Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, April 2018

SUBJECT: FUEL CELL & HYDROGEN ENERGY [CHE5283]

REVISED CREDIT SYSTEM
(30/04/2018)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A.	Consider aluminium and oxygen. Every kilogram of aluminium has (at STP) an entropy of 1.05 kJ/K, whereas every kilogram of oxygen has an entropy of 6.41 kJ/K. Aluminium burns fiercely forming an oxide (Al_2O_3) and releasing energy. The standard enthalpy of formation of the oxide is -1.67 GJ/kmole. The entropy of the oxide is 51.0 kJ/K per kilomole. Calculate the free energy of the aluminium/oxygen reaction.	**3**
1B.	Explain the measurement of flexural strength and electrical conductivity of a bipolar plate.	**3**
1C.	With the help of a neat diagram, describe about solar thermal and steam reforming reactions for H_2 production.	**4 (2+2)**
2A.	What is Nernst Equation? Derive it, considering any chemical reaction.	**3 (1+2)**
2B.	Define fuel cell. Write the half-cell reactions for different transport species (H^+, O^{2-}, OH^-, and CO_3^{2-}).	**4 (1+3)**
2C.	With the help of a neat diagram explain the working principle and instrumentation of XRD instrument.	**3**
3A.	Briefly explain about the two preparation methods of fuel cell catalysts.	**3**
3B.	Explain about electrochemical impedance spectroscopy. With the help of a neat diagram explain the Nyquist plot for a fuel cell.	**4 (2+2)**
3C.	Define spectroscopy. Write about the working of raman spectroscopy.	**3**

		(1+2)
4A.	The enthalpies and the free energies of formation (at RTP) of each species of interest in this problem are: $\Delta\overline{h}_f^\circ$ (MJ/kmole) $\quad \Delta\overline{g}_f^\circ$ CH_3OH (g) $\quad -201.2 \quad -161.9$ CH_3OH (l) $\quad -238.6 \quad -166.2$ O_2 (g) $\quad 0 \quad 0$ CO_2 (g) $\quad -393.5 \quad -394.4$ H_2O (g) $\quad -241.8 \quad -228.6$ H_2O (l) $\quad -285.9 \quad -237.2$ Owing to the methanol/oxygen reaction, reaction, the changes in enthalpy and in free energy are: Methanol — Water — $\Delta\overline{h}^\circ$ MJ/kmole — $\Delta\overline{g}^\circ$ MJ/kmole liquid — gas — -638.5 — -685.3 gas — gas — -676.5 — -689.6 liquid — liquid — -726.5 — -702.4 gas — liquid — -764.5 — -706.7 Consider methanol, a fuel that has been proposed for both internal combustion (IC) engines and for fuel cells. a. How much heat do you get by burning 1 kg of methanol in an IC engine? b. How much electric energy will an ideal fuel cell (using methanol and air) produce per kg of fuel? c. How much heat does the cell reject?	**4**
4B.	Write about gas diffusion layers and bipolar plates of PEMFC.	**3**
4C.	Explain in brief about storage of H_2 using chemical methods and via metal hydrides.	**3**
5A.	Explain clearly about the working of SEM instrument.	**3**
5B.	Describe about ohmic polarization considering if only the mass transfer is by diffusion.	**4**
5C.	Explain in detail about microbial fuel cell. Draw neat diagram of the cell.	**3** **(1+2)**