RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, JUNE 2022

SECOND YEAR [BATCH 2020-23]

Date : 21/06/2022

INDUSTRIAL CHEMISTRY (HONOURS)

Time : 11 am – 1 pm

Paper : VIII [CC8]

Full Marks : 50

[Use a separate Answer Book for **each Group**]

Group : A

Answer **any five** of the following questions: [5×5]

1. Answer the following questions (**any five**): [5×1]

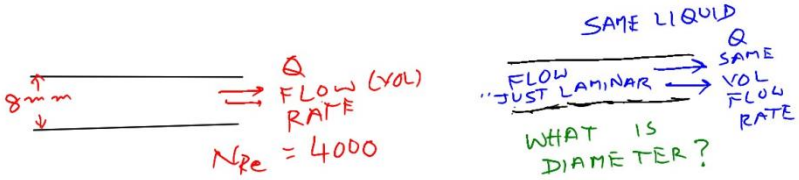
   a) How is Reynolds no for a flow through a circular pipe defined
   b) What is Fannings Friction Factor
   c) Name an instrument that measures " point velocity"
   d) A fluid is flowing through a circular pipeline. What is the shear stress at the center of the pipe.
   e) Define the term "sphericity" of a particle
   f) What is the Reynolds number upto which Stokes law can be used for a spherical particle falling through a liquid.

2. a) A vertical dam 150 m in length and 20 m high holds water of a reservoir. What is the total force on the dam wall exerted by the water of the reservoir?

   b) Air pressure at the surface of Earth is 760 mm Hg. Density of Hg is 13.4 g/ml. Calculate the weight of a column of air with base area 1 cm^2, extending from the surface to the top of the atmosphere. [2.5×2]

3. a) Water is flowing through a flexible pipeline of diameter 12 mm, at a flow rate of 500 cc/s. What would be the velocity at the outlet, if the outlet is pinched to reduce its diameter to 4 mm. Assume the flow rate to decrease by 30% due to this pinching.

   b) A fluid is flowing through a circular pipe at a Reynolds number of 4000. Another tube of different diameter is added at the end of this tube. If we intend the flow in this added tube to be laminar, what should be the limiting diameter of this added tube? Diameter of the first tube is 8 mm.



[2+3]

4. a) Write down Bernoullis equation for an ideal fluid flowing through a conduit, explain the terms.

   b) Starting from above, obtain the working equation for finding the volumetric flow rate of a fluid in a circular pipe using a normal venturimeter. Explain all the symbols and terms you are using. [2+3]

5. Answer the following questions (**any five**): [5×1]

   a) How is Reynolds no for a past a sphere defined
   b) What is the value of Fannings Friction Factor in terms of Reynolds number for laminar flow through a circular pipe.
   c) Name a "variable area" flow meter
   d) What is meant by the term "ideal fluid".
   e) Define the term "diameter volume based)" of an arbitrary shaped particle
   f) Name a valve that is used only for opening and closing of pipeline during normal operating conditions.

6. a) Write down Bernoullis equation for an ideal fluid flowing through a conduit, explain the terms.

   b) A young engineer proposes the following arrangement for measuring the flow rate instead of a venturimeter where a cylinder is placed coaxially with the tube, leaving an annular space for the flow as shown in the figure [2+3]

7. Air when flowing through a bed of spherical particles of uniform but unknown size shows a pressure drop of 10 cm of water for a particular flow rate.

   When this bed is replaced by a bed of spherical particles of dia 0.15 mm, for maintaining the same flow rate of air under same pressure drop, a bed height of 1.25 times the previous bed height is required. Assuming bed porosities remain the same, estimate the diameter of the particles of the first bed.

