Minerals Council South Africa

EXAMINATION MEMORANDUM

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – INTERMEDIATE CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 2	**EXAMINER:** JJ PIENAAR
SUBJECT CODE: COMIMEC2	**MODERATOR:** N. KRUGER
EXAMINATION DATE: 11 OCTOBER 2021	**TOTAL MARKS:** 100
TIME: 14:30 – 17:30	**PASS MARK:** 60

NUMBER OF PAGES: 09

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 112.5 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)**

Define the following:

1.1. Thermal Capacity (3)

Is the amount of heat required (½) to raise or lower the temperature (½) of substance(½) having a mass of one kilogram(½) by one degree Celsius (½), expressed in kJ/kg°C).(½)

1.2. Heat stress (4)

Heat stress can be defined as environment measurements (½) of air temperature (½), air flow rate (½), the level of radiant heat exchange (½) (where applicable) and evaluation (½) of a person's metabolic (½) heat production rate(½) from exercise and / or work (½).

1.3. Gases (3)

Gases are formless fluids (½) that expand to fill the space they are in (½). They can be transformed to the liquid (½) or solid phase (½) only by the combined effect of increased pressure(½) or decreasing the temperature alone (½) (diffusion).

1.4. Joule (3)

Is the work done (½) when the point of application of a force of 1 Newton (½) is displaced (½) through a distance of one metre (½) in the direction of the force (½).

1 Joule = 1 Newton metre (1 J = 1 Nm) (½)

1.5. Fibre (2)

Is any particle having parallel sides (½) of which the length to diameter ratio is more than three to one (½), which is more than 5 micrometers long (½) and which has a diameter of less than 3 micrometers (½).

1.6. Toxic Gases (2)

Toxic Gases is a gas, if breathed in sufficient concentrations (½) for a sufficient time (½) will disable (½) or kill (½) a person.

1.7. Explosive Gases (3)

Explosive Gases are gases which are safe to breathe (½), but may in certain instances be explosive (½), also known as "flammable gases" (½). These gases usually explode when they are mixed with air (½), reaching the explosive concentration or range (½) and, are then ignited by a flame, spark on any other potential source of ignition (½).

1.8. Industrial water (2)

Industrial water is water either derived from a natural source (½) in the mine or is water which, after having been used once (½), is treated, filtered (½) and pumped up to a higher level, (½) for re-use.

1.9. Equivalent Continuous A Weighted Sound Pressure Level (L_{Aeq}) (3)

L_{Aeq} is that constant (½) A- weighted sound pressure level (½) which is equivalent (½) to the Varying (½) A-weighted sound pressure level (½) (L_{PA}) over a given time interval. (½)

1.10. Illumination (2)

Illumination is a measure of the brightness (½) of the light falling on an object (½), expressed in lux (lx) (½). 1 lux = 1 lumen per square metre. (½)

1.11. Boyle`s Law and give the formula. (3)

This law states, that at a constant temperature (½), the volume of a given mass of a gas (½) is inversely proportional (½) to the absolute pressure exerted on it (½).

$P1V1 = P2V2$ (at constant temperature) (½)

P = Absolute pressure (kPa) V = Volume (m^3, m^3/s, m^3/kg) (½)

Total Marks: **(30)**

QUESTION 2 **(Theory)**

2.1. List the data to be measured and recorded on during a noise survey? (5)

Any Five of the following: (5)

- Sound pressure levels at the noise source and at ear position of the operator.
- Sound pressure levels at suitable intervals from noise source.
- Sound pressure levels of background noise.
- ‘A’ weighted scale and 'slow' response to be used throughout measurements.
- Description and sketch of area surveyed.
- Record environmental conditions.
- Nature and dimensions of floor, roof and walls.
- Type of work being performed.
- Approximate exposure time of workers to various noise levels above 85dB (A).
- Date and time measurements were taken.
- Name of observer and type and number of equipment used.
- Type of machine or appliance producing the noise (i.e. what produces the noise).
- In open areas, record wind direction, as it might affect measurements.

