Past Papers Advanced Higher Chemistry

2015 Marking Scheme

Grade Awarded	Mark Required		% candidates achieving grade
	(/125)	%	
A	89+	71.2%	32.5%
B	75+	60.0%	22.9%
C	62+	49.6%	21.7%
D	55+	44.0%	8.3%
No award	<55	<44.0%	11.8%

Section:	Multiple Choice	Extended Answer	Investigation
Average Mark:	29.4 /40	33.8 /60	15.0 /25

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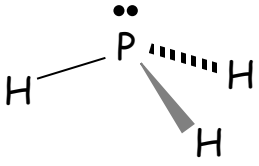
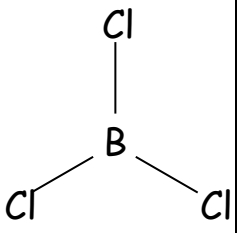
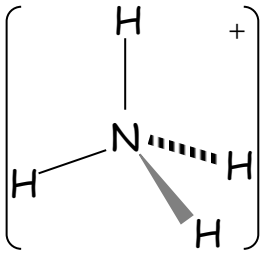
MC Qu	Answer	% Pupils Correct	Reasoning
1	C	80	

EM Radiation	Gamma	X-ray	UV	Visible	Infrared	Microwave	Radio & TV
Velocity	$3x10^8 m\ s^{-1}$	$3x10^8 m\ s^{-1}$	$3x10^8 m\ s^{-1}$	$3x10^8 m\ s^{-1}$	$3x10^8 m\ s^{-1}$	$3x10^8 m\ s^{-1}$	$3x10^8 m\ s^{-1}$
Wavelength	short ←						→ Long
Frequency	high →						Low

2	D	92	☒A Sr= $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 5s^2$ ∴ $Sr^{2+} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ ☒B Se= $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$ ∴ $Se^{2-} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ ☒C As= $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3$ ∴ $As^{3-} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$ ☑D Zr= $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^2 5s^2$ ∴ $Zr^{3+} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^1$
3	D	91	☒A Each line is a particular wavelength of light from a particular energy difference ☒B Electrons moving up a level absorb energy not release energy ☒C The visible spectrum lies between the wavelengths 450nm – 700nm ☑D Excited electrons dropping down release exact wavelengths as energy is released
4	A	88	☑A KCl electronegativity difference = (3.0-0.8) = 2.2 ∴ most ionic character ☒B NaI electronegativity difference = (2.6-0.9) = 1.7 ☒C BH_3 electronegativity difference = (2.2-2.0) = 0.2 ☒D PH_3 electronegativity difference = (2.2-2.2) = 0.0 ∴ least ionic character

5	B	77	A	B	C	D
			Co^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$			
			Metals rarely form covalent bonds	pyramidal	trigonal	tetrahedral

6	C	73	☒A BH_3 has a trigonal planar shape. ☒B CH_3^+ has a trigonal planar shape. ☑C CH_3^- has a trigonal pyramidal shape. Ammonia NH_3 has a trigonal pyramidal shape. ☒D CO_3^{2-} has resonance structures but not in a trigonal pyramidal shape.
7	C	90	☒A Group 3 elements like boron produce p-type semiconductors when added to Si ☒B Group 4 elements like carbon do not produce semiconductors when added to Si ☑C Group 5 elements like arsenic produce n-type semiconductors when added to Si ☒D Group 3 elements like aluminium produce p-type semiconductors when added to Si
8	D	80	☒A calcium salts give an orange flame colour ☒B oxides do not release hydrogen gas when added to water ☒C calcium salts give an orange flame colour ☑D potassium salts give off a lilac flame colour and hydrides release hydrogen gas forming a strongly alkaline solution when added to water
9	B	55	Tetraamminedichloridocopper(II) = $[Cu(NH_3)_4Cl_2]$

Tetraammine (no. of ligands) dichlorido (no. of ligands) copper (metal name) (II) (Charge on metal ion)

