higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY

12 August 2021

This marking guideline consists of 8 pages.

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SECTION A

QUESTION 1

1.1	1.1.1	E		
	1.1.2	D		
	1.1.3	C		
	1.1.4	C		
	1.1.5	B		
			(5 × 2)	(10)
1.2	1.2.1	High rates		
	1.2.2	Viscous liquids		
	1.2.3	Falls		
	1.2.4	Rises		
	1.2.5	Moderately		
	1.2.6	Decreases		
	1.2.7	Forced-circulation units		
	1.2.8	Natural-circulation units		
	1.2.9	Effective		
	1.2.10	Viscous heat		
			(10 × 1)	(10)
1.3	1.3.1	False		
	1.3.2	False		
	1.3.3	True		
	1.3.4	False		
	1.3.5	True		
			(5 × 2)	(10)
1.4	1.4.1	Product discharge		
	1.4.2	Air inlet		
	1.4.3	Moist air outlet		
	1.4.4	Dryer shell		
	1.4.5	Steam		
	1.4.6	Gear drive		
	1.4.7	Dry solid discharge		
	1.4.8	Shell supporting rolls		
	1.4.9	Steam condensate		
	1.4.10	Feed		
			(10 × 1)	(10)
1.5	1.5.1	Equilibrium moisture content		
	1.5.2	Crystallisation		
	1.5.3	Evaporation		
	1.5.4	Economy		
	1.5.5	Humidity lines		
			(5 × 2)	(10)
				[50]

TOTAL SECTION A: 50

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SECTION B

QUESTION 2

2.1 2.1.1

- It is the operation involving 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✓ and acting as a heat source will be in direct contact with the water.✓
- Resistance to heat and mass will be due only to the liquid and gas film.✓
- 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 thereafter.✓ (10)

2.1.2

- Seeds usually carry on the surfaces.✓
- Many small crystals are formed✓ during the drying and storage of the seeds.✓
- The small crystals soon wash off✓ and grow in the supersaturated solution.✓ (5)

2.1.3

- Molecules of matter✓ are in constant motion.✓
- Heat is conducted through matter✓ by means of vibration.✓✓
- Hot molecules vibrate more rapidly.✓ (5)

2.2 Drying is the removal of water from material✓ containing a relatively small amount of water.✓
Freeze drying is the sublimation of water vapour✓ from ice under high vacuum✓ at temperatures below 0 °C.✓ (5)

2.3 2.3.1

$$D = \frac{120}{1\,000} + \frac{80}{100}$$

$$= 0{,}12 + 0{,}8$$
$$= 0{,}92 \text{ m}$$

$$A = \pi DL$$
$$= \pi \times 0{,}92 \times 1 ✓$$
$$= 2{,}89 \text{ m}^2 ✓$$ (2)

2.3.2 $D = 2\left(\frac{50}{100}\right) + \frac{120}{1\,000} + \frac{80}{100}$✓

$= 2(0,05) + 0,12 + 0,8$
$= 1,02\ m$✓

$A = \pi DL$
$= \pi \times 1,02 \times 1$✓
$= 3,204\ m^2$✓ (4)

2.3.3 Logarithmic mean area $\frac{2,89 + 3,204}{2}$✓✓

$= 3,047\ m^2$✓ (3)

2.3.4 $Q = \frac{KA\Delta T}{x}$

$= \frac{0,07 \times 3,047 \times (100 - 30)}{0,05}$✓✓✓

$= 289,606 \frac{W}{m}$ pipe✓ (4)

2.3.5 $A_{inside} = \pi DL$
$= \pi \times 0,05 \times 1$✓
$= 0,157\ m^2$✓ (2)

2.3.6 $A_{outside} = \pi DL$
$= \pi \times 0,92 \times 1$✓
$= 2,89\ m^2$✓ (2)

2.3.7 Logarithmic mean area $= \frac{2,89 + 0,157}{2}$✓
$= 1,524\ m^2$✓

$Q = \frac{KA\Delta T}{x}$

$\Delta T = \frac{Q\,x}{KA}$

$= \frac{289,606 \times 0,8}{60 \times 1,524}$✓✓✓

$\Delta T = 2,534\ ℃$✓

$T_{inside} = 100 + 2,534$✓
$T_{inside} = 102,534\ ℃$✓ (8)

[50]

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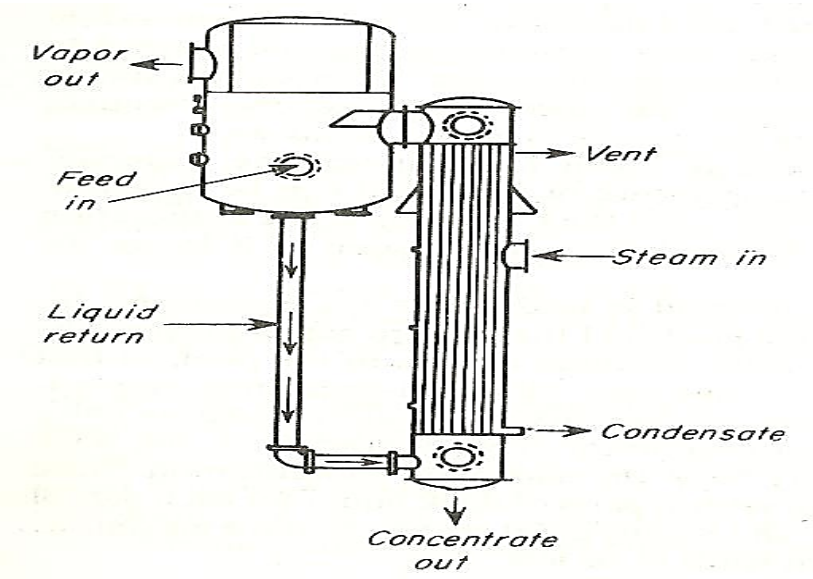
QUESTION 3

