$$\text{No. of mole} = \frac{15.5}{208.5} = 0.0743$$

$$\text{conc.} = \frac{0.0743 \times 1000}{250} = 0.297\text{mol. dm}^{-3}$$

(ii) $N^0$of mol of Cl_2 = $N^o$of mole of PCl_3 = 0.025mol

$N^0$of mole of PCl_5left at equilibrium = 0.0743 − 0.025 = 0.0493mol

$$\text{conc. of } PCl_5 = \frac{0.0493}{250} \times 1000 = 0.1972\text{mol. dm}^{-3}$$

$$\text{conc. of } PCl_3 = \frac{0.025}{250} \times 1000 = 0.1\text{mol. dm}^{-3}$$

$$\text{conc. of } Cl_2 = \frac{0.025}{250} \times 1000 = 0.1\text{mol. dm}^{-3}$$

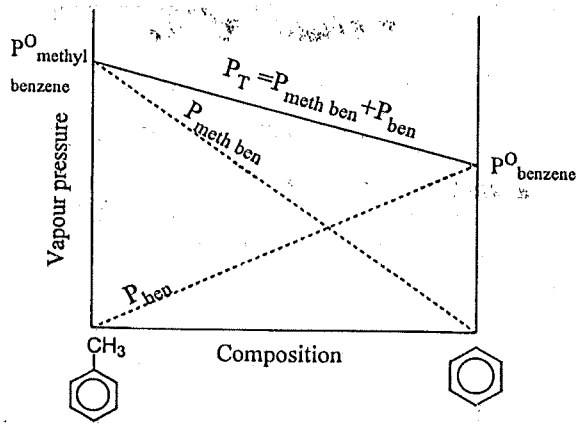
$$Kc = \frac{0.1 \times 0.1}{0.1972} = 0.05071\text{mol. dm}^{-3}$$

(c) (i) For an ideal solution, the total vapour pressure above the mixture of two liquids varies linearly with the composition of the mixture express as mole fraction at constant temperature. OR
For an ideal solution, the partial vapour pressure of each component in the mixture is equal to the mole fraction multiplied by the vapour of the pure component at constant temperature

(ii) The two liquids have similar intermolecular forces in the mixture as in the individual liquids (components) in the mixture.

- On mixing the two liquid do not show any heat change as whereas volume change.

(iii)



(iv) Fractional distillation

(d) (i) Ethanol and water, tetrachloromethane and ethanol, propanone and carbon disulphite, benzene and ethanol, water and ethylethanoate, carbon tetrachloride and methanol. Etc

(ii) The two liquid components have different molecular structure hence dissimilar intermolecular forces. The force of attraction between the molecules in solution is weaker than the force of attraction between similar molecules.

---

3. (a) (i) These are clusters of atoms in a reaction at the point of maximum potential energy which can decompose to either give the products or revert to reactants.

(ii) This is the number of reactant atoms or molecules participating in the reaction as given in the stoichiometric equation for a single step process.

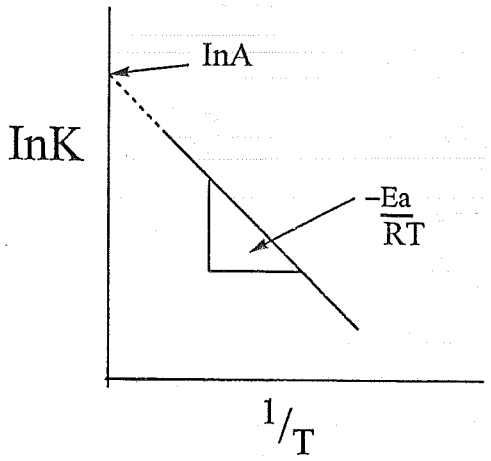
(b) (i) Increase in temperature increases the rate constant since there are many more reactant particle colliding with energy greater than the activation energy.

NB: let analyse the Arrhenius equation

$$K \alpha e^{-\frac{Ea}{RT}} \Rightarrow K = Ae^{-\frac{Ea}{RT}}$$

$$\ln K = \ln A - \frac{Ea}{RT}$$

Plotting a graph of $\ln K$ *against* $\frac{1}{T}$ *with slope* $= -\frac{Ea}{R}$ and intercept $\ln A$



There for as the temperature increases, there are many more molecules with energy greater than the activation energy

(ii) The collision frequency increases since the distances between the reacting particles have reduced.