NH_3 ligand; Cl^- ligand; Ligands in formula are listed

Neutral ligands include:		Negative Ligands include:		Central Ion:	Charge:
Ligand	Name	Ligand	Name	Positive Complex: metals keep their name Negative Complex: Metals end in ATE e.g. Cuprate, Ferrate, Cobaltate	Charge of central ion is converted into roman numerals and put in brackets
OH_2	aqua	Chloride Cl^-	chlorido		
NH_3	ammine	Cyanide CN^-	cyanido		
CO	carbonyl	Nitrite NO_2^-	nitrito		

10	C	81	Write down the main species involved in the reaction: ClO_3^- → Cl^- Add H_2O to other side to balance O atoms: ClO_3^- → $Cl^- + 3H_2O$ Add H^+ ions to other side to balance H atoms: $ClO_3^- + 6H^+$ → $Cl^- + 3H_2O$ Add e^- to most positive side to balance charge: $ClO_3^- + 6H^+ + 6e^-$ → $Cl^- + 6H_2O$
11	A	90	☑A solubility of X in each solvent varies differently at different temperatures ☒B volume of water does not alter the partition coefficient ☒C mass of X will separate between the layers according to the partition coefficient ☒D conc of X will separate between the layers according to the partition coefficient
12	C	67	☒A silica is the solid which the stationary phase (non-polar liquid) is coated to ☒B silica is the solid which the stationary phase (non-polar liquid) is coated to ☑C helium is the mobile phase and non-polar liquid is the stationary phase ☒D helium is the mobile phase which carries the hydrocarbons through the column
13	B	77	☒A buffer: salt of a weak acid (sodium borate) dissolved in a weak acid (boric acid) ☑B buffers need a weak acid but nitric acid is a strong acid ☒C buffer: salt of a weak acid (sodium benzoate) dissolved in a weak acid (benzoic acid) ☒D buffer: salt of a weak acid (sodium propanoate) dissolved in a weak acid (propanoic acid)
14	D	27	☒A additional water should allow more solid to be dissolved ☒B the pH of a buffer remains same when diluted ☒C a tenfold dilution would increase pH number by 1 ☑D the pH of a weak acid will increase after a tenfold dilution but not by 1
15	B	83	❶ $BN + 1\frac{1}{2}F_2 \rightarrow BF_3 + \frac{1}{2}N_2$ ΔH=-885kJ mol^{-1} ❷ $B + 1\frac{1}{2}F_2 \rightarrow BF_3$ ΔH=-1136kJ mol^{-1} ❶x-1 $BF_3 + \frac{1}{2}N_2 \rightarrow BN + 1\frac{1}{2}F_2$ ΔH=+885kJ mol^{-1} ❷ $B + 1\frac{1}{2}F_2 \rightarrow BF_3$ ΔH=-1136kJ mol^{-1} Add ❶'+❷ $B + \frac{1}{2}N_2 \rightarrow BN$ ΔH=-251kJ mol^{-1}
16	A	78	☑A NH_3 has 3 N—H bonds broken in the reaction and no bonds formed ☒B N≡N bonds and H—H bonds also formed in this reaction ☒C N≡N bonds and H—H bonds also formed in this reaction ☒D N≡N bonds and O—H bonds also formed in this reaction
17	C	81	☒A enthalpy of solution of potassium fluoride: $KF(s) \rightarrow K^+(aq) + F^-(aq)$ ☒B enthalpy of formation of potassium fluoride: $K(s) + \frac{1}{2}F_2(g) \rightarrow KF(s)$ ☑C hydration energy of potassium: $K^+(g) \rightarrow K^+(aq)$ hydration energy of potassium: $F^-(g) \rightarrow F^-(aq)$ ☒D 1st ionisation of potassium: $K(g) \rightarrow K^+(g) + e^-$ electron affinity of fluorine: $F(g) + e^- \rightarrow F^-(g)$
18	A	75	At absolute zero temperature (0 K) crystals have perfect order and an entropy value of zero J K^{-1} mol^{-1}
19	A	89	☑A line never crosses zero into positive and ΔG is always negative ∴ reaction always feasible ☒B when line crosses into positive ΔG value, reaction is not thermodynamically feasible ☒C when line has positive ΔG value, reaction is not thermodynamically feasible ☒D when line has positive ΔG value, reaction is not thermodynamically feasible
20	B	77	$K = \frac{[SO_3]^2}{[SO_2]^2 \times [O_2]^1} = \frac{16^2}{0.2^2 \times 0.2} = \frac{256}{0.04 \times 0.2} = \frac{256}{0.008} = 32000$ ☒A products are formed ∴ thermodynamically feasible ∴ ΔG must be less than zero ☑B K > 1 (much more products than reactants) and $\Delta G < 0$ (products formed ∴ must be feasible) ☒C products are formed ∴ thermodynamically feasible ∴ ΔG must be less than zero ☒D much more products in equilibrium mixture than reactants ∴ K greater than 1
21	D	71	$\Delta G - \Delta H$ = approximately zero ∴ $-T\Delta S$ = approximately zero ∴ ΔS = approximately zero ☒A carbon dioxide gas is released ∴ disorder increases ∴ ΔS must be large & positive ☒B hydrogen gas is released ∴ disorder increases ∴ ΔS must be large and positive ☒C hydrogen gas is released ∴ disorder increases ∴ ΔS must be large and positive ☑D disorder and ΔS relatively unchanged as reaction proceeds ∴ ΔS approx zero

