Past Papers Advanced Higher Chemistry

2007 Marking Scheme

Grade Awarded	Mark Required		% candidates achieving grade
	(/125)	%	
A	90+	72%	27.0%
B	75+	60%	27.8%
C	60+	48%	23.6%
D	52+	42%	9.3%
No award	<52+	<42%	12.2%

Section:	Multiple Choice	Extended Answer	Investigation
Average Mark:	27.8 /40	33.1 /60	15.4 /25

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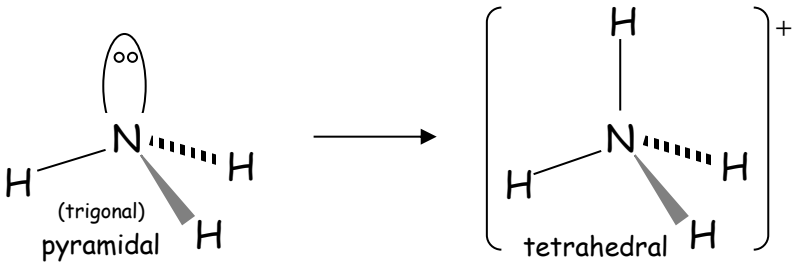
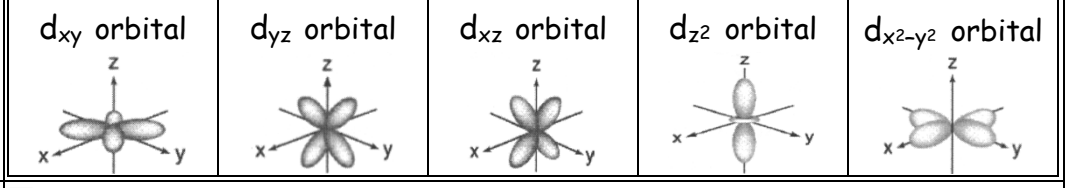
MC Qu	Answer	% Pupils Correct	Reasoning
1	C	48	☒A no elements contain ionic bonding (ionic bonding found in metals+non-metals compounds) ☒B no elements contain polar covalent bonding as electronegativity is same in elements ☑C elements can have non-polar covalent bonds which can form gaseous covalent oxides ☒D metal elements form ionic oxides which are solid are room temperature
2	A	72	☑A Electronegativity: Sn=1.8 & I=2.6 ∴ difference= 0.8 (most covalent character) ☒B Electronegativity: Fe=1.8 & Cl=3.0 ∴ difference= 1.2 ☒C Electronegativity: Li=1.0 & F=4.0 ∴ difference= 3.0 (least covalent character) ☒D Electronegativity: K=0.8 & Br=2.8 ∴ difference= 2.0
3	A	86	<table><tr><td>EM Radiation</td><td>Gamma</td><td>X-ray</td><td>UV</td><td>Visible</td><td>Infrared</td><td>Microwave</td><td>Radio & TV</td></tr><tr><td>Particles</td><td colspan="4">Alpha</td><td colspan="4">Beta</td></tr></table>
4	D	44	☒A s-orbital is outermost orbital in Helium only and not other Noble Gases ☒B p-orbital is outermost orbital in all Noble Gases except Helium ☒C d-orbital is never the outermost orbital in any atom ☑D s-orbital is outermost orbital in Helium and p-orbital is outmost in other Noble Gases
5	C	70	<table><tr><td>EM Radiation</td><td>Gamma</td><td>X-ray</td><td>UV</td><td>Visible</td><td>Infrared</td><td>Microwave</td><td>Radio & TV</td></tr><tr><td>Velocity</td><td>$3x10^8 m\ s^{-1}$</td><td>$3x10^8 m\ s^{-1}$</td><td>$3x10^8 m\ s^{-1}$</td><td>$3x10^8 m\ s^{-1}$</td><td>$3x10^8 m\ s^{-1}$</td><td>$3x10^8 m\ s^{-1}$</td><td>$3x10^8 m\ s^{-1}$</td></tr><tr><td>Wavelength</td><td>short ←</td><td colspan="5"></td><td>→ Long</td></tr><tr><td>Frequency</td><td>high →</td><td colspan="5"></td><td>Low</td></tr></table>
6	A	71	
7	A	82	<table><tr><td colspan="3">NH_4^+</td></tr><tr><td>Element</td><td>N</td><td>H</td></tr><tr><td>Electrons per atom</td><td>7</td><td>1</td></tr><tr><td>Number of atoms</td><td>1</td><td>4</td></tr><tr><td rowspan="2">Electrons</td><td>7x1 = 7</td><td>1x4=4</td></tr><tr><td colspan="2">= 11</td></tr><tr><td>Charge effect on Electrons</td><td colspan="2">-1</td></tr><tr><td>Total Electrons</td><td colspan="2">10</td></tr></table> <table><tr><td colspan="3">CH_4</td></tr><tr><td>Element</td><td>C</td><td>H</td></tr><tr><td>Electrons per atom</td><td>6</td><td>1</td></tr><tr><td>Number of atoms</td><td>1</td><td>4</td></tr><tr><td rowspan="2">Electrons</td><td>6x1 = 6</td><td>1x4=4</td></tr><tr><td colspan="2">= 10</td></tr><tr><td>Charge effect on Electrons</td><td colspan="2">0</td></tr><tr><td>Total Electrons</td><td colspan="2">10</td></tr></table>
8	C	92	☒A conductivity increases with decreasing temperature in conductors and superconductors ☒B semiconductors do not conduct unless doped with another material ☑C as temperature drops, superconductors start to conduct with zero resistance ☒D conductivity increases with increasing temperature in semiconductors only
9	C	57	☒A Hund's Rule: Electron half-fill degenerate orbitals before doubly-filling orbitals ☒B Aufbau Principle: Electrons fill in order of increasing energy ☑C Pauli Exclusion Principle: Orbital can hold 2 electrons only and they have opposite spins ☒D Heisenberg's Uncertainty Principle: Position and Energy of electron cannot be known at same time
10	D	72	
11	B	60	☒A Hydrogen given off at the negative electrode ∴ Hydrogen H^+ ions not hydride H^- ions ☑B Hydride ions become hydrogen gas at positive electrode: $2H^- \rightarrow H_2 + 2e^-$ ☒C Hydrides react with water and break down to release H_2 gas ☒D Hydrides react with water and break down to release H_2 gas

