A-Level June 2012 Chemistry paper 2 Corrections

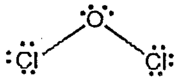
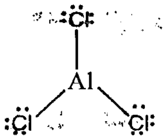
SECTION A (CGCEB 2012)

Physical And General Chemistry

1. (a) (i) (A) metallic bonding

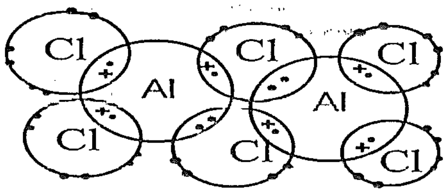
(B) Ionic, simple covalent and dative covalent bonding

(b)

Species	Shape	Bond angle
Cl_2O	 V-shape or bent shape	105° or 104.5°
$AlCl_3$	 Trigonal planar	120°

(C) (i) A dimer is the combination of two monomers of the same kind.

(ii)



(b) (i) From PH_3 to SbH_3 is due to an increase in the strength of the van der waal force with increase molecular weight and number of electrons

(ii) Due to the presence of hydrogen bonding in ammonia molecule as a result of high electonegativity of nitrogen and the presence of lone pair of electrons on the nitrogen atom.

(c) (i) It is the enthalpy change when one mole of an ionic crystal is formed from its gaseous ions under standard condition 298K, 1atm.

$Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl_{(s)}$

OR The energy required to break one mole of an ionic solid to its constituent ions in their gaseous state under standard condition.

$NaCl_{(s)} \longrightarrow Na^+_{(g)} + Cl^-_{(g)}$

(ii)The enthalpy change when one mole of gaseous atoms is formed from the element or molecule under standard conditions of 298K, 1atm.

${}^1/_2\, Cl_{2(g)} \longrightarrow Cl_{(g)}$

$Na_{(s)} \longrightarrow Na_{(g)}$

(d) (i) standard enthalpy of neutralization

(ii) $m_{acid} + m_{base} = 25 + 25 = 50g$

mass in Kg $- \frac{50}{1000} = 0.05kg$

heat evolved $= -0.05 \times 4.2(34.5 - 27)K = -1.575kJ$

eqn $= NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

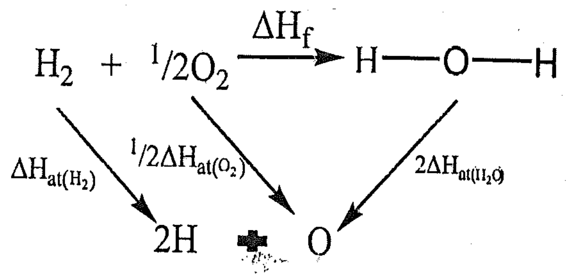
Mole ratio 1:1

N° mole of HCl $= \frac{1x25}{1000} = 0.025$ mol

0.025mol → $-1.575kJ$

1mol $= \frac{-1.575}{0.025} = -63KJmol^{-1}$

(g)



$\Delta H_{at(H)} + {}^1/_2\,\Delta H_{at(o)} = \Delta H_f + 2\Delta H_{dis(H_2O)}$

$(436) + {}^1/_2\,(498) = -285.8 + 2\Delta H_{dis(H_2O)}$

$(436) + {}^1/_2\,(498) + 285.8 = 2\Delta H_{dis(H_2O)}$

$436 + 249 + 285.8 = 2\Delta H_{dis(H_2O)}$

$436 + 249 + 285.8 = 2\Delta H_{dis(H_2O)}$

$\frac{970.8}{2} = \Delta H_{dis(H_2O)} = +485.4KJmol^{-1}$

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2. (a) (i) (A) A standard hydrogen electrode

(B) Under 1 atm, 25°C (298K) using a platinum electrode in 1molar solution of H^+ (1MHCl)

(ii) *using a platinum electrode

*the temperature of the solution should be 25°C (298k)

*the pressure should be 1 atmosphere

*1molar solution of Fe^{2+} and Fe^{3+}

*The salt bridge should be made up of filter paper soak in saturated solution of KCl, KNO_3 (Or porous pot)

(iii) (A) * To complete the circuit by allowing ions carrying charges to move from one half cell to another

* It provides cations and anions to replace those consumed at the electrodes and balanced the charge of any ion formed at the electrode.

