Solution

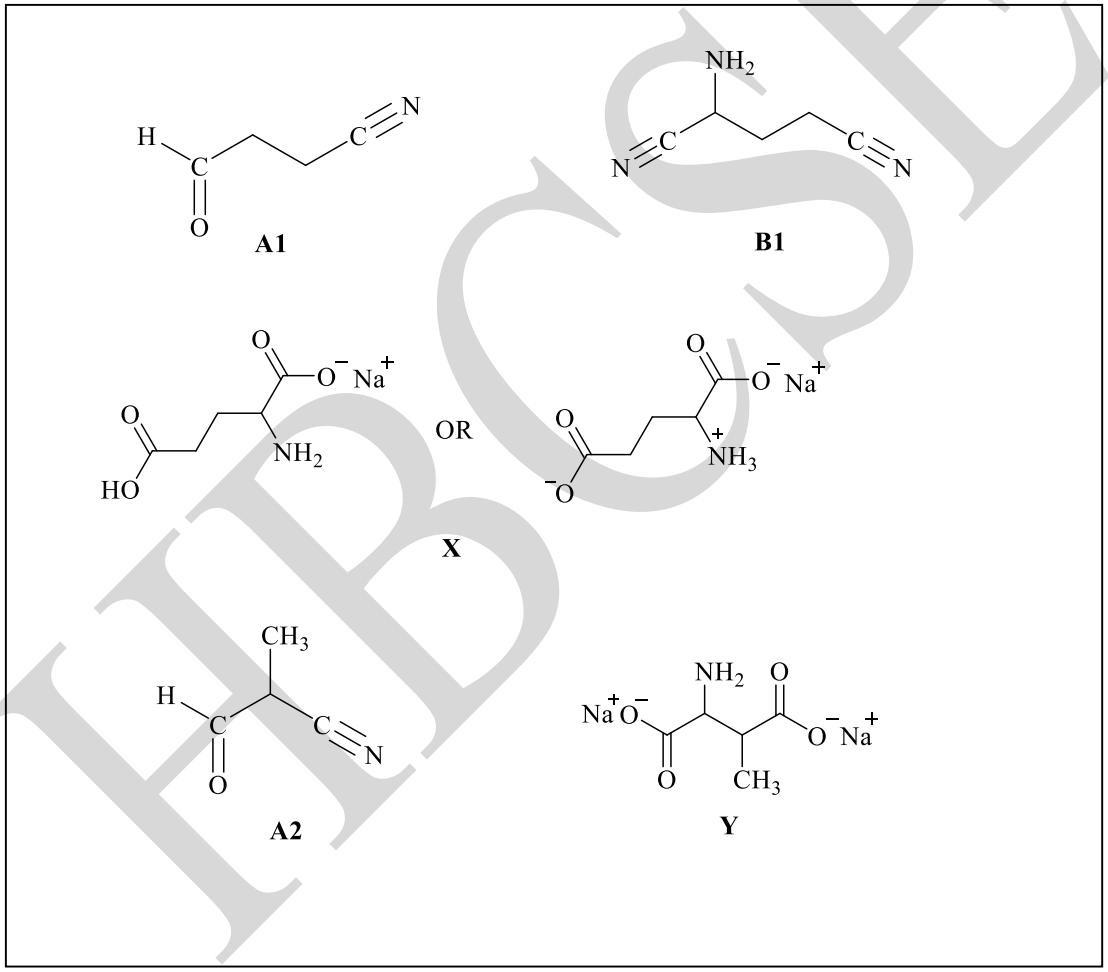
Any alternative method of solution to any question that is scientifically and mathematically correct, and leads to the same answer will be accepted with full credit. Partially correct answers will gain partial credit.

For questions requiring calculations, full credit is given only if necessary steps of the calculations are written. In problems having related sub-parts, consistency of answers of the related sub-parts is also checked in evaluation.