12 C 73

Flask X: 1mol of Ne = 20g ∴ 5g of Ne = 0.25mol = 1.50×10^{23}atoms
Flask Y: 1mol of Ar = 40g ∴ 5g of Ar = 0.125mol = 0.75×10^{23}atoms

13 C 65

1mol Ag_2CrO_4 = (2x107.9)+(1x52)+(4x16) = 215.8+52+64 = 331.8g

$$\text{no. of mol} = \frac{\textbf{mass}}{\textbf{gfm}} = \frac{5.795\ g}{332.8\ g\ mol^{-1}} = 0.0175mol$$

$$2Ag^+ + K_2CrO_4 \longrightarrow Ag_2CrO_4 + 2K^+$$

2mol : 1mol
0.0349mol : 0.0175mol

mass = **n**o. of mol x **gfm** = 0.0349mol x 107.9g mol^{-1} = 3.769g

14 C 77

☒A Catalysts give same concentrations of reactants and products at equilibrium
∴ no change to value of equilibrium constant
☒B Pressure increase favours pressure-reducing reverse reaction
∴ less products lowers value of equilibrium constant
☑C Increase in temperature favours endothermic (forward) reaction
∴ more products increases the value of the equilibrium constant
☒D Decrease in temperature favours the exothermic (reverse) reaction
∴ less products decreases the value of the equilibrium constant

15 B 82

no. of mol X in ethoxyethane = **v**olume x **c**oncentration = 0.015 x 0.010 = 0.00015mol
no. of mol X in water = **v**olume x **c**oncentration = 0.012 x 0.010 = 0.00012mol

$$K = \frac{[X]_{ethoxyethane}}{[X]_{water}} = \frac{0.00015mol\ in\ 20cm^3}{0.00012mol\ in\ 20cm^3} = 1.25$$

16 A 80

❶ $2Fe + 1\frac{1}{2}O_2 \longrightarrow Fe_2O_3$ $\Delta H = -822kJ\ mol^{-1}$
❷ $C + O_2 \longrightarrow CO_2$ $\Delta H = -394kJ\ mol^{-1}$
❶x-1 $Fe_2O_3 \longrightarrow 2Fe + 1\frac{1}{2}O_2$ $\Delta H = +822kJ\ mol^{-1}$
❷x$1\frac{1}{2}$ $1\frac{1}{2}C + 1\frac{1}{2}O_2 \longrightarrow 1\frac{1}{2}CO_2$ $\Delta H = -591kJ\ mol^{-1}$
Add ❶'+❷' $Fe_2O_3 + 1\frac{1}{2}C \longrightarrow 2Fe + 1\frac{1}{2}CO_2$ $\Delta H = +231kJ\ mol^{-1}$

17 A 67

☑A Enthalpy of formations are calculated using experimental values from at least two experiments. Hess's Law is used to calculate the enthalpy of formation.
☒B Enthalpy of combustion is calculated by a single $\Delta H = cm\Delta T$ experiment
☒C Enthalpy of solution is calculated by a single $\Delta H = cm\Delta T$ experiment
☒D Enthalpy of neutralisation is calculated by a single $\Delta H = cm\Delta T$ experiment

