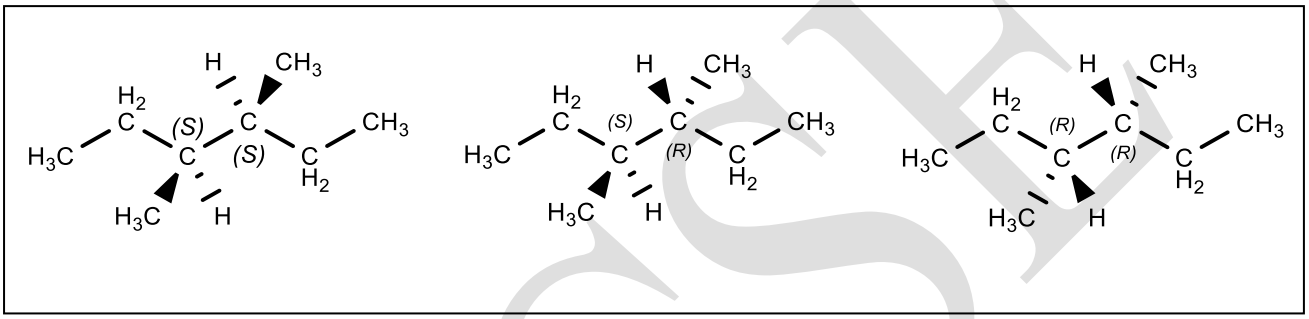
Any alternative method of solution to any question that is scientifically and mathematically correct and leads to the same answer will be accepted with full credit. Partially correct answers will gain partial credit.

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

Problem 1 — 28 marks

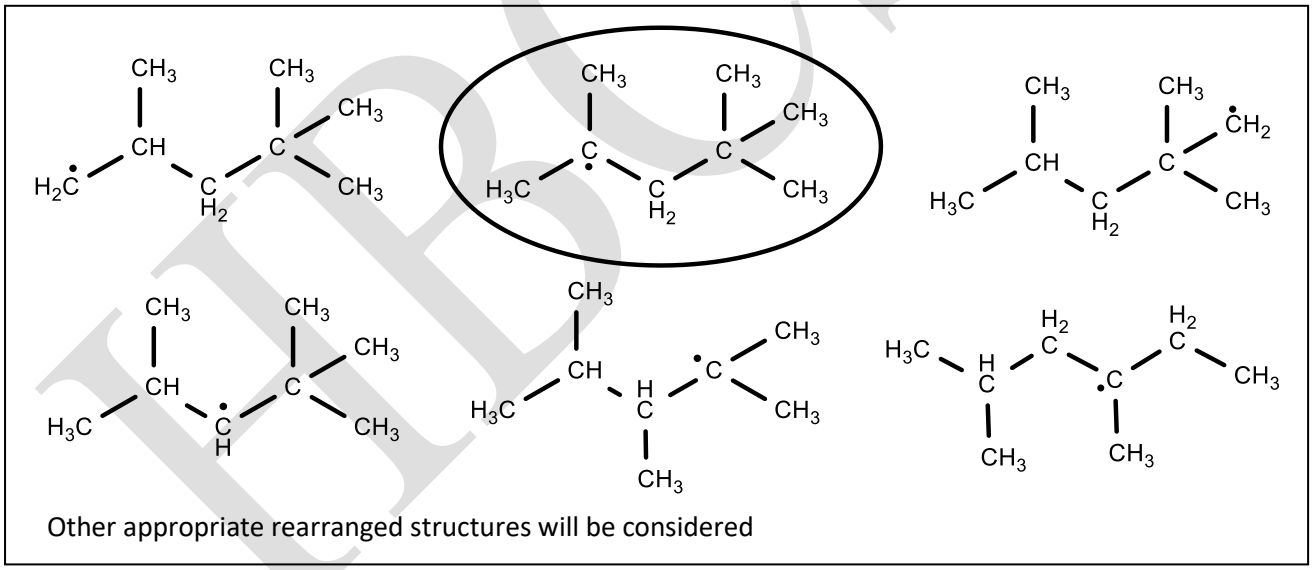
Fuel for Petrol Engines

1.1



(1.5 marks)