(B) Filter paper soaked in saturated solution of KCl or KNO_3 (or porous pot)

(iv) (A) $Cr_2O_7^{2-}$

(B)

$Cr_2O^{2-}_{7(aq)} + 6Fe^{2+}_{(aq)} + 14H^+_{(aq)} \rightarrow 2Cr^{3+}_{(aq)} + 6Fe^{3+}_{(aq)} + 7H_2O_{(l)}$

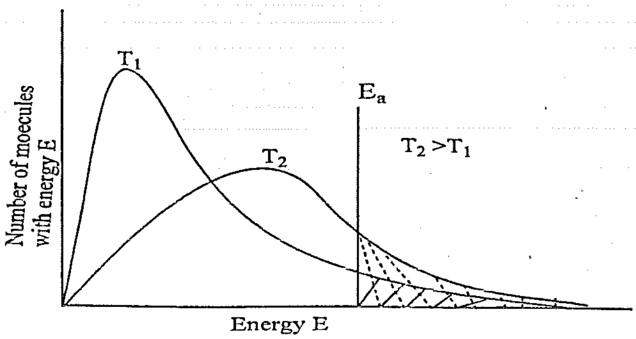
(b) (i) $P^H = -\log\sqrt{Ka([CH_3COOH]}$

$-\log\sqrt{1.8\times10^{-5}(0.1)}] = 2.8$

(ii) Phenophthalein.

The end point of strong base/weak acid is in the alkaline zone between pH 8-10.

(C) (i)



T₂ is higher than T₁. (NB: the area under each curve represents the total number of molecules. There is a wider range of molecular energies at the higher temperature (T₂).The average peak of the curve lies at higher energy at higher temperature; the average energy also increases at higher temperature. The activation energy is represented by the vertical line. Ea. The number of molecules which have at least this energy is much greater at higher temperature than at lower temperature. This is shown by the shaded portion of the curve.

(ii) The collision theory and the transition state theory (activated complex theory)

(iii) (A) $H_2O_{2(aq)} \rightarrow H_2O_{(l)} + O_{2(g)}$

(B) Property: monitoring by measuring the volume of oxygen produce as a function of time OR concentration of hydrogen peroxide with time

(C) The reaction mixture is connected to a gas syringe. The volume of oxygen produced after a catalyst is added is measured using the syringe within a time range.

Apparatus: Syringe closed with a rubber cap, Burette, conical flask pipette etc

$2MnO^-_{4(aq)} + 16H^+_{(aq)} + 5C_2O^{2-}_{4(aq)} \rightarrow Mn^{2+}_{(aq)} + 10CO_{2(g)} + 8H_2O(l)$

(B) Property: *Timing the disappearance of $MnO^-_{4(aq)}$ pink colour.

* by timing the decrease in electrical conductivity. Or by titration

Method: light is passed through the coloured solution. The colorimeter produces an electrical signal which increases with time as the colour of the solution fades away

(C) *Apparatus: Colorimeter

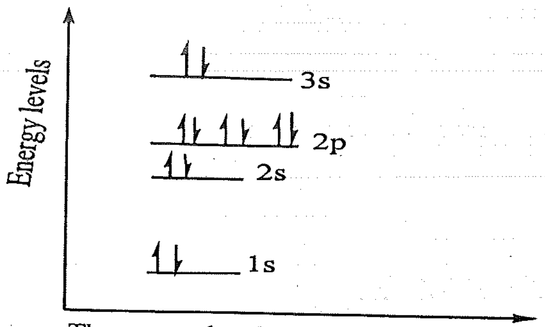
*A conductivity cell

3. (a) (i) They have the same number of protons or the same number of electrons thus they have the same chemical reactivity

(ii) The mass spectrometer

(iii) $\frac{79.0\times50.5+49.5\times81}{100} = 79.99$

(b) $1s^2 2s^2 2p^6 3s^2$



The energy level of an element with atomic number 12

(c) (i) The partial vapour pressure of each constituent in an ideal solution is equal to the vapour pressure exerted by each pure component multiply by its mole fraction at that temperature

(ii) *There is a rise in temperature when the two solutions are mixed

*The boiling point of the mixture is greater than the boiling point of individual component of the mixture.