3.1
- Upward flow/climbing film
- Downward flow/falling film
- Forced circulation (3)

3.2
- The liquid is exposed to the heat source
- The transfer of heat through a suitable retaining medium (2 × 2) (4)

3.3
- Very short drying time
- Drying of highly heat-sensitive materials
- Production of solid or hollow spherical particles
- Yield from a solution, slurry or thin paste of dry product in a single step
- Many combine the functions of an evaporator
- A crystalliser dryer, a size reduction unit and a classifier (6)

3.4



7 marks for correct labels and 3 marks for correct drawing (10)

Advantages:
- Sufficient static head ensures that no boiling occurs in the tubes
- Overall coefficient can be increased by increasing the liquid velocity through the evaporator tubes
- Greatest improvement of heat transfer coefficient with viscous liquid (3)

3.5 3.5.1 Dühring's rule states that a linear relationship✓ exists between the temperatures✓ at which two solutions exert the same vapour pressure.✓ Dühring's plot is a graphical representation of such a relationship,✓ with each line of the graph representing a constant concentration.✓ (5)

3.5.2 The fraction of incident radiation✓ that is absorbed✓ by a material✓ (3)

3.5.3 The amount of radiation energy✓ emitted is proportional to the fourth power✓ of the absolute temperature✓ of the heat source body.✓ (4)

3.6 Basis: 100 kg

Mass of water = 100 – 72 = 28 kg
Mass of glucose = 28 kg

$n_w = \frac{28}{18}$ = 1,556 moles✓
$n_{glucose} = \frac{72}{346}$ = 0,208 moles✓

$X_w = \frac{1{,}556✓}{1{,}556 + 0{,}208✓}$ = 0,882✓

T = 369,7 – 273 = 96,7 °C and P = 90 KPa✓

P = × P_a
= 0,882 × 90✓
= 79,38 KPa✓

Temperature (°C)	91,8	×	93,5
Pressure (KPa)	75	79,38	80

$$\frac{x - 91{,}8}{79{,}38 - 75} = \frac{93{,}5 - 91{,}8}{80 - 75}✓$$

$$x - 91{,}8 = 4{,}38\left(\frac{1{,}7}{5}\right)$$
$$x = 1{,}489 + 91{,}8$$

$$x = 93{,}29\ ℃✓$$

$$\text{BPR} = 96{,}7 - 93{,}29✓$$

$$\text{BPR} = 3{,}41\ ℃✓$$ (12)
[50]

QUESTION 4

4.1 4.1.1 A – Tubular exchange✓
- To hold steam in the shell✓
- Allows liquid to be concentrated in the tubes✓

B – Separator/Vapour space✓
- Removes entrained liquid from the vapour✓

C – Circulation unit✓
- Return leg for the liquid from the separator to the bottom of the exchanger✓ (7)

4.1.2 When a fluid flows past a stationary surface,✓ a thin film of fluid is postulated as existing✓ between the flowing fluid and the stationary surface.✓ It is assumed that all the resistance to transmission of heat✓ between the flowing fluid✓ and the body containing the fluid is due to the film at the stationary surface.✓ (6)

4.1.3 The extent of saturation of an air and water vapour mixture✓ is sometimes expressed on the basis of water–vapour partial pressure.✓ The degree of saturation✓ is expressed as 100 times the actual partial pressure✓ of the pure water vapour in the air,✓ divided by the saturation vapour pressure✓ of the pure water✓ at the same temperature.✓
Its symbol is H_R✓
Its formula is $H_R = P_{(actual)} / P_{(saturated)}$✓ (10)

4.1.4 Dry bulb temperature is the ambient air temperature.✓ The air temperature is indicated by a thermometer that is not affected by moisture in the air.✓ The thermometer may be freely exposed to air,✓ but should be shielded from any moisture and radiation in order to indicate the dry bulb temperature.✓ (4)

4.1.5 Always introduce the cooler fluid first.✓ Add the hotter fluid slowly,✓ until the unit is at operating condition.✓ Ensure that the entire unit is filled with fluid✓ and that there are no pockets of trapped inert gases.✓ Use the bleed valve to bleed off trapped gases.✓ (6)

4.1.6 It occurs at large supersaturations or accompanies poor magma circulation.✓ It is characterised by abnormal needle-like and whisker-like growth from the ends of the crystals,✓ which under these conditions may grow much faster than the sides.✓ The spikes are imperfect crystals that are bound to the crystal✓ by weak forces and break off to give crystals of poor quality.✓ (5)

4.2 Multi-pass heat exchangers✓
Overall heat transfer coefficient✓
Constant fluid heat capacity✓ (3)

4.3 The extent of drying using air is limited✓ at a set temperature and humidity.✓ A stage could be reached were the air becomes saturated✓ with moisture and no more drying will take place.✓ Equilibrium moisture content is the level where a material neither gains nor loses moisture✓ because it is at equilibrium with the relative humidity and temperature✓ of the surrounding environment.✓ The equilibrium moisture content depends on the nature of the solid to be dried✓ and the temperature and humidity of the air.✓ (9)
[50]

TOTAL SECTION B: 150
GRAND TOTAL: 200

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