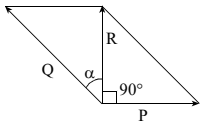
Section – I

1.(b)



$\tan\alpha = \frac{P}{R} = 1 = \tan 45°$

$\alpha = 45°$

$\theta = 90° + \alpha = 90° + 45° = 135°$

$= 135 \times \frac{\pi}{180}$

$= \frac{3\pi}{4}$

2.(c) If force is perpendicular to velocity then path is circular and speed remain constant.

i.e. KE constant.

3.(a) When floating

ωt = upthrust, volume of water

formed by melting ice = volume of water displaced

4.(a) $\Delta V = V_0\gamma\Delta\theta$ = constant

V_0 = dimension

γ = material

$\Delta\theta$ = change in temperature

5.(c) Change in internal energy depends only on initial and final state and independent of path.

6.(b) Standing wave eq^n is

$y = 2a \sin kx \cos\omega t$

Where $kx = \frac{\pi x}{3}$

or, $\frac{2\pi x}{\lambda} = \frac{\pi x}{3}$

or, $\lambda = 6$ cm

Distance between nodes $= \frac{\lambda}{2} = \frac{6}{2} = 3$ cm

7.(a) $\frac{8}{\lambda_g} = \frac{10}{\lambda_w}$

or, $\frac{10}{8} = \frac{\lambda_w}{\lambda_g} = {}_w\mu_g = \frac{{}_a\mu_g}{{}_a\mu_w}$

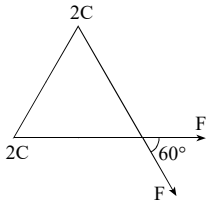
$\therefore \quad {}_a\mu_g = \frac{5}{4} \times \frac{4}{3} = \frac{5}{3}$

8.(b) $\frac{\delta_{\text{min in water}}}{\delta_{\text{min in air}}} = \frac{({}_w\mu_{g-1})\,A}{(\mu_{g-1})\,A} = \frac{\left(\frac{{}_a\mu_g}{{}_a\mu_w} - 1\right)}{{}_a\mu_{g-1}}$

$= \frac{\left(\frac{1.5}{4} \times 3 - 1\right)}{1.5 - 1}$

$= \frac{0.5}{4 \times 0.5} = \frac{1}{4}$

9.(d)



$F_R = \sqrt{F^2 + 2F^2\cos 60° + F^2} = \sqrt{3}F$

10.(a) Potential gradient $= \frac{V}{l} = \frac{i\rho l}{Al} = \frac{i\rho}{A}$

11.(b) $F = \frac{\mu_0 I_1 I_2}{2\pi b} = \frac{\mu_0 i^2}{2\pi b}$

12.(b) $T = 2\pi\sqrt{\frac{I}{M_H}}$

If $I = \left(\frac{l^2 + b^2}{12}\right)$ m

If mass is made four times

$I' = \left(\frac{l^2 + b^2}{12}\right) 4m = 4I$

$T' = 2\pi\sqrt{\frac{I'}{MH}} = 2T$

13.(d) $\frac{\lambda_1}{\lambda_2} = \frac{\frac{h}{P_1}}{\frac{h}{P_2}} = \frac{P_2}{P_1}$

During explosion $P_1 = P_2$ So, $\frac{\lambda_1}{\lambda_2} = 1{:}1$

14.(b) $I_c = 90\%$ of I_e

$I_c = \frac{10 \times 10}{9} = 11$ mA

15.(b) **Hint:** Find the number of moles (mass ÷ molar mass of $N_2 = 28$), then multiply by Avogadro's number.
Solution: Moles of $N_2 = 2.8/28 = 0.1$ mol.
Molecules $= 0.1 \times 6.022 \times 10^{23} = 6.022 \times 10^{22}$.

16.(c) **Hint:** Isotopes = same atomic number; isobars = same mass number. Identify the term for the same neutron number.
Solution: Atoms with the same number of neutrons (but different mass numbers) are called isotones, e.g. ^{30}Si, ^{31}P, ^{32}S all have 16 neutrons.

17.(c) An element with electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ belongs to the:
Hint: The last/differentiating electron enters the 3d subshell. The block is named after the subshell receiving the differentiating electron.
Solution: This is chromium (Z = 24): [Ar]$3d^5 4s^1$. The differentiating electron is in the 3d subshell, so it is a d-block element.

