2007
AG: Agricultural Engineering

Duration : Three Hours Maximum Marks : [illegible]

Read the following instructions carefully.

1. This question paper contains 85 objective type questions. Q.1 to Q.20 carry **one** mark each and Q.21 to Q.85 carry **two** marks each.
2. Attempt all the questions.
3. Questions must be answered on **O**bjective **R**esponse **S**heet (**ORS**) by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the **ORS**. **Each question has only one correct answer.** In case you wish to change an answer, erase the old answer completely.
4. Wrong answers will carry NEGATIVE marks. In Q.1 to Q.20, **0.25** mark will be deducted for each wrong answer. In Q.21 to Q.76, Q.78, Q.80, Q.82 and in Q.84, **0.5** mark will be deducted for each wrong answer. However, there is no negative marking in Q.77, Q.79, Q.81, Q.83 and in Q.85. More than one answer bubbled against a question will be taken as an incorrect response. Unattempted questions will not carry any marks.
5. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the **ORS**.
6. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.
7. Calculator is allowed in the examination hall.
8. Charts, graph sheets or tables are NOT allowed in the examination hall.
9. Rough work can be done on the question paper itself. Additionally blank pages are given at the end of the question paper for rough work.
10. This question paper contains **20** printed pages including pages for rough work. Please check all pages and report, if there is any discrepancy.

S/121 Food/06–AG–1A

Given data: Universal gas constant = 8.314 kJ $kgmol^{-1}$ K^{-1} and 0 °C = 2

Q. 1 – Q. 20 carry one mark each.

Q.1 An ellipsoidal object has three axes measuring 40 cm, 20 cm and 20 cm respecti The volume of the object is

(A) 4.23 litres (B) 8.38 litres (C) 12.63 litres (D) 17.05 litres

Q.2 $\dfrac{\omega}{(s+a)^2+\omega^2}$ is the Laplace Transform of

(A) $\exp(-at)\sin\omega t$ (B) $\exp(-at)\sinh\omega t$
(C) $at\sin\omega t$ (D) $at\sinh\omega t$

Q.3 For station X, the maximum one day rainfall with 25 years return period is 100 mm. The probability of a one day rainfall equal to or greater than 100 mm at station X occurring at least once in 15 successive years is

(A) 0.458 (B) 0.500 (C) 0.637 (D) 0.990

Q.4 Taking $y(0) = 0$ and using Euler's method with step size h = 0.1 solution of the differential equation $\dfrac{dy}{dx} = 2xy + 1$ gives the value of $y(0.3)$ as

(A) 0.3101 (B) 0.3142 (C) 0.6202 (D) 4.080

Q.5 Integrating the function $f(x) = 1 + e^{-x}\sin(4x)$ over the interval [0,1] using Simpson's 1/3rd rule gives

(A) 1.021 (B) 1.091 (C) 1.321 (D) 2.642

Q.6 A lubricating oil with high viscosity index is desirable for tractor engine due to

(A) More variation of viscosity with temperature
(B) Less variation of viscosity with temperature
(C) High pour point
(D) High cloud point

Q.7 In a tractor cab, the temperature comfort zone for the tractor operator is between

(A) 287 and 290 K (B) 288 and 293 K (C) 291 and 297 K (D) 295 and 301 K

Q.8 As per ASABE standards, the three-point hitch of a two-wheel drive tra[ctor with] maximum drawbar power of 45 kW comes under the category

(A) I (B) II (C) III (D) IV

Q.9 As compared to diesel, the heating value and exhaust emissions such as CO, CO_2 and smoke density of biodiesel when used in compression ignition engine are

(A) Lower and higher respectively (B) Higher and lower respectively
(C) Lower and lower respectively (D) Higher and higher respectively

Q.10 The theoretical percentage variation in speed of a chain as it leaves an 8 teeth sprocket rotating at a uniform velocity is

(A) 0.0 (B) 7.9 (C) 29.3 (D) 34.3

Q.11 The angle between the lines AB and BC whose respective bearings are 35^{o} and 140^{o} is

(A) 75^{o} (B) 115^{o} (C) 175^{o} (D) 185^{o}

Q.12 A fluid in which shear stress is more than the yield value and proportional to the rate of shear strain is called

(A) Newtonian fluid (B) Non-Newtonian fluid
(C) Ideal plastic fluid (D) Real fluid

Q.13 When the water level in a well is at a depth of 7 m from the surface, the most suitable pump to lift water for irrigation is

(A) Submersible pump (B) Horizontal centrifugal pump
(C) Axial flow pump (D) Reciprocating pump