*The total vapour pressure is less than that predicted by Raoult's law.

*There is a decrease in total volume when mixed

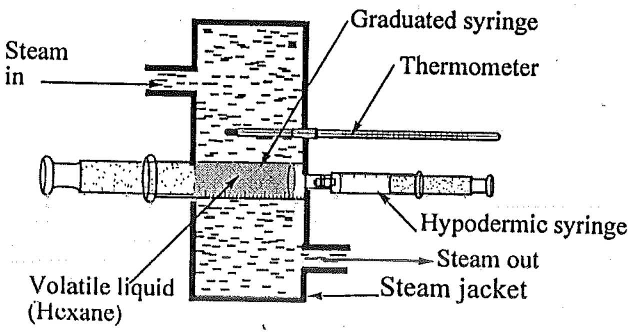
(d) (i) Due to the presence of a constant boiling point mixture with the same composition in the vapour as in the liquid (azeotropic mixture) in each fragment.

(ii) *Shake each fragment in benzene to break the hydrogen bonds between water and ethanol molecules

*Shake the mixture (ethanol/water) in ether

*Add a drying agent (CaO) to the mixture to absorb water molecules. (All these methods are called Extractive distillation or Azeotropic distillation)

(e) (i)



(ii) $PV = nRT$ but $n = \frac{w}{Mr} \Rightarrow PV = \frac{wRT}{Mr}$

$\Rightarrow Mr = \frac{wRT}{PV}$

(iii) $R=8.314Jk^{-1}mol^{-1}$,

$100atm = 1.0 \times 10^7 Nm^{-2}$

$1\ cm = 10^{-2} m$

$(1\ cm)^3 = (10^{-2}m)^3$

$\Rightarrow 1cm^3 = 10^{-6}m^3$

$\text{volume} = \frac{30.6}{10^6} = 3.06 \times 10^{-5}\text{m}^3$

$470°C + 273K = 743K$

$\text{Mr} = \frac{4.3 \times 8.314 \times 743}{1.0 \times 10^7 \times 3.06 \times 10^{-5}} = 86.81\ \text{g mol}^{-1}$

[OR

from $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow V_1 = \frac{(P_2V_2)T_1}{T_2P_1} \Rightarrow V_1 = \frac{(100\times1.0\times10^5)\times30.6\times(273)}{(470+273)\times1.0\times10^5} = \frac{8.3536\times10^{10}}{7.43\times10^7} \Rightarrow V_1 =$ 1124.306864cm^3]

For the same number of moles of volatile liquid

$$\text{N}^0\text{of moles} = \frac{1124.306864}{22400} = 0.05019227\text{mol}$$

$$\text{Molar mass} = \frac{4.3}{0.05019227} = 85.67\text{gmol}^{-1}$$

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SECTION B : CGCEB 2012

Inorganic (Mineral) Chemistry

4. (a) (i)

Element	Colour	Solid/liquid
Bromine	Reddish brown	Liquid
Iodine	Shiny black	Solid

(ii) Astatine black solid

(b) (i)

$IO_{3(aq)}^{-} + 5I_{(aq)}^{-} + 6H_{(aq)}^{+} \rightarrow 3H_2O_{(l)} + 3I_{2(aq)}$

(ii) Starch

(c) (A) No observation (no change)

(B) An orange (Or reddish brown) coloration is observed due to the displacement of bromine by chlorine

(d) HBr > HCl > HF

(e) Chlorofluorocarbons (CFC) cause the depletion of the ozone layer.

