# Minerals Council South Africa

**EXAMINATION MEMORANDUM**

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| **SUBJECT:**<br>CHAMBER OF MINES OF SOUTH AFRICA – INTERMEDIATE CERTIFICATE IN MINE ENVIRONMENTAL CONTROL<br>PAPER 2 | **EXAMINER:** JJ PIENAAR<br><br>**MODERATOR:** N. KRUGER |
| **SUBJECT CODE: COMIMEC2** | |
| **EXAMINATION DATE: 14 OCTOBER 2019** | **TOTAL MARKS:** 100 |
| **TIME**: 14:30 – 17:30 | **PASS MARK:** 60 |

**NUMBER OF PAGES: 10**

SPECIAL REQUIREMENTS:
THIS IS **NOT** AN OPEN BOOK EXAMINATION. THERE IS **NO** FORMULA HANDOUT

INSTRUCTIONS TO CANDIDATES:
1. Answer all questions **legibly** in English.

Write your **ID number** on the outside cover of each book used and on any graph paper or other loose sheets handed in. **Psychrometric chart at 107.5 kPa is provided for Question 3.**
**NB:** Your name **must not** appear on any answer book or loose sheets.

2. Show all calculations **and check calculations on which the answers are based.**
3. Hand-held electronic calculators may be used for calculations.
4. Write **legibly** in ink on the **right hand page** only – **left hand pages will not be marked**.
5. Illustrate your answers by means of sketches or diagrams wherever possible.
6. Answers must be given to an accuracy which is typical of practical conditions.
   **NB** Ensure that the correct unit of measure (SI unit) are recorded as marks will be deducted from answers if the incorrect unit is used. (Even if the calculated value is correct).
7. In answering the questions, full advantage should be taken of your practical experience as well as data given.
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** **(Definitions)**

1.1. Define the term Occupational Hygiene in terms of MHSA (29 of 1996). (2)
Means the anticipation, recognition (½), evaluation and control (½) of conditions (hazards) at the mine (½), that may cause illness or adverse health effects (½) to persons.

1.2. Define the term auto compression and give the value per 1000m. (2)
The pressure on the air at the bottom is greater than the top due to extra mass of the air. The air compresses and becomes heated. (1) 9.79 kJ/kg of air per 1000m (1)

1.3. Define apparent specific volume and density and state the units of each. (2)
Apparent specific volume: is the volume of an air-water vapour mixture per unit mass of dry air (½). ($m^3$/kg) (½)
Density: is the mass of dry air per unit volume of an air-water vapour mixture (½). (kg/$m^3$) (½)

1.4. Define the term Airborne Particles. (1)
Is particles that is so small that they remain airborne for a considerable period of time before they settle on the ground.

1.5. Define the term Dust. (1)
Is finely divided solid matter generated during the handling, grinding, crushing, etc. of organic substances such as rock, ore, metal, etc.

1.6. Define the term Threshold Limit Value (TLV). (2)
Refers to the concentration of a hazardous substance (½) to which nearly all workers may be repeatedly exposed to (½) day after day (½) without any adverse effects (½).

1.7. Define the term Occupational Exposure Limit – Short Term Exposure Limit (OEL - STEL) (2)
Means a 15 minute TWA exposure (½) which should not be exceeded at any time during a working day. (½) It should not occur more than four times per day (½) with at least 60 minute intervals between successive exposures in this range. (½)

1.8. Define the term Heat Exhaustion. (1)
Is the most commonly seen heat related disorder for which treatment is sought (½). It is the result of a decline in the circulating volume of blood as a result of dehydration (½)

1.9. Define Evaporation as a heat exchange between man and environment. (1)
Sweat on the skin surface (½) absorbs heat from the skin when evaporating into the air. (½)

1.10. Define Radiation as a heat exchange between man and environment. (1)
The heat transfer from a hot to a cold body (½) by means of heat rays or waves. (½)

1.11. Define the term Medical Surveillance. (2)
Means a planned programme of periodic examination (½), which may include clinical examinations (½), biological monitoring or medical tests (½), of employees by an occupational medical practitioner. (½)

1.12. Define illumination and state the unit. (1)
Is a measure of the brightness of light falling on an object expressed (½) in lux (½)

1.13. Define the term Vibration. (2)
Vibration can be defined as the mechanical oscillation (½), produced by either regular (½) or irregular periodic movement (½) of a body around a central point or its resting point. (½)