18.(a) **Hint:** Draw H − C ≡ C − H. Every single bond is one σ bond; a triple bond = 1 σ + 2 π.
Solution: H − C ≡ C−H: σ bonds = 2 (C−H) + 1 (C−C) = 3; π bonds = 2 (in the triple bond).
So 3 σ and 2 π.

19.(b) **Hint:** Compare the 2p sub-shell stability of N and O. Exactly half-filled subshells have extra stability.
Solution: Nitrogen ($2p^3$) has a stable, exactly half-filled p-subshell, so extra energy is needed to remove an electron. Hence its first ionization energy exceeds that of oxygen ($2p^4$).

20.(b) **Hint:** Take K as +1 and O as −2. Solve for the oxidation number of each Cr atom.
Solution: $2(+1) + 2(x) + 7(-2) = 0$
$2 + 2x - 14 = 0 \Rightarrow 2x = 12 \Rightarrow x = +6$.

21.(b) **Hint:** Charles's law relates volume to temperature at constant pressure. Recall whether they increase or decrease together.
Solution: Charles's law: at constant pressure, $V \propto T$ (absolute temperature). Volume increases with increasing temperature.

22.(b) **Hint:** By Le Chatelier's principle, increasing pressure favours the side with fewer moles of gas. Count moles on each side.
Solution: Left side has 2 moles of gas, right side has 1 mole. Increasing pressure shifts equilibrium towards fewer moles, i.e. towards N_2O_4 (to the right).

23.(c) **Hint:** Oxalate ($C_2O_4^{2-}$) is a bidentate ligand — each oxalate occupies two coordination sites.
Solution: Oxalate is bidentate, so 3 oxalate ligands occupy $3 \times 2 = 6$ sites.
Coordination number = 6.

24.(b) **Hint:** Think about how partially filled d-orbitals allow more than one stable oxidation state and how reactant molecules can be adsorbed on the metal surface.
Solution: Transition metals show variable oxidation states (allowing them to form intermediates) and provide a large surface for adsorption of reactants, which makes them effective catalysts.

25.(a) **Hint:** SN^2 proceeds through a crowded transition state, so it is fastest for the least hindered (most accessible) carbon. The reactivity order is methyl > 1° > 2° > 3°.
Solution: SN^2 reactivity decreases with steric hindrance: methyl > primary > secondary > tertiary.
CH_3Cl (methyl halide) is the least hindered and reacts fastest.

26.(b) **Hint:** Compare the stability of the conjugate bases. Resonance stabilisation of the negative charge increases acidity.
Solution: Phenol (pKa ≈ 10) is the most acidic because the phenoxide ion is resonance-stabilised over the aromatic ring, unlike alcohols and water (pKa ≈ 15–16).

27.(a) **Hint:** Aldehydes are easily oxidised but ketones are not. Look for a mild oxidising reagent that gives a visible change with aldehydes only.
Solution: Tollens' reagent gives a silver mirror with aldehydes (which are oxidised to acids) but not with ketones, so it distinguishes the two.

28.(b) **Hint:** Consider the structure in which every carbon is tetrahedrally bonded to four others in a rigid three-dimensional network.
Solution: Diamond has a rigid three-dimensional network of sp^3 carbon atoms, making it the hardest natural substance.

29.(b) Given $a < b$ or $\frac{1}{a} > \frac{1}{b}$ i.e. $\frac{1}{a} - \frac{1}{b} > 0$

30.(c) Given n(U) = 120, n(A) = 60, n(B) = 80
Here n(A) + n(B) = 60 + 80 = 140 > 120 = n(U)
So, max. possible value of $n(A \cup B) = n(U) = 120$

31.(d) Since identity matrix is inverse of itself, so inverse of I = I.

