Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: **CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL**	EXAMINER**:** **JJ Pienaar**
PAPER 2 – THERMAL ENGINEERING	MODERATOR: **Marthinus v/d Bank**
SUBJECT CODE: **COMMEC2**	
EXAMINATION DATE: **10 May 2023**	TOTAL MARKS: **[100]**
TIME: **14:30 – 17:30 (3 HOURS)**	PASS MARK: **(60%)**

NUMBER OF PAGES: **05**

SPECIAL REQUIREMENTS:

THIS IS **NOT** AN **OPEN BOOK EXAMINATION**.
FORMULA HANDOUTS AVAILABLE INSTRUCTIONS TO CANDIDATES:

1. Answer all 4 questions **legibly** in English.
2. Write your **ID number** on the outside cover of each book used and on any graph paper or other loose sheets handed in.

NB: Your name **must not** appear on any answer book or loose sheets.

3. Show all calculations and **check calculations on which the answers are based**.
4. Hand-held electronic calculators may be used for calculations.
5. Write **legibly** in ink on the **right hand page** only – **left hand pages will not be marked**.
6. Illustrate your answers by means of sketches or diagrams wherever possible.
7. Answers must be given to an accuracy which is typical of practical conditions.

NB: Ensure that the correct unit of measure (SI unit) is recorded as marks will be deducted from answers if the incorrect unit is used. (Even if the calculated value is correct).

8. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
9. Cell phones and any other electronic devices are **NOT** allowed in the examination room. **Only Calculator**
10. **The following chart is included: Psychrometric chart: 115 kPa**

QUESTION 1

1.1. Define the following:

1.1.1	Superheat.	(3)
1.1.2	Dalton's law.	(4)
1.1.3.	Thermodynamic wet-bulb temperature.	(4)
1.1.4.	Normal temperature and pressure (N.T.P.)	(1)
1.1.5.	Isothermal Process	(1)
1.1.6.	Wet-bulb temperature	(3)

1.2. Briefly describe three processes of heat transfer and give two properties which influence the rate of heat transfer for each of these processes (12)

1.3. Give typical conductivity values for the following materials: (2)

1.3.1 HDPE
1.3.2 Still air
1.3.3 Still water
1.3.4 Glass 1

Total Marks: (30)

QUESTION 2 (General Calculations)

2.1 An un-insulated galvanized steel pipe, 100mm in diameter, carrying water at a temperature of 80.0 ºC, passes through an office.
The office dimensions are: 10m (long) x 6m (wide) x 3m (high). This pipe traverses the full length of the office.

The office has an average temperature of 24.0 ºC. The walls of this office have an emissivity value of 0.95 and the emissivity value of the galvanised pipe is 0.8.

Determine the rate, in kilowatts (kW), at which heat is radiated from the hot water pipe into this office. (10)

2.2 The heat-produced effect of rock in an ore pass needs to be determined. The temperature of the rock that enters the ore pass is 31.0 ºC. The thermal capacity of the rock is 825 J/kgºC. The rate of rock transfer through the ore pass is 850 tons/hour.

The height through which the rock falls is 100 m. The mining ore is discharged onto a conveyor belt. The temperature of the air at the shaft bottom is 27.0/29.0 ºC.

Determine the heat load from the ore on the conveyor belt. (5)

Total Marks: (15)

QUESTION 3 **(Psychrometry)**

3.1. The following measurements were taken at a counter-flow cooling coil:

Air circuit:		**Water circuit:**	
Inlet ventilation flow rate:	8.2 m³/s	Water flow rate:	6.0 l/s
Inlet air temperature:	29.0/30.1 ºC	Water inlet temperature:	13.5 ºC
Discharge temperature:	23.1/23.1 ºC	Water outlet temperature:	22.5 ºC
Barometric pressure:	102.5 kPa		

Assume that air pressure loss across this coil is negligible. The following psychrometric values (tabulated below) for the air on both sides of the coil were obtained from the psychrometric charts.

Coil Intake		**Coil Discharge**	
Sigma Heat	90.9 kJ/Kg	Sigma Heat	90.9 kJ/Kg
Apparent Specific Humidity	24.9 g/Kg	Apparent Specific Humidity	24.9 g/Kg
Apparent Specific Volume	0.883 m³/Kg	Apparent Specific Volume	0.883 m³/Kg

Determine the following:

3.1.1. Calculate true density of the air entering the coil. (2)

3.1.2. Calculate duty of the coil (from both air and water circuits). By means of a heat balance, determine the accuracy of this duty, comment on your findings. (5)

3.1.3. Determine the overall heat transfer co-efficient (UA value) of this coil.
Given that: q = UA x LMTD (3)

q = duty of coil (kW)
UA = heat transfer co-efficient (kW/ºC)
LMTD = log mean temperature difference

3.2. When conditions are measured with the following parameters:

70.0 m³/s air at a temperature of 27.5/31.0 ºC enters a stoping section at a barometric pressure of 115 kPa. If the maximum allowable wet-bulb temperature in the stopes is 29.5 ºC, determine the heat absorption capacity of the air. (8)

3.3. When conditions are measured with the following parameters:

49.0 m³/s of air at a temperature of 24.5/27.5 ºC is mixed with 24.7 m³/s of air at a temperature of 32.0/33.5 ºC. The barometric pressure is 115kPa.

