Total No. of Questions : 12]

SEAT No. :

P873

[Total No. of Pages : 3

[4659]-310
B.E. (Chemical)
d-FUEL CELL TECHNOLOGY
(2008 Pattern) (Elective-IV) (Semester-II)

Time : 3 Hours] *[Max. Marks : 100*

Instructions to the candidates:

1) ***Answers to the two sections should be written in separate books.***
2) ***Neat diagrams must be drawn wherever necessary.***
3) ***Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.***
4) ***Assume suitable data, if necessary.***

SECTION-I

Q1) a) Describe the Phosphoric acid fuel cell with respect to processing, catalyst and fuel. **[9]**

b) Describe the Solid oxide fuel cell with respect to processing, catalyst and fuel. **[9]**

OR

Q2) a) Discuss the advantages and limitations of fuel cell operating at low and high temperature respectively, taking the example of PEM and SOFC. **[9]**

b) State the difference between fuel cell vehicle vs combustion engine vehicles. **[9]**

Q3) Gibbs free energy for the formation of water vapor is –55.14 cal/mol at STP. In the typical SOFC, pure methane is fed at the pressure of 3 atm. Total pressure of gases on anodic side of fuel cell is observed to be 3.5atm. Air is supplied at 1.2 atm. Fuel and air are supplied at the same operating temperature of 900 C. F = 96486 J/mol. Calculate, **[16]**

i) Standard open circuit potentials.

ii) Open circuit potential at the operating condition.

iii) What will be the effect if the operating temperature is increased to 1000 C?

OR

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Q4) a) A current density of 15 A/m^2 is obtained when pure hydrogen in fed to SOFC at the pressure of 1.8 atm. Total pressure of gases at anodic side is observed to be 2.5 atm. Air is supplied at 1.8 atm. The cell is operated at 1000 C. The diffusion factors for hydrogen, oxygen and water vapor are 95, 70 and 55 C/s.m^2 atm, respectively. Calculate concentration overpotentials across anode and cathode. **[8]**

b) Calculate the fuel utilization factor, air ratio, power output and fuel efficiency of SOFC using the following data: **[8]**

Average Current density = 15 A/m^2

Active anode surface area = 0.4 m^2

Fuel flow rate = 25 mol/h

Fuel composition = H_2: 70% and CO: 30%

Air flow rate = 20 mol/h

Output potential = 230 V

Lower heating value of the fuel = 2,50,000 kcal/kg.

Q5) Derive the Nernst equation for calculating open circuit potential of SOFC using air as an oxidizer for the following conditions. **[16]**

i) Pure butanol as fuel,

ii) H_2 as a fuel.

OR

Q6) Calculate material balance for SOFC generating 400 kW power at 80% CHP efficiency, using methane as fuel and 40% theoretical excess air as an oxidizer. **[16]**

SECTION-II

Q7) a) Discuss in detail defects in materials, Frenkel defects, Schottky defects. **[7]**

b) Explain the defect equilibrium in solid structures. **[7]**

OR

Q8) a) Explain the mechanism of charge transfer in TPB. **[7]**

b) What is steam reforming? What is its importance in SOFC? **[7]**

Q9) a) Design a tubular SOFC stack to generate 500 kW power for methane as a fuel. Single tube has anodic diameter of 18mm and active length of 1.5m. **[8]**

b) Derive correlation to calculate defect mole fraction for pure solids at thermal equilibrium. **[8]**

OR

Q10) a) Derive the Butler-Volmer form of the charge transfer rates. **[8]**

b) Explain the mechanism of Direct oxidation of hydrocarbons in fuel cell. **[8]**

Q11) Develop a mathematical model for SOFC system using the anodic system of Ni, H_2-H_2O/YSZ. Hydrogen is used as a fuel and air as an oxidizer. Explain the: **[20]**

i) Approach

ii) Assumption

iii) Flow chart and

iv) Reaction

OR

Q12) a) Explain the required characteristics of materials of construction of electrode, electrolyte, and interconnect for SOFC. **[10]**

b) Design a planar SOFC to generate 400 kW power for ethanol as fuel. **[10]**

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