32.(a) If A is idempotent matrix then $A^2 = A$.
So $|A|^2 = |A|$ or $|A|(|A| - 1) = 0 \quad \therefore \ |A| = 0$ or 1

33.(b) Given system is $kx + 3y = 0$, $x + 2y = 0$
For no solution, $\begin{vmatrix} k & 3 \\ 1 & 2 \end{vmatrix} = 0$
$\Rightarrow 2k - 3 = 0 \quad \Rightarrow k = \frac{3}{2}$

34.(a) By joining these points, right angle is formed at (0, 0)
$\therefore$ Orthocentre = (0, 0)

35.(c) Given equation is $x^2 + y^2 + kx + 6y + 13 = 0$
Comparing it with $x^2 + y^2 + 2gx + 2fy + c = 0$, we get $g = \frac{k}{2}$, f = 3, c = 13.
For point circle, $g^2 + f^2 - c = 0$
or, $\frac{k^2}{4} + 9 - 13 = 0$
or, $k^2 = 16 \qquad \therefore \ k = \pm 4$

36.(b) Given parabola is $y^2 = -8x$. So, a = –2
$\therefore$ Focal distance = $|x + a| = |-2 - 2| = |-4| = 4$ units

37.(a) Given parabola is $y^2 = 16x$.
So, a = 4. And the line is
$y = 2x + k$. So line touches the parabola if $c = \frac{a}{m}$
i.e. $k = \frac{4}{2} = 2$

38.(c) Given conic sections are $xy = c^2$, $x^2 - y^2 = a^2$ which are rectangular hyperbola.
So $e = \sqrt{2}$, $e' = \sqrt{2}$.
Then $ee' = \sqrt{2}.\sqrt{2} = 2$

39.(b) As $\frac{1}{2}, \frac{1}{3}$, K are direction cosines.
So $\left(\frac{1}{2}\right)^2 + \left(\frac{1}{3}\right)^2 + K^2 = 1$
i.e., $K^2 = 1 - \frac{1}{4} - \frac{1}{9} = \frac{23}{36}$

40.(a) Eq^n of plane cutting equal intercepts is $x + y + z = a$.
If it passes through the point (2, 3, 4) then
$2 + 3 + 4 = a$ i.e. a = 9.
So the equation of the plane is $x + y + z = 9$

41.(d) $2\sin^{-1}x + 2\cos^{-1}x + \cos^{-1}x = \frac{3\pi}{2}$

or, $2(\sin^{-1}x + \cos^{-1}x) + \cos^{-1}x = \frac{3\pi}{2}$

or, $2 \times \frac{\pi}{2} + \cos^{-1}x = \frac{3\pi}{2}$

or, $\cos^{-1}x = \frac{\pi}{2}$ $\therefore$ $x = \cos\frac{\pi}{2} = 0$

42.(c) As the vectors $\vec{i} + \vec{j} - 4\vec{k}$ and $-3\vec{i} - \lambda\vec{k} + 12\vec{k}$ are collinear. So $-\frac{1}{3} = -\frac{1}{\lambda} = -\frac{4}{12}$ $\therefore$ $\lambda = 3$

43.(d) When a coin is tossed 3 times then the sample space is {HHH, HHT, HTH, HTT, THH, THT, TTH, TTT}

So probability of at least one head $= \frac{7}{8}$

44.(c) Given equation is $3x + 5y = 15$

or, $5y = 15 - 3x$

i.e. $y = -\frac{3}{5}x + 3$

$\therefore$ $b_{yx} = -\frac{3}{5}$

45.(a) $\lim_{x \to \infty} x \sin\frac{1}{x}$ ....

Put $y = \frac{1}{x}$

Then $y \to 0$ as $x \to \infty$

So, we have $\lim_{y \to 0} \frac{\sin y}{y} = 1$

46.(c) Since the function is continuous so

$\lim_{x \to 1^-} f(x) = \lim_{x \to 1^+} f(x)$

or, $\lim_{x \to 1^-} (3x + 1) = \lim_{x \to 1^+} (kx - 2)$

or, $3 \times 1 + 1 = k \times 1 - 2$

$\therefore$ $k = 6$

47.(d) Given $f(x) = x^2 - 2x + 5$

So $f'(x) = 2x - 2$ $\therefore$ $f(1) = 2 \times 1 - 2 = 0$

48.(a) Given, $y = ke^x$

On differentiation, $\frac{dy}{dx} = ke^x$

i.e. $\frac{dy}{dx} = y$ $\therefore$ $\frac{dy}{dx} - y = 0$

49.(d) 50.(a) 51.(a) 52.(b) 53.(c) 54.(d)
55.(b) 56.(a) 57.(c) 58.(d) 59.(b) 60.(a)