(f) (i) (A) ns^2np^2

(B) +4 and +2

(ii) The stability of the +4 oxidation state decreases down the group while that of the +2 increases due to inert pair effect

(e) (i)

$SiCl_{4(l)} + 2H_2O_{(l)} \longrightarrow SiO_{2(s)} + 4HCl_{(aq)}$

$CCl_{4(l)} + 2H_2O_{(l)} \longrightarrow$ *no reaction*

(ii) $CCl_{4(l)}$ does not hydrolyses in water because carbon lacks available low lying d-orbital to accept lone pairs of electrons from water molecules for dative bond formation while Si has. OR *The Si-Cl is longer and weaker than the C-Cl bond length which is shorter and stronger. This makes the chlorine atoms to crowd around the carbon atoms preventing attack by water molecules

(h) (i) Ionic bond

(ii) Simple covalent bond

(i) * Carbon has the ability to catenate (Carbon has the ability to form strong C-C, C=C, C≡C, C≡N, C=S, and C=O with itself and other elements on the periodic table)

*Carbon lacks available low laying d-orbital so its compounds are kinetically stable

* it has a maximum covalency of 4

*The oxides of carbon are gases while those of other group IV elements are solids at room temperature

*Carbon show allotropy but other do not

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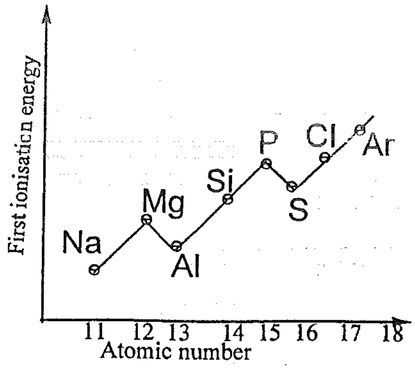
5. (a) The way the physical and chemical properties of elements and their compounds show a repeating pattern when ordered by the atomic number. Or The reoccurrence of the physical and chemical properties of elements and their compounds with atomic number

across the period and down the group. Or the variation in the physical and chemical properties of and elements with atomic number across the period and down the group

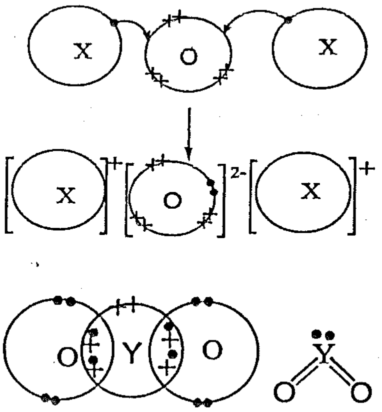
(b)



(c) (i) (X) Group I (Y) Group VI

NB: The oxide with YO_2 could possibly be SiO_2 but SiO_2 is insoluble in water.

(ii)



(iii) YO_3: acidic

(d)

Na	Mg	Al	Si	P	S	Cl
NaCl	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3 PCl_5	S_2Cl_2	Cl_2

(ii) The bonding changes from ionic in Na, and Mg, ionic/covalent in aluminium to covalent in the rest

(e) (i) $Na^+ = 1s^2 2s^2 2p^6$

$Mg^{2+} = 1s^2 2s^2 2p^6$

(ii) The ions are isoelectronic therefore; they have the same electronic structure.

(iii) Na^+ because it has one proton less thus the effective nuclear charge is smaller than that of Mg^{2+} OR Mg^{2+} has 2 protons, charge of 2+ exert a greater pull on outer electrons

(f) The increase is due to increase in number of shells, screening or shielding effect of outer electrons by inner electrons down the group.

(g) Increase in metallic strength in the group II since each atom donates two electrons into the sea of delocalization whereas in group I each atom donates only an electron into the sea of electron delocalisation.