Determine the temperature of the mixture. (17)

Total Marks: (35)

QUESTION 4 **(Refrigeration)**

4.1. The following measurements were taken at an underground refrigeration plant:

Evaporator:		**Condenser:**	
Water Flow rate:	85.0 l/s	Water Flow rate:	128.0 l/s
Water inlet temperature:	14.4 ºC	Water inlet temperature:	31.3 ºC
Water outlet temperature:	3.5 ºC	Water outlet temperature:	40.9 ºC
Evaporating temperature:	0.9 ºC	Condensing temperature:	44.9 ºC
Evaporating pressure:	186.5kPa	Condensing pressure:	1046.6 kPa

Compressor:

Motor current:	117.9 A
Voltage:	6.6 kV
Power factor:	0.82
No. of phases:	3
Motor efficiency:	97%

Cooling at coils: 2867 kW

The type of refrigerant used in the plant is R134a. The barometric pressure inside the plant room was 112.5 kPa. Assume that all gauge pressures are correct. Below is a short extract from the tabulated properties of saturated refrigerant R134a

Temperature (ºC)	Absolute pressure (kPa)
0	293
2	315
4	338
6	363
8	388
10	416
40	1017
42	1075
44	1133
46	1191
48	1256
50	1321

4.1.1. Determine the plant duty. (2)

4.1.2. Conduct a heat balance of this plant and comment on your findings. (9)

4.1.3. Determine the Carnot COP of this plant, (note, it is suspected that the measured evaporating and condensing temperatures are incorrect). (5)

4.1.4. Determine the actual COP of this plant. (1)

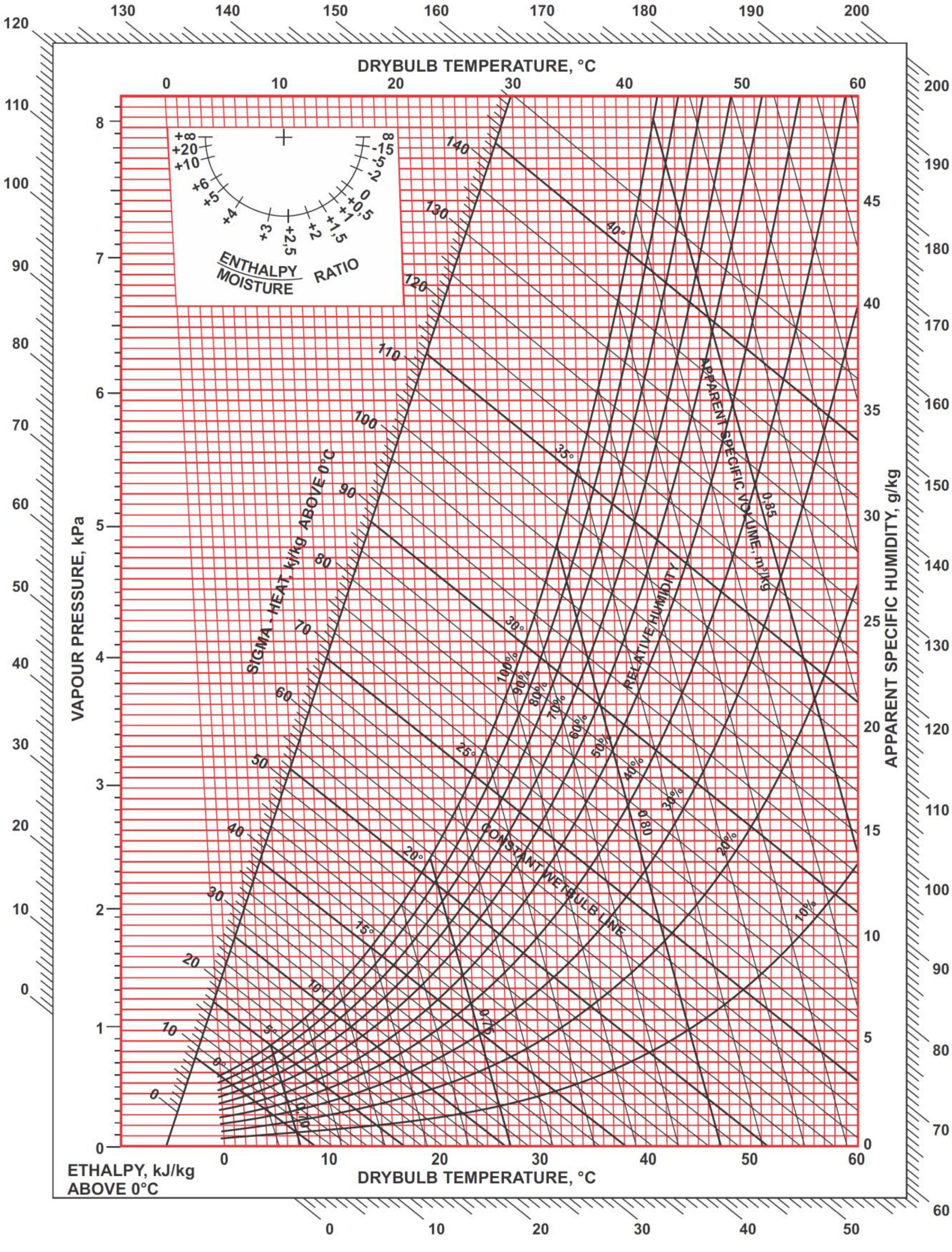
4.1.5. Determine the cycle efficiency of this plant. (1)

4.1.6. Explain the relevance of the Carnot COP. (1)

4.1.7. Determine the positional efficiency of this plant. (1)

Total Marks: (20)

PSYCHROMETRIC CHART
115,0 kPa



A.W.T.B.