(c) (i) The initial rate of reaction is the rate of the reaction at the very beginning at time t=0 when there is very small fixed amount of product formed

➢ The rate of a reaction is the changed in reactant concentration with time in the cause of the reaction.

(ii) (A) Considering Exp't 2 and 3. The concentration of X is doubles and the rate of the reaction is quadruples. Hence the reaction is 2nd order w.r.t. X

(B) Considering Exp,t 1 and 2. The concentration of Y is double and the rate of the reaction is doubles. Hence the reaction is 1st order w.r.t Y. The overall order of the reaction is 1+2=3

OR

By calculation

Taking reaction 1 and 2

$$0.18 = K[0.1]^m[0.1]^n - - - - - (1)$$

$$0.36 = K[0.1]^m[0.2]^n - - - - - (2)$$

Equation (1)/(2) $\Rightarrow \frac{0.18}{0.36} = \frac{K[0.1]^m[0.1]^n}{K[0.1]^m[0.2]^n}$

$$\frac{1}{2} = \left(\frac{1}{2}\right)^n = 2^{-1} = 2^{-n} \Rightarrow -n = -1 \Rightarrow n = 1$$

Hence 1st order w.r.t Y

Considering reaction 2 and 3

$$0.36 = K[0.1]^m[0.2]^n - - - - - (2)$$

$$1.44 = K[0.2]^m[0.2]^n - - - - - (3)$$

$$\frac{eqn(2)}{eqn(3)}$$

$$\frac{0.36}{1.44} = \frac{K[0.1]^m[0.2]^n}{K[0.2]^m[0.2]^n}$$

$$\frac{1}{4} = \left(\frac{1}{2}\right)^m = 4^{-1} = 2^{-m} = 2^{-2} = 2^{\ m} \Rightarrow$$

$$-m = -2 \Rightarrow m = 2$$

Hence 2nd order w.r.t X

Overall order =1+2=3

(iii) $Rate = K[X]^2[Y]^1$

(iv) Using data for equation 1

$$0.18 = K[0.1]^2[0.1]^1 \Rightarrow \frac{0.18}{[0.1]^2[0.1]^1} = K$$

$$\frac{0.18}{1 \times 10^{-3}} = K \Rightarrow K = 180$$

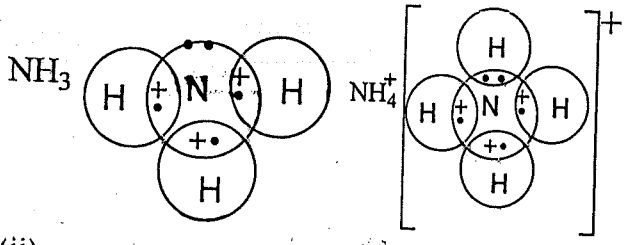
Unit

$$\frac{mol.dm^{-3}.s^{-1}}{(mol.dm^{-3})^2 mol.dm^{-3}} = K = \frac{.s^{-1}}{(mol.dm^{-3})^2} \Rightarrow K = \frac{.s^{-1}}{mol^2.dm^{-6}} = K = dm^6 mol^{-2} s^{-1}$$

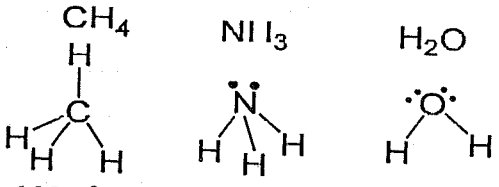
Therefore $K = 180 dm^6 mol^{-2} s^{-1}$

(v) The reaction cannot take place in single step. This is because the reaction is 3rd order overall requiring the collision of three particles at once, which is difficult.

(d) (i)



(ii)



(iii) CH_4, weak intermolecular van der waal force

NH_3, weak intermolecular hydrogen bond

(iv) **CH_4** has four C-H bonded pair which repels each order equally making the molecule to have a bond angle of 109.5° with tetrahedral shape

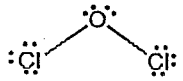
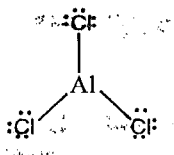
NH_3. The molecule has three bonded pair and one lone pair. The lone pair repels the bonded pair with greater repulsion than the way bonded pair repel each other. The molecule has a bond angle of 107° and it is trigonal pyramidal in shape

H_2O. The molecule has two lone pairs and two bonded pair. The lone pair repels the bonded pair as far apart as possible more than the way the bonded pair repels each other. This makes the molecule to have a V-shape or a bent shape with bond angle of 104.5°.