2.2. List five effects (hazards) of whole body vibration and localised vibration. (10)

Effects of whole body vibration are (Any Five): (5)

- Influence muscle tone and speech (14 - 20 Hz).
- Chest pains, backache, spontaneous muscle contraction, stomach- ache and general feeling of discomfort (5 - 10 Hz).
- Cause respiratory problems (± 2 Hz).
- Affects the heart rate (irrespective of frequency).
- Increases blood pressure (± 5 Hz).
- Affects human performance - deterioration in clarity of sight and task requiring muscular control (precision work) are influenced, (10 - 30 Hz).
- Impair a person’s ability to maintain his balance.
- Affects visual perception (image becomes blurred and unsteady).
- Affects skeletal and muscle systems to a lesser extent.
- Sea- or car- sickness.
- Muscular tension, headaches, eyestrain, throat pain and intestinal irritation.

Effects of localised vibration are (Any Five): (5)

- Causes small areas of calcification of the carpal joints in the hand.
- Results in soft tissue injury and nerve injury in the hands.
- Osteo-arthritis of the arm joints occurs in the shoulder, joints and elbows, resulting from degenerative destruction of bones, joints and tendons.
- Vascular disturbance known as “white finger disease” or “vibration induced white finger” (v.w.f.) and medically known as Raynaud’s Syndrome.
- Cause reduced sensation of grip, feeling and pressure. (Sensory disturbances).
- Atrophy of bones and in severe cases, fracture of the affected bones.

2.3. List and discuss the three categories of Colour Blindness. (6)

Partial colour blindness (1):	is the inability to distinguish the different shades of the compound colours, such as brown and grey. (1)
Total colour blindness (1):	is the inability to distinguish any colour so that only light and darkness can be seen (i.e white and black) (1)
Red/green colour blindness (1):	is the inability to distinguish between the primary colours, red, yellow and blue or between the secondary colours, green, orange, brown and purple. (1)

2.4. Supply the required properties and hazards of the following gases: Record the answers in your answer sheet from item (1) to (8). (4)

Answer:

Gas	Sources of gas	Dangers	Explosive range	Occupational Exposure limit (OEL)
Hydrogen		(1) Highly explosive (½)	(2) (4%- 74%) (½)	
Carbon monoxide	(3) Incomplete combustion Fires, Blasting and Diesel equipment (½)		(4) Yes 12.5% – 74.2% (½)	
Carbon dioxide		(5) Oxygen deficiency – Asphyxia (½)		
Methane			(6) Yes 5.0% – 15.0% (½)	
Hydrogen Cyanide	(7) Cyanide process in gold recovery. Back-filling. Burning plastics. (½)	(8) Poisonous. Explosive (5.6 - 40%). Can be absorbed through the skin (½)		

2.5. Complete the following table on water (Service and drinking water) limits according to the South African Bureau of Standards (SANS 241): Record the answers in your answer sheet from item (1) to (6). (3)

Answer:

Organism	Recommended Limit	Maximum Allowable Limit
Coliform organisms, number per 100 ml …	(1) *	(2) 10 (½)
E. coli, number per 100 ml …………………	(3) Nil (½)	(4) Nil (½)
Total viable organisms, colonies per ml …	(5) 10 (½)	(6) Not Specified (½)

* (a) If any coliform organisms are found in a sample, a *second* sample shall be taken immediately after the tests on the first sample have been completed and shall be free from coliform organisms,

and (1)
(b) Not more than 5 per cent of the total number of water samples (from any one reticulation system) tested per year may contain coliform organisms. (1)

2.6. Complete the following table on potable water bacteriological limits according to MH&SA Act and Regulations - Act 29 of 1991 Regulation 22.9(2)(c)(ii) (2)

Answer:

Organism	Maximum Allowable Limit
2.6.1 Total Coliforms bacteria count.	5 (½) per 100 ml (½)
2.6.2 Faecal coliform bacteria count.	Nil (½) per 100 ml (½)

Total Marks: (30)

QUESTION 3 **(Psychrometry)**

NOTE! - Ensure that the correct Standard index **<u>(SI)</u>** 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 **<u>NOT</u>** be marked.