22	A	83	☑A Volume is not a condition for standard electrode potentials ☒B Temperature of 298K is a standard condition for standard electrode potentials ☒C concentration of 1mol l^{-1} is a standard condition for standard electrode potentials ☒D pressure of 1atmosphere is a standard condition for standard electrode potentials
23	B	54	☒A Cu^{2+} are formed by Cu metal releasing electrons $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$ ☑B Cu metal turns into Cu^{2+} to release the electrons travelling Y→X: $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2e^-$ ☒C Cu^{2+} ions reduced into Cu metal joining with electrons $Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$ ☒D electrons travel through wires not salt/ion bridges
24	A	71	Slow step is the rate determining step: $(CH_3)_3CBr \rightarrow (CH_3)_3C^+ + Br^-$ Slow step has only one reactant $(CH_3)_3CBr$ ∴ $(CH_3)_3CBr$ is 1st order and OH^- is zero order Rate = k x $[(CH_3)_3CBr]^1$ x $[OH^-]^0$ = k $[(CH_3)_3CBr]$
25	B	60	☒A reaction is not thermodynamically feasible as $\Delta G > 0$ ☑B no information available on the effect of varying concentration of each reactant ☒C the balanced equation gives the stoichiometry of the equation (the mole ratio) ☒D as $\Delta G > 0$ then position of equilibrium lies well to left as no products are formed
26	D	73	<table><tr><td>Temperature rise</td><td>20°C→30°C</td><td>30°C→40°C</td><td>40°C→50°C</td><td>50°C→60°C</td></tr><tr><td>Rate</td><td>x2</td><td>x2</td><td>x2</td><td>x2</td></tr></table>
27	B	88	☒A termination step: free radicals before arrow but none after arrow ☑B propagation step: free radicals on both sides of the arrow ☒C termination step: free radicals before arrow but none after arrow ☒D initiation step: free radicals after arrow but none before arrow
28	C	81	☒A C_3H_8 has no C=C double bond for an addition reaction to take place in Reaction 1 ☒B C_3H_8 has no C=C double bond for an addition reaction to take place in Reaction 1 ☑C reaction 1 is a free radical substitution reaction, reaction 2 is a nucleophilic substitution reaction and reaction 3 is an elimination reaction ☒D C_3H_7Br has no C=C double bond for an addition reaction to take place in Reaction 2
29	A	68	☑A KOH in ethanol is an elimination reaction where HBr is eliminated from C_3H_7Br ☒B CN^- ions swaps with Br in a nucleophilic substitution reaction ☒C $C_2H_5O^-$ ions swaps with Cl in a nucleophilic substitution reaction ☒D OH^- ions swaps with Br in a nucleophilic substitution reaction
30	A	62	☑A both ethene and Br^- are attracted to positive charge ∴ both acting as nucleophiles ☒B Br^- is attracted to δ+ on cyclic intermediate ∴ Br^- is acting as a nucleophile ☒C ethene is attracted to δ+ on Br-Br ∴ ethene is acting as a nucleophile ☒D ethene is attracted to δ+ on Br-Br ∴ ethene is acting as a nucleophile
31	A	77	☑A increase in number of –OH groups increases both boiling point and viscosity due to H bonds ☒B increase in number of –OH groups ∴ more hydrogen bonding ∴ increasing in viscosity ☒C increase in number of –OH groups ∴ more hydrogen bonding ∴ increasing in boiling point ☒D increase in number of –OH groups ∴ more hydrogen bonding ∴ increasing in boiling point
32	D	40	☒A halogenalkane would convert into alcohol and then into an aldehyde/carboxylic acid ☒B halogenalkane would convert into alkanenitrile and then into a carboxylic acid ☒C halogenalkane would eliminate a hydrogen halide molecule into an alkene ☑D halogenalkane reacts with $C_2H_5O^-$ ions to form an ether by nucleophilic substitution
33	B	70	☒A propanal oxidises to propanoic acid but propanal cannot react to form an ester ☑B propan-1-ol oxidises to propanoic acid and they react together to form an ester ☒C propan-2-ol oxidises to propanone. Propanone cannot react to form an ester ☒D propanoic acid does not oxidise
34	A	60	☑A aldehydes form a solid derivative with 2,4-dinitrophenylhydrazine ☒B carboxylic acids do not form derivatives with 2,4-dinitrophenylhydrazine ☒C esters do not form derivatives with 2,4-dinitrophenylhydrazine ☒D amides do not form derivatives with 2,4-dinitrophenylhydrazine
35	B	76	☒A boiling point analysis would be harder to achieve compared to melting point analysis ☑B a sharp melting point is essential for melting point analysis of a substance ☒C the derivative must not decompose if it is to be identified by melting point ☒D a low relative molecular mass is not essential for melting point analysis

