higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY

29 NOVEMBER 2022

This marking guideline consists of 8 pages.

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QUESTION 1

1.1 indirect-heat
1.2 screw conveyor or paddle conveyor
1.3 jacket shell
1.4 heated zone
1.5 vapour evolved
1.6 fine and sticky
1.7 completely enclosed
1.8 moderate vacuum
1.9 volatile solvents
1.10 desolventisers

(10 × 1) **[10]**

QUESTION 2

2.1 E
2.2 A
2.3 C
2.4 D
2.5 B

(5 × 2) **[10]**

QUESTION 3

3.1 3.1.1
- Granular and crystalline materials which must be kept clean and may not be exposed to direct hot gases
- Material that cannot be agitated
- Sugar
- Salt (Any 3 × 1) (3)

3.1.2
- Rigid or granular solids
- Materials that cannot be agitated
- Fine and sticky solids
- Flaky materials
- Fibrous materials (Any 3 × 1) (3)

3.2
- Vertical agitated evaporator-dryer
- Horizontal paddle-conveyor dryer (2)

3.3 A – Clean gas discharge
B – Stack
C – Dust collector
D – Dry product discharge
E – Plenum
F – Fluidising blower
G – Air inlet
H – Heat source
I – Distributor plate
J – Feeder
K – Wet feed
L – Fluidising chamber (12 × 1) (12)

3.4 3.4.1 Drum dryer
3.4.2 Rotary dryer
3.4.3 Vacuum dryer / flash dryer
(3 × 2) (6)

3.5 3.5.1 Turbo-shelf dryer (1)

3.5.2 A – Heating elements
B – Turbine (fan)
C – Circular/annular shelves (3)

3.5.3 In these types of dryers, wet solid is fed in a thin layer to the top✓ member of a series of annular shelves,✓ each made of a number of segmental plates with slots between them.✓ These shelves rotate by means of suitably placed arms. The material is pushed through a slot onto a shelf below.✓ After repeated movements, the dried solid leaves at the bottom of the dryer.✓ The shelves are heated✓ by a row of steam pipes, and in the centre there are three or more fans that suck✓ the hot air over the material and remove it at the top.✓ A turbo dryer combines cross-circulation drying,✓ as in a tray dryer, with drying by showering (counter-current flow)✓ the particles through the hot air as they tumble from one tray to another.✓ (10)
[40]

QUESTION 4: CRYSTALLISATION

4.1 4.1.1 It is a liquid from the solution in which crystals are formed. (2)

4.1.2
- Filtration
- Centrifugation
- Washing with fresh solvent (3)

4.2
- Cluster
- Embryo
- Nucleus
- Crystal (4)

4.3
- Salting
- Precipitation (2)

4.4 4.4.1 It is the number of new particles formed✓ per unit time✓ per unit volume of magma or solids-free mother liquor.✓ (3)

4.4.2 Growth-related spurious nucleation occurs at large supersaturations✓ or accompanies poor magma circulation.✓ It is characterised by abnormal needle-like✓ and whisker-like✓ growths from the ends of the crystals,✓ which, under these conditions, may grow much faster than the sides.✓ The spikes are imperfect crystals, which are bound to the parent crystal✓ by weak forces and which break off to give crystals of poor quality.✓ (6)

4.5 4.5.1 During initial breeding, seeds usually carry on their surfaces many small crystals✓ which were formed during the drying✓ and storage of the seeds after their own manufacture.✓ The small crystals soon wash off✓ and subsequently grow in the supersaturation.✓

Veiled growth occurs at moderate supersaturations.✓ It is the result of the occlusion of the mother liquor into the crystal face,✓ giving a milky surface✓ and an impure product.✓ The cause of the veiled growth is too rapid crystal growth,✓ which traps mother liquor in the crystal faces.✓ (10)

4.5.2 It can be prevented by curing the seed crystal before using,✓ either by contact with undersaturated solution or solvent✓ or by a preliminary growth in a stagnant supersaturated solution.✓ (3)

4.5.3
- Growing crystals at supersaturations
- Well-designed and operated pumps and agitators (2)

[35]

