B.TECH. AUTUMN (VII SEMESTER) EXAMINATION
(Chemical Engineering)
Energy Engineering and Management
(CH-410)

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.

Q.No. Question M.M.
1(a) What is the difference between a 'caking coal' and a 'cooking coal'. [02]
1(b) Compare low and high temperature carbonization of coal. [04]

OR

1(b') With the help of a neat flow diagram, describe the Bergius process for hydrogenation of coal in the presence of a catalyst. [04]

1(c) Draw the flow chart of continuous formed coke production. Also briefly describe the five stages in its production. [05]

OR

1(c') The following data refers to an experimental determination of the calorific value of a sample of fuel oil containing 14% of hydrogen:
Specific gravity of fuel oil = 0.845
Mass of water in calorimeter = 2 kg
Water equivalent of calorimeter = 600 gm
Mass of sample of fuel oil = 1 gm
Temperature of water in calorimeter before combustion = 19.5°C
Temperature of water in calorimeter after combustion = 23.75°C
Find the higher and lower calorific values of fuel oil. Take specific heat of water as 4.187 kJ/kg K and enthalpy of evaporation of steam as 2,275 kJ/kg at atmospheric pressure. [05]

1(d) Find out the efficiency of a coal fired boiler by direct method with the data given below: (a) quantity of steam (dry) generated = 8 Tons per hour, Steam pressure
(gauge) / temp = 10 kg/cm²(g) / 180°C, Quantity of coal consumed = 1.8 Tons per hour, Feed water temperature = 85°C, GCV of coal = 3,200 kcal/kg, Enthalpy of steam at 10 kg/cm² pressure = 665 kcal/kg (saturated), Enthalpy of feed water = 85 kcal/kg.

2(a) Calculate the following parameters of a biogas system.
   i) The volume of biogas digester,
   ii) The power available from digester in watts.

Given: Number of cows = 8, Retention period = 20 days, Temperature for fermentation = 30°C, Dry matter consumed per cow per day = 2 kg, Burner efficiency = 0.7 and Methane proportion = 0.7.

OR

2(a') Discuss the chemical reaction mechanism involved during biomass gasification process.

2(b) Mention briefly about two emerging technologies in hydrogen production.

2(c) With the help of a neat diagram describe the reaction mechanism in an Alkaline Fuel Cell and a Molten Carbonate Fuel Cell.

OR

2(c') A fuel cell car draws 30 kW of power at 60 kilometers per hour and is 40% efficient at rated power. (It converts 40% of the energy stored in the hydrogen fuel to electric power). Estimate the size the fuel cell system so that the car can go at least 300 kilometers at 60 kilometers per hour before refueling. Calculate the minimum volume and weight requirements for the fuel cell system (fuel cell and fuel tank) given the following information: i) Fuel cell power density: 1 kW/litres. and ii) Fuel tank energy density (compressed hydrogen): 4 MJ/litres.

2(d) With the help of a neat diagram describe the working principle of a lead acid battery along with the reaction mechanism.

3(a) Differentiate between ‘Solar Constant’ and ‘Solar Insolation’.

cont'd
3(b) What is the energy conversion efficiency of a 175-watt solar panel that measures 0.75 x 1.50 metres, if the solar insolation is 1,000 W/m²?.

3(c) With the help of a neat flow diagram briefly describe the working principle of a single basin solar still. Mention formula used to calculate the total solar still area.

3(d) With the help of a neat flow diagram briefly describe the nuclear fuel cycle.

OR

3(d') The fission of each U²³⁵ atom generates 200 MeV of energy. Calculate
(a) The total energy generated (express in Joules, kWhr and MW days) from fission of 1 kg of U²³⁵ if 1 MeV = 1.6021 x 10⁻¹³ J.

(b) Equivalent weight of Carbon or Coal of Calorific Value 30 MJ/kg required to give same energy as one kg of U²³⁵.

(c) Mass of U²³⁵ and enriched uranium (containing 3% U²³⁵) required per day and per year for a 500 MW nuclear reactor.

4(a) Describe any two energy audit methodologies:
   i) Walk through Energy Audit
   ii) Preliminary Energy Audit
   iii) Detailed Energy Audit

4(b) List four devices and the parameters monitored by each of them in an energy monitoring of a facility.

4(c) Briefly describe the four salient features of 'Energy Conservation Act, 2001'.

4(d) Briefly describe five key energy efficiency improvement/energy conservation opportunities in a specific industry or factory.
B.TECH. (AUTUMN SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
PROCESS DYNAMICS AND CONTROL
CH -411
Maximum Marks: 60 Credits: 04 Duration: Three Hours

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

1(a) The laplace transform of output variable is given by:

\[ \bar{y}(s) = \frac{s+1}{s^2-2s+5} \]

Derive the dynamic response y(t) of the system.

