L-Università ta' Malta

Marking Scheme
AM Chemistry

Main Session 2019
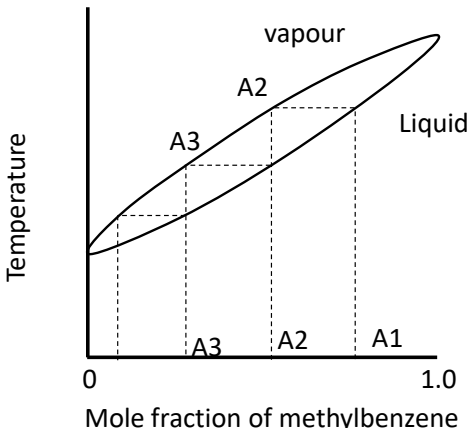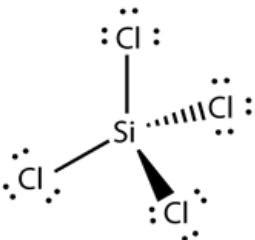
Paper I
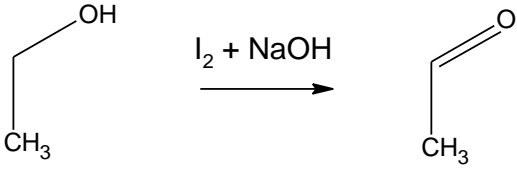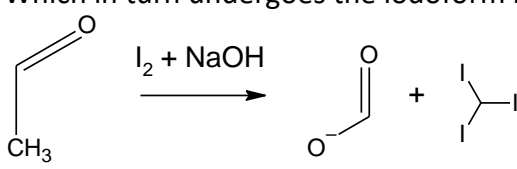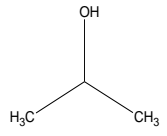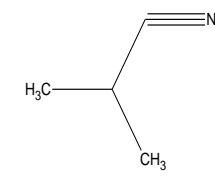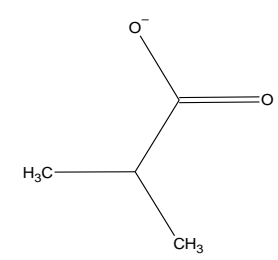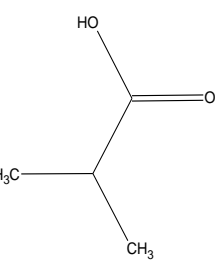
Question			Suggested Answer	Mark	Comments
1	a		Isotopes are variants of a particular chemical element which have the same atomic number	½	Also accept: Isotopes are variants of a particular chemical element which have the same number of protons
			but a different atomic mass	½	but a different number of neutrons
	b		$\left(\dfrac{0.337}{100}\times36\right)+\left(\dfrac{0.0630}{100}\times38\right)$ $+\left(\dfrac{99.600}{100}\times40\right)=39.985$	2	Deduct ½ mark if answer is not given to 3 decimal places. Award 1 mark if method of calculation is correct but final answer is wrong
	c	i	$^{39}_{18}\text{Ar} \rightarrow ^{39}_{19}\text{K} + ^{0}_{-1}\beta$	1	
		ii	Half-life is the time taken for the activity of a radioactive substance	½	
			to decrease by half	½	
		iii	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$	1	Also accept: [Ar]$4s^1$ [Ne] $3s^2 3p^6 4s^1$ [He] $2s^2 2p^6 3s^2 3p^6 4s^1$ Also award full marks if the candidate uses the 'electron-in-box' method.
			Total:	**6**	
2	a	i	An increase in pressure at constant temperature results in a shift of the equilibrium to the right	1	
			as on the right hand side there are fewer molecules of gas	1	
		ii	an increase in temperature at constant pressure results in a shift of the equilibrium to the left	1	
			in order to favour the endothermic reaction.	1	
	b		In order obtain a high yield of ammonia, the temperature should be low	½	
			However, the lower the temperature the lower rate of reaction.	½	
			Thus a compromise must be found to have a temperature which is low enough to have an acceptable yield, and high enough for the reaction to take an acceptable time.	1	
	c		$K_p = \dfrac{p(NH_3)^2}{p(N_2)\times p(H_2)^3}$	1	
	d		$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$	1	
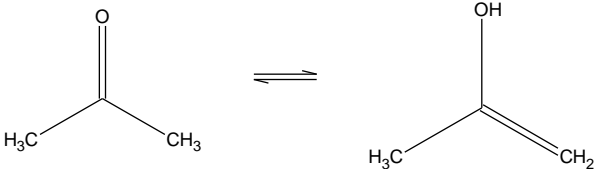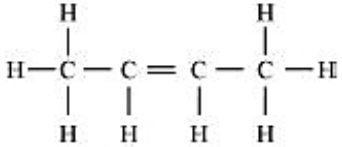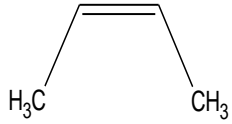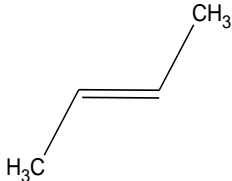
			Finding the concentration of ammonia RMM of NH$_3$: 14.0 + (1.0×3) = 17.0	½	
			17.0g = 1 mol 0.59g = ? mol		
			$\dfrac{0.59g}{17.0g} \times 1mol = 0.035mol$	½	
			In 100 cm^3 there are 0.035 mol In 1000 cm^3 there are ? mol		
			$\dfrac{1000cm^3}{100cm^3} \times 0.035mol = 0.35M$	½	Accept also: $k_b = \dfrac{\left[NH_4^+\right]\left[OH^-\right]}{\left[NH_3\right]}$
			$k_b = \dfrac{[x][x]}{[0.35 - x]}$ Assuming x is very small compared to 0.35. $0.35 - x \approx 0.35$	1	but, deduct 1 mark if assumption that x is small is not written specifically.
			$k_b \times 0.35 = x^2 = 1.8 \times 10^{-5} \times 0.35$		
			$x = \sqrt{6.30 \times 10^{-6}} = 7.94 \times 10^{-3}$	½	
			$pOH = -\log\left[OH^-\right]$ $pOH = -\log\left(7.94 \times 10^{-3}\right) = 2.10$	½ ½	
			$pH = 14 - pOH$ $pH = 14 - 2.10 = 11.90$	½ ½	
			Total:	**13**	
3	a	i	An ideal solution is a solution whose enthalpy of mixing is zero	1	
		ii	Raoult's law states that the saturated vapour pressure of a volatile component of a solution will be equal to its mole fraction multiplied by the vapour pressure of the pure solvent at the same temperature	½ ½	
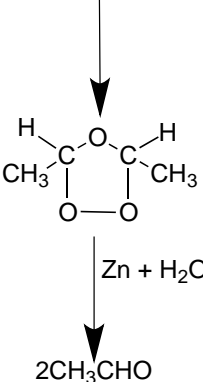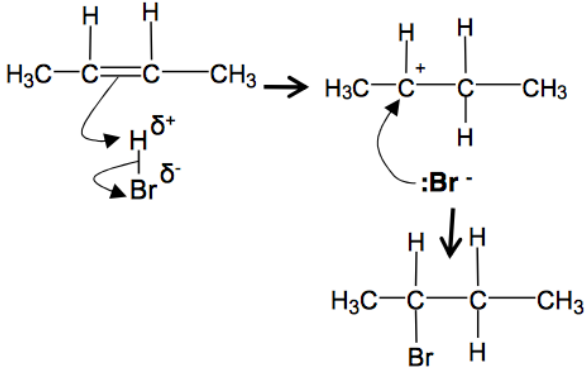
	b		Boiling a liquid mixture having a composition A1, results in a vapour with composition A2.	3 ½	Deduct ½ mark (each) if the vapour or liquid curves are not labelled Deduct ½ mark for each axis which is not labelled Deduct 1 mark if the general shape of the graph is incorrect
			Cooling of the vapour results in a liquid with composition A2.	½	
			Boiling of the liquid A2 results in a vapour with composition A3, on cooling, the vapour condenses back to a liquid with composition A3.	½	
			As these boiling-condensation steps continue, one would end with pure benzene vapour.	½	
	c		An zaeotropic mixture is formed because ethanol and water show a large positive deviation from Raoult's law.	1	
			It cannot be fully separated as the liquid and vapour of an azeotropic mixture has the same composition.	1	
	d		For two non-missible liquids, the total vapour pressure is equal to the sum of the individual saturated vapour pressure of the pure liquids in the mixture	1	
			Boiling occurs when the total vapour pressure is equal to the atmospheric pressure (normally 1 atmosphere).	½	
			Thus, when the total vapour pressure of the mixture is equal to the atmospheric pressure, the mixture will boil.	½	
			Total:	**11**	
4	a	i	CCl_4	½	
			liquid	½	
		ii	$SiCl_4$	½	
			Liquid	½	

