Chamber of Mines Examination
October 2017

Question 1.1 5 Marks

Give the definitions and Units of the following:-

1.1.1 Wet-bulb temperature
1.1.2 Dry-bulb temperature
1.1.3 Sensible heat
1.1.4 Latent heat
1.1.5 Wet Kata

Answer 1.2

1.1.1 Together with the dry-bulb temperature it is a measure of the evaporating capacity of the air in °C. (1)
1.1.2 Is a measure of the sensible heat content of the air expressed in °C. (1)
1.1.3 Is the heat which produces a change in temperature without a change in state. kJ/kg (1)
1.1.4 Is the heat which produces a change in state without a change in temperature. kJ/kg (1)
1.1.5 Is the rate at which the environment is capable of removing heat from a body. $mCal/cm^2/s$ (1)

Question 1.2 10 Marks

1.2.1 Calculate the kata reading when given the following:-
Velocity = 0.6 m/s
Temperature = 31.0/32.5 (Unventilated Wet Bulb temperature).
State whether the calculated kata is acceptable or not
1.2.2 The measured wet kata reading in a working place is 9.8 and the wet-bulb Temperature (Unventilated) is 30.9. Calculate the air velocity?
1.2.3 Calculate the approximate VRT at a depth of 2500 m for a gold mine in the Free State?

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Answer 1.2

1.2.1 $H = 0.7\Theta + \Theta v0.6)$
$H = (0.7 \times 5.5) + (5.5 \times \sqrt{0.6})$
$H = 3.85 + 4.26$
$H = 8.1$ (acceptable) 3 Marks

1.2.2 $H = 0.7\Theta + \Theta v0.6)$

$V = (\frac{9.8-(0.7\ x\ 5.6)}{5.6})^2$

V = 1.1 m/s 3 Marks

1.2.3 VRT – Free State = 20 + (14.6 x depth in km)

= $20 + (14.6 \text{ x } (\frac{2500)}{1000})$

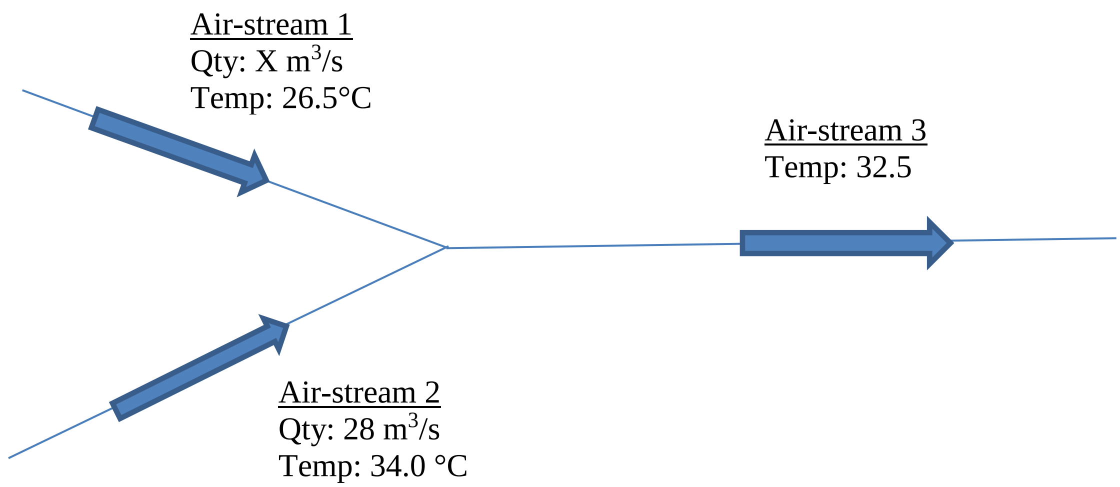
= 20 + (14.6 x 2.5)

= 20 + 36.5

= 56.5 °C 4 Marks

Question 1.3 3 Marks

1.3.1 Calculate the air quantity to be supplied from air-stream 1 to make sure that the dry-bulb temperature after mixing does not exceed 32.5°C.