1.2



Other appropriate rearranged structures will be considered

(3.5 marks)

1.3 Toluene < isooctane < methylcyclohexane < *n*-octane **(1.5 marks)**

1.4 In 100 cm^3 of fuel, moles of octane = 0.429, moles of cyclohexane = 0.275

Moles of O_2 required = 7.9 mol

% of oxygen in air (w/w) = 23.18%

Stoichiometric amount of air required for complete combustion = 1089.6 g **(6 marks)**

1.5 a) X c) X d) X e) X f) X **(2 marks)**

1.6 (i) **(4 marks)**

Heat released per g of F_0 = 47.90 kJ g^{-1}

Mass of 100 cm^{-3} of F_{20} = 71 g

Heat released per g of F_{20} = 43.86 kJ g^{-1}

The difference in calorific value per g = – 4.04 kJ

(ii) **(4.5 marks)**

Amount of CO_2 released per mol of F_0 = 352.0 g per '***x***' km by complete combustion of 114 g of F_0

Amount of F_{20} fuel required to cover the same distance '***x***' km = 124.5 g

124.5 g of F_{20} contains 96.8 g of *iso*-octane and 27.7 g of ethanol

Amount of CO_2 released by of F_{20} to travel **x** km distance is = 351.8 g

The percentage reduction in CO_2 released = 0.06 %

1.7 **(5 marks)**

Correct Statement (S1 - S5)	Supporting Fact/s (F1 - F7)
S1	F4 (and F7)
S2	F7
S3	F1, F5

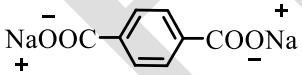
Incorrect Statement (S1 - S5)	Supporting Fact/s (F1 - F7)
S4	F3 (and F6)
S5	F6 (and F3)

 # Note: In presence of a spark, fuel can burn in air at a much lower temperature than its ignition temperature.

Problem 2 — 21 marks

Polymer Recycling

2.1 (i) **(2 marks)**



Disodium Terephthalate

$OH\text{-}CH_2CH_2\text{-}OH$

Ethylene Glycol

(6 marks)

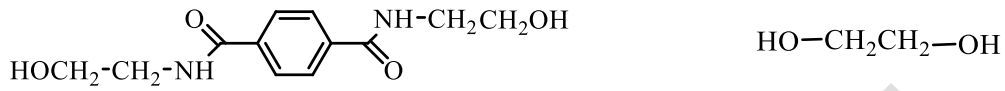
(ii)

S. No.	Process No. (I - IX)	Constituents of Mixture on which the process is carried out	Compound(s) separated out after the process (if applicable)
1.	VII	Ethylene Glycol + Na_2TPA+Water solution	TPA(s) precipitated
2.	I	TPA(s) in Ethylene Glycol + Na_2SO_4 + Water solution	TPA solid
3.	VIII	Ethylene glycol + water + Na_2SO_4 solution	water
4.	I	Ethylene glycol + Na_2SO_4 solution + Na_2SO_4 (as suspension)	Na_2SO_4(s)
5.	II	Ethylene glycol + Na_2SO_4 solution	Ethylene glycol; Na_2SO_4