		iii	PCl_3	½	Also accept PCl_5
			Liquid	½	Accept solid if the answer to the previous question is PCl_5
	b		Silicon (IV) chloride	1	Also accept: Silicon tetrachloride Award only ½ mark for: Silicon chloride
	c		Silicon tetrachloride may be prepared by the chlorination of ferrosilicon.	2	Award full marks for any other correct answer.
	d		$SiCl_4$ (l) + $2H_2O$ → SiO_2 (s) + 4HCl (aq)	2	Deduct ½ mark if the equation is not balanced well. Deduct ½ mark for each incorrect designation of physical state except for $SiCl_4$. Deduct 1 mark for each incorrect chemical.
	e		CCl_4 does not have empty (low energy) d-orbitals so it cannot form complexes and react. $SiCl_4$ does.	1 ½ ½	
	f			2	Deduct 1 mark for the absence of the wedge and dots. Deduct 1 mark for the incorrect organization of the bonds around the central atom. Do not deduct marks if Cl electrons are not shown.
	g		Even though the individual bonds are slightly polar, they are organized symmetrically around the central Carbon atom, resulting in a net dipole moment of zero (the dipoles cancel out).	1 1 1	
			Total:	**15**	
5	a	i	Shows both typical acid and basic reactions.	1	Or equivalent wording.
		ii	$Al_2O_3(s)$ + 6HCl(aq) → $2AlCl_3(aq)$ + $3H_2O(l)$	1	Or equivalent acid. Deduct ½ mark if the equation is not balanced well. Deduct ½ mark for each incorrect designation of physical state. Award no marks if there are mistakes in chemical formulae.
			$Al_2O_3(s)$ + 2NaOH(aq) + $3H_2O(l)$ → $2NaAl(OH)_4(aq)$	1	Or equivalent alkali. Deduct ½ mark if the equation is not balanced well. Deduct ½ mark for each incorrect designation of physical state. Award no marks if there are mistakes in chemical formulae.

