Minerals Council South Africa

EXAMINATION PAPER

SUBJECT:**CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL**	EXAMINER**: Marthinus v/d Bank**
PAPER 2 – THERMAL ENGINEERING	MODERATOR: **Marco Biffi**
SUBJECT CODE: **COMMEC2**	
EXAMINATION DATE: **14 May 2018**	TOTAL MARKS: **[100]**
TIME: **<u>14:00 – 17:30 (3½ HOURS)</u>**	PASS MARK: **(60%)**

NUMBER OF PAGES: **12**

SPECIAL REQUIREMENTS:

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

INSTRUCTIONS TO CANDIDATES:

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

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

3. Show all calculations and **<u>check calculations on which the answers are based</u>**.
4. Hand-held electronic calculators may be used for calculations.
5. Write **<u>legibly</u>** in ink on the **<u>right hand page</u>** only – **<u>left hand pages will not be marked</u>**.
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.

<u>NB</u>: 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 **<u>NOT</u>** allowed in the examination room. **<u>Only Calculator</u>**
10. **<u>The following charts to be included: PH Diagram 134a; Psychrometric charts: 85.0kPa, 95.0kPa, 97.5kPa, 100.0kPa, 105.0kPa and 115kPa.</u>**

QUESTION 1.

1.1 The heat production in a stope is 2kW/m of face when the entering stope wet-bulb temperature is 26ºC. Air enters the stope at 26/29ºC.

Assume that the wet-bulb temperature in the stope is 1ºC lower than the temperature of the air leaving the stope. It is considered essential that a wet-kata of 12 is to be maintained at the mean stope face wet-bulb temperature.

It has been determined empirically that the mean stope face velocity can be expressed as:

$$V = 0{,}2 \times \sqrt{Q}$$

where V = mean stope face velocity (m/s)

Q = quantity entering the stope (m^3/s)

Consider stope quantities between 10 and 20 m^3/s and determine what is the minimum quantity of air that should be supplied to the stope to meet the conditions required without refrigeration, if the stope face length is 150 m. Assume that the difference between the ventilated and unventilated wet-bulb is insignificant. Barometric pressure is 100 kPa.

In your calculations you have to write the Sigma heat gain in the stope in terms of a Q value. (**Hint**: You have to eventually draw a graph of the Wet kata versus various entering quantities, to be able to read off the actual quantity required, graph paper attached). (15)

1.2 Give brief explanation for the following terms:

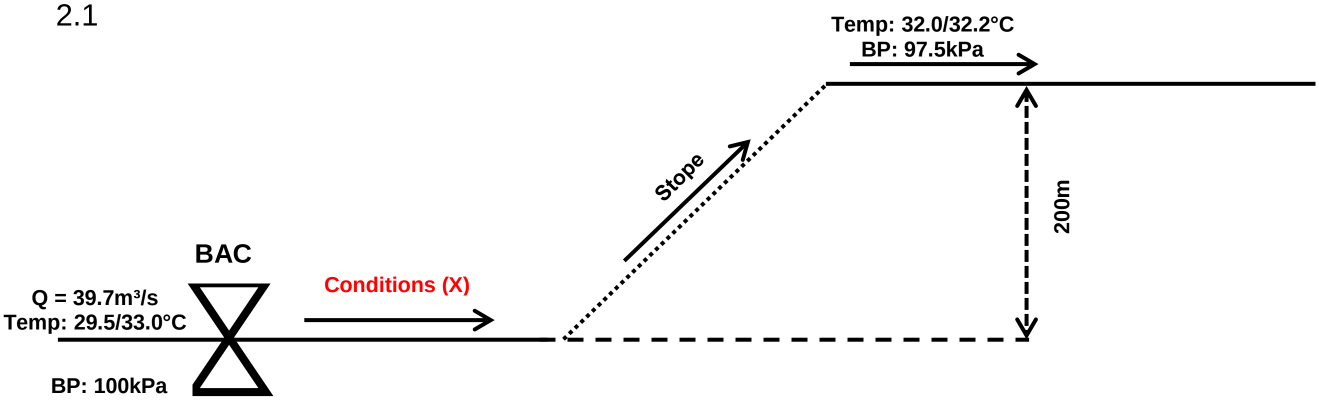
- Dry-bulb Temperature
- Wet-Bulb Temperature
- Dew-point temperature
- Super Heat
- Enthalpy

(5)

(20)

QUESTION 2.