Q.14 The specific gravity and void ratio of a soil sample are G and e respectively. The hydraulic gradient is

(A) $\frac{G-1}{1+e}$ (B) $\frac{G+1}{1-e}$

(C) $\frac{1-G}{1+e}$ (D) $\frac{1+G}{1+e}$

Q.15 A soil 0.8 m deep has volumetric water content of 0.12. The qua[illegible]r needed to bring the volumetric water content to 0.30 is

(A) 0.144 m of water (B) 0.180 m of water
(C) 0.336 m of water (D) 0.420 m of water

Q.16 A heater is placed in front of a continuous countercurrent dryer. Air at 40 °C and 70% RH is fed into the heater from which the air exits at 65 °C. If saturation vapour pressure at 40 °C and 65 °C are 0.074 bar and 0.250 bar respectively, then relative humidity of the air coming out of the heater and entering the dryer is

(A) 21% (B) 27% (C) 32% (D) 38%

Q.17 Crushing efficiency of any grinder rarely exceeds

(A) 1% (B) 5% (C) 10% (D) 20%

Q.18 Bacterial population in milk increases 200 times in 18 hours of storage at 20 °C. The increase in population in 3 hours of storage at the same temperature is

(A) 1.34 times (B) 2.42 times (C) 7.02 times (D) 14.14 times

Q.19 A vegetable oil is flowing through a vertical wall as a film. The density and viscosity of the oil are 920 kg m^{-3} and 0.28 Pa s respectively. If the average velocity of the film is 0.05 m s^{-1}, the thickness of the film is

(A) 0.14 mm (B) 0.36 mm (C) 1.76 mm (D) 2.16 mm

Q.20 Air at 101.325 kPa pressure is used to dry a vegetable material at 52 °C. Saturation pressure of water at 52 °C is 13.51 kPa. If the mass transfer coefficient for the case of equimolar counter diffusion (k_y') is 4.79×10^{-4} kg mole m^{-2} s^{-1} mole fraction^{-1}, then, the mass transfer coefficient for the case of diffusion through non diffusing gas (k_y) in kg mole m^{-2} s^{-1} mole fraction^{-1} is

(A) 4.96×10^{-4} (B) 5.14×10^{-4} (C) 7.83×10^{-4} (D) 1.02×10^{-3}

Q. 21 to Q. 75 carry two marks each.

Q.21 An oil engine works on the ideal diesel cycle with a compression ratio of 18:1. The constant pressure energy addition ceases at 10% of the stroke. The intake pressure and temperature are 100 kPa and 300 K respectively. The hourly air consumption is 100 m^3. If the ratio of specific heats is 1.4, the maximum temperature in the cycle is

(A) 953.3 K (B) 1334.6 K (C) 2154.5 K (D) 2573.9 K

Q.22 While testing a tractor, the airborne sound intensity is increased so that the square sound pressure is doubled. The corresponding increase in sound press to the reference sound pressure of 2×10^{-5} Pa is

(A) 2 dB (B) 4 dB (C) 6 dB (D) 8 dB

Q.23 A piston with 50 mm diameter and length 50 mm is to be moved at a velocity of $0.25\ m\ s^{-1}$ in a hydraulic cylinder with 50.2 mm diameter. The cylinder is full of oil with a kinematic viscosity of $9\times10^{-4}\ m^2\ s^{-1}$ and a density of $880\ kg\ m^{-3}$. Assuming pressure difference between inside and outside of the cylinder as zero, the force required to move the piston is

(A) 7.772 N (B) 15.543 N (C) 76.243 N (D) 152.476 N

Q.24 A single phase 230 V electric motor while running at 1400 rpm develops a torque of 3.1 Nm. If the phase angle between the voltage and current is 38° and the power efficiency of the motor is 80%, the amount of electric current drawn by the electric motor is

(A) 2.470 A (B) 3.135 A (C) 4.810 A (D) 5.512 A

Q.25 The mechanical efficiency of a power tiller engine developing 7.5 kW is 80%. The calorific value of diesel is $45\ MJ\ kg^{-1}$. If the indicated thermal efficiency is 35%, the brake specific fuel consumption of the engine is

(A) $0.135\ kg\ kW^{-1}h^{-1}$
(B) $0.228\ kg\ kW^{-1}h^{-1}$
(C) $0.245\ kg\ kW^{-1}h^{-1}$
(D) $0.286\ kg\ kW^{-1}h^{-1}$