	b	$[Al(H_2O)_6]^{3+}$ forms.	1	
		$[Al(H_2O)_6]^{3+}(aq) + H_2O (l) \rightleftharpoons [Al(H_2O)_5(OH)]^{2+} (aq) + H_3O^+(aq)$	2	
	c	Aluminium undergoes Passivation i.e. the formation of a hard oxide layer on Aluminium which prevents further corrosion. Iron does not form such a layer.	1 ½ ½ 1	
d	i	$2\ Al + 3\ Cl_2 \rightarrow 2\ AlCl_3$	1	Deduct ½ mark if the equation is not balanced well. Deduct all marks if there is a mistake in the any chemical formula.
	ii		2	Accept also answers in which only the dative electrons are shown.
e	i	Alum is a double salt of aluminium Having the general formula $MAl(SO_4)_2.12H_2O$ where M could be any monovalent cation.	1 1	
	ii	$KAl(SO_4)_2.12H_2O$ $NaAl(SO_4)_2 \cdot 12H_2O$	½ ½	Accept other correct alums examples
Total:			**15**	

6	a	X: ethanoic acid	2	For X and Y: Award 1½ marks for the identification of the correct compound. Award ½ a mark for: giving the systematic name (if identification of the molecule is done by giving the structural formula) **OR** the structural formula (if identification of the molecule is done by giving the systematic name)
		Justification from IR: C-O at about 1300 cm^{-1} C=O at about 1720 cm^{-1} OH at about 3300 – 2700 cm^{-1}	1	
		Y: ethanol	2	
		Justification from IR: C-O at about 950 cm^{-1} OH at about 3200 – 3500 cm^{-1}	1	
		Z: ethyl ethanoate	1	For Z: Award ½ mark for the correct name Award ½ mark for the correct structural formula

	b		X can be made by oxidation of ethanal using acidified $K_2Cr_2O_7$ and refluxing.	1	Also accept other suitable oxidising agents.
			Y can be made by the reduction of ethanal using aqueous $NaBH_4$.	1	Also accept other suitable reducing agents.
	c	i	$2CH_3CO_2H + Na_2CO_3 \rightarrow 2CH_3CO_2Na + CO_2 + H_2O$	1	Reduce ½ mark if equation is not balanced
		ii	effervescence a colourless gas is evolved	½	Accept also bubbling
			The gas can be identified as CO_2 since it turns lime water milky	½	
	d		Ethanol is first oxidised to ethanal	½	Award 2 marks if candidates go directly from the alcohol to the correct products
				1	
			Which in turn undergoes the iodoform reaction	½	
				1	
			Total:	**14**	
7	a			1	Award ½ mark instead of 1 if the systematic name is given and not the structural formula as requested.
			B:	1	
			C:	1	
			D:	1	
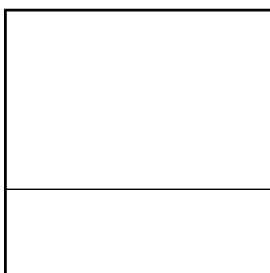
b	r: H_2 s: Raney Ni t: PCl_5 u: KCN v: OH^- (aq) w: $LiAlH_4$	½ ½ ½ ½ ½ ½	Award full marks if r and s are replaced by another reducing agent Also accept PCl_3; HCl ($ZnCl_2$); $SOCl_2$
c	The term tautomerism refers to isomers of a compound which differ only in the position of the protons and electrons. The tautomeric forms of propanone are as follows: 	1 1	
d	Tollens's test In the case of the tollen's test, propanal will be oxidised to a propanoate ion Forming metallic silver (silver mirror) in the process Propanone will not react with tollen's reagent	1 1 ½ ½	Also except: Fehling's test and any other correct test This should reflect the chosen test
	Total:	**12**	
8	a	The molecular weight of Aldehyde F is 44	1	
	b	m/e 15: $[CH_3]^+$ m/e 29: $[CHO]^+$ m/e 44: $[CH_3CHO]^+$	1 1 1	Deduct ½ mark if the fragment is not written as a positive ion.
	c	 The fact that ozonolysis results in one product indicates that alkene B is symmetrical The initial alkene has four carbons since the aldehyde produced from ozonolysis has two carbons. Alkene E can exist as: Cis-but-2-ene **OR** Trans-but-2-ene	1 ½ ½ ½ ½ ½ ½	Deduct ½ mark if systematic name is given instead of the structural formula as requested
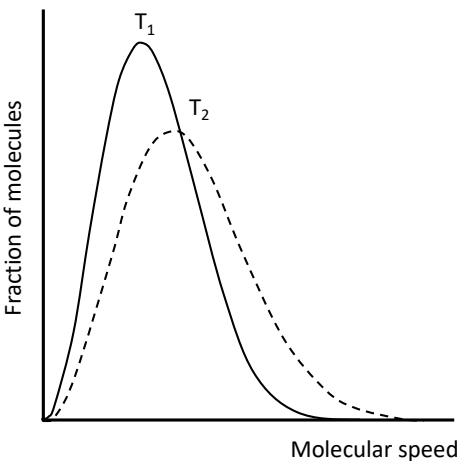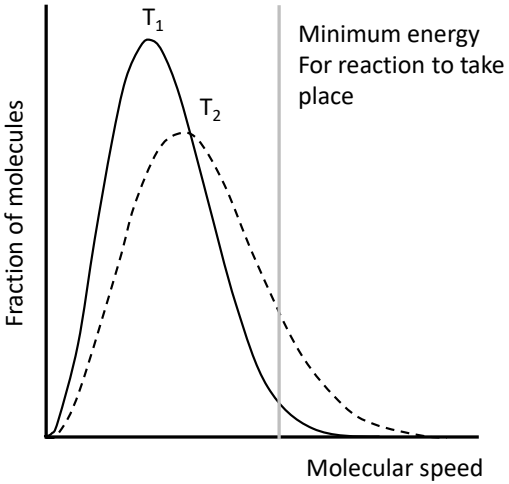
d		$H_3C-CH=CH-CH_3 + O_3$ ↓ H, C-O-C, H structure with CH_3, CH_3, O—O Zn + H_2O ↓ $2CH_3CHO$	2	1 mark for the ozonide intermediate 1 mark for the reagents
e		Mechanism: $H_3C-C=C-CH_3$ with H atoms, $H^{\delta+}$, $Br^{\delta-}$ → $H_3C-C^+-C-CH_3$ with $:Br^-$ → $H_3C-C-C-CH_3$ with Br, H	4	Do not deduct any marks if the candidate started from an incorrect alkene as was identified in question (c) above. Award: ½ mark for each correct arrow (maximum of 1½) 1 mark for the correct intermediate structure 1 mark for the final product structure. Award ½ mark for showing partial charges
			Total:	**14**