A quantity of 75m³/s of air enters a bulk air cooler at 29.5/33.8°C. The barometric pressure is 112.5 kPa and the total heat removed from the air is 3850kW. The water flow rate through the bulk air cooler is 80.0ℓ/s and the temperature of the water entering the cooler is 9.5°C.

Using the attached Psychrometric Chart calculate the following:

3.1 The temperature of the air leaving the bulk air cooler (state any assumptions) (5)

Mass flow of air entering the cooler

(Where ASV = 0.811 m3/kg from 112.5 kPa chart @ 29.5/33.8°C)

M = Q/ASV
= 75/0.811
= 92.5kg/s (1)

But Total heat = Mass flow x ΔΣH (T = M x ΔΣH)
ΔΣH = T/M
= 3850/92.5
= 41.6kJ/kg (1)

ΣH removed from the air = 41.6kJ/kg
ΣH entering the cooler = 87.4 kJ/kg (From 112.5kPa chart @ 29.5/33.8°C) (1)
ΣH content of the air leaving = 87.4 – 41.6
= 45.8 kJ/kg

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

Temperature of the air leaving the cooler = 17.7/17.7°C (air is saturated) (1)

3.2. Calculate the air quantity leaving the bulk air cooler (3)

Mass flow of air entering the cooler = 92.5 kg/s
Mass flow of air exiting the cooler = 92.5 kg/s – mass flow remains constant (1)
ASV of air leaving the cooler at 17.7/17.7°C from 112.5 kPa chart = 0.755m³/kg (1)

$$M = Q/ASV$$
$$Q = M \times ASV$$
$$= 92.5 \times 0.755$$
$$= 69.8 m^3/s$$ (1)

3.3. How much water has evaporated or condensed in litres per day (5)

Moisture content of air entering the cooler = 21.9 g/kg (from 112.5 kPa chart at 29.5/33.8°C) (1)
Moisture content of air leaving the cooler = 11.4 g/kg (from 112.5 kPa chart at 18.4/18.4°C) (1)

$$mc = 21.9 – 11.4$$
$$= 10.5 \text{ g/kg}$$ (1)

Amount of water condensed = $(M \times \Delta mc) / 1000$
$= (92.5 \times 10.5) / 1000$
$= 0.969$ ℓ/s (1)

Amount of water condensed in litres per day (ℓ/day)

$= 0.969 \times 60 \times 60 \times 24$
$= 83721.6$ ℓ/day (1)

3.4. Calculate the temperature of the water leaving the cooler (2)

$$Q = M \times C_p \times \Delta t$$ (1)
$$3850 = 80 \times 4.187 \times (t_o – 9.5)$$
$$3850 = 334.96t_o – 3182.12$$
$$t_o = \frac{(3850+3182.12)}{334.96}$$
$$t_o = 21.0°C$$

Water leaving the cooler = 21.0°C (1)

3.5. Name five (5) methods to reduce the effects of heat. (5)

- Reducing heat flow from rock (1)
- Removal of machinery (1)
- Dilution by ventilation (1)
- Acclimatisation (1)
- Refrigeration (1)

Total Marks: (20)

QUESTION 4 **(General Calculations)**

4.1. A new cooling car with a designed duty of 500kW is installed in an underground section with an operating efficiency of 80%. The water inlet temperature is 12°C at a flow rate of 10ℓ/s.

a) What will the outlet water temperature be? (3)

Operating duty = Design Duty x (efficiency/100)
= 500 x (80/100)
= 400 kW (1)
Delta Temp = Operating duty / (Flowrate x Thermal Capacity)
= 400 / (10 x 4.187)
= 9.553°C (1)

