Past Papers Advanced Higher Chemistry

2002 Marking Scheme

Grade Awarded	Mark Required	
	(/125)	%
A	90+	72%
B	74+	59%
C	58	46%
D	?	?
No award	?	?

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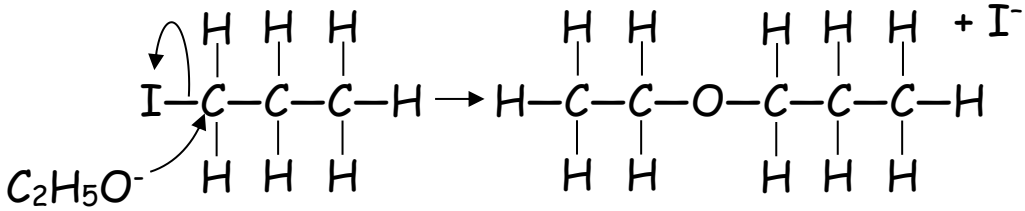
MC Qu	Correct Answer	% Correct	Reasoning
1	C	66	Pressure: Forward reaction increases pressure ∴ *low pressure* required to favour decomposition of NH_3 Temperature: Forward reaction is endothermic ∴ *high temperature* favours decomposition of NH_3
2	B	89	☒A The electronegativity difference makes the substance ionic but doesn't decide the arrangement of the ions in the salt. ☑B The size of the ionic radii decides the arrangement of the ions (either 6:6 NaCl or 8:8 CsCl) ☒C Electrode potentials are not important in solid ionic substances. ☒D Ionisation energies are important in the formation of the salt but not the ion arrangement in the salt
3	B	74	1656kJ of energy = 4x C-H bond enthalpy = 4x414kJ (412kJ in current data booklet) ☒A In burning CH_4, 1656 kJ is put in to break 4xC-H bond but energy is given out on burning ☑B $CH_4(g) \rightarrow C(g) + 4H(g)$ is the breaking 4xC-H bonds ∴ 1656kJ of energy required ☒C reaction is exothermic so energy is given out as 1mol of CH_4 is burned ☒D Energy must be put in to break bonds in H_2 and graphite before 1656kJ are released
4	C	68	<table><tr><td>Elements</td><td>Cu</td><td>O</td></tr><tr><td>Mass of element</td><td>16g</td><td>2g</td></tr><tr><td>No. of moles (divide mass by gfm)</td><td>$\frac{16}{63.5}$ = 0.252</td><td>$\frac{2}{16}$ = 0.125</td></tr><tr><td>Mole ratio (divide through by smallest value)</td><td>$\frac{0.252}{0.125}$ = 2.02</td><td>$\frac{0.125}{0.125}$ =1</td></tr><tr><td>Round to whole number</td><td>2</td><td>1</td></tr></table>
5	C	80	☒A Secondary Amine: 2 carbons attached to the Nitrogen atom ☒B Primary Amine: 1 carbon attached to each of the Nitrogen atoms ☑C Tertiary Amine: 3 carbons attached to the Nitrogen atom ☒D Secondary Amine: 2 carbons attached to the Nitrogen atom
6	A	80	❶ $Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ $\Delta H^o = a$ ❷x-1 $Zn^{2+} + H_2 \rightarrow Zn + 2H^+$ $\Delta H^o = -b$ Add ❶+❷′ $Mg + Zn^{2+} \rightarrow Mg^{2+} + Zn$ $\Delta H^o = a-b = c$
7	D	69	☒A $2NaH + H_2O \rightarrow 2NaOH + H_2$ ∴ alkaline solution produced ☒B $MgH_2 + H_2O \rightarrow Mg(OH)_2 + H_2$ ∴ alkaline solution produced ☒C Forms $Si(OH)_4$ when added to water ∴ not acidic ☑D weakly acidic when added to water
8	A	75	☑A The conductivity of semiconductors increases with increasing temperature ☒B superconductors have zero resistance at temperatures near absolute zero ☒C ionic substances conduct when molten but not as a solid ☒D Photovoltaic Cells (solar cells) have increasing electrical resistance on exposure to light
9	B	53	The higher the value of K_b, the more dissociated the substance is. The more dissociated a base is the higher the $[OH^-]$ and higher the pH is.
