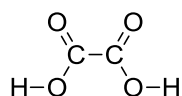


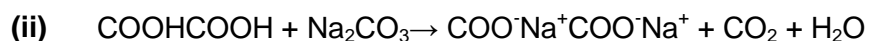
PAPER 2 SECTION A

1 (a)

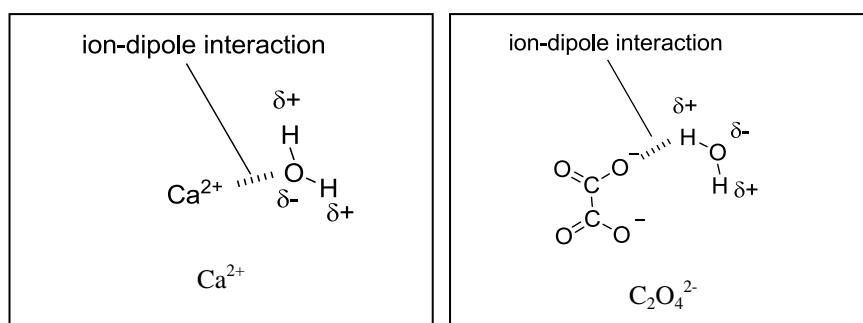


Hybridisation around each carbon: sp^2

(b) (i) Effervescence is observed. Gas forms white ppt with limewater



(c)



(d) $|L.E.| \propto \left| \frac{q^+ \cdot q^-}{r^+ + r^-} \right|$

The magnitude of lattice energy of CaC_2O_4 is greater than that of SrC_2O_4 as the size of Sr^{2+} is larger than that of Ca^{2+} .

(e) Oxidation number of C in CaC_2O_4 simultaneously increases from +3 to +4 in CO_2 and decreases from +3 to +2 in CO .
disproportionation reaction.

2 (a) Amount of $\text{N}_2(\text{g}) = 720 / 24000 = 0.0300 \text{ mol}$

Amount of N_2 : amount of NaN_3

3 : 2

Amount of $\text{NaN}_3 = 2/3 (0.0300)$

= 0.0200 mol

Amount of NaN_3 : amount of NaNH_2

1 : 1

amount of $\text{NaNH}_2 = 0.0200 \text{ mol}$

mass of $\text{NaNH}_2 = 0.0200 \times (23.0 + 14.0 + 2(1.0))$

= 0.780 g

(b) Na_2O has a giant ionic structure while N_2O has a simple molecular structure, more energy is needed to overcome the strong electrostatic forces of attraction between Na^+ and O^{2-} ions than the weak van der Waals forces of attraction between the N_2O molecules, thus Na_2O is a solid with high melting point (1280°C) while N_2O exists as a gas.

(c) (i) Relative atomic mass is defined as the average mass of one atom of an element compared with $1/12$ the mass of one ^{12}C atom;

(ii) Relative atomic mass of element X

= $0.9502(32.0) + 0.0075(33.0) + 0.0421(34.0) + 0.0002(36.0)$

= 32.1 (1 d.p.)

(iii)

	X	O	F
Mass/g	37.3	18.6	44.1
mol	1.162	1.162	2.321
ratio	1	1	2

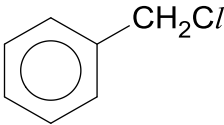
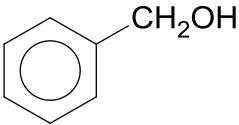
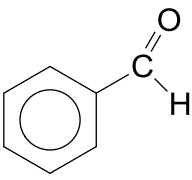
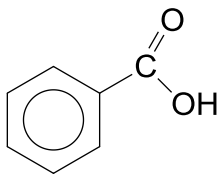
$86.1 = n(32.1 + 16.0 + 2 \times 19.0)$