18 B 66

Bond Breaking Steps			Bond Forming Steps		
6x C-H	6x 414	= 2484kJ	5x C-H	5x 414	=2070kJ
1x C-C	1x 346	= 346kJ	1x C-C	1x 346	= 346kJ
1x Br-Br	1x 194	= 194kJ	1x C-Br	1x 285	= 285kJ
			1x H-Br	1x 362	= 362kJ
		3024kJ			3063kJ

$\Delta H = \Sigma$endothermic steps - Σexothermic steps
= +3024kJ -3063kJ
= -39kJ mol^{-1}

(NB the data in this question is based on the old data booklet)

19 D 64

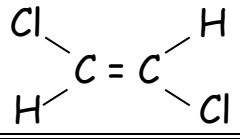
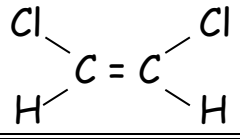
☒A Melting and boiling are both endothermic processes
☒B 1st Ionisation energy is an endothermic process
☒C Breaking Br-Br bond and boiling are both endothermic processes
☑D Electron Affinity of Bromine is an exothermic process (-324.6kJ mol^{-1})

20 C 75

☒A Neon is a gas at 100°C and is more disordered than a solid at 100°C
☒B Mercury is a liquid at 100°C and is more disordered than a solid at 100°C
☑C Sulphur is a solid at 100°C and is the most ordered and has lowest entropy
☒D Phosphorus is a liquid at 100°C and is more disordered than a solid at 100°C

21	D	88	Ellingham diagrams have ΔG^o on the y=axis and temperature on the x-axis. Where the lines of different reactions cross, the reaction becomes feasible at this temperature (upper line is the reaction is reversed)
22	C	59	$\Delta G^o = \Delta H^o - T\Delta S^o$ $\Delta H^o = \Delta G^o + T\Delta S^o$ For ΔH^o to always be negative — ΔG^o must be negative — ΔS^o must be negative
23	B	70	❶ $Cr^{3+} + 3e^- \rightarrow Cr$ $E^o = -0.74V$ ❷ $Ag^+ + e^- \rightarrow Ag$ $E^o = +0.80V$ ❶x-1 $Cr \rightarrow Cr^{3+} + 3e^-$ $E^o = +0.74V$ ❷x3 $3Ag^+ + 3e^- \rightarrow 3Ag$ $E^o = +0.80V$ Add ❶'+❷' $3Ag^+ + Cr \rightarrow 3Ag + Cr^{3+}$ $E^o = +1.54V$ ☒A The voltage of this cell is +1.54V ☑B Silver ions gain electrons and deposit on the silver electrode making electrode heavier ☒C Cr metal is oxidised and loses electrons to become Cr^{3+} ions ☒D Metal higher in electrochemical series gives electrons to metal lower down
24	D	71	☒A Both reactants are 1st order. Reaction rate is dependent on their concentration ☒B Overall order is 2 if both reactants are 1st order. ☒C If both [A] and [B] are double then rate of reaction is quadrupled not doubled ☑D Rate decreases as reactants are used up during the reaction
25	C	60	☒A Free radicals are made by homolytic fission ☒B A free radical chain reaction is set in the reaction of methane and chlorine ☑C Carbocations are made during S_N1 type nucleophilic substitution reactions ☒D A free radical chain reaction is set in the reaction of methane and chlorine
26	D	61	☒A $C_4H_9NH_2$ is a primary amine and hydrogen bonding raises its boiling point ☒B $C_3H_7NHCH_3$ is a secondary amine and hydrogen bonding raises its boiling point ☒C $C_2H_5NHC_2H_5$ is a secondary amine and hydrogen bonding raises its boiling point ☑D $C_2H_5N(CH_3)_2$ is a tertiary amine: no hydrogen bonding to raise its boiling point
27	A	70	☑A benzene readily undergoes a variety of electrophilic substitution reactions ☒B benzene has no C=C double bonds so does not undergo addition reactions ☒C nucleophiles are not attracted to the electron-dense benzene ring ☒D benzene has no C=C double bonds so does not undergo addition reactions
28	B	62	See table below
29	D	81	☒A Na is not attracted to centres of positive charge as it has no charge itself ☒B Br^+ is positive and is not attracted to centres of positive charge ☒C CH_3^+ is positive and is not attracted to centres of positive charge ☑D NH_3 has a lone pair of electrons and is attracted to centres of positive charge
30	B	74	☒A Volatility decreases as chain increases. Solubility decreases as chain increases ☑B Both volatility and solubility decrease as hydrocarbon chain length increases ☒C Volatility decreases as chain length increases ☒D Solubility decreases as chain length increases

