Sustainable and Renewable Energy Development Authority (SREDA)

Power Division, Ministry of Power, Energy and Mineral Resources

4th Energy Auditor Certification Examination-2023

Paper- 2

Candidate's Roll No. | 2 | 0 | 2 | 3 | 0 | 5 | | | |

Examinee's Name _____

Invigilator's Signature

B

Paper 2: Energy Efficiency in Thermal Systems

Total Marks- 150, Time- 3.00 Hours, Date: 24 May 2023

- **Important Instruction:**

1. This Paper has 50 MCQs + 8 Short Questions + 6 Long Questions = Total 64 Questions.
2. Mark indicated on the right side of each question.
3. Fill in correct circle with permanent ink ballpoint pen shown on the top sheet only corresponding to the MCQ given in Section A.
4. Answer in the blank space provided after each question (short/long).
5. Do not put any sign or write anything on the answer script except written answer.
6. Any unfair means, peer talking, keeping any communication device and misbehavior will lead to cancellation of examination.

Invigilator's Signature

MCQ Answer (Section A):

1	Ⓐ	Ⓑ	Ⓒ	Ⓓ	18	Ⓐ	Ⓑ	Ⓒ	Ⓓ	35	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2	Ⓐ	Ⓑ	Ⓒ	Ⓓ	19	Ⓐ	Ⓑ	Ⓒ	Ⓓ	36	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20	Ⓐ	Ⓑ	Ⓒ	Ⓓ	37	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4	Ⓐ	Ⓑ	Ⓒ	Ⓓ	21	Ⓐ	Ⓑ	Ⓒ	Ⓓ	38	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5	Ⓐ	Ⓑ	Ⓒ	Ⓓ	22	Ⓐ	Ⓑ	Ⓒ	Ⓓ	39	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23	Ⓐ	Ⓑ	Ⓒ	Ⓓ	40	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24	Ⓐ	Ⓑ	Ⓒ	Ⓓ	41	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25	Ⓐ	Ⓑ	Ⓒ	Ⓓ	42	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26	Ⓐ	Ⓑ	Ⓒ	Ⓓ	43	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27	Ⓐ	Ⓑ	Ⓒ	Ⓓ	44	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28	Ⓐ	Ⓑ	Ⓒ	Ⓓ	45	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29	Ⓐ	Ⓑ	Ⓒ	Ⓓ	46	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30	Ⓐ	Ⓑ	Ⓒ	Ⓓ	47	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14	Ⓐ	Ⓑ	Ⓒ	Ⓓ	31	Ⓐ	Ⓑ	Ⓒ	Ⓓ	48	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15	Ⓐ	Ⓑ	Ⓒ	Ⓓ	32	Ⓐ	Ⓑ	Ⓒ	Ⓓ	49	Ⓐ	Ⓑ	Ⓒ	Ⓓ
16	Ⓐ	Ⓑ	Ⓒ	Ⓓ	33	Ⓐ	Ⓑ	Ⓒ	Ⓓ	50	Ⓐ	Ⓑ	Ⓒ	Ⓓ
17	Ⓐ	Ⓑ	Ⓒ	Ⓓ	34	Ⓐ	Ⓑ	Ⓒ	Ⓓ					

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MCQ	:	[ ]	
Short Question	:	[ ]	
Long Description Question	:	[ ]	
Total Marks	:	[ ]	Signature of Examiner

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Section A: MCQ

Fill the appropriate circle in the OMR answer sheet at the top page.

1 x 50 =50

1 Turn down ratio is an important aspect for selecting

A) fuel tank
C) fuel
B) fuel pump
D) burner

2 The flash point of a fuel is the temperature at which fuel can be heated so that the vapour gives off flashes momentarily when an open flame is passed over it.