2.2 (i) HO−CH_2CH_2−OH **(0.5 mark)**

(ii) (a) X **(1 mark)** **(iii) (c)** X **(1 mark)**

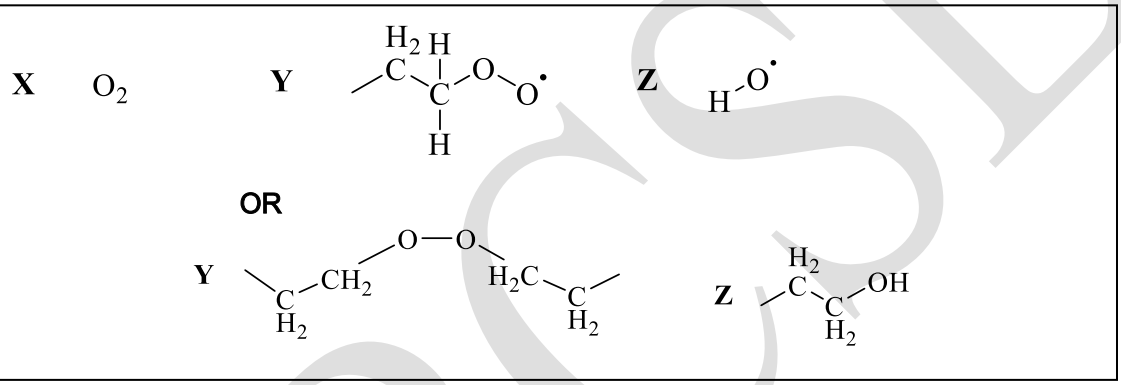
2.3



(1.5 marks)

2.4 **(c)** X **(1 mark)**

2.5 **(2.5 marks)**



2.6 **(a)** X **(d)** X **(2 marks)** **2.7 (a)** X **(b)** X **(2 marks)**

2.8 **(1.5 marks)**

	Mechanical recycling	Chemical recycling
(a)	X	
(b)		X
(c)	X	

Problem 3 — 21 Marks

CaO Production

3.1 $CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (s)$

$Ca(OH)_2\ (s) + CO_2\ (g) \rightarrow CaCO_3\ (s) + H_2O\ (l)$ **(1 mark)**

3.2 $K_c = 2.59 \times 10^{-3}$ **(1.5 marks)**

3.3 **(3.5 marks)**

i) $\Delta H° = 177.8 \text{ kJ mol}^{-1}$, $\Delta S° = 160.5 \text{ J K}^{-1} \text{ mol}^{-1}$

$\Delta G°_{298.15\text{ K}} = 129.95 \text{ kJ mol}^{-1}$

$\Delta G°_{1123.15\text{ K}} = -2.46 \text{ kJ mol}^{-1}$

ii) $T = \Delta H°/\Delta S° = 1107.78 \text{ K or } 834.64 °C$

3.4 **(3.5 marks)**

Modification	Observed relative change/s (A-E)
1]	A, B
2]	A, B
3]	A, B
4]	C

3.5 *T* (zone 3) $<$ *T* (Zone 4), due to

(a) X **(c)** X **(d)** X **(2 marks)**

3.6 **A)** Zone 5 **B)** Zone 4 **C)** Zone 4

D) Zone 5 **E)** Zone 2 or 3 **(5 marks)**

3.7 $4CaO(s) + Al_2O_3(s) + Fe_2O_3(s) \rightarrow Ca_4Al_2Fe_2O_{10}(s)$ $(4CaO.Al_2O_3.Fe_2O_3)$ **(0.5 mark)**

3.8 $3Ca(OH)_2(s) + Al_2O_3(s) \rightarrow Ca_3Al_2O_6.3H_2O(s)$ $(3CaO.Al_2O_3.3H_2O)$ **(0.5 mark)**

3.9

(i) Equation 1 $2H_2O\,(l) \rightarrow 4H^+\,(aq) + O_2\,(g) + 4e^-$

Equation 2 $2H_2O\,(l) + 2e^- \rightarrow H_2\,(g) + 2OH^-\,(aq)$

Equation 4 $4H^+\,(aq) + 2CO_3^{2-}\,(aq) \rightarrow 2H_2O\,(l) + 2CO_2\,(g)$

Equation 5 $2CaCO_3\,(s) \rightarrow 2Ca^{2+}\,(aq) + 2CO_3^{2-}\,(aq)$

Equation 6 $2Ca^{2+}\,(aq) + 4OH^-\,(aq) \rightarrow 2Ca(OH)_2\,(s)$

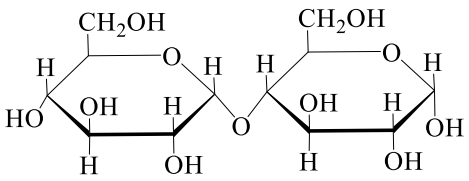
(ii) Overall reaction $2CaCO_3(s) + 4H_2O\,(l) \rightarrow 2Ca(OH)_2\,(s) + 2H_2\,(g) + O_2\,(g) + 2CO_2\,(g)$