Compound	X ethanoic acid	Y ethanol	Z phenol
pH	Acidic	Neutral	Acidic
pK_a	4.8	-	9.9
Acid Strength	<u>Strongest</u> Largest dissociation of H^+ ions due to higher pK_a value than in Z	<u>Weakest</u> No dissociation of H^+ as alcohols do not dissociate into acids	<u>Medium</u> Some dissociation of H^+ ions but lower pK_a value than X so less dissociaton of H^+ than in X

31	B	72	☒A hybridisation refers to s and p orbitals becoming of equal energy ☑B sigma (single) bonds involves overlapping orbitals lying on the axis of the bond ☒C pi (double) bonds involve the overlapping of orbitals outside axis of the bond ☒D pi (double) bonds involve the overlapping of orbitals outside axis of the bond
32	D	71	☒A ethanal and propanal are produced in this reaction ☒B ethanal and ethanal are produced in this reaction ☒C propanone and methanal are produced in this reaction ☑D ethanal and propanone are produced in this reaction
33	B	80	☒A too many Br atoms to be a tertiary halogenalkane ☑B $(CH_3)_3CBr$ is a tertiary halogenalkane: 3 carbons attached to the C-Br carbon ☒C too many Br atoms to be a halogenalkane ☒D $BrCH_2C(CH_3)_3$ is a primary halogenalkane: 1 carbon attached to C-Br carbon
34	A	80	☑A hydrocarbons: compounds containing carbon and hydrogen atoms only ☒B C_6H_{12} could be hexene or cyclohexane ☒C C_6H_{12} could be hexene or cyclohexane ☒D C_6H_{12} has various isomers of alkenes and cycloalkanes.
35	B	64	☒A propan-1-ol oxidises to propanal (reacts with Tollen's) and propanoic acid (reacts with carbonate) ☑B propan-2-ol oxidises to propanone: does not react with carbonate or react with Tollen's Reagent ☒C propanone does not undergo oxidation reaction with acidified dichromate solution ☒D propanoic acid does not undergo oxidation reaction with acidified dichromate solution
36	B	53	☒A $\mathbf{2}C_2H_5OH + 2Na \rightarrow 2C_2H_5O^-Na^+ + H_2$ ☑B $HOCH_2CH_2OH + 2Na \rightarrow Na^+O^-CH_2CH_2O^-Na^+ + H_2$ ☒C $\mathbf{2}CH_3COOH + 2Na \rightarrow 2CH_3COO^-Na^+ + H_2$ ☒D CH_3CHO: alkanals do not react with sodium
37	B	41	☒A Propanal: aldehydes react with 2,4-dinitrophenylhydrazine to make a derivative ☑B Propanoic acid: Carboxylic acids do not react with 2,4-dintrophenylhrydrazine ☒C Propanal: aldehydes react with 2,4-dinitrophenylhydrazine to make a derivative ☒D Benzaldehyde: aldehydes react with 2,4-dinitrophenylhydrazine to make a derivative
38	A	68	☑A This structure has formula mass of 134 ∴ 2x $-CH_3$ methyl groups & a di-substituted ring ☒B This structure has a tri-substituted benzene ring ☒C $C_9H_{12}O$ has a formula mass of 136 ☒D This structure does not have two $-CH_3$ methyl groups
39	D	81	☒A Geometric isomers have a C=C double bond ☒B Two Cl atoms on opposite sides of C=C bond are required for geometric isomers ☒C Two Cl atoms on opposite sides of C=C bond are required for geometric isomers ☑D 1,2-dichloroethene has two geometric isomers: trans-1,2-dichloroethene  cis-1,2-dichloroethene 
40	D	71	In mass spectrometry, the heaviest peak is the formula mass of the compound (58) ☒A propane C_3H_8 has a formula mass of 44 ☒B Propan-1-ol C_3H_7OH has a formula mass of 60 ☒C Propan-2-ol C_3H_7OH has a formula mass of 60 ☑D Propanone CH_3COCH_3 has a formula mass of 58