A) highest
C) medium
B) lowest
D) None of the above

3 How much air is required for burning of 3 kg of Carbon in fuel.

A) 8.0 Kg
C) 3.6 Kg
B) 34.7 Kg
D) 47.8 Kg

4 Which is the highest carbon content fuel

A) Fuel Oil
C) Natural Gas
B) Coal
D) Paddy Husk

5 In a CFBC boiler the capture and recycling of bed materials is accomplished by

A) Bag filter
C) Cyclone
B) Settling chamber
D) Scrubber system

6 Which is not true for the definition of boiler according to the Boilers Act 1923

A) It must be a closed vessel
C) volume of vessel must be over 22.76 m^3
B) It must generate steam for external use
D) working pressure more than 1.0 kg/cm^2

7 Which is true for a boiler of capacity 10 Ton operating at 10 bar

A) it can produce 10 ton of steam at 10 bar and respective saturation temperature
C) it can produce higher than 10 ton of steam at 10 bar and respective saturation temperature
B) it can produce 10 ton of steam at 1 bar and 100^0C
D) it can produce 10 ton of steam at 10 bar and 100^0C

8 The maximum efficiency of boiler can usually be obtained at

A) full load
C) 50%
B) two-third of full load
D) no load

9 If 10% air is entrained in a steam system at 5 kg/cm^2g then the saturation temperature of steam will be

A) less than the saturation temperature at 5 kg/cm^2g
C) equal to the saturation temperature at 5 kg/cm^2g
B) more than the saturation temperature at 5 kg/cm^2g
D) equal to the saturation temperature at 5.5 kg/cm^2g

10 Across the pressure reducing valve of a steam system

A) Output enthalpy decreases

C) Steam temperature increases

B) Steam becomes wet

D) Enthalpy remains the same

11 The TDS level in boiler water, in the context of boiler blow down, can be determined by measuring :

A) alkalinity of water

C) electrical conductivity of water

B) thermal conductivity of water

D) turbidity of water

12 The evaporation ratio of a coal-fired boiler is 4. Steam enthalpy is 640 kCal/kg; feed water temperature is 55^0C, Calorific Value of coal is 4000 kCal/kg. The boiler efficiency is _____

A) 49 %

C) 58.5 %

B) 82 %

D) 70 %

13 Removal of condensate from main steam line is done to prevent

A) Steam locking

C) Water hammer

B) Air locking

D) All of the above

14 Recuperators are used for.

A) Preheating of combustion air

C) Preheating of water.

B) Preheating of Fuel

D) Preheating the stock.

15 The efficiency of a reheating furnace, operating at 10 tonnes per hour consuming furnace oil of 230 kg/hour for reheating the material from 40 ^{0}c -1100 ^{0}c (consider specific heat of material is 0.13 kcal/kg ·c and calorific value of furnace oil is 10000 kcal/kg) is

A) 55

C) 65

B) 60

D) 70

16 Heat loss through openings in furnaces is directly proportional to

A) fourth power of furnace temperature

C) absolute furnace temperature

B) square of absolute furnace temperature

D) fourth power of absolute furnace temperature

17 Refractories with higher thermal conductivity is preferred in

A) boilers

C) kiln

B) furnaces

D) regenerator

18 Which property is the most important, for an insulating brick?

A) Mechanical strength

C) Compact strength

B) Chemical resistance

D) Porosity

19 In a CFBC boiler the capture and recycling of bed materials is accomplished by

A) Bag filter

C) Cyclone

B) Settling chamber

D) Scrubber system

20 Which of the following pollutants is controlled effectively by a FBC or CFBC boiler?

A) SOx
C) CO
B) NOx
D) Particulate matter

21 For same inlet conditions of the steam, which of the following will generate the maximum mechanical power ?

A) Condensing turbine
C) Extraction-cum-condensing turbine
B) Back pressure turbine
D) Extraction-cum-back pressure turbine

22 Which of the following is a challenge associated with the integration of cogeneration with the electric grid?

A) Variable electricity generation
C) High electricity demand
B) High transmission losses
D) Low electricity prices

23 Heat wheels are mostly used in situation of

A) high temperature exhaust gases
C) heat transfer between a liquid and gas
B) heat exchange between large masses of air having small temperature differences
D) corrosive gases

24 In a low temperature waste heat recovery system, which of the following, is the most suitable?

A) Economizer
C) regenerator
B) Heat Pipe
D) ceramic recuperator

25 Which of the following heat recovery equipment, requires a compressor for its operation?

A) thermo-compressor
C) Heat pump
B) heat wheel
D) heat pipe

26 A heat exchanger has hot fluid inlet and outlet temperatures of 120°C and 80°C, respectively, and cold fluid inlet and outlet temperatures of 20°C and 60°C, respectively. The LMTD for the heat exchanger is:

A) 40°C
C) 60°C
B) 50°C
D) 70°C

27 The efficiency of a reheating furnace, operating at 10 tonnes per hour consuming furnace oil of 230 kg/hour for reheating the material from 40°C to 1100°C (consider specific heat of material is 0.13 kCal/kg°C and calorific value of furnace oil is 10,000 kCal/kg) is_____.