1(b) Discuss the role of digital computer in process industry.

OR

1'(a) Explain the terms MIMO and SISO with suitable examples.

1'(b) Linearize the following nonlinear dynamic model, stating the reason for nonlinearity.

\[ \frac{dy}{dt} = \frac{1-y}{y} m + y m^2 + \sin(\alpha m) \]

Here y and m are output and manipulated variable and \( \alpha \) is a constant term.

2 Derive the dynamic models and transfer functions of the following first order processes with clearly elaborating the assumptions made if any.

- CSTR with first order reaction
- Single effect evaporator
- Mercury thermometer

OR

2' A first order process with gain and time constant of 2 and 0.3 minutes respectively is subjected to sinusoidal input with amplitude of 0.03 m³/min about a mean flow
rate of 0.3 m$^3$/min. The frequency of input sine wave is 4 cycles/min. Derive the expression to determine the response. Tabulate the temperature versus time data.

3. Draw the root locus of the closed loop system with transfer functions given below:

\[ G_p(s) = \frac{2}{s - 4}, \quad G_c(s) = K_c \left(1 + \frac{1}{s}\right), \quad G_m(s) = G_f(s) = 1 \]

4(a) Write the discretized form of the model equations of following controller:
- Proportional
- PID

4(b) Write in brief about sampler and hold element with reference to digital control.

4(c) For a specified voltage range of -10 V to +10 V, find the resolution range of 12-bit and 8-bit A/D converter. What is possible conversion error in volts.
Maximum Marks: 60               Credits: 04               Duration: Three Hours

Answer all the questions.

<table>
<thead>
<tr>
<th>Q.No.</th>
<th>Question</th>
<th>M.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>Explain in detail the experimental method for the determination of calorific value of a solid fuel.</td>
<td>[06]</td>
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<tr>
<td></td>
<td><strong>OR</strong></td>
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<tr>
<td>1(a')</td>
<td>Describe the proximate and ultimate analysis of coal.</td>
<td>[06]</td>
</tr>
<tr>
<td>1(b)</td>
<td>Give the classification of coal by Rank.</td>
<td>[03]</td>
</tr>
<tr>
<td>1(c)</td>
<td>Write in brief the environmental problems associated with coal.</td>
<td>[03]</td>
</tr>
<tr>
<td></td>
<td><strong>OR</strong></td>
<td></td>
</tr>
<tr>
<td>1(c')</td>
<td>Discuss the demerits of renewable energy sources.</td>
<td>[03]</td>
</tr>
<tr>
<td>2(a)</td>
<td>Discuss the commonly used burners used in chemical and allied industries.</td>
<td>[04]</td>
</tr>
<tr>
<td>2(b)</td>
<td>Write short notes on any two of the following:</td>
<td>[08]</td>
</tr>
<tr>
<td></td>
<td>(i) Coal gas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) Blast furnace gas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) Water gas</td>
<td></td>
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<tr>
<td></td>
<td>(iv) Producer gas</td>
<td></td>
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<tr>
<td>3.</td>
<td>Explain any three of the following:</td>
<td>[12]</td>
</tr>
<tr>
<td></td>
<td>(i) Factors affecting biogas generation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) Floating head biogas digester.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) Fixed dome biogas digester.</td>
<td></td>
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<tr>
<td></td>
<td>(iv) Types of biomass.</td>
<td></td>
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<td></td>
<td>(v) Biomass conversion options.</td>
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</tr>
</tbody>
</table>
4(a) What are the various methods for collection of solar energy? Describe any one of them.

OR

4(a') Define any three of the following terms: (i) Zenith angle, (ii) Solar constant, (iii) Air mass, (iv) Declination angle, (v) Surface Azimuth angle, (vi) Hour Angle.

4(b) List the basic components of a liquid flat plate collector.

4(c) Describe the working principle of a Solar Pond.

5(a) Discuss possible approaches for energy conservation in a process industry. Are there any practical limitations in achieving these goals? If so discuss them briefly.

5(b) List various devices for energy recovery in process industry. Explain the salient features and use of one such device.

OR

5(b') Discuss in detail the energy conservation options in nitrogenous fertilizers industry or steel industry?
### Question 1(a)

For the production of soap, the following reactions are carried out in hydrolyzer and mixer-neutralizer respectively.

1. \((C_{17}H_{35}COO)_{3}C_{3}H_{5} + 3H_{2}O\rightarrow 3C_{17}H_{35}COOH + C_{3}H_{5}(OH))_{3}\)
   - Glyceryl acetate
   - Stearic acid
   - Glycerine

2. \(C_{17}H_{35}COOH + NaOH \rightarrow C_{17}H_{35}COONa + H_{2}O\)
   - Stearic acid
   - Sodium stearate (soap)

If glyceryl stearate costs Rs. 45.5/kg and caustic soda Rs. 90.7/kg and if byproduct Glycerine can be sold for Rs. 190.9/kg. What is the lower bound on the sales price of sodium stearate soap?