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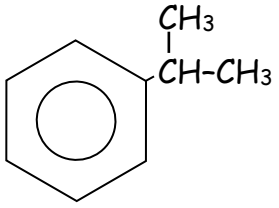
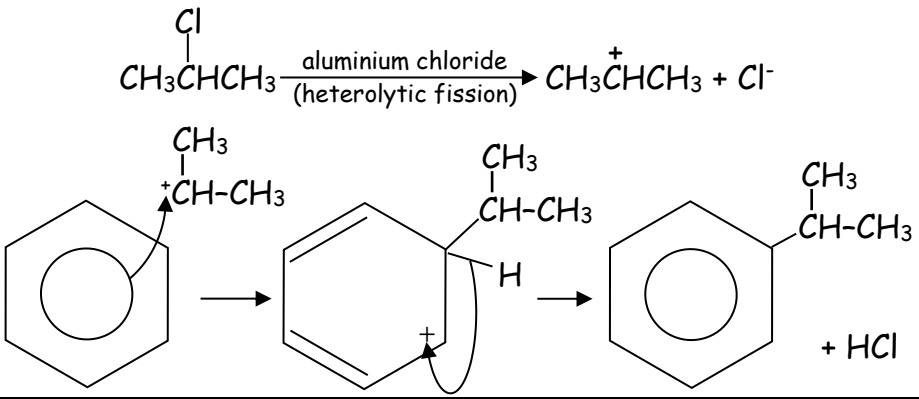
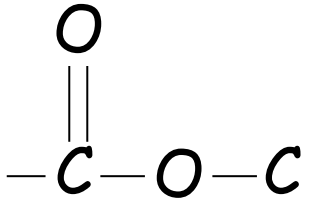
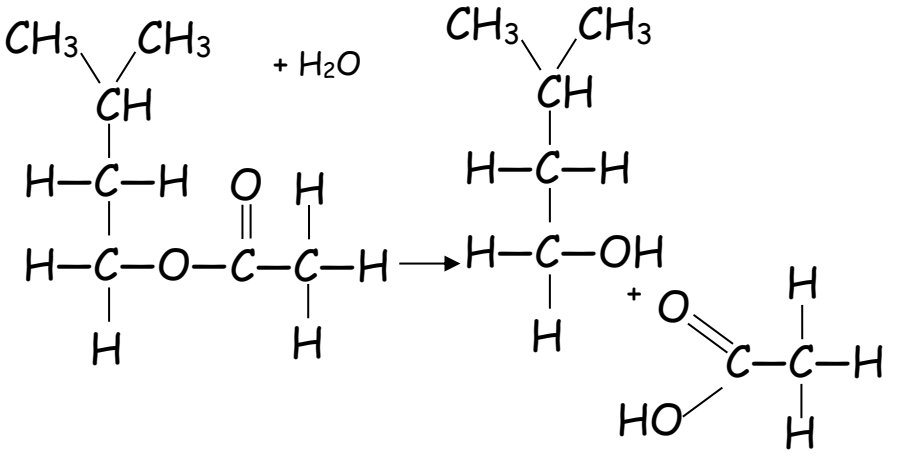
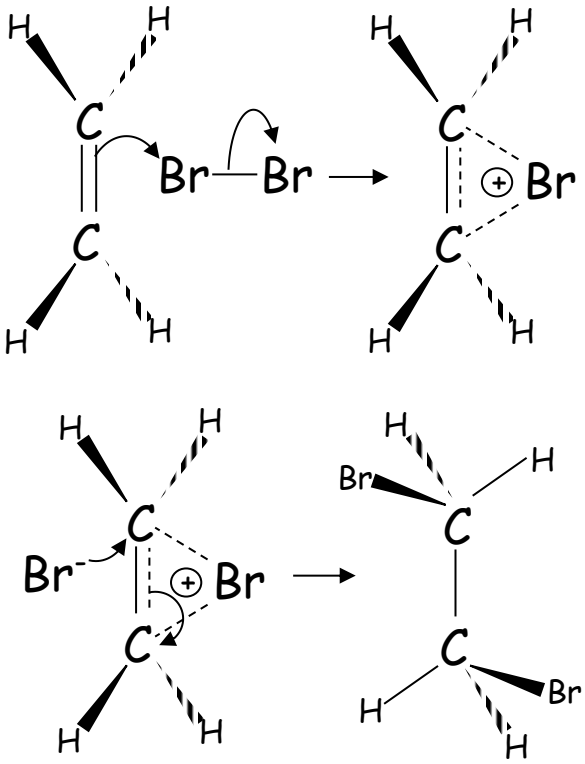
Long Qu	Answer	Reasoning
1a	173.9	$\Delta S^\circ = \Sigma S^\circ_{(products)} - \Sigma S^\circ_{(reactants)}$ $= (1\times72.1) + (1\times213.8) - 112.0$ $= 72.1 + 213.8 - 112.0$ $= 285.9 - 336$ $= 173.9\ J\ K^{-1}\ mol^{-1}$
1b	1529.6K	The reaction becomes thermodynamically feasible when $\Delta G^\circ = 0$ $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = 0 \quad \therefore T\Delta S^\circ = \Delta H^\circ \quad \therefore T = \frac{\Delta H^\circ}{\Delta S^\circ} = \frac{266 \times 1000\ J\ mol^{-1}}{173.9\ J\ K^{-1}\ mol^{-1}} = 1529.6K$
2a	$K = \frac{[CH_4]\,[H_2S]^2}{[CS_2]\,[H_2]^4}$	$K = \frac{[CH_4]^1\,[H_2S]^2}{[CS_2]^1\,[H_2]^4} \quad \therefore \quad K = \frac{[CH_4]\,[H_2S]^2}{[CS_2]\,[H_2]^4}$
2b	281.25	$K = \frac{[CH_4]\,[H_2S]^2}{[CS_2]\,[H_2]^4} = \frac{(0.0054)\times(0.00010)^2}{(0.012)\times(0.0020)^4} = \frac{5.4\times10^{-11}}{1.9\times10^{-13}} = 281.25$
3a	Donates H^+/proton	Bronsted-Lowry Definition: Acid – Donates a proton/H^+ (forms the conjugate base); Base – Accepts a proton/H^+ (forms the conjugate acid)
3b	HCO_3^-	$H_2O + CO_2 \rightleftharpoons H^+ + HCO_3^-$ (HCO_3^-: conjugate base) H_2O and CO_2 combine to form molecules of H_2CO_3 ∴ better version of this equation is: H_2CO_3 (acid) + H_2O (base) $\rightleftharpoons$ H_3O^+ (conjugate acid) + HCO_3^- (conjugate base)
3c	3.7	$pH = \frac{1}{2}pK_a - \frac{1}{2}\log_{10} c$ $= (\frac{1}{2}\times 6.4) - \frac{1}{2}\times\log_{10}(0.1)$ $= 3.2 - (-0.5)$ $= 3.7$
4a(i)	1st Order	
4a(ii)	1st Order	

