higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

XX AUGUST 2019

This marking guideline consists of 8 pages.

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QUESTION 1

1.1
1.1.1 Free moisture content
1.1.2 Crystallisation
1.1.3 Evaporation
1.1.4 Distillation
1.1.5 Rate of nucleation

(5 × 2) (10)

1.2
- Pure liquid or solvent exerts a certain vapour pressure at any given temperature.✓
- If another substance is dissolved in pure liquid, the vapour pressure of the solvent✓ over the mixture will be less than that of the pure solvent at the same temperature.✓
- Vapour pressure of the solvent is less than that of the pure solvent.✓
- A solution boils when its vapour pressure✓ equals the pressure of the surroundings.✓
- A solution of non-volatile material in water✓ must be heated above the boiling point of pure water before boiling occur.✓
- The boiling point rise in a solution is the actual surface temperature of the mixture✓ minus the temperature of the pure solvents if it exerts the same vapour pressure as the mixture.✓ (10)

1.3
1.3.1 Cylindrical shells
1.3.2 Hot gases
1.3.3 Rotating action
1.3.4 Wet material
1.3.5 Dry solids
1.3.6 Gravity
1.3.7 Blade scraper
1.3.8 Pitch
1.3.9 Thick cakes
1.3.10 Cylinder walls

(10 × 1) (10)

1.4 *Equilibrium moisture content* is the number of kg of water per kg of dry solid✓ when the drying limit has been attained✓ using air at any given temperature and humidity.✓

Critical free moisture content is the amount of water that can be removed from wet solid✓ under any given air humidity and temperature.✓ (5)

1.5
- Cluster
- Embryo
- Cluster
- Crystals (4 x 1) (4)

1.6	1.6.1	Thin film dryer		(1)
	1.6.2	A – Vapour B – Feed C – Vertical dryer D – Horizontal dryer E – Solids F – Dry powder zone G – Heating and crystallising zone H – Slurry zone I – Free-flowing powder zone J – Blade configuration	(10 × 1)	(10) **[50]**

QUESTION 2

2.1	2.1.1	It is the flow of heat from a hot body✓ to a cold body.✓ Radiant energy is emitted in all directions by a body.✓ If the energy makes contact with a receiver,✓ some of it is absorbed by that receiver.✓		(5)
	2.1.2	Growth-related spurious nucleation occurs at large super saturations✓ or accompanies poor magma circulation.✓ It is characterised by abnormal, needle-like and whisker-like growth✓ from the end of the crystals which under these conditions may grow further than the sides.✓ The spikes are imperfect crystals, which brake off and form crystals of poor quality.✓		(5)
2.2	2.2.1	Forced circulation evaporator		(1)
	2.2.2	A – Vapour out B – Deflector plate C – Feed in D – Condensate E – Concentrate out F – Steam in	(6 x 1)	(6)

2.2.3
- Liquid enters the tubes at low velocity.✓
- The linear velocity increases greatly✓ as vapour is formed in the tubes.✓
- A centrifugal pump forces liquid through the tubes.✓
- Tubes are under enough static head to prevent boiling.✓
- Liquid becomes superheated as static head is reduced.✓
- Liquid flash into a mixture of vapour and spray.✓
- Mixture of vapour and liquid impinges on deflector plate.✓
- Vapour leaves at the top of the evaporator to the condenser.✓
- Part of the liquid leaving the separator is continuously withdrawn as concentrate.✓ (10)

2.2.4
- Extra coefficient and cost for power force liquid through the tubes at higher velocity
- Extra cost not good for thin liquid but justified for viscous liquids. (2)

2.2.5
- Caustic soda
- Salting liquids
- Foaming liquids
- Corrosive liquids
- Moderately heat-sensitive liquids (Any 3 × 1) (3)

2.3
- Curing the seed crystals before use
- Contact with under-saturated solution or solvent
- Preliminary growth in a stagnant super-saturated solution (3 × 2) (6)