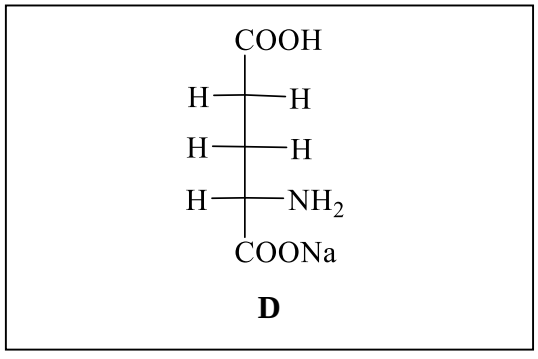
Problem 1 — 15 marks

The Fifth Taste

1.1



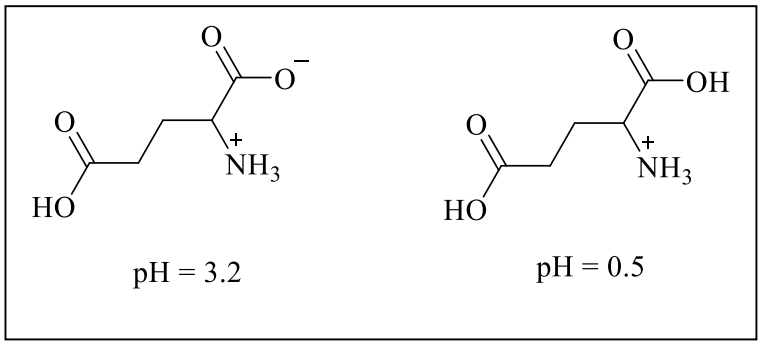
1.2



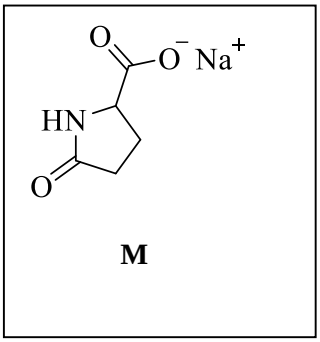
1.3

2-methyl-3-oxopropanenitrile

1.4



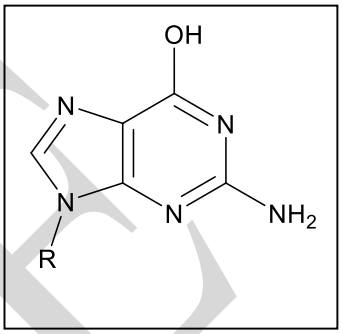
1.5



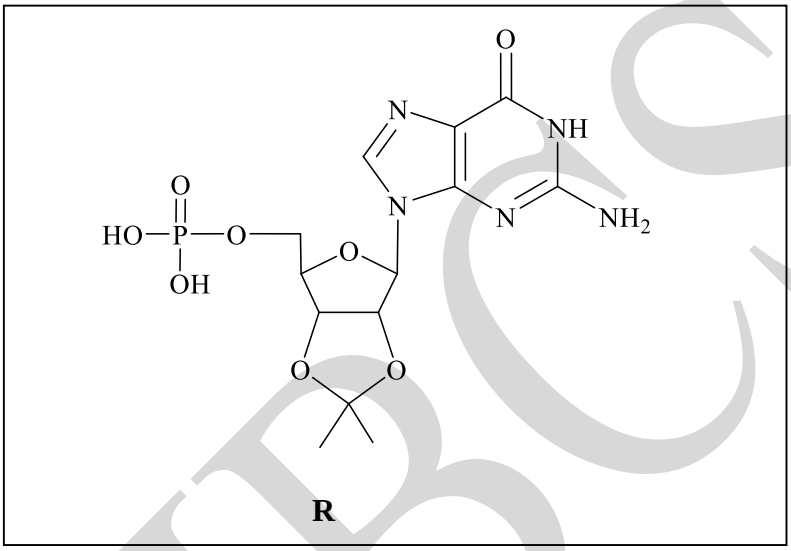
1.6 Nucleotides [X]

(Glycosides also accepted in addition)