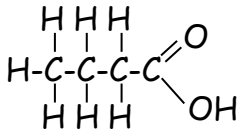
Experiment	Change	Effect on Rate	Order of reactant
1+2 or 3+4	$[H_2O_2]$ x2	x2	$[H_2O_2]^1$
1+3 or 2+4	[HI] x2	x2	$[HI]^1$

4b	Rate = k $[H_2O_2]$ [HI]	Rate = k x $[H_2O_2]^1$ x $[HI]^1$ ∴ rate = k $[H_2O_2]$ [HI]
4c	0.0328 l mol^{-1} s^{-1}	rate = k x $[H_2O_2]$ x [HI] $k = \frac{rate}{[H_2O_2]\times[HI]}$ $= \frac{4.3\times10^{-9}\ mol\ l^{-1}\ s^{-1}}{3.2\times10^{-4}\ mol\ l^{-1}\times 4.1\times10^{-4}\ mol\ l^{-1}}$ $= 0.0328\ l\ mol^{-1}\ s^{-1}$
5a	-181.42kJ mol^{-1}	2mol of e^- transferred in redox reaction: $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ $\Delta G^\circ = -nFE^\circ = -2\times96500\times0.94 = -181420\ J\ mol^{-1} = -181.42\ kJ\ mol^{-1}$
5b	Concentrations of solutions should be 1 mol l^{-1}	Under standard conditions: Temperature = 298K (25°C); Pressure = 1 atmosphere; Concentration = 1 mol l^{-1}
5c	1.10V	❶ $Zn^{2+} + 2e^- \rightarrow Zn$ $E^\circ = -0.76V$ ❷ $Cu^{2+} + 2e^- \rightarrow Cu$ $E^\circ = +0.34V$ Upper equation in electrochemical series reverses ❶′ $Zn \rightarrow Zn^{2+} + 2e^-$ $E^\circ = +0.76V$ ❷ $Cu^{2+} + 2e^- \rightarrow Cu$ $E^\circ = +0.34V$ Add equations together ❶′+❷ $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ $E^\circ = +1.10V$