2.4 2.4.1

$$H_R = \frac{P_a}{P_s} \times 100$$

$$72 = \frac{P_a}{13.2} \times 100 ✓$$

$$P_a = \frac{72 \times 13.2}{100} ✓$$

$$P_a = 9.504 \text{ KPa} ✓$$ (3)

2.4.2

$$H_a = \frac{m_B \times P_a}{m_{N_2} \times (P - P_a)} ✓$$

$$= \frac{79 \times 9.504}{28 \times (101.3 - 9.504)} ✓✓✓✓$$

$$H_a = 0.292 \text{ Kg Benzene per Kg } N_2 ✓$$ (6)

2.5
- Upward flow/Climbing film
- Downward flow/Falling film
- Forced circulation (3 x 1) (3)

[50]

QUESTION 3

3.1
- Boiling point rise due to hydrostatic head is the difference between the temperature of the heat source✓ and that of the evaporating liquid.✓
- In many types of evaporators, the heat source✓ is submerged below the surface of the evaporating liquid.✓
- The solution on the outside of the steam tubes has a higher pressure✓ than the solution on the surface of the liquid because of the presence of the head of the fluid. ✓
- If boiling occurs in the steam tubes,✓ the temperature of the liquid will be higher than that of the surface.✓ (8)

3.2
- *Absorptivity* is the fraction of incident radiation✓ which is absorbed by a material.✓
- *Emissivity* is the total radiant energy emitted from a unit area✓ of a body in a unit time divided by the total radiant energy✓ emitted from a unit area of a black body✓ at the same temperature.✓ (6)

3.3 3.3.1 Holds steam in the shell and allow the liquid to be concentrated in the tubes (2)

3.3.2 Removes entrained liquids from the vapour (2)

3.3.3 Return leg for the liquid from the separator to the bottom of the exchanger (2)

3.4 3.4.1 The difference between the temperature✓ of the condensing steam✓ in the steam chest✓ and the temperature of the boiling solution✓ at the liquid vapour interface✓ in the evaporator body ✓ (6)

3.4.2 The difference between the steam temperature✓ and the apparent saturation of vapour✓ leaving the evaporating mixture✓ as determined from the pressure of the vapour✓ (4)

3.4.3 The temperature difference when the individual heat transfer coefficient✓ starts to decrease markedly✓ through formation of an insulating✓ and vapour film✓ (4)

3.5
- Shell and tube heat exchangers
- Plate heat exchangers
- Plate and shell heat exchangers
- Adiabatic wheel heat exchangers
- Plate fin heat exchangers
- Pillow plate heat exchangers
- Fluid heat exchangers
- Waste heat recovery units (Any 5 × 1) (5)

3.6 The amount of radiant energy✓ emitted is proportional✓ to the fourth power✓ of the absolute temperature✓ of the heat source body.✓ (5)

3.7 When a cool gas is exposed to a warm surface,✓ the temperature of the gas close to the surface increases.✓
This warm gas has a smaller density✓than the surrounding gases.✓
The warmer gas flows upwards from the hot surface,✓ setting up a natural flow of the surrounding gases past the hot surface.✓ (6)
[50]

QUESTION 4

4.1 4.1.1 The number of kilogram✓ of water vapour✓ carried by 1 kg of dry air✓

4.1.2 A straight line✓ giving the relationship between humidity✓ and humid heat✓

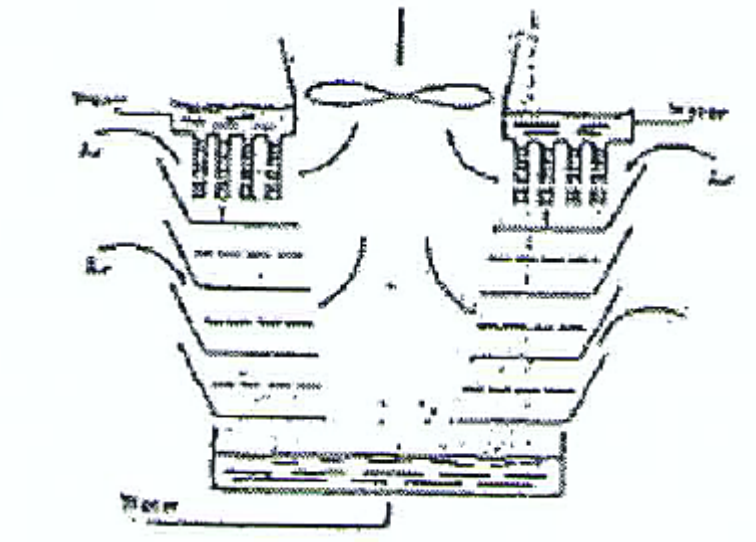
4.1.3 A line presenting the temperature✓ and humidity✓ at different adiabatic saturation temperature values✓

