higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

29 NOVEMBER 2019

This marking guideline consists of 9 pages.

Copyright reserved

QUESTION 1

1.1
1.1.1 Magma
1.1.2 Salting
1.1.3 Comminution
1.1.4 Frothing
1.1.5 Absorptivity

(5 × 2) (10)

1.2
- Drying involves the simultaneous transfer of mass✓ and heat.✓
- The rate of water removal is determined by the rate of mass and heat transfer.✓
- If water is present on the surface,✓ hot air passing over the surface will act as a heat source and be in direct contact with the water.✓ Resistance to mass and heat transfer will be due only to the liquid and gas films.✓
- If water is not present on the surface,✓ evaporation will occur beneath the surface✓ and added heat and mass transfer resistance will be encountered.✓
- In a batch process, the rate of drying should be greatest at the beginning and will decrease.✓

(10)

1.3
1.3.1 wet solids/feed
1.3.2 heat transfer
1.3.3 high temperature
1.3.4 paddle conveyor
1.3.5 dry material
1.3.6 hammer mill
1.3.7 long duct
1.3.8 cyclone
1.3.9 star feeder
1.3.10 refeeding

(10 × 1) (10)

1.4 1.4.1
A. Fan exhaust to atmosphere
B. Fan exhaust
C. Fan platform
D. Floor level
E. Finished product to storage
F. Hooper
G. Cyclone
H. Motorised dust valve
I. Rotary product valve
J. Spiral conveyor
K. Furnace
L. Stack
M. Feed tank
N. Feed pump
O. Atomiser

(15 × 1) (15)

Copyright reserved

1.4.2
- Very short drying time
- Drying of highly sensitive materials
- Production of solids or hollow spherical particles
- Flow properties of some products such as food or synthetic detergents
- Yielding a single step
- Dry product ready for package from a solution, slurry or thin paste
- Combines the function of the evaporator, classifier, dryer and size-reduction unit (Any 5 × 1) (5)

[50]

QUESTION 2

2.1 2.1.1
- The most common method used in the industry.✓
- It occurs at low super saturations where the growth rate of the crystals is at optimum for good quality.✓
- Crystals are struck which results in the breakage of microscopic dendritic growth✓ on the surface of the growing crystals.✓
- These dislodged particles that survive then grow into new particles.✓ (5)

2.1.2
- A small crystal can be in equilibrium with a super saturated solution.✓
- Such equilibrium is unstable✓ because a larger crystal is also present in the solution.✓
- The smaller crystal will dissolve✓ and the larger one will grow until the small crystal disappears.✓ (5)

2.2
- Purity
- Yield
- Energy requirement
- Rates of nucleation and growth (4)

2.3 2.3.1 Agitated film evaporator (2)

2.3.2
A. Motor
B. Vapour outlet
C. Stationary plates
D. Agitator
E. Vapour separator
F. Vent
G. Feed inlet
H. Steam jacket
I. Condensate
J. Concentrate

(10 × 1) (10)

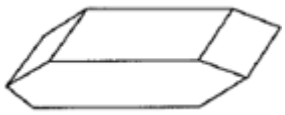
2.3.3
- Feed enters the top-jacket section✓ and spreads out in thin, highly turbulent film by vertical blades.✓
- Concentrate leaves from the bottom of the jacketed section.✓
- Vapour rises from the vaporising zone✓ into the unjacketed section.✓
- In the separator, agitated blades throw entrained liquid✓ outwards against stationary vertical blades.✓
- Droplets blend/unite on these plates and return to the evaporating section.✓
- Liquid-free vapour escapes through the outlet✓ at the top of the unit.✓ (10)

2.3.4
- High cost
- Small capacity of single units
- Internal moving parts require considerable maintenance (3)

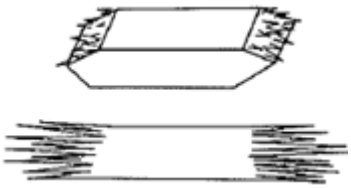
2.3.5
- Gelatine
- Rubber latex
- Antibiotics
- Fruit juices (4)

2.4 Capacity is the kilograms of water✓ vaporised per hour,✓ while economy is the kilograms of water vaporised in an evaporator✓ per kilogram of the original steam supplied.✓ (2 + 2) (4)