Section – II

61.(a) $t = \sqrt{x} + 3$

or, $\sqrt{x} = t - 3$

or, $\frac{d(x^{1/2})}{dx}\frac{dx}{dt} = 1$

or, $x^{1/2-1}\, v = 1$

or, $\frac{v}{\sqrt{x}} = 1$

or, $v = \sqrt{x}$

If $v = 0$, $x = 0$

62.(a) For constant velocity $mg\sin\theta = \mu mg\cos\theta$

or, $\mu = \tan\theta$

While moving up

$0 = u^2 - 2g(\sin\theta + \mu\cos\theta)\, S'$

$S' = \frac{u^2}{2g(\sin\theta + \tan\theta\cos\theta)} = \frac{u^2}{4g\sin\theta}$

63.(a) Loss in wt = upthroust

or, $120 - 80 = V\sigma g$

or, $V = \frac{40}{1000 \times 10} = 4 \times 10^{-3}\ m^3$

$\therefore$ $\rho = \frac{m}{V} = \frac{120}{10 \times 4 \times 10^{-3}}$

$= 3 \times 10^3\ kg/m^3 = 3\ g/cc$

$\therefore$ Specific gravity = 3

64.(c) $\alpha_{mean} = \frac{(\Delta l)_{1st} + (\Delta l)_{2nd}}{(l_1 + l_2)\,\Delta\theta}$

$= \frac{50 \times 12 \times 10^{-6} + 100 \times 24 \times 10^{-6}}{50 + 100}$

$= \frac{3000}{150} \times 10^{-6} = 20 \times 10^{-6}/°C$

65.(b) $P_1V_2\gamma = P_1V_1\gamma$

$P_2 = 150\left(\frac{1600}{400}\right)^{1.5}$

$= 1200$ KPa

$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$

$= \frac{150 \times 10^3 \times 1600 \times 10^{-6} - 1200 \times 10^3 \times 400 \times 10^{-6}}{1.5 - 1}$

$= \frac{240 - 480}{0.5} = -480\ J$

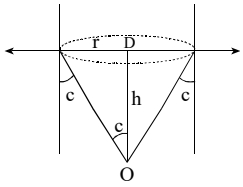
66.(d) Partical vel = $a\omega = y_0 \times 2\pi f$

Wave vel. = $f\lambda$

$\therefore$ $y_0 \times 2\pi f = 2 \times f\lambda$

or, $\lambda = \pi y_0$

67.(a)



$\tan c = \frac{r}{h}$

or, $r = h\frac{\sin c}{\cos c} = \frac{h}{\mu} \times \frac{1}{\sqrt{1 - \frac{1}{\mu^2}}}$

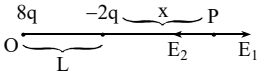
$= \frac{h}{\sqrt{\mu^2 - 1}} = \frac{12}{\sqrt{\left(\frac{4}{3}\right)^2 - 1}} = \frac{36}{\sqrt{7}} = 13.6$ cm

68.(b) Distance of 3rd minima is

$= 2.5\beta$

$= \frac{2.5 \times 2 \times 5000 \times 10^{-10}}{0.2 \times 10^{-3}} = 1.25$ cm

69.(b)



$E_1 = E_2$

or, $9 \times 10^9 \frac{Q_1}{(L+x)^2} = 9 \times 10^9 \frac{Q_2}{x^2}$

or, $\frac{8q}{(L+x)^2} = \frac{2q}{x^2}$

or, $2x = L + x$

$x = L$

∴ Distance = L + L = 2L

70.(c) $r = R\left(\frac{l_1}{l_2} - 1\right)$

$= 2\left(\frac{240}{120} - 1\right) = 2\Omega$

71.(c) $V - L\frac{dI}{dt} = IR$

or, $5 - 2\frac{dI}{dt} = 0.2 \times 10$

or, $\frac{dI}{dt} = \frac{5-2}{2} = 1.5$ A/s

72.(a) **First case**

$hf = \phi + \frac{eV_0}{2}$

or, $eV_0 = 2(hf - \phi)$ ... (i)

2nd case

$\frac{hf}{2} = \phi + eV_0$

or, $eV_0 = \left(\frac{hf}{2} - \phi\right)$ ... (ii)

From (i) & (ii)

$2(hf - \phi) = \frac{hf}{2} - \phi$

or, $2hf - 2\phi = \frac{hf}{2} - \phi$

or, $\phi = \frac{3}{2}hf$

or, $hf_0 = \frac{3}{2}hf$

or, $f_0 = \frac{3}{2}f$

73.(d) $\frac{N_A}{N_B} = \frac{N_0 e^{-10\lambda t}}{N_0 e^{-\lambda t}}$

or, $\frac{1}{e} = \left(\frac{1}{e}\right)^{9\lambda t}$

or, $9\lambda t = 1$

or, $t = \frac{1}{9\lambda}$

74.(b) **Hint:** Molarity = moles of solute ÷ volume of solution in litres. Find moles using molar mass of NaCl = 58.5.

