Instruction:

NOTE: This question paper consists of 2 sections, General Aptitude (GA) for 15 marks and the subject specific GATE paper for 100 marks. Both these sections are compulsory. The GA section consists of 10 questions. Question numbers 56 to 60 are of 1-mark each, while question numbers 61 to 65 are of 2-mark each. The technical subjects section consists of 55 questions, out of which question numbers 1 to 25 are of 1 mark each, while question numbers 26 to 55 are of 2 marks each.

All questions that are not attempted will result in 0 marks. However, wrong answers for multiple choice type questions (MCQ) will result in NEGATIVE marks. For all MCQ questions a wrong answer will result in deduction of ⅓ marks for a 1-mark question and ⅔ marks for a 2-mark question. *There is NO NEGATIVE MARKING for NUMERICAL ANSWER TYPE questions*

TECHNICAL SECTION

1) When the Newton Raphson method is applied to solve the equation $x^3 + 2x - 1 = 0$, the solution at the end of the first iteration with the initial guess value as $x_o = 1.2$ is

(A) –0.82 (B) 0.49 (C) 0.705 (D) 1.69

2) Consider the following set of linear algebraic equations

$$x_1 + 2x_2 + 3x_3 = 2$$
$$x_2 + x_3 = -1$$
$$2x_2 + 2x_3 = 0$$

The system has

(A) A unique solution (B) No solution

(C) An infinite number of solutions (D) Only the trivial solution

3) The maximum value of $f(x) = xe^{-x}$ where $x \geq 0$ is _____(upto 2 decimal places).

4) A solution of $NaNO_3$ in water contains 18% $NaNO_3$ by weight. From 1000 lb of this solution, 700 lb of water are evaporated. The remaining solution cooled at 10^0C. Calculate the percentage yield of $NaNO_3$ crystals produced. Solubility of $NaNO_3$ at 10^0C is 0.4 lb mole per 1000 lb of H_2O_____(upto one decimal place)

5) Carbon dioxide is added at a rate of 10 kg/h to an air stream and the air is sampled at a sufficient distant downstream to ensure complete mixing. If the analysis shows 0.45 percent v/v CO_2, the air- flow rate will be _____(kg/h).

(A) 1560 (B) 1570 (C) 1550 (D) 1580

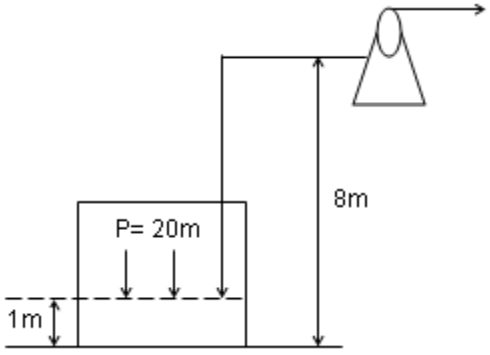
6) A Carnot engine rejects 30% of absorbed heat to a sink at 30°. The temperature of the heat source is

(A) 100° C (B) 433°C (C) 737°C (D) 1010°C

7) Determine mole fraction of methane (x_1) dissolved in a light oil at 200 k and 20 bar. Henry's law is valid for the liquid phase and the gas phase may be assumed to be an ideal solution. At these conditions, Henry's law constant for methane in oil = 200 bar, fugacity coefficient of pure methane gas = 0.90 and mole fraction of methane in the gas phase (y_1) = 0.95

(A) 0.1 (B) 0.055 (C) 0.0855 (D) 0.015

8) A pressure vessel (absolute pressure =20 m of water) has a diameter of 4cm and is initially filled with water to a height of 1m. The pump draws water from the vessel and is located at an elevation of 8m above the bottom of the vessel. The frictional head loss in the suction pipe is 4 m of water. If the vapour pressure of liquid at the temperature of operation is 4 m of water then the available NPSH is



(A) 2m (B) 4m (C) 5m (D)13m

9) The fugacity of component 1 in binary liquid mixture of components 1 and 2 at 298 K and 20 bar is given by

$\bar{f}_1 = 50x_1 - 80x_1^2 + 40x_1^3$, where $\bar{f}_1$ is in bar and x_1 is the mole fraction of component 1. Determine the activity coefficient $\gamma_1|_{x_1=0.6}$.