Answer 1.3 3 Marks

$(Q_1 \text{ x } T_1) + (Q_2 \text{ x } T_2) = (Q_1 + Q_2)T_3$

Let Q_1 be = X

$$\therefore (X\ x\ 26.5) + (28\ x\ 34) = (X +\ 26.5)32.5$$

$$26.5X + 952 = 32.5X + 861.25$$

$$952 - 861.25 = 32.5X -\ 26.5X$$

$$90.75 = 6X$$

$$\therefore X = \frac{90.75}{6}$$

= 15.1 m^3/s

$\underline{\therefore Qty\ air - stream\ 1 = 15.1\ \mathrm{m3/s}}$

Question 1.4 7 Marks

Calculate the heat energy required to convert 2kg of ice at -2 ^oC to superheated water vapour at 105 ^oC. If the process took 0.0833 hours, calculate the power involved.

Answer 1.4 7 Marks

Process Change		**SH/LH**	**Calculation**	**Answer**	
To change 2kg ice at = -2 ^oC	To ice at 0 ^oC	**SH**	2 x 2,094 x 2	= 8.4	kJ
To change 2kg ice at 0 ^oC	To water at 0 ^oC	**LH**	2 x 335	= 670	kJ
To change 2kg water at 0 ^oC	To water at 100 ^oC	**SH**	2 x 4.187 x 100	=837.4	kJ
To change 2kg water at 100 ^oC	To vapour at 100 ^oC	**LH**	2 x 2440	= 4880	kJ

To change 2kg vapour at 100 ^{o}C	To vapour at 105 ^{o}C	**SH**	2 x 1,884 x 5	= 18.8	kJ
			∴Total heat required	**6415**	**kJ**

Now the process took 0.0833 hours and 0.0833 x 60 x 60 = 300 seconds

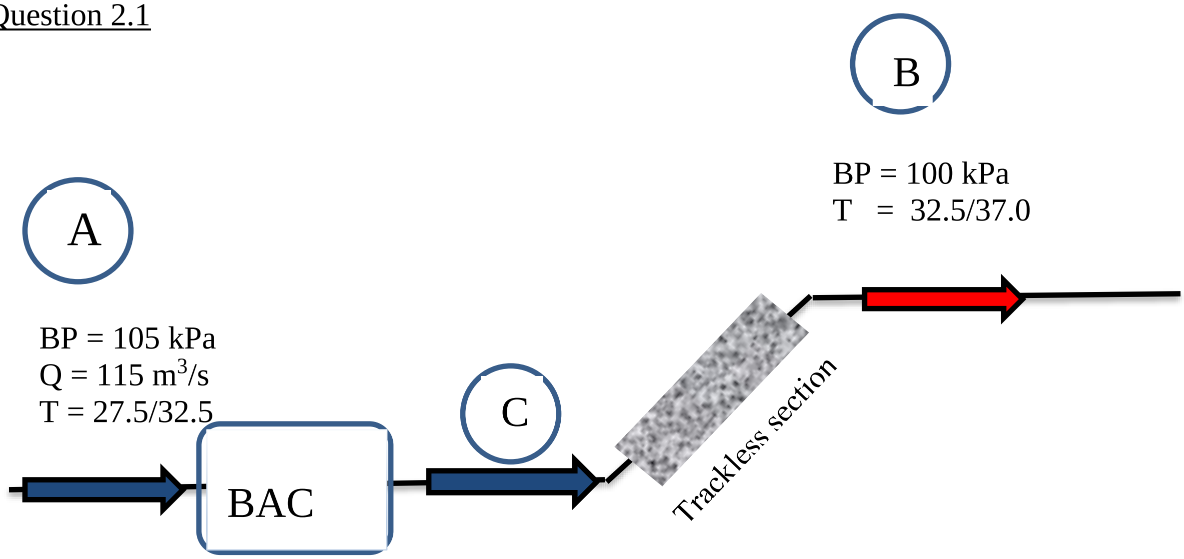
$$\therefore \text{Power involved} = \frac{Total\ Heat\ Required}{Seconds}$$

$$= \frac{6415}{300}$$

$$= \underline{\mathbf{21.4\ kW}}$$

25 Marks

Question 2.1



A trackless section in a deep underground mine experienced high reject temperatures and installed a BAC on the intake side of the section. By using psychrometric charts calculate the following parameters:- Marks 12