(h) Because the hydration energy increases faster than the lattice energy in group I than in group II

(i) (a) Due to similarity in their electronegativity, atomic size and ionic size

(c)

$$4LiNO_{3(s)} \underset{\Delta}{\rightarrow} 2Li_2O_{(s)} + 4NO_{2(g)} + O_{2(g)}$$

$$2Mg(NO_3)_{2(s)} \underset{\Delta}{\rightarrow} 2MgO_{(s)}{}_{(s)} + 4NO_{2(g)} + O_{2(g)}$$

$$Li_2CO_{3(s)} \underset{\Delta}{\rightarrow} Li_2O_{(s)} + CO_{2(g)}$$

$$MgCO_{3(s)} \underset{\Delta}{\rightarrow} MgO_{(s)} + CO_{2(g)}$$

$$6Li_{(s)} + N_{2(g)} \underset{\Delta}{\rightarrow} 2Li_3N_{(s)}$$

$$6Mg_{(s)} + 2N_{2(g)} \underset{\Delta}{\rightarrow} 2Mg_3N_{2(s)}$$

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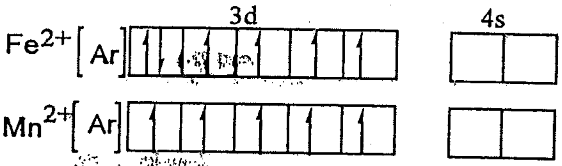
6. (a) (i) Their valence electrons enter the inner d-subshell

(ii) They form at least one stable ion or compound with a partially filled d-subshell.

(b) (i)



(ii) **Fe^{2+} will easily be oxidized to Fe^{3+}** because Fe^{3+} will have a half filled 3d-orbital which is more stable while Fe^{2+} has a partially filled 3d-orbitl which is less stable. Mn^{2+} has a more stable half filled 3d-orbital which is more stable than a partially filled 3d in Mn^{3+}.

(c) (i) $Co + 4(0) + 2(-1) = +1 \Rightarrow Co = 1 + 2 = +3$

(ii) (A) $CoCl_4^-$, tetrahedral in shape

(B) $[Co(CN)_4]^{2-}$, square planar

(d) (i)

$$4NH_{3(g)} + 5O_2 \xrightarrow{\text{Platinum-rhodium}} 4NO_{(g)} + 6H_2\,O_{(g)}$$

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$$

(ii)

$$S_{(s)} + O_2 \longrightarrow SO_{2(g)}$$

$$2SO_{2(g)} + O_2 \xrightarrow{V_2O_5} 2SO_{3(g)}$$

(e) Passing it through an electric chamber or dust precipitator.

(f) (i) nitrogen dioxide (NO_2) and sulphur dioxide (SO_2)

(ii) NO_2 and SO_2 combined with other atmospheric particles to form mist and fog which cause blurred vision.

*React with atmospheric moisture to form acid which burn trees.

(iii) It promotes the corrosion of metals

*It causes a decrease in the pH of water making it intolerant for aquatic life

*It increases the soil acidity

*It causes the leaching of aluminium from the soil as well as nutrients and minerals which are required for plant growth

(g) Use to manufacture nitrogenous fertilizers
*Use as precursors for nylon.
*Manufacture of explosives

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SECTION C (CGCEB 2012)

Organic Chemistry

7. (a) (i) (x) KCN/in ethanol; heat under reflux
(y) H^+/H_2O; heat under reflux
OR OH^-/H_2O; heat under reflux

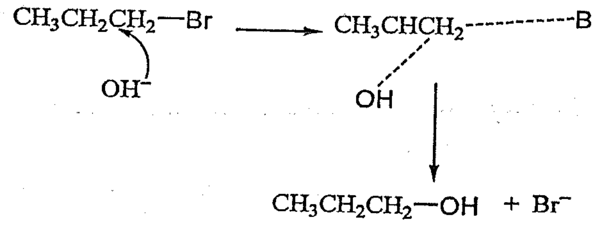
(ii)

Product	Formula or name
B	Pentanonitrile (Or Cyanopropane) ($CH_3CH_2CH_2CH_2C \equiv N$

D	Ammonium ion (NH_4^+) with acid hydrolysis or ammonia (NH_3) with alkaline hydrolysis
E	$CH_3CH_2CHClCOOH$ (2-chlorobutanoic acid)
G	Propane $CH_3CH_2CH_3$
H	Propan-1-ol ($CH_3CH_2CH_2OH$)

(iii) Nucleophilic substitution reaction

(iv)



(b) (i)

$CH_3CH_2CHBrCH_3$ (major product)

$CH_3CH_2CH_2CH_2Br$ (minor product)

(ii) $CH_3CH_2CHBrCH_3$

Because secondary (2°) carbocation is more stable than primary (1°) carbocation.