(A) 1.64 (B) 1.46 (C) 6.14 (D) 4.16

10) In a 0.10 m diameter pipe, fluid is flowing such that velocity measured 0.01 m away from the pipe wall is 0.8 m/s. If flow is laminar, the average velocity is:

(A) 2.22 m/s (B) 1.11 m/s (C) 1.48 m/s (D) 0.5 m/s

11) A water tank having capacity of 88 liters is filled to $1/10^{th}$ of its full capacity in 7 minutes using a supply pipe of 2 cm diameter. Maximum velocity through the pipe is:

(Take μ = 1 cP and ρ = 1000 kg/m^3 for water)

(A) 1.33 m/s (B) 0.066 m/s (C) 0.133 m/s (D) 0.66 m/s

12) The collection efficiency of a cyclone is 45% over the size range 0–5 μm, 80 % over the size range 5 – 10 μm, and 96% for particles exceeding 10 μm. Calculate the efficiency of collection for a dust with a mass distribution of 50 % 0 – 5 μm, 30% 5 – 10 μm and 20 % above 10 μm. (up to 1 decimal places)

13) Extent of Solute Extraction, and Concentration of Solute in Extract and Raffinate Phases for Stage-wise Extraction with Immiscible Solvent: An acetaldehyde-toluene solution containing 6% battery to remove acetaldehyde. Water and toluene are completely immiscible and the equilibrium distribution of acetaldehyde between them is given by the relation.

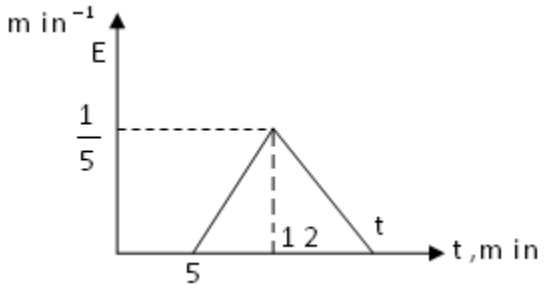
$Y^* = 2.2X$

Where, Y^* = kg acetaldehyde per kg water and X = kg acetaldehyde per kg toluene. If 60 kg water is used in each stage per 100 kg feed, calculate the percentage of acetaldehyde extracted (upto two decimal places)

14) In a parallel flow heat exchanger, the NTU is calculated to be 3. The lowest possible effectiveness for this heat exchanger is

(A) 10 % (B) 27% (C) 41% (D) 50%

15) Find out time, t, at which entire tracer has left the reactor, for the curve given below (upto two decimal places)



16) For equimolar counter Diffusion in case of gases:

(A) Diffusivities are always Directional dependent.

(B) Diffusivities are always Directional independent.

(C) Diffusivities may or may not be directional independent.

(D) None of these.

17) For distillation of an equimolar binary mixture of A& B, the equations of the operation lines are rectifying section y = 0.663 x + 0.32 stripping section: = 1.329 x 0.01317

What is the condition of feed?

(A) Saturated liquid

(B) Saturated vapor

(C) Partial liquid

(D) None of these

18) Reduction in the surface area of catalyst due to continued steam reactivation is termed

(A) Poisoning

(B) Ageing

(C) Neither (A) nor (B)

(D) Both (A) and (B)

19) The cost of a new furnace is Rs. 30K. The furnace has useful life of 5 years. Its salvage value is Rs. 5K. Calculate the value of the amount that the company would have saved in order to perpetually replace the equipment. Given that the interest rate is 10%.

20) The characteristic equation for a system is $s^3 + 9s^2 + 26s + 12(2 + K_c) = 0$ using the Routh test, the value of Kc that will keep the system on the verge of instability is

(A) 20.9 (B) 18.4 (C) 17.5 (D) 19.3

21) A device used to convert the temperature into emf (Voltage) signal. For a range of (0 to 100^0) F the range of voltage signal be (2 to 30) V. Proportional band of the input range is 50%.

Calculate the value of voltage signal (in V, to nearest integer) for a range of 25^0 F.