2.1.1 Calculate the total heat load in the trackless with the readings at points A and before the BAC was installed. (Ignore the effects of auto compression). (2)

2.1.2 The BAC installed is rated at 5000 kW, but can only operate at 50% of the designed duty due to insufficient water supply. Determine what will be the expected wet and dry bulb temperatures at point C (BAC return). Assume the air/water heat transfer was 100%. (4)

2.1.3 Determine the wet and dry bulb temperatures at point B (trackless return) with the BAC operating. The return humidity is 70%. (3)

2.1.4 An additional trackless fleet has been allocated to increase production and will generate at least 1200 kW more heat into the section. Determine new reject temperature at point B. (3)

<u>Answer 2.1</u>

2.1.1 Sigma heat of intake air at A = 82.5 kJ/kg (105 kPa chart at 27.5/32.5)

Sigma heat of return air at B = 110.0 kJ/kg (100 kPa chart at 32.5/37.0)

Sigma heat from workings = ∑H return air - ∑H intake air
= 110.0 – 82.5
= 27.5 kJ/kg (1)

Thus heat from workings = Mass flow x Δ∑ Heat
= 133.1 x 27.5
= 3660.3 kW (1)

Massflow = (115.0/0.864)
= 133.1 kg/s

2.1.2 BAC operating duty = Design duty x (rating %/100)
= 5000 x (50/100)
= 2500kW (1)

BAC Δ∑ = BAC duty/ Massflow
= 2500/133.1
= 18.8 kJ/kg (1)

BAC Return ∑ H = Intake ∑ H - Δ∑ H
= 82.5 – 18.8
= 63.7 kJ/kg (1)

BAC return wet bulb temp = 23.2 °C (from 105 kPa chart at 63.7 kJ/kg)
Assume that dry bulb temp is the same as air is saturated. (1)

2.1.3 ∑ H at Trackless return = ∑ BAC outlet + ∑ workings
= 63.7 + 27.5
= 91.2 kJ/kg (1)

Trackless return wet bulb temp = 28.8 °C (from 100 kPa chart at 91.2 kJ/kg) (1)

Return dry bulb temp = 32.0 °C (from 100 kPa chart at 70% humidity) (1)

2.1.4 New fleet $\Delta \sum$ heat = heat/ Massflow
= 1200 / 133.1
= 9.0 kJ/kg (1)

$\sum$ H at Trackless return = $\sum$ BAC outlet + $\sum$ workings + new fleet
= 63.7 + 27.5 + 9.0
= 100.2 kJ/kg (1)

New return wet bulb temp = 30.6 °C (from 100 kPa chart at 100.2 kJ/kg)
(1)

Question 2.2

A bulk Air cooler (BAC) was installed in the main intake to an underground section. The water intake temperature was 8 °C, water outlet temperature only 16 °C with a flowrate of 90 l/s. An air volume of 105 m^3/s enters the BAC at 29.0/32.0 °C with a barometric pressure of 105 kPa. (13)

2.2.1 Calculate the water heat transfer duty of the BAC and the air Massflow through the BAC. (2)

2.2.2 The wet bulb air outlet temperature of the BAC if it was operating at 100 % and 50 % efficiencies. (7)

2.2.3 What is the minimum BAC efficiency to be maintained to ensure an outlet wet bulb temperature of not less than 25 °C. (3)

2.2.4 What will be the main reason for a BAC to start losing efficiency if the water flow remains constant? (1)

Answer 2.2

2.2.1 Water heat transfer duty

W = M x Cp x ΔT — M = 90 l/s
= 90 x 4.187 x (16 – 8) — Cp = 4.187
= 3 014.6 kW

M = Q / ASV — ASV of BAC intake = 0.866 m^3/kg
= 90 / 0.866 — (105 kPa chart at 29.0 / 32.0)
= 103.9 kg/s (1)

2.2.2 The heat transfer to the air is less due to the water /air inefficiencies.

100% air duty = Water duty — efficiency = 100%
= 3014.6 (1)