(3.5 marks)

Problem 4 — 17 Marks

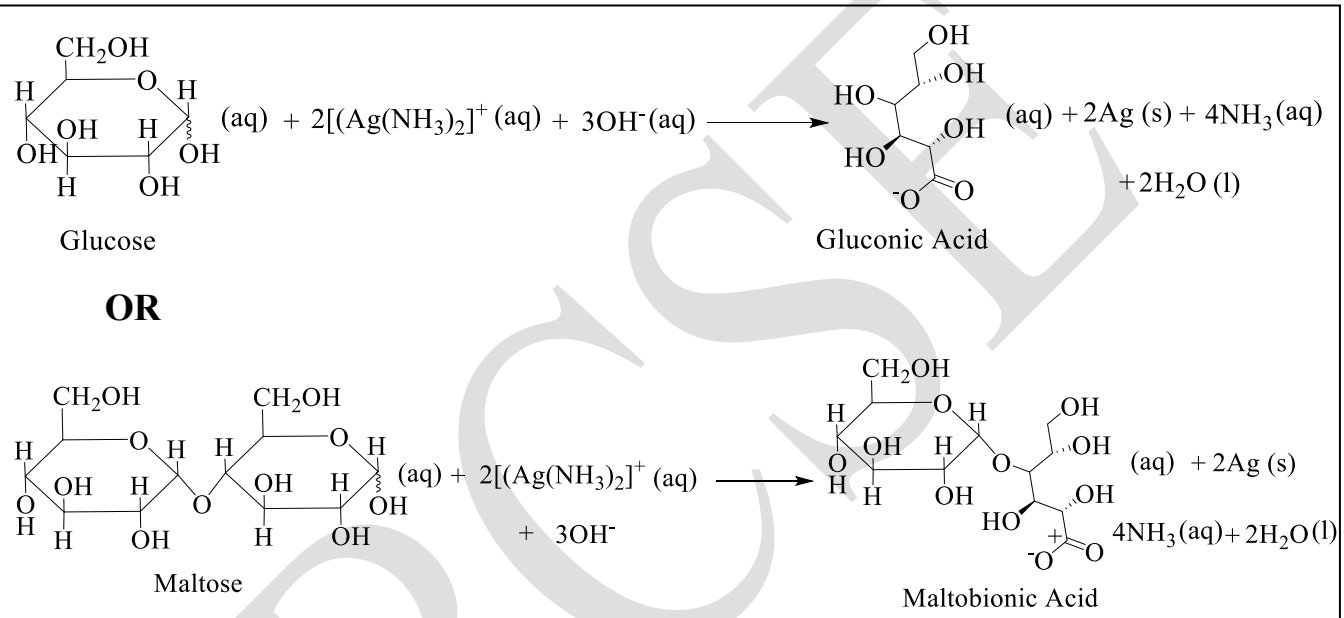
Urinary Amylase

4.1



(1 mark)

4.2 a)



(2.5 marks)

b) $Ag(NO_3)\,(aq) + NaOH\,(aq) \rightarrow Ag(OH)\,(s) + NaNO_3\,(aq)$

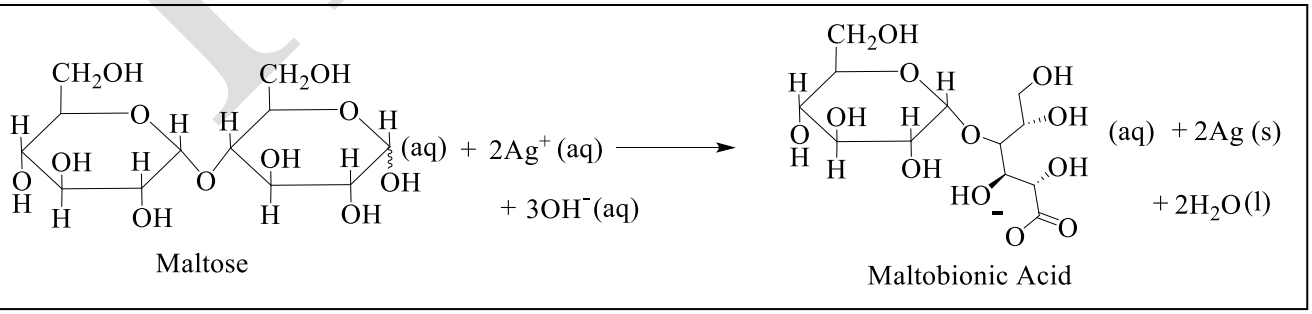
$2AgOH\,(s) \rightarrow Ag_2O\,(s) + H_2O$