36	D	61	☒A C_6H_5OH will react with bases but not acids ☒B $C_6H_5NH_2$ will react with acids but not bases ☒C HOC_6H_4COOH will react with bases but not acids ☑D $H_2NC_6H_4COOH$ will react with both acids and bases
37	B	89	☒A Carbon only has 3 different groups attached to the central carbon ☑B Carbon only has 4 different groups attached to the central carbon ☒C Carbon only has 3 different groups attached to the central carbon ☒D Carbon only has 3 different groups attached to the central carbon
38	C	71	☒A Carbon atoms are relatively small but show up in X-ray crystallography ☒B Hydrogen atoms are so small they barely register in X-ray crystallography ☑C Large atoms like iodine are easiest to locate in X-ray crystallography ☒D Oxygen atoms are relatively small but show up in X-ray crystallography
39	C	93	☒A agonist: molecule which binds to receptor binding site and cause a biological response ☒B receptor: binding site for molecules with same pharmacophore shape ☑C antagonist: molecule which binds to binding site and does not cause a biological response ☒D pharmacophore: particular shape which fits the binding site of receptor exactly
40	C	45	☒A $-O-CH_3$ is polar covalent but not ionic ∴ no ionic interaction ☒B no H atom attached to O atom to be a hydrogen-bond donor ☑C O atom has lone pair of electrons to be a hydrogen-bond acceptor ☒D no H atom attached to O atom to be a hydrogen-bond donor