Q.26 A tractor engine developing 30 kW rejects heat at the rate of 0.58 kW per kW of engine output. A water cooling system is to be installed in the tractor. The expected temperature rise as air moves through the radiator is 20 K. The frontal area of the radiator is limited to $0.16\ m^2$. If density of air is $1.29\ kg\ m^{-3}$ and specific heat of air is $1.0\ kJ\ kg^{-1}\ K^{-1}$, the amount of air to be blown per unit time through the radiator frontal area is

(A) $0.674\ m^3s^{-1}$ (B) $0.870\ m^3s^{-1}$ (C) $1.162\ m^3s^{-1}$ (D) $1.502\ m^3s^{-1}$

Q.27 A two-wheel drive tractor weighing 20 kN has a wheel base of 2.1 m with a static weight distribution of 35% and 65% at the front and rear axles respectively. On a level ground, the tractor moves at a speed of $4\ km\ h^{-1}$. Considering small steer angle, the cornering force acting on each of the front tyre for a turning radius of 1.8 m is

(A) 0.244 kN (B) 0.454 kN (C) 0.489 kN (D) 0.907 kN

Q.28 A tractor drawn rotary cultivator in concurrent revolution mode is ... ted at a depth of 150 mm and at a forward speed of 3.6 km h^{-1}. The radius ... et is 280 mm. The number of blades, which would cut identical path is 3. ... g width of the cultivator is 1.8 m. The cultivator is to be powered from the t... running at 540 rpm through a suitable gearbox. For getting a tilling pitch of 7... the suitable gear ratio is

(A) 1:2 (B) 1:1.5 (C) 1.5:1 (D) 2:1

Q.29 A solar photovoltaic system comprising solar photovoltaic array, inverter and a motor-pump unit is installed for supplying drinking water in a village. There are 24 modules in the array and each module contains 36 number of cells of size 104×104 mm with a conversion efficiency of 12.8%. The global solar radiation incident normally on the cells is 945 W m^{-2}. The power consumed in lifting the water is found to be 435 W. If the pump-motor unit efficiency is 45%, the efficiency of the inverter is

(A) 56.21% (B) 69.42% (C) 80.25% (D) 85.52%

Q.30 A farmer has a choice of buying a 4 bottom × 41 cm mould board plough for Rs 8570 or a 5 bottom × 45 cm mould board plough for Rs 12000. Each plough has a life of 15 years. Neglect salvage value, interest charges and other costs on the ploughs. With either plough the operating speed is 6.5 km h^{-1} and field efficiency is 82%. Assume that the cost per hectare for tractor energy to be same for both the ploughs. If the labor cost is Rs 10 per hour, the minimum number of hectares that would justify the purchase of the larger plough (i. e. break even point) is

(A) 73.7 (B) 89.9 (C) 737.3 (D) 899.4

Q.31 A flange mounted shear pin is used on a shaft as a safety device. The steel shear pin has a diameter of 2.38 mm and is to be mounted on the flange of a shaft rotating at 650 rpm. The maximum power transmitted by the shaft is 4.5 kW. If the shear strength of the material of pin is 310 MPa, the radial distance of its mounting is

(A) 5.02 mm (B) 11.98 mm (C) 47.94 mm (D) 301.20 mm

Q.32 A right hand offset disk harrow is operating with front and rear gang angles of 15° and 21° respectively. The centers of the two gangs are 2.45 m and 4.25 m behind a transverse line through the hitch point on the tractor drawbar. The horizontal soil force components are : $L_f = 3.1$ kN, $S_f = 2.65$ kN, $L_r = 3.35$ kN, and $S_r = 2.65$ kN. The amount of offset of the center of cut with respect to the hitch point is

(A) 0.740 m (B) 0.795 m (C) 0.968 m (D) 1.006 m

Q.33 A gravity feed type liquid fertilizer distributor has fixed orifices for m[illegible]uid is supplied from a top vented tank with a height of 460 mm. The bottom [illegible] 610 mm above the ground and the ends of the delivery tube are 75 mm [illegible] ground level. The metering heads (including orifices) are just below the tank, [illegible] delivery tubes are small enough so that each one remains full of liquid between [illegible] orifice and the outlet end (thereby producing a negative pressure head on the orifice). The ratio between flow rates when the tank is full and when it is filled to a height of only 25 mm is

(A) 1.27 (B) 1.61 (C) 2.31 (D) 4.28

Q.34 A 6 bladed forage blower operates at 540 rpm. For a feed rate of 6.5×10^4 kg h^{-1}, the mass of corn silage carried on each impeller blade is