Outlet temp = Inlet Temp + Delta Temp
= 12 + 9.553
= 21.553
= 21.6°C (1)

b) Determine the operating water duty per litre when compared to the design of 50kW per litre (1)

Factor = Operating Duty / Flowrate

= 400 / 10

= 40 kW per litre (1)

4.2. A new shaft is being sunk in the Rustenburg area. It is known that the surface rock temperature is 20.7°C and the temperature gradient is 12.3°C per 100m. Calculate the virgin rock temperature at a depth below datum of 2350m. Given that datum is estimated at 500m above collar. (2)

Depth = VRT depth – datum collar
= 2350 - 500
= 1850 m (1)

VRT = Surface rock temp + (Temp gradient x depth in km)
= 20.7 + (12.3 x 1850 / 1000) Depth = VRT depth – datum collar
= 20.7 + 22.8 = 2350 - 500
= 43.4 °C (1)

4.3. The A volume of 580 m^3/s of air enters the downcast shaft of a mine at a pressure of 87.5kPa and a temperature of 19.0/29.0°C. At the bottom of the shaft the pressure is 110kPa and the temperature is 25.0/35.0°C. Assuming there is no leakage calculate the air quantity at the bottom of the shaft: (4)

Formula $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

T_1 = Temp dry bulb + Kelvin
= 29.0 + 273

T_2 = Temp dry bulb + Kelvin
= 35.0 + 273

= 302 K (1) = 308 K (1)

Re-arrange formula $V_2 = \frac{P_1 V_1 T_2}{P_2 T_1}$ (1)

$= \frac{87.5 \times 580 \times 308}{110 \times 302}$

$= 470.5\ m^3/s$ (1)

4.4. Ventilation doors leading into a return airway have been damaged, resulting in 25.5m^3/s of air at a wet bulb temperature of 27.0ºC short circuiting into the return airway. The wet bulb temperature of the air flowing in the return airway upstream of the doors is 32.0ºC. As a result of the air short circuiting into the return airway, the wet bulb temperature downstream of the doors is 31.0ºC. Calculate the volume of air flowing upstream of the ventilation doors. (5)

$(Q_1T_1) + (Q_2T_2) = (Q_1+Q_2)T_3$ (1)

$(25.5 \times 27) + (Q_2 \times 32) = (25.5 + Q_2) \times 31$ (1)

$688.5 + 32Q_2 = 790.5 + 31Q_2$ (1)

$32Q_2 - 31Q_2 = 790.5 - 688.5$ (1)

$Q_2 = 102\ m^3/s$

Upstream volume = 102 m^3/s (1)

4.5. The measured wet kata reading in a development end is 10.0mC/cm²/s and the wet bulb temperature is 30.0°C.

a) Calculate the air velocity. (2)

If $H = 0.7\theta + \theta\sqrt{v}$ (1)

Then $v = [(H-0.7\theta) / \theta]^2$ $\theta = 36.5 - 30.0 = 6.5$

$= [(10 - 0.7 \times 6.5) / 6.5]^2$

$= [5.45 / 6.5]^2$

$= 0.70$ m/s (1)

b) What does the wet kata reading represent? (1)

In essence, wet-kata readings are a measure of the cooling power of the air (1)

4.6. A worker in an open pit is exposed to a temperature of 28.0/35.0°C and a globe temperature of 31.6°C. Calculate the WBGT index. (2)

WBGT $= 0.7\ Twb + 0.2\ Tg + 0.1\ Tdb$ (1)