22) In a chemical reaction $X + Y + Z \xrightarrow{k} P$, it is observed that the

(i) rate of formation of 'P' is doubled on doubling the concentration of 'X'.

(ii) rate of formation of 'P' is quadrupled on doubling the concentration of 'Y'.

(iii) doubling the concentration of 'Z' does not affect the rate of formation of 'P'.

What is the order of the above chemical reaction?

(A) Zeroth order

(B) First order

(C) Second order

(D) Third order

23) For the elementary auto catalytic reaction A + R → R + R_1 operating in a MPR to achieve 45% Conversion. What will be the size of MFR required for that? Given that the rate constant k = 0.15 l/mol.min and feed conc^n CA_0 = 10 mol/l and CR_0 = 2 mol/l. and feed rate = 5 l/min. (up to 2 decimal places)

24) A first order reaction takes place in liquid phase mixture in a reactor. if the half life of the reaction is 60 sec then what will be the half life of second order reaction when initial concentration of component is 1.5 time than that of present in 1st order reaction, other condition remain constant while $C_{A0} = 2 kmol/m^3$

(A) 12 sec (B) 29 sec (C) 24 sec (D) 15 sec

25) The reaction A → B, $(-r_A) = kC_A$, occurs in plug flow tubular reactor with 90% conversion, where k = 0.5 min^{-1}, C_{A0} = 2 mol/lit, and v_0 = 4 lit/min, for a 2 cm diameter tube. What would be the fluid velocity in cm/sec (up to two decimal places)

26) A continuous random variable X has a probability density function f (x) = $e^{-x}, x > 0$. The P [x<1] is

(A) 0.5 (B) 1 (C) 0.632 (D) 0.368

27) The directional derivative of

$$f(x, y, z) = x^2 + y^2 + z^2$$

at the point (1, 1, 1) in the direction of (i – k) is

(A) 0 (B) 1 (C) $\sqrt{2}$ (D) $2\sqrt{2}$

28) If $f = a_0x^n + a_1x^{n-1}y + ... + a_{n-1}xy^{n-1} + a_ny^n$, where a_i (i=0 to n) are constants then $x\frac{\partial f}{\partial x} + y\frac{\partial f}{\partial y}$ is

(A) $\frac{f}{n}$ (B) $\frac{n}{f}$ (C) nf (D) $n\sqrt{f}$

29) Given, $z = \dfrac{(1+i)\left(\sqrt{3}-i\right)}{\left(-1+\sqrt{3}i\right)}$

Find arg(z) . (Principal value).

(A) $\dfrac{5\pi}{4}$ (B) $-\dfrac{5\pi}{4}$ (C) $\dfrac{3\pi}{4}$ (D) $\dfrac{-3\pi}{4}$

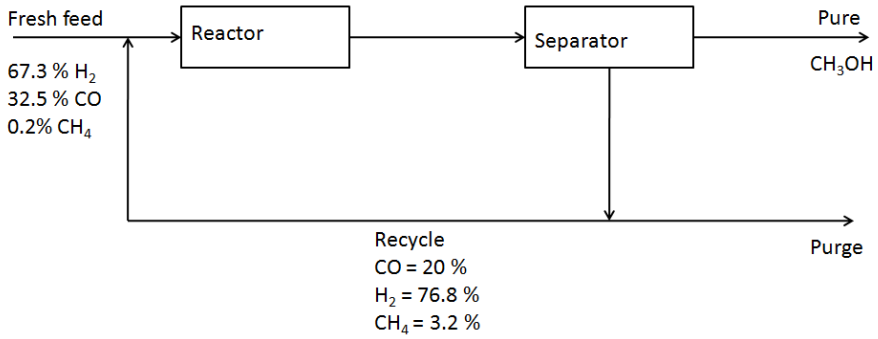
30) A & B plays a game of tossing a coin alternately starting with A. If getting a tail in winning then determine the probability of winning of A.