10	A	43	☑A Equilibrium shifts to keep value of equilibrium constant the same ☒B The higher the value of equilibrium constant K, the more negative the value of ΔG^o is ☒C Catalysts do not change proportions of products/reactants so equilibrium constant is same ☒D Not enough information (e.g. ΔH^o for reaction is required)
11	D	65	Salt produced from neutralisation of weak acid (CH_3COOH) and strong alkali (NaOH) gives alkaline pH ∴ indicator range should be in alkaline pH range
12	D	39	Enthalpy of solution = Enthalpy of hydration – lattice enthalpy = -2871 – (-2913) = +42kJ mol^{-1} ☒A Solubility cannot be deduced from this information ☒B Solubility is unknown from the information given. ☒C Enthalpy of solution is not exothermic so energy will not be given out if soluble ☑D Enthalpy of solution is endothermic so will take in energy if soluble.

13	C	62	$\Delta G^o = \Delta H^o - T\Delta S^o \therefore \Delta G^o - \Delta H^o = T\Delta S^o$ $\therefore T\Delta S^o$ = approx zero then ΔS^o = approx zero and little change to disorder ☒A Solid becoming a gas has a large increase in disorder ☒B A solid releasing a gas has a large increase in disorder ☑C A solid and a solution react to become a solid and a solid $\therefore$ similar levels of disorder ☒D A solid releasing a gas has a large increase in disorder
14	B	74	<table><tr><td>Experiments</td><td>Change in conditions</td><td>Effect of Time</td><td>Effect on Rate</td><td>Order</td></tr><tr><td>1+2</td><td>[Q] x 2</td><td>$x\frac{1}{2}$</td><td>x2</td><td>$[Q]^1$</td></tr><tr><td>1+3</td><td>[P] x 2</td><td>No change</td><td>No change</td><td>$[P]^0$</td></tr></table> Rate = $k[P]^0[Q]^1 = k[Q]$
15	D	44	☒A Enthalpy of formation starts from elements in their natural state ($Mg^{2+}(g)$ not an element) ☒B Enthalpy of formation starts from elements in their natural state ($Mg^{2+}(g)$ not an element) ☒C Enthalpy of formation starts from elements in their natural state ($Br(g)$ is not natural state) ☑D Enthalpy of formation starts from elements in their natural state
16	D	60	☒A Liquid mercury (mpt=-39°C) has higher entropy (disorder) than solid sulphur ☒B Gaseous neon (bpt=-246°C) has higher entropy (disorder) than solid sulphur ☒C Liquid phosphorus (mpt=44°C) has higher entropy (disorder) than solid sulphur ☑D Solids have lower entropy/disorder than liquids or gases. (sulphur mpt =113°C)