6a	Murexide has one colour when it is bound to metal ions and a different colour when free	Murexide binds to metal ions less strongly than EDTA so EDTA will displace it and the murexide changes colour as it is displaced
6b	20.96%	Ignore rough titre & titre 1 to work out average as titres must be within 0.2cm^3 of each other Average volume of titre = $\frac{24.2+24.3}{2} = \frac{48.5}{2} = 24.25\text{cm}^3$ **n**o of mol EDTA = **v**olume x **c**oncentration = 0.02425 x 0.101 = 0.002449mol EDTA and Ni^{2+} complex in a ratio of 1:1 ∴ **n**o. of mol Ni^{2+} ions in 20cm^3 = 0.002449mol **n**o. of mol Ni^{2+} ions in 100cm^3 = 0.01227mol **m**ass = **n**o. of mol x **gfm** = 0.01227mol x 58.7 g mol^{-1} = 0.719g % Ni = $\frac{\text{mass of Ni}}{\text{mass of salt}} = \frac{0.719g}{3.43g} \times 100 = 20.96\%$
6c	Impurities in sample or Sample might be damp (contains extra water)	Impurities will make the sample heavier than it would be pure so the increased mass of the salt due to the impurity would lower the percentage of Ni^{2+} or Nickel (II) sulphate is a hexahydrate salt with 6 wqter molecules in the crystal structure. If extra water molecules get in then the salt will be heavier than it should
7a(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9 4s^2$ is incorrect as an electron from 4s subshell is borrowed to complete the 3d subshell to form $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$
7a(ii)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$	Co atoms have electron arrangement: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$ Co^{2+} ions lose 2 electrons from 4s subshell: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7$
7b(i)	$Cu^+(g) \rightarrow Cu^{2+}(g) + e^-$	2nd Ionisation Energy: 1 mole of electrons removed from 1 mole of 1+ ions in the gaseous state
7b(ii)	Electron removed is from a full d subshell	Copper has an electron arrangement of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$ and the removal of the 2nd electron breaks the complete $3d^{10}$ subshell. Complete or half-filled shells require more energy to break.
8a(i)	Aluminium Chloride: Covalent Magnesium chloride: Ionic	Magnesium chloride is an ionic compound as it has a high melting point and is stable when dissolved in water. Aluminium chloride is covalent as it sublimes into a gas at a temperature far too low for it to be ionic and breaks down when added to water releasing $HCl_{(g)}$ white fumes.
8a(ii)	Al_2H_6	By following the cross-over rule, aluminium chloride has a formula of $AlCl_3$. Formula mass of $AlCl_3$ = (1x27)+(3x35.5) = 27+106.5 = 133.5 ∴ if formula mass = 267 then formula must be Al_2Cl_6
8b	Hydrogen chloride HCl	Hydrogen chloride gas is released as white fumes when a covalent compound like aluminium chloride is added to water. $Al_2Cl_{6(g)} + 3H_2O_{(l)} \longrightarrow Al_2O_{3(s)} + 6HCl_{(g)}$
8c		
8d(i)	Cs^+ bigger than Na^+ or ratio of ionic radii are different	The caesium Cs^+ ion is similar in size to the Cl^- and takes 8:8 co-ordination in the ionic lattice. The sodium Na^+ ion is smaller in ionic radii than the Cl^- ion and takes 6:6 co-ordination in the lattice
8d(ii)	6:6 as ratio of radii similar to NaCl	Ionic radii: Na^+ = 95pm and Cl^- = 181pm ∴ ratio 95:181 = 1.91:1 Fe^{2+} = 61 pm and O^{2-} = 136pm ∴ ratio 61:136 = 2.23:1

<table>
<tr><td>9a</td><td>Lone pairs of electrons</td><td>The lone pairs of electrons on the N atom and the O atom are able to form dative covalent bonds with metal ions</td></tr>
<tr><td>9b(i)</td><td>+3</td><td>The Picolinate ion has a -1 charge ∴ 3 x picolinate ions will have a total -3 charge.
If the complex is neutral overall then the Cr ion must have a 3+ charge.</td></tr>
<tr><td>9b(ii)</td><td>to oxidise Cr^{3+}
or
oxidising agent</td><td>If Cr^{3+} ions are changed into chromium with an oxidation state of VI, this is an increase in the oxidation state of chromium ∴ oxidation.
If hydrogen peroxide is causing the oxidation of Chromium, the hydrogen peroxide is an oxidising agent.</td></tr>
<tr><td>9c</td><td>Hexacyanochromate (II)</td><td>Hexacyanochromate (II)
No. of ligands | Cyanide ion ligand | Metal name | negative complex | Charge on metal ion
<table>
<tr><th>Neutral ligands include:</th><th>Negative Ligands include:</th><th>Central Ion:</th><th>Charge:</th></tr>
<tr><td>
<table>
<tr><th>Ligand</th><th>Name</th></tr>
<tr><td>H_2O</td><td>aqua</td></tr>
<tr><td>NH_3</td><td>ammine</td></tr>
<tr><td>CO</td><td>carbonyl</td></tr>
</table>
</td><td>
<table>
<tr><th>Ligand</th><th>Name</th></tr>
<tr><td>Chloride Cl^-</td><td>chlorido</td></tr>
<tr><td>Cyanide CN^-</td><td>cyanido</td></tr>
<tr><td>Nitrite NO_2^-</td><td>nitrito</td></tr>
</table>
</td><td><u>Positive Complex</u>:
metals keep their name
<u>Negative Complex</u>:
Metals end in ATE
e.g. Cuprate, Ferrate, Cobaltate</td><td>Charge of central ion is converted into roman numerals and put in brackets</td></tr>
</table>
</td></tr>
<tr><td>10a(i)</td><td>esters</td><td>Iso-amyl acetate is an ester with the following functional group:
(acetate is the old name for ethanoate)
  </td></tr>
<tr><td>10a(ii)</td><td>solvents or perfumes</td><td>Esters are used as flavourings, perfumes and solvents</td></tr>
<tr><td>10b(i)</td><td>3-methylbutan-1-ol</td><td> 
ester + water → alcohol + carboxylic acid
isoamyl acetate — 3-methylbutan-1-ol — ethanoic acid</td></tr>
<tr><td>10b(ii)</td><td>condensation or esterification</td><td>alcohol + carboxylic acid → ester + water</td></tr>
<tr><td>11a</td><td>carbon 4 & carbon 5</td><td>A chiral carbon is a carbon which has four different groups attached to it.</td></tr>
<tr><td>11b</td><td>Structural fragment which binds to receptor and can cause a biological response</td><td rowspan="2">Every pharmacologically-active substance has a part of the molecule which has a specific shape which fits the receptor.
• Agonists and the natural substrate cause a biological response inside the cell.
• Antagonists fit the binding site of the receptor but do not cause the biological response and prevent any other chemical doing so.</td></tr>
<tr><td>11c</td><td>Agonist</td></tr>
</table>