(iii) In the addition of HX (hydrogen halide) to unsymmetrical alkene the hydrogen atom is added to the unsaturated carbon atom with more hydrogen atoms.

(c) (i)

Elements	C	H	Cl
Ratio of % composition	45.9	8.9	45.2
Ratio by mole	$\frac{45.9}{12} = 3.825$	$\frac{8.9}{1} = 8.9$	$\frac{45.2}{35.5} = 1.273$
Mole ratio (divide by the smallest)	$\frac{3.825}{1.273} = 3$	$\frac{8.9}{1.273} = 7$	$\frac{1.273}{1.273} = 1$
Empirical formula	C_3H_7Cl		

(ii) $(C_3H_7Cl)n = Mf$

$$(4 \times 12 + 7 \times 1 + 35.5 \times 1)n = 78.5$$

$$(36 + 7 + 35.5)n = 78.5$$

$$(78.5)n = 78.5 \Rightarrow n = \frac{78.5}{78.5} = 1$$

C_3H_7Cl

(iii) The halogeno-alkane is heated with sodium metal to convert any chorine atom present to sodium chloride. Add nitric acid and add aqueous silver nitrate. If a white precipitate is observed, then chlorine is present in the compound

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8. (a) (i) They have the C=O group present in all their compounds

The general formula is RC=O (aldehyde) and RR'CO (ketone), R and R' may be aliphatic or aromatic.

(ii) By the oxidation of primary or secondary alcohol.

(iii) *Aldehyde will give a silver mirror with ammoniaccal silver nitrate ($NH_3/AgNO_3$) but ketone will not

$$RCHO + Ag(NH_3)_2^+ + H_2O \rightarrow RCOOH + 2Ag + 2NH_4^+$$

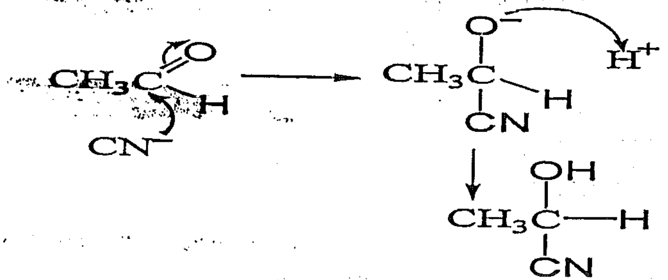
*Aldehyde will reduce fehling's solution from blue to a red precipitate of copper(I) oxide while ketone will not.

(v) This is because the carbonyl group is highly polar due to differences in electronegativity. This leads to a significant dipole-dipole interaction between the molecules.

(e) (i) The addition of an electron rich species to an electron deficient side.

(ii) CN^-

(iii)



(iv) H^+/H_2O or OH^-/H_2O; heat under reflux

(c) (i) P, CH_3CH_2CHO (Propanal) and

Q, CH_3COCH_3

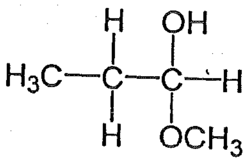
(ii) propanone-2,4-dinitrophenylhydrazone

(iii)

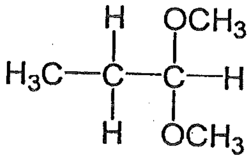
CH_3CH_2OH and $CH_2CH(OH)CH_3$ =(position isomer)

$CH_3CH_2CH_2OH$ and CH_3-O—CH_2CH_3 (functional group isomer)

(iv)

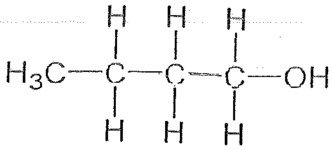


1-methoxypropan-1-ol
(Hemi-acetal)