17	A	65	Most covalent character $\therefore$ lowest difference in electronegativity ☑A difference in electronegativity = 2.6 - 1.8 = 0.8 ☒B difference in electronegativity = 3.0 – 1.8 = 1.2 ☒C difference in electronegativity = 4.0 – 1.0 = 3.0 ☒D difference in electronegativity = 2.8 – 0.8 = 2.0
18	B	57	☒A Hexammine → 6xNH_3 ligand molecules in complex ☑B 6 neutral NH_3 ligands and Ni^{2+} central ion in complex ☒C NH_3 is a neutral ligand and Nickel ion must be positive (Ni^{4-} would be ion in this complex) ☒D Hexammine → 6xNH_3 ligand molecules in complex
19	D	75	☒A ClO^-: Oxidation number of Cl=+1 as 1xO=-2 $\therefore$ Cl – 2 = -1 $\therefore$ Cl = +1 ☒B ClO_2^-: Oxidation number of Cl=+3 as 2xO=-4 $\therefore$ Cl – 4 = -1 $\therefore$ Cl = +3 ☒C ClO_3^-: Oxidation number of Cl=+5 as 3xO=-6 $\therefore$ Cl – 6 = -1 $\therefore$ Cl = +5 ☑D ClO_4^-: Oxidation number of Cl=+7 as 4xO=-8 $\therefore$ Cl – 8 = -1 $\therefore$ Cl = +7
20	A	26	☑A $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ 1mol 2mol 100g 2mol 50g 1mol 0.5g 0.01mol ☒B $2HCl + Ba(OH)_2 \rightarrow BaCl_2 + 2H_2O$ **n**o. of mol = **v** x **c** = 0.1 x 0.1 = 0.01mol $Ba(OH)_2$ 2mol 1mol 0.02mol 0.01mol ☒C $Mg + 2HCl \rightarrow MgCl_2 + H_2$ 1mol 2mol 24.3g 2mol 0.243g 0.02mol ☒D $HCl + AgNO_3 \rightarrow AgCl + HNO_3$ **n**o. of mol = **v** x **c** = 0.025 x 0.2 = 0.05 mol $AgNO_3$ 1mol 1mol 0.05mol 0.05mol
21	D	43	No of electron pairs = $\frac{\text{No. of outer electrons in central atom + No. of bonds - charge}}{2}$ $= \frac{7 + 4 - (-1)}{2}$ $= \frac{12}{2}$ = 6 electron pairs $\therefore$ octahedral arrangement of electrons pairs Lone pair : lone pair repulsion > lone pair : bonding pair repulsion > bonding pair : bonding pair repulsion 2 Lone pairs will be 180° apart and 4 bonding pairs will be planar at 90° apart

22	A	37	❶ $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ E^o=+1.51V ❷ $Fe^{2+} \rightarrow Fe^{3+} + e^-$ E^o=-0.77V ❶+❷ $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$ E^o=+0.74V
23	C	50	Reduction of TiO_2 would produce Ti metal: $TiO_2 \rightarrow Ti + O_2$ Mg/Ti: Titanium line is upper line at temperatures below 2000K (upper line reverses) $\therefore$ Magnesium would reduce TiO_2 at temperatures **below** 2000K Ti/C: Titanium line is upper line at temperatures above 2000K (upper line reverses) $\therefore$ carbon would reduce TiO_2 at temperatures **above** 2000K
