

Total No. of printed pages = 15

TR/FST/CHEME/I/21

CHEMICAL ENGINEERING

Paper – I

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

Instructions :

1. Answer to Question No. 1(i to xx) i.e, MCQ type questions under Section-A must be written in English only.

Example : The capital of India is

- (a) Delhi (b) New Delhi
(c) Indraprastha (d) None of these

Answer : (b) New Delhi.

2. Answers to other questions except mathematical part must be written either in English or in Bengali. It must not be answered partly in English and partly in Bengali. This instruction must be followed scrupulously.
3. Candidates are required to give their answers in their own words as far as practicable.

[Turn over

SECTION - A

1. Choose the correct answer and write it on the answer script. 1×20=20

(i) If V_s and V_L are the specific volume of vapour and liquid of a wet steam and x is dryness factor of steam. The specific volume (V) of wet steam is given by

- (a) $V = x \times V_s$
- (b) $V = V_L + V_s$
- (c) $V = V_L + x(V_s - V_L)$
- (d) $V = V_L + x(V_L - V_s)$

(ii) A 30% (by volume) suspension of spherical sand particles in a viscous oil has a hindered settling velocity of $4.44 \mu\text{m/s}$. If the Richardson Zaki hindered settling index is 4.5, then the terminal velocity of sand grain is

- (a) $1 \mu\text{m/s}$ (b) $0.90 \mu\text{m/s}$
- (c) $0.02 \mu\text{m/s}$ (d) $22.1 \mu\text{m/s}$

(iii) An ideal gas is compressed in a perfectly insulated compressor from 25°C and 1 bar pressure to a final pressure of 10 bar. Calculate the final temperature of compressed gas is ($\gamma = 1.28$)

- (a) 220°C (b) -92.8°C
- (c) -56.6°C (d) $+493^\circ\text{C}$

(iv) A flat plate with perforations of diameter d_p and the perforations are arranged in a pitch p_p . Each perforation has tube of inside diameter of d_{pi} passing through it. The efficiency of ligament can be determined by

- (a) $\frac{P_p - d_p}{P_p}$ (b) $\frac{P_p - d_p d_{pi} / 2}{P_p}$
- (c) $\frac{P_p - d_{pi}}{P_p}$ (d) $\frac{P_p - d_p}{d_p}$

(v) Ultra centrifuge running at speeds upto 100000 rpm is normally used for the

- (a) Separation of isotopes
- (b) Concentration of latex
- (c) Separation of cream from milk
- (d) Dewaxing of lubricating oil

(vi) A furnace wall made of two materials P and R the thermal conductivity of P is twice of that of material R, while the thickness of layer P is half of that of R. If the temperature at the two sides of wall are 500 K and 1300 K, then the temperature drop across the layer of material P is

- (a) 150 (b) 125
- (c) 160 (d) 133

(vii) In a double pipe heat exchanger a fluid is flowing inside the inner tube of diameter D . The tube side heat transfer coefficient for a fixed mass flow rate for turbulent flow conditions is proportional to

- (a) $D^{0.8}$ (b) D^{-1}
(c) $D^{-0.2}$ (d) $D^{-1.8}$

(viii) A compressor with heat removal facility compresses air at constant temperature 406K from a pressure of 1 bar to 50 bar. Calculate the change in enthalpy (kJ/mol) between the inlet and outlet gas ($c_p = 30 \text{ J/mol K}$) is

- (a) 13.2 (b) 1.32
(c) 0 (d) None of these

(ix) The maximum emissive power of a surface at an absolute temperature T_1 occurs at a wavelength of λ_1 . If the surface temperature is halved, the maximum in the emissive power would occur at a wavelength of

- (a) $0.5\lambda_1$ (b) $2\lambda_1$
(c) $0.5\lambda_1$ (d) λ_1

(x) The hydrogen and iodine in gaseous state reacts to form HI gas at 721 K. The value of equilibrium constant is found to be 50. One mole of each reactant is added to the system. The value of equilibrium constant will be

- (a) 40 (b) 50
(c) 60 (d) 30

(xi) A solid is being dried in a cross flow tray drier with air at 60°C and 0.015 humidity. If conduction and radiation are neglected, the approximate surface temperature of the solid will be

- (a) 51°C (b) 41°C
(c) 31°C (d) 0°C

(xii) In a continuous counter current packed absorber operating on very dilute concentrations, the volumetric gas mass transfer coefficient is proportional to $G^{0.8}$, where G : gas flow rate in mole per unit empty area. If G is doubled what will be the ratio of height of gas transfer unit at the increased gas flow rate to the one at the original gas flow rate?

- (a) $2^{0.8}$ (b) $2^{-0.8}$
(c) $2^{0.2}$ (d) $2^{-0.2}$



(xiii) In a binary hydrocarbon liquid mixture of P and R ($K_p=1.5$) containing 60 mole% P is flash vaporised. If 40% of the feed is vaporised, the mole fraction of P in the liquid product is

- (a) 0.3 (b) 0.6
(c) 0.4 (d) 0.5

(xiv) If S_i and $\bar{S}_i$ are the molar entropy and partial molar entropy of a component i in a mixture,

then the quantity $\left(\frac{\partial \mu_i}{\partial T}\right)_{P,x}$ is given by

- (a) $-\bar{S}_i$ (b) S_i
(c) $-S_i$ (d) $\bar{S}_i$

(xv) Froude's number is defined as the ratio of square root of

- (a) inertia force to viscous force
(b) inertia force to gravity force
(c) viscous force to gravity force
(d) inertia force to pressure force

(xvi) In Joule's experiment, an insulated container contain 20kg of water initially at 25°C. It is stirred by an agitator, which is made to turn by a slowly falling body weighing 30 kg through a height of 3m. The process is repeated 250 times, the acceleration due to gravity is 9.8m/sec², neglecting the heat capacity of agitator, the temperature of water (in °C) is

- (a) 27.6 (b) 25
(c) 34.4 (d) 40.5

(xvii) Consider a hollow sphere insulated with a material of thermal conductivity k . The convective heat transfer coefficient in outer surrounding is h . The critical radius of insulation is

- (a) $\frac{2k}{h}$ (b) $\frac{h}{2k}$
(c) $\frac{k}{2h}$ (d) $\frac{2h}{k}$

(xviii) The efficiency of Carnot cycle is 1/6. By lowering the temperature of cold reservoir by 65K, it increases to 1/3. The initial and final temperature of the cold reservoir are

- (a) 325 K, 260 K (b) 345 K, 280 K
(c) 365 K, 300 K (d) 340 K, 275 K

(xix) The substance on which surface the adsorption takes place is called (A) and the substance that is adsorbed is called B. Then

- (a) (A) is adsorbate, (B) is adsorbent
- (b) (A) is adsorbent, (B) is adsorbate
- (c) (A) is absorbed, (B) is absorbent
- (d) None of these

(xx) Assume toluene is insoluble in water. The normal boiling point of toluene and water are 110.6°C and 100°C respectively. The boiling point of the mixture for a total pressure of 1 atm will be

- (a) 110.6°C
- (b) 100.6°C
- (c) less than 100°C
- (d) greater than 100°C but less than 110.6°C .