A) 60 %
C) 80 %
B) 70 %
D) None of the above

28 In FBC boiler the combustion is carried out at a temperature

A) Closer to saturated steam temperature
C) At adiabatic combustion temperature of fuel
B) Below ash fusion temperature of fuel used
D) At and above ash fusion temperature of fuel

29 The evaporation ratio of a coal-fired boiler is 4. Steam enthalpy is 640 kCal/kg; feed water temperature is 55^{o}C, Calorific Value of coal is 4000 kCal/kg. The boiler efficiency is _____

A) 49 %
C) 58.5 %
B) 82 %
D) 70 %

30 Removal of dissolved gases from the boiler feed water is called

A) Degasification
C) Deoxidation
B) Deaeration
D) None of the above

31 Air venting in a steam system is required because air is _____.

A) A good conductor
C) Inert
B) An insulator
D) Diluent

32 Which material is used to control SO_2 emissions in FBC boilers

A) CaO
C) Silica
B) Lime stone
D) Sand

33 Which of the following fuel needs maximum amount of excess air for complete combustion?

A) Furnace oil
C) Pulverized coal
B) Natural gas
D) Wood

34 In a coal fired boiler, which parameter influences flame profile the most?

A) Fixed carbon
C) Hydrogen
B) Volatile matter
D) All of the above

35 In an oil-fired steam boiler, the Air to Fuel ratio by mass is 15:1 and evaporation ratio is 14:1. The flue gas to fuel ratio will be

A) 29:1
C) 1:1
B) 16:1
D) 15:1

36 Desirable boiler water pH should be?

A) 5 - 7
C) 9 - 11
B) 7 - 9
D) None of the above

37 Soot deposition on boiler tubes is due to

A) Poor water treatment
C) High excess air
B) High moisture content in fuel
D) Incomplete combustion

38 In a coke fired cupola, carbon monoxide is produced in the

A) Preheating zone
C) Combustion zone
B) Reducing zone
D) Melting zone

39 Emissivity is a measure of material's ability to

A) Only absorb heat
C) Absorb and radiate heat
B) Only radiate heat
D) None of the above

40 Moisture content in coal

A) Increases heat loss due to evaporation and superheating of water vapour

C) Aids in radiation heat transfer

B) Helps in binding fines

D) All of the above

41 The difference between mean solid and mean gas velocity in FBC boiler is called

A) Fluidization factor

C) Settling velocity

B) Slip velocity

D) Terminal velocity

42 Which of the following has the lowest stoichiometric oxygen demand (kg/kg of fuel)

A) hydrogen

C) sulphur

B) carbon

D) methane

43 The unit of overall heat transfer coefficient is

A) W/m^2 K

C) W^2/m^3 K

B) W^2/m^2 K

D) W/m^3 K

44 The thermal resistance of an insulation

A) decreases with increased thermal conductivity

C) decreases with decreased thermal conductivity

B) increases with increased thermal conductivity

D) has no relation with thermal conductivity

45 Presence of _____ in flue gas confirms incomplete combustion in furnace

A) CO

C) SOx

B) NOx

D) All of the above

46 Hydrometer is used for the measurement of

A) viscosity

C) water content

B) density

D) humidity

47 Corrosion in chimney, air pre-heater and economizer is mainly influenced by

A) sulphur content in fuel

C) moisture content in fuel

B) ash content in fuel

D) All of the above

48 An oil-fired boiler is operating at 5% O_2 in the flue gas. The percentage excess air supplied to the boiler is approximately