(A) 0.334 kg (B) 2.006 kg (C) 12.037 kg (D) 20.060 kg

Q.35 A flat leather belt with 9 × 250 mm cross section is used to drive a cast iron pulley of diameter 0.90 m running at 336 rpm. The active arc of contact on the smaller pulley is 120°. The belt weighs 980 kg m^{-3}. Coefficient of friction between the leather and cast iron is 0.35. Centrifugal tension experienced by the belt is

(A) 5.5 N (B) 56.4 N (C) 552.8 N (D) 2211.2 N

Q.36 A strain gauge of 120 Ω nominal resistance and 2.1 gauge factor is mounted on a tensile steel member. The longitudinal axis of the strain gauge is along the length of the member. Young's modulus of steel is 2.1×10^{11} Pa. The change in resistance of the gauge is 0.08064 Ω. The stress experienced by the steel member is

(A) 67.2×10^6 Pa (B) 141.1×10^6 Pa (C) 268.8×10^6 Pa (D) 296.4×10^6 Pa

Q.37 In a four bar linkage, the fixed link is horizontal and has a length of 60 mm. The crank makes an angle of 30° with the fixed link and is attached to one end of the fixed link. The lengths of crank, coupler, and follower links are 20, 70 and 50 mm respectively. For the open chain configuration, the angle of coupler with respect to the horizontal is

(A) 2 degrees (B) 32 degrees (C) 122 degrees (D) 152 degrees

Q.38 The left limb of a U-tube manometer is connected to a pipe in which water flows and the right limb containing mercury is open to the atmosphere. The center of the pipe is 200 mm below the level of mercury in the right limb and difference of mercury levels in the two limbs is 300 mm. The pressure in the pipe line is

(A) 19 kPa (B) 29 kPa (C) 39 kPa (D) 49 kPa

Q.39 A hydraulically efficient trapezoidal drainage channel has to be desi[illegible]ining 400 ha of land with a drainage coefficient of 20 mm. If the recommen[illegible]pe and depth are 2:1 and 1.06 m respectively, the bottom width is

(A) 0.25 m (B) 0.50 m (C) 0.75 m (D) 1.00 m

Q.40 An unconfined aquifer is pumped at a constant rate of 10 l s^{-1}. Steady state drawdowns measured at radial distances of 30 m and 60 m are 0.80 m and 0.70 m, respectively. Original thickness of aquifer is 30 m. Transmissibility of the aquifer is

(A) 19 m^2 d^{-1} (B) 760 m^2 d^{-1} (C) 952 m^2 d^{-1} (D) 982 m^2 d^{-1}

Q.41 A centrifugal pump delivers 30 l s^{-1} of water against static suction and delivery heads of 6 m and 10 m respectively. The length and diameter of delivery pipe are 100 m and 100 mm respectively. The outlet of delivery pipe is submerged. Friction factor for the pipe is 0.03. If the minor losses in the delivery pipe amount to 1.0 m, pressure at delivery end of the pump is

(A) 327 kPa (B) 385 kPa (C) 680 kPa (D) 984 kPa

Q.42 The areas within the contour lines at the site of a proposed reservoir and dam are as follows:

Contour, m	20	22	24	26	28	30	32
Area, m^2	100	220	600	1800	4500	10000	25000

If 20 m R.L. represents the bottom of the reservoir and 32 m R.L. represents the water surface, the volume of water in the reservoir obtained by the trapezoidal formula is

(A) 21110 m^3 (B) 32220 m^3 (C) 42220 m^3 (D) 59340 m^3

Q.43 In a sub-surface drainage system, tile drains are laid with a slope of 0.28% to carry a peak discharge of 3 litre s^{-1} per drain. If the Manning's n is 0.011, the practical diameter of tile required is

(A) 50 mm (B) 75 mm (C) 100 mm (D) 150 mm

Q.44 A recharge well of 300 mm diameter is constructed in a confined aquifer of 1000 m^2 d^{-1} transmissibility. From the top of impermeable bed, the water level in the well is 50 m and the height of constant water level is 40 m. The constant water level occurs at a distance of 150 m from the center of the well. The possible maximum recharge rate is

(A) 3.16 m^3 min^{-1} (B) 6.32 m^3 min^{-1} (C) 9.48 m^3 min^{-1} (D) 12.64 m^3 min^{-1}

Q.45 The discharge through a 90° V-notch for a head of 0.5 m and coefficient of discharge of 0.6 is

