Minerals Council South Africa

EXAMINATION PAPER

SUBJECT:**CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL** **PAPER 2 – THERMAL ENGINEERING** SUBJECT CODE: **COMMEC2** EXAMINATION DATE: **10 October 2018** TIME: **14:30 – 18:00 (3½ HOURS)**	EXAMINER**: Eugene Botha** MODERATOR: **Marco Biffi** TOTAL MARKS: **[100]** PASS MARK: **(60%)**

NUMBER OF PAGES: **6**

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 are **NOT** allowed in the examination room.

QUESTION 1. **(20)**

The following measurements were made during a routine check on the performance of an underground refrigeration plant.

Evaporator

Water flow rate	39,7 l/s
Inlet water temperature	22,8 ºC
Delivery water temperature	7,7 ºC
Evaporating pressure (absolute)	341 kPa

Condenser

Water flow rate	70,2 l/s
Inlet water temperature	37,3 ºC
Delivery water temperature	44,8 ºC

Condensing pressure (absolute) 1 201 kPa

Barometric pressure	116 kPa
Electric input power to compressor motor	645 kW
Compressor discharge temperature	66ºC

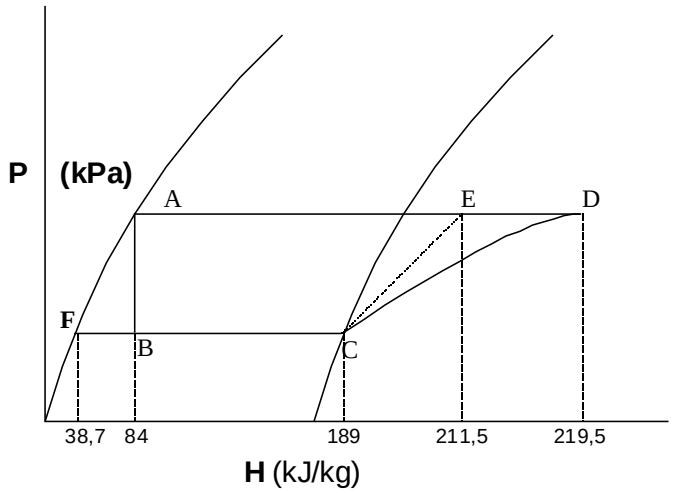
The plant operates a single stage refrigerant 12 compressor. The compressor is driven via a gearbox and gearbox and motor efficiencies are 98% and 94% percent respectively. Previous measurements on this cooling plant have indicated that water flow rate measurements in the condenser and evaporator are suspect, but that the electrical input power is known to be a reliable measurement as are the condensing and evaporating pressures.

The values as plotted on a Pressure-Enthalpy diagram are as follows:

HA =84 kJ/kg HD =219,5 kJ/kg

HB =84 kJ/kg HE =211,5 kJ/kg

HC =189 kJ/kg HF =38,7 kJ/kg



The specific volume of the refrigerant at the compressor inlet is 0,052 m^3/kg. Using the results from the pressure-enthalpy diagram and calculate the following:

1.1 The gauge pressures for the condenser and evaporator (2)

1.2 The compressor efficiency (2)

1.3 The actual work of compression (in kW) (2)

1.4 The ideal work of compression and heat losses in compressor expressed in kW (3)

1.5 The refrigerant mass flow (1)

1.6 The refrigerant volume flow rate at the compressor inlet (1)

1.7 The plant duty (kW) (1)

1.8 The correct evaporator and condenser water flow rate expressed in litres/second (7)

1.9 The correct final heat balance with correct water flow rates (1)

QUESTION 2. **(25)**

A base metal mine is extending its workings and you are required to determine whether acclimatisation will be necessary (a reject temperature of higher than 27.5°C will necessitate acclimatisation). Information from 12 different stopes near the new stoping section is summarised in the table below. The air will reach the new stoping section (which consists of 3 stopes in series) at 23.5/26.5°C, and 15 m^3/s is available and will be used in series for each stope.