24	C	23	The -OH group on a benzene ring (known as a phenol group) is acidic and would react with KOH(aq)
25	B	39	Lithium aluminium hydride $LiAlH_4$ reduces aldehydes/ketones and carboxylic acids and aldehydes and ketones will reaction with hydrogen cyanide HCN in an addition reaction. ☒A X is aldehyde or ketone but only aldehydes oxidise to acids ☑B X is aldehyde or ketone $\therefore$ both contain the carbonyl C=O group ☒C alkene would react with HCN in an addition reaction but alkenes do not react with $LiAlH_4$ ☒D X is aldehyde or ketone
26	C	67	☒A methoxyethane is an ether and has no hydrogen bonding in between molecules ☒B propanal is an alkanal and has no hydrogen bonding in between molecules ☑C propan-2-ol is an alkanol and has hydrogen bonding in between molecules ☒D propanone is an alkanone and has no hydrogen bonding in between molecules
27	B	66	
28	A	44	1mol H_2 = 24litres ☑A $CH_3C{\equiv}CH + 2H_2 \rightarrow CH_3CH_2CH_3$ 1mol 2mol 0.5mol 1mol = 24 litres ☒B $CH_3CH_2CHO + H_2 \rightarrow CH_3CH_2CH_2OH$ 1mol 1mol 0.5mol 0.5mol = 12 litres ☒C $HC{\equiv}CCH_2CH{=}CH_2 + 3H_2 \rightarrow CH_3CH_2CH_2CH_2CH_3$ 1mol 3mol 0.5mol 1.5mol = 36litres ☒D $CH_3CH{=}CHCH_2OH + H_2 \rightarrow CH_3CH_2CH_2CH_2OH$ 1mol 1mol 0.5mol 0.5mol = 12litres
29	C	53	1mol $BaSO_4$ = (1x137.3)+(1x32.1)+(4x16) = 137.3+32.1+64 = 233.4g metal sulphate + $BaCl_2$ ⟷ $BaSO_4$ + metal chloride 1.204g ⟷ 2.334g 1.204 x $^{233.4}/_{2.334}$ ⟷ 233.4g = 120.4g ☒A $CaSO_4$: 1mol =(1x40)+(1x32.1)+(4x16) = 40+32.1+64 = 136.1g ☒B $CuSO_4$: 1mol =(1x63.5)+(1x32.1)+(4x16) = 63.5+32.1+64 = 159.6g ☑C $MgSO_4$: 1mol =(1x24.3)+(1x32.1)+(4x16) = 24.3+32.1+64 = 120.4g ☒D Na_2SO_4: 1mol =(2x23)+(1x32.1)+(4x16) = 46+32.1+64 = 142.1g
30	C	48	Ethene is attracted to δ+ of Br_2 so ethene is acting as nucleophile Br^- is attracted to positive cyclic ion intermediate so Br^- is acting as nucleophile

The style of question in Q31-33 has been abandoned but the content of the questions is still relevant.		
31a	C,D (1 mark each)	Visible and UV absorption spectroscopy involve the absorption of certain wavelengths of energy which correspond to certain energy level differences. These wavelengths are removes from the spectrum of colour produces and appear as dark lines at certain wavelengths.