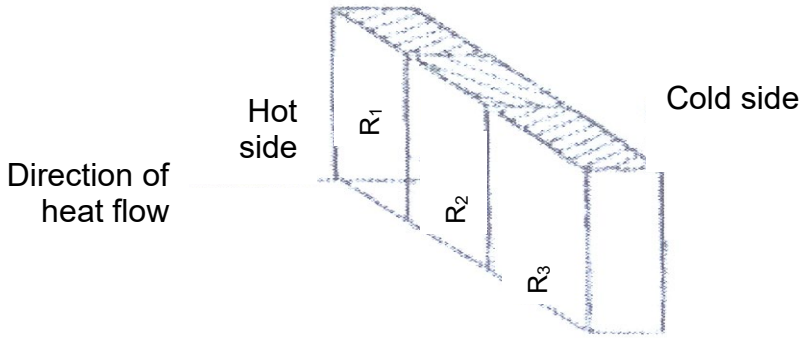
QUESTION 5: HEAT TRANSFER

5.1 5.1.1 It states that the amount of radiant energy emitted✓ is proportional to the fourth power of the absolute temperature✓ of the heat source body.✓ (3)

5.1.2 The instantaneous rate of heat transfer through a homogenous body by conduction✓ is directly proportional to the temperature difference driving force✓ across the body and to the cross-sectional area of the body✓ through which heat flows.✓ The rate of heat transfer is inversely proportional to the thickness of the body (the length of the path along which heat flows).✓ (4)

5.2 5.2.1 If one solid is placed in series with another solid✓ so that heat must pass through both of these,✓ the resistance to the flow of heat will be greater than it would be for one of the solids alone.✓ If three solids of equal cross-sectional areas, designated as 1, 2, and 3, are placed in series✓ when a steady flow of heat exists, exactly the same amount of heat per unit time✓ must be transferred through each of the solids.✓ (6)

5.2.2



1 mark for the correct drawing and 4 marks for correct labelling (5)

5.3
- Thermal conductivity
- Cross-sectional area
- Thickness of the conductor (3)

5.4 When heat flows through a solid by conduction,✓ there is a certain resistance to the flow determined by the thermal conductivity,✓ cross-sectional area✓ and thickness of the particular substance.✓ To obtain any given rate of heat flow, this resistance must be overcome✓ by setting up a certain temperature difference driving force.✓ (6)

[27]

QUESTION 6: EVAPORATION

6.1 6.1.1 The difference between the temperature of the condensing steam in the steam chest✓ and the temperature of the boiling liquid in the evaporator body.✓

6.1.2 When a fluid is flowing past a stationary surface,✓ a thin film of the fluid is postulated as existing between the flowing fluid and the stationary surface.✓

6.1.3 The phenomenon that the boiling point of a liquid (solvent) will be higher when another compound is added, meaning that a solution has a higher boiling point than a pure solvent.

6.1.4 The carry-over of liquid droplets into the vapour space of an evaporator✓ – a carry-over that occurs as the result of the vapour velocity – is high enough to overcome the tendency of the liquid drops to settle.✓

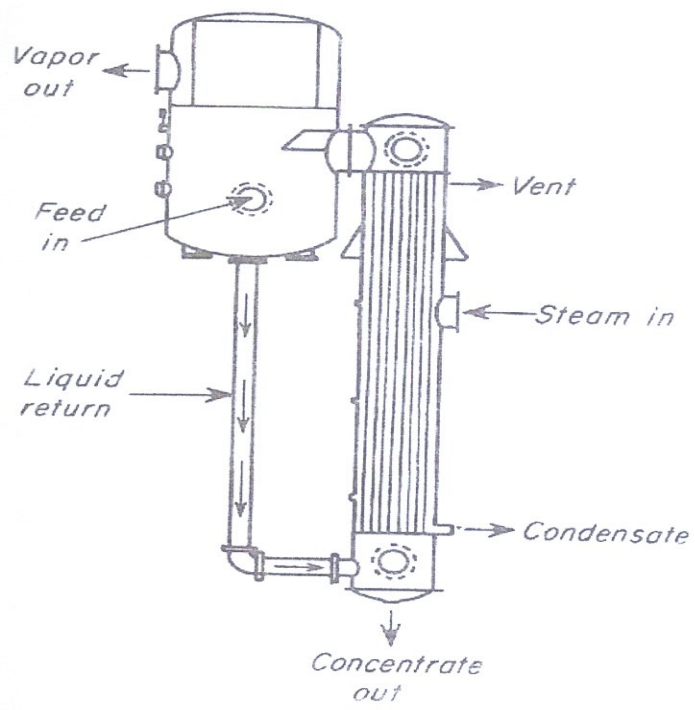
(4 × 2) (8)