(A) 1/3 (B) 2/3

(C) 1 (D) None of these

31) The gases CO & H_2 react to give methanol by the reaction: $CO + 2H_2 \rightarrow CH_3OH$

Stream compositions in mole percent is shown in the figure. Single pass conversion of CO is 18%. The % yield of methanol (moles of methanol formed) to moles of fresh feed is _____. (up to 2 decimal places)



32) Two identical finite bodies of constant heat capacity at temperatures 25°C and 225°C are available to do work in a heat engine. The final temperature reached by bodies on deliver of maximum work is,

(A) 75°C (B) 125°C (C) 112°C (D) 62°C

33) The equilibrium constant of a reaction A + B $\rightleftharpoons$ 2 R is 4. If 5 moles of A and b moles of B are fed to the reactor, the % transformation of A is 37.5 %. Find b.

(A) 1 mole (B) 1.875 moles (C) 3 moles (D) 9.8 moles

34) A venturi meter of 20 mm throat diameter is used to measure the velocity of water in a horizontal pipe of 40 mm diameter. If the pressure difference between the pipe and throat sections is found to be 30 kPa, then the flow velocity is: (Neglecting frictional losses)

(A) 0.2 m/s (B)1.0 m/s (C)1.4 m/s (D) 2.0 m/s

35) Consider steady flow of an incompressible fluid through two long and straight pipes of diameters d1 and d2 arranged in series. Both pipes are of equal length and the flow is turbulent in both pipes. The friction factor for turbulent flow though pipes is of the form, $f=K(Re)^{-n}$ where K and n are known positive constants and Re is the Reynolds number. Neglecting minor losses, the ratio of the frictional pressure drop in pipe 1 to that in pipe 2 i.e. ($\triangle P_1/\triangle P_2$) is given by

(A) $(d2/d1)^{(5-n)}$ (B) $(d2/d1)^{5}$ (C) $(d2/d1)^{(3-n)}$ (D) $(d2/d1)^{(5+n)}$

36) A constant pressure filtration experiment is done twice with different pressure drop for compressible cake with compressibility coefficient of 0.2

	$K\left(\frac{sec}{ltr^2}\right)$	$C\left(\frac{sec}{ltr}\right)$	ΔP
Experiment 1	3	4.3	20 bar
Experiment 2	---	---	80 bar

$$\frac{dt}{dv} = KV + C$$

t is in second

v is in ltr

K and C values are given for experiment 1. Compute the time taken for collecting 5 ltr of filtrate according to experiment 2. Assume filter medium resistance is independent of pressure drop _____second (up to two decimal places).

37) Consider an incompressible laminar boundary layer flow over a flat plate of length L, aligned with the direction of an oncoming uniform free stream. If F is the ratio of the drag force on the front half of the plate to the drag force the rear half, then

(A) F < 1/2 (B) F = ½ (C) F =1 (D) F > 1

38) In a solid cylindrical particle, the sphericity is found to be 0.778. if the ratio of height to diameter is 'f' then, what will be the value of 'f' ?

(A) 2 (B) 2.5 (C) 3 (D) 3.5

39) Nitrogen gas at 0°C is flowing over 4 m long, 2 m wide plate maintained at 80°C with a velocity of 4 m/s, for Nitrogen ρ = 1.6 kg/m^3 , c_p = 1 kJ/KgK, $\nu = 2\times10^{-7}$ m^2/s and k = 0.0262 W/mK. Net average heat transfer coefficient for the flow is 5 W/m^{2}K. Then the heat flux flowing from plate at a distance of 4 m from leading edge.

Given:

For laminar flow, Average Nusselt number,

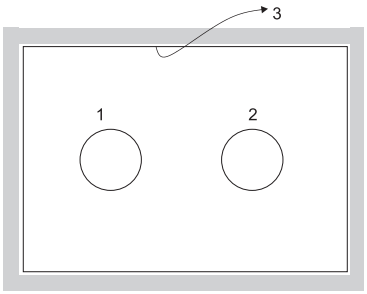
$\overline{Nu_x}$ = 2×(local Nusselt Number) = $2\times Nu_x$

For turbulent flow, Average Nusselt number,

$$\overline{Nu_x} = \frac{5}{4}\times(local\ \ Nusselt\ number) = \frac{5}{4}\times Nu_x$$

(A) 320 W/m^2 (B) 420 W/m^2 (C) 220 W/m^2 (D) 300 W/m^2

40) What is the shape factor F_{33} for the given figure? If both spheres are placed symmetrically with each other and with respect to cube in which they are placed. Inner surface area of cube = 8 m^2 and F_{12} = 0.2, surface area of each sphere = 2 m^2



(A) 0.3 (B) 0.6 (C) 0.4 (D) 0.8

41) Two fluids A and B exchange heat in a counter flow heat exchanger. Fluid A enters at 420°C and has a mass flow rate of 1 kg/s. Fluid B enters at 20°C and has a mass flow rate of 1 kg/s. The effectiveness of heat exchanger is 75%. What is the exit temperature of fluid B?