Paper II
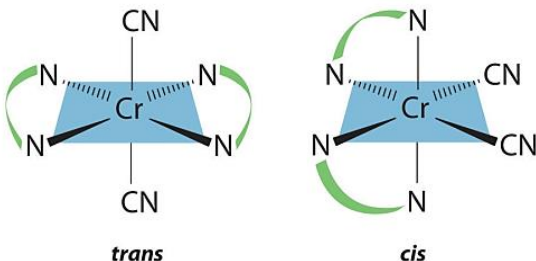
Question			Suggested Answer	Mark	Comments
1	a	i	The standard bond enthalpy of chlorine gas is the energy required	½	Deduct 2 marks if the correct definitions are given but are not related to chlorine and/or sodium chloride Award full marks if equations are given instead of text which shows the same reasoning as the answer given here
			To break one mole of Cl-Cl bonds	½	
			On the other hand, the standard atomisation enthalpy for chlorine is the energy required	½	
			To form 1 mole of gaseous chlorine atoms	½	
			From the element in its standard state (i.e. Cl_2 (g)).	½	
			In the case of chlorine, the value of the standard bond dissociation enthalpy will be double that of the standard atomisation enthalpy	½	
		ii	The standard enthalpy of formation of sodium chloride is the change in heat energy	½	
			When one mole of sodium chloride is formed	½	
			Form its elements	½	
			in their standard state (i.e. Na(s) and Cl_2(g)).	½	
			On the other hand, the standard lattice enthalpy for sodium chloride is the heat evolved	½	
			When 1 mole of solid crystal is formed	½	
			from gaseous ions.	½	
			Note that in all cases, measurements would have be carried out under standard conditions.	½	
	b			5	½ mark for each correct equation 2 marks for the correct direction of the arrows
	c			3	½ mark for each correct equation ½ mark for each direction of the arrows