(A) 0.25 $m^3\ s^{-1}$ (B) 0.50 $m^3\ s^{-1}$ (C) 0.65 $m^3\ s^{-1}$ (D) 0.75 $m^3\ s^{-1}$

Q.46 A cohesive soil has an angle of shearing of 15° and a cohesion of 35 kPa. The value of lateral pressure in the cell for failure to occur at a total stress of 300 kPa during the triaxial test is

(A) 59.58 kPa (B) 122.92 kPa (C) 140.41 kPa (D) 230.34 kPa

Q.47 The normal annual rainfall at stations I, II, III and IV in a basin are 155, 150, 120 and 105 cm respectively. In the year 2000, stations I, II and III received annual rainfalls of 156, 140 and 104 cm respectively. Estimated value of rainfall at station IV during the year 2000 is

(A) 98.2 cm (B) 105.0 cm (C) 133.3 cm (D) 141.7 cm

Q.48 The maximum rainfall with a return period of 25 years is given below for a watershed having a time of concentration of 47.65 minutes:

Time (min)	10	20	30	40	60
Rainfall depth (mm)	52.50	55.00	57.50	60.00	65.00

In this watershed, 2.0 km^2 area has cultivated sandy soil (C = 0.2) and the remaining 3.0 km^2 has cultivated clay soil (C = 0.7). The peak rate of runoff from the watershed is

(A) 4.29 $m^3\ s^{-1}$ (B) 5.41 $m^3\ s^{-1}$ (C) 42.99 $m^3\ s^{-1}$ (D) 54.13 $m^3\ s^{-1}$

Q.49 A drop spillway is subjected to horizontal and vertical forces of 40.8 kN and 36.5 kN respectively. The area of plane of sliding is 10 m^2. Angle of internal friction and cohesive resistance of foundation material are 25° and 4.9 kPa respectively. The factor of safety against sliding is

(A) 0.53 (B) 0.61 (C) 1.62 (D) 1.86

Q.50 The soil loss from a field with 5% slope and for crop management factor of 0.25 is 44.80 Mg ha^{-1}. Contouring along with crop management factor of 0.15 is adopted as the soil conservation measure in the field. The changed soil loss from the field is

(A) 1.61 Mg ha^{-1} (B) 2.68 Mg ha^{-1} (C) 16.12 Mg ha^{-1} (D) 26.87 Mg ha^{-1}

Q.51 A field is irrigated by constructing 100 m long furrows spaced at [illegible] rt. The advance time to the end of furrows was 30 min with an inflow rate of [illegible] fter that the inflow rate was cutback to 0.5 litre s^{-1} and continued for o[illegible] average depth of irrigation is

(A) 2.4 cm (B) 7.2 cm (C) 9.0 cm (D) 18.0 cm

Q.52 A sprinkler system consists of two 192 m long laterals. On each lateral, sixteen sprinklers are located at an interval of 12 m. The spacing between the laterals is 10 m. The required capacity (in litre s^{-1}) of sprinkler system for application rate of 1.0 cm h^{-1} is

(A) 5.33 (B) 10.66 (C) 14.22 (D) 17.06

Q.53 A 50 km long canal with an average width of 25 m is used for irrigation. Mean daily evaporation as measured from a Class A evaporation pan is 5 mm d^{-1}. Considering the pan coefficient as 0.80, the mean daily evaporation loss from this canal is

(A) $5.00 \times 10^3\ m^3\ d^{-1}$
(B) $6.25 \times 10^3\ m^3\ d^{-1}$
(C) $5.00 \times 10^4\ m^3\ d^{-1}$
(D) $6.25 \times 10^4\ m^3\ d^{-1}$

Q.54 To deliver 1.3 litre min^{-1} discharge, the operating pressure of a 3 m long, 3 mm diameter bubbler tube is

(A) 1.64 kPa (B) 16.46 kPa (C) 164.61 kPa (D) 1646.20 kPa

Q.55 Dry bulb and wet bulb temperatures of air fed into a dryer are found to be 60 °C and 35 °C respectively. Saturation humidity at wet bulb temperature is 0.0365 kg H_2O kg dry air^{-1}. If specific heat capacities of dry air and water vapour are 1.008 and 1.915 kJ kg^{-1} K^{-1} respectively and latent heat of vaporization at wet bulb temperature is 2.42 MJ kg^{-1} then humidity ratio of air is

(A) 0.0193 kg H_2O kg dry air^{-1}
(B) 0.0225 kg H_2O kg dry air^{-1}
(C) 0.0256 kg H_2O kg dry air^{-1}
(D) 0.0275 kg H_2O kg dry air^{-1}