(Specific heat of fluid A is 1 kJ/kgK and that of fluid B is 4 kJ/kgK).

(A) 95 K (B) 120°C (C) 393°C (D) 95°C

42) A counter- current packed tower is to be designed to recover 90% carbon tetrachloride from an air-CCl4 mixture containing 5 mol% CCl_4 . The gas rate will be 800 kg/hr m^2 of tower cross section. A non- volatile CCl_4 - free organic oil of molecular weight 260 is to be used as solvent. The solvent rate should be twice the minimum. The tower will be operated at 30°C and 1 atm pressure.

Under the operating condition, the equilibrium relation is given by y* = 20x, where y* and x are mole fractions of CCl_4 in gas and liquid respectively.

If the gas and liquid phase mass transfer coefficients kya and kxa are 60 and 900 kmol/(hr)(m^3) mol fraction) respectively, determine the packed height of the tower.

43) Match the product in group I with the nature of the reaction in group II

	Group I	Group II
P	Urea	1. Ammonia and carbon dioxide
Q	Polyester	2. Dimenthylteraphthalate and ethylene glycol
		3. Ammonia and carbon monoxide
		4. Hexamethylene diamine and adipic acid

(A) P-1, Q-4 (B) P-3, Q-2

(C) P-3, Q-4 (D) P-1, Q-2

44) A feed solution of 100 kmol/hr containing 5% of solute C in gas phase.

To absorb the solute, pure solvent is being used. 90 % separation is required in the process.

The value of mass transfer coefficient is $0.1\frac{kmoL}{hr \cdot m^3 (\Delta y)}$.

The cross-sectional area of the packed tower is 1 m^2.

Ls = 1.5 Ls_{min} can be used to determine the optimum solvent flow rate.

Equilibrium relation be given as Y = 0.5 X, where Y and X are on the basis of solute free.

Calculate the height of the packed tower (in m, up to nearest integer).

45) Match the chemicals in Group I with their function in Group II

Group I		Group II	
P.	PET	1.	Fibre
Q.	Polyurethane	2.	Elastomers
R.	Epoxy Resin	3.	Thermoset
S.	Polycarbonates	4.	Thermoplastic

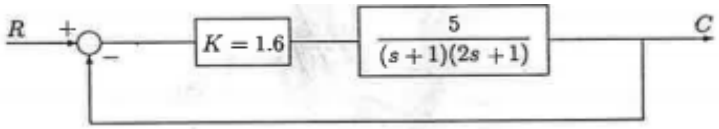
Codes:	P	Q	R	S
A)	1	2	3	4
B)	1	3	4	2
C)	1	4	2	3
D)	2	3	4	1

46) A reactor needs to be painted with a corrosion resistant paint. One company offers it at Rs. 5 Lakh and is expected to last of 2 years. Also it need regular maintenance of re-painting at a price of 50 K. Another company offers the same that expected to last for 3 years but needs 70 K regularly for x-painting. If both choices have to be equally economical, with the effective interest rate being 15 % , the price one should pay for the 2nd offer would be _____ (in Lakhs of Rs., up to 3 decimal places).