SECTION - B

Answer any six questions :

5×6=30

2. A sludge in a washing plate and frame press, is of such a nature that the filtration equipment is $V^2 = K\theta$, where V is the volume of filtrate obtained in time θ , when the pressure is constant 30 cu.m of filtrate is produced in 10 hrs.

- (i) 3 cu.m of wash water is forced through the cake at the end of filtration. What is the washing time ?
- (ii) If the filtering surface of the press is doubled, all other conditions remaining constant, how long would it take to produce 30 cu.m of filtrate ?

3. A hydro carbon oil (viscosity 0.025 Pa.s and density 900 kg/m^3) is transported using a 0.6m diameter 10km long pipe. The maximum allowable pressure drop across the pipe length is 1 MPa. Due to a maintenance schedule on this pipe line, it is required to use a 0.4m diameter, 10 km long pipe to pump the oil at the same volumetric flow rate as in the previous case. Estimate the pressure drop for the 0.4m diameter pipe. Assume both pipes to be hydro dynamically smooth and in the range of operating conditions, the Fanning friction factor is given by

$$F = 0.079 N_{Re}^{-0.25}.$$

4. 160 kg of water is to be heated in a steam heated in a steam jacketed vessel from 26°C to 81°C . Steam is condensing at 120°C and the heat transfer area is 0.26 m^2 . The heat transfer coefficients for condensation of steam and heating of water by convection are $1000 \text{ W/m}^2 \text{ K}$ and $500 \text{ W/m}^2 \text{ K}$ respectively. Write appropriate unsteady state balance equations and find the time required for heating the water. Assume specific of water in the temperature range of interest is $4.18 \times 10^3 \text{ J/kg K}$.
5. The wall of a cold storage unit comprise a brick layer (thickness 0.2 m , thermal conductivity $k_b = 1.5 \text{ W/m K}$) and an inner layer of polyurethane foam (thickness = 0.06 m , thermal conductivity $k_p = 0.016 \text{ W/m.K}$). Assume one dimensional heat transfer by conduction through the composite wall, and that the inner surface of the polyurethane layer is at temperature T_c and the outer surface of the brick layer I at temperature T_h .
 - (a) Derive an expression for the heat flux per unit area through the wall.
 - (b) Calculate the rate of heat gain when $T_c = -10^{\circ}\text{C}$ and $T_h = 40^{\circ}\text{C}$. The surface area for the heat transfer is 260 m^2 .
6. The latent heat of vaporization of water is 2257 kJ/kg at 100°C . Calculate the change in latent heat of vaporization when the temperature is increased to three times. The critical temperature of water is 647.1 K . Use the exponent for the reduced temperature and latent heat of vaporization relationship as 0.38 .
7. Calculate the work done when 112 g of iron is dissolved in HCL at 27°C in an open beaker. The atomic weight of iron 56 g/mol . Also calculate the volume of liberated gas if kept at 1 atm pressure.
8. Define relative saturation and per cent relative saturation of a mixture of dry air and water vapour at a given temperature T and total pressure P_t . Hence derive the expression of each in terms of physical properties of gas mixture (use suitable notation if needed with their names). Derive the relation between the two.
9. A vessel is divided into two parts by a 4 kmol of nitrogen gas at 80°C and 40 bar and the other side 2 kmol of argon at 120°C and 20 bar are kept. If the partition is removed and the gases are mixed adiabatically, what is the change in entropy? Assume N_2 as an ideal gas $C_p = 5/2R$, $C_v = 3/2 R$.

SECTION – C

Answer any *five* questions :

10×5=50

10. A zero order exothermic chemical reaction occurs in a spherical catalyst. For this particular reactant - catalyst pair, the rate of reaction, and, therefore, the rate of heat liberation are virtually uniform in the catalyst pellet. Let ψ_v be the uniform volumetric heat generation rate. The pellet also losses heat to the surrounding fluid, the heat transfer coefficient being h . Other pertinent parameters are: radius of the pellet = r_0 , and the thermal conductivity = k . Determine the steady state temperature distribution and also the average temperature of the catalyst.

11. Water is to be supplied to the inhabitant of a institute campus through a supply main.

The following data is available :

Distance of the reservoir from the campus : 1000m

Number of inhabitants : 4000

Consumption of water per day of each inhabitant : 180 liters

Loss of head due to friction : 18m

Coefficient of friction for the pipe : $f : 0.007$

If half of the daily supply is pumped in 8 hours, determine the size of the supply main.

12. A continuous rectification column is used to separate a binary mixture of P and R. Distillat is produced at 100 kg mole/h containing 98 mole% P, The mole fraction of P in the liquid and in the vapour, x and y , respectively, from two adjacent ideal plates in the enriching section are as follows :

x	y
0.65	0.82
0.56	0.76

If the latent of vaporisation is the same for all mixtures and if the feed is a saturated liquid, calculate :

- (i) The reflux ratio
- (ii) Vapour rate in the stripping section in kg moles/h.

13. The heat capacity of a substance is represented by the following equation :

$C_p = A + BT + CT^2$. For enthalpy calculation a student use the arithmetic mean temperature for initial temperature T_1 and final temperature T_2 for mean heat capacity calculation instead of integration approach. Calculate the error in enthalpy calculation. Express the error in terms of constants A, B, C and temperatures T_1 and T_2 .

14. Show with detailed derivation that the Joule Thomson coefficient μ may be expressed by the following expression :

$$\mu = \frac{RT^2}{PC_p} \left(\frac{\partial Z}{\partial T} \right)_P$$

Where Z is the compressibility factor.

The following definition may be used for the

derivation $\left(\frac{\partial H}{\partial P} \right)_T = V - T \left(\frac{\partial V}{\partial T} \right)_P$.