Q.56 A refrigerator with a COP of 3.2 uses 2.4 kg min^{-1} refrigerant extracting 150 kJ kg^{-1} heat in the evaporator. Assuming compressor efficiency of 85% the minimum size of the motor is

(A) 0.5 hp (B) 1.5 hp (C) 2.0 hp (D) 3.0 hp

Q.57 If thermal conductivity, mass diffusivity, equimolar mass transfer [illegible] based on concentration gradient, density and specific heat capacity of [illegible] 03 $W\ m^{-1}\ K^{-1}$, $2.4 \times 10^{-5}\ m^2\ s^{-1}$, $0.3\ m\ s^{-1}$, $1.0\ kg\ m^{-3}$ and $1.0\ kJ\ kg^{-1}\ K^{-1}$ [illegible] then convective heat transfer coefficient of air is

(A) $7.43\ W\ m^{-2}\ K^{-1}$
(B) $74.27\ W\ m^{-2}\ K^{-1}$
(C) $348.12\ W\ m^{-2}\ K^{-1}$
(D) $794.39\ W\ m^{-2}\ K^{-1}$

Q.58 At 65 °C, Henderson constants C and n are $7.4 \times 10^{-4}\ K^{-1}$ and 0.56 respectively. The equilibrium moisture content corresponding to 40% relative humidity is

(A) 38% (wet basis)
(B) 78% (dry basis)
(C) 87% (wet basis)
(D) 358% (dry basis)

Q.59 Effectiveness of countercurrent heat exchanger is given by

$$\varepsilon = \frac{1 - \exp\left[-NTU\left(1 - \frac{C_{\min}}{C_{\max}}\right)\right]}{1 - \frac{C_{\min}}{C_{\max}} \exp\left[-NTU\left(1 - \frac{C_{\min}}{C_{\max}}\right)\right]}$$

If same liquid at the same flow rate is used as heating and cooling media through a countercurrent double tube heat exchanger then effectiveness is given by.

(A) $\frac{NTU-1}{NTU}$
(B) $\frac{NTU}{NTU+1}$
(C) $\frac{NTU-1}{NTU+1}$
(D) $\frac{NTU-1}{NTU+2}$

Q.60 A pulse mill grinds Bengal gram of 2 mm volume-surface mean diameter to powder of 100 μm volume-surface mean diameter. The ratio of Rittinger's to Kick's constant in the grinding operation is

(A) $0.317\ kWh\ kg^{-1}$
(B) 3.15 mm
(C) 315.34 μm
(D) $152.793\ kWh\ ton^{-1}$

Q.61 Angle of internal friction for rice grain is 27 °, bulk density of rice at 14% moisture content is $833\ kg\ m^{-3}$ and coefficient of friction between rice and concrete wall is 0.5. For a silo of 5 m diameter and 20 m height, the ratio between the lateral pressures at the bottom of the silo obtained by Rankine and Janssen formulae is

(A) 1.63 (B) 3.16 (C) 6.13 (D) 9.47

Q.62 Assuming psychrometric ratio to be unity, milk of 50% total solids d to powder of 5% moisture content on dry basis. Dry bulb and wet bulb te of the inlet air to the spray dryer are 200 °C and 50 °C respectively. Late vaporization at the wet bulb temperature is 2393 kJ kg^{-1}. Assuming no heating of powder the outlet air temperature is 80 °C. If inlet air absolute hum was 0.015 kg H_2O kg dry air^{-1}, then kg of dry air required per kg feed is

(A) 4.7 (B) 5.9 (C) 7.4 (D) 9.5

Q.63 Peas of 1.1 cm diameter are dried by air at 65.8 °C in a packed bed drier. The void fraction of the bed is 0.35 and the bed has a diameter of 0.5 m and a height of 0.8 m. The flow rate and the viscosity of air are 0.12 kg s^{-1} and 2.03×10^{-5} Pa s respectively. Reynolds number for the packed bed is

(A) 13 (B) 340 (C) 908 (D) 1359

Q.64 A rectangular fin of length 12 cm, width 22 cm and thickness 1.5 cm is connected to a tube at a temperature of 0 °C. The thermal conductivity of the fin material is 150 W m^{-1} K^{-1}. The tip of the fin is not insulated. Air at a temperature of 5 °C is in contact with the fin. The heat transfer coefficient between the fin and the air is 25 W m^{-2} K^{-1}. The rate of heat transfer is