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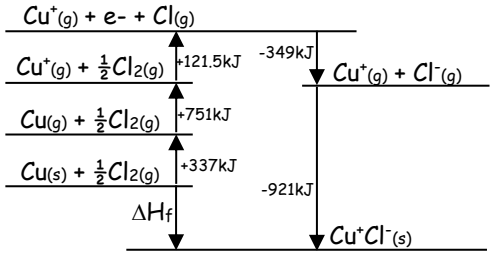
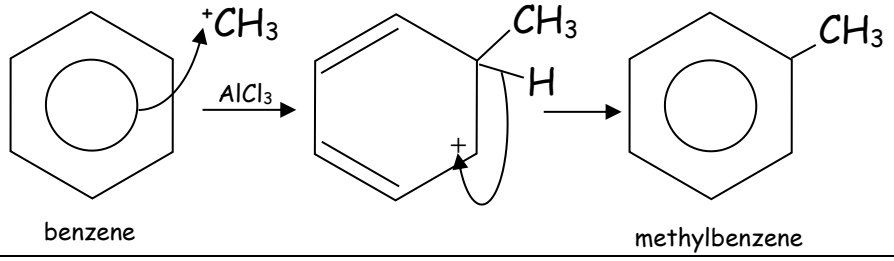
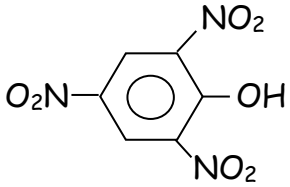
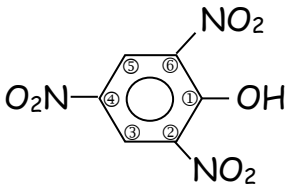
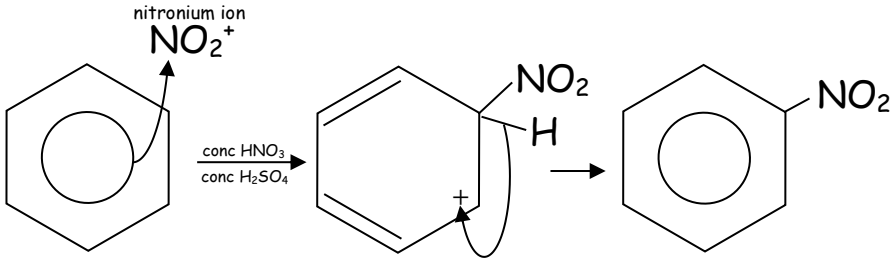
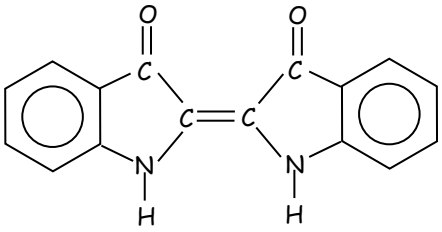
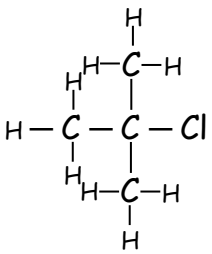
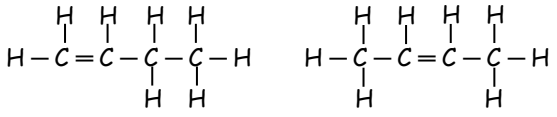
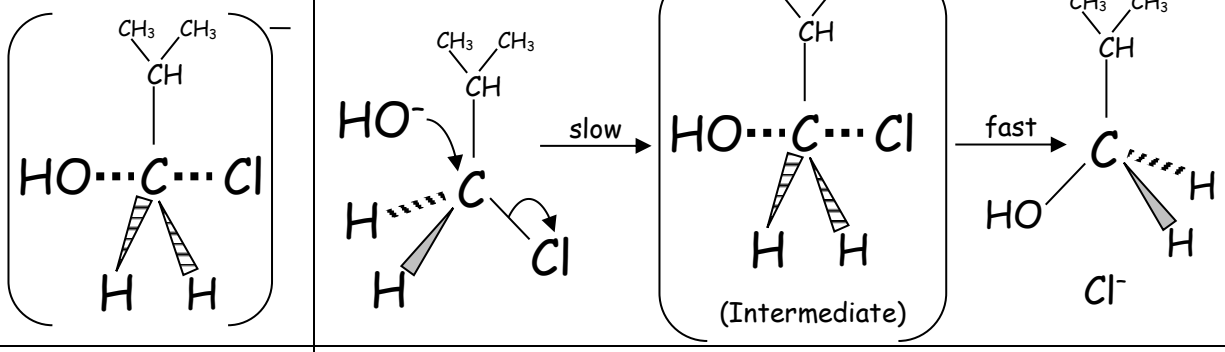
Long Qu	Answer	Reasoning
1a(i)	Equal/same energy	Degenerate means the orbitals are of equal energy.
1a(ii)	Any correct statement of Hund's Rules	Each orbital should be filled singly before a second electron fills each orbital.
1b(i)	239nm or 2.39×10^{-7}m	$E = \frac{L \times h \times c}{\lambda} \therefore \lambda = \frac{L \times h \times c}{E} = \frac{6.02\times10^{23}\text{mol}^{-1} \times 6.63\times10^{-34}\text{ J s} \times 3\times10^{8}\text{ m s}^{-1}}{502 \times 1000\text{ J mol}^{-1}}$ $= 2.39 \times 10^{-7}$ m = 239 nm
1b(ii)	No, wavelength of visible too short	Visible light is between the wavelength of 450nm (violet end) and 700nm (red end). The wavelength 239nm is in the UV band of the electromagnetic spectrum.
2a	194 kJ mol^{-1}	$\Delta H^o = \Sigma\Delta H_f{}^o{}_{(products)} - \Sigma\Delta H_f{}^o{}_{(reactants)}$ $= (1x+130) + (1x-394) - (1x-348)+(1x-110)$ $= +130 - 394 - (-348 - 110)$ $= -264 - (-458)$ $= +194$ kJ mol^{-1}
2b	133 J K^{-1} mol^{-1}	$\Delta S^o = \Sigma S^o{}_{(products)} - \Sigma S^o{}_{(reactants)}$ $= (1x161) + (1x214) - (1x44)+(1x198)$ $= 161 + 214 - (44 + 198)$ $= 375 - 242$ $= +133$ J K^{-1} mol^{-1}
2c	1459 K	The reaction becomes thermodynamically feasible when $\Delta G^o = 0$ $\Delta G^o = \Delta H^o - T\Delta S^o = 0 \therefore T\Delta S^o = \Delta H^o \therefore T = \frac{\Delta H^o}{\Delta S^o} = \frac{+194 \times 1000\text{ J mol}^{-1}}{+133\text{ J K}^{-1}\text{ mol}^{-1}} = 1458.6\text{K}$
3a(i)	1.26V	❶ $V^{3+} + e^- \rightarrow V^{2+}$ $E^o = -0.26$V ❷ $VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$ $E^o = +1.00$V ❶ x-1 $V^{2+} \rightarrow V^{3+} + e^-$ $E^o = +0.26$V ❷ $VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$ $E^o = +1.00$V ❶'+❷ $VO_2^+ + 2H^+ + V^{2+} \rightarrow VO^{2+} + H_2O + V^{3+}$ $E^o = +1.26$V
3a(ii)	-121.59 kJ mol^{-1}	3mol of electrons transferred between half reactions $\therefore$ n=1 $\Delta G^o = -\ n \times F \times E^o$ $= -\ 1 \times 96500\text{ C mol}^{-1} \times 1.26\text{V}$ $= -\ 121590$ J mol^{-1} $= -\ 121.59$ kJ mol^{-1}
3b(i)	4 or IV	VO^{2+}: Vanadium oxid no. + (-2) = +2 $\therefore$ vanadium oxid no. = +2 – (-2) = +4
3b(ii)	Green colour from mixture of blue and yellow	During the reaction there will be a mixture of yellow VO_2^+ ions and blue VO^{2+} ions. For a short period the yellow and blue colours mix together
3b(iii)	3	V = $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2 \therefore V^{2+} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
3b(iv)	Vanadium ions oxidised/ reacts with oxygen	When the stopper is removed , oxygen enters flask and reacts with vanadium ions to form blue VO^{2+} by an oxidation reaction (oxidation number increases 2→4)
4a	Green	PPA Technique Question
4b	hydrogen peroxide/H_2O_2	PPA Technique Question
4c	octahedral	Octahedral has 4 bonds in a square planar around the central atom and 2 bonds vertically above and below the central ion.