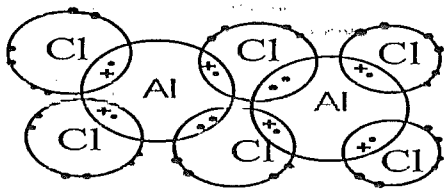
(i) H_2O:. Each molecule forms, two hydrogen bonds since the oxygen is more electronegative, with two lone pairs of electrons and two hydrogen atoms. NH_3 forms only one hydrogen bond per molecule since nitrogen contains only one lone pair of electron.

SET 4: 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 $= -0.05 \times 4.2(34.5 - 27)K = -1.575kJ$

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

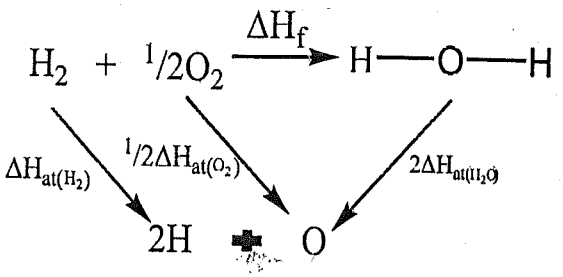
Mole ratio 1:1

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

$0.025mol \rightarrow -1.575kJ$

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

(g)



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

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

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

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

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

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

---

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)

$Cr_2O_{7(aq)}^{2-} + 6Fe_{(aq)}^{2+} + 14H_{(aq)}^{+} \rightarrow 2Cr_{(aq)}^{3+} + 6Fe_{(aq)}^{3+} + 7H_2O_{(l)}$

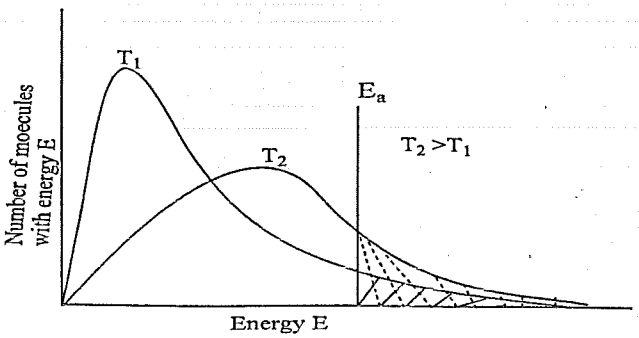
(b) (i) $P^H = -\log\sqrt{\text{Ka}([CH_3COOH]}$

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

(ii) Phenophthalein.

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

(C) (i)



T_2 is higher than T_1. (NB: the area under each curve represents the total number of molecules. There is a wider range of molecular energies at the higher temperature (T_2).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

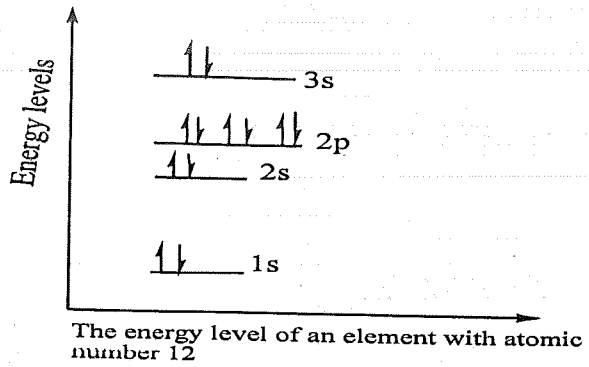
*A conductivity cell

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

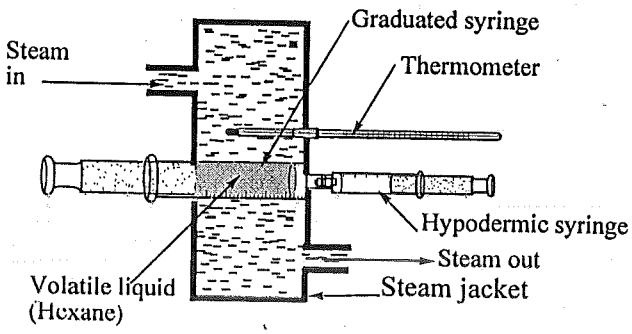
(d) (i) Due to the presence of a constant boiling point mixture with the same composition in the vapour as in the liquid (azeotropic mixture) in each fragment.