$\Delta \sum$ heat at 100% = BAC duty / Massflow
= 3014.6 / 103.9

= 29.0 kJ/kg (1)

∑ heat BAC out = ∑ heat in - ∆ ∑ ∑ heat of BAC intake = 89.0 kJ/kg
= 89.0 – 29.0
= 60.0 kJ/kg
(105 kPa chart at 29.0 / 32.0)
Thus wet bulb temp BAC outlet = 21.5 °C (air saturated at BAC outlet) (1)

50% air duty = Water duty x (50/100) efficiency = 50%
= 3014.6 x 0.5
= 1507.3 kW (1)

∆ ∑ heat at 50% = BAC duty / Massflow
= 1507.3 / 103.9
= 14.5 kJ/kg (1)

∑ heat BAC out = ∑ heat in - ∆ ∑
= 89.0 -14.5 ∑ Heat of BAC intake = 89.0 kJ/kg
= 74.5 kJ/kg (105 kPa chart at 29.0/32.0) (1)

Thus wet bulb temp BAC outlet = 25.5 °C (air saturated at BAC outlet) (1)

2.2.3 ∆ ∑ heat required = ∑ heat in - ∑ heat out
= 89.0 – 74.5 ∑ Heat of BAC outlet = 74.5 kJ/kg
= 14.5 kJ/kg (105 kPa chart at 25.0 /25.0) (1)

Air duty required = ∆ ∑ x Massflow
= 14.5 x 103.9
= 1506.6 kW (1)

Efficiency required = Air duty / water duty x 100
= 1506.6 / 3014.6 x 100
= 50.0 %
BAC heat transfer duty may not be less than 50.0% (1)

2.2.4 Heat transfer efficiency loss is mainly due to incorrect spray patterns when the supply water flow remains unchanged. Spray nozzle openings have increased and must be replaced to ensure an effective spray pattern.(1)

Marks 25

Question 3

3.1 Name any 6 of the objectives for sampling the airborne pollutants. (6)

Answer 3.1 To detect any working places/areas with unhealthy conditions.
To determine the cause of air contamination by airborne pollutants.
To indicate the necessary control measures.
To determine effectiveness of suppression methods
To confirm satisfactory conditions have been obtained
To comply with legislation.
To supply records for medical surveillance.
For various research purposes.

3.2 Name advantages and disadvantages of cyclones in a filtration of air in a table form. (6)

Cyclones	Advantage	Disadvantage

Answer 3.2

Cyclones	Advantage	Disadvantage
	• No moving parts • Excellent to remove course dust. • Filtered air is not recirculated but discharged into atmosphere , where it is diluted further & carried away • Easy and cheap to install	• Not effective in removing fine dust particles from the air. • Undesirable for underground use • Erosion of the of the cyclone

3.3 Name any 6 reasons for sampling mine water. (6)

Answer 3.3

(a) To determine the amount of silica dust present in the water
(b) Bacteriological analysis (E Coli, etc.)
(c) Chemical analysis for dissolved and suspended solid, toxic metallic and chemical compounds.
(d) To determine the pH value of the water (Acidity/Alkanlinity).
(e) To determine the amount of free chlorine in the water
(f) For radioactive analysis
(g) For legal compliance.

3.4 Complete the following properties of the following gases:- (6)

Properties	**Butane**	**Ethane**	**Propane**
Explosive range			
Specific gravity			

Answer 3.4 (6)

