Q.No. Question M.M. 
1(a). Differentiate the Actual vapour-compression refrigeration cycle from the Ideal vapour-compression cycle using T-S diagram. [06] [CO-1] 

OR 
1(a'). Differentiate the distillate and residual fuel oils as per ASTM D396. Discuss the various factors affecting selection of burners for fuel oil combustion. [06] [CO-1] 

1(b). Describe a vapour-compression refrigeration cycle as shown below in which Refrigerant 134a circulates at a rate of 6 kg/min. If the isentropic compressor efficiency of the cycle is 67% then determine 

(i) the coefficient of performance 
(ii) the refrigerant capacity, in tons 

[Assumption: There are no appreciable pressure drops as the refrigerant flows through the condenser and evaporator and ignore heat transfer between the compressor and surroundings. Given: \( h_1 = 243.4 \); \( h_{2a} = 278.06 \); \( h_3 = 82.9 \); \( s_1 = 0.9606 \); and \( s_3 = 0.3113 \); All values of \( h \) in kJ/kg and \( s \) in kJ/kg.K] 

1(e). Answer the following: 
(i) Effect of high carbon-to-hydrogen ratio on calorific value of fuel oil. [04] [CO-1]
(ii) Importance of pour point of fuel oil.

(iii) Low pressure with large orifice means ______ FN (flow number) which results ______ drop sizes of fuel oil.

(iv) Air is used to atomize the fuel oil (in addition to the burning of fuel) in ______ atomizer.

2(a). Classify different types of steam traps and explain the working of float-thermostatic steam trap.

2(b). Answer any ONE of the following:

(i) Describe the lime-soda process used for external treatment of boiler feed-water.

(ii) Discuss the importance of condensate recovery and flash steam recovery for the efficient generation of steam.

2(c). Mention the different systems/process in the refinery where waste-water generates. Discuss the “Zero liquid discharge (ZLD)” in the refinery.

3(a). Discuss the types of ‘Energy Savings by Management’ in detail.

OR

3(a') (i) What are the advantages and disadvantages if ‘Energy Management Program’ initiated/originated at the corporate level?

(ii) How the use of economizer can save the energy?

3(b). A five streams problem is given in the table. Draw hot and cold composite curves for ΔT_{min} = 20 °C. What are the values of (i) hot and cold pinch temperature (ii) hot utility, cold utility, and heat recovery amount from the process streams.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Supply Temperature T_s (°C)</th>
<th>Target Temperature T_t (°C)</th>
<th>CP (kW/°C)</th>
<th>ΔH (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot – 1</td>
<td>350</td>
<td>290</td>
<td>3.5</td>
<td>-210</td>
</tr>
<tr>
<td>Hot – 2</td>
<td>400</td>
<td>290</td>
<td>1.8</td>
<td>-198</td>
</tr>
<tr>
<td>Hot – 3</td>
<td>320</td>
<td>200</td>
<td>2.0</td>
<td>240</td>
</tr>
<tr>
<td>Cold – 1</td>
<td>150</td>
<td>350</td>
<td>2</td>
<td>400</td>
</tr>
<tr>
<td>Cold – 2</td>
<td>290</td>
<td>400</td>
<td>2.5</td>
<td>275</td>
</tr>
</tbody>
</table>

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Also, discuss the effect of $\Delta T_{\text{min}}$ on the energy costs and capital costs.

4(a). Discuss the working of any **TWO** of the following waste heat recovery equipments (with proper diagram). 
(i) Fluidized bed boiler
(ii) Thermo-compressor
(iii) Heat pipe

4(b). A large paper manufacturing company identifies an opportunity to save money by recovering heat from hot wastewater. The discharge of the wastewater from the operation range is 10000 kg/hr at 75 °C. Rather than discharging this water to drain, it was decided to preheat the 10000 kg/hr of cold inlet water having a yearly average temperature of 20 °C, by passing it through a counter flow heat exchanger with automatic back flushing to reduce fouling. Based on a heat recovery factor of 58% and an operation of 5000 hours per year, calculate the annual financial saving if cost of oil = 0.35 US$/litre (Gross calorific value of oil = 10.200 kCal/kg and specific gravity = 0.9 at 20 °C).