Solution: Moles of NaCl = 5.85/58.5 = 0.1 mol.

Volume = 500 mL = 0.5 L.

Molarity = 0.1/0.5 = 0.2 M.

75.(b) **Hint:** $[H^+]$ = concentration × degree of ionisation. Then pH = −log$[H^+]$.

Solution: $[H^+] = 0.01 \times 0.05 = 5 \times 10^{-4}$ M.

$pH = -\log(5 \times 10^{-4}) = 4 - \log 5 = 4 - 0.70 = 3.30$.

76.(c) **Hint:** Rate has units mol L^{-1} s^{-1}. For a second-order reaction, rate = $k[A]^2$. Rearrange for k and work out the units.

Solution: Rate = $k[A]^2 \Rightarrow k$ = rate/$[A]^2$ = (mol L^{-1} s^{-1})/(mol $L^{-1})^2$ = L mol^{-1} s^{-1}.

77.(a) **Hint:** ΔH = (energy to break bonds in reactants) − (energy released in forming product bonds). Remember to take half a mole of each reactant bond.

Solution: $\Delta Hf = \frac{1}{2}$ BE of H_2) + $\frac{1}{2}$ BE of Cl_2) − BE(HCl)

$= \frac{1}{2}(436) + ½(242) - 431$

$= 218 + 121 - 431 = -92$ kJ/mol.

78.(b) **Hint:** Use $\Delta G° = -nFE°cell$. Be careful with the sign and convert the answer to kJ.

Solution: $\Delta G° = -nFE°cell = -(2)(96500)(0.46)$

$= -88780$ J ≈ -88.8 kJ.

79.(c) **Hint:** Each Cr goes from +6 to +3 (a change of 3 electrons). There are 2 Cr atoms in the dichromate ion.

Solution: $Cr_2O_7^{2-} \rightarrow 2Cr^{3+}$. Each Cr: +6 → +3 (gain of 3 e^-).

Total electrons = 2 × 3 = 6 per mole of $Cr_2O_7^{2-}$.

80.(c) **Hint:** Use $E_n = E_1/n^2$ for the hydrogen atom, with $E_1 = -13.6$ eV.

Solution: $E_n = E_1/n^2 = -13.6/2^2 = -13.6/4 = -3.4$ eV.

81.(b) **Hint:** Draw 2-methylbutane and identify the sets of chemically equivalent (non-equivalent) hydrogen atoms. Each distinct type of H gives one constitutional product.

Solution: 2-Methylbutane is $CH_3–CH(CH_3)–CH_2–CH_3$. It has 4 distinct types of hydrogen:

1. The two equivalent CH_3 on C-2 → 1-chloro-2-methylbutane
2. The tertiary C-2 H → 2-chloro-2-methylbutane
3. The CH_2 (C-3) → 2-chloro-3-methylbutane
4. The terminal CH_3 (C-4) → 1-chloro-3-methylbutane

Total = 4 monochloro structural isomers.

82.(d) Given, $\log_{x-3} 81 = 4$

or, $81 = (x-3)^4$

or, $3^4 = (x-3)^4$

83.(d) Given $y = \frac{1}{x} + \frac{1}{x^2} + \frac{1}{x^3} + \ldots = \frac{\frac{1}{x}}{1 - \frac{1}{x}} = \frac{1}{x-1}$

or, $x - 1 = \frac{1}{y}$ i.e. $x = 1 + \frac{1}{y}$

∴ $x = \frac{y+1}{y}$

84.(c) $\frac{a+b\omega+c\omega^2}{a\omega+b\omega^2+c}=\frac{a+b\omega+c\omega^2}{a\omega+b\omega^2+c\omega^3}=\frac{(a+b\omega+c\omega^2)}{\omega(a+b\omega+c\omega^2)}$

