JABchem

Past Papers Higher Chemistry

REVISED 2015

Marking Scheme

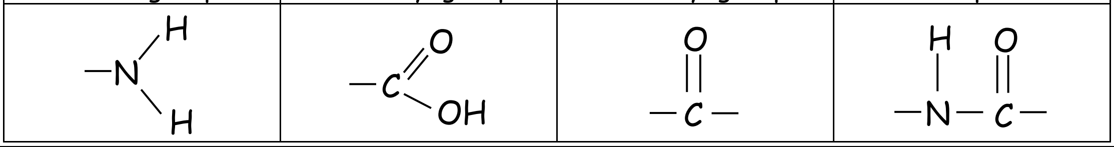
