Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

Course: Chemical Eng I (Thermodynamics & Measuring A. Inst.) – HSFS2001 **Semester: III**
Programme: BTech (FSE)

Time: 03 hrs. **Max. Marks: 100**

Instructions:

(i) **All Questions in Section A are compulsory. Section B has 4 Questions with 1 question having internal choice. Section C has 2 questions with one question having internal choice.**

(ii) **Answer all the questions sequentially.**

SECTION A
(5Qx4M=20Marks)

S. No.		**Marks**	**CO**
Q 1	Define: a) Thermodynamic System b) Adiabatic System c) Isolated System d) Open System	**4**	**CO1**
Q2	True or False (a) As per 0^{th} Law of Thermodynamics – temperature is an extensive property of a thermodynamic system. (b) Degree of freedom of boiling pure water is one i.e. only one thermodynamic parameter is require to estimate all other thermodynamic parameters. (c) In an adiabatic process heat flows from a system to the surrounding. (d) A Isochoric process is the process where the volume of the system remains constant	**4**	**CO1**
Q3	In a combustion chamber, ethane (C_2H_6) is burned at a rate of 8 kg/h with air that enters the combustion chamber at a rate of 176 kg/h. Determine the percentage of excess air used during this process	**4**	**CO2**
Q4	Draw and label the T-*v* diagram for the heating process of water at constant pressure. Describe various segments of the curve in the diagram.	**4**	**CO1**
Q5	(a) What is the role of instrumentation and controllers in a process plant? (b) What is Offshoot in a controller? (c) Which controller is best suited for a process with frequent startups and shutdowns and why?	**1+1+2**	**CO4**

SECTION B
(4Qx10M= 40 Marks)

Q6	Define total derivatives and explain how they are used to derive Maxwell's relations that interrelate various thermodynamic properties.	**10**	**CO1**
Q7	Level sensing is used in a variety of industries to ensure that levels of stored fluid and even solids is maintained in a process as desired. Describe any two advanced methods used for level measurement (one in solids and other for fluids) and explain their application with the help of examples.	**10**	**CO5**

<table>
<tr><td>Q8</td><td>a) Explain inversion line, inversion temperature and maximum inversion temperature in context with Joule-Thompson coefficient. Which part of refrigeration cycle exploits Joule-Thompson effect and how?
b) A food department is kept at -12°C by a refrigerator in an environment at 30°C. The total heat gain to the food department is estimated to be 3300 kJ/h and the heat rejection in the condenser is 4800 kJ/h. Determine the power input to the compressor, in kW and the COP of the refrigerator.</td><td>5+5</td><td>CO3</td></tr>
<tr><td>Q9</td><td>Write Bernoulli’s equation and derive the expression for velocity of fluid flowing out from the bottom of water tank filled to a height of h meters. Explain all the assumptions made in the derivation.

OR

What is the purpose of flow measurement? Discuss the advantage and disadvantage of using various flow measurement devices viz a viz orifice meter, venturi and nozzle.</td><td>10</td><td>CO5</td></tr>
<tr><td colspan="3">SECTION-C
(2Qx20M=40 Marks)</td></tr>
<tr><td>Q10</td><td>(a) What is the difference between instrument and machine?
(b) List the advantage of instrumental methods of chemical analysis over the classical methods.
(c) What is Beer-Lambert law and what are its limitations?</td><td>20</td><td>CO5</td></tr>
<tr><td>Q11</td><td>Knowing kinetics of a chemical reaction enhances our understanding of the heating and cooling requirements for a chemical reactor. It also enables a fire safety engineer to estimate hazards associated with runaway reactions.
i) What are the various methods used for the determination of rate equations?
ii) Using the initial rate and chemical data given in the table below. Determine a) rate equation and b) the rate constant.
$5Cl^-(aq) + ClO_3^-(aq) + 6H^+(aq) \rightarrow 3Cl_2(aq) + 3H_2O(l)$
<table><tr><th>Expt</th><th>$[Cl^-(aq)]$ / mol dm^{-3}</th><th>$[ClO_3^-(aq)]$ / mol dm^{-3}</th><th>$[H^+(aq)]$ / mol dm^{-3}</th><th>Initial rate / mol dm^{-3} s^{-1}</th></tr><tr><td>1</td><td>0.15</td><td>0.08</td><td>0.20</td><td>1.0×10^{-5}</td></tr><tr><td>2</td><td>0.15</td><td>0.08</td><td>0.40</td><td>4.0×10^{-5}</td></tr><tr><td>3</td><td>0.15</td><td>0.16</td><td>0.40</td><td>8.0×10^{-5}</td></tr><tr><td>4</td><td>0.30</td><td>0.08</td><td>0.20</td><td>2.0×10^{-5}</td></tr></table>OR
Temperature monitoring and its control has substantial effect on the overall economy of any process. Proper monitoring and control also enhances the overall safety of a chemical process plant.
i) Explain the working principle of four temperature measurement techniques.
ii) With the help of examples, explain the advantage and disadvantage of the temperature measurement techniques explained in part (i).
iii) What is the relationship between temperature and pressure of an ideal gas system?</td><td>20</td><td>CO5</td></tr>
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