4.1.4 The volume in m^3 occupied by 1 kg of dry air✓ at any specific temperature and pressure✓ plus enough water vapour to saturate the air✓

(4 × 3) (12)

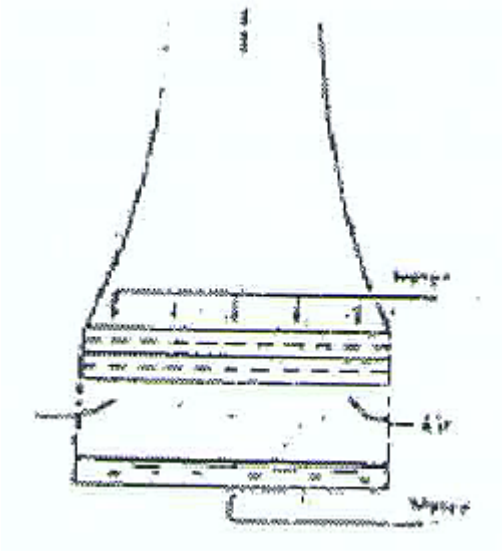
4.2
- In heat balance calculations for crystallisers,✓ the heat of crystallisation is important.✓
- This is the latent heat that evolves when solids form from a solution.✓
- Ordinary crystallisation is exothermic✓ and the heat of crystallisation varies✓ with both temperature and concentration.✓
- The heat of crystallisation is equal to the heat absorbed by the crystals.✓
- The absorbed crystals dissolve in a saturated solution✓ which may be found from the heat of the solution in a very large amount of the solvent.✓
- The heat of dilution of the solution from saturation to high dilution.✓ (10)

4.3 4.3.1



WET TRAY TOWER (5)

4.3.2



NATURAL DRAFT (4)

4.4 4.4.1

$$H_a = \frac{m_w}{m_{air}} \checkmark$$

$$= \frac{18}{186} \checkmark$$

$$H_a = 0.097 \text{ Kg water per Kg dry air} \checkmark$$ (3)

4.4.2

$$H_a = \frac{18\ P_a}{29\ (P - P_a)}$$

$$0.097 = \frac{18\ P_a}{29\ (101.3 - P_a)} \checkmark$$

$$18\ P_a = 284.9569 - 2.813\ P_a \checkmark$$

$$20.813\ P_a = 284.9569 \checkmark$$

$$P_a = 13.69 \text{ KPa} \checkmark$$ (4)

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4.4.3 From the steam tables: When $T = 93.5\ ^0C$ then $P_s = 80\ KPa$

$$H_s = \frac{18\ P_s}{29\ (P - P_s)}\checkmark$$

$$= \frac{18 \times 80}{29\ (101.3 - 80)}\checkmark\checkmark\checkmark\checkmark$$

$$H_s = 2.331\ Kg\ water\ per\ Kg\ dry\ air\checkmark$$ (6)

4.4.4 $$H_p = \frac{H_a}{H_s} \times 100\checkmark$$

$$= \frac{0.097}{2.331} \times 100\checkmark$$

$$H_p = 4.16\ \%\checkmark$$ (3)

4.4.5 $$H_R = \frac{P_a}{P_s} \times 100\checkmark$$

$$= \frac{13.69}{80} \times 100\checkmark$$

$$H_R = 17.11\ \%\checkmark$$ (3)

[50]

TOTAL: 200

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