**Total Marks:** **(20)**

**QUESTION 2** **(Theory)**

2.1. List and describe two kinds of latent heat with an example of each. (4)

<u>Latent heat of Fusion (1)</u>

That which causes a change of state of a substance from a liquid to a solid, e.g. water that changes to ice. (1)

<u>Latent heat of Evaporation (1)</u>

That which causes a change of state of a substance from a liquid to a vapour, e.g. water that changes into steam (1)

2.2. Convert the following temperatures. (2)

Kelvin (308.2°K) to Celsius 35.2°C (1)

Celsius (29.4°C) to Kelvin 302.4°K (1)

2.3. Explain the effect of water evaporating into air in the underground environment and how this should be prevented. (3)

When water evaporates, sensible heat is taken from intake air and changed to latent heat, evaporating the water (½). When sensible heat is removed from intake air, the dry bulb temperature drops to below the temperature of the rock (½). Heat starts to flow from the rock to the air (½). Heat flow from the rock increases the wet bulb temperature of the air making conditions worse (½). Thus, to reduce heat flow from rock, evaporation of water must be prevented to maintain a large gap between wet and dry bulb temperature (½) and to keep the dry bulb temperature as close as possible to the temperature of the rock. (½)

2.4. State the physiological effects that heat can have on a worker. (5)

Cramps; (1)
Heat rush; (1)
Dehydration; (1)
Heat exhaustion; and (1)
Heat stroke. (1)

2.5. Name and describe the three routes of entry how toxic substances can enter the human body. (6)

<u>Inhalation (1):</u> The respiratory route is the most common and probably the most important route of absorption in the workplace, because the worker inhales the air for the duration of his entire shift. (1)

<u>Ingestion (1):</u> This route of entry is mostly the result of accidental swallowing a hazardous substance and being regarded as being of minor importance (1)

<u>Skin Absorption (1):</u> Some hazardous substances, upon contact with the skin, are absorbed into the skin or bloodstream and transported to other parts of the body (1)

2.6. List and briefly explain six reasons or objectives for sampling airborne pollutants. (6)

To detect any working place / areas with unhealthy conditions. (1)
To determine the cause of air contamination by airborne pollutants. (1)
To indicate the necessary control measures. (1)
To determine effectiveness of suppression methods. (1)
To confirm satisfactory conditions that has been obtained. (1)
To comply with legislation. (1)
To supply records for medical surveillance. (1)
For various research purposes. (1)

2.7. List the three important measures, <u>**in sequence of priority**</u>, which you will implement to control any occupational exposure. (3)

Engineering controls (1)
Administrative controls (1)
Personal protective equipment (1)