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

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

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

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

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

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

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

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

SET 5: SECTION A (CGCEB 2013)

Physical chemistry

1. (a) (i) The number of atoms in exactly 12g of carbon-12 isotopes.

(ii) This is the mass of a substance that contain as many elementary particles as there are atoms in exactly 12g of carbon-12 isotope.

(b). (i) Molar mass $(2 \times 27) + (3 \times 32) + (4 \times 3 \times 16) + 6(18) = 450$

Number of mole $\frac{9}{450} = 0.02$ mol

(ii) $Al_2(SO_4)_3H_2O \rightarrow 2Al^{3+} + 3SO_4^{2-} + 6H_2O$

$1mole\ of\ Al_2(SO_4)_3H_2O\ contain\ 3mole\ of SO_4^{2-}$

$0.02\text{mol}Al_2(SO_4)_3H_2O$ will contain $0.02x3 = 0.06\text{mol}$

(iii) $molarity = \frac{0.02}{250} \times 1000 = 0.08M$

(c). (i) It is a change that takes place in the nucleus of an atom either spontaneously or as a result of bombardment with a ray or high energy neutron. OR it involves changes in the nucleus of an atom.

$2(^1_1\text{H}) + 2^1_0\text{n} \rightarrow {}^4_2\text{He}$

$^{238}_{92}\text{U} \rightarrow {}^4_2\text{He} + {}^{234}_{90}\text{Th}$

(ii) $^{238}_{92}\text{U} \rightarrow \text{a}(^4_2\alpha) + \text{b}(^0_{-1}\beta) + {}^{226}_{88}\text{R}$

$238 = 4a + 226 \Rightarrow a = \frac{238-226}{4} = 3$

$92 = 2a - b + 88 \Rightarrow -b = 92 - 2(3) - 88 = -2$

$\Rightarrow b = 2$

A: 3 alpha, B 2 beta

(d). (i) $\frac{10.65}{35.5} = 0.3\ mol$ (ii) $\frac{5.6}{56} = 0.1\ mol$

(iii)

Element	Fe	Cl
	0.1	0.3
Mole ratio	$\frac{0.1}{0.1}=1$	$\frac{0.3}{0.1}=3$
Formula of chloride	$FeCl_3$	

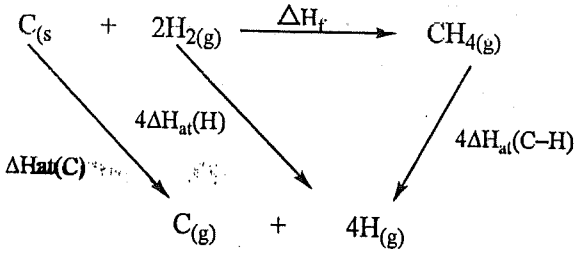
equation : $2Fe_{(s)} + 3Cl_{2(g)} \longrightarrow 2FeCl_{3(s)}$

(e). (i) It is the average bond energy per mole of a specific bond with respect to it environment (or in a range of molecules)

(ii) $CaCl_{2(s)} \longrightarrow Ca^{2+}_{(g)} + Cl^{-}_{(g)}\ \Delta H = +Ve$

Or $Ca^{2+}_{(g)} + Cl^{-}_{(g)} \longrightarrow CaCl_{2(s)}\ \Delta H = -Vc$

(f).



$\Delta H_{at(C)} + 4\Delta H_{at(H_2)} = \Delta H_f + 4\Delta H_{dis(C-H)}$

$\Delta H_{at(C)} + 4\Delta H_{at(H_2)} - \Delta H_f = 4\Delta H_{dis(C-H)}$

$\frac{\Delta H_{at(C)} + 4\Delta H_{at(H_2)} - \Delta H_f}{4} = \Delta H_{dis(C-H)}$

$\frac{717 + 4(218) - (-75)}{4} = 416 KJmol^{-1}$

(g). (i) This is because the bond is not purely ionic but intermediate between ionic and covalent duc to bond polarization.

