Ene-39.4048 NATURAL GAS ENGINEERING

EXAM 2 - 16.2.2015

Maximum points 300

Question 1

Explain briefly:

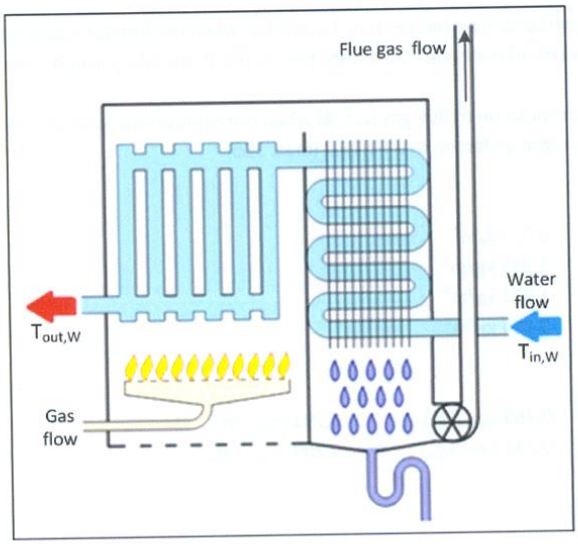
a) the LNG (liquid natural gas) supply chain ('dwell to wheel') (~200 words) (max. 50p)
b) the traditional pipeline gas supply chain and what are the pros and cons between the LNG supply chain and the pipeline supply chain. (~200 words) (max. 50p)

Question 2

Describe the main bio-based gas production routes(s): raw materials, their process routes and gas output qualities. (~200 words) (max. 50p)

Question 3 – Heating values in condensing boilers

Water flow (W) is heated in a condensing boiler by natural gas (NG), which consists of methane (98 mol-%) and nitrogen (2 mol-%). Condensation of water vapor in the flue gas (FG) is assumed to be complete i.e. all of the water in the flue gases is liquefied before exiting the boiler.



a) What is the water output temperature? Use HHV of methane. (max. 35p)
b) What is thermal efficiency of the boiler determined by LHV of the gas? (max. 15p)

$H_{HHV,CH4}$	HHV of methane	39,82 MJ/m^3
$H_{LHV,CH4}$	LHV of methane	35,88 MJ/m^3
$\dot{V}_{NG}$	Gas flow	5,1 m^3/h
$\dot{m}_W$	Water flow	1400 kg/h
$T_{in,W}$	Input water temperature	20 °C
$c_{P,W}$	Specific heat capacity of water	4,18 kJ/kgK
η_{th}	Thermal efficiency (from HHV) of the boiler	92,5 %

Question 4 – Gas combustion and flue gas losses

A furnace is fuelled by natural gas, composition of which is:

Methane	97,8 vol-%
Nitrogen	2,2 vol-%

Thermal input (fuel energy input) to the furnace is 3,7 MW and the air factor for combustion is 1,25. Lower heating value of methane is 9,965 kWh/m^3.

a) How much combustion air (m^3 per hour) is needed when the furnace operates at full capacity based on the LHV of methane? Start from the chemical reaction in combustion. (max. 50p)

b) What's the composition of flue gas (vol-%) when the combustion is assumed to be stoichiometric (the air factor is still 1,25)? (max. 50p)

Densities of gases:

Methane	ρ_{CH4}	0,72 kg/m^3
Air	ρ_{air}	1,293 kg/m^3
CO_2	ρ_{CO2}	1,977 kg/m^3
H_2O (vapour)	ρ_{H2O}	0,854 kg/m^3

Composition of air:

Nitrogen	0,769 kg_{N2}/kg_{air}	0,791 m_{N2}^3/m_{air}^3
Oxygen	0,231 kg_{O2}/kg_{air}	0,209 m_{O2}^3/m_{air}^3