2.1



The above sketch shows various measurements made in a section of a mine.
Determine:

2.1.1 The duty of the bulk cooling installation
2.1.2 The amount of water condensed in the bulk cooling installation
2.1.3 The heat sources in the stope
2.1.4 The amount of water evaporated into the air in the stope

NOTE: Air conditions (X) at outlet from the bulk air cooler are:
BP: 100kPa; Temp: 25.0/25.0 ºC (15)

2.2 The following measurements were taken at an underground booster fan inlet:

Intake air volume	236 m^3/s
Fan pressure	5.0 kPa
Temperature	24.0/27.0ºC
Barometric pressure	115 kPa
Power input to fan motor	1 775 kW
Motor efficiency	95%

2.2.1 Determine air conditions at the fan discharge (10)
2.2.2 What are the efficiency and overall efficiency of the fan (5)

(30)

QUESTION 3.

3.1 The following measurements were taken at a condenser cooling tower:

Quantity entering tower	230 m^3/s
Air temperature entering	31.5/32.0^{0}C
Air temperature leaving	38.0^{0}C saturated
Water temperature entering	47.0^{0}C
Water temperature leaving	40.0^{0}C
Barometric pressure	105 kPa

Assume heat added to air is hear removed from water.

Determine:

3.1.1 Total heat added to the air
3.1.2 The water flow rate through the tower
3.1.3 Has water evaporated or condensed
3.1.4 How much water has evaporated or condensed in litres per day. (24 hours) (15)

3.2 Calculate the density of the dry air at 95 kPa and a temperature of 30.0ºC dry bulb using the ideal gas law (5)

(20)

QUESTION 4.

4.1 The following measurements were taken at a surface refrigeration plant (using refrigerant R134A).

Barometric Pressure in plant room = 85kPa
Evaporator water flow rate = 98 l/s
Evaporator inlet water temperature = 18.8^{O}C
Evaporator outlet water temperature = 6.1^{O}C
Evaporating pressure = 202 kPa (gauge)
Condensing pressure = 661 kPa (gauge)
Condensing temperature = 29.0^{O}C
Evaporator inlet temperature = -1.0^{O}C
Compressor outlet temperature = 52.0^{O}C

NB: Attached chart 4 (ph chart R134A) will be required to answer the following questions.

On this chart, clearly indicate all points plotted to obtain your answer; remember to submit this chart with your answer book(s).

4.1.1 Plot the refrigeration cycle on this ph diagram, indicating the main components of the cycle. (10)
Briefly describe what happens to the refrigerant at each component of the cycle.