**OR**

4(b'). Tabulate the matrix of waste heat recovery equipments and their applications (Heat recovery equipments, Temperature range, Typical sources, and Typical uses).

4(c). Match column A to Column B

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>boiler feed water</td>
<td></td>
</tr>
<tr>
<td>preheat air entering the furnace</td>
<td></td>
</tr>
<tr>
<td>A3. Reverse of refrigeration</td>
<td>B3. Economizer</td>
</tr>
<tr>
<td>A4. Hot water/steam generation</td>
<td>B4. Recuperator</td>
</tr>
</tbody>
</table>
**Question**

1(a) Match the followings:

<table>
<thead>
<tr>
<th>Name</th>
<th>Photographs/ symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Differential Pressure Transducer (DPT)</td>
<td>A</td>
</tr>
<tr>
<td>2. Directional Control Valve</td>
<td>B</td>
</tr>
<tr>
<td>3. Diaphragm actuated control valve</td>
<td>C</td>
</tr>
<tr>
<td>4. Proximity Sensor</td>
<td>D</td>
</tr>
</tbody>
</table>

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

**M.M.** [9]
1(b) Describe the selection criteria and precautions that must be taken into account while installing a pressure transducer in a process line.

OR

1(b') What do you mean by primary and secondary variables? Give the name of few primary variables for which pressure may act as secondary variable. Explain the construction and working of capacitive pressure transducer with the help of a neat line diagram.

2(a). What do you mean by pH of a solution? If hydrogen ions concentration changes from 0.15 g/L to 0.0025 g/L, find out the change in pH. Also explain the contraction and working of sensing electrode in a pH meter.

2(b). A process flow diagram (PFD) for an evaporator and knock out drum is given in Figure-1. Draw and explain the P&I diagram (P&ID) for this.
2(b'). Draw the P&ID for the following control task that are needed for a reactor as shown in figure-2;
   i. Rate of catalyst feed to reactor.
   ii. Control of agitator.

Fig-2. Process Flow Diagram (PFD) of a reactor

3(a). What do you mean by control valve characterization? Differentiate between installed and inherent characteristics. How plug design is related with inherent characteristics of valve?

3(b). Explain the construction and working of **diaphragm actuated double ported sliding stem globe valve** with the help of neat and clean cross-sectional diagram.

OR

3(b'). Draw the instrumentation & control symbols for followings;

4(a). What is the role of a PLC in modern instrumentation? What do you mean by modular PLCs?

4(b). What do you mean by SCADA? Why the Distributed control system (DCS) is preferred for large scale process plant? Explain with the help of neat line diagram.

OR

4(b'). Explain **any three** terms of the following;
B.TECH (WINTER SEMESTER) EXAMINATION
(PETROCHEMICAL ENGINEERING) (FERTILIZER TECHNOLOGY)
(PK-442A)
(CREDIT-04)

Max Marks: 60
Note: Answer all questions.
All question carry equal marks.

1. (a) Develop and describe the manufacture of Ammonium phosphate sulphate with the help of a process flow sheet with reference to chemical reactions involved and major engineering problems. 7+2
(b) Describe with the help of reaction(s) involved in the manufacture of nitrophosphate by carbonitrinc process. List the major engineering problem(s) encountered in the process. 4
(c) List the key process features in the manufacture of potassium nitrate. 2
(c) List the various types of Nitrogen and phosphorous bio fertilizers with at least two examples of each.