The mean virgin rock temperature of each stope is 35.3°C, 34.3°C and 33.3°C respectively. Assume that

- the air leaves each stope with a dry-bulb temperature of 2°C higher than the wet-bulb temperature;
- The barometric pressure for each stope remains the same for each stope;
- No additional air is injected into successive stopes;
- Heat load from stope equipment and moisture is ignored.

Calculate the wet-bulb temperature leaving each stope on its way to the next stope and state whether acclimatisation is necessary. The barometric pressure is 95 kPa.

Note: A simple method of expressing the heat gain in a stope is as a function of the difference between the virgin rock temperature and the entering dry-bulb temperature.

Air entering the stope		Air leaving the stope		Qty	VRT	Stope heat gain
wet-bulb (°C)	Dry-bulb (°C)	wet-bulb (°C)	Dry-bulb (°C)	(m3/s)	(°C)	(kW)
18.5	21.0	21.5	22.0	18.3	32.3	212
22.5	24.0	23.8	24.2	24.3	30.6	136
20.2	22.0	22.5	23.0	20.2	32.3	184
18.5	20.5	22.8	23.3	13.9	32.3	230
17.6	19.1	20.8	21.4	8.6	23.6	100
12.4	14.7	15.3	16.9	24.9	23.7	187
17.0	19.5	21.0	22.3	6.7	23.7	96
20.5	21.6	25.4	26.2	8.0	30.3	166
23.2	25.1	24.4	24.8	10.8	27.3	53
18.4	19.9	19.7	20.5	16.2	22.7	76
22.0	25.5	24.4	26.0	16.4	33.3	153
20.5	25.0	22.8	26.3	17.3	33.3	160

QUESTION 3. (25)

(a) Use the Steady Flow Energy equation to discuss the heat that is added to the air by the use of fans underground. (3)

(b) The following measurements were taken at an underground booster fan inlet: (13)

Intake air volume	236 m^3/s
Fan pressure	5 kPa
Temperature	24 / 27 °C
Barometric pressure	115 kPa
Power input to fan motor	1 775 kW
Motor efficiency	95 %

(i) Determine the condition at the fan discharge
(ii) What are the efficiency and overall efficiency of the fan

(c) The following measurements were taken at the inlet of an underground hoist chamber. (9)

Temperature	26.3 / 29.5 °C
Barometric pressure	115 kPa
Hoist motor input power	2 170 kW
Motor efficiency	87 %

What air quantity must be supplied to the hoist chamber to ensure that the wet-bulb temperature in the chamber does not exceed 28.5 °C wet-bulb?.

QUESTION 4. (10)

4.1 In a stope, the ventilation air has a speed of 1m/s. Calculate the rate at which heat is removed form a worker by convection, assuming that his body has an average diameter of 200 mm. (3)

Assume, further, that:

a) The workman has a skin area of 1.5 m^2, and an average skin temperature of 35°C.

b) The condition of the air is 29°C wet-bulb, 31°C dry-bulb and a 100 kPa pressure.

4.2 A steam pipe in a processing plant is 26 mm in diameter and is covered with insulation 50 mm thick. The conductivity of the insulating material is 0.2 W/m°C. Calculate the heat loss per metre length of pipe if the temperatures of the inner and outer surfaces of the insulation are 300°C and 40°C.

4.2.1 Using the average area (3)

4.2.2 Using the log mean area (3)

4.2.3 What is the percentage error when using the different areas to calculate the heat loss? (1)

QUESTION 5. (20)

5.1.1 Name two commonly used refrigerants employed in underground refrigeration plants.(2)

5.1.2 Non-corrosive and non-flammable are two properties of an ideal refrigerant name 3 other properties that a refrigerant should have ideally (3)

5.2.1 Sketch an underground vertical cooling tower with typical operating conditions. (6)

5.2.2 What are the limitations of such towers? (2)

5.3.1 Sketch a coil type cooling car with typical flow rates and temperatures. (5)

5.3.2 If a survey of such a coil showed that its performance had worsened since the last survey what would you suspect? (state any two conditions) (2)