$n = 1$

XOF_2

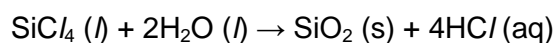
- 3 (a) (i) Amount of cooking oil = $10 \times 0.92 / 896.0 = 0.01027 \text{ mol}$
Amount of methanol = $1.5 \times 0.79 / 32.0 = 0.03703 \text{ mol}$
Assume cooking oil to be L.R., 0.01027 mol of oil requires $3 \times 0.01027 = 0.03080$ mol of methanol. Hence, methanol is in excess, cooking oil is L.R.
- (ii) Amount of biodiesel produced = $0.80 \times 3 \times 0.01027 = 0.02464 \text{ mol}$
Mass of biodiesel produced = $0.02464 \times 313 = 7.713 \text{ g}$
Volume of biodiesel produced = $7.713 / 0.88 = 8.77 \text{ cm}^3$
- (iii) The compounds present after reaction is methanol, cooking oil, glycerol and biodiesel. Glycerol and methanol have -OH groups, they form hydrogen bonds with each other, hence they are miscible. Biodiesel and cooking oil contains a non-polar long-chain hydrocarbon group and polar ester group, thus the more extensive vdw interactions between the long chain hydrocarbon group cannot be overcome by the hydrogen bonds with glycerol and methanol, thus biodiesel and cooking oil forms a separate layer.
- (iv) Top layer: biodiesel and cooking oil
Bottom layer: methanol and glycerol
- (b) (i) **Step I:** Elimination
Step II: Reduction
- (ii) CH_3COOH , conc H_2SO_4 , heat
- (iii)
$$\begin{array}{c} \text{CH}_2\text{--O}^-\text{Na}^+ \\ | \\ \text{CH--O}^-\text{Na}^+ \\ | \\ \text{CH}_2\text{--O}^-\text{Na}^+ \end{array}$$
- (iv) Functional Group: alkene
Reagents and conditions: Br_2 (aq)
Observation: Orange bromine decolourises.
Functional Group: aldehyde
Reagents and conditions: Tollens' reagent / Fehling's reagent/acidified $\text{K}_2\text{Cr}_2\text{O}_7$, warm
Observation: Silver mirror observed / Reddish brown ppt of Cu_2O observed/
orange solution turns green.

Observation	Deductions
compound P has molecular formula, C_7H_7Cl	C:H ratio is 1:1. P is an alkyl or aryl halide with a benzene ring.
When P is refluxed with aqueous NaOH, Q is formed	P undergoes substitution to form Q an alcohol. P is an alkyl halide.
Controlled oxidation of Q gives R . R gives a silver mirror with Tollen's reagent but does not react with Fehling's reagent.	Q is oxidised to give R an aromatic aldehyde. Q is a primary alcohol.
Continued oxidation of R gives S , a white solid.	R is further oxidised to give S a carboxylic acid.

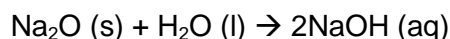
<p style="text-align: center;">P</p> 	<p style="text-align: center;">Q</p> 
<p style="text-align: center;">R</p> 	<p style="text-align: center;">S</p> 

PAPER 2 SECTION B

5. (a) X is Si. SiO_2 does not dissolve in water. SiCl_4 hydrolyses in water to produce a strongly acidic solution of pH 1-2:



Y is Na. Sodium oxide dissolves in water to form an alkaline solution while NaCl dissolves in water to give a neutral solution.



(b) (i)
$$K_c = \frac{[\text{PCl}_5]}{[\text{PCl}_3][\text{Cl}_2]}$$

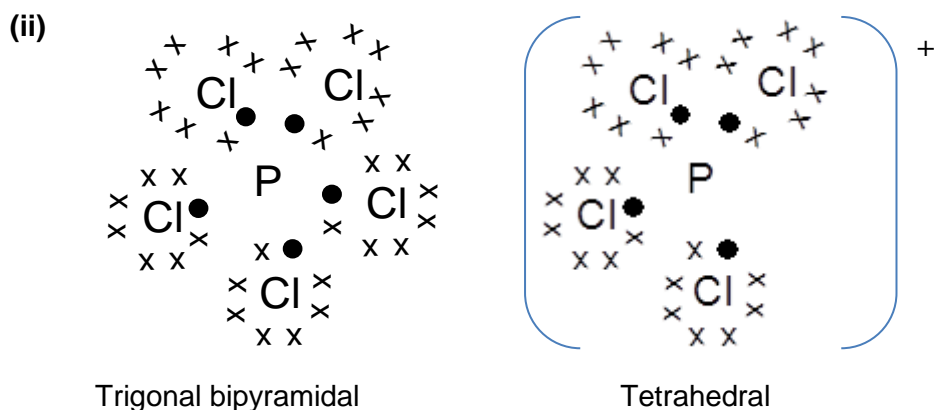
Units: $\text{mol}^{-1} \text{ dm}^3$

(ii)

	$\text{PCl}_3(g)$	$+ \text{Cl}_2(g)$	\rightleftharpoons	$\text{PCl}_5(g)$
I (mol dm^{-3})	1.0	1.0		0
C (mol dm^{-3})	-0.6	-0.6		+0.6
E (mol dm^{-3})	0.4	0.4		0.6

$$K_c = \frac{[\text{PCl}_5]}{[\text{PCl}_3][\text{Cl}_2]}$$
$$= \frac{0.6}{0.4 \times 0.4} = 3.75 \text{ mol}^{-1} \text{ dm}^3$$