2.8. Discuss six properties of an ideal dust filter. (3)

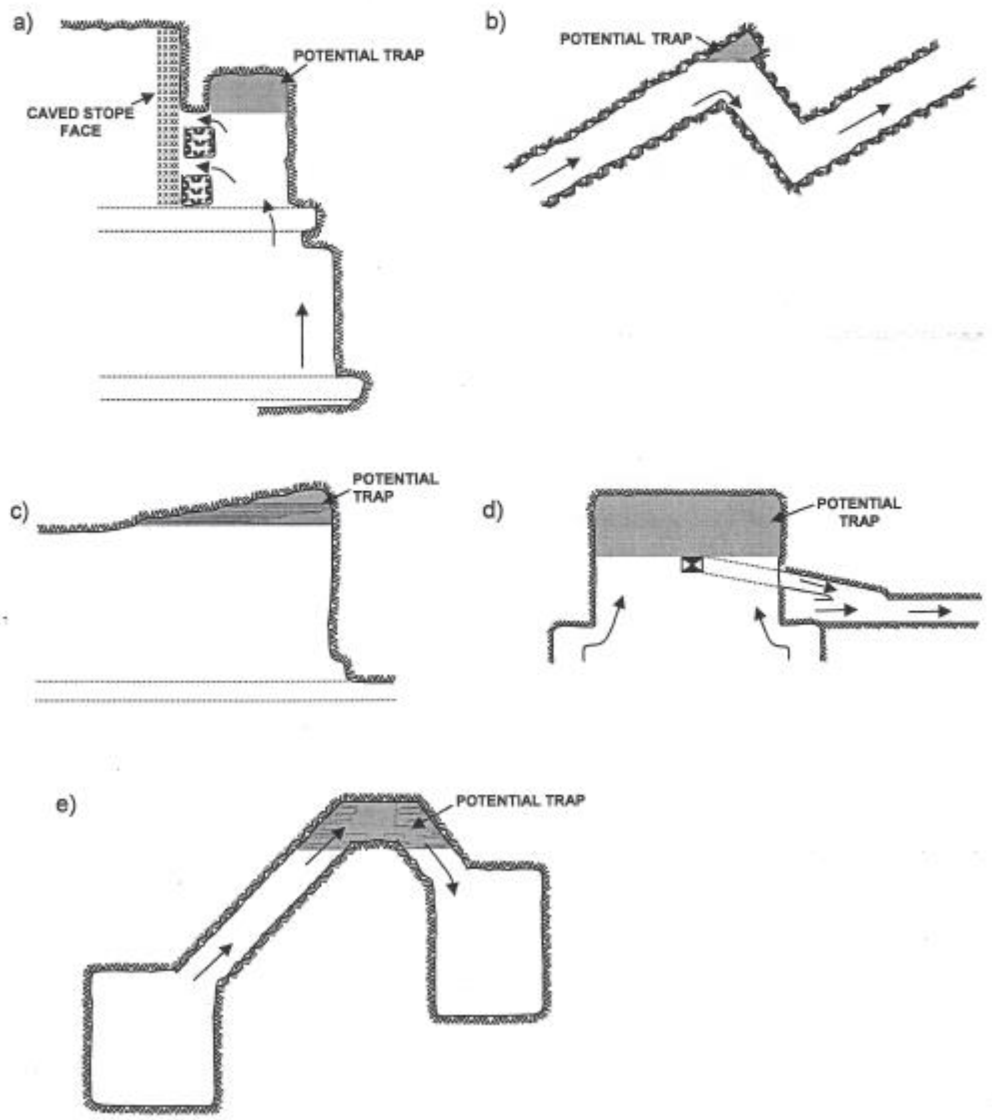
An ideal dust filter should:

• be cheap and easy to install (½)

- have a low capital cost, including the cost of any necessary excavations (½)
- be easy to maintain and clean (½)
- have a satisfactory efficiency, particularly for fine particles (½)
- have a low power consumption (½)
- be reliable (½)

2.9. Mining configurations and methods of mining can sometimes lead to flammable gas traps being formed. Sketch 3 of these typical gas traps? (3)

Answer: (1 mark for each sketch correct, maximum of 3 marks)

