

August 2021

SEPARATION PROCESS-II

Time Allowed: 1.5 Hours

Full Marks: 70

Answer to Question No. 1 is compulsory and Answer any two questions from the rest.

1. Choose the correct answer or fill in the blanks (any twenty): 2×20
- i) The vapor pressure exerted by the moisture contained in a wet solid depends upon the (a) nature of the moisture (b) temperature (c) nature of the solid (d) all a, b and c.
 - ii) To remove all the moisture from a wet solid requires exposure to (a) perfectly dry air (b) highly humid air (c) air at high temperature.
 - iii) Milk is usually dried in a (a) freeze dryer (b) spray dryer (c) tray dryer (d) rotary dryer.
 - iv) If moisture content of a solid on dry basis is X then the same on wet basis is (a) $X/(X+1)$ (b) $X/(1-X)$ (c) $(1+X)/X$ (d) $(1-X)/X$.
 - v) Moisture content of a substance when at equilibrium with a given partial pressure of the vapor is called (a) free moisture (b) unbound moisture (c) bound moisture (d) equilibrium moisture.
 - vi) Rotary dryer cannot handle (a) free flowing materials (b) dry materials (c) sticky materials (d) granular materials.
 - vii) In constant rate period of the rate of drying curve for batch drying (a) cracks develop on the surface of the solid (b) rate of drying decreases abruptly (c) surface evaporation of unbound moisture occurs (d) none of these.
 - viii) Sticky materials can be dried in a (a) tray dryer (b) rotary dryer (c) fluidized bed dryer (d) none of these.
 - ix) Wet bulb and dry bulb temperatures are identical at (a) 100% saturation (b) 50% saturation (c) 78% saturation (d) none of these.
 - x) In case of cooling towers, the ratio of the rates of heat and mass transfer is indicated by (a) Lewis number (b) Grashoff number (c) Sherwood number (d) none of these.
 - xi) Humidification involves mass transfer between a pure liquid phase and a fixed gas which is (a) insoluble in the liquid (b) soluble in the liquid (c) non-ideal in nature (d) at a fixed temperature.
 - xii) Adsorption is a unit operation which generally involves (a) liquid-solid (b) gas-solid (c) fluid-solid (d) solid-solid.
 - xiii) Relative humidity is the ratio of the (a) partial pressure of the vapor to the vapor pressure of the liquid at room temperature (b) partial pressure of the vapor to the vapor pressure of the liquid at gas temperature (c) actual humidity to saturation humidity (d) none of these.
 - xiv) Humid volume is the total volume in m^3 of 1 kg of (a) vapor laden gas at 1 atm and room temperature (b) gas plus its accompanying vapor at 1 atm and room temperature (c) gas plus its accompanying vapor at 1 atm and gas temperature (d) vapor laden gas at 1 atm and gas temperature.

- xv) The dew point of a saturated gas phase is equal to (a) gas temperature (b) room temperature (c) wet bulb temperature (d) none of these.
- xvi) Steady state temperature reached by a small amount of liquid in an unsaturated vapor-gas mixture is (a) dry bulb temperature (b) wet bulb temperature (c) dew point (d) adiabatic saturation temperature.
- xvii) In crystallisation the birth of a new particle is called _____.
- xviii) Swensen-Walker crystalliser is a _____ unit.
- xix) Chemisorption is (a) same as van der Waals adsorption (b) characterized by adsorption of heat (c) an irreversible phenomenon (d) a reversible phenomenon.
- xx) Which of the following adsorbent is used to decolorize yellow glycerine? (a) silica gel (b) alumina (c) activated carbon (d) Fuller's earth.
- xxi) Dry bulb temperature of the gas is (a) less than wet bulb temperature (b) more than wet bulb temperature (c) equal to that of wet bulb temperature (d) none of these.
- xxii) In case of unsaturated air (a) dew point < wet bulb temperature (b) wet bulb temperature < dry bulb temperature (c) neither a nor b (d) both a and b.
- xxiii) Calcium ammonium nitrate (a fertilizer) is dried in a (a) rotary dryer (b) tunnel dryer (c) vacuum dryer (d) tray dryer.
- xxiv) Heat sensitive materials like certain pharmaceuticals and foodstuffs can be dried (a) in indirect tray dryer (b) in spray dryer (c) by freeze drying (d) none of these.
- xxv) Moisture contained by a substance in excess of the equilibrium moisture is called (a) free moisture (b) unbound moisture (c) bound moisture (d) equilibrium moisture.
2. Define molal absolute humidity and percentage saturation of a gas-vapor mixture. The partial pressure of water vapor in a mixture of water vapor and air at a total pressure of 106.6 kPa and a temperature of 60°C is 13.3 kPa. Express the concentration of water vapor in (i) mole fraction (ii) absolute humidity (iii) relative humidity (iv) g water/m³ of mixture. The vapor pressure of water at 60°C = 19.9 kPa. 5+10
3. Define relative humidity, dew point, dry bulb temperature and wet bulb temperature. A mixture of acetone vapor and nitrogen contains 14.8% acetone by volume. Calculate the relative saturation and the percentage saturation of the mixture at a temperature of 20°C and a pressure of 745 mm Hg. Vapor pressure of acetone at 20°C = 184.8 mm Hg. <https://www.wbsctonline.com> 7+8
4. An air-water vapor mixture has a dry bulb temperature 55°C and an absolute humidity 0.03kg water/kg dry air at 1 std atmosphere pressure. Calculate (i) relative humidity (ii) percentage saturation (iii) wet bulb temperature (iv) humid volume (v) humid heat. The vapor pressure of water at 55°C is 133 mm Hg pressure. Use psychrometric chart for calculation. 15
5. 30,000 m³ of gas (at 289 K, 101.3 KN/m², saturated with water vapor) is compressed to 340 KN/m², cooled to 289 K and condensed water is drained off. Subsequently the pressure is reduced to 170 KN/m² and the gas is distributed at the pressure and 289 K. What is the percentage humidity after this treatment? Vapor pressure of water at 289 K is 1.8 KN/m². 15
6. A wet solid is dried from 35% to 10% moisture under constant drying conditions in 18 ks. If the equilibrium moisture content is 4% and the critical moisture content is 14%, how long will it take to dry to 6% moisture under the same conditions? 15

7. a) Define unbound moisture and equilibrium moisture content of a substance.
b) A wet solid is to be dried from 80% to 5% moisture on wet basis. Calculate the amount of moisture to be evaporated per 100 kg of the dried product. 7+8
8. A hot solution containing 5000 kg of Na_2CO_3 and water with a concentration of 25 wt% Na_2CO_3 is cooled to 293 K and crystals of $\text{Na}_2\text{CO}_3 \cdot 10 \text{H}_2\text{O}$ are precipitated. At 293 K, the solubility is 21.5 kg anhydrous/100 kg of total water. Calculate the yield of crystals obtained if 5% of the original water in the system evaporates on cooling. 15
9. 1 Kg of activated carbon is used to adsorb benzene from 2.5 m^3 of an air-benzene vapor mixture containing 5% of benzene by volume at 20°C . Benzene is desorbed from the activated carbon by superheated steam at 200°C . Calculate the benzene content of the air after the adsorption process, and the degree of utilization of activated carbon in the adsorption of benzene.
The adsorption capacity of activated carbon at 20°C is 382 g and at 200°C is 69.6 g of benzene per 1 Kg of activated carbon. 15
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