### Question 1(b)

What reactor configuration would you use to maximize the selectivity in the following mixed parallel and series reaction system:

- **FEED \rightarrow PRODUCT**
  
  \[ r_1 = k_1 C_1^{a_1} \text{FEED} \]

- **FEED \rightarrow BYPRODUCT**
  
  \[ r_2 = k_2 C_1^{a_2} \text{FEED} \]

- **PRODUCT \rightarrow BYPRODUCT**
  
  \[ r_3 = k_3 C_1^{a_3} \text{PRODUCT} \]

### Question 2(a)

Explain with the help of diagrams, various options for recycle structure, when

1. Feed contains an impurity
2. There is a byproduct formation.

Contd....2.
2(b) During manufacture of ethylene and propylene, streams to be separated consists of the following species:

<table>
<thead>
<tr>
<th>Species</th>
<th>b.p. (°C)</th>
<th>composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
<td>-253</td>
<td>18</td>
</tr>
<tr>
<td>CH₄</td>
<td>-161</td>
<td>15</td>
</tr>
<tr>
<td>C₂H₄</td>
<td>-104</td>
<td>24</td>
</tr>
<tr>
<td>C₂H₆</td>
<td>-88</td>
<td>15</td>
</tr>
<tr>
<td>C₃H₆</td>
<td>-48</td>
<td>14</td>
</tr>
<tr>
<td>C₃H₈</td>
<td>-42</td>
<td>06</td>
</tr>
<tr>
<td>Heavies</td>
<td>-1</td>
<td>08</td>
</tr>
</tbody>
</table>

Which distillation sequence will lead to most economic separation. Justify your selection.

OR

2′

Synthesize a heat integration network for the following four process streams existing in a chemical plant.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Tin (°C)</th>
<th>Tout (°C)</th>
<th>M(kg/hr)</th>
<th>Cₚ(Kcal/kg °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>60</td>
<td>160</td>
<td>9350</td>
<td>2.9</td>
</tr>
<tr>
<td>B</td>
<td>160</td>
<td>95</td>
<td>12620</td>
<td>2.5</td>
</tr>
<tr>
<td>C</td>
<td>115</td>
<td>260</td>
<td>10530</td>
<td>2.1</td>
</tr>
<tr>
<td>D</td>
<td>250</td>
<td>140</td>
<td>11350</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Steam utility is available at 120 °C, 175 °C, and 285 °C. Cooling water is available at 25 °C and brine is available at -1 °C.

3(a) Select the design variables using persistent recycle technique for design relations shown below in the form of the following structural array. Also give the precedence order of the calculation.
3(b) Find out the degrees of freedom of mixer, and partial condenser with specification of variables having \( n \) components.

OR

3' For the following process material flow diagram determine the economic degrees of freedom for the whole system.
4(a) Differentiate between the steady state and process flow sheets for chemical process plants.

4(b) Discuss in brief the use of scaling factor with respect to the flow sheet calculations.

4(c) Which factors should be considered while preparing the plant layout.

4(d) Discuss in brief the several means of disposal for solid waste from chemical industries.
2015-16
B.TECH. (WINTER SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
PROCESS INSTRUMENTATION
CH-423

Maximum Marks: 60
Credits: 04
Duration: Three Hours

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

Q.No.  Question  M.M.
1(a)  List and explain the static characteristics of instruments.  [10]
1(b)  With the help of the general differential equation describing the response of a second order measuring instrument, explain the meaning of the following terms: damping ratio, un-damped natural frequency and gain/static sensitivity.
Sketch the step response for the said instrument for the under-damped, critically damped and over-damped cases.  [05]

2(a)  Give five classes of sensing elements and the principles on which they operate. Also, give two examples from each class.  [05]

OR

2(a')  Describe with the help of a neat sketch, the roles of the various elements of a measurement system for controlling a process variable.  [05]

2(b)  Show with a neat diagram, how lead compensation is used in a bridge circuit to avoid errors from lead resistance when the sensor is located remotely.  [05]

OR

2(b')  Why is a current balance bridge preferred over a Wheatstone bridge with a high impedance detector? Explain with an appropriate circuit diagram and relevant equations, the working of a current balance bridge.  [05]
2 (c) Mention the function of a DAC. Furnish the expressions for the output voltage of a unipolar DAC and bipolar DAC. What is meant by the conversion resolution of a DAC? Determine how many bits a DAC must be provided with for output increments of 0.04 or less. The reference voltage being 9 V.