2.5 2.5.1

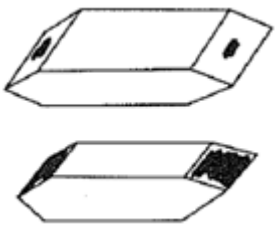


2.5.2



(Any correct diagram)

2.5.3



(Any correct diagram)
(3 × 1) (3)
[50]

QUESTION 3

3.1
- The operation of a natural-circulation tower depends on the prevailing winds for air movement.✓
- More positive air movement✓ depends on the displacement of warm air✓ inside the tower by the cooler outside air.✓
- Fairly tall chimneys are required✓ to operate at wet-bulb temperature.✓
- They are used where the humidity are low.✓ (7)

3.2
- Crystallisation from solution
- Crystallisation from melting
- Condensation of the fog drops in a super-cooled vapour
- Generation of bubbles in super-heated liquids (4)

3.3 3.3.1 It is the actual temperature of the mixture✓ minus the temperature of the pure solvent✓ if it exerted the same vapour pressure✓ as the mixture.✓ (4)

3.3.2 It is the difference in temperature✓ of the liquid at the heat source✓ and the liquid✓ at the evaporating surface.✓ (4)

3.3.3 The equilibrium vapour pressure exerted by a component in a liquid✓ solution equals the mole fraction of the component in the solution✓ times the equilibrium vapour pressure the component✓ would exert if it was pure✓ and at the same temperature as the solution.✓ (6)

3.4 3.4.1 112,54 mmHg = x kPa
760 mmHg = 101,3 kPa

$$x = \frac{112.54 \times 101.3}{760} = 15.00 \text{ KPa}$$ ✓✓

From steam table: t_s = 54 °C when P = 15 kPa✓ (3)

3.4.2 From steam table: h_{fg} = 2 373 kJ/kg✓✓ when P = 15 kPa

$m' = 30\,000$ kg

$q_v = m' \times h_{fg}$

$= 30\,000 \times 2\,373$✓

= 71 190 000 kJ/h✓ (4)

3.4.3 $$m' = m - \frac{\text{conc. of the feed}}{\text{conc. of the product}} \times m$$

$$30\,000 = m - \frac{0.25}{0.7} \times m \checkmark\checkmark$$

$$30\,000 = m\left(1 - \frac{0.25}{0.7}\right)$$

$$0.643m = 30000 \quad \text{or} \quad 0.64m = 30\,0000 \checkmark$$

$$m = 46\,656.30 \text{ Kg} \quad \text{or} \quad m = 46875 \text{ Kg} \checkmark$$ (4)

3.4.4 $$q_s = mC\Delta t$$

$$= 46\,656.3 \times 4.75 \times (54 - 16) \checkmark\checkmark$$

$$= 8\,421\,426.15 \text{ KJ/hr} \checkmark$$

$$= \frac{8\,421\,426.15 \times 1000}{3600} \checkmark$$

$$= 2\,339\,295.04 \text{ J/s} \checkmark$$

$$Q = UA\Delta t$$

$$2\,339\,295.04 = (1800)A(88 - 54) \checkmark\checkmark\checkmark$$

$$2\,339\,295.04 = 61\,200\,A \checkmark$$

$$A = 38.22\ m^2 \checkmark$$

OR

$$q_s = mC\Delta t$$

$$= 46\,875 \times 4.75 \times (54 - 16) \checkmark\checkmark$$

$$= 8\,460\,937.5 \text{ KJ/hr} \checkmark$$

$$= \frac{8\,460\,937.5 \times 1000}{3600} \checkmark$$

$$= 2\,350\,260.42 \text{ J/s} \checkmark$$

$$Q = UA\Delta t$$

$$2\,350\,260.42 = (1800)A(88 - 54) \checkmark\checkmark\checkmark$$

$$2\,350\,260.42 = 61\,200\,A \checkmark$$

$$A = 38.40 m^2 \checkmark$$ (10)

Copyright reserved

3.4.5 From steam table: h_{fg} = 2 288 kJ/kg✓✓ when P = 65 kPa

m_s = ?
$q_s = m' \times h_{fg}$

$$8\,460\,937.5 = 2288 \times m_s ✓$$

$$m_s = \frac{8\,460\,937.5}{2288}$$

$$m_s = 3697.96\ Kg/hr ✓$$

OR

From steam table: h_{fg} = 2 288 kJ/kg✓✓ when P = 65 kPa

m_s = ?