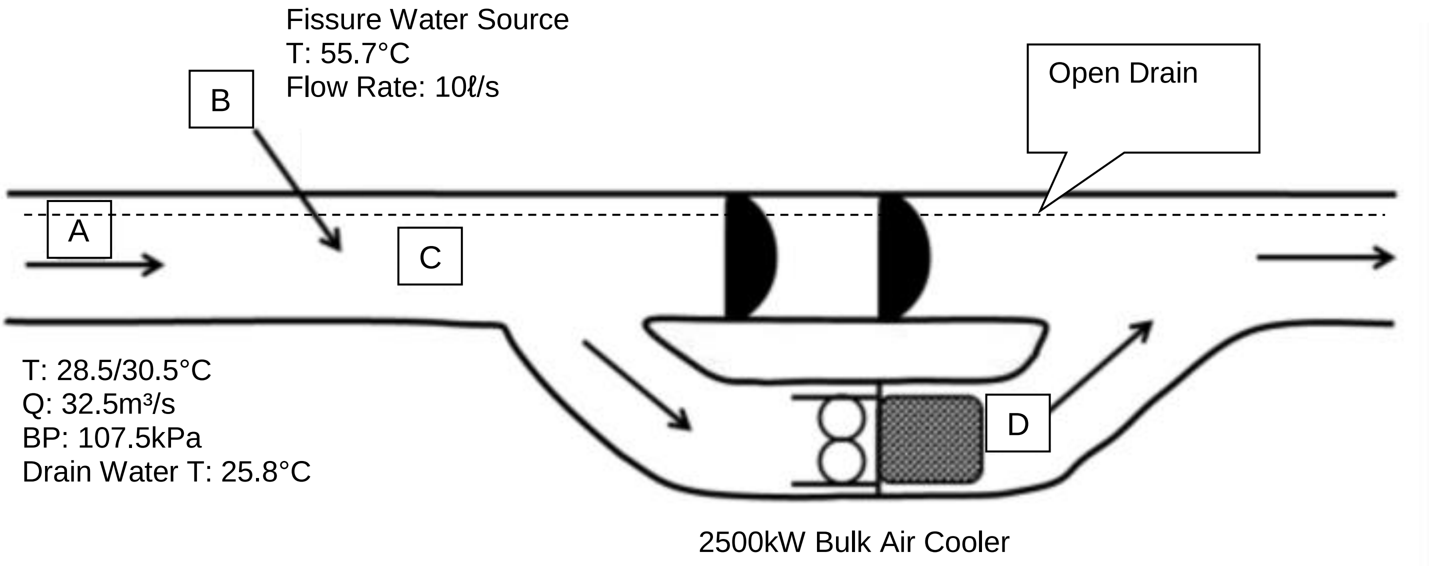



**Total Marks: (35)**

**QUESTION 3** **(Psychrometry)**

NOTE! - Ensure that the correct units of measure **(SI unit)** are recorded as answers will be marked wrong if the incorrect unit is used, even if the value calculated is correct.
If psychrometric charts are not used with these questions, it will **NOT** be marked.

In an underground tunnel, at point (A), a quantity of 32.5 $m^3/s$ is flowing with a temperature of 28.5/30.5°C and a barometric pressure of 107.5 kPa. The water in the drain is 25.8°C. Downstream, point (B), a water bearing fissure was intersected (water temperature is 55.7°C with a flow rate of 10 l/s). A 2500 kW bulk air cooler is installed at point (D). (See sketch).




Using the attached Psychrometric Chart calculate the following: (State all values read of the chart)

3.1. Calculate the air temperature at point (C), assuming a relative humidity of 95%. (12)

**Info from 107.5 kPa Chart, temperature 28.5/30.5°C**

Sigma Heat ($\Sigma H$) = 88.44 kJ/kg (1)
Apparent Specific Volume = 0.84 m³/kg (1)

Mass flow of air at point (A) (2)

$M = Q \div ASV$
$= 32.5 \div 0.84$
$= 38.7\ kg/s$

Heat given off by fissure water at point (B) (3)

$q = M \times cp \times (t_o - t_i)$
$= 10 \times 4.187 \times (55.7 - 25.8)$
$= 1252\ kW$

But Total heat = Mass flow x $\Delta\ \Sigma\ H$ ($T = M \times \Delta\Sigma H$) (2)

$\therefore \Delta\Sigma H = T/\mathrm{M}$
$= 1252 / 38.7$
$= 32.35\ kJ/kg$

$\therefore \Sigma H\ content\ of\ air\ after\ the\ water\ fissure = 88.44 + 32.35$
$= 120.79\ kJ/kg$ (2)

Relative Humidity = 95% (given)

∴Temperature of the air after the water fissure = 35.4/36.2°C (1)

3.2. Calculate the amount of water condensed out or evaporated into the air at point (C) in ℓ/h. (6)

**Info from 107.5 kPa Chart, temperature 28.5/30.5°C (before water fissure)**

Moisture content of air before the water fissure = 22.60 g/kg (1)

**Info from 107.5 kPa Chart, temperature 35.4/36.2°C (after water fissure)**

Moisture content of air after the water fissure = 34.91 g/kg (1)

$\therefore mc = 34.91 - 22.60$

$= 12.31\ g/kg$ (1)

$\therefore amount\ of\ water\ evaporated = (m \times \Delta\ mc)/1000$

$= (38.7 \times 12.31) / 1000$

$= 0.476\ \ell/s$ (2)

Amount of water *evaporated* in litres per hour (ℓ/h):

$= 0.476 \times 60 \times 60$

$= 1713.6$ ℓ/h (1)

3.3. State whether water is condensed out of or evaporated into the air at point (C) and give your reason. (2)

Water evaporated into the air (1) because there is an increase in moisture content. (1)

3.4. Calculate the air temperature at point (D) after the cooler. State any assumptions made. (5)

Total heat removed = Mass flow x $\Delta\ \Sigma\ H\ (T = M \times \Delta\Sigma H)$ (2)

$\therefore \Delta\Sigma H = T/M$

$= 2500 / 38.7$

$= 64.6\ kJ/kg$

$\therefore \Sigma H\ removed\ from\ the\ air = 64.6\ kJ/kg$

$and\ \Sigma H\ entering\ the\ cooler = 120.74\ kJ/kg\ (previously\ calculated)$

$\therefore \Sigma H\ content\ of\ air\ leaving = 120.74 - 64.6$

$= 56.14\ kJ/kg$ (1)

Assuming that the air leaving the cooler is saturated (1)

∴Temperature of the air leaving the cooler = 20.6/20.6°C (air is saturated) (1)

**Total Marks: (25)**

**QUESTION 4** **(General Calculations)**

1.1 A gravimetric dust sampling pump was issued to an underground employee in a gold mine. The dust pump operated for 540 minutes at a flow rate of 2.2ℓ/min. The pollutant is crystalline silica quartz and was determined as 17.9% by means of laboratory analysis.