31b	E	In Mass spectroscopy, the sample is broken down as it picks up charge and is passed through an electric field.
31c	F	X-ray crystallography uses the diffraction of X-rays as they bend as they pass objects forming a precise 3D structure of a substance to be determined.
32a	E	Chromium atoms have electronic configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ and not $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4\ 4s^2$ because an electron is borrowed from $4s^2 \rightarrow 4s^1$ to half fill the 3d orbital $3d^4 \rightarrow 3d^5$ to achieve higher stability.
32b	C	Sodium atoms in the ground state have the electronic configuration of $1s^2\ 2s^2\ 2p^6\ 3s^1$ and to excite this atom and electron from $3s^1$ can move to a high energy level e.g. $3s^1 \rightarrow 3p^1$
32c	D,F (1 mark each)	☑D $3d^4$ has 4 unpaired electrons (all other orbitals are full and paired) ☑F $3d^6$ has 4 unpaired electrons and 1 pair of electrons (all other orbitals are full and paired)
33	A,C (1 mark each)	☑A H_2O is amphoteric as it acts as an acid (donates H^+) and acts as a base (accepts H^+) ☒B SiO_2 will dissolve in alkalis to form the silicate ion but does not react with acids ☑C Al_2O_3 is amphoteric as it acts both as an acid and a base ☒D CO_2 partially dissolves in water to act as a acid but does not act as a base ☒E CO does not dissolve in water and acts neither as an acid or base ☒F Na_2O dissolves in water to form an alkali but does act as an acid

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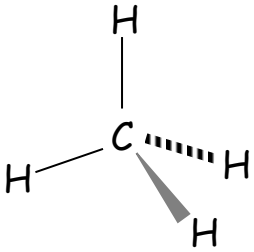
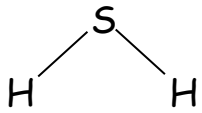
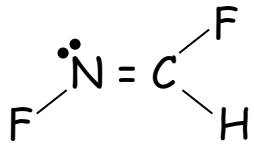
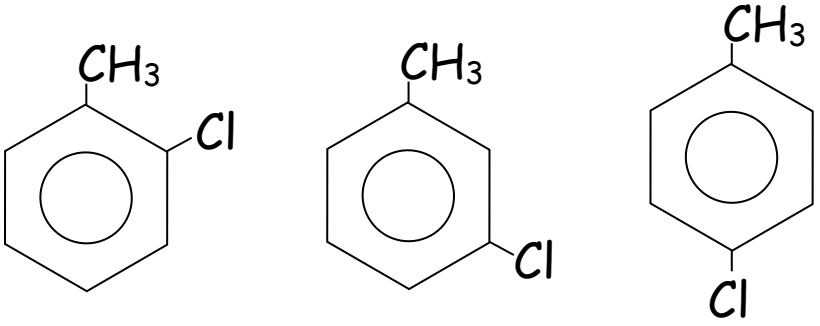
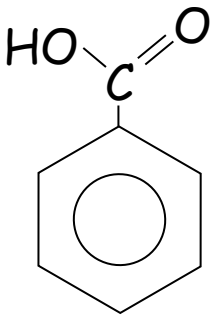
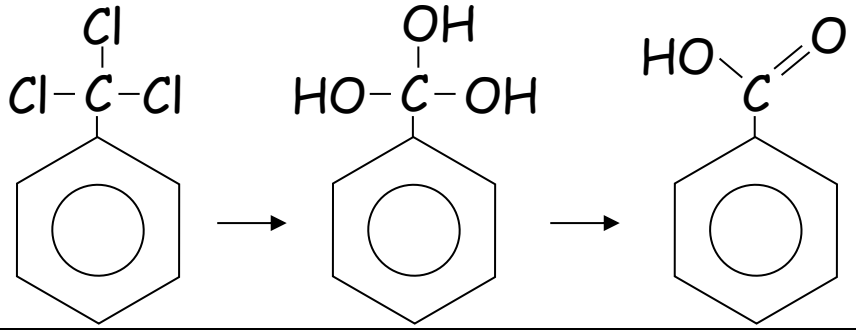
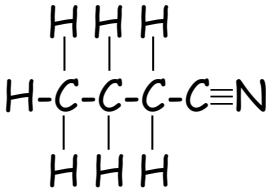
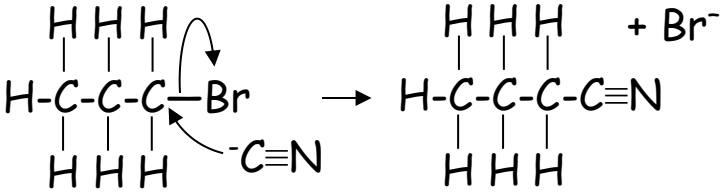
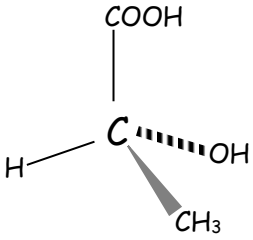
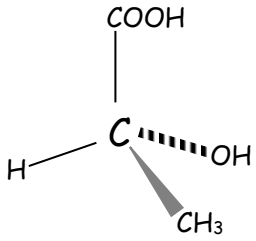
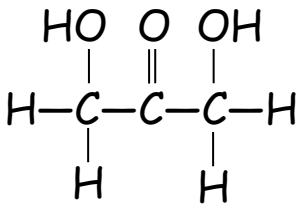
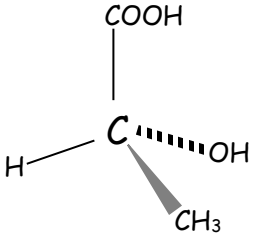
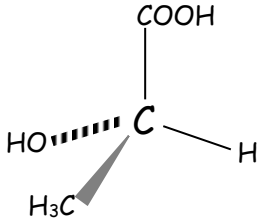
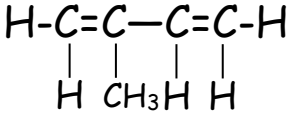
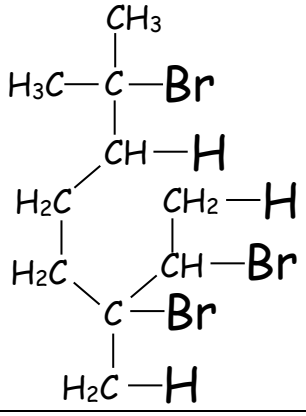
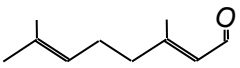
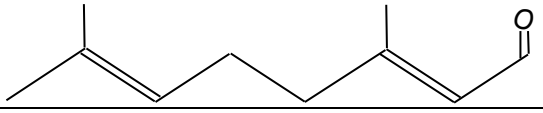
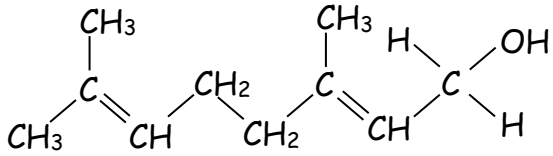
Long Qu	Answer	Reasoning
1a	Hydrogen chloride	Hydrogen chloride is a white gas which dissolves in water to form an acid.
