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**Section A**

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## Section A (continued)

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**Section B : Long Answer Questions**
**Ans 61.**

Any three points in the space fixes a plane. Note that ABC and ADC are two right-angled triangles (but possibly in different planes). Fixing the plane of ABC, the locus of D is a circle with AC as axis. If X is the point on this circle closest to B then it lies in the plane of ABC and ABXC is an isosceles trapezium. One can calculate BX using Pythagoras theorem to get  $BX = 4.6$ . For any other point Y on the circle, triangle BXY is right-angled at X, and hence BY is maximum when XY is maximum (which happens when Y is diametrically opposite to X). Again by Pythagoras theorem we get  $BY = 10$ . Thus the maximum and minimum possible distances between B and D are 10 and 2.8 light years, respectively.

**Ans 62.**

- i. X:  $I^A I^O$ , Y:  $I^B I^B$  or  $I^B I^O$ , P:  $I^B I^O$ , R:  $I^B I^O$ , Q:  $I^A I^B$   
 ii. Phenotypes of offsprings: either O or A blood group  
 Genotypes:  $I^O I^O$  or  $I^O I^A$   
 iii.

Blood group phenotype	Genotype	Antigen on the surface of RBC	Serum antibody
O	$I^O I^O$	Nil	Anti-A and Anti-B
A	$I^A I^A$ or $I^O I^A$	A antigen	Anti-B
B	$I^B I^B$ or $I^O I^B$	B antigen	Anti-A
AB	$I^A I^B$	A and B antigen	Nil

- iv. c) O -ve and AB +ve

**Ans 63.**

- i. Nitrogen fixation, Ammonification, Nitrification, Denitrification  
 ii. a) - True  
 b) - False  
 c) - False  
 d) - False  
 e) - True  
 f) - True  
 iii. a) No Fixation of nitrogen in leguminous plants of the field.  
 iv. a) Ammonium ions

**Ans 64.**

- i.  $2\text{MnO}_2 + \text{As}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow 2\text{Mn}^{2+} + 2\text{AsO}_4^{3-} + 2\text{H}^+$
- ii. i)  $0.0750 \text{ L} \times 0.0125 \text{ mol/L} = 9.38 \times 10^{-4} \text{ mol As}_2\text{O}_3$
- ii)  $0.01600 \text{ L} \times 2.25 \times 10^{-3} \text{ mol/L} = 3.6 \times 10^{-5} \text{ mol MnO}_4^-$   
 $3.6 \times 10^{-5} \text{ mol MnO}_4^- \times (5 \text{ mol As}_2\text{O}_3 / 4 \text{ mol MnO}_4^-)$   
 $= 4.5 \times 10^{-5} \text{ mol As}_2\text{O}_3 \text{ left}$
- iii)  $9.38 \times 10^{-4} - 4.5 \times 10^{-5} = 8.93 \times 10^{-4} \text{ mol As}_2\text{O}_3 \text{ react with}$   
 $8.93 \times 10^{-4} \text{ mol As}_2\text{O}_3 \times (2 \text{ mol MnO}_2 / 1 \text{ mol As}_2\text{O}_3)$   
 $= 1.8 \times 10^{-5} \text{ mol MnO}_2$
- iii.  $1.8 \times 10^{-5} \text{ mol MnO}_2 \times (87 \text{ g MnO}_2 / \text{mol MnO}_2) = 0.156 \text{ g MnO}_2$   
 mass % of  $\text{MnO}_2 = (0.156 \text{ g MnO}_2 / 0.255 \text{ g sample}) \times 100 = 62 \% \text{ MnO}_2$  in sample.
- iv. The endpoint corresponds to a slight purple (pink) color due to excess  $\text{MnO}_4^-$  (aq).

**Ans 65.**

The average velocity in the first 20 seconds is 2 units/sec. The same during the next 20 seconds is 1 unit/sec and during the last 20 seconds is 1.5 unit/sec. Let  $M_1$  denote the maximum velocity during the first 20 seconds and  $M_2$  denote the same during the last 20 seconds. Let  $m$  denote the minimum velocity during the middle 20 seconds. Then  $M_1$  is at least 2,  $M_2$  is at least 1.5 while  $m$  is at most 1. So at some point of time the acceleration must have been negative and at some other point of time positive. Somewhere between these two points, the acceleration must have been zero.

**Ans 66 a.**

$10 \times 20 \times 30$  has a base of  $10 \times 20$  with marbles of  $r = 2 \text{ cm}$

i.e. there are 10 in a line with 5 lines of marbles

i.e. 50 marbles on the lowest layer with 30 cm height impels 18 layer

i.e. 750 marbles 48% empty space = 48% of total volume should be available for water.

**Ans 66 b.**

We have considered the smaller mass  $m$  to be consisting of 2 smaller masses as shown in the figure. We have labled the smaller masses as  $m_1$  and  $m_2$ . Each will be having a mass of  $m/2$ . The distance between the two smaller masses will just be  $r$  itself. Note that  $r \ll R$ .

