Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: **CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL**	EXAMINER: **JOHAN PIENAAR**
PAPER 2 – THERMAL ENGINEERING	MODERATOR: **MARTHINUS VD BANK**
SUBJECT CODE: **COMMEC2**	
EXAMINATION DATE: **08 October 2025**	TOTAL MARKS: **[100]**
TIME: **14:00 – 17:00 (3 HOURS)**	PASS MARK: **(60%)**

NUMBER OF PAGES: **7** (including this one)

SPECIAL REQUIREMENTS:

All candidates are advised to read the below instructions/requirements and adhere to them. Not adhereing to them could lead to the loss of marks.

THIS IS **NOT** AN **OPEN BOOK EXAMINATION**. FORMULA HANDOUTS AVAILABLE

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. You are encouraged to make use of the **CoMCert Tip-off Hotline** whenever you witness or suspect any wrongdoing related to the CoMCert Examinations on landline **0800 118 998** or alternatively you can use email **COMCert@tip-offs.com**. This tip-off hotline and tip-off email is managed anonymously and confidentially through an independent service provider.
11. **The following chart is included: Psychrometric chart: 85.0 kPa and PH Diagram: Refrigerant R134 A**

QUESTION 1

1.1 In an underground mining operation, two front-end loaders are used. Each loader performs mechanical work at a rate of 45 kW under full load.
Loader A is diesel-driven, consuming 13.5 litres of diesel fuel per hour under full load.
Loader B is electrically driven, with an overall efficiency of 95%.

Assume the calorific value of diesel fuel is 38 MJ/Liter.

1.1.1 Calculate the energy input per hour for Loader A in megajoules (MJ). (2)

1.1.2 Determine the mechanical energy output per hour for Loader A in MJ. (2)

1.1.3 Calculate the overall efficiency of Loader A. (1)

1.1.4 Calculate the electrical energy input required per hour for Loader B in MJ. (1)

1.1.5 Compare the energy input of both loaders and discuss which is more energy efficient and why. (1)

1.2. 500 l/s of chilled service water at 1.2°C flows from a surface storage reservoir into two 353 mm diameter shaft feed columns. The first feed column (Feed Column No. 1) discharges directly into a dam situated 2100 m below the surface. The second feed column (Feed Column No. 2) drives an electrical turbine before discharging into the same dam. The turbine has an efficiency of 79.3%. Both shaft feed columns are new, and for a flow rate of 250 l/s, the head loss due to friction (hf) is 1.7 m per 100 m. Ignore thermal losses across the insulation of both feed columns.

Determine the following:

1.2.1. Calculate the temperature of the water discharged from Feed Column No. 1 into the dam. (7)

1.2.2. Calculate the temperature of the water discharged from Feed Column No. 2 into the dam, assuming the turbine extracts energy based on its efficiency and the same frictional head loss applies. (8)

1.2.3. Assuming the water discharged from both feed columns mixes evenly in the dam, calculate the final temperature of the water in the dam after mixing. (3)

Total Marks: (25)

QUESTION 2

2.1 The following measurements were taken on a surface refrigeration plant using R134a as the working fluid. Refer to Figure 5: Pressure-Enthalpy Diagram for Refrigerant R134a to answer the questions below.

Measured data:

Evaporator inlet pressure	= 0.2 MPa
Evaporator outlet pressure	= 0.2 MPa
Evaporator outlet enthalpy	= 410 kJ/kg
Compressor outlet pressure	= 1.2 MPa
Compressor outlet enthalpy	= 450 kJ/kg
Condenser outlet enthalpy	= 270 kJ/kg
Mass flow rate of refrigerant	= 0.05 kg/s

2.1.1. Using the p-h diagram, identify the state points of the refrigerant at the evaporator inlet, evaporator outlet, compressor outlet, and condenser outlet. (6)

2.1.2. Calculate the refrigeration effect (in kW) provided by the evaporator. (4)

2.1.3. Calculate the work input to the compressor (in kW). (4)

2.1.4. Determine the Coefficient of Performance (COP) of the refrigeration cycle. (3)

2.1.5. Briefly explain how the shape of the p-h diagram helps in visualising the refrigeration cycle and identifying inefficiencies. (3)

Total Marks: (20)

QUESTION 3

3.1. An air / water vapour mixture has the following properties:

Wet bulb temperature: 27.5°C

Dry bulb temperature: 32.5°C

Barometric pressure: 110kPa

Using first principles, calculate the following barometric properties:

3.1.1. Vapour pressure (pw) (2)

3.1.2. Dew point temperature (T_{dp}) (2)

3.1.3. Density (w) (2)

3.1.4. Sigma energy (S) (4)

3.2. 300 m³/s of air at a temperature of 13.6/20.0ºC enters a 1 800m deep downcast shaft. The barometric pressure is 85.0 kPa. During its passage down the shaft the air picks up heat from the surroundings at a rate of 1,15 kJ/kg per 300m and moisture from the surroundings at a rate of approximately 0,5 g/kg per 200m.