1b	covalent	Covalent bonding is present due to: a) Hydrolysis of $TiCl_4$ when added to water b) $TiCl_4$ is a liquid at room temperature
1c	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1$	Titanium atom: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$ Ti^{3+} ion: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1$ (4s electrons lost before 3d)
1d	239.5	$E = \frac{Lhc}{\lambda} = \frac{6.02\times10^{23}\,mol^{-1} \times 6.63\times10^{-34}\,J\,s \times 3\times10^{8}\,m\,s^{-1}}{500\times10^{-9}\,m} = 239475.6\ J\ mol^{-1}$ $= 239.5\ kJ\ mol^{-1}$
2a(i)		No of electron pairs $= \frac{\text{No. of outer electrons in central atom + No. of bonds - charge}}{2}$ $= \frac{4+4-0}{2}$ $= \frac{8}{2}$ = 4 electron pairs ∴ tetrahedral arrangement of electrons 4 bonding pairs = tetrahedral shape
2a(ii)		No of electron pairs $= \frac{\text{No. of outer electrons in central atom + No. of bonds - charge}}{2}$ $= \frac{6+2-0}{2}$ $= \frac{8}{2}$ = 4 electron pairs ∴ tetrahedral arrangement of electrons 2 bonding pairs + 2 non-bonding pairs = angular shape
2b	Answer should include:	Repulsion: lone pair : lone pair > lone pair : bonding pair > bonding pair : bonding pair The 2 lone pairs of electrons on the sulphur in H_2S have more repulsion than the 2 bonding pairs which forces the bonding pairs closer together (104.5°). In methane CH_4 the 4 bonding pairs have equal repulsion and have a bond angle of 109.5° between them
3a	157.6 kJ mol^{-1}	$\Delta H^o = \sum\Delta H_f^o(\text{products}) - \sum\Delta H_f^o(\text{reactants})$ $= 0 + 0 + 34 - (-123.6)$ $= 34 - (-123.6) = +157.6\ kJ\ mol^{-1}$
3b	245 J K^{-1} mol^{-1}	$\Delta S^o = \sum S^o(\text{products}) - \sum S^o(\text{reactants})$ $= 42.6 + (\frac{1}{2}\times205) + 241.4 - 141.5$ $= 386.5 - 141.5 = +245\ J\ K^{-1}\ mol^{-1}$
3c	643K	The reaction becomes thermodynamically feasible when $\Delta G^o = \Delta H^o - T\Delta S^o = 0$ $\therefore T\Delta S^o = \Delta H^o \quad \therefore T = \frac{\Delta H^o}{\Delta S^o} = \frac{157.6\times1000\ J\ mol^{-1}}{245\ J\ K^{-1}\ mol^{-1}} = 643K$
4a		The lone pair of electrons must be remembered when the angle of the N-F bond is drawn. As the C=N bond is non-rotational, then trans- and cis- geometric isomers of difluoromethanimine exist.
4b	Answer should include:	Pi bonds are formed as a result of sp^2 hybridisation. In sp^2 hybridisation, 2s and two 2p orbitals become equal in energy and form sigma bonds (single bonds). The unhybridised p orbitals in the N and the C atoms overlap to form the pi bond and therefore a C=N double bond.
