FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

FUELS, ENERGY AND ENVIRONMENT

EMR 2205

Final Examination Paper

May 2023

This examination paper consists of 5 pages

Time Allowed: **3 hours**

Total Marks: **100**

Examiner's Name: **Dr. Chiteka**

INSTRUCTIONS

1. Choose any 4 **QUESTIONS** out of a total of **SIX** questions.
2. Each question **carries 25 marks**.
3. Where a question contains subdivisions, the mark value of each subdivision is shown in brackets.
4. Illustrate your answer, where appropriate, with large clearly labelled diagrams.
5. Start each question on a new page.

Additional Requirements

Calculator

MARK ALLOCATION

Question 1 to 6	**20 Marks**
Part Questions	**As shown in each part question**
Total Attainable	**100**

Question 1

a. With the aid of a diagram, explain the different types and classification of fuels. [15]

b. Giving examples, discuss the differences between "clean energy", "conventional energy" and "renewable energy" systems. [10]

Question 2

a. Nuclear energy can be considered a renewable energy source. Discuss. [15]

b. A CFB boiler consumes 5 t/h coal having the following composition:

i. Sulphur, 4.34%;
ii. Ash, 19%;
iii. HHV, 24.4 MJ/kg.

Other details are:

i. Height, H = 30 m
ii. Fluidizing velocity, U = 5 m/sec
iii. Suspension density, $\rho_b(\chi) = 2 + 480e^{-0.328x}$

From TGA data, reactivity of limestone, K = 50.5(0.41- δ) per second, where δ is the average rate of sulfation.

SO_x limit, L = 0.52 g/MJ or 90% (whichever gives lower pollution)

Weight fraction of calcium in limestone, C_{Ca} = 0:35

Cyclone efficiency on average size sorbents = 99%

X_{CaCO3} = 0.875;

M_{CaCO3} = 100.

Compute the limestone consumption rate. [10]

Question 3

c. What are the mole fractions of CO_2, H_2O, CO, N_2, and H_2 produced when octane (C_8H_{18}) is burned in rich conditions at ϕ = 1.2 and T = 1000 K? [15]

d. During a boiler trial the coal analysis on mass basis was reported as;

C = 62.4%,

H_2 = 4.2%,

O_2 = 4.5%,

Moisture = 15%, and

Ash = 13.9%.

Compute the following

i. The air required to burn 1 kg of coal if 15% excess air is considered.

ii. H.C.V.

iii. L.C.V. [10]

Question 4

a. Drinking water in a mineral processing environment is contaminated by 1.0 mg/L of toluene and 0.01 mg/L of tetrachloroethylene. A 70-kg adult drinks 2 litres per day of this water for 10 years.

i. Determine if the hazard index suggest that this was a safe level of exposure.

ii. Tetrachloroethylene is a B2 carcinogen. Evaluate the carcinogenic risk faced by someone drinking this water and determine whether it is less than a goal of 10^{-6}?

[15]

b. A mineral processing plant consists of the following equipment powered using electricity;

	Equipment	**Power rating (W)**
1	Induction furnace	5000
2	Muffle furnace	3000
3	Oven	2000
4	Lights	500
5	Jaw crusher	8000
6	Ball mill/rod mill	7000
7	Pulveriser	3500
9	Sieve Shaking machine	1500

Design a renewable energy based energy supply system that can power all the equipment simultaneously. [10]

Question 5

a. Articulate the concept of integrated solid waste management. [15]

b. Outline the merits of liquid fuels over gaseous fuels. [10]

Question 6

Explain the following terms and phrases and briefly discuss their importance in metallurgical engineering;

a. Combustion,
b. Sustainable energy and energy efficiency,
c. Fire classes,
d. Climate change, and
e. Bio-hazards.

END OF QUESTION PAPER

Appendix A

Toxicity Data for Selected Potential Carcinogens

Chemical	Category	Potency Factor Oral Route $(mg/kg\text{-}day)^{-1}$	Potency Factor Inhalation Route $(mg/kg\text{-}day)^{-1}$
Arsenic	A	1.75	50
Benzene	A	2.9×10^{-2}	2.9×10^{-2}
Benzol(a)pyrene	B2	11.5	6.11
Cadmium	B1	—	6.1
Carbon tetrachloride	B2	0.13	—
Chloroform	B2	6.1×10^{-3}	8.1×10^{-2}
Chromium VI	A	—	41
DDT	B2	0.34	—
1,1-Dichloroethylene	C	0.58	1.16
Dieldrin	B2	30	—
Heptachlor	B2	3.4	—
Hexachloroethane	C	1.4×10^{-2}	—
Methylene chloride	B2	7.5×10^{-3}	1.4×10^{-2}
Nickel and compounds	A	—	1.19
Polychlorinated biphenyls (PCBs)	B2	7.7	—
2,3,7,8-TCDD (dioxin)	B2	1.56×10^{5}	—
Tetrachloroethylene	B2	5.1×10^{-2}	$1.0 - 3.3 \times 10^{-3}$
1,1,1-Trichloroethane (1,1,1-TCA)	D	—	—
Trichloroethylene (TCE)	B2	1.1×10^{-2}	1.3×10^{-2}
Vinyl chloride	A	2.3	0.295

Source: U.S. EPA, www.epa.gov/iris.