

# MCL 241: ENERGY SYSTEMS AND TECHNOLOGIES

## Minor Exam # 1

Date: February 14, 2016

Time: 1 hour

Marks: 35

### Instructions:

1. Show all necessary and important steps used to obtain the final solution.
2. You are allowed the use of printed class handouts and class notes written in your own handwriting only.

### PROBLEM 1 (20 marks)

During a diagnostic test on a poorly performing boiler, a partial analysis of the dry exhaust gas showed 13.2% CO<sub>2</sub> and 3.2% O<sub>2</sub> by volume. Some CO was present but its percentage was not measured. The analysis of the coal burnt was 88% carbon, 4.4% hydrogen and 7.6% ash. Assuming that all the carbon and hydrogen have been burnt, estimate

- a) The complete volumetric composition of the exhaust gas, (8)
- b) The actual amount of air supplied per kg of fuel, (4)
- c) The mixture strength, (4)
- d) The mass of water vapor formed per kg of fuel, and (2)
- e) The dew point temperature of the exhaust gas. (2)

### PROBLEM 2 (15 marks)

A test on a single-cylinder, four-stroke engine having a bore of 15 cm and stroke of 30 cm gave the following results: speed 300 rpm; brake torque 200 Nm; indicated mean effective pressure 7 bar; fuel consumption 2.4 kg/h; cooling water flow rate 5 kg/min; cooling water temperature rise 50 K; air-fuel ratio 22; exhaust gas temperature 410 °C; atmospheric pressure 1.013 bar; room temperature 20 °C. The fuel has a calorific value of 42 MJ/kg and contains 15% by weight of hydrogen. Determine,

- a) The indicated and brake thermal efficiencies, (4)
- b) The volumetric efficiency based on atmospheric conditions, (5)
- c) The fraction of total energy taken away by brake power, cooling water and dry exhaust gases. Take  $C_p$  for dry exhaust gases = 1 kJ/kg-K. (6)

