Section A

Q.No.	(a)	(b)	(c)	(d)	Q.No.	(a)	(b)	(c)	(d)
1	X				16				X
2			X		17	X			
3	X				18				X
4		X	X		19				X
5				X	20			X	
6			X		21				X
7			X		22	X			
8			X		23	X			
9	X				24				X
10		X			25			X	
11			X		26	X			
12			X		27				X
13			X		28		X		
14				X	29		X		
15			X		30				X

Section A (continued)

Q.No.	(a)	(b)	(c)	(d)	Q.No.	(a)	(b)	(c)	(d)
31		X			46	X			
32	X				47	X			
33			X		48		X		
34				X	49		X		
35		X			50		X		
36	X				51		X		
37				X	52			X	
38				X	53			X	
39		X			54				X
40		X			55		X		
41	X				56	X			
42	X				57				X
43			X		58	X			
44			X		59		X		
45	X				60		X		

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^AI^O, Y: I^BI^B or I^BI^O, P: I^BI^O, R: I^BI^O, Q: I^AI^B

ii. Phenotypes of offsprings: either O or A blood group
Genotypes: I^OI^O or I^OI^A

iii.

Blood group phenotype	Genotype	Antigen on the surface of RBC	Serum antibody
O	I^OI^O	Nil	Anti-A and Anti-B
A	I^AI^A or I^OI^A	A antigen	Anti-B
B	I^BI^B or I^OI^B	B antigen	Anti-A
AB	I^AI^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. $2MnO_2 + As_2O_3 + H_2O \rightarrow 2Mn^{2+} + 2AsO_4^{3-} + 2H^+$

ii. i) $0.0750\ L \times 0.0125\ mol/L = 9.38 \times 10^{-4}$ mol As_2O_3

ii) $0.01600\ L \times 2.25 \times 10^{-3}$ mol/L = 3.6×10^{-5} mol MnO_4
3.6×10^{-5} mol MnO_4^- × (5 mol As_2O_3/4 mol MnO_4^-)
= 4.5×10^{-5} mol As_2O_3 left

iii) $9.38 \times 10^{-4} - 4.5 \times 10^{-5} = 8.93 \times 10^{-4}$ mol As_2O_3 react with
8.93×10^{-4} mol As_2O_3 × (2 mol MnO_2/1 mol As_2O_3)
= $1.8 \text{ x } 10^{-5}$ mol MnO_2

iii. 1.8×10^{-5} mol MnO_2 × (87 g MnO_2/ mol MnO_2) = 0.156 g MnO_2
mass % of MnO_2 = (0.156 g MnO_2/ 0.255 g sample) × 100 = 62 % MnO_2 in sample.

iv. The endpoint corresponds to a slight purple (pink) color due to excess 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 x 20 x 30 has a base of 10 x 20 with marbles of r = 2 cm

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

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

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

(Initial H = 14.4 cm)

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<<R .

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

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

The force due to mass M on m2 will be given by:

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

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

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

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.

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

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

Rearranging the above equation will give

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

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

Here we have used r<< R, in saying that $(R + r/2)^2 (R - r/2)^2 \approx R^4$

This will give

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

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

Ans 67.

i. 2NaN3 : 0.2 KNO3
2 X 65 : 0.2 x101
130 : 20.2
3.22 : 1 (mass by ratio)

ii. $K_2O + Na_2O + SiO_2 \rightarrow Na_2K_2SiO_4$ (alkaline silicate glass)

iii.

$$2\,NaN_3\,(s) \longrightarrow 2Na\,(s) + 3N_2\,(g)$$

$$+\ \underline{10\,Na(s) + 2KNO_3(s) \longrightarrow K_2O\,(s) + 5Na_2O(s) + N_2(g)}$$

$$10NaN_3(s) + 2KNO_3\,(s) \longrightarrow K_2O\,(s) + 5Na_2O + 16N_2$$

24 dm^3 = 1 mole N_2

72 dm^3 = 3mole N_2

16 moles N_2 = 10 moles NaN_3

3Moles = (10 x 3)/ 16 = 15/8 moles of NaN_3

Mass of NaN_3 = (15/8) x 65 = 121.5

16 moles N_2 = 2 mole KNO_3

3moles of N_2 = (3 x 2) / 16 = 3/8mole

3/8 mole of KNO_3 = (3/8) x 101 = 303/8 = 37.9

Total mass of NaN3 + KNO3 = 121.5 + 37.9 = 159.4g

iv. ΔH_f for NaN_3 = 361.7 KJ/mol
For $2NaN_3\,(s) \rightarrow 2Na\,(s) + 3N_2\,(g)$
ΔHr = - 2 X 361.7 KJ/mol = -723.4 KJ/mol

Ans 68.

i. $(Q/t) = m\,s\,(\theta_1 - \theta_0) = 2\,m\,s\,(\theta'_1 - \theta_0)$ $\theta_1 = 40^0$ C
(40 – 30) = 2 x (35 – 30)

ii. $(Q/t) = m\,s\,(\theta_1 - \theta_0)$ => 3000 = m 4200 (40 – 30) => m = 1/14 kg/s (V = 1/14 lit/sec)

iii. (1/14) x 3.5 x 60 = 15 x 2 = 30 lit

∴ Water used = 15 hot + 15 lit cold = 30 lit

iv. $Q/t = m\,s\,(\theta_2 - \theta_0)$ => $3000 = (1/14)\,4200\,(\theta_2 - 25)$ => $\theta_2 = 35^0C$

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^o C instead of 35^o C (An increase of 5^o C instead of 10^o C), making the final temperature of the water as 30^oC, since the cold water tap is closed. In the summer, the hot water tap will give water at 35^o C instead of 40^o C (An increase of 5^o C instead of 10^o C), and the cold water tap will still be at 30^o C. Thus the net temperature would be at 32.5^o C, since both will be open by the same amount.