4c	19	$K = \frac{[\text{cis-isomer}]}{[\text{trans-isomer}]} = \frac{95\%}{5\%} = 19$

4d	95%	If starting position was 100% cis-isomer then the equilibrium would shift to left to get back to equilibrium position of 95% cis-isomer and 5% trans-isomer
5a(i)	Zero order	Rate is zero order as rate is independent of $[C_6H_6]$. As the line is straight, the gradient is equal at all concentrations. As the gradient of the line is equal to the reaction rate, the rate of reaction is constant at all concentrations of Benzene.
5a(ii)	Rate = k $[HNO_3]$	Rate = k $[HNO_3]^1$ $[C_6H_6]^0$ = k $[HNO_3]$
5a(iii)	2	Benzene is not involved in the slow rate determining step Mechanism must have a 2nd faster step which benzene takes part in.
5b	Acid: H_2SO_4 Conjugate base: HSO_4^-	$HNO_3 + 2H_2SO_4 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ (acid; conjugate base) Acid: Species capable of donating a proton (H^+) Conjugate Base: The species formed by the acid donating a proton (H^+)
6a	Electrophilic	Only electrophiles are attracted to the delocalised electrons in a benzene ring
6b	Any one from:	
6c(i)	$Cl_2 \rightarrow Cl^\bullet + Cl^\bullet$	Initiation: $Cl_2 \longrightarrow Cl^\bullet + Cl^\bullet$ (formation of free radicals)
6c(ii)	One from:	$Cl^\bullet + C_6H_5CH_3 \longrightarrow C_6H_4CH_2^\bullet + HCl$ $C_6H_4CH_2^\bullet + Cl_2 \longrightarrow C_6H_4CH_2Cl + Cl^\bullet$
6d		
7a	$Mn^{2+} + 4H_2O$ $\downarrow$ $MnO_4^- + 8H^+ + 5e^-$	$Mn^{2+} + 4H_2O \longrightarrow MnO_4^- + 8H^+ + 5e^-$
7b	Answer should include:	Permanganate MnO_4^- ions are purple and Mn^{2+} ions have no colour. The intensity of the colour is proportional to the concentration of MnO_4^- ions present.
7c	0.28%	Absorbance = 0.22 $\therefore$ $[MnO_4^-] = 11\times10^{-5}$ mol $l^{-1} = 1.1\times10^{-4}$ mol l^{-1} no. of mol MnO_4^- = v x c = $0.1 \times 1.1\times10^{-4} = 1.1\times10^{-5}$ mol $Mn^{2+} + 4H_2O \longrightarrow MnO_4^- + 8H^+ + 5e^-$ (1mol, 1.1×10^{-5} mol; 1mol, 1.1×10^{-5} mol) **m**ass = **n**o. of mol x **gfm** = $54.9 \times 1.1\times10^{-5} = 0.0006039$ g $\%Mn = \frac{\text{Mass of Mn}}{\text{Total Mass}} \times 100 = \frac{0.0006039}{0.214} \times 100 = 0.28\%$

8a	-0.81V	Oxidation Step: $Cd + 2OH^- \rightarrow Cd(OH)_2 + 2e^-$ $E^o = X$ Reduction Step: $NiO_2.2H_2O + 2e^- \rightarrow Ni(OH)_2 + OH^-$ $E^o = 0.49V$ Redox: $Cd + OH^- + NiO_2.2H_2O \rightarrow Cd(OH)_2 + Ni(OH)_2$ $E^o = 1.30V$ $\therefore$ 1.30V = X + 0.49V $\quad \therefore$ X = 1.30V – 0.49V = +0.81V $\therefore$ standard reduction potential for Cadmium = -0.81V
8b	-250.9	2 moles of electrons transferred in redox equation $\therefore$ n=2 $\Delta G^o = -nFE^o = -2 \times 96500 \times 1.30 = -250900$ J mol^{-1} = -250.9kJ mol^{-1}
9a	11.286kJ mol^{-1}	1mol NaCl = (1x23)+(1x35.5) = 23+35.5 = 58.5g $\Delta H^o = cm\Delta T = 4.18 \times 0.150 \times 3.6 = 2.2572$kJ 11.7g $\leftrightarrow$ 2.2572 kJ 58.5g $\leftrightarrow$ 2.2572 kJ $\times$ $^{58.5}/_{11.7}$ = 11.286kJ mol^{-1}