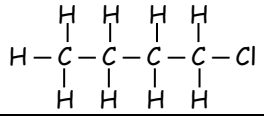
5a(i)	0.36	$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ 1mol 2mol 0.12mol 0.24mol ∴ no of mol of N_2O_4 at equilibrium = 0.28mol – 0.12mol = 0.16mol $K = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(0.24)^2}{0.16} = \frac{0.0576}{0.16} = 0.36$
5a(ii)	Forward reaction is endothermic as decreasing temperature favours reverse reaction	Decreasing temperature favours the reverse reaction. At 127°C, K=0.36 and at 25°C, K=0.12 ∴ as temperature decreases K decrease ∴ value of K decreases when [products] decreases and [reactants] increases ∴ reverse reaction is favoured
5b(i)	$x = 7.40x10^{-4}$ $y = 2.96x10^{-3}$	From equation: rate = $k[NO]^2$ 2nd order with respect to NO zero order with respect to H_2 Compare ❶+❷: $[H_2]$x2 but H_2 is zero order ∴no change of rate ∴ $x = 7.40x10^{-4}$ Compare ❷+❸: [NO]x2 but NO is 2nd order ∴ rate quadruples ∴ $y = 7.40x10^{-4}$ x4 = $2.96x10^{-3}$
5b(ii)	185 l mol^{-1} s^{-1}	Rate = $k[NO]^2$ ∴ $k = \frac{\text{Rate}}{[NO]^2} = \frac{7.40x10^{-4} \text{ mol l}^{-1} \text{ s}^{-1}}{(2.00x10^{-3} \text{ mol l}^{-1})^2} = \frac{7.40x10^{-4} \text{ mol l}^{-1} \text{ s}^{-1}}{4.00x10^{-6} \text{ mol}^2 \text{ l}^{-2}} = 185 \text{ l mol}^{-1} \text{ s}^{-1}$
6a	-171	ΔH_5 = 2x 1st electron affinity of Cl = 2x-349 = -698 kJ $\Delta H_f = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6$ = 337 + 243 + 751 + 1970 + (-698) + (-2774) = -171 kJ mol^{-1}
6b	-60.5	 $\Delta H_f = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5$ = 337 + 751 + 121.5 + (-359) + (-921) = -60.5 kJ mol^{-1}
6c	$CuCl_2$ as ΔH_f is more negative	The more negative the value of ΔH_f the more stable the ionic solid.
7a	Phenolphthalein	PPA technique question
7b(i)	$4.33x10^{-4}$mol	Ignore rough titration in average: Ave titre = $\frac{8.7+8.6}{2} = \frac{17.3}{2} = 8.65cm^3$ **n**o. of mol sulphuric acid = **v**olume x **c**oncentration = 0.00865litres x 0.050mol l^{-1} = 0.0004325mol
7b(ii)	$8.66x10^{-3}$mol	$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O$ 2mol 1mol $8.66x10^{-4}$mol $4.33x10^{-4}$mol $25cm^3$ of solution contains $8.66x10^{-4}$mol NaOH $250cm^3$ of solution contains $8.66x10^{-3}$mol NaOH
7b(iii)	0.01634mol or $1.63x10^{-2}$mol	**n**o. of mol NaOH at start = **v**olume x **c**oncentration = 0.025litres x 1.00mol l^{-1} = 0.025mol **n**o. of mol NaOH reacted = 0.025mol – $8.66x10^{-3}$mol = 0.01634mol
7b(iv)	0.294g	1mol acetylsalicylic acid $C_9H_8O_4$ = (9x12)+(8x1)+(4x16) = 108+8+64 = 180g $2NaOH + C_9H_8O_4 \longrightarrow C_7H_5O_3Na + CH_3COONa + H_2O$ 2mol 1mol 0.01634mol 0.00817mol **m**ass aspirin in 5 tablets = **n**o. of mol x **gfm** = 0.00817 x 180 = 1.4706g **m**ass aspirin in 1 tablet = 0.294g
8a	sp^2	The carbon atoms is a benzene ring have sp^2 hybridisation and the electron in the 4th unhybridised p–orbital becomes part of the delocalised ring of 6 π electrons

