higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CHEMICAL TECHNOLOGY N6

26 MARCH 2018

This marking guideline consists of 8 pages.

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QUESTION 1

1.1 1.1.1 False
1.1.2 False
1.1.3 True
1.1.4 False
1.1.5 True

(5 × 2) (10)

1.2 1.2.1 This is the removal of water from materials✓ containing a relatively small amount of water.✓

OR

This is the removal of small amounts of water✓ by passing air over the material having a low water content.✓

1.2.2 The total kilogram (kg) of water contained by 1 kg of dry solids✓ minus the equilibrium moisture content.✓

(2 × 1) (2)

1.3 1.3.1 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 transfer will be due only to the liquid and gas films.✓✓

1.3.2 Evaporation will occur beneath the surface✓✓ and added heat and mass transfer resistance will be encountered.✓✓

(2 × 4) (8)

1.4 1.4.1
- Coarse grain solids
- Heat-sensitive product
- Dyes
- Pharmaceuticals
- Vitamins (Any TWO)

1.4.2
- Salt
- Sugar
- Granular and crystalline materials which must be kept clean (Any TWO)

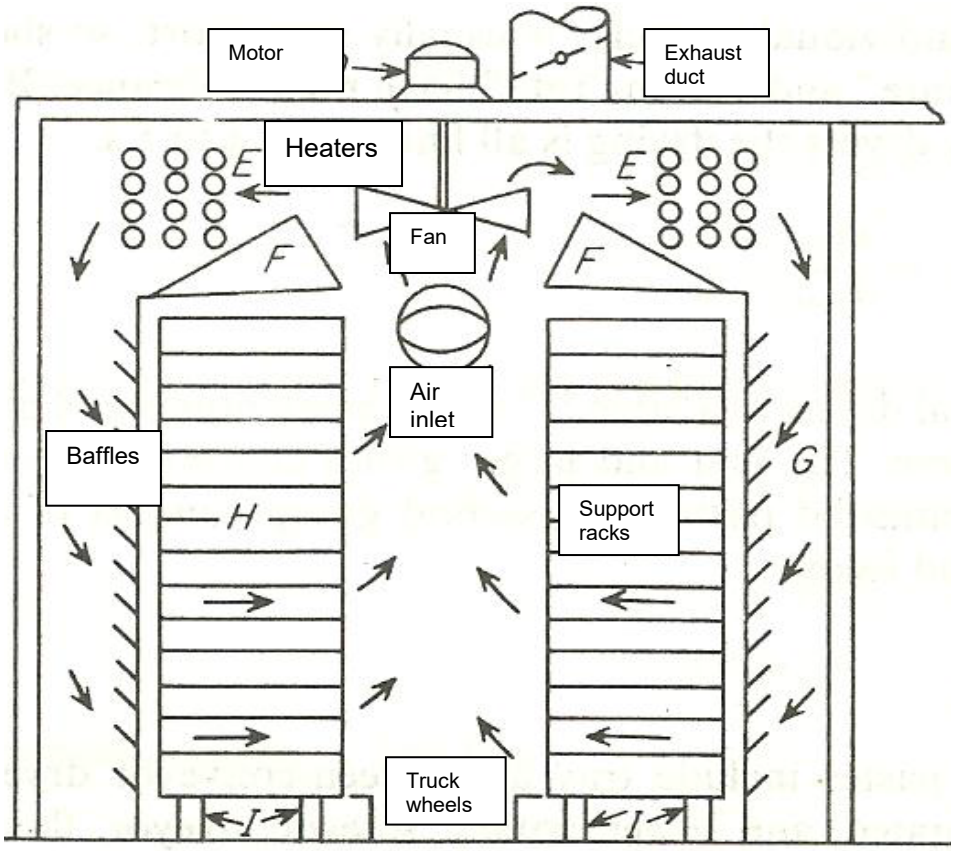
1.4.3
- Heat-sensitive material
- Synthetic detergents
- Foodstuff like milk, coffee
- Materials that produce porous hollow particles (Any TWO)