OR

2(c') Give the significance of an ADC in process industries. How does a bipolar ADC differ from a unipolar ADC? What are the hex and binary output of a bipolar 8-bit ADC with a 6V reference for inputs of -0.80V to +1.6V? What input voltage would cause an output of 72H?

3(a) Explain the application of the law of intermediate temperatures for the correction of non-zero reference junction temperature of a thermocouple.

OR

3(a') Describe the procedure to find the Viscosity Index of lubricating oil.

3(b) i) List the various classes of instruments for the measurement of pressure.
   ii) Explain in detail the working of the Pirani gauge for the measurement of vacuum.

OR

3(b') i) Give the various classes of instruments for the measurement of pressure.
   ii) What are the important considerations in the protection and manufacture of thermocouples?
   iii) Explain the working of radiation pyrometer.

4(a) Draw the standard symbols for the following elements of a P&ID:
Electric signal, pneumatic signal, capillary tube, standalone instrument at field location, shared display or control inaccessible to operator, PLC accessible to operator, pneumatic actuator, heat exchanger, solenoid actuator and first letter

4(b) Classify the methods for spectroscopic analysis. Describe with the help of a neat diagram, the working of a mass spectrometer.
2015-16
B.TECH. (AUTUMN SEMESTER) EXAMINATION
CHEMICAL ENGINEERING
PETROLEUM PROCESSING
CH-442 (DE)

Maximum Marks: 60
Credits: 04
Duration: Three Hours

Answer all the questions.

Q.No.          Question                                                                                   M.M.
1           Answer the following questions briefly.                                                    2
(i) Give the elemental composition of petroleum?                                                   1
(ii) Determine the class of crude oil whose specific gravity values for Key Fractions I and II are 0.59 and 0.84.
(iii) Mention two methods of exploration and two methods of drilling of crude oil.                2
(iv) List two environmental problems associated with refineries.                                  1
(v) Give two quality issues pertaining to diesel fuels that are currently of importance.          1
(vi) Define and give the significance of the following (in brief): sensitivity of gasoline, aniline point, cetane number and smoke point. 8

2           Write notes on any three of the following:                                                    15
(i) Desalting of crude oil.                                                                      3
(ii) Working of a tube still heater.                                                              3
(iii) Types of vacuum distillation column based on different process objectives.                 3
(iv) Merox sweetening process                                                                       3
(v) Sulfur recovery in a refinery.                                                                3
(vi) Refluxing schemes for an ADU.                                                                3

3(a) Answer any three of the following:                                                              9

Contd.....2.
i. Fuel oil instability

ii. Flow sheet of a thermal cracking process to maximize gas oil production.

iii. The effect of independent process variables in Delayed Coking.

iv. Flow sheet for the FCC process.

v. Dual function catalyst in catalytic reforming

vi. Reactions in catalytic reforming.

3(b) Describe the reaction mechanism of either thermal cracking or catalytic cracking.

4(a) List five desirable properties of a lube oil base stock. Describe in brief the processes in the conventional technology for the production of lube oil base stocks.

4(b) Describe with the help of a neat flow sheet a process for the utilization of isobutane and low molecular weight olefins to a higher value product.
Answer all the questions.

Q.No.                  Question                        M.M.  
1    Answer any five of the following questions briefly. (03x5=15)  
      (i) Describe briefly the composition of non-hydrocarbons in petroleum?  
      (ii) Explain the knocking tendency of gasoline?  
      (iii) Explain the procedure for the TBP distillation of light distillates.  
      (iv) Describe briefly, the US Bureau of Mines method for the classification of crude oils.  
      (v) Write a note on crude oil assay.  
      (vi) Explain the working of a compression ignition engine?  
2(a)    Why is vacuum employed in the distillation of crude oil? Explain with the help of a neat flow sheet, the working of a VDU in a modern refinery. [10]  

OR

(a')    List any five processes for removing the impurities in crude oil. What is meant by 'sweetening' in a refinery? Discuss with the help of a neat flow sheet, the Merox extraction process for a kerosine.  
2(b)    Write a note on any one of the following: [05]  
      a) Sulfur recovery in a refinery  
      b) Electric desalting process  
3(a)    Describe with a neat flow sheet the process of visbreaking. [10]  

OR
(a') What are the feedstocks for hydrocracking? Discuss the Isomax process for hydrocracking.

3(b) Answer any one of the following questions.

(i) Discuss the reaction mechanism of catalytic cracking.

(ii) Independent variables in delayed coking.

4(a) What are the lights ends management processes in a refinery? Explain one such process that uses light naphtha as a feedstock in a refinery.

4(b) List the important undesirable properties that lube oil base stocks may possess and mention the treatment processes for them.