$=\frac{1}{\omega}=\frac{\omega^3}{\omega}=\omega^2$

85.(b) AM of roots = A i.e. Sum of roots = 2A

GM of roots = G i.e. Product of roots = G^2

$\therefore$ Quadratic equation is $x^2-2Ax+G^2=0$

86.(c) Given C(20, r + 1) = C(20, 3r – 1)

So $3r-1=r+1 \Rightarrow r=1$

or, $r+1+3r-1=20 \Rightarrow r=5$

87.(a) Here, $t_5=C(p,4)(2x^2)^{p-4}\left(\frac{3}{x}\right)^4=C(p,4)\,2^{p-4}3^4x^{2p-12}$

For independent of x, $2p-12=0 \Rightarrow p=6$

88.(b) Given equation is $4x^2-2hxy+9y^2=0$

For coincident line, $(-h)^2-4\times9=0$

or, $h^2=36 \quad \therefore h=\pm6$

89.(d) Given, $\frac{2b^2}{a}=\frac{1}{2}\times2a \Rightarrow a^2=2b^2$

So, $e=\sqrt{1-\frac{b^2}{a^2}}=\sqrt{1-\frac{1}{2}}=\frac{1}{\sqrt{2}}$

90.(a) Here, $\vec{a}=\vec{i}+2\vec{j}+2\vec{k} \quad \vec{b}=3\vec{i}-2\vec{j}+6\vec{k}$

So, $|\vec{a}|=3, |\vec{b}|=7$

Now, $\frac{\text{Projection of } \vec{a} \text{ on } \vec{b}}{\text{Projection of } \vec{b} \text{ on } \vec{a}}=\frac{|\vec{a}|}{|\vec{b}|}=\frac{3}{7}$

91.(d) Given acosA = bcosB

or, 2RsinAcosA = 2RsinBcosB

or, $\sin2A=\sin2B \Rightarrow 2A=2B \Rightarrow A=B$

92.(d) Given $y=\coth^{-1}\sin2x$

$\therefore \frac{dy}{dx}=\frac{d\coth^{-1}}{d\sin2x}(\sin2x)\frac{d}{dx}\sin2x$

$=\frac{1}{\sin^2 2x-1}\cos2x.2$

$=\frac{2\cos2x}{1-\sin^2 2x}=\frac{2\cos2x}{\cos^2 2x}$

$=2\sec2x$

93.(c) Given $y=ax^2-12x+20$

So, $\frac{dy}{dx}=2ax-12$

At x = 2, we have local minimum value

So $2a\times2-12=0 \Rightarrow a=3$

94.(b) $I=\int\frac{dx}{1+e^{-x}}=\int\frac{e^{-x}\,dx}{1+e^{-x}}$

Put $y=1+e^{-x} \quad \therefore -dy=e^{-x}dx$

Then $I=-\int\frac{dy}{y}=-\log_e y+c=-\log_e(1+e^{-x})+c$

95.(b) Put $y=x^2$ and $\frac{1}{(y+4)}(y+9)=\frac{A}{y+4}+\frac{B}{y+9}$

i.e. $1=A(y+9)+B(y+4)$

Then $A=\frac{1}{5}, B=-\frac{1}{5}$

So, $\int\frac{dx}{(x^2+4)(x^2+9)}=\frac{1}{5}\int\frac{dx}{x^2+2^2}-\frac{1}{5}$

$\int\frac{dx}{x^2+3^2}=\frac{1}{10}\tan^{-1}\frac{x}{2}-\frac{1}{15}\tan^{-1}\frac{x}{3}+c \Rightarrow A=\frac{1}{10}$

96.(a) Given curves are $y^2=4x, y=x$

On solving $x^2=4x$ i.e., x = 0, 4

$\therefore$ Required area $=\int_0^4(y_1-y_2)\,dx$

$=\int_0^4(2\sqrt{x}-x)\,dx$

$=\left[2.\frac{x^{3/2}}{\frac{3}{2}}-\frac{x^2}{2}\right]_0^4=\frac{4}{3}4^{3/2}-\frac{4^2}{2}$

$=\frac{32}{3}-8=\frac{32-24}{3}=\frac{8}{3}$ sq. units

97.(c) 98.(c) 99.(b) 100.(b)

...Best of Luck...