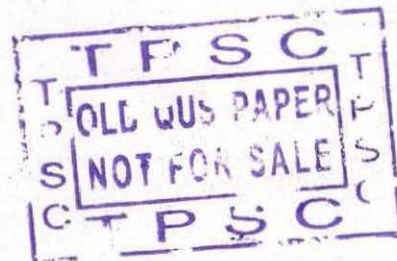
15. The wall of a cold storage unit consists of a inner insulation wall of thickness $d_i = 0.05$ m and $K_i = 0.015$ W/mK followed by a outer brick wall of thickness $d_b = 0.1$ m, $K_b = 1.4$ W/mK. Assume 1D heat transfer by conduction through the composite wall. The temperature of inner most surface of insulation is at T_i and that of the outer most brick wall is at T_b .

- Derive the expression of heat flux per unit area through the wall.
- Calculate the rate of heat gain (W), if $T_i = -10^\circ\text{C}$ and $T_b = 40^\circ\text{C}$ with heat transfer area is 260 m^2 .

16. A continuous distillation column is used to separate a binary mixture of A and B. The distillate is produced at 100 k mol/hr with $98 \text{ mol\%}$ of A. The composition of A in liquid and vapour streams are x and y from two adjacent ideal plates in the enriching section (upper section) are as

x	y
0.67	0.78
0.65	0.76

The latent heat of vaporization of the components are equal and the feed is saturated liquid. Calculate the reflux ratio.



Total No. of printed pages = 19

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CHEMICAL ENGINEERING

Paper : II

Full Marks – 100

Time – Three hours

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Instructions :

1. Answer to Question No. 1 (i to xx) i.e., MCQ type questions under Section – A must be written in English.

Example : The capital of India is

- | | |
|------------------|-------------------|
| (a) Delhi | (b) New Delhi |
| (c) Indraprastha | (d) None of these |

Answer : (b) New Delhi.

2. Answers to other questions except mathematical part must be written either in English or in Bengali. It must not be answered partly in English and partly in Bengali. This instruction should be followed scrupulously.
3. Candidates are required to give their answers in their own words as far as practicable.

[Turn over

SECTION - A

1. Choose the correct answer and write it on the answer script : $1 \times 20 = 20$

(i) A packed bed reactor converts P to R by first order reaction with 9mm pellets in strong pore diffusion regime to 63.2% level. If 18 mm pellets are used what is the conversion ?

(a) 0.61 (b) 0.39

(c) 0.632 (d) 0.865

(ii) The eddy diffusivity for a liquid in plug flow must be

(a) 1 (b) ∞

(c) 0 (d) Between 0 and 1

(iii) For the reversible reaction $P \rightleftharpoons 2R$, if the equilibrium constant K is 0.05 mole/litre; starting from initially 2 moles of P and Zero moles of R, how many moles will be formed at equilibrium ?

(a) 0.298 (b) 0.338

(c) 0.178 (d) 0.673

(iv) For a gaseous reaction $2P \rightarrow R$, where the feed consists of 50 mole % A and 50 mole % inerts, the expansion factor is

(a) 1 (b) -0.5

(c) -0.25 (d) 0

(v) The reaction $P \rightarrow R$, is conducted in an adiabatic plug flow reactor (PFR). Pure R at concentration of 2 kmol /m³ is fed to the reactor at the rate of 0.01m³/s and at a temperature of 500 K. If the exit conversion is 20%, then the exit temperature in (K) is

(a) 500 (b) 400

(c) 600 (d) 1000

Heat of reaction at 298 K = - 50,000 KJ.
kmol of P rejected. Heat capacity $C_{P,P} = C_{P,R}$
= 100 kJ/kmol K.

(vi) Select the correct statement from the following :

(a) The phase lag of a pure time delay system decreases with increasing frequency.

(b) The frequency response of a pure capacity process is unbounded.

(c) The amplitude ratio of a capacity process is inversely proportional to the frequency.

(d) The amplitude ratio of a pure time delay system increases with frequency.

(vii) The response of two interacting tanks of same size and resistance in series is

(a) Under damped

(b) Critically damped

(c) Over damped

(d) Undamped

(viii) A first order system with unity gain and time constant τ_p is subjected to a sinusoidal input of frequency $\omega = 2/\tau_p$. The amplitude ratio for this system is

(a) 1

(b) $\frac{1}{2}$

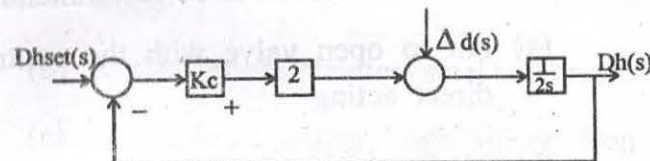
(c) $1/\sqrt{2}$

(d) $1/\sqrt{5}$

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(4)

(ix) The block diagram of an integrating level process is given below. For unit step change in the set point $D_{hset} = 1$ with $\Delta d = 0$, the offset exhibited by the system is



(a) $\frac{K_c}{1+K_c}$

(b) $\frac{1}{1+K_c}$

(c) 0

(d) $\frac{2K_c}{1+2K_c}$

(x) Which of the following techniques are used for continuous viscosity measurement ?

1. Bubbler or purge technique

2. Dielectric gauge

3. Ultrasonic gauge

4. Nucleonic gauge

(a) 1, 2 and 3

(b) 2 and 4

(c) 1, 3, and 4

(d) 1, 2, 3 and 4

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(5)

[Turn over

(xi) Temperature control of an exothermic chemical reaction taking place in a CSTR is done with the help of cooling water flowing in a jacket around the reactor. The types of valve and controller action to be recommended are

- (a) Air to open valve with the controller direct acting
- (b) Air to close valve with the controller indirect acting
- (c) Air to open valve with the controller indirect acting
- (d) Air to close valve with the controller direct acting.

(xii) The behaviour of visco-elastic material is time dependent. This behaviour is common in ——— materials.

- (a) Non-crystalline solid
- (b) Crystalline
- (c) Rubbery
- (d) Non-crystalline organic polymer

12/TR/FST/CHEME/II/21 (6)

(xiii) Which of the following materials may prove unsuitable for handling acetic acid (glacial and anhydrous) at 40°C ?

- (a) Silicone rubber, Teflon, porcelain and wood
- (b) Nickel, monel, stainless steel and graphite
- (c) Aluminium, copper, high silicon iron
- (d) Brass, cast iron, mild steel and tin

(xiv) Spark plugs, ignition tube and electrodes are made of nickel ——— alloys.