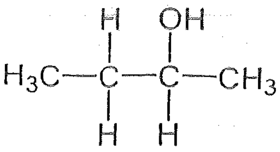


1,1-dimethoxypropane
(Acetal)

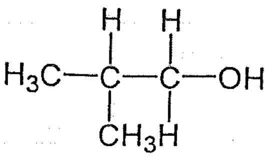
9. (a)



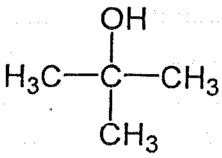
butan-1-ol



butan-2-ol



2-methylpropan-1-ol



2-methylpropan-2-ol

(b) Both compounds will liberate white fumes of HCl with PCl_5 at room temperature indicating the presence of OH-group

(c) (i) S is more acidic than R

The phenoxide ion in S is stabilized by resonance. Or the negative charge in the phenoxide ion in S is delocalized around the benzene ring while in R the hydroxyl group is attached to an alkyl group thus the negative charge on the alcoxide group is localized.

Or The $CH_3CH_2^-$ in R is electron donating (+ inductive) so reduces tendency to lose proton (H^+)

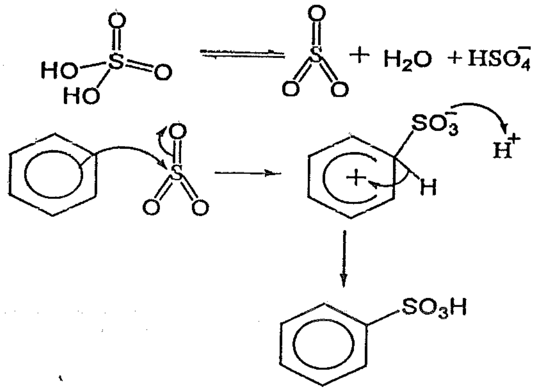
(ii) S will give a violet (or purple) colour with neutral iron(III) chloride solution. While T will not

(iii)

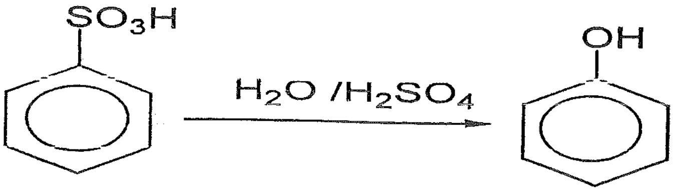
$$CH_3CH_2OH + CH_3COOH \xrightleftharpoons[reflux]{H_2SO_4} CH_3COOCH_2CH_3 + H_2O$$

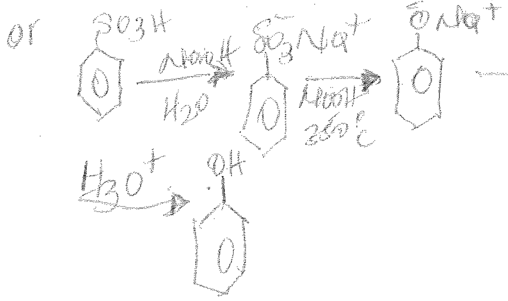
$$C_6H_5OH + CH_3COOH \xrightarrow[heat]{NaOH} C_6H_5-O-\overset{O}{\overset{\|}{C}}-CH_3$$

(d) (i)

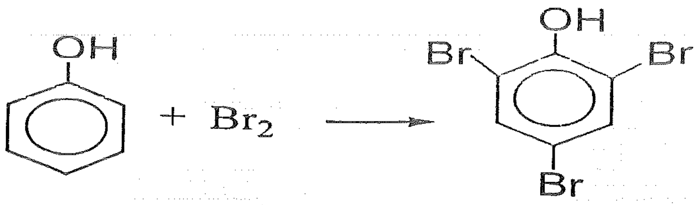


(ii) The sodium phenoxide is extracted from the mixture with water and acidified with sulphuric acid to obtain free phenol





(iii)



(e)