$q_s = m' \times h_{fg}$

$$8\,421\,426.15 = 2288 \times m_s ✓$$

$$m_s = \frac{8\,421\,426.15}{2288}$$

$$m_s = 3680.71\ Kg/hr ✓$$ (4)

[50]

QUESTION 4

4.1 4.1.1 In most industrial processes, heat is transferred from one point to another under steady conditions✓ regarding temperature difference,✓ length of heat flow✓ and cross-sectional area.✓ (4)

4.1.2 When heat flows through a solid by conduction,✓ there is a certain resistance to the flow which is determined by thermal conductivity,✓ the cross-sectional area✓ and thickness of the substance.✓ (4)

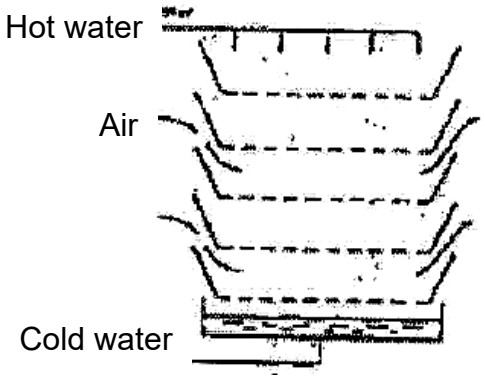
4.1.3 It is the extent of saturation of air✓ and water-vapour mixture, and✓ sometimes it is expressed on the basis of water-vapour✓ partial pressure.✓ The degree of saturation,✓ expressed as 100 times the actual partial pressure of pure water vapour in the air✓ divided by the saturation vapour pressure of pure water✓ at the same temperature.✓ (8)

4.1.4 The volume in m^3✓ occupied by 1 kg of dry air✓ at any specific temperature and pressure✓ plus sufficient water vapour to saturate air.✓ (4)

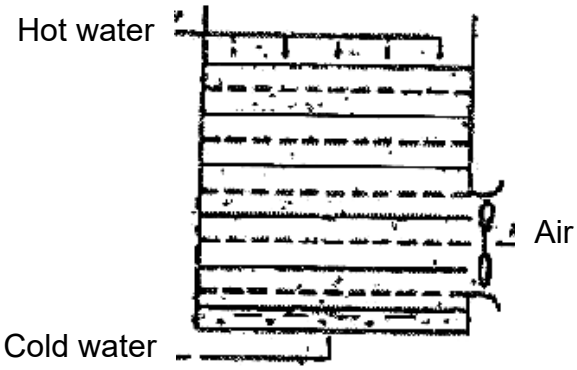
4.2
- Chemical methods
- Mechanical methods

(2)

4.3 4.3.1



4.3.2



(4 × 2) (8)

4.4
$$A = 4\pi r^2$$
$$= 4\pi(\frac{0.25}{2})^2 \checkmark$$
$$= 0.196\ m^2 \checkmark$$
$$Q = 0.173\ A\ [(\frac{T_2}{100})^4 - (\frac{T_1}{100})^4]$$
$$= 0.173 \times 0.196\ [(\frac{1073}{100})^4 - (\frac{623}{100})^4] \checkmark\checkmark$$
$$= 398.39\ J/hr \checkmark$$

OR

$$A = 4\pi r^2$$
$$= 4\pi(\frac{0.25}{2})^2 \checkmark$$
$$= 0.2\ m^2 \checkmark$$
$$Q = 0.173\ A\ [(\frac{T_2}{100})^4 - (\frac{T_1}{100})^4]$$
$$= 0.173 \times 0.2\ [(\frac{1073}{100})^4 - (\frac{623}{100})^4] \checkmark\checkmark$$
$$= 406.52\ J/hr \checkmark$$

(5)

4.5 4.5.1

- Always introduce the colder fluid first.✓
- Add hotter fluid slowly✓ until the unit is up to operating conditions.✓
- Be sure the entire unit is filled with fluid and there are no pockets of trapped inert gases.✓
- Use the bleed valve to bleed off trapped gases.✓ (5)

4.5.2

- Shut off the hot fluid first✓ but do not allow the unit to cool✓ too rapidly.✓
- Drain any materials which may cause trouble✓ if left in the exchanger.✓ (5)

4.5.3

- Always drain any steam condensate✓ from the heat exchanger when starting up or shutting down.✓
- This reduces the possibility of water hammer✓ caused by steam forcing the trapped water✓ through the lines at high velocity.✓ (5)

[50]

TOTAL: 200

Copyright reserved