- (a) Beryllium
- (b) Manganese
- (c) Copper
- (d) Iron

(xv) Hastelloy C is a good material of construction in chemical process industry, since it is

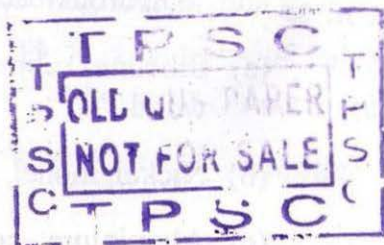
- (a) highly corrosion resistant and is readily fabricated
- (b) relatively inexpensive although it can be fabricated with some difficulty
- (c) corrosion resistant to most alkalis, particularly because of its copper content
- (d) light and resists attack by acids

12/TR/FST/CHEME/II/21 (7)

[Turn over

(xvi) For the production of very high vacuum a _____ pump is normally used.

- (a) Diffusion
- (b) Centrifugal
- (c) Jet ejector
- (d) Piston



(xvii) A centrifugal pump is used to pump water through a horizontal distance of 150m, and then raised to an overhead tank 10m above. The pipe is smooth with an I.D of 50 mm. What head (m of water) must the pump generate at its exist to deliver water at a flow rate of $0.001 \text{ m}^3/\text{s}$? The fanning friction factor, $f : 0.062$.

- (a) 10m
- (b) 11m
- (c) 12m
- (d) 20m

(xviii) Working of a _____ pump characterises mixed flow.

- (a) Turbine
- (b) Piston
- (c) Diaphragm
- (d) None of these

(xix) Pick out the wrong statement :

- (a) Greater is the kinematic viscosity of the liquid, greater is the thickness of the boundary layer.
- (b) Blowers develop a maximum pressure of 2 atm.
- (c) Friction losses in pipe firings are generally expressed in terms of velocity heads.
- (d) Fanning friction factor in case of turbulent flow of liquids in pipe depends upon relative roughness and Reynold number.

(xxi) In a cylindrical vessel subjected internal pressure, the longitudinal stress σ_l and the circumferential stress σ_h are related by

- (a) $\sigma_h = 2\sigma_l$
- (b) $\sigma_h = \sigma_l$
- (c) $\sigma_h = \sigma_l / 2$
- (d) no relation exists.

SECTION - B

Answer any six questions : $5 \times 6 = 30$

2. A six blade disk turbine ($D_a = 36 \text{ cm}$) is used to disperse hydrogen gas into a slurry reactor containing methyl linoleate 90°C and 60 kgf/cm^2

gauge with 2 per cent suspended catalyst particles (Dia=50 μm , $\rho_p = 4 \text{ g/cm}^3$). The reactor diameter is 108 cm and the depth 360 cm. The gas flow rate is 1900 std cm^3/min . The oil viscosity is 1.6 kg-m/s and the density is 0.84 gm/cm^3 at 90°C. The reactor is fully baffled. What agitator speed is required to give 5 HP/3780 ltr during the reaction?

3. Derive the relationship between steady state error and feedback closed-loop transfer function for three basic types of inputs (step, ramp and parabolic).

4. Consider a feedback control system with process transfer function $G_p(s) = \frac{1}{(s+4)(s+6)}$ measurement $G_m = 8$ and $G_a(s) = \frac{1}{(s+1)}$ and suppose that a simple proportional controller is used $G_c = K_c$.

(a) Find the minimum value of gain using Routh-Hurwitz criteria hence the closed-loop system becomes unstable.

(b) Draw a root locus sketch and discuss the stability analysis with the help of sketch.

(c) If the process transfer function

$$G_p(s) = \frac{4(2s+1)}{(5s+1)(25s^2+5s+1)} \quad \text{measurement}$$

$G_m=1$ and actuator $G_a(s)=1$ and suppose that a simple proportional controller is used $G_c = K_c$. Draw a root locus sketch and discuss the stability analysis with the help of sketch.

5. An irreversible series reaction $A \rightarrow R \rightarrow S$ is taking place in a constant volume batch reactor. Each individual reaction is of 1st order. Derive an expression for estimating concentration of reactants and products at any time t . Also calculate the time at which C_R is maximum.

6. With fresh catalyst the packed bed reactor is run at 600 K. Four weeks later when the temperature reaches 800K the reactor is shut down to reactivate the catalyst. In addition, at any instant the reactor is isothermal. Assuming optimal operations what is the activity of the catalyst at the time of reactivation? The rate of reaction with fresh catalyst is

$$-r_A = k C_A^2, \quad k = k_0 e^{-7200/T}$$

7. An agitation system is to be designed for a fluid having a density of 950 kg/m^3 and a viscosity of $0.005 \text{ Pa}\cdot\text{s}$. The vessel volume is 1.50 m^3 and a standard six-blade open turbine with blades at 45°C with $Da/W = 8$ and $Da/Dt = 0.35$. For the preliminary design, a power of 0.5 kW/m^3 volume will be used. Calculate the dimensions of the agitation system.

8. A process vessel is to be designed for the maximum operating pressure of 500 kN/m^2 . The vessel has the nominal diameter of 1.2m and tangent to tangent length of 2.4m . The vessel is made of IS : 2002-1962 Grade 2B quality steel having allowable design stress value of 118 MN/m^2 at working temperature. The corrosion allowance is suggested to be 2mm for the life span expected for the vessel. The vessel is to be fabricated according to class 2 of Indian Standard specifications which stipulate the weld joint efficiency of 0.85 .

(i) What is the standard plate thickness to fabricate this vessel ?

(ii) If a spherical vessel having the same diameter and thickness is fabricated with the same quality steel, what maximum internal pressure the sphere will withstand safely ?

9. Design the bracket support for vertical cylindrical vessel. The data is given as follows :

Diameter = 3.0m , height = 4.0m , clearance of vessel from bottom of vessel to foundation = 1.0m , weight of vessel with its content = $60,000\text{N}$, wind pressure (P_w) = 1285 N/m^2 , diameter of anchor bolt circle bolt = 3.15m , number of bracket = 6 , base plate bracket = $150 \text{ mm} \times 200 \text{ mm}$. Permissible stress for structural steel tensile $\sigma_t = 140 \text{ N/mm}^2$; bending $\sigma_{bm} = 157.5 \text{ N/mm}^2$, compressive $\sigma_{comp} = 123.3 \text{ N/mm}^2$, permissible bearing pressure for concrete = 3.5 N/mm^2 .