- (iii) Le Chatelier's Principle states that when a system in equilibrium is disturbed, the position of the equilibrium will shift in a direction that tends to reduce that change so as to re-establish the equilibrium.
- (iv) The forward reaction is exothermic. When the temperature is increased, equilibrium position shifts to the left to favour the endothermic reaction to absorb heat by Le Chatelier's principle. The value of K_c decreases.
- (v) $\Delta H_f = \text{Energy (Bond breaking)} - \text{Energy (Bond making)}$
 $-124 = 244 - (2 \times \text{P-Cl})$
Bond energy of P-Cl = $+184 \text{ kJ mol}^{-1}$
- (c) (i) Phosphorus, being in period 3, has vacant energetically accessible 3d orbitals and can expand its octet structure to form the chloride PCl_5 which has 10 electrons around P but N cannot expand its octet structure to form NCl_5 .



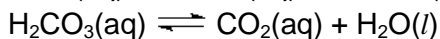
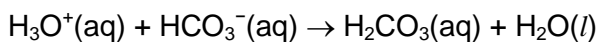
- (d) (i) $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$; substitution.
(ii) Ethanolic KOH, heat.

6. (a) (i) A weak acid is one that dissociates partially in water to form H^+ ions.
(ii) Benzoic acid. As it has the largest K_a value, it would dissociate the most to form a solution with the highest $[\text{H}^+]$.
(iii) In methanol, the CH_3 group is electron releasing, it strengthens the O-H bond and ionisation is more difficult and the methoxide ion is destabilised by the electron releasing CH_3 group.
In carboxylic acids and carbonic acid, the presence of the extra O polarise the O-H bond making ionisation easier. The negative charge on the anion formed is stabilised by the delocalisation of the negative charge over the carbon atom and both oxygen atoms.
(iv) An acidic buffer consists of a weak acid and its conjugate base. The buffer solution in blood is able to resist pH changes when small amounts of acid or base are added.

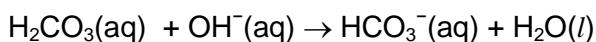
In blood, a buffer of a weak acid, carbonic acid (H_2CO_3), and its conjugate base, bicarbonate (HCO_3^-) is present.

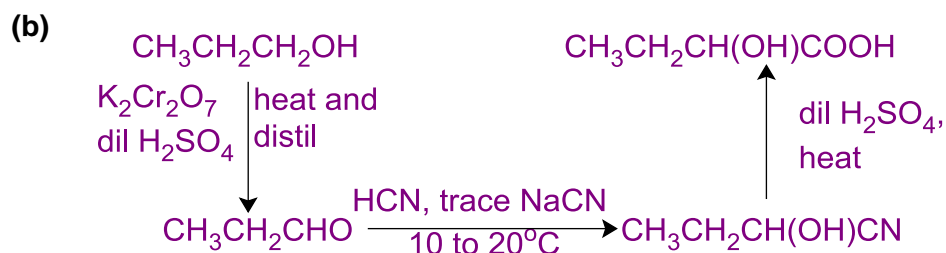


When blood is too acidic, HCO_3^- removes H_3O^+ by



When blood is too alkaline, H_2CO_3 removes OH^- by





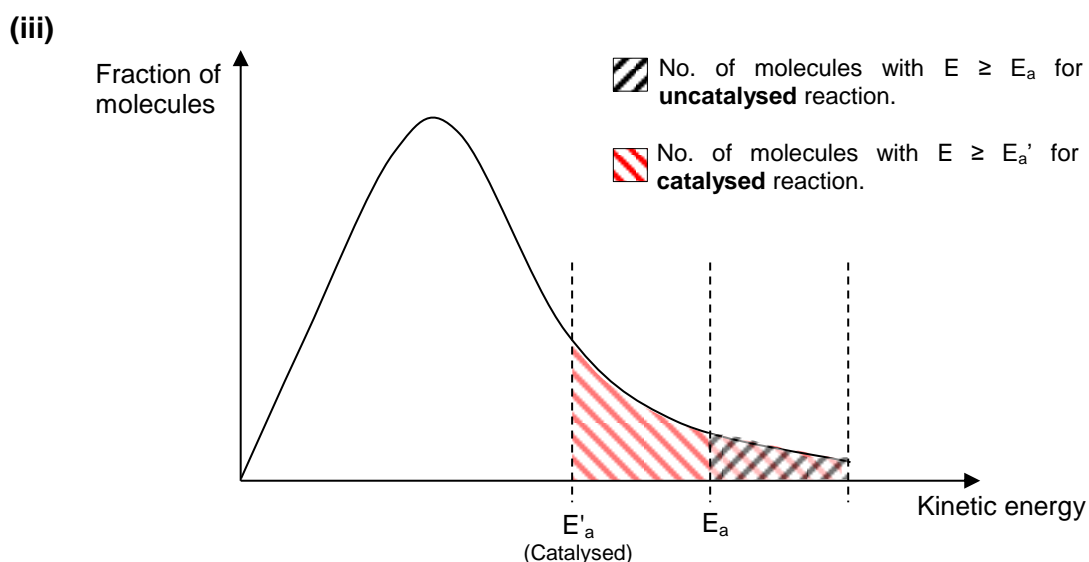
- (c) (i) $\text{CH}_3\text{CH}_2\text{NH}_2 + \text{HCl} \rightarrow \text{CH}_3\text{CH}_2\text{NH}_3^+\text{Cl}^-$
- (ii) The enthalpy change of neutralisation of ethylamine and hydrochloric acid hydroxide will be less exothermic that of sodium hydroxide and hydrochloric acid.