6.2 6.2.1
- It has the ability to give high rates of heat transfer with viscous liquids.
- The product may have a high viscosity at the evaporation temperature.
- For moderate viscous materials the overall coefficient falls as the viscosity rises.
- With highly viscous materials the coefficient is greater than forced-circulation evaporators and much greater in natural-circulation units. (4)

6.2.2
- High cost
- Small capacity of single unit
- Internal moving parts requiring considerable maintenance (3)

6.2.3
- Rubber latex
- Gelatin
- Antibiotics
- Fruit juices (Any 3 × 1) (3)

6.3



1 mark for the correct drawing and 7 marks for correct labelling (8)

6.4 Climbing-film, rising-film or vertical long-tube evaporators are typical evaporators with essentially a vertical shell and tube heat exchanger.✓ The liquid being evaporated is fed from the bottom of the evaporator body✓ into a long-tube heat exchanger✓ and heated with steam condensing on the outside of the tube from the shell side.✓ Vapour is continually produced inside the tubes as the liquid is heated and brought to boil.✓ The vapour produced then presses the liquid against the walls of the tubes and causes the ascending force of this liquid.✓ As more vapour is formed, the centre of the tube will have a higher velocity, which forces the remaining liquid against the tube wall, forming a thin film which moves upwards.✓ Bubbles grow rapidly near the top of the tubes.✓ In this zone, bubbles of vapour alternating with slugs of liquid rise very quickly through the tubes and emerge at high velocity from the top.✓ Mixture of liquid and vapour then enters the evaporator body (separator). The evaporator body has a larger diameter than that of tubes, resulting in greatly reduced linear velocity of the vapour.✓ The evaporator body has baffle plates which prevent liquid droplets from leaving with vapour.✓ Concentrated liquid is withdrawn as product at the bottom of the heat exchanger.✓ (12)

[38]

QUESTION 7: HUMIDIFICATION AND DE-HUMIDIFICATION

7.1
- Latent heat transfer
- Sensible heat transfer (2)

7.2 The temperature of the liquid/water must be higher than the dew point of the air.✓ Air may be humidified by spraying water or steam into the air✓ by using a packed or bubble cap tower,✓ where the air and liquid water may come into contact immediately.✓ If the water temperature is higher than the wet-bulb temperature of the air,✓ the water will be cooled and approach the wet-bulb temperature of the air.✓ In an adiabatic humidifier,✓ the water is recirculated and the temperature of the water as well as the temperature of the exit gases✓ become approximately the same as the wet-bulb temperature.✓ (9)

7.3
- The wet-bulb temperature is obtained when the heat required to vaporise a small amount of water✓ into a large volume of air✓ exactly equals✓ the sensible heat transferred✓ from the air✓ to the liquid water.✓
- The amount of heat necessary to vaporise the water✓ depends on the rate at which the water can escape✓ from the liquid surface.✓
- This rate depends upon the diffusion coefficient.✓
- The sensible heat transferred to the water✓ depends upon the heat transfer coefficient✓ between the air✓ and the liquid water.✓
- For water and air systems,✓ the relationship between the diffusion coefficient✓ and heat-transfer coefficient✓ is such that the wet-bulb temperature✓ and the adiabatic saturation temperature are almost equal.✓ (15)

7.4 P_a = 93 mm.Hg✓
P = 101,3 kPa = 760 mm.Hg✓

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

$= \frac{18\ (93)}{29\ (760 - 93)}$ ✓ = 0,0865 kg water per kg dry air✓

Mass of air = 8 ÷ (1 + H_a)✓
= 8 ÷ (1 + 0,0865)✓
= 7,363 kg dry air✓

C_s = 1 + (1,88 × H_a)✓
= 1 + (1,88 × 0,0865)✓
= 1,163 kJ/kg.K✓

Q = 1,163 × 7,363 × (60 – 50)✓✓
= 85,632 kJ✓ (14)
[40]

TOTAL: 200

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