(3 × 2) (6)

1.5 1.5.1 Its operation is quick. (2)

1.5.2
- More expensive to operate
- Requires a lot of labour for loading and unloading (2 × 2) (4)

1.6



(TWO marks for the correct drawing) (10)

1.7
- Time and drops
- Size and shape of the chamber
- Size and terminal velocity of the drops
- Flow pattern and velocity of the air (4)

1.8 Direct dryer:✓ The solids are exposed to a hot gas.✓
Indirect dryer:✓ The heat is transferred to the solids from the external source.✓ (4)
[50]

QUESTION 2

2.1
2.1.1 E
2.1.2 G
2.1.3 B
2.1.4 D
2.1.5 A

(5 × 2) (10)

2.2 2.2.1 Crystallisation is the formation of solid particles✓ within a homogeneous phase; it may occur as a formation of solid particles in vapour, or in snow.✓ (2)

2.2.2 Evaporation is the operation whereby a fluid changes✓ from the liquid state into a vapour state.✓ (2)

2.3 2.3.1 In an industrial crystallisation processes, the crystals and mother liquor are in contact long enough to reach equilibrium.✓ The mother liquor is saturated at the final temperature of the saturation process.✓ The yield of the process is calculated from the concentration of the original solution✓ and the solubility of the final temperature.✓ When the rate of crystal growth is slow,✓ a lot of time is required to reach equilibrium.✓ (6)

2.3.2 Homogeneous nucleation is a consequence✓ of raid local fluctuations✓ on a molecular scale✓ in a homogenous phase✓ that is in a state of metastable equilibrium.✓ (5)

2.3.3 Ostwald ripening occurs with large✓ and small crystals✓ in a solution.✓ The larger crystals grow✓ and the smaller crystals dissolve and disappear.✓ (5)

2.4
- A solution is left at room temperature.
- A supersaturated solution is made above room temperature. (2)

2.5
- Size of the crystals
- Uniformity of the crystals (2)

2.6
- Filtration
- Centrifuging
- Washing with fresh solvent (3)

2.7
- Spurious nucleation
- Primary nucleation
- Secondary nucleation (3)

2.8
- Crystals from impure solutions are pure.
- It provides a practical method of supplying pure chemical substances.
- The crystals thus obtained are in a condition satisfactory for storing and packing. (3)

2.9 This occurs when a saturated solution is cooled.✓ When the solubility of a solute increases strongly with an increase in temperature;✓ the subsequent reduction in temperature can result in supersaturation.✓ Evaporation of a portion of the solvent can cause supersaturation when solubility is relatively independent of temperature.✓ The addition of a third component is used for rapid creation of very big supersaturation.✓ The third component may act physically by forming a mixed solvent with the original solvent.✓ (6)

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2.10
- Curing the seed crystals before using
- Preliminary growth in a stagnant supersaturated solution (Any 1 × 1) (1)

[50]

QUESTION 3

3.1 3.1.1 Economy

3.1.2 Raoult's law

3.1.3 Boiling point rise due to hydrostatic head

3.1.4 Scale formation

3.1.5 Entrainment

(5 × 2) (10)

3.2 3.2.1 All heat transferred through the heating surface is available✓ for evaporation and the capacity is proportional to the heat transfer.✓

3.2.2 A large amount of heat is used to heat it to boiling point,✓ thus the capacity is decreased.✓

3.2.3 Some of the feed evaporates spontaneously by adiabatic equilibrant with the vapour space pressure.✓ In this case the capacity is greater than the heat transfer.✓

(3 × 2) (6)

3.3
- Number of effects
- Enthalpy of the vaporisation of steam
- Temperature of the feed (3)

