EX/CHE/T/414/2017

BACHELOR OF CHEMICAL ENGINEERING FINAL EXAMINATION, 2017
(4th Year, 1st Semester)

CHEMICAL PROJECT ENGINEERING & ECONOMICS

Full Marks: 100

All questions carry equal marks (25 each). Answer four questions of which at least one of Q.5 or Q.4 must be attempted.

1. (a) An improvement project for a wastewater treatment process is being considered. The project will involve installing an advanced 'smart' control system for the metering of neutralizing chemicals. With this system in place, the existing neutralizer can be scrapped, which will save a significant amount of money due to decreased maintenance costs and wasted chemicals. Costs and savings involved are as follows:
Cost of installing 'smart' control system = $ 375,000.
Projected savings = $ 85,000 p.a.
Time over which cost comparison is to be made = 5 years.
Benchmark rate of return = 8%.
Should the new control system be implemented?
(b) You can choose between twp exchangers A and B. Their purchase costs are Rs. 23000 and Rs. 12000 respectively; annual operating costs are Rs.1200 and Rs.3300 respectively. Both have operating life of 12yrs. Internal rate of return is 8%. Which is the better option based on Net Present Value? **[15+10]**

2. State clearly the working formulas for estimating annual depreciation by the commonly used methods, viz. straight-line (SL), Sum-of-years-digits (SY). Double declining balance (DD) and Modified accelerated cost recovery system (MA). If the purchase price of a piece of equipment is Rs. 2 lakhs and salvage value is Rs. 20,000/- with an equipment life of 10 years, make a comparative estimation of yearly depreciation allowances by the above methods. Now, suppose the yearly depreciation allowances (and the salvage value, at the end of equipment life) are deposited, as they accrue, into a 'depreciation reserve account' that pays 10% p.a. interest with annual compounding. Which of these methods gives the highest sum at the end of the equipment life?

3. (a) Derive the working formula for Capitalized Cost of a piece of equipment if it is replaceable indefinitely (every time its working life ends). What is the said cost for a machine that has a purchase price of Rs. 12,000, salvage value of Rs. 2,000, working life of 10 years. (Money is worth 6%)?
(b) Two reactor options, one mild steel (MS), the other Carbon steel (CS) are available for a certain duty, neither having any salvage value at the end of their working life. The former costs USD 5000 and lasts 3 years. For how many years should the other last, if it costs three times more than the former, and should be economically as cost-effective? **[15+10]**

4. (a) If the resistance to the motion of a fluid is due to the combined effect of viscous drag, gravity and surface tension, show that for geometrically similar homologous systems, individual scale-up criteria obtained separately on the basis of Reynolds No., Froude No. and Weber No. are mutually incompatible.
(b) For heat transfer by natural convection in the turbulent zone, the Nusselt no. varies as $(Gr.Pr)^{1/3}$, where Gr and Pr denote respectively Grashof no. and Prandtl No..Based on this, obtain a scale-up relation for the convective heat transfer coefficient for geometrically similar homologous systems. **[10+15]**

5. (a) With regard to design and scale-up of gravity settling tanks, define Grade efficiency and show how it depends on Stokes No. and Froude No. What is the Euler No.? Explain the concept of Stk_{50} and how it is linked to the Euler No. by Rietema's Equation.
(b) An aerobic fermentation in a mechanically agitated cylindrical tank bioreactor is to be scaled up. Considering Aeration No. as the scale-up basis, show that if k_La is to be maintained constant across scale, then both agitation rate (n) and volumetric aeration rate scale as $\lambda^{0.5}$ where λ is the scale ratio. Assume k_La to vary as $(v_S.n)^{0.5}$ where v_S is the superficial air velocity. **[15+10]**

6. Write short notes on: **[5 x 5]**
(a) Equivalent Annualized Operating Cost (EAOC).
(b) Discounted Payback Period (DPBP).
(c) Net Present Worth (NPW).
(d) Perpetuity and Sinking Fund.
(e) Rate of Return on Incremental Investment.