4.1.2 From the ph diagram, calculate the heat balance of this refrigeration plant. (10)

4.1.3 From the ph diagram, calculate the Carnot COP of this refrigeration plant. (2)

4.1.4 From the ph diagram, calculate the Cycle COP of this refrigeration plant. (2)

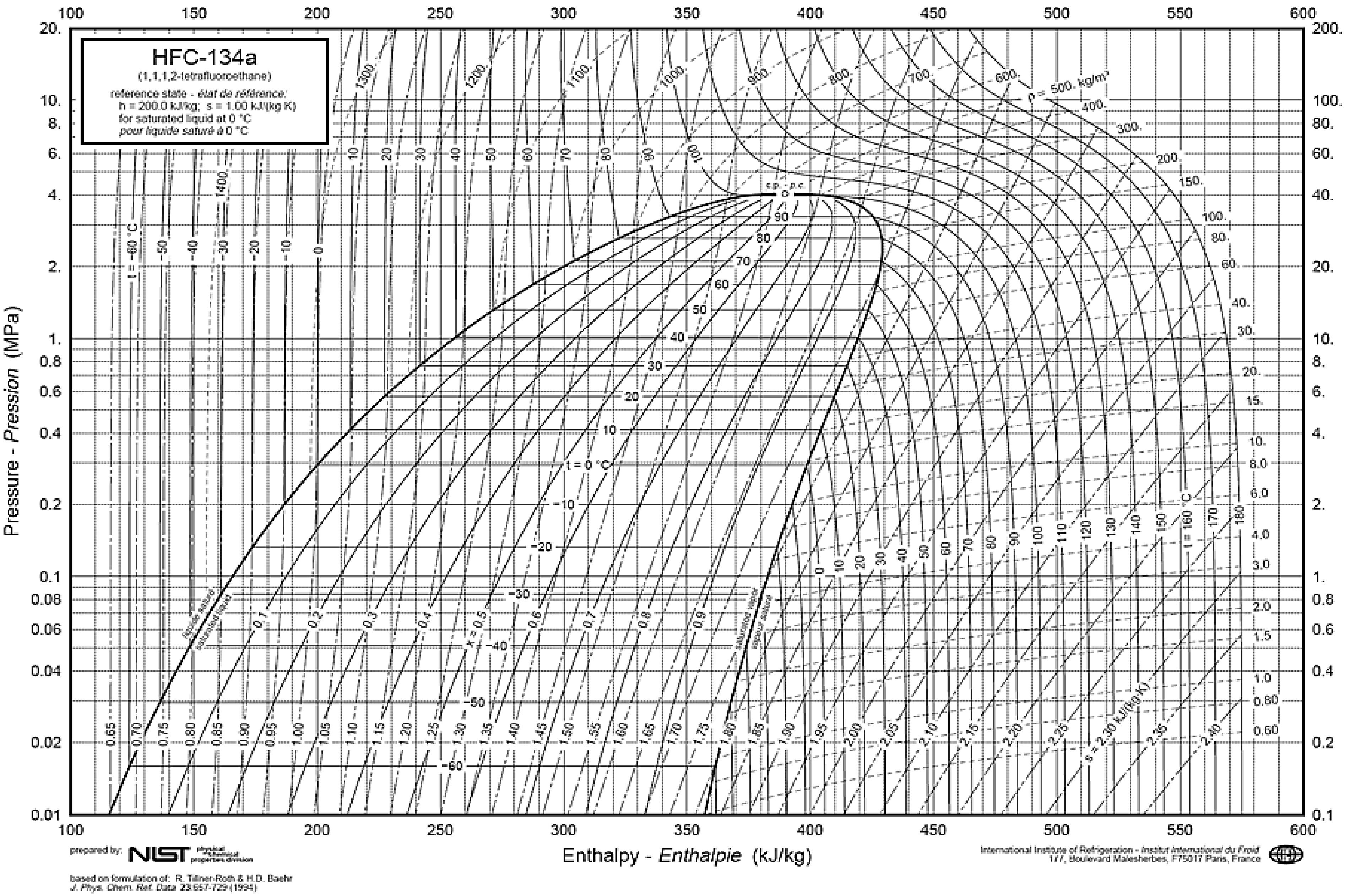
4.1.5 From the ph diagram, calculate the Cycle efficiency of this refrigeration plant. (2)

4.1.6 From the ph diagram, calculate the percentage (%) flash gas in the evaporator of this refrigeration plant. (2)

4.1.7 Briefly comment on the differences (if any) between your answers to 4.1.3 and 4.1.4 (2)

(30)

Question 4


HFC-134a
(1,1,1,2-tetrafluoroethane)
reference state - état de référence:
h = 200.0 kJ/kg; s = 1.00 kJ/(kg K)
for saturated liquid at 0 °C
pour liquide saturé à 0 °C
Pressure - Pression (MPa)
Pressure - Pression (bar)
Enthalpy - Enthalpie (kJ/kg)
c.p. - p.c.
saturated liquid
liquide saturé
saturated vapor
vapeur saturée
ρ = 500. kg/m³
s = 2.30 kJ/(kg K)
t = 160 °C
prepared by: NIST physical & chemical properties division
based on formulation of: R. Tillner-Roth & H.D. Baehr
J. Phys. Chem. Ref. Data 23 657-729 (1994)
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