This is because ethylamine is a weak base which only dissociates partially in water. Energy is taken in for the dissociation of the weak base. Therefore, enthalpy change of neutralisation will be less exothermic.

- (iii) Excess ammonia, ethanol, heat in sealed tube;
 LiAlH_4 in dry ether;

7. (a) (i) Standard enthalpy change of formation of is the enthalpy change when 1 mole of pure compound is formed from its constituent elements in their standard states under standard conditions of 1 atm and 298 K.

- (ii) $\Delta H_r = \Sigma \Delta H_f(\text{products}) - \Sigma \Delta H_f(\text{reactants})$
 $-182 = \Delta H_f(\text{CH}_3\text{CHO}(\text{g})) + (-242) - (-238)$
 $\Delta H_f(\text{CH}_3\text{CHO}(\text{g})) = -178 \text{ kJ mol}^{-1}$

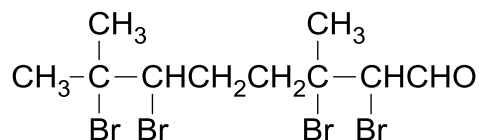


- Axes labels
- Curve starts from origin
- Correctly labelled activation energies and shadings for catalysed and uncatalysed reactions

The addition of catalyst provides an alternative pathway for reaction with lower activation energy. Number of molecules with $E \geq E_a$ increases, number of effective collisions increases. Since rate is proportional to frequency of effective collisions, Hence, the rate of reaction increases.

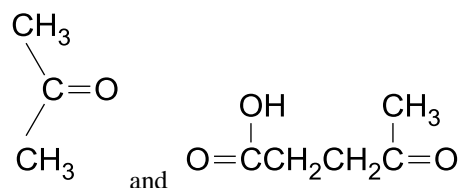
[6]

(b) (i)



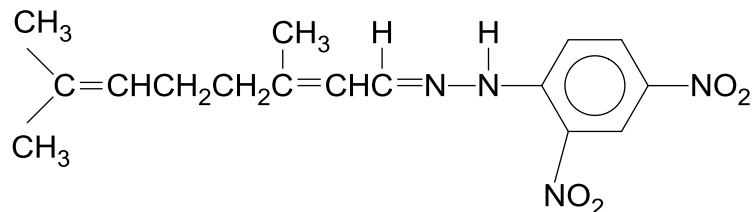
reddish-brown bromine decolourised

(ii)



Purple KMnO_4 decolourised, effervescence observed, gas gives white ppt in limewater.

(iii)



orange ppt observed

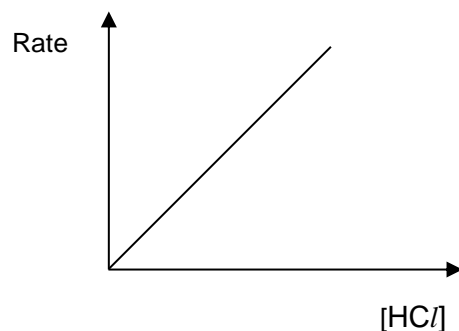
(c) (i)

Comparing expt 1 & 2, [ester] increases to 1.25 times while $[\text{HCl}]$ remains constant, rate increase to 1.25 times. Order wrt ester is one.
Comparing expt 3 & 1, [ester] doubles while $[\text{HCl}]$ doubles, rate increases to 4 times. Order wrt HCl is one.

(ii)

Rate = $k[\text{ester}][\text{HCl}]$
units of k : $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$

(iii)



(iv)

$\text{I}_2(\text{aq})$, $\text{NaOH}(\text{aq})$, warm.
Yellow ppt of CHI_3 observed for butan-2-ol. No yellow ppt observed for butan-1-ol.