Applicant Id: B _____ Name: _____

DEPARTMENT OF ENERGY SCIENCE AND ENGINEERING, IIT BOMBAY

M.TECH ADMISSIONS WRITTEN TEST

|DATE: 13-05-2016| |TIME: 1 HR| |MAX. MARKS: 40| |**GATE Discipline:** _____|

PART A: 20 Marks (10 Questions x 2 marks per Question)

- **Answers to be filled in the blanks**
- **No partial marking**

1. The equation of the line, tangent to $y = x^2$ at $x = -1$ is _____.

2. A battery of emf 10 V and internal resistance 3 Ω is connected to a load. If the current in the circuit is 0.5 A, the resistance of the load is _____. The terminal voltage of the battery when the circuit is closed is _____.

3. The half-life for radio-active decay of ^{14}C is 5730 years. If a sample of wood has only 80% of the ^{14}C found in a living tree, the age of the sample is _____ years.

4. Lead has a melting point of 327 °C, specific heat (solid) of 0.128 J/g °C and its enthalpy of fusion is 86 J/g. The amount of heat needed to melt 500 g of lead that is at 27 °C initially is _____ kJ.

5. A train traveling at 100 km/h overtakes a motorbike traveling at 64 km/h in 40 seconds. The length of the train is _____ m.

6. The solutions for $4\ sin^3(x) + 2\ sin^2(x) - 2\ sin(x) - 1 = 0$ in the interval $[-\pi/2, 0]$ are _____ and _____.

7. A solution is obtained by mixing 300 g of 25% solution and 400 g of 40% solution by mass. The mass percentage of solute in the resulting solution is _____.

8. An average-sized fly-ash particle has a constant settling velocity of 0.3 m/s. If these particles are emitted from a 200 m high chimney and there is a wind of 15 km/h, the distance traveled by the particle before reaching the ground is _____.

9. The number of photons of wavelength 10 μm required for a total incident energy of 1 kJ is _____. ($h = 6.63 \times 10^{-34}$ J-s; $c = 3 \times 10^8$ m/s).

10. A die is rolled and a coin is tossed at the same time. The probability that the die shows an odd number and the coin shows a head is _____.

-END of PART A-

PART B: 20 Marks (2 Questions x 10 marks per Question)

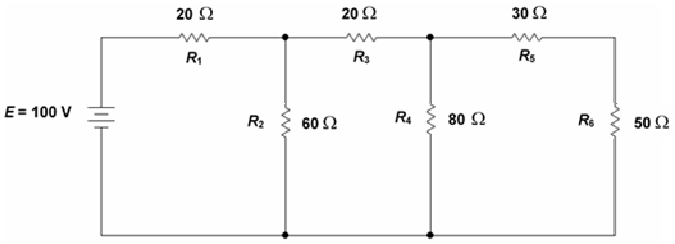
- **Answers to be written in the booklets given. No additional sheets will be provided.**
- **Question 1 is compulsory. Answer any one of the remaining questions (Q2 to Q6).**
- **Write your Name, Applicant ID, Gate discipline and the Question number to be graded on the top of the first page of the answer booklet.**

1. **(a)** An oil-fired thermal power plant has a rated capacity of 220 MW, gross efficiency of 40%, and uses oil of calorific value 34 MJ/kg. Compute the annual net electricity generation and annual oil consumption. **(b)** In a particular month, an industry produces 150 tonnes of finished product. The consumption of various energy sources are as follows. Coal: 40 tonnes, Oil: 10000 gallons, Electricity: 90 MWh. The calorific values of coal and oil are 27.9 MJ/kg and 177 MJ/gallon, respectively. Determine the energy consumption in MWh per tonne of product.

2. Consider a column AB of length, L fixed at both ends. A compressive, centric load P acts vertically downwards at end A. **(a)** Derive the equation of the elastic curve. **(b)** Derive an expression for the critical load for buckling and the effective length. **(c)** Prove that the effective length of the column starts at a distance L/4 from the top.

3. A single-phase transformer has 2000 turns on the primary and 800 turns on the secondary. Its no-load current is 5 A at a power factor of 0.2 lagging. Assuming the voltage drop in the windings is negligible, determine the primary current and power factor when the secondary current is 100 A at a power factor of 0.85 lagging.

4. For the circuit shown in the figure: **(a)** Find the current and power dissipated in branch R_4 using Thevenin's theorem; **(b)** Find current in resistance R_6 using Norton's theorem.



5. **(a)** Air at 20 °C and 2 atm enters a finned-tube steam heater through a 50 mm tube at an average velocity of 15 m/s. It leaves the heater through a 65 mm tube at 90 °C and 1.6 atm. What is the average air velocity at the exit? **(b)** Ethanol is flowing in a pipe at a velocity of 1 m/s and a pressure of 101300 Pa. This ethanol is needed at a pressure of 202600 Pa on a lower level. How far must the pipe drop in height in order to achieve this pressure? Assume the velocity does not change. Density of ethanol is 789 kg/m^3.

6. In a CSTR, a liquid phase, second order (in A) reaction: A → B + C converts 90% of the reactant A fed to it. Now, another reactor identical to the first one is available to be used in series with the first reactor. If the inlet flow-rate remains the same as for the above single reactor, what is the overall conversion at the exit of the second reactor?

-END of PART B-