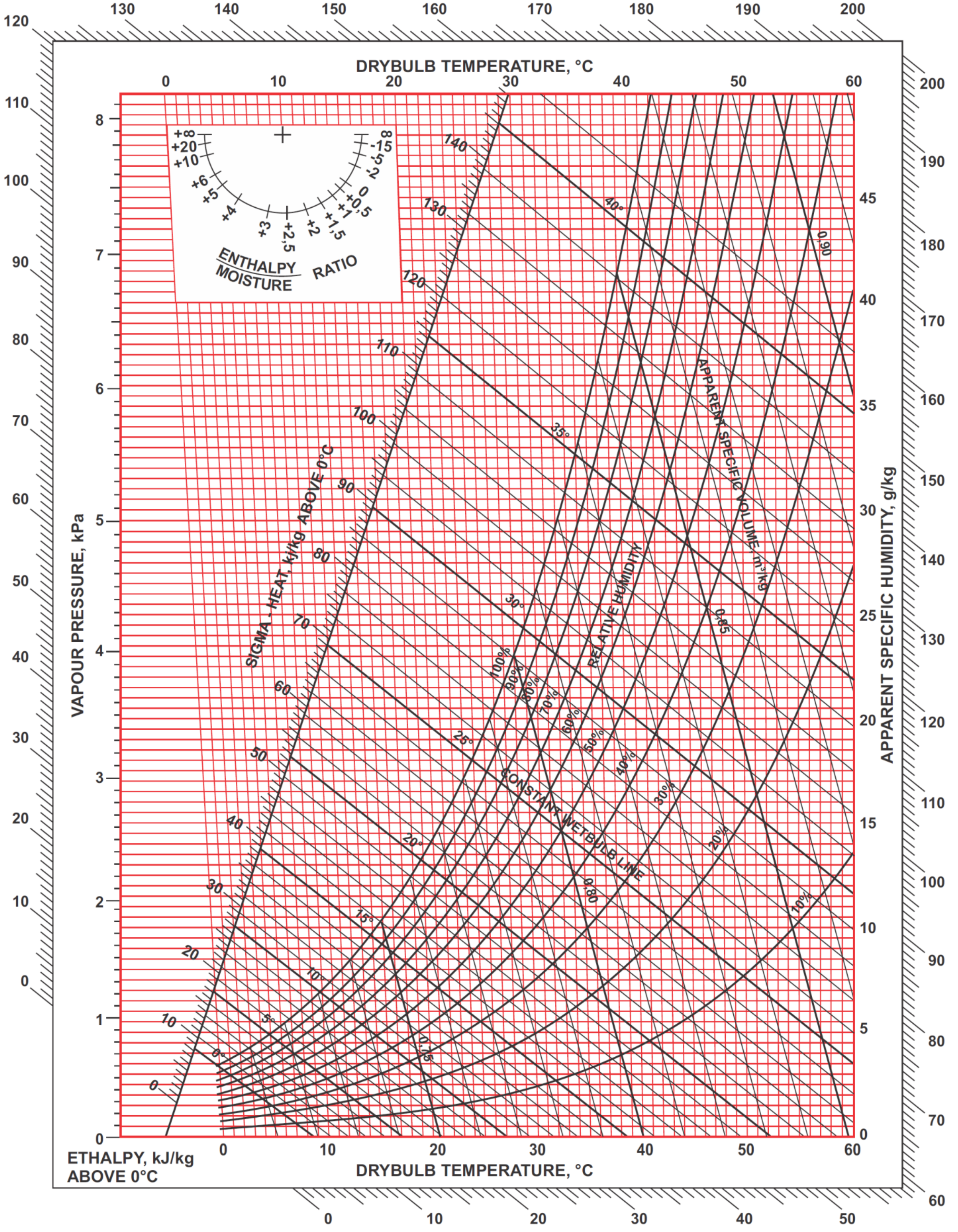
$= (0.7 \times 28) + (0.2 \times 31.6) + (0.1 \times 35)$

$= 19.6 + 6.32 + 3.5$

$= 29.42^{\circ}C$ (1)

Total Marks: (20)

PSYCHROMETRIC CHART
112,5 kPa



A.W.T.B.

CHART NO 15
112,5 kPa