12a(i)	Hydrolysis	The ester is hydrolysed into its alcohol and carboxylic acid. The carboxylic acid then is neutralised by sodium hydroxide to form a salt
12a(ii)	concentrated hydrochloric acid	Sodium benzoate + hydrochloric acid → sodium chloride + benzoic acid $Na^+C_6H_5COO^-$ H^+Cl^- Na^+Cl^- C_6H_5COOH
12a(iii)	Recrystallisation	
12a(iv)	7.02g	70% yield benzoic acid = 4.0g ∴ 100% yield benzoic acid= 4.0g x $^{100}/_{70}$ = 5.71g 1mol Benzoic acid C_6H_5COOH = (7x12)+(6x1)+(2x16) = 84+6+32 = 122g no. of mol = $\frac{\textbf{mass}}{\textbf{gfm}} = \frac{5.71}{122}$ = 0.0468mol ethyl benzoate → benzoic acid 1mol 1mol 0.0468mol 0.0468mol 1mol Ethyl Benzoate $C_9H_{10}O_2$ = (9x12)+(10x1)+(2x16) = 108+10+32 = 150g **m**ass = **n**o. of mol x **gfm** = 0.0468mol x 150 g mol^{-1} = 7.02g
12b(i)	Dehydration	Dehydration is an elimination reaction where H_2O is removed and a C=C double bond is created at the removal point
12b(ii)	Diagram showing:	
13a(i)	0.64g	mass of C in CO_2 = $^{12}/_{44}$ x 3.52g = 0.96g mass of H in H_2O = $^{2}/_{18}$ x 1.44g = 0.16g Mass of Oxygen = total mass - mass of carbon - mass of hydrogen = 1.76g - 0.96g - 0.16g = 0.64g
13a(ii)	C_2H_4O	<table><tr><td>Element</td><td>C</td><td>H</td><td>O</td></tr><tr><td>Mass</td><td>0.96</td><td>0.16</td><td>0.64</td></tr><tr><td>No. of moles (divide % by gfm)</td><td>$\frac{0.96}{12}$ = 0.08</td><td>$\frac{0.16}{1}$ = 0.16</td><td>$\frac{0.64}{16}$ = 0.04</td></tr><tr><td>Mole ratio (divide through by smallest value)</td><td>$\frac{0.08}{0.04}$ = 2</td><td>$\frac{0.16}{0.04}$ = 4</td><td>$\frac{0.04}{0.04}$ = 1</td></tr></table>
13b(ii)	$C_4H_8O_2$	Formula mass of C_2H_4O = (2x12)+(4x1)+(1x16) = 24+4+16 = 44g since mass of compound X = 88g ∴ formula of X = $C_4H_8O_2$

<table>
<tr>
<td>13c(i)</td>
<td>Butanoic acid
  </td>
<td>
<table>
<tr><td>Peak at Chemical Shift</td><td>0.9</td><td>1.6</td><td>2.6</td><td>10.8</td></tr>
<tr><td>Relative area under peak</td><td>3</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>Number of hydrogens in group</td><td>3</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>Chemical Group</td><td>$-CH_3$</td><td>-OH</td><td>$-CH_2-C=O$</td><td>-COOH</td></tr>
</table>
Molecule must have 4 carbons and -COOH group (not an ester!)
$\therefore$ Butanoic acid: $CH_3-CH_2-CH_2-COOH$
</td>
</tr>
<tr>
<td>13c(ii)</td>
<td>Standard reference substance for reference purposes</td>
<td>Tetramethylsilane (TMS) is the standard reference substance used to measure all the other substances are measured against.</td>
</tr>
</table>