(1 mark)

c) $Ag_2O\,(s) + 4Na_2S_2O_3\,(aq) + H_2O\,(l) \rightarrow 2Na_3[Ag(S_2O_3)_2]\,(aq) + 2NaOH\,(aq)$

(1.5 marks)

d)



(1 mark)

e)

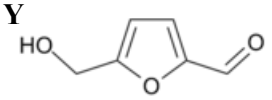
A: glucose	D: glucose	F: maltotriose

(1.5 marks)

f) **(C)** [X] **(D)** [X] **(2 marks)**

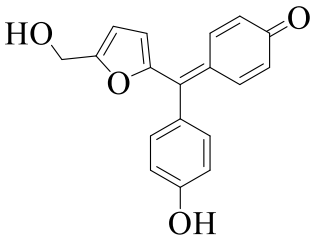
4.3 **a)** **(2.5 marks)**

Y

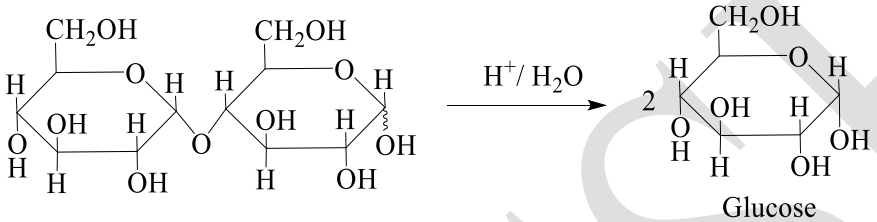


5-(hydroxymethyl)furfural

Z



b) **(1.5 marks)**



Maltose

c) **(C)** [X] **(1 mark)**

4.4 **(B)** [X] **(0.5 mark)** **4.5** **(B)** [X] **(D)** [X] **(1 mark)**

Problem 5 — 19 Marks

A purple haze

5.1 **(c)** [X] **(0.5 mark)**

5.2 **(1 mark)**

$8KI\,(s) + 5H_2SO_4\,(aq) \rightarrow H_2S\,(aq) + 4I_2\,(s) + 4H_2O\,(l) + 4K_2SO_4\,(aq)$

or

$6KI\,(s) + 4H_2SO_4\,(aq) \rightarrow S\,(s) + 3I_2\,(s) + 4H_2O\,(l) + 3K_2SO_4\,(aq)$

or

$2KI\,(s) + 2H_2SO_4\,(aq) \rightarrow SO_2\,(aq) + I_2\,(s) + 2H_2O\,(l) + K_2SO_4\,(aq)$

5.3 **(2 marks)**

i. $2IO_3^-\,(aq) + 6HSO_3^-\,(aq) \rightarrow 2I^-\,(aq) + 6SO_4^{2-}\,(aq) + 6H^+\,(l)$

ii. $5I^-\,(aq) + IO_3^-\,(aq) + 6H^+\,(aq) \rightarrow 3I_2\,(aq) + 3H_2O\,(l)$

5.4 Iodate ion (IO_3^-) = + 5 Iodide ion (I^-) = – 1
Solid iodine (I_2) = 0 **(1 mark)**

5.5 (a) [X] **(0.5 mark)**

5.6

$2NaI\,(aq) + 2CuSO_4\,(aq) + 2FeSO_4\,(aq) \rightarrow 2CuI\,(s) + Na_2SO_4\,(aq) + Fe_2(SO_4)_3\,(aq)$