   ERGUN EQUATION

   (symbols have their usual significance)

$$\frac{\Delta P}{L} = \frac{150\,yu}{\phi^2 D_p^2}\,\frac{(1-\in)^2}{\in^3} + 1.75\frac{Pu^2}{\phi D_p}\,\frac{1-\in}{\in^3}$$ [5]

8. Draw a neat sketch of characteristic curve (head developed vs volumetric flow rate) for a centrifugal pump and on the same diagram draw schematically the behaviour of a gear pump. Explain the nature of the curves in brief. [3+2]

Group : B

[All symbols are of usual significance]

Answer **any five** of the following questions: [5×5]

9. a) Sodium chloride weighting 600 kg is mixed with 200 kg of potassium chloride. Find the composition of the mixture in (i) mass % and (ii) mole %.

   b) A gaseous mixture analyzing CH_4 : 10%; C_2H_6 : 30%; rest H_2 at 15^oC and 1.5 atm is flowing through an equipment at the rate of 2.5 m^3/min. Find (i) the average molecular weight of the gas mixture; (ii) weight % and (iii) the mass flow rate. [2+3]

10. a) A mixture of methane and ethane has an average molecular weight of 21.6. Find the composition.

   b) Two engineers are estimating the average molecular weight of gas containing oxygen and another gas. One uses the molecular weight as 32 and finds the average molecular weight as 39.8 and another uses the atomic weight of oxygen as 16 and finds the average molecular weight as 33.4. Estimate the composition of the gas mixture. [2+3]

11. 10 kg of PbS and 3 kg of oxygen react to yield 6 kg of Pb and 1 kg of PbO_2 according to the reaction shown below

$$PbS + O_2 \rightarrow Pb + SO_2 \qquad (1)$$

$$PbS + 2O_2 \rightarrow PbO_2 + SO_2 \qquad (2)$$

   Estimate (i) unreacted PbS; (ii) % excess oxygen supplied; (iii) total SO_2 formed and (iv) the % conversion of PbS to Pb. [5]

12. A coke is known to contain 90% carbon and 10% noncombustible ash (by wt%).

   a) How many gmmole of oxygen are theoretically required to burn 100 kg of coke of completely?

   b) If 50% (mole) excess air is supplied calculate the analysis of gases at the end of combustion. [2.5+2.5]

13. In synthesis of methanol fresh feed, containing 32% CO; 64% H_2 and 4% inerts (by volume), is mixed with recycle feed. Mixed feed entering the reactor results in 20% per pass conversion of CO. The product stream from reactor is fed to condenser where all methanol formed gets condensed and the gases from condenser are recycled. In order to prevent buildup of inerts in recycle loop a small portion of gases leaving the condenser is continuously purged. If the mixed feed contains 13 mole% inerts. Calculate (a) recycle ration; (b) purge ratio. (5)

14. a) State and explain Fick's law of diffusion.

b) Differentiate between (I) adsorption and absorption; (ii) molecular diffusion and eddy diffusion.

c) 1000 kg/hr of a thermic fluid to be used as a heat transfer medium, is being indirectly heated in a heater from 380 K to 550 K. Calculate the heat load on the heater in kW. The heat capacity equation for the thermic fluid is

$C_P = 1.436 + 0.00218T$

Where, C_P is in kJ/kgK and GT is in K. [1+2+2]

15. Calculate the amount of diffusion of acetic acid (A) in 2 hrs. across a film on non-diffusing water (B) solution 1 mm thick at 17^oC when the concentration on opposite side of the film are 9 % and 3% acid respectively.

Given, $D_{AB} = 0.95 \text{ X } 10^{-9} \text{ m}^2/\text{s}$

Density of 9% solution = 1012 kg/m^3; Density of 3% solution = 1003.2 kg/m^3

$M_{\text{acetic acid}} = 60.03$; $M_{\text{water}} = 18.02$ [5]

16. In an oxygen-nitrogen gas mixture at 1 atm 25^oC, the concentration of oxygen at two phases 0.2 cm apart are 10% and 20% (by volume) respectively. Calculate the flux of oxygen when (i) nitrogen is non-diffusing and (ii) there is equimolal counter diffusion.

Given, $D_{\text{oxygen-nitrogen}} = 0.215 \text{ cm}^2/\text{s}$. [5]

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