(ii) A: AgCl, or AgBr, or AgI

B: NaI,or NaCl, Or NaBr

(iii) Because it shows all the other energy changes which can be determined experimentally except the lattice energy. OR it is an indirect method of determining the lattice energy since the cycle shows all other enthalpy changes which can be determine experimentally.

---

2. (a)(i) It is the rate at the time when the reactants are just brought together. OR it is the rate at time t=0, when an infinitely small amount of the reactant has been used up.

(ii) It is the power to which the reactant concentration is raised in an experimentally determined rate equation.

(b) It is uses to calculate the rate of a reaction when the reactant concentration has change. It is also useful in determining the mechanism of a reaction.

(c) (i) Consider experiment 1 and 2

$[CH_3COCH_3]$ is constant

$[I_2]$ is double

$[H^+]$ is constant. The rate is constant therefore, the reaction is 0^{th} order with respect to $[I_2]$

Considering experiment 1 and 3

$$5.7 \times 10^{-5} = (0.3)^x(0.05)^y(0.05)^z \ldots\ldots(1)$$
$$1.2 \times 10^{-4} = (0.3)^x(0.05)^y(0.1)^z \ldots\ldots\ldots(2)$$
$$\frac{eqn(1)}{eqn(2)} \Rightarrow \frac{5.7 \times 10^{-5}}{1.2 \times 10^{-4}} = \left(\frac{0.05}{0.1}\right)^z$$
$$0.475 = (0.5)^z \Rightarrow z = 1.$$

Thus the reaction is 1st order with respect to $[H^+]$

Considering experiment 1 and 5

$$5.7 \times 10^{-5} = (0.3)^x(0.05)^y(0.05)^z \ldots\ldots(1)$$
$$7.1 \times 10^{-5} = (0.36)^x(0.05)^y(0.05)^z \ldots\ldots\ldots(2)$$
$$\frac{eqn(2)}{eqn(1)} \Rightarrow \frac{7.1 \times 10^{-5}}{5.7 \times 10^{-5}} = \left(\frac{0.36}{0.30}\right)^x$$
$$1.2 = (1.2)^z \Rightarrow x = 1.$$

Thus the reaction is 1st order with respect to $[CH_3COCH_3]$

(ii) Overall order is 1+1=2

(iii) $rate = K[CH_3COCCH_3]^1[H^+]^1$

(iv) $Using\ exp't\ 5$

$7.1 \times 10^{-5} = K[0.36]^1[0.05]^1$

$\Rightarrow 7.1 \times 10^{-5} = 0.018K$

$\frac{7.1 \times 10^{-5}}{0.018} = K \Rightarrow K = 3.9 \times 10^{-3}$

Unit$=\frac{mol}{dm^3 s} \times \frac{dm^3}{mol} \times \frac{dm^3}{mol} = dm^3 mol^{-1} s^{-1}$

Hence $K = 3.9 \times 10^{-3} dm^3 mol^{-1} s^{-1}$

(v) **Colorimetry method** since iodine is coloured while iodide is colourless.

(d) A solution with similar intermolecular forces as in the separate components of the liquid. Or a solution which obeys Raoult's law.

(e) Molar mass of methanol=12+4+16=32

Number of moles$=\frac{30}{32} = 0.94$

Molar mass of ethanol=46

Number of moles$=\frac{45}{46} = 0.98$

Total number of moles=0.94+0.98=1.92

(ii) $X_{meth} = \frac{0.94}{1.92} = 0.49$

$X_{eth} = \frac{0.98}{1.92} = 0.51$ Or $1 - 0.49 = 0.51$

Where X, is the partial pressure of each component in the liquid. (or mole fraction)

$P_{meth} = X_{met}P^0_{met} = 0.49 \times 94 = 46.06mmHg$

$P_{eth} = X_{eth}P^0_{eth} = 0.51 \times 44 = 22.44mmHg$

(iii) $P_T = P_{meth} + P_{eth} = 46.06 + 22.44 = 68.49mmHg$

(iv) Mole fraction of methanol in vapour

$$y_{meth} = \frac{P_{meth}}{P_T} = \frac{46.06}{68.49} = 0.68$$

Where y is the partial pressure of each component in the vapour