GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

FUELS, ENERGY AND ENVIRONMENT

EMR 2205

Part II Second Semester Examination Paper

August 2022

This examination paper consists of 4 printed pages

Time Allowed: **3 hours**

Total Marks: **100**

INSTRUCTIONS

1. Answer **ALL questions in Section A and any TWO from Section B**
2. Each question carries 25 marks
3. Use of calculators is permissible

Additional Requirements

1. Periodic table
2. Calculator

MARK ALLOCATION

Section A	50 Marks
Section B	50 Marks
Part Questions	As shown in each part question
Total Attainable	100

SECTION A (50 MARKS)

ANSWER ALL QUESTIONS

Question A1

a) Outline the three merits and three limitations of gaseous fuels **[6]**

b) A furnace is fired with fuel oil having a calorific value of 46.4 MJ/kg. The fuel contains 86% Carbon, 1% Nitrogen and 0.1% Sulphur. Saturated air at a temperature of 25 °C and a pressure of 740 mmHg was used to combust the fuel oil. The composition of stack gases emanating from the combustion process is as follows: 10.62% CO_2, 1.17% CO, 6.34% O_2 and 81.87% N_2. The stack gases leave the furnace combustion chamber at a temperature of 400 °C and pressure of 765 mmHg. Calculate:

i. Percent excess air required for combustion. **[4]**

ii. Complete the elemental analysis of the oil **[4]**

iii. Volume of air required for combustion of the fuel oil per kg of fuel oil **[3]**

iv. Volume of stack gas produced per kg of oil **[3]**

v. Percent loss in calorific value due to unburnt combustibles. **[4]**

Question A2

(a) List and explain four characteristics of a good fuel? **[8]**

(b) With the aid of a diagram, identify 5 possible contributors to pollution during gold ore beneficiation. **[6]**

(c) Explain four preventative and mitigation measures to pollution attributed to gold ore beneficiation? **[5]**

(d) A coal sample has the following composition on a mass basis: Carbon 82%, Hydrogen 8%, Sulphur 2%, Oxygen 4% and Ash 4%.

Using Dulong's formula calculate

i. Higher calorific value (HCV) **[3]**

ii. Lower calorific value (LCV) **[3]**

SECTION B (50 MARKS)

ANSWER ANY TWO QUESTIONS

Question B1

(a) Differentiate between coal and coke **[4]**

(b) Briefly discuss three properties of coal essential for the production of metallurgical grade coke **[6]**

(c) A coke oven plant has an annual production capacity of 3 million tonnes. The plant yields 71% of coke from good quality coking coal. A stamped coal charging technology is used to make green coal cake having a bulk density (dry) of 1 ton/ m^3, which is used as a raw material in coke ovens. The coke oven chamber is 16.19 m long, 6.3 m high and 540 mm wide. The coking time is set at 24 hours/batch. There are 60 coke ovens in one battery. Assuming that the plant works for 340 days/yr leaving 25 days for plant maintenance. Considering that 95% of the volatiles including moisture are removed during coking, then, calculate

i. The percentage of volatile matter + moisture in the coal charge **[4]**

ii. The amount (ton) of coal used by the plant annually **[6]**

iii. Determine the number of coke oven batteries in the plant **[5]**

Question B2

a) List and explain three precautionary measures to be followed during storage and handling of methane gas to prevent fire outbreaks **[6]**

(b)With the aid of a diagram discuss any four environmental concerns associated with iron ore processing using a blast furnace **[8]**

(c) Natural gas (100 m^3) with the following composition: CH_4 - 85%, C_2H_4 - 3%, C_6H_6 - 3%, H -5%, N_2 - 4%, was burnt with 20% excess air. The moisture content of the air is 1.5%

Calculate:

(i) The dry theoretical air needed for burning 1 m^3 of natural gas, **[3]**

(ii) Volume of moist air used to completely burn the gas **[3]**

(iii) Volumes of products of combustion at standard temperature and pressure **[5]**

Question B3

(a) List and explain three factors to consider when selecting refractory material **[6]**

(b) A tar fired boiler is used by company X to produce steam. Recently, there has been a lot of downtime due to clogging of the combustion system of the boiler by tar. Explain how this problem can be prevented? **[3]**

(c) Discuss any three safety precautions that should be practiced to prevent accidents when operating a tar- fired boiler **[6]**

(d) A steel billet reheating furnace was supplied energy by burning oil at the rate of 20 liters per hour (calorific value 9000 kcal/liter). 25% of the total energy was used for heating the steel billets. The energy lost through various sources were as follows: 7% through conveyor system, 10% radiation losses through doors, 6% conduction losses through walls, 34% loss through hot flue gases. 18% energy is recovered from recuperative system to preheat air and recycled in the system. Draw a Sankey diagram showing the furnace energy balance and label the values in J/hr. **[10]**

END OF QUESTION PAPER