			$\Delta H_2 + \Delta H_1 = \Delta H_3$	½	Deduct ½ mark if the units are not given or incorrectly given
			$\Delta H_2 = \Delta H_3 - \Delta H_1$		
			$\Delta H_2 = -424 + (-364) - (+3.87)$	½	
			$\Delta H_2 = -791.87$ KJ mol^{-1}	1	
	d		For a process to be spontaneous ΔG must be negative	1	
			Where, $\Delta G = \Delta H - T \Delta S$	1	
			Since ΔH is positive, ΔS for the dissolution of NaCl must be positive at room temperature since the process is spontaneous.	1	
			Total:	**20**	
2	a	i	$K_{sp} = [Ag^+][Cl^-]$	1	
		ii	$\sqrt{1.8 \times 10^{-10}} = 1.3 \times 10^{-5}$ mol dm^{-3}	2	Deduct 1 mark for missing working. Deduct ½ mark for missing units in final answer.
		iii	The solubility will increase.	1	Or equivalent. Also accept chemical equations
			Ammonia forms a soluble complex with Ag$^+$,	½	
			keeping it from precipitating.	½	
	b		Acid strength increases down group 7.	½	
			HF has a short, strong covalent bond (and high hydrogen bonding) due to the smaller size of the Fluorine atom.	1	
			HI has the longest, weakest bond.	1	
			This makes it easier for HI to dissociate to give H$^+$ than HF.	½	
	c		HCl does not react with sulfuric acid.	½	
			HBr reacts, forming sulfur dioxide and Br$_2$.	½	
			HI reacts, forming Hydrogen sulfide and I$_2$.	½	
			$H_2SO_{4\,(aq)} + 2\,HBr_{(aq)} \rightarrow SO_{2\,(g)} + H_2O_{(l)} + Br_{2\,(aq)}$	1½	Award full marks for ionic equation. Reduce ½ mark if half equations are given instead of full equation
			$H_2SO_{4\,(aq)} + 8\,HI_{(aq)} \rightarrow H_2S_{(g)} + 4\,H_2O_{(l)} + 4\,I_{2\,(aq)}$	1½	
			HI is a much strong oxidising agent than HBr.	½	
			HCl is a very weak oxidising agent, and so it does not react.	1	
	d		The oxidising agent (potassium dichromate) is reacted with excess (acidified) KI.	½	
			This releases I$_2$,	½	
			which is then titrated against a standard solution of sodium thiosulfate.	½	
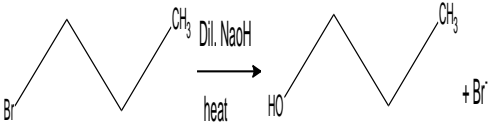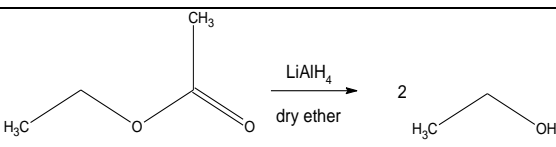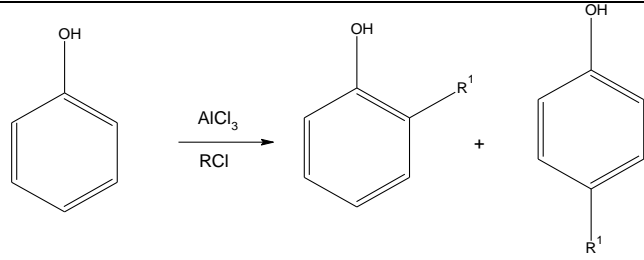
			The concentration of the oxidising agent in the original solution can thus be determined	½	
			$7\ H_2SO_4\ _{(aq)} + K_2Cr_2O_7\ _{(aq)} + 6\ KI\ _{(aq)} \rightarrow 2\ Cr_2(SO_4)_3\ _{(aq)} + 7\ H_2O\ _{(l)} + 3\ I_2\ _{(aq)} + K_2SO_4\ _{(aq)}$	2	Award full marks for ionic equation or half equations. Deduct 1 mark for an unbalanced equation
			$I_2\ _{(aq)} + 2\ Na_2S_2O_3\ _{(aq)} \rightarrow Na_2S_4O_6\ _{(aq)} + 2\ NaI\ _{(aq)}$	2	Deduct ½ mark if the state symbols are not given
			Total:	**20**	
3	a		$x_B = \dfrac{100 - 75}{100} = 0.25$	½	
			$P_B = x_B P_T$	½	
			$P_B = 0.25 \times 150$ $P_B = 37.5\,KPa$	1	Deduct ½ mark if units are not given or incorrectly given.
	b	i	 PV/nRT 1 P (atm)	1	Deduct ½ mark if the value of '1' on the y-axis is not given
		ii	For an idal gas, PV = nRT.	½	
			Thus the ratio between PV and nRT should be 1 for an ideal gas	½	
			At low pressure, the y-axis of the plots provided has a value of approximately 1	½	
			Which means that nitrogen behaves as an ideal gas at low pressures	1	
			At high pressures or	½	
			low temperatures, this ideal behaviour is lost	½	
			This is because the behaviour of an ideal gas is based on a set of assumptions i.e.	½	
			The volume of the atoms is negligible when compared to the volume they occupy	½	
			This assumption fails at high pressures	½	
			There are no intermolecular forces of attraction between different molecules of the gas	½	
			This assumption is incorrect at low temperatures	½	

c		i	Fraction of molecules (y-axis), Molecular speed (x-axis), T_1, T_2	3	Award ½ mark for correctly labelling each axis (for the x-axis also accept kinetic energy or energy) Award 1 mark for the distribution of each temperature Deduct ½ mark if the distributions of T_1 and T_2 have same height or the distribution of T_2 is higher than T_1
		ii	For a reaction to occur, the molecules taking part in the reaction must collide with each other	1	
			At the right orientation	½	
			And they must have enough energy	½	
			The molecular distribution diagram, see below, shows that at low temperatures (T1) only a small fraction of the molecules will have enough energy	½	
			Note that the area under the curve represents the number of molecules	½	
			However, as the temperature is increased (T2), the fraction of molecules having the right amount of energy increases	½	
			Meaning that the rate of reaction increases	½	
			Fraction of molecules (y-axis), Molecular speed (x-axis), T_1, T_2, Minimum energy For reaction to take place	1	
		iii	Addition of a catalyst results in the lowering of the activation energy,	1	Award 2 marks if candidates mention how a catalyst lowers the activation energy by bond formation to reactants, whilst not refereeing to the energy distribution plot.
			Thus referring to the figure below, the energy needed will shift to lower values (at a particular temperature)	½	
			An thus more molecules will have enough energy for the reaction to take place	½	
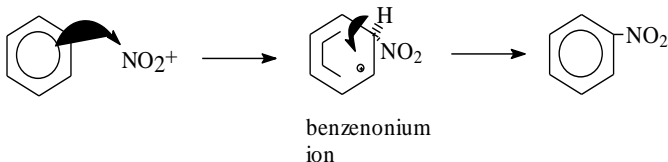
				1	
			Total:	**20**	
4	a		$1s^2\ 2s^2 2p^6\ 3s^2\ 3p^6\ 3d^5 4s^2$	1	
			Oxidation states: (VII), (VI), (IV), (II)	2	(III) also acceptable. ½ mark each.
			Since they can easily change oxidation states, they can oxidise/reduce one of the reactants to provide an additional mechanism for the reaction to occur.	2	Also acceptable: Transition metals have 3d electrons which can be used to adsorb a reactant to a surface. This increases the concentration of the reactants at the surface while decreasing the energy in their bonds. Both help the reaction to occur.
	b		A complex ion is made of a central atom (transition metal atom for example)	½	
			surrounded by a number of ligands.	½	
			The ligands have at least one lone pair of electrons	½	
			with which they form a dative bond with the central atom.	½	
			When a transition metal element is ligated in a complex ion, the energy levels of its sub-orbitals do not remain the same (degenerate).	½	
			They split into sub-shells of different energy.	½	
			When light shines on the ligand it can excite an electron to a sub-shell of higher energy.	½	
			This absorbs part of the light, reflecting light of a different colour back.	½	
	c		Any correct example and drawing that makes sense e.g. $[CuCl_4]^{2-}$	4	Deduct 1 mark if the tetrahedral geometry is not drawn correctly.
	d		Bidentate ligands are ligands which donate two pairs of electrons to the same central atom.	1	
			Any correct named example (ex: oxalate).	1	