Determine the following:

3.2.1. The wet-bulb and dry-bulb temperature of the air at the end of the airway. (15)

Total Marks: (25)

QUESTION 4

4.1. Please explain the 9 steps required for the Hyland and Wexler's calculations method for equations and numerical values needed to calculate psychrometric properties of temperatures and pressures? (9)

4.2. List and briefly describe a type of heat index which would be best suited to:

4.2.1. The underground workings of a deep South African mine (5)

4.2.2. An open pit operation in Central Africa. (3)

4.3. Give brief explanation for the following terms:

4.3.1. Normal temperature and pressure (N.T.P.) (2)

4.3.2. Standard vair (2)

4.3.3. Temperature of adiabatic saturation (4)

4.3.4. Enthalpy (total heat) (3)

4.3.5. Humid thermal capacity of vair (2)

Total Marks: (30)

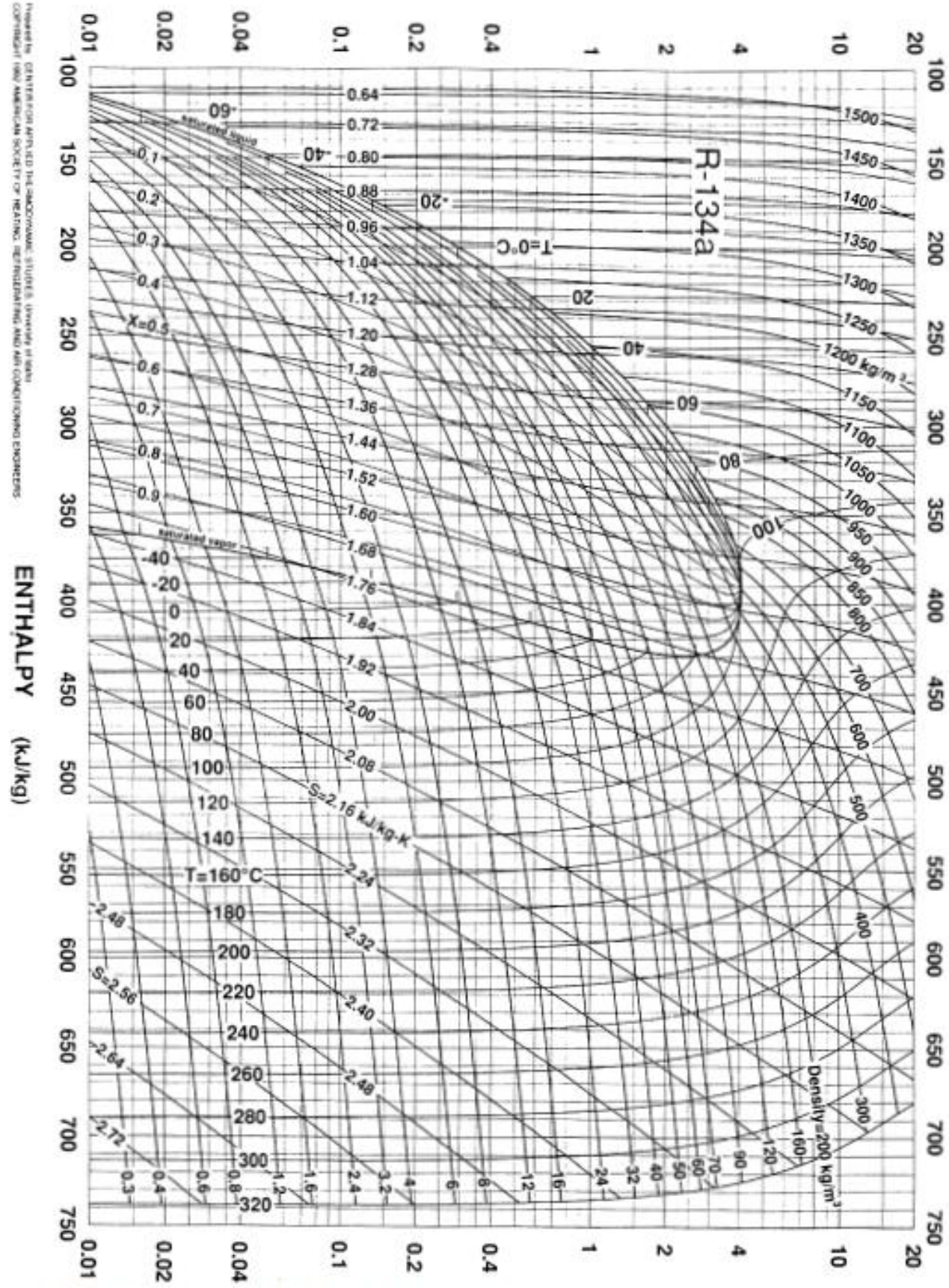
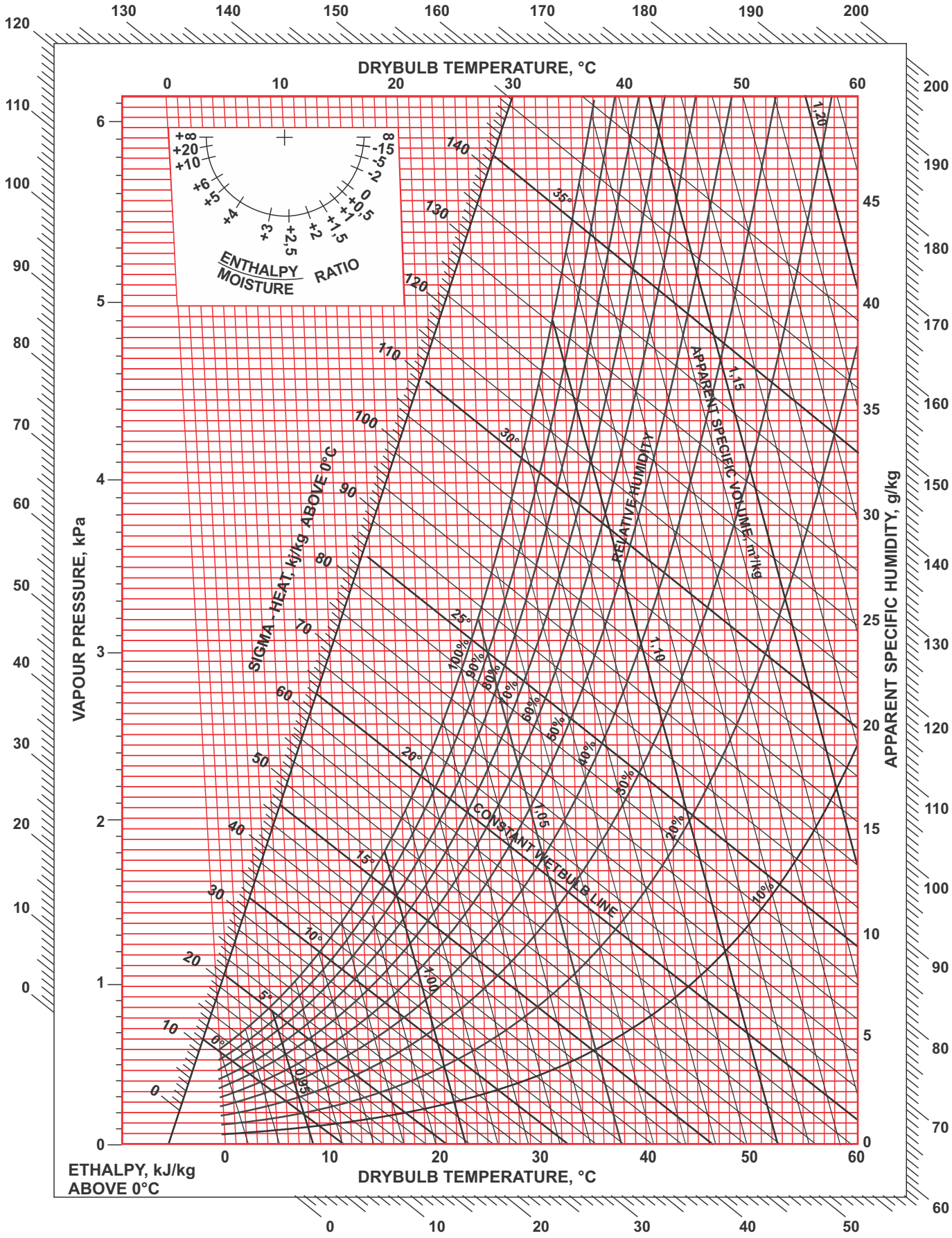


Figure 5. Pressure-Enthalpy Diagram for Refrigerant 134a

PSYCHROMETRIC CHART
85,0 kPa



A.W.T.B.

CHART NO 4
85,0 kPa