(A) 3.33 W (B) 6.63 W (C) 9.13 W (D) 15.23 W

Q.65 In order to reduce heat loss, a steam line with a tube diameter of 1.0 cm is insulated with a material having thermal conductivity of 0.108 W m^{-1} K^{-1}. Heat is dissipated from the outer surface of the insulating material by natural convection with a heat transfer coefficient of 12 W m^{-2} K^{-1} into the ambient at a constant temperature. The heat loss becomes maximum when the thickness of insulation is

(A) 0.5 mm (B) 2 mm (C) 4 mm (D) 6.5 mm

Q.66 Air carrying particles of density of 700 kg m^{-3} and average diameter of 25 μm enters a cyclone of 0.7 m diameter at a tangential velocity of 30 m s^{-1} at 0.35 m. The density and viscosity of air are 1.1614 kg m^{-3} and 1.85×10^{-5} Pa s respectively. The terminal radial velocity of the particle is

(A) 0.17 m s^{-1} (B) 1.69 m s^{-1} (C) 3.37 m s^{-1} (D) 16.52 m s^{-1}

Q.67 A long cylindrical piece of meat having a diameter of 0.02 m c... ...0% moisture is being frozen with air at –30 °C. Initial temperature of the mea... (freezing point). The heat transfer coefficient of the freezer unit is 20 W m... density of the unfrozen meat is 1050 kg m^{-3} and the thermal conductivity ... frozen meat is 1.025 W m^{-1} K^{-1}, the latent heat of fusion for water is 335 kJ kg... shape factors P and R are (1/4) and (1/16) respectively, the freezing time is

(A) 0.158 h (B) 0.373 h (C) 0.464 h (D) 2.12 h

Q.68 A single effect evaporator is used to concentrate 5000 kg h^{-1} of a 1.5 wt% sugar solution entering at 50 °C to a concentration of 2 wt% at 101.325 kPa. Steam supplied is saturated at 169.06 kPa (115 °C). The overall heat transfer coefficient is 1550 W m^{-2} K^{-1}. The boiling point of solution is the same as that of water. The specific heat of the feed is 4.21 kJ kg^{-1} K^{-1}. The latent heat of water at 100 °C is 2257.06 kJ kg^{-1} and the latent heat of steam at 115 °C is 2216.52 kJ kg^{-1}. The required surface area for heat transfer is

(A) 6.9 m^2 (B) 10.7 m^2 (C) 13.9 m^2 (D) 46.3 m^2

Q.69 In a cold store of 30 m × 15 m × 15 m size, 4000 tonnes of potato having the specific heat of 3.62 kJ kg^{-1} K^{-1} and heat of respiration of 20 W m^{-3} is kept at 30 °C. Potato is required to be cooled to 2 °C in 30 days. Neglecting other sources of heat, the capacity of the refrigeration plant required is

(A) 6 TR (B) 38 TR (C) 44 TR (D) 83 TR

Q.70 A diatomic, adiabatically compressible fluid having the molecular mass of 16 is flowing through a nozzle at a temperature of 20 °C. If the velocity of the fluid is 430 m s^{-1}, the Mach Number is

(A) 0.93 (B) 0.97 (C) 1.03 (D) 1.07

Common Data Questions

Common Data for Questions 71,72,73:

A 35 kW two-wheel drive tractor weighing 20 kN is fitted with 6-16 8PR tyre at the front axle and 13.6-28 12PR tyre at the rear axle. The ratio of section height and section width for all tyres is 0.75. The tractor has a wheel base of 2.1 m and the center of gravity is located 0.7 m ahead of the rear axle center on a horizontal plane. The tractor is to be towed on a level ground having sandy clay loam soil at 10% moisture content with a cone index of 1200 kPa.

Q.71 The wheel numeric for each of the rear wheels is

(A) 39.50 (B) 58.17 (C) 79.01 (D) 116.37

Q.72 Rolling resistance of each of the front wheels is

(A) 0.244 kN (B) 0.354 kN (C) 0.575 kN (D) 0.70

Q.73 If the same tractor is to be towed on a level ground with compacted dry clay soil, th force required for towing is

(A) 0.27 kN (B) 0.40 kN (C) 0.53 kN (D) 0.80 kN

Common Data for Questions 74, 75:

A discharge of 10 $m^3 s^{-1}$ passes through a 4 m wide rectangular channel at a depth of 1.25 m. The slope of the channel is 9.08×10^{-3}.