The gravimetric sampling analyst recorded the following information in the laboratory:

The control filter pre and post mass were as follows:

| **Pre filter mass** | **Post filter mass** |
|---|---|
| 20.01mg | 20.08mg |
| 19.98mg | 20.00mg |
| 20.17mg | 20.2mg |

The pre weight of the sample filter mass was 20.15mg whilst the post weight of the Control was 20.98mg.

Determine the following:

4.1.1. The corrected sample mass. (5)

Determine average pre filter mass = (20.01 + 19.98 + 20.17) / 3
= 60.16 / 3
= 20.05mg (1)

Determine average post filter mass = (20.08 + 20.00 + 20.17) / 3
= 60.28 / 3
= 20.09mg (1)

Corrected mass = Post filter mass – Pre filter mass
= 20.09 – 20.05
= 0.04mg (heavier and must be subtracted from the sample mass) (1)

Sample mass = Post weight – Pre weight
= 20.98 – 20.15
= 0.83mg (1)

Corrected sample mass = 0.83mg – 0.04mg
=0.79mg (1)

4.1.2. The sample concentration. (2)

Determine the volume of air sampled = (2.2ℓ/min x 540) / 1000
= 1188ℓ / 1000
= 1.188m$^3$ (of air) (1)

Sample concentration = 0.79 / 1.188
= 0.665mg/m$^3$ (1)

4.1.3. The TWA dust concentration. (1)

TWA = sample concentration x (total sampling time (min) / 480)
= 0.665 x (540 / 480)
= 0.748mg/m³ (1)

4.1.4. The pollutant concentration. (1)

= TWA concentration x (% pollutant / 100)
= 0.748 x (17.9/100)
= 0.134mg/m³ (1)

4.1.5. Air quality index. (1)

AQI = TWA concentration / OEL
= 0.134 / 0.1
= 1.34 (1)

4.2. The measurements below were taken on a 150mm insulated chilled water pipe. The heat pick-up for an insulated pipe provided by the supplier was 24 W/m for product A and 150 W/m for product B. Given the following parameters:

Water flow rate = 20 l/s
Water temp at station dam = 7.5 °C
Water temp at working place = 15.5 °C
Length of pipe = 2 500 m

4.2.1. Calculate the heat pick-up by the water from the station to the working place. (2)

Heat = M x Cp x $\Delta$T (1)
= 20 x 4.187 x (15.5 – 7.5)
= 669.9 kW (1)

4.2.2. Determine which insulation product was used and state if you will recommend the supplier? Motivate your answer ignoring any commercial aspects. (2)

Heat per m = Heat / length
= 669.9 / 2 500
= 0.268 kW per m or = 268 W per metre (1)

It is expected that product B was used as it is the closest to the measured rate. The supplier is not credible as the rate for product B differs significantly from the measured rate (1)

4.2.3. What will be the water temperature at the working place be if the specifications of both products were met? (4)

Product A Heat = Rate x length / 1000
= 24 x 2 500 / 1000
= 60 kW (1)

Heat = M x Cp x $\Delta T$
Tout A = Tin + (Duty / M x Cp)
= 7.5 + (60 / 20 x 4.187)
= 7.5 + 0.7
= 8.2 °C (1)

Product B Heat = Rate x length / 1000
= 150 x 2 500 / 1000
= 375 kW (1)

Heat = M x Cp x $\Delta T$
Tout B = Tin + (Duty / M x Cp)
= 7.5 + (375 / 20 x 4.187)
= 7.5 + 4.5
= 12.0 °C (1)