A) 15 %

C) 31 %

B) 25 %

D) 42 %

49 The percentage raise in boiler efficiency by a 20^0C raise in combustion air temperature is

A) 0.1%

C) 10%

B) 0.2%

D) 1%

50 Thermo-compressor is commonly used for

A) compressing hot air

C) distillation

B) upgrading low pressure steam

D) reverse compression of CO_2

Section B: Short Question

		Marks
01	For combustion of 500 kg/hr of natural gas containing 100% methane, calculate the percentage of CO_2 in the flue gas while 15% excess air is supplied.	5
02	An economizer was installed in the furnace-oil fired boiler. The following are the data monitored after commissioning the economiser. Air to fuel ratio = 20 Evaporation ratio of the boiler = 12 Specific heat of flue gas = 0.25 kcal/kg^{o}C. Condensate recovery in the plant = Nil. Calculate the rise in temperature of feedwater in an economizer, which brings down the flue gas temperature from 280 ^{O}C to 180 ^{O}C.	5
03	A reheating furnace is operating with deteriorated wall insulation. The existing average outer surface temperature of the furnace (of area = 100 m^2) with surrounding ambient air temperature of 40 ^{0}C, is recorded to be 120 ^{0}C. After revamping the refractory, the furnace outer surface temperature reduces to 50 ^{0}C. If the fuel oil (GCV = 11,000 kcal/kg) cost is Tk. 25,000 per tonne, and efficiency of the furnace is 35%, estimate annual savings for 300 working days per year.	5
04	Write short note on regenerative heat exchanger.	5
05	What is meant by critical point of steam and give two advantages of Super Critical boilers?	5
06	List down five energy conservation measures in steam system.	5
07	If one 1.0 kW gasoline generator consumes 1 liter/hr gasoline, estimate the thermal efficiency of the engine. Gasoline has the following properties: S.G. = 0.75, LHV = 45 MJ/kg.	5
08	A heat exchanger is to be designed to condense a vapour at the rate of 10 kg/sec which is available at its saturation temperature of 80^{o}C. The latent heat of condensation of vapour is 550 kJ/kg. The cooling water at 20^{o}C and a flow rate of 70 kg/sec is used to remove the heat. Determine the LMTD of the heat exchanger.	5

Section C: Long Question

		Marks
01	Write short notes on following refractory properties and their significance. a) Porosity b) Bulk density c) Pyrometric cone equivalent d) Thermal conductivity	10
02	A process industry consuming 10 TPH of saturated steam at 10 kg/sq.cm(g) pressure has been using coal as fuel in boiler. Typical ultimate analysis of the coal: Carbon : 41.11% Hydrogen : 2.76 % Nitrogen : 1.22 % Oxygen : 9.89 % Sulphur : 0.41% Ash : 38.63	5+5

Water : 5.89
Flue gas temperature = 200°C
Ambient temperature = 30°C
Enthalpy of steam = 668 kcal/kg
Feed water temperature = 80°C
Specific heat of flue gases = 0.23 kcal/kg^{o}C
Boiler efficiency with Indian coal =72 %
GCV of coal = 4,000 kCal/kg
Oxygen content in dry flue gases = 10%
Annual Hours of operation = 8000 hrs.
Determine:
(i) Quantity of annual coal requirement in tonnes/year
(ii) Calculate % dry flue gas losses

03 An oil-fired reheating furnace has an operating temperature of around 1000^{O}C. Average furnace oil consumption is 440 litres/hour. The flue gas exit temperature after the air preheater is 300^{O}C. Combustion air is preheated from ambient temperature of 35^{O}C to 200^{O}C through the air preheater. 10

The other data are as given below.

Specific gravity of oil = 0.92
Calorific value of oil = 10,200 kcal/kg
Average O_2 percentage in flue gas = 14%
Theoretical air required = 14 kg of air per kg of oil
Specific heat of air = 0.24 kcal/kg^{O}C
Specific heat of flue gas = 0.23 kcal/kg^{O}C
Find out the sensible heat carried away by the exhaust gases and heat recovered by the combustion air in kcal/hr as a percentage of the energy input.

04 A counter flow double pipe heat exchanger using hot process liquid is used to heat water which flows at 20 m3/hr. The process liquid enters the heat exchanger at 180^{0}C and leaves at 130^{0}C. The inlet and exit temperatures of water are 30^{0}C and 90^{0}C. Specific heat of water is 4.187 kJ/kg K. Calculate the heat transfer area if overall heat transfer coefficient is 820 W/m2 K. What would be the percentage increase in the area if fluid flow were parallel assuming same overall heat transfer coefficient? 10

05 a) List the advantages of CFBC boilers over AFBC boilers. 5+5

b) What are the advantages of plate heat exchanger over shell and tube heat exchanger?

06 Draw a block diagram of a typical heat pump. What are the advantages of heat pumps? 5+5