settling prevails [Hint: Wall effect].

3(c) A three-bladed marine propeller (pitch = 2.0) is used to agitate a solution of specific gravity 1.3 and viscosity 12.5 centipoise in an unbaffled tank of 1.0 m diameter and 1.5 m deep. The tank is filled to a depth of 1.0 m with the...
solution and the impeller (diameter = 0.3Dv) is set at one impeller diameter above the vessel floor. Estimate the speed of the impeller if the power consumed to drive it is 0.34 kW. [Given: \( K_L = 43.5 \), \( K_T = 0.9 \)]

4(a) Answer any **TWO**: (CO4) [05]

(i) Write the expression for Froude Number and its criterion for fluidization classification.

(ii) Calculate the length of bed when bed is under fluidization (given: length of static bed = 1 m, void fraction of static bed = 0.2, void fraction of fluidized bed = 0.3).

(iii) Describe the ‘Slugging’ behaviour of fluidized column.

4(b) Derive the standard form of *Ergun’s equation* for the pressure drop across the bed when fluid is passing through packed bed or porous media. (CO4) [10]

OR

4(b') A plate and frame press (filter) of 1.2 m\(^2\) filtering area handling a homogeneous slurry containing 10% (by weight) of solids (specific gravity = 2.33) in water gave the following results:

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>10</th>
<th>30</th>
<th>60</th>
<th>110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of filtrate (m(^3))</td>
<td>80</td>
<td>115</td>
<td>152</td>
<td>200</td>
</tr>
</tbody>
</table>

Test shows that the following relation is valid for the present case (for \( t_f > 0 \)): \( V_f^2 = K_1 t_f + K_2 \)

where, \( V_f \) is the volume of filtrate (m\(^3\)) delivered in filtering time \( t_f \) hours and \( K_1 \) and \( K_2 \) are constants.

The cake is washed with water at a constant rate of one-third of final rate of filtration. The volume of wash water used is equal to one-twelfth of the volume of filtrate delivered per cycle. Opening, closing and reassembling take 45 minutes. Determine the optimum cycle time that will produce maximum daily output of filtrate.