Q.74 The specific energy of flowing water is

(A) 1.25 m (B) 1.45 m (C) 2.25 m (D) 3.25 m

Q.75 The depth for minimum specific energy is

(A) 0.56 m (B) 0.66 m (C) 0.86 m (D) 1.06 m

Linked Answer Questions: Q.76 to Q.85 carry two marks each.

Statement for Linked Answer Questions 76 & 77:

A flat plate solar collector with an absorber area of 1.0×1.5 m receives a solar flux of 850 W m^{-2} on the top cover. The indicated solar flux absorbed in the absorber plate is 600 W m^{-2}. The ambient temperature is 297 K. The heat loss coefficients of the collector at the side, bottom and top are 0.35, 0.65 and 3.50 W m^{-2} K^{-1} respectively with a collector heat-removal factor of 0.85. The collector fluid temperature is 333 K.

Q.76 Useful heat gain rate for the collector is

(A) 558.45 W (B) 604.35 W (C) 657.01 W (D) 711.02 W

Q.77 Instantaneous collector efficiency is

(A) 43.80% (B) 47.40% (C) 51.53% (D) 55.76%

Statement for Linked Answer Questions 78 & 79:

A field sprayer having a boom with 20 nozzles spaced 0.46 m apart is to be designed for a maximum application rate of 750 litre ha^{-1} at 520 kPa pressure. The forward speed is 6.5 km h^{-1}. Neglect field losses and assume that 10% of the pump output is bypassed.

Q.78 The required pump capacity is

(A) 67.95 litre min^{-1}
(B) 74.75 litre min^{-1}
(C) 82.22 litre min^{-1}
(D) 83.06 litre min^{-1}

Q.79 If mechanical agitation requires 375 W input power and the pump efficiency is 70%, the maximum power input required is

(A) 720 W (B) 879 W (C) 1095 W (D) 1403 W

Statement for Linked Answer Questions 80 & 81:

A 4- h unit hydrograph (UH) is used to derive S-hydrograph. The ordinates of 4-h UH are given below:

Time (h)	0	4	8	12	16	20	24	28	32	36	40	44
4-h UH ordinates ($m^3 s^{-1}$)	0	20	80	130	150	130	90	52	27	15	5	0

Q.80 Equilibrium discharge and its time of occurrence for the derived S-hydrograph are

(A) 150 $m^3 s^{-1}$ and 16 h
(B) 380 $m^3 s^{-1}$ and 16 h
(C) 699 $m^3 s^{-1}$ and 40 h
(D) 699 $m^3 s^{-1}$ and 44 h

Q.81 Area of watershed is

(A) 215.98 km^2 (B) 251.61 km^2 (C) 547.15 km^2 (D) 1006.47 km^2

Statement for Linked Answer Questions 82 & 83:

Bacillus stearothermophilus has a z value of 10.20 °C at a reference temperature of 121

Q.82 The activation energy for the destruction of *Bacillus stearothermophilus* is

(A) 327.56 MJ kg $mole^{-1}$
(B) 298.95 MJ kg $mole^{-1}$
(C) 208.35 MJ kg $mole^{-1}$
(D) 75.62 MJ kg $mole^{-1}$

Q.83 The z value of the same organism at a reference temperature of 135 °C is

(A) 9.73 °C (B) 10.20 °C (C) 10.95 °C (D) 11.15 °C

Statement for Linked Answer Questions 84 & 85:

Ice cream at a temperature of –18 °C is being transported through a refrigerated truck having outside dimensions of 6 m length, 3 m width and 2 m height. The truck is traveling at a speed of 90 km h^{-1} on a highway where the air temperature is 45 °C. The truck is insulated in a way such that the outside surface temperature of the truck is maintained at 15 °C. Assume that there is no heat transfer from the front and back of the truck.
Properties of air at 30 °C are: $\rho = 1.1514$ kg m^{-3}, $\mu = 1.86 \times 10^{-5}$ Pa s, $C_p = 1.007$ kJ kg^{-1} K^{-1}, $k = 0.0265$ W m^{-1} K^{-1}. Use the relation: $Nu = 0.036\, Re^{0.8}\, Pr^{0.33}$.

Q.84 The average heat transfer coefficient of the system is

(A) 22.06 W m^{-2} K^{-1}
(B) 30.52 W m^{-2} K^{-1}
(C) 49.56 W m^{-2} K^{-1}
(D) 53.18 W m^{-2} K^{-1}

Q.85 The rate of heat transfer at the four surfaces is

(A) 47.8 kW (B) 86.1 kW (C) 95.7 kW (D) 114.7 kW

END OF THE QUESTION PAPER