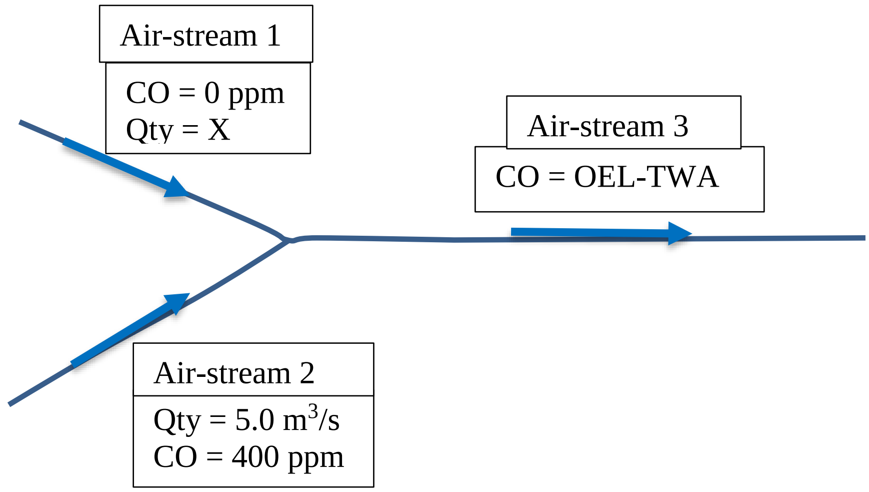
Properties	**Butane**	**Ethane**	**Propane**
Explosive range	1.5% - 8.8%	2.7% - 14%	2.1% - 9.5%
Specific gravity	2.05	1.04	1.56

3.1.5. Name the Occupational Exposure Limit of Oxygen.

Answer 3.1.5 >19%

Marks 25

Question 4.1



Calculate the quantity to be supplied from air-stream 1 to ensure that the CO concentration after mixing does not exceed the OEL-TWA. (5)

Answer 4.1 (5)

$(Q_1 \text{ x } g_1) + (Q_2 \text{ x } g_2) = (Q_1 + Q_2)g_3$

Let Q_1 be = X

$$\therefore (X\ x\ 0) + (5\ x\ 400) = (X + 5)30$$

$$0 + 2000 = 30X + 150$$

$$2000 - 150 = 30X$$

$$1850 = 30X$$

$$\therefore X = \frac{1850}{30}$$

$= 61.7$ m^3/s

4.2 Name and describe the three types of hearing loss induced by exposure to noise and describe each effect. (6)

Answer 4.2 (6)

(a) **Temporary hearing loss**;- **is a short lived impairment of auditory sensitivity directly after exposure to noise**, which may last for minutes, hours or even days before the ear sensitivity returns to normal. Also called **Temporary Threshold Shift**

(b) **Permanent Hearing loss:- is an irreversible impairment of the auditory sensitivity after prolonged exposure to noise,** which is a slow process that can develop over a number years**. Also called Permanent Threshold Shift (PTS).**

(c) **Acoustic trauma:-** Is a single intense exposure to noise for example an explosion or a gun shot, and may be reversible.

4.3 Name any five (5) effects of whole body vibration (5)

Answer 4.3 (5)

(a) Influence muscle tone and speech
(b) Chest pains, backache, spontaneous muscle contraction, stomach-ache and general feeling of discomfort.
(c) Cause respiratory problems
(d) Affects the heart rate (irrespective of frequency)
(e) Increases blood pressure
(f) Affect human performance – deterioration in clarity of sight and task
(g) Impair a person's ability to maintain his balance.
(h) Affects visual perception (image becomes blurred and unsteady).
(i) Affects skeletal and muscle systems to a lesser extent.
(j) Sea – or car – sickness.
(k) Muscular tension, headaches, eyestrain, throat pain and intestinal irritation.

4.4 Name any five effects of localized vibration. (5)

Answer 4.4 (5)

(a) Causes small areas of calcification of the carpal joints in the hand.
(b) Results in soft tissue injury and nerve injury in the hands
(c) Osteoarthritis of the arm joints occurs in the shoulder, joints and elbows, resulting from degenerative destruction of bones, joints and tendons.
(d) Vascular disturbance known as "white finger disease" or "vibration induced white finger" (v.w.f.) or medically known as Raynaud's Syndrome.

(e) Cause reduced sensation of grip, feeling and pressure. (Sensory disturbances).
(f) Atrophy of bones and in severe cases, fracture of the affected bones.

4.5 Name any 4 (Four) beneficial effects of good or improved illumination? (4)

Answer 4.5

(a) Decrease the risk of accidents and reduce errors.
(b) Increase productivity
(c) Improve working conditions, morale and motivation.
(d) Preserves human energy.
(e) Reduce eye strain and minor illnesses.
(f) Prevent the accumulation of waste and rubbish.
(g) Better utilization of men and material.
(h) Improve the ability to move around and provide greater safety.

Marks 25