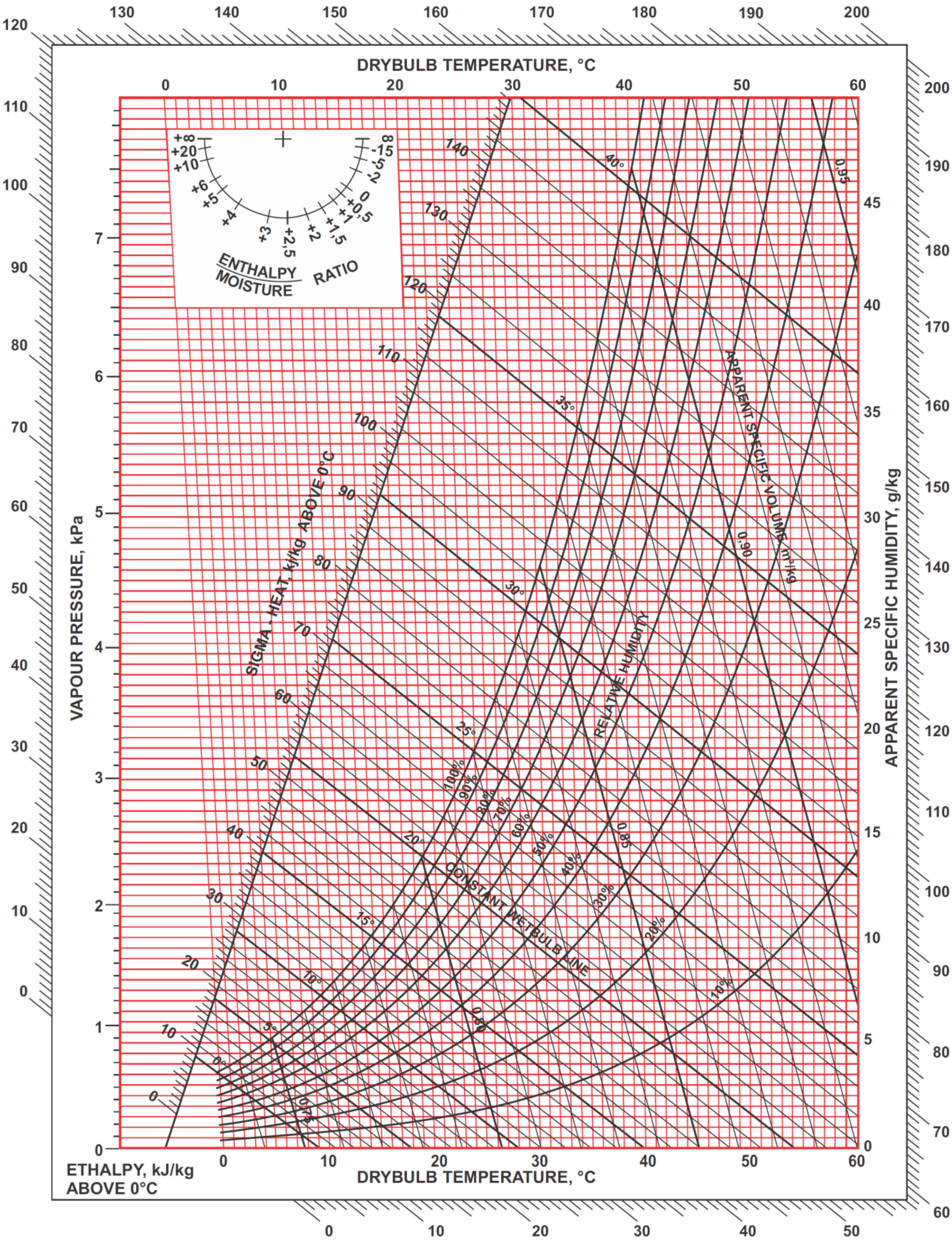
4.3. The wet Kata reading in a working place is 10.0mcal/s/$cm^2$ and the unventilated wet bulb is 30.5 °C. Calculate the air velocity. (2)

If H $= 0.7\theta + \theta\sqrt{v}$
Then v $= (H - 0.7\theta / \theta)^2$
$= (\{10 - (0.7 \times 6)\} / 6)^2$
$= (\{10 - 4.2\} / 6)^2$
$= (0.966)^2$
= 0.93 m/s (1)

$\theta$ = 36.5 – wet bulb temp
= 36.5 – 30.5
= 6.0 (1)

**Total Marks: (20)**

# PSYCHROMETRIC CHART
# 107,5 kPa




A.W.T.B.

CHART NO 13
107,5 kPa