



KISII UNIVERSITY
UNIVERSITY EXAMINATIONS

SPECIAL EXAMINATION
FOURTH YEAR EXAMINATION FOR THE AWARD OF THE DEGREE OF
BACHELOR OF EDUCATION (SCIENCE)
FIRST SEMESTER 2021/2022
(JULY, 2022)

PHRE 412: ENERGY STORAGE SYSTEM II

STREAM: Y4 S1

TIME: 2 HOURS

DAY: FRIDAY, 11.30 AM – 1.30 PM

DATE: 27/07/2022

INSTRUCTIONS:

- 1. Do not write anything on this question paper.**
- 2. Answer Question ONE (Compulsory) and any other TWO questions.**

QUESTION ONE

- Describe Latent Heat Thermal Energy Storage Phase; concepts and applications (5marks)
- State what is a Fuel cells and The basic physical structure or building block of a fuel cell (10 marks)
- Given a desired output of 1.0 MWAC, and an inverter efficiency of 96.5%, what DC output level is required from the fuel cell stack? (5marks)
- Discuss the following fuel cells (10 marks)
 - Polymer Electrolyte Fuel Cell (PEFC)
 - Alkaline Fuel Cell (AFC)
 - Phosphoric Acid Fuel Cell (PAFC)
 - Molten Carbonate Fuel Cell (MCFC)
 - Solid Oxide Fuel Cell (SOFC)

QUESTION TWO

Given a 2.0 MWAC fuel cell cycle operating on 700 lb/hr of methane, what is

- the HHV55 thermal input of the methane gas. (4marks)
- the LHV thermal input (4marks)

- c) the HHV electric efficiency (4marks)
- d) the LHV electric efficiency, and the HHV Heat Rate? Assume the higher and lower heating value of methane as 23,881 and 21,526 Btu/lb respectively (8marks)

QUESTION THREE

- a) What are the characteristics of Fuel cells that make them favorable as energy conversion devices? (5 marks)
- b) What hydrogen flow rate is required to generate 1.0 ampere of current in a fuel cell? (4marks)
- c) A 1.0 MWDC fuel cell stack is operated with a cell voltage of 700 mV on pure hydrogen with a fuel utilization, U_f of 80%.
- i) How much hydrogen will be consumed in lb/hr? (4marks)
 - ii) What is the required fuel flow rate? (4marks)
 - iii) What is the required air flow rate for a 25% oxidant utilization, U_{ox} ? (3marks)

QUESTION FOUR

A PAFC, operating on reformed natural gas (900 lb/hr) and air, has a fuel and oxidant utilization of 86% and 70% respectively. With the fuel and oxidant composition and molecular weights listed below,

- a) How much hydrogen will be consumed in lbmol/hr? (5marks)
- b) How much oxygen is consumed in lbmol/hr? (5marks)
- c) What is the required air flow rate in lbmol/hr and lb/hr? (3marks)
- d) How much water is generated? Discuss the benefits of energy inventories in an industry (7marks)

QUESTION FIVE

Discuss the following performance parameters below of a cell (20 marks)

- Charging time
- Energy stored
- Discharging time
- Energy recovered
- Energy efficiency.