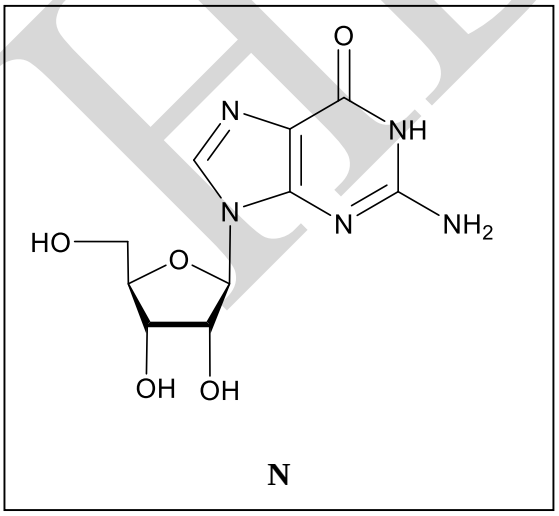
1.7

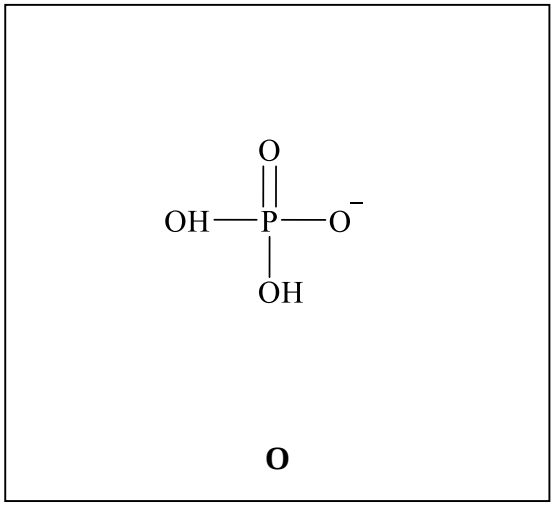


1.8



1.9





Problem 2 — 23 marks

A hand-made Freezer

2.1 $T_2 = 571\ K$
$P_2 = 9.52\ atm$

2.2 $P_3 = 5.01$ atm or 5.00 atm

2.3 iii) X

2.4 $T_4 = 157.9$ K, $P_4 = 0.53$ atm

2.5 Surface area of chamber **B** in contact with chamber **A** = 775 cm^2
Remaining surface area of chamber **B** = 3750 cm^2
x = 0.171

2.6 Heat lost from chamber **A** (air + icecream mix + two copper wall)
$= x \times$ Heat gained by air in chamber **B**

$\therefore T_5 = 299.78$ K

With T_4 = 220 K, $T_5 = 299.88$ K

2.7 i) X
ii) X
iii) X

2.8 Parameters which will remain same: P_3, P_4, T_3, T_4
Parameters which will decrease: T_2, T_5, P_2, P_4
Parameters which will increase: none

2.9 i) T
ii) T
iii) T
iv) F

Problem 3 — 23 marks

Acetic acid

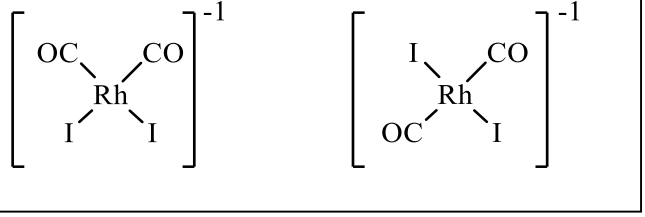
Part-I

3.1 i) X
iii) X

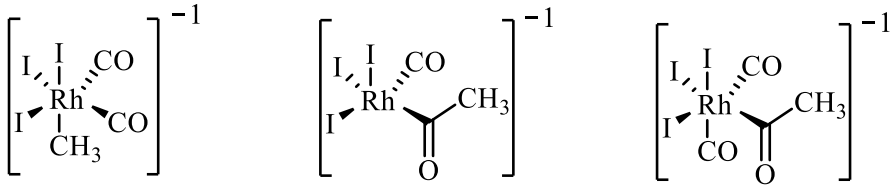
3.2 i) X
iv) X

Part-II

3.3



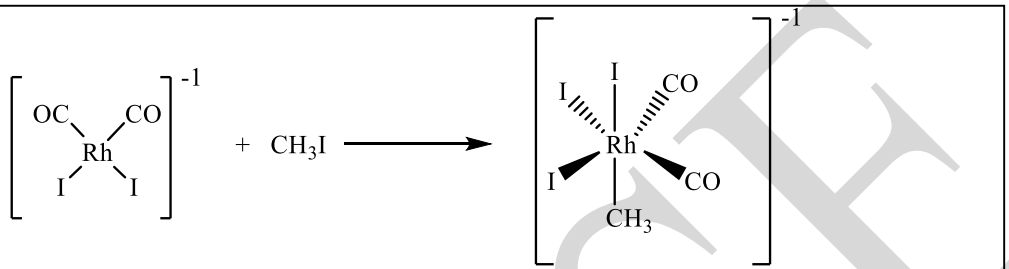
3.4



C1 **C2** **C3**

V = CH_3COI, **Y** = H_2O **Z** = HI

3.5

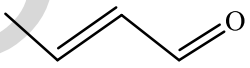


C1

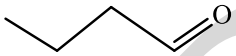
Part-III

3.6

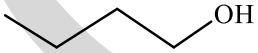
M = H_2 **N** = CO_2 **P**



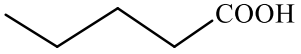
Q



R



S



3.7

	Possible	Not Possible
i) Aldehydes	2n	2n – 1
iii) Carboxylic acids	2, 2n + 1	2n + 2