2. (a) List the major products of a fully developed phosphate industry in our country (India). 1.5
(b) Mention the various processes for the manufacture of phosphoric acid with reference to their merits and demerits. 3
(c) Describe the dry process for the manufacture of phosphoric acid or Mono calcium phosphate with the help of a process flow sheet and with special reference to environment sustainability and chemical reactions involved. 9
(d) Specify the material of construction for reaction tank, filter, air vent system and storage tank employed in the manufacture of phosphoric acid via wet process. 1.5

3. (a) Describe the manufacture of nitric acid (Ammonia oxidation process) with the help of a process flow sheet with reference to chemical reactions involved and operating to chemical reaction involved and operating conditions particularly the effect of pressure. 8
(b) Manufacture of Nitrolime or Ammonium Nitrate with the help of a process flow sheet with reference to major engineering problems encountered in the process. 6
(c) Why the use of ammonium chloride as fertilizer is limited? 1

4. (a) List the importance of Sulphur and magnesium in the fertilizer. 1
(b) What is generally the source of carbon and sulphur in a fertilizer? 1
(c) Describe the role of guard converter in the synthesis of ammonia with reference to chemical reactions involved. 2
(d) List the merit(s) and demerits of V₂O₅ vis-a-vis Pt catalyst in the manufacture of sulphuric acid. 2
(e) List the various processes available for the manufacture of synthetic ammonia with reference to pressure, temperature and conversion. 2
(f) Discuss the manufacture of Hydrogen from heavier hydrocarbons such as Fuel Oil. or Clauss process for the manufacture of sulphuric acid. or Synthetic ammonia employing low pressure process with chemical reaction(s) involved and major problems encountered in the process. 7
Max Marks: 60

Note: All questions carry equal marks. Answer all questions.

1(a) List the importance of sulfur and magnesium in the fertilizer. 01

(b) Mention the various types of Micro and Macro nutrients employed in the fertilizer and their sources. 04

(c) Explain why chamber process could not compete with the contact process. 01

(d) Though the pressure helps in the conversion of $\text{SO}_2$ to $\text{SO}_3$ yet its advantage is not taken in the manufacture of sulfuric acid. 01

(e) What is the significance of guard converter in the manufacture of synthetic ammonia. 01

(f) Describe with the help of a suitable process flow sheet the manufacture of either sulfuric acid from elemental sulfur or hydrogen employing the steam reforming process from Natural Gas with reference to catalyst, chemical reactions and operating conditions. 07

2(a) Develop a suitable process flow sheet for the manufacture of Ammonium sulfate from the Mersberg process with reference to chemical reactions involved and the operating conditions. 07

2(b) Describe with the help of a process flowsheet the manufacture of Urea or Nitric acid with reference to operating conditions, reactions involved and major engineering problems encountered in the process. 08

3(a) List the important types of phosphatic fertilizers produced in our country. 02

(b) Why the phosphatic rock available in our country is not being utilized generally? 01

(c) What are the various processes employed for making the phosphate rock of our country usable for phosphatic fertilizer. 02

(d) Though the chemical formula of super phosphate and triple super phosphate is same yet the content of $\text{P}_2\text{O}_5$ is three times in triple super phosphate over super phosphate. Explain it with reference to chemical reactions involved. 03

Contd......2
(e) Develop and describe the manufacture of phosphoric acid either by Dry process or by wet process with reference to chemical reactions involved, safety aspects and operating conditions.

4(a) List the key process features in the manufacture of potassium Nitrate.

(b) Explain the term Bio-fertilizer. What are the advantages and limitations of Bio-fertilizers?

(c) Name the various types of Nitrogen and phosphorous Bio-fertilizers with at least two examples of each and also the precautions involved in the application of Bio-fertilizers.

(d) Describe the process for manufacture of Nitrophosphates with reference to chemical reactions involved and merits and demerits over each other.

OR

(d') Describe the manufacture of diammonium phosphate with the help of chemical reactions, process flow sheet. What is the role of sulfuric acid in the manufacture of ammonium phosphate sulfate.

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