8b(i)	CH_3Cl and $AlCl_3$	Combination from: Reactant: Chloromethane CH_3Cl | Bromomethane CH_3Br Catalyst: $FeCl_3$ | $AlCl_3$ | $FeBr_3$ | $AlBr_3$
8b(ii)	Electrophilic substitution	CH_3Cl heterolytically splits into CH_3^+ and Cl^- with $AlCl_3$ catalyst  benzene methylbenzene
8c(i)	 	-OH group is carbon number 1 in benzene ring -NO_2 nitro groups then placed on carbons 2,4 and 6 
8c(ii)	NO_2^+	Nitronium ion formed by: $HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$  benzene nitrobenzenenium intermediate ion nitrobenzene
9a	Red and green wavelengths are absorbed but blue wavelengths are transmitted	The colour of a substance corresponds to the colour wavelengths that are not absorbed by the substance. For a substance to be blue in colour, the red and green wavelengths are absorbed by the substance and the remaining wavelengths (in this case blue) are transmitted to give the blue colour.
9b	Diagram showing:	
9c	Addition	The C=O double bond opens up and H from propanone is added onto the O atom and the remainder of the propane molecule adds onto the carbon.
10a	2-chloro-2-methylpropane or 2-chloromethylpropane	$(CH_3)_3CCl$ has the full structural formula: 
10b	Both structures:	 $CH_2{=}CHCH_2CH_3$ (but-1-ene) $CH_3CH{=}CHCH_3$ (but-2-ene)
10c(i)	2-methylpropan-1-ol	3 carbon alkane with –OH group on C_1 and $-CH_3$ group on C_2