$2CuI\,(s) + K_2CO_3\,(aq) \rightarrow 2KI\,(aq) + Cu_2O\,(s) + CO_2\,(g)$

$6KI\,(aq) + Na_2Cr_2O_7\,(aq) + 7H_2SO_4\,(aq) \rightarrow 3I_2\,(g) + Cr_2(SO_4)_3\,(aq) + Na_2SO_4\,(aq) + 3K_2SO_4\,(aq) + 7H_2O\,(l)$

(4 marks)

5.7

$KIO_3\,(aq) + 5KI\,(aq) + 3H_2SO_4\,(aq) \rightarrow 3K_2SO_4\,(aq) + 3I_2\,(aq) + 3H_2O\,(l)$

or $IO_3^-\,(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$

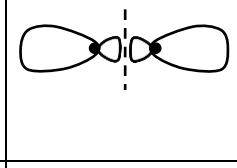
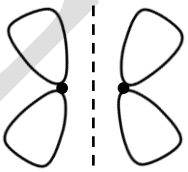
$2Na_2S_2O_3\,(aq) + I_2\,(aq) \rightarrow 2NaI\,(aq) + Na_2S_4O_6\,(aq)$

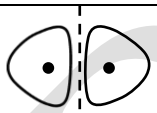
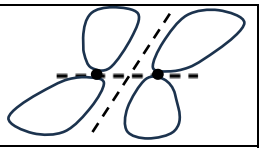
Moles of KIO_3 in 50 g of salt = 20.65×10^{-6} mol

Mass of Iodine in 1 kg of salt = 52.41 mg

(3.5 marks)

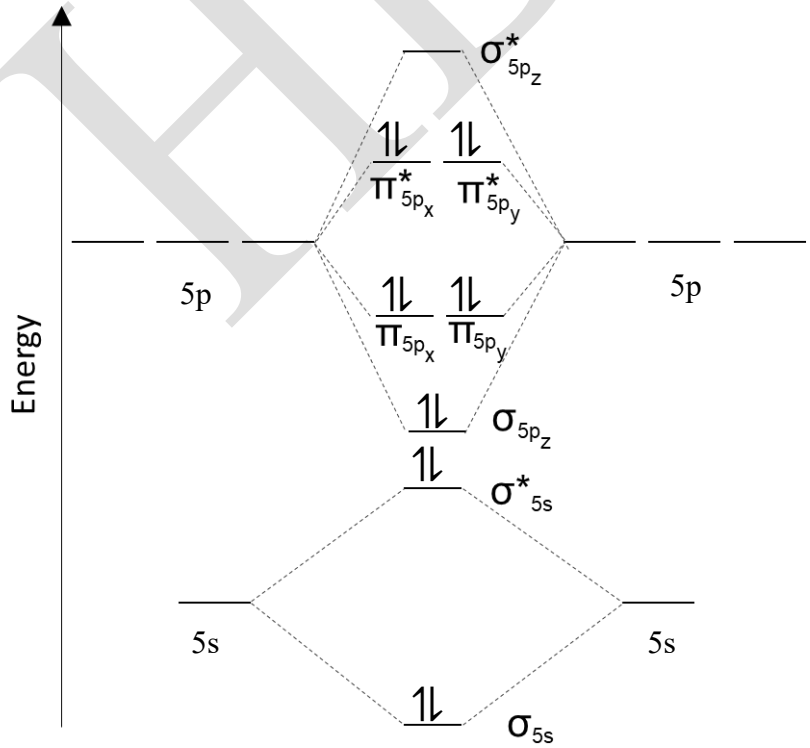
5.8

Orbital Shape				
Label	σ^*_{5pz}	π_{5px} / π_{5py}	π_{5py} / π_{5px}	π^*_{5px} / π^*_{5py}

Orbital Shape				
Label	σ^*_{5s}	σ_{5pz}	σ_{5s}	π^*_{5py} / π^*_{5px}

(3 marks)

5.9



(1.5 marks)

5.10 $\pi^*_{5py} \rightarrow \sigma^*_{5pz}$ or $\pi^*_{5px} \rightarrow \sigma^*_{5pz}$ **(1 mark)**

5.11 $5p_z$ AO of I^- to the LUMO σ^*_{5pz} of I_2 **(1 mark)**

END OF SECTION