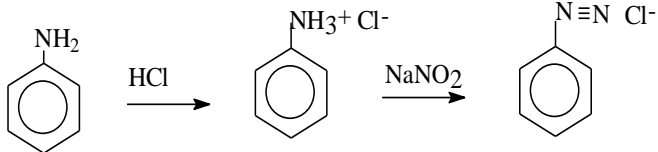|					
			The correct structure for the named example.	1	Do award ½ mark for the structure if the structure is drawn but not named or wrongly named.
	e		Stereoisomers cannot be superimposed on their mirror images (even after rotation).	1	
			Any correct example drawn. E.g.	3	
			Total:	**20**	
5	a	i	$Pt \mid 2Br^{-} (aq), Br_2(aq) \mid\mid 2Ce^{4+} (aq), 2Ce^{3+}(aq) \mid Pt$	2	Deduct 1 mark if Pt is not included Deduct ½ mark for each incorrect phase boundary
		ii	$2Ce^{4+}(aq) + 2Br^{-} (aq) \rightarrow 2Ce^{3+} (aq) + Br_2(aq)$	1	Deduct ½ mark for each incorrect physical state. Deduct ½ mark for a reaction which is not balanced.
		iii	$E^o = E^o(reduction) + E^o (oxidation)$	1	
			$= 1.61 + (-1.07)$	1	
			$= + 0.54$ V	1	Deduct ½ mark if units are not given or given incorrectly
		iv	Oxidation agent is a substance that is reduced	½	
			whilst a reducing agent is a substance that is oxidised.	½	
			The more positive the standard electrode potential the more prone a substance is of being reduced,	½	
			meaning it is a better oxidising agent.	½	
			In this case, the half equation: $Ce^{4+}(aq) + e^{-} \rightarrow Ce^{3+}(aq)$ has the most positive standard electrode potential, meaning that for this system Ce^{4+} will accept electrons with most ease to be reduced to Ce^{3+}.	½	
			This makes Ce^{4+} the strongest oxidation agent.	½	
			On the other hand, the half equation: $\frac{1}{2} Br_2(aq) + e^{-} \rightarrow Br^{-} (aq)$ has the least positive standard electrode potential, meaning that for this system Br^{-} will give electrons with most ease to be oxidised to Br_2.	½	
			This makes Br^{-}, the strongest reducing agent.	½	

			For the Fe^{2+}/ Fe half-cell and Zn^{2+}/Zn half cell. When these two half cells are connected together, the Fe^{2+}/ Fe half-cell acts as the cathode,	½	
			meaning that Fe^{2+} will be reduced to Fe.	½	
			While the Zn^{2+}/Zn half-cell will act as the anode	½	
			meaning that Zn will be oxidised to Zn^{2+}.	½	
			Therefore, the Fe^{2+}/ Fe half-cell must have a more positive standard electrode potential when compared to the Zn^{2+}/Zn half-cell.	½	
	b		For the Fe^{2+}/ Fe half-cell and Cu^{2+}/Cu half cell When these two half cells are connected together, the Fe^{2+}/ Fe half-cell will act as the anode,	½	
			meaning that Fe will be oxidised to Fe^{2+}.	½	
			While the Cu^{2+}/Cu half-cell will act as the cathode	½	
			meaning that Cu^{2+} will be reduced to Cu.	½	
			Therefore, the Cu^{2+}/Cu half-cell must have a more positive standard electrode potential than the Fe^{2+}/ Fe half-cell.	½	
			Thus in this case, Cu^{2+}/Cu half-cell must have the most positive electrode potential,	½	
			followed by the Fe^{2+}/ Fe half-cell,	½	
			whilst the Zn^{2+}/Zn half-cell must have the least positive standard electrode potential.	½	
			Thus the strongest reducing agent (i.e. the one which is oxidised most easily) is Zinc.	½	
	c		Magnesium oxidises more readily than iron.	½	
			Thus, when magnesium is attached to an iron structures underwater a galvanic cell forms whereby iron becomes the cathode	½	
			and therefore does not corrode.	½	
			On the other hand, magnesium becomes the anode,	½	
			which corrodes.	½	
			This is called sacrificial protection	½	
			Total:	**20**	
6	a	i	Barium peroxide (excess) is reacted with sulfuric acid at 0°C.	1	
			Since Barium peroxide and barium sulfate are solids, the excess reactant and the unwanted product can be filtered off.	1	
			$BaO_{2\,(s)} + H_2SO_{4\,(aq)} \rightarrow BaSO_{4\,(s)} + H_2O_{2\,(aq)}$	2	Deduct ½ mark for each incorrect physical state. Deduct 1 mark for each incorrect chemical. Deduct 1 mark for a reaction which is not balanced.