SECTION - C

Answer any five questions :

$10 \times 5 = 50$

10. Gaseous ethylene is to be dispersed in water in a turbine-agitated vessel at 120°C and an absolute pressure of 4 atm . The vessel is 3m in diameter with a maximum liquid depth of 3m . For a flow rate of $1000 \text{ m}^3/\text{h}$ of ethylene, measured at process conditions, specify

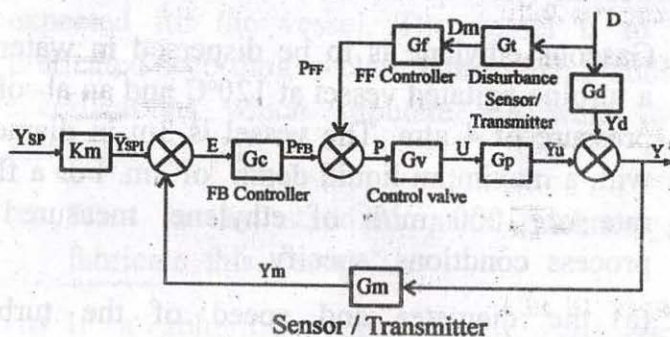
(a) the diameter and speed of the turbine impeller

(b) the power drawn by the agitator

(c) the maximum volume of water allowable.

Assume that none of the ethylene dissolves in the water and that the ethylene leaving is saturated with water.

11. Consider the blending system, assume that pneumatic control valve and an I/P transducer are used. A feed forward-feedback control system is to be designed to reduce the effect of disturbances in feed composition x_1 on the controlled variable, product composition x . Inlet flow rate w_2 can be manipulated. Using the information given below, design the following systems and compare the closed-loop responses for a +0.2 step change in x_1 .



- (a) A feed forward controller based on a steady state model of the process.

(b) Static and dynamic feed forward controllers based on a linearized dynamic model.

(c) A PI feedback controller based on the Ziegler-Nicholas settings for the continuous cyclic method.

(d) The combined feedback forward control system that consists of the feed forward controller of part (a) and the PI controller of part (c). Use the configuration in above figure.

Process Information :

The pilot scale blending tank has an internal diameter of 2m and a height of 3m. Inlet flow rate w_1 and inlet composition x_2 are constant. The nominal steady state operating conditions are as follows :

$$\bar{w}_1 = 650 \frac{\text{kg}}{\text{min}}, \quad \bar{x}_1 = 0.2, \quad \bar{h} = 15\text{m}, \quad \bar{w}_2 = 350 \frac{\text{kg}}{\text{min}},$$

$$\bar{x}_2 = 0.6, \quad \rho(\text{density}) = 1 \frac{\text{kg}}{\text{cm}^3}, \quad \bar{x} = 0.34.$$

The flow-head relation for the valve on the exit line is given by $W = C_v \sqrt{h}$.

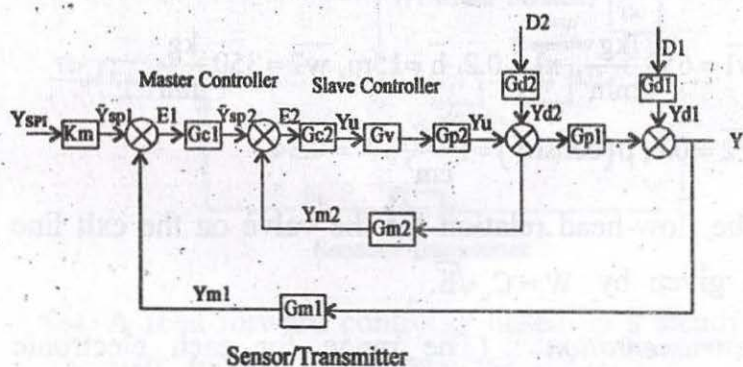
Instrumentation : (The range for each electronic signal is 4.20 mA).

Current to pressure transducer : The I/P transducer acts as a linear device with negligible dynamics. The output signal changes from 3 to 15 psi when the input signal changes full scale from 4 to 20 mA.

Control valve : The behaviour of the control valve can be approximated by a first-order transfer function with a time constant of 5s (0.0833 min). A 3-15 psi change in the signal to the control valve produces a 300 kg/min change in w_2 .

Composition measurement : The zero and span of each composition transmitter are 0 and 0.50 (mass fraction) respectively. A one minute time delay is associated with each measurement.

12. Consider the block diagram in below figure with the following transfer function.



$$G_v = \frac{5}{(s+1)} G_{p1} = \frac{4}{(4s+1)(2s+1)} G_{p2} = 1$$

$$G_{d2} = 1 G_{m1} = 0.05 G_{d1} = \frac{1}{(3s+1)} G_{m2} = 0.2.$$

Where the time constant have units of minutes and the gains have consistent units. Determine the stability limits for a conventional proportional controller as well as for a cascade control system consisting of two proportional controllers. Assume $K_{c2} = 4$ for the secondary controller. Calculate the resulting offset for a unit step change in the secondary disturbance variable D_2 .

13. A feed rate of 200 lpm of a hydrocarbon mixture at 70°C is being pumped from a tank at 1 atm abs pressure to a distillation tower. The density of the feed is 46.8 kg/cm³ and its vapor pressure is 8.45 psia. The velocity in the inlet line to the pump is 36 cm/s and the friction loss between the tank and pump is 42 cm of fluid. The net positive suction head required is 72 cm.

- How far below the liquid level in the tank must the pump be to obtain this required (NPSH)_R?
- If the feed is at the boiling point, calculate the pump position.

14. In an aqueous solution, reaction $A \rightarrow B$ occurs under isothermal conditions following first order kinetics. The feed rate is $550 \text{ cm}^3/\text{min}$ and concentration of A in the feed is $1.6 \times 10^{-4} \text{ mol/cm}^3$, the reaction is carried out in a 6 litre CSTR. At steady state 65% conversion is observed.

(i) Determine the rate constant.

(ii) The 6 litres CSTR is replaced by 6 CSTRs in series. If the capacity of each new CSTR is 1 litre, then determine the overall conversion (in %).