3.8 i) propionic acid (by-product) $CH_3{}^{13}CH_2{}^{13}CO_2H$

ii) **S** (by-product) $CH_3{}^{13}CH_2CH_2{}^{13}CH_2{}^{13}CO_2H$

3.9 $\Delta H_{f\,(acetic\ acid)} = -36.4\ kJ\ mol^{-1}$

3.10 i) X

ii) X

Problem 4 — 21 marks

Inter-atomic Forces and Static Friction

4.1 $F(r) = -2D\alpha\left(1 - e^{-\alpha(r-r_e)}\right)e^{-\alpha(r-r_e)}$

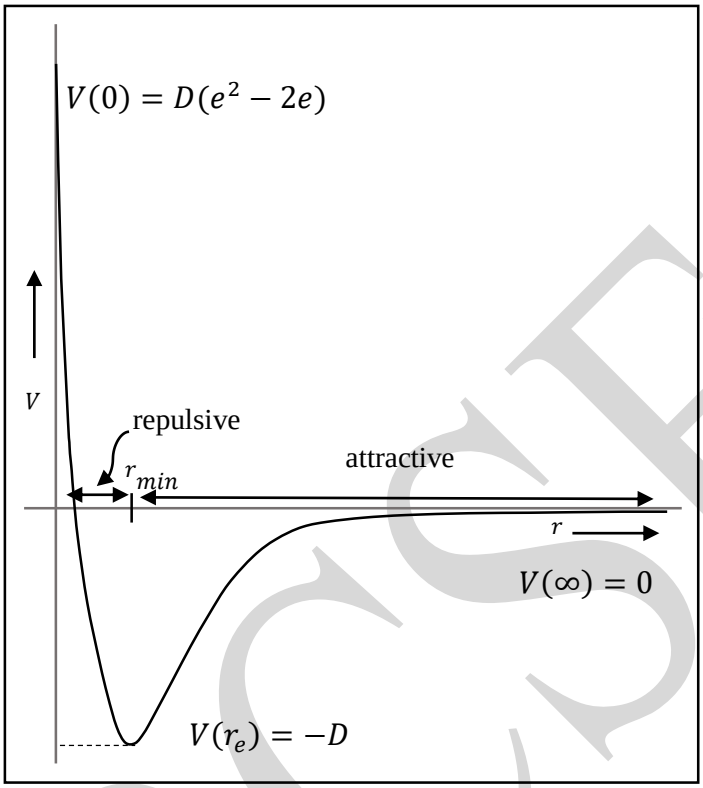
4.2

V(r) is minimum where $\frac{\partial V_M(r_0)}{\partial r} = 0$

$r_0 = r_e$

$\epsilon = D$

4.3



4.4 a) X

4.5 *Mg/n*

4.6

i) $\Delta z = r_{AB} - \sqrt{r_{AB}^2 - a^2}$

ii) $\mu = \frac{\left(r_{AB} - \sqrt{r_{AB}^2 - a^2}\right)}{a}$

4.7

(i) At $x = 0$: $F_z = -\frac{\partial V}{\partial z} = -4D\alpha^2(r - r_e)\frac{z}{r} = \frac{Mg}{n}$

$r\frac{z}{r} - r_e\frac{z}{r} = -\frac{Mg}{4nD\alpha^2}$

$z(0) = \sqrt{r_e^2 - a^2} - \frac{Mg}{4nD\alpha^2}$

(ii) At $x = a$: $F_z = -2D\alpha^2(r - r_e) = \frac{Mg}{n}$

$z(a) = r_e - \frac{Mg}{2nD\alpha^2}$

4.8

$\mu = \frac{\left(r_e - \sqrt{r_e^2 - a^2}\right) - \frac{Mg}{4ND\alpha^2}}{a}, K = \frac{nD}{a}$

4.9

$\mu = \frac{(0.5\ \text{Å}) - 0.039\ \text{Å}}{1.5\ \text{Å}} = 0.31$

Problem 5 — 14 marks

Analysis of a solid mixture containing iron and iron oxides

5.1 i)

Method A)

$FeO(s) + H_2(g) \rightarrow Fe(s) + H_2O(l)$

$Fe_2O_3(s) + 3H_2(g) \rightarrow 2Fe(s) + 3H_2O(l)$

Method B)

B) $Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_4(aq)$

ii)

$n(\text{Fe}) = 0.031$ mol

$n(\text{FeO}) = 0.017$ mol

$n(Fe_2O_3) = 0.011$ mol

5.2 i)

$Fe(s) + 2\,HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$

$FeO(s) + 2\,HCl(aq) \rightarrow FeCl_2(aq) + H_2O(l)$

$Fe_2O_3(s) + 6\,HCl(aq) \rightarrow 2\,FeCl_3(aq) + 3\,H_2O(l)$

ii) $V = 77.7$ mL

iii)

$Fe + 2\,HCl \rightarrow FeCl_2 + H_2$

V = 0.757 L