9b	13 kJ mol^{-1}	Enthalpies of hydration: $Na^+_{(g)} + Cl^-_{(g)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$ = -418 + (-338) = -756kJ mol^{-1} Enthalpy of solution = enthalpies of hydration – lattice enthalpy = -756 – (-769) = 13 kJ mol^{-1}
9c	One from:	Heat loss in experiment to surroundings; Solution not stirred enough to get same temperature across whole solution
10a		
10b	hydrolysis	C≡N bond is broken down and water is added at the break
10c	3.4	pH = $\frac{1}{2}pK_a$ - $\frac{1}{2}\log_{10}$ c = ($\frac{1}{2}$ x 4.83) - $\frac{1}{2}$ x $\log_{10}$(0.01) = 2.415 - $\frac{1}{2}$ x (-2) = 2.415 - -1 = 3.415
10d	Answer should include:	A buffer has a large quantity of an weak acid/alkali (butanoic acid) and its salt (sodium butanoate) and the following equilibrium is maintained: $C_3H_7COO^- + H^+ \rightleftharpoons C_3H_7COOH$ If acid is added: equilibrium moves to right to remove H^+ If alkali is added: equilibrium moves to left to replace the H^+ ions that have been neutralised by the alkali
11a	RAM = 90.0g	no. of mol NaOH = volume x concentration = 0.0178litres x 0.049mol l^{-1} = 8.722 x 10^{-4}mol mass of X = volume x concentration = 0.01litres x 7.85g l^{-1} = 0.0785g X + NaOH $\rightarrow$ salt + H_2O (NB X is a monocarboxylic acid) 1mol 8.722x10^{-4}mol; 1mol 8.722x10^{-4}mol 8.722x10^{-4}mol $\leftrightarrow$ 0.0785g 1mol $\leftrightarrow$ 0.0785g x $\frac{1}{8.722\text{x}10^{-4}}$ = 90.0g
11b	$C_3H_6O_3$	Empirical formula = CH_2O = (1x12)+(2x1)+(1x16) = 12+2+16 = 30 mass of X = 90 $\therefore$ formula = $(CH_2O)_3$ = $C_3H_6O_3$

11c(i)		 Asymmetrical $C_3H_6O_3$  Symmetrical $C_3H_6O_3$
11c(ii)	Equal concentration of both optical isomers present (racemic mixture)	  Both optical isomers (mirror images) present in the mixture so no rotation of plane polarised light
12a		2-methyl (-CH_3 on C_2) buta (4C in main chain) -1,3- (functional groups on C_1 and C_3) diene (2x C=C bonds)
12b	myrcene	No. of mol = v x c = 0.0475 x 1.2 = 0.057mol Br_2 0.019mol unknown terpene is decolourised by 0.057mol Br_2 1mol ↔ 0.057mol Br_2 x $^1/_{0.019}$ = 3mol Br_2 1mol of unknown terpene reacts with 3mol of Br_2 ∴ Unknown terpene contains 3x C=C bonds ∴ myrcene
12c		Markovnikov's Rule: H of HBr adds onto the C of a C=C bond which has the highest number of H atoms already attached to it. Any correct drawing of: 2,3,7-tribromo-3,7-dimethyloctane
12d		
12e	structure showing:	
13a	Answer should include:	Sulphanilamide and 4-aminobenzoic acid contain the same pharmacophore shape (H_2N-C_6H_4-). Sulphanilamide will fit into the active site of the enzyme and prevents 4-aminobenzoic acid from entering the active site of the enzyme.
13b	Antagonist	As sulphanilamide prevents the enzyme from producing folic acid, it is blocking the biological response in the bacterial cell. Agonists produce the biological response and antagonists block the biological response.