15. A storage tank (Class-A) is having the following data :

Tank diameter : 30m

Tank height : 18m

Specific gravity of liquid : 1.18

Conical roof slope permissible 1 in 5

Super imposed load — 125 kg/m^2

Material carbon steel (structural)

Permissible stress : 980 kgf/cm^2

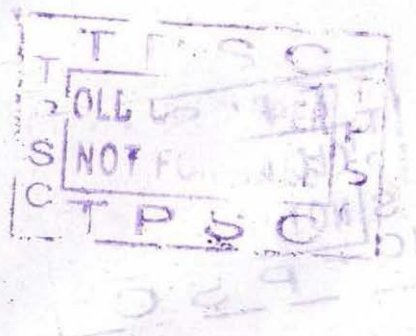
Density of plate material : 7800 kg/m^3

Modulus of elasticity : $2 \times 10^6 \text{ kg/cm}^2$

Standard plate size = 1.8 m width $\times$ 6.3m length

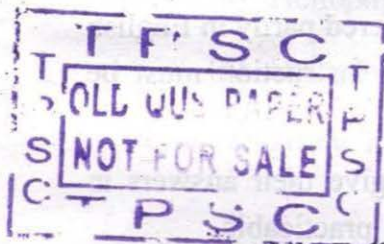
Design the shell and bottom. Verify that self-supporting conical roof can work for this storage tank or not.

16. The rate controlling step for the solid-catalyzed irreversible reaction $P + Q \rightarrow R$ is known to be reaction of adsorbed P with adsorbed Q to give adsorbed R. If P_i is the partial pressure of component i and K_i is the adsorption equilibrium constant of component i then determine rate expression in form of Langmuir Hinshelwood.



Total No. of printed pages = 10

TR/FST/BOT/II/21



BOTANY

Paper : II

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

Instructions :

1. Answer to Question No.1(i to xx) i.e., MCQ type questions under Section-A must be written in English only.

Example :

Question : The base which is not found in DNA is

- | | |
|--------------|--------------|
| (i) Cytosine | (ii) Thymine |
| (iii) Uracil | (iv) Adenine |

Answer : (iii) Uracil.

[Turn over

2. Answers to other questions except mathematical part must be written either in English or in Bengali. It must not be answered partly in English and partly in Bengali. This instruction must be followed scrupulously.
3. Candidates are required to give their answers in their own words as far as practicable.

SECTION - A

Answer *all* questions

1. Select the single best answer and write it in the answer script : $1 \times 20 = 20$

(i) The organisms which grow only on living tissues are called

- (a) Obligate parasites
- (b) Saprophytes
- (c) Facultative parasites
- (d) Facultative saprophytes

(ii) Osmotic potential of pure water is

- (a) Zero
- (b) One
- (c) Less than Zero
- (d) More than One

(iii) Plants of salty sea shore wet lands are

- (a) Heliophytes
- (b) Hydrophytes
- (c) Halophytes
- (d) Saprophytes

(iv) Premature leaf fall is due to the deficiency of

- (a) Phosphorus
- (b) Nitrogen
- (c) Iron
- (d) Calcium

(v) Whiptail of crucifers is due to the deficiency of

- (a) Zn
- (b) Cu
- (c) Mo
- (d) P

(vi) The ratio of F_2 generation of dihybrid cross is

- (a) 9:3:3:1
- (b) 1:1:1:1
- (c) 1:2:1
- (d) 3:1

(vii) Oxidation of one molecule of glucose produces

- (a) 30 mol. ATP
- (b) 38 mol. ATP
- (c) 8 mol. ATP
- (d) 28 mol. ATP

(viii) "Guttation" is caused by

- (a) Clogged Vessels
- (b) Transpiration
- (c) High root pressure
- (d) High leaf pressure

(ix) Richmond – Lang effect due to cytokinins pertains to

- (a) Root formation
- (b) Apical dominance
- (c) Delay of senescence
- (d) Leaf formation

(x) Crossing over occurs in

- (a) Leptotene
- (b) Zygotene
- (c) Pachytene
- (d) Diplotene

(xi) Most widely grown bast fibre in India is

- (a) Jute
- (b) Flax
- (c) Hemp
- (d) Sunn Hemp

(xii) Which is the largest and most stable ecosystem ?

- (a) Grassland
- (b) River
- (c) Forest
- (d) Ocean

(xiii) The condition under which transpiration in plants would be most rapid is _____.

- (a) High humidity
- (b) Excess of water in the soil
- (c) Low humidity and high temperature
- (d) Low wind velocity

(xiv) The casual agent of Red disease in Sugarcane is _____.

- (a) *Phytophthora*
- (b) *Venturia*
- (c) *Xanthomonas*
- (d) *Colletotrichum*

(xv) The fibrous part of coconut is the

- (a) Pericarp
- (b) Mesocarp
- (c) Endocarp
- (d) Seed coat.

(xvi) Which of the following is mis-matched ?

- (a) Vasaka – Adhatoda Vasica
- (b) Sal – Tectona grandis
- (c) Sunflower – Helianthus annuus
- (d) Castor – Ricinus Communis

(xvii) What happens during S-phase of interphase during mitosis ?

- (a) DNA Synthesis
- (b) RNA Synthesis
- (c) Protein Synthesis
- (d) Chromosome segregation

(xviii) Which enzymes are called 'Biological scissors' ?

- (a) Ligase
- (b) Restriction Endonucleases
- (c) Polymerase
- (d) Transferase

(xix) The number of thymine bases in a DNA chain is

- (a) Equal to guanine
- (b) Equal to cytosine
- (c) Equal to uracil
- (d) Equal to Adenine

(xx) The water potential and osmotic potential of pure water is _____.

- (a) 100 and 100
- (b) 100 and Zero
- (c) Zero and 100
- (d) Zero and Zero.

SECTION – B

Answer any six questions from the following :

5×6=30

2. Describe the physiological effects which are influenced by Gibberellins. 5
3. Give an account on botanical regions of India. 5
4. How Meiosis is different from Mitosis ? 5

5. What is called Synecology ? Discuss in brief about the biotic component of a pond eco-system.

5

6. Explain ecosystem, ecological niche, plant community, ecological pyramids and autogenic succession.

5

7. What is called heterosis or hybrid vigour ? In brief write few lines about the role of plant breeding in modern agriculture.

1+4=5

8. Give the botanical names of two commercially grown jute plants. Mention the anatomical nature of jute. Name the States of India where cottons are grown in large scale.