3.4 Pure liquid or solvent exerts a certain vapour pressure at any given temperature.✓ If other substances are 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 can occur.✓ The actual surface temperature of the mixture minus the temperature of the pure solvent, if it exerts the same vapour pressure as the mixture, is known as boiling point rise due to material in the solution.✓ (7)

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3.5 3.5.1

- Feed enters the top of the jacketed section and is spread out into a 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 against stationary vertical plates.
- 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. (6)

3.5.2

- It has the ability to give high rates of heat transfer with viscous liquids.
- The overall coefficient falls as the viscosity rises.
- For moderate viscosity materials, the evaporator keeps the decrease slow.
- With highly viscous materials, the coefficient is appreciably bigger than in forced circulation evaporators and much greater than in a natural circulation unit.
- The evaporators are particularly effective with viscous heat-sensitive products. (Any 3 × 1) (3)

3.5.3

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

3.5.4

- Gelatin
- Rubber latex
- Antibiotics
- Fruit juices (Any 2 × 1) (2)

3.6

- The standard temperature difference is based on the temperature of the boiling liquid at the liquid vapour interface in the evaporator body.✓
- The heat required to vaporise 1 kg of the solvent✓ is taken as the latent heat of vaporisation at the exposed surface temperature of the solution.✓
- For feed of inorganic salts in water, the heat capacity may be assumed as equal to that of the water alone.✓
- The effect of the boiling point rise due to the hydrostatic head is commonly neglected.✓
- Boiling point rise calculations for continuous evaporators✓ are based on a mixture having the same concentrations as the liquid leaving the evaporator.✓
- The sensible heat necessary to heat the feed to the boiling point✓ may be approximated by assuming the heat capacity✓ of the original feed is constant until the feed has reached the boiling point temperature of the mixture.✓ (Any 5 × 2) (10)

[50]

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QUESTION 4

4.1 4.1.1 flowing past
4.1.2 stationary surface
4.1.3 postulated
4.1.4 flowing fluid
4.1.5 stationary surface
4.1.6 heat transfer
4.1.7 homogeneous body
4.1.8 directly proportional
4.1.9 temperature difference driving force
4.1.10 cross-sectional area

(10 × 1) (10)

4.2 4.2.1 Heat may be transferred from one point✓ to another by the physical process of mixing✓ hot substances with a cold substance.✓ (3)

4.2.2 If air and water are kept in contact,✓ the water will continue to vaporise✓ until the vapour pressure of the water equals✓ the equilibrium vapour pressure of water at the temperature of the mixture.✓ (4)

4.2.3 This is the fraction of incident radiation✓ which is absorbed✓ by a material.✓ (3)

4.2.4 If the thermometer is kept wet✓ by means of a cloth saturated✓ with water,✓ the thermometer indicates the equilibrium temperature✓ attained in the adiabatic vaporisation.✓ (5)

4.2.5 This is the temperature✓ at which a given air✓ and water vapour✓ mixture would be saturated.✓ (4)

4.3 4.3.1 When a saturated vapour condenses on a cool surface,✓ the condensation may be either drop-wise or as a liquid film.✓ When the condensation is in drops, a much higher film✓ coefficient is obtained than when the condensation takes place to give a liquid film over the cool surface.✓ Theoretical methods have been developed for estimating individual coefficients✓ of heat transfer for film-type condensation.✓ (6)

4.3.2 When mechanical means are used to force a fluid to flow past a surface✓ which is hotter or colder than the fluid,✓ the method of heat transfer between the fluid✓ and the surface is designated as forced convection.✓ The gases flow at right angles to a single cylinder.✓ (5)

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4.4 4.4.1
- Always introduce the cooler fluid first.
- Add the hotter fluid slowly, until the unit is up to the 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. (4)

4.4.2 Shut the hot fluid first✓ and do not allow the unit to cool too rapidly.✓ Drain any materials which may cause trouble if left in the exchanger.✓ Examples are water or any other material which would become solid when cold.✓ (4)

4.4.3 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 velocities.✓ (2)
[50]

TOTAL: 200

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