		ii	Sodium sulfide is reacted with any dilute acid.	1	
			H_2S can be collected in a gas syringe (or by downward delivery).	1	
			$Na_2S_{(s)} + HCl_{(aq)} \rightarrow H_2S_{(g)} + 2\ NaCl_{(aq)}$	2	Deduct ½ mark for each incorrect physical state. Deduct 1 mark for each incorrect chemical. Deduct 1 mark for a reaction which is not balanced.
		iii	D_2O is added to CaC_2 in a controlled fashion	1	
			C_2D_2 is collected over water	1	
			$CaC_2(s) + 2D_2O(l) \rightarrow Ca(OD)_{2(aq)} + C_2D_{2(g)}$	2	Deduct ½ mark for each incorrect physical state. Deduct 1 mark for each incorrect chemical. Deduct 1 mark for a reaction which is not balanced.
	b	i	$2\ Cr_{(s)} + 6\ NaOH_{(aq)} + 6\ H_2O_{(l)} \rightarrow 2\ Na_3[Cr(OH)_6]_{(aq)} + 3\ H_{2\ (g)}$	2	Award full marks if ionic equation is given. Award full marks if the reaction is split into steps. Deduct ½ mark for each incorrect physical state. Deduct 1 mark for each incorrect chemical. Deduct 1 mark for a reaction which is not balanced.
		ii		2	
		iii		2	Accept any other correct reducing agent.
		iv		2	Award 1 mark if only the ortho (or para) substituent is given. Do not award any marks if the meta substituent is given.
			Total:	**20**	

7	a	i	Award 1 mark for each intermediate and ½ mark for each reagent and condition.	4	Award full marks for other correct pathways. Deduct ½ mark for each incorrect/ omitted reagent. Deduct 1 mark for each incorrect/ omitted step).
		ii	Award 1 mark for each intermediate and ½ mark for each reagent and condition.	4	
		iii	Award 1 mark for each intermediate and ½ mark for each reagent and condition	4	
	b		A: $CH_3CH_2CH_2CN$ B: $CH_3CH_2CH_2COOH$ C: $CH_3CH_2CH_2COOCH_2CH_2CH_3$ D: $CH_3CH_2CH_2MgBr$ E: $CH_3CH_2CH_2OH$ G: $CH_3CH_2CH(OH)CH_2CH_2CH_3$ x: $Cr_2O_7{}^{2-}$ y: H^+	8	Award 1 mark for each correct structure / reagent. Award 2 marks if the term acidified dichromate is stated for reagents x and y.
			Total:	**20**	
8	a		Concentrated sulfuric acid is carefully added to concentrated nitric acid, placed in a cooled round bottom flask, while stirring.	½	
			To the well stirred, cooled mixture of concentrated acids, benzene is added dropwise	½	
			With the temperature being maintained between 50 and 55ºC while adding the benzene.	½	

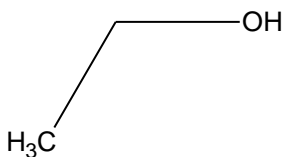|			A reflux condenser is attached to the round bottom flask containing the reaction mixture, and the reaction is allowed to continue for 30 minutes at a temperature of 60°C.	½	
			Nitrobenzene is then purified as follows: The reaction mixture is poured into a large volume of cold water and mixed.	½	
			Two layers forms (nitrobenzene being the bottom layer)	½	
			And the top aques layer is decanted	½	
			Nitrobenzene is transferred to a separating funnel and washed with water	½	
			Followed by two washing with dilute sodium carbonate.	½	
			Calcium chloride is then added to remove any traces of water.	½	
			Nitrobenzene is then filtered and distilled.	½	
			The mechanism for this reaction is given below: 1 mark for NO_2^+ 1½ marks for intermediate ½ mark for structure of nitrobenzene 1 mark for arrows (½ mark for each correct arrow)	4	
			The intermediate benzenonium ion is unstable	½	
			because the aromatic character of benzene has been lost (i.e. the delocalisation of 6 π electrons over the 6 C-C bonds has been destroyed).	½	
			The intermediate loses H^+ to regain aromatic character and form the product	½	
	b		Nitrobenzene is added to grandulated tin in a round bottom flask.	½	
			HCl is added to slowly, making sure that the temperature does not rise above 60°C	½	
			The reaction is then allowed to proceed at 60°C for 15 minutes	½	
			After which, the temperature is increased to 100°C and the reaction is allowed to proceed for a further 15 minutes.	½	