The force due to mass  $M$  on  $m_1$  will be given by

$$F_1 = G \frac{M \frac{m}{2}}{\left(R - \frac{r}{2}\right)^2} \quad (1)$$

The force due to mass  $M$  on  $m_2$  will be given by:

$$F_2 = G \frac{M \frac{m}{2}}{\left(R + \frac{r}{2}\right)^2} \quad (2)$$

The mutual force between the 2 smaller halves will be given by

$$F_m = G \frac{\left(\frac{m}{2}\right)\left(\frac{m}{2}\right)}{r^2} \quad (3)$$

The condition for the comet to break up will be when the difference of the forces on the two smaller masses will be greater than the mutual force of attraction between the two small masses.

$$F_1 - F_2 > F_m \quad (4)$$

$$G \frac{M \frac{m}{2}}{\left(R - \frac{r}{2}\right)^2} - G \frac{M \frac{m}{2}}{\left(R + \frac{r}{2}\right)^2} > G \frac{\left(\frac{m}{2}\right)\left(\frac{m}{2}\right)}{r^2} \quad (5)$$

Rearranging the above equation will give

$$\frac{m}{2M} < r^2 \left( \frac{\left(R + \frac{r}{2}\right)^2 - \left(R - \frac{r}{2}\right)^2}{\left(R + \frac{r}{2}\right)^2 \left(R - \frac{r}{2}\right)^2} \right) \quad (6)$$

$$\frac{m}{2M} < r^2 \left( \frac{2Rr}{R^4} \right) \quad (7)$$

Here we have used  $r \ll R$ , in saying that  $\left(R + \frac{r}{2}\right)^2 \left(R - \frac{r}{2}\right)^2 \approx R^4$

This will give

$$\frac{m}{r^3} < \frac{4M}{R^3} \quad (8)$$

$$\rho < \frac{3M}{\pi R^3} \quad (9)$$

**Ans 67.**

- i.  $2\text{NaN}_3 : 0.2\text{KNO}_3$   
 $2 \times 65 : 0.2 \times 101$   
 $130 : 20.2$   
 $3.22 : 1$  (mass by ratio)
- ii.  $\text{K}_2\text{O} + \text{Na}_2\text{O} + \text{SiO}_2 \rightarrow \text{Na}_2\text{K}_2\text{SiO}_4$  (alkaline silicate glass)
- iii. 1 mole of  $\text{N}_2$  occupy  $24.0\text{ dm}^3$  of volume  
 There for  $72\text{ dm}^3$  corresponds to 2.7 mole of  $\text{N}_2$   
 $2.7\text{ mole of N}_2 (2\text{ mole of NaN}_3 / 3\text{ mole of N}_2) = 1.8\text{ mole of NaN}_3$   
 $1.8\text{ mole of NaN}_3 (65\text{ gm of NaN}_3 / 1\text{ mole of NaN}_3) = 117\text{ gm of NaN}_3$   
 $117\text{ gm of NaN}_3 \times 20.2\text{ gm of KNO}_3 / 130\text{ gm of NaN}_3 = 18.2\text{ gm of KNO}_3$   
 Total mass of the mixture of sodium azide and potassium nitrate = 135 gm
- iv.  $\Delta H_f$  for  $\text{NaN}_3 = 361.7\text{ KJ/mol}$   
 For  $2\text{NaN}_3(\text{s}) \rightarrow 2\text{Na}(\text{s}) + 3\text{N}_2(\text{g})$   
 $\Delta H_r = -2 \times 361.7\text{ KJ/mol} = -723.4\text{ KJ/mol}$

**Ans 68.**

- i.  $(Q/t) = m s (\theta_1 - \theta_0) = 2 m s (\theta'_1 - \theta_0) \quad \theta_1 = 40^\circ\text{C}$   
 $(40 - 30) = 2 \times (35 - 30)$
- ii.  $(Q/t) = m s (\theta_1 - \theta_0) \Rightarrow 3000 = m \times 4200 (40 - 30) \Rightarrow m = 1/14\text{ lit/s}$
- iii.  $(1/14) \times 3.5 \times 60 = 15\text{ lit.}$
- iv.  $Q/t = m s (\theta_2 - \theta_0) \Rightarrow 3000 = (1/14) \times 4200 (\theta_2 - 25) \Rightarrow \theta_2 = 35^\circ\text{C}$   
 The cold water tap should not be opened.
- v. On the second floor, the pressure is doubled (Assuming that heater is located at the top of bathroom). As a result, the rate of flow of water will be doubled. Doubling the rate of flow into the heater will cause the increase in temperature by half the amount as earlier. Thus in the winter, the hot water tap will give water at  $30^\circ\text{C}$  instead of  $35^\circ\text{C}$  (An increase of  $5^\circ\text{C}$  instead of  $10^\circ\text{C}$ ), making the final temperature of the water as  $30^\circ\text{C}$ , since the cold water tap is closed. In the summer, the hot water tap will give water at  $35^\circ\text{C}$  instead of  $40^\circ\text{C}$  (An increase of  $5^\circ\text{C}$  instead of  $10^\circ\text{C}$ ), and the cold water tap will still be at  $30^\circ\text{C}$ . Thus the net temperature would be at  $32.5^\circ\text{C}$ , since both will be open by the same amount.