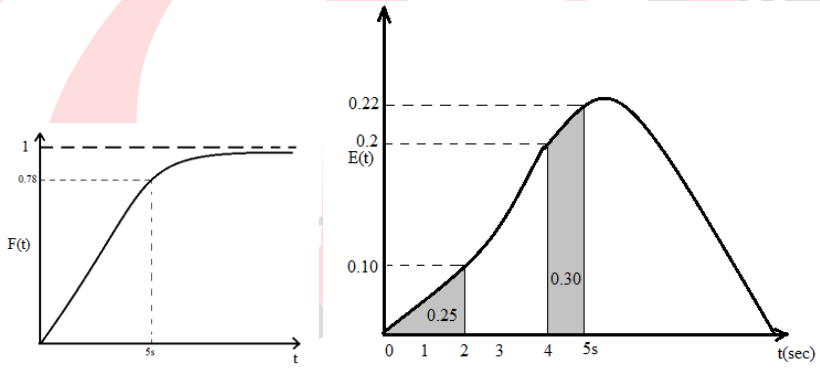
47) If the open – loop transfer function for a system is given as $G(s) = \dfrac{(s+4)}{s(s+1)(10s+1)}$

Then find the value of offset for the unit step change in set point?

48) The setpoint of the control system shown in figure is given a step change of 0.1 unit. The time period of oscillation will be _____ (up to one decimal place).



49) For a non-ideal reactor, the F-curve is as follows



For the same non-ideal reactor, the following E-curve is plotted. The shaded area is given in the shaded region. What is the fraction of tracer that has spent time between 2 sec to 4 sec in the reactor?

(A) 0.55 (B) 0.12 (C) 0.3 (D) 0.23

50) A separation column for vapour liquid contact processes 300 kmol/hr of vapour. The flooding velocity is 3 m/s if the column operates at 80% of flooding velocity and the down comer area is 10% of the total cross sectional area what is the diameter of the column, average density of vapour is 4 kg /m^3 and molecular weight is 44. $\dfrac{kg}{mol}$

(A) 6 m (B) 7 m (C) 0.6 m (D) 0.98 m

51) The following reactions take place in a continuous reactor at steady state

$$A \rightarrow B + C$$
$$A + C \rightarrow 2D$$

The feed contains 80 mole% A and rest inerts. The fractional conversion of A is 0.5 and fractional yield of B is 0.45 .What is the selectivity of B to D.

Note: use the definition of yield as (moles of B actually formed)/ (moles of B that would have formed if there were no side reactions and A reacted completely)._____(up to two decimal place)

52) For a liquid phase second order reaction 2 A + 3 B $\rightarrow$ products, the reactions are initially present in stoichiometric ratio. If the rate law is given by rate = K$C_A^{0.5} C_B^{1.5}$ then the value of 'C' in the given expression is

$$\frac{X_A}{1 - X_A} = C\,KC_{Ao}t$$

(A) $\left(\frac{3}{2}\right)^{0.5}$ (B) $\left(\frac{2}{3}\right)^{1.5}$ (C) $\left(\frac{3}{2}\right)^{1.5}$ (D) $\left(\frac{2}{3}\right)^{0.5}$

53) A liquid antibiotic containing 500 mg of active ingredient is given to a patient with a body fluid of 40 liters. In the stomach, the antibiotic can either be absorbed into the bloodstream through the stomach wall or can be eliminated through the gastrointestinal tract. Both these processes are first order with rate constants of 0.25 h^{-1} and 0.5 h^{-1} respectively. The only mechanism for the antibiotic to leave the bloodstream is by elimination through urine. This reaction can also be assumed to be first order with a rate constant of 0.4 h^{-1}. The doctor wants to find out the exact time at which the concentration of this antibiotic in the blood peaks in the patient. Determine this time and the concentration of the antibiotic in the blood stream at this time.

(A) t = 2.796 hours, C_B = 1.03 mg/l

(B) t = 1.796 hours, C_B = 2.03 mg/l

(C) t = 0.796 hours, C_B = 3.03 mg/l

(D) None of these

54) Find the value of Median from the following data:

No. of days for which absent (less than)	5	10	15	20	25	30	35	40	45
No. of students	29	224	465	582	634	644	650	653	655

(A) 103.5 (B) 241 (C) 12.15 (D) 10

55) At a given temperature K_1, K_2, and K_3 are equilibrium constants for the following reaction 1,2,3 respectively.

$CH_4(g) + H_2O(g) \leftrightarrow CO(g) + 3H_2(g)$.

$CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g)$

$CH_4(g) + 2H_2O(g) \leftrightarrow CO_2(g) + 4H_2(g)$

Then K_1 K_2 and K_3 are related as:

(A) $K_3 = K_1 \times K_2$ (B) $K_3 = (K_1 \times K_2) \times 0.5$

(C) $K_3 = (K_1 + K_2)/2$ (D) $K_3 = (K_1 + K_2) \times 2$

GENERAL APTITUDE

56) Pick out the most effective word(s) from the given words to fill in the blank to make the sentence meaningfully complete.

Fate smiles ..... those who untiringly grapple with stark realities of life.

(A) with (B) over (C) on (D) round

57) In the following the questions choose the word which best expresses the meaning of the given word.

FRUGALITY

(A) Foolishness (B) Extremity (C) Enthusiasm (D) Economy

58) In questions below, each passage consist of six sentences. The first and sixth sentence are given in the begining. The middle four sentences in each have been removed and jumbled up. These are labelled as P, Q, R and S. Find out the proper order for the four sentences.

S_1: Once upon atime there lived three young men in a certain town of Hindustan.

P : All the people of the neighbourhood were mortally afraid of them.

Q : They were so powerful that they could catch growing lions and tear them to pieces.

R : Someone told them that they would become immortal if they killed Death.

S : The young men believed themselves to be very good friends.

S_6: All of them set out in search of their foe called Death.

The Proper sequence should be:

(A) QPRS (B) SQPR (C) RSQP (D) SRPQ

59) Look at this series: 80, 10, 70, 15, 60, ... What number should come next?

(A) 20 (B) 25 (C) 30 (D) 50

60) It takes eight hours for a 600 km journey, if 120 km is done by train and the rest by car. It takes 20 minutes more, if 200 km is done by train and the rest by car. The ratio of the speed of the train to that of the cars is:

(A) 2 : 3 (B) 3 : 2 (C) 3 : 4 (D) 4 : 3

61) Each of the questions given below consists of a question followed by three statements. You have to study the question and the statements and decide which of the statement(s) is/are necessary to answer the question. By selling an article what is the profit percent gained?

I. 5% discount is given on list price.

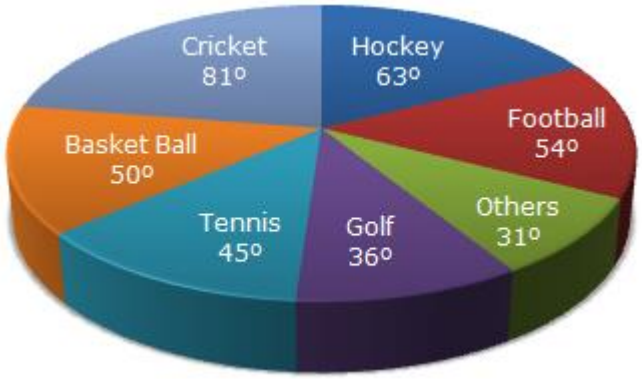
II. If discount is not given, 20% profit is gained.

III. The cost price of the articles is Rs. 5000.

(A) Only I and II (B) Only II and III

(C) Only I and III (D) All I, II and III

62) The circle-graph given here shows the spending of a country on various sports during a particular year. Study the graph carefully and answer the questions given below it.



How much percent more is spent on Hockey than that on Golf?

(A) 27% (B) 35% (C) 37.5% (D) 75%

3) If $x = 3 + 2\sqrt{2}$, then the value of $\left(\sqrt{x} - \frac{1}{\sqrt{x}}\right)$ is:

(A) 1 (B) 2 (C) $2\sqrt{2}$ (D) $3\sqrt{3}$

64) The cost of Type 1 rice is Rs. 15 per kg and Type 2 rice is Rs. 20 per kg. If both Type 1 and Type 2 are mixed in the ratio of 2 : 3, then the price per kg of the mixed variety of rice is:

(A) Rs. 18 (B) Rs. 18.50 (C) Rs. 19 (D) Rs. 19.50

65) To fill a tank, 25 buckets of water is required. How many buckets of water will be required to fill the same tank if the capacity of the bucket is reduced to two-fifth of its present?

(A) 10 (B) 35 (C) 62.5 (D) Can't say