10c(ii)



10d



Isomer A	Isomer B	Isomer C	Isomer D
$CH_3CHClCH_2CH_3$	$(CH_3)_2CHCH_2Cl$	$(CH_3)_3CCl$	$CH_3CH_2CH_2CH_2Cl$
2-chlorobutane	1-chloro-2-methylpropane	2-chloro-2-methylprapane	1-chlorobutane

10e

3

Isomer B $(CH_3)_2CHCH_2Cl$ would produce three peaks on a Proton NMR spectrum

Structural Unit	RCH_2X	RCH_3	R_3CH
Chemical Shift	4.2-2.2	1.5-0.9	1.5-0.9
Relative intensity	2	3	1

10f

A must be racemic
B has no chiral carbon

A has a chiral carbon with four different groups attached. For isomer A to be optically inactive then the sample must have equal quantities of each optical isomer (called a racemic mixture). Isomer B is optically inactive as it lacks a chiral carbon with 4 different groups attached.

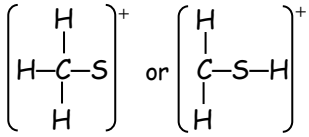
11a

C_2H_6S

Mass of carbon in $CO_2 = {}^{12}/_{44} \times 3.52g = 0.96g$
Mass of hydrogen in $H_2O = {}^{2}/_{18} \times 2.16g = 0.24g$
Mass of sulphur in $SO_2 = {}^{32.1}/_{64.1} \times 2.56g = 1.28g$

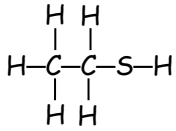
Elements	C	H	S
Mass or %	0.96g	0.24g	1.28g
Divide by RAM	$\frac{0.96g}{12g\ mol^{-1}}$ = 0.08mol	$\frac{0.24g}{1g\ mol^{-1}}$ = 0.24mol	$\frac{1.28g}{32.1g\ mol^{-1}}$ = 0.04mol
Divide through by smallest number	$\frac{0.08mol}{0.04mol}$ = 2	$\frac{0.24mol}{0.04mol}$ = 6	$\frac{0.04mol}{0.04mol}$ = 1
Empirical Formula	2	6	1

11b



Peak at $^m/_z = 47$ ∴ fragment has mass of 47amu
As S atom has mass or 32, remaining fragment has mass of 15
∴ remaining fragment is CH_3 with mass of 15

11c



Peak	1	2	3
Chemical Shift/ppm	1.2	1.5	2.4
Structure	CH_3	SH	CH_2
Relative Area under peak	97	32	65
No of Hydrogen in group	3	1	2