			The reaction mixture is then allowed to cool to room temperature.	½	
			Alkali is then added to the mixture to neutralise any unreacted HCl and liberate free phenylamine form its salt	½	
			Steam is pushed into the mixture and the steam distillate is distilled off	½	
			The steam distillate is placed in a separating funnel, and	½	
			NaCl is added to reduce the solubility of phenylamine in the aqueous layer	½	
			The aqueous and organic layers are separated and,	½	
			further solvent extraction is carried out on the aqueous layer to reduce losses.	½	
			Phenylamine is then dried using anhydrous sodium sulphate	½	
			The solid sodium sulphate is then filtered off.	½	
			The phenylamine is finally distilled under reduced pressure	½	
	c			2	

Paper III

Question		Suggested Answer	Mark	Comments
1	b	ODD titre value: 19.50 cm^3 EVEN titre value: 22.07 cm^3	20	Award 20 marks if mean titre value is within 0.12 cm^3 of the actual value Award 15 marks if mean titre value is within 0.17 cm^3 of the actual value Award 10 marks if mean titre value is within 0.22 cm^3 of the actual value Deduct 5 marks if the readings that were used to work out the average are not within 0.1 cm^3 of each other.
	c	**ODD:** Moles of hydrochloric acid = (0.10 X 25)/1000 = 2.50 x 10^{-3} Moles of sodium hydroxide -> 2.50 x 10^{-3} in 19.50mL Hence, concentration of NaOH is (1000 X 2.50 x 10^{-3}) / 19.50 = 0.128M **EVEN:** Moles of hydrochloric acid = (0.10 X 25)/1000 = 2.50X10^{-3} Moles of sodium hydroxide -> 2.50 X10^{-3} in 22.07mL Hence, concentration of NaOH is (1000X2.5X10^{-3})/22.07 = 0.113M	4	
	d	ODD titre value: 22.51 cm^3 EVEN titre value: 25.47 cm^3	20	Award 20 marks if mean titre value is within 0.1 cm^3 of the actual value. Award 15 marks if mean titre value is within 0.15 cm^3 of the actual value. Award 10 marks if mean titre value is within 0.2 cm^3 of the actual value. Deduct 5 marks if the readings that were used to work out the average are not within 0.1 cm^3 of each other.
	e	**ODD:** Moles of sodium hydroxide = (0.128 X 22.51)/1000 = 0.00289 moles Hence moles of H = 0.00289 moles in 25mL	6	

			Hence there are (0.00289 X 1000)/25 moles in 1L = 0.115 moles Hence 23.52 g are equivalent to 0.115 moles molar mass=23.50/0.115 = 204 g/mol Mass of H = 165 + X = 204 X = 204 - 165 = 39 g/mol **EVEN:** Moles of sodium hydroxide = (0.113 X 25.47)/1000 = 0.00289 moles Hence moles of H = 0.00289 moles in 25mL Hence there are (0.00289 X 1000)/25 moles in 1L = 0.115 moles Hence 23.52 g are equivalent to 0.115 moles molar mass = 23.50/0.115 = 204 g/mol Mass of H = 165 + X = 204 X = 204 - 165 = 39 g/mol		
			Total:	**50**	
2	a		Observation: White residue and colourless filtrate	1	Do not award marks if candidate states that a component is soluble in water.
			Inference: Mixture contains at least one component that is insoluble in water	2	
	b	i	Observation: Effervescence Lime water turns milky Solid dissolves to give clear solution Inference: CO_2 evolved Carbonate present. Solid cannot be hydrogen carbonate as the solid is soluble in water	½ ½ ½ ½ 1 1	
		ii	Observation: White precipitate Soluble in excess Inference: Amphoteric metal ion present Al^{3+}, Pb^{2+}, Zn^{2+} Metal hydroxide forms forming a soluble complex in excess NaOH	½ ½ 1 ½ ½	
		iii	Observation: White precipitate insoluble in excess	1	

		iv	Inference: $Pb(OH)_2$ or $Al(OH)_3$ formed Pb^{2+} or Al^{3+} present	1 1	
			Observation: White precipitate Which dissolves on heating But reappears on cooling Inference: Precipitate is probably lead(II) chloride Which is soluble in water at elevated temperature But insoluble at room temperature	1 ½ ½ 1 1 1	
	c	i	Observation: Brown ring at base of tube Inference: Formation of $[Fe(NO)(H_2O)_5]^{2+}$ Nitrate(V) present	1 1 1	Also accept brown coloration noted
		ii	Observation: Transient streaks of lilac Inference: Potassium ion present Ions present: Cations: Pb^{2+} K^+ Anions: CO_3^{2-} NO_3^-	1 1 ½ ½ ½ ½	
			Total:	**25**	
3	a		Observation: Non-sooty, pale blue flame Inference: Indicates saturation Absence of Aromatic groups	1 1 1	
	b		Observation: No reaction Inference: Not an aldehyde Or ketone	1 1½ 1½	
	c		Observation: Pale yellow precipitate	1	

		Inference: OH group	1	
		Adjacent to a methyl group	1	
		Ethanol or	1	
		A 2-ol present	1	
	d	Observation: Orange solution to green solution.	1	
		Orange precipitate with 2,4-DNPH	1	
		Inference: OH group oxidised to carbonyl	1	
		Which reacts with 2,4-DNPH	1	
		To form the orange precipitate	1	
	e	Observation: Fruity smell	2	
		Inference: Indicative of ester formation	2	
		Therefore alcohol present	1	
		Possible structure of P	2	
				If proposed structure has more than 6 carbon, award 1 mark.
		Systematic name of p	1	
		ethanol		
		Total:	**25**	