2+1+2=5

9. Explain the functions of any five of the following :

1×5=5

(i) Endoplasmic reticulum

(ii) Mitochondria

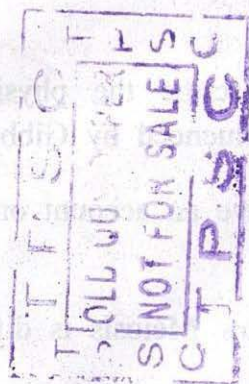
(iii) Golgi bodies

(iv) Nucleolus

(v) Cell wall

(vi) Plastids

(vii) Cytoplasm.



SECTION – C

Answer any five questions from the following :

10×5=50

10. (a) Write a short note on causes and effect of noise pollution.

6

(b) Explain ex-situ and in-situ conservation. Why conservation of biota is essential ? Give three names each of National parks, Wildlife sanctuaries and Biosphere reserves in India.

4

11. What is called photophosphorylation ? How does it differ from oxidative phosphorylation ? With suitable scheme describe the non-cyclic photophosphorylation in plants.

1+2+(2×5)=10

12. Discuss the mechanism and significance of C_4 cycle.

10

13. Name Phytogeographical regions of India as proposed by D. Chatterjee (1960). With the help of Indian map, demarcate the regions along with the name of the places included in each region.

1+3+6=10

14. Describe in detail the structure of a chromosome.

10

15. What is called amphidiploidy ? Discuss the role of allo-polyploidy in agricultural practices. What is bulk method ? What is its difference with pedigree method ?

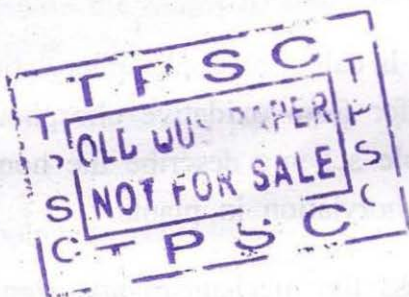
1+5+2+2=10

16. (a) Define mutation. What are mutagens ? Discuss the process of repair mechanism in damaged DNA.

6

(b) Write a short note on economic use of plants for timber and fibre.

4



Total No. of printed pages = 8

TR/FST/AS/II/21

AGRICULTURE SCIENCE

Paper – II

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

Instructions :

1. Answer to Question No. 1 (i to xx) i.e., MCQ type questions under Section-A must be written in English only.

Example : The capital of India is

- (a) Delhi (b) New Delhi
(c) Indraprastha (d) None of these

Answer : (b) New Delhi.

2. Answers to other questions except mathematical part must be written either in English or in Bengali. It must not be answered partly in English and partly in Bengali. This instruction must be followed scrupulously.
3. Candidates are required to give their answers in their own words as far as practicable.

[Turn over

SECTION - A

1. Choose the correct option of the following and write it on the answer script :

- (i) National Horticulture Board was setup in
(a) 1988 (b) 1984
(c) 1990 (d) 1999
- (ii) Assessment of horticulture crops through Remote Sensing and Sample Survey Techniques is known as
(a) HAPIS (b) CHAMAN
(c) NHP (d) MIDH
- (iii) Standard Technique for production of disease free quality planting materials is called
(a) Micro propagation
(b) Grafting
(c) Air-layering
(d) None of the above
- (iv) India is the — largest producer of fruits and vegetables globally
(a) First (b) Second
(c) Third (d) Fourth

(v) Blanching is done in

- (a) Fruits
(b) Vegetables
(c) Both (a) & (b)
(d) None of the above

(vi) Which of the following is not a preservative ?

- (a) Vinegar (b) Citric acid
(c) Salt (d) Sugar

(vii) National Horticulture Board is situated at

- (a) Haryana
(b) Himachal pradesh
(c) Uttar pradesh
(d) New Delhi

(viii) Intercultural operation in groundnut is avoided at

- (a) Flowering stage
(b) Seedling stage
(c) Pegging stage
(d) Pod developing stage

(ix) Growing of coconut, black pepper and ginger simultaneously in the same field is called

- (a) Relay cropping
- (b) Intercropping
- (c) Multiple cropping
- (d) Multi-storied cropping

(x) Frost damage can be reduced in horticultural crops using these methods except

- (a) Overhead sprinklers at night
- (b) Green houses and shade nets
- (c) Wind breaks placement
- (d) Appropriate fungicide application

(xi) Potato crop grows well under

- (a) Acid soil
- (b) Saline soil
- (c) Alkali soil
- (d) Both Saline soil and Alkali soil

(xii) Cutting is not suitable for propagation in

- (a) Lime
- (b) Sugar-cane
- (c) Oleander
- (d) Tapioca

(xiii) Green manure plants used by farmers mainly belong to family

- (a) Compositae
- (b) Leguminosae
- (c) Solanaceae
- (d) Poaceae

(xiv) Gundhi bug insects attack on rice during

- (a) seedling stage
- (b) boot stage
- (c) milking stage
- (d) harvesting stage

(xv) Bio herbicides have been recommended

- (a) to prevent eco-degradation
- (b) because of their ready availability
- (c) because of their cheap rates
- (d) because of their abundance

(xvi) First irrigation of wheat is given at

- (a) CRI stage
- (b) Flowering stage
- (c) Tillering stage
- (d) Jointing stage

(xvii) Rootex contains

- (a) Auxins
- (b) ABA
- (c) Kinetin
- (d) Ethylene

(xviii) The inflorescence of sugarcane is called

- (a) Arrowing (b) Panicle
(c) Capitulum (d) Ear head

(xix) Which one of the following is best example of catch crop ?

- (a) Rice (b) Wheat
(c) Maize (d) Toria

(xx) The most critical stage of maize from irrigation point of view is

- (a) Seedling stage (b) Tasseling stage
(c) Boot stage (d) Dough stage.

SECTION – B

Answer any *six* questions :

5×6=30

2. Discuss the scope of fruits and vegetables preservation in Tripura. 2+3=5
3. What is farm management. Explain the basic principles of farm management. 5
4. What are the problems and prospects of agricultural marketing ?

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(6)

5. Classify citrus species which are generally cultivated in Tripura. Differentiate between Citrus decline and citrus dieback 2+3=5

6. Discuss the importance of pulse cultivation in crop rotation. Why top one-third to half portion of a cane being used as planting material of sugarcane ? 2+3=5

7. Explain the different methods of fruits and vegetables processing. 5

8. Explain harvesting and storing procedures for oil seeds and pulses. 5

9. Discuss the importance of Quality Protein Maize. Mention the constraints for achieving the higher productivity in kharif pulses. 2+3=5

SECTION – C

Answer any *five* questions :

10×5=50

10. Describe production techniques of Pineapple, Litchi, Turmeric, Coriander.
11. What are the roles of co-operatives in agricultural economy.

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(7)

[Turn over

12. Mention the reasons for low productivity of groundnut in Tripura as well as in India. Suggest appropriate spacing, seed rate and method of sowing of groundnut for higher productivity. Write in brief nutrient management of groundnut crop with special reference to Ca, S and Boron.

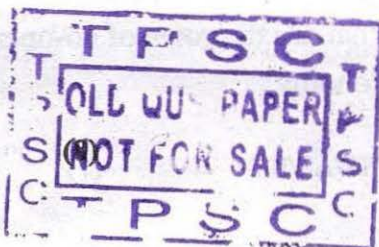
2+5+3=10

13. Explain briefly intercultural operations of Tea, Papaya, Guava, Carrot. 10

14. Write in details about the nutrient management and weed management of jute. Write in short about the ideal stage of harvesting of jute as a fibre crop. State the different factors influencing quality of jute fibre. 4+2+4=10

15. Explain production technology of Cucumber, Brinjal, Cashewnut, Cocoa.

16. State the reasons for puddling in transplanted rice. Why are the productivity of rice low in *kharif* season than *boro* season? Discuss the principles of fertilization (fertilizer application) in a water logged rice soil. 2+3+5=10



Total No. of printed pages = 8

TR/FST/CE/I/21

CIVIL ENGINEERING

Paper – I

Full Marks – 100

Time – Three hours

The figures in the margin indicate full marks for the questions.

Instructions :

1. Answer to Question No. 1 (i to xx) i.e., MCQ type questions under Section-A must be written in English only.

Example : The capital of India is

- (a) Delhi (b) New Delhi
(c) Indraprastha (d) None of these

Answer : (b) New Delhi.

2. Answers to other questions except mathematical part must be written either in English or in Bengali. It must not be answered partly in English and partly in Bengali. This instruction must be followed scrupulously.
3. Candidates are required to give their answers in their own words as far as practicable.

[Turn over

SECTION – A

1. Choose the correct answer and write it on answer script : $1 \times 20 = 20$

(i) The normal consistency of Portland cement is about

- (a) 10% (b) 15%
(c) 20% (d) 25%

(ii) State the form for which tiles are used

- (a) For paving
(b) As road metal
(c) As an excellent roof covering material
(d) None of these

(iii) The compressive strength of sandstone is

- (a) 550 kg/cm^2 (b) 800 kg/cm^2
(c) 650 kg/cm^2 (d) None of these

(iv) For construction of retaining walls, which type of stone must be used ?

- (a) Soft (b) Hard
(c) Heavy (d) Strong

(v) The average out-turn of first class bricks in clamp burning is about

- (a) 50% (b) 60%
(c) 70% (d) 80%

(vi) The ratio of linear stress to the linear strain is called

- (a) Modulus of rigidity
(b) Modulus of elasticity
(c) Bulk modulus
(d) Poisson's ratio

(vii) The Poisson's ratio for cast iron varies from

- (a) 0.23 to 0.27 (b) 0.25 to 0.33
(c) 0.31 to 0.34 (d) 0.32 to 0.42

(viii) Shear modulus is the ratio of

- (a) Linear stress to linear strain
(b) Linear stress to lateral strain
(c) Volumetric strain to linear strain
(d) Shear stress to shear strain

(ix) When a closely-coiled helical spring is subjected to an axial load, it is said to be under

- (a) Bending
- (b) Shear
- (c) Torsion
- (d) Crushing

(x) The columns whose slenderness ratio is less than 80 are known as

- (a) Short columns
- (b) long columns
- (c) weak columns
- (d) medium columns

(xi) The main advantage of a steel member is that it

- (a) has high strength
- (b) is gas and water tight
- (c) has long service life
- (d) All of these

(xii) Rolled steel angle sections are classified as

- (a) Two series
- (b) Three series
- (c) Four series
- (d) Five series

(xiii) The live loads

- (a) change their position
- (b) do not change their position
- (c) vary in magnitude
- (d) Both (a) and (c)

(xiv) The bearing stress is calculated on the

- (a) Cross-sectional area of contact
- (b) Net projected area of contact
- (c) Mean of cross-sectional area of contact and net projected area of contact
- (d) None of these

(xv) The Euler's formula for columns is valid for

- (a) zero slenderness ratio
- (b) small slenderness ratio
- (c) large slenderness ratio
- (d) None of these

(xvi) A twisted bar has about _____ more yield stress than ordinary mild steel bar.

- (a) 10%
- (b) 20%
- (c) 35%
- (d) 50%

(xvii) In singly reinforced beams, steel reinforcement is provided in

- (a) Tensile zone
- (b) Compressive zone
- (c) Both Tensile and Compressive zones
- (d) Neutral zone

(xviii) Analysis of reinforced concrete can be done by

- (a) Straight line theory
- (b) Elastic theory
- (c) Ultimate load theory
- (d) All of these

(xix) Normally the tensile strength of the concrete is about _____ of its compressive strength.

- (a) 10 to 15% (b) 15 to 20%
- (c) 20 to 25% (d) 25 to 30%

(xx) For M 150 grade concrete shear reinforcement is necessary, if shear stress is more than

- (a) 5 kg/cm² (b) 10 kg/cm²
- (c) 15 kg/cm² (d) 20 kg/cm²

SECTION – B

Answer any *six* questions :

5×6=30

2. What are the characteristics of a good brick ?
3. What is meant by the terms : seasoning of timber and preservation of timber ?
4. Define Hooke's law, Young Modulus, Bulk Modulus, Modulus of Rigidity, Poisson's Ratio.
5. What are the differences between lap joint and butt joint ?
6. Define web buckling and web crippling.
7. Define column. What are the classification of a column based on mode of failure ?
8. Why HYSD bars are preferred over plain mild steel bars as reinforcement in RCC ?
9. What are the types of load on RCC structure ?

SECTION – C

Answer any *five* questions :

10×5=50

10. What do you mean by workability of concrete ? Describe briefly a test for its in-situ determination.

11. Describe briefly about the test which are carried out for cement in laboratory.
12. What are the requirements of a good concrete mix ?
13. Elaborate the Stress-strain curve of mild steel with neat-sketch.
14. Give a few advantages and disadvantages of welded connections.
15. How are rivets arranged and what are the failure modes of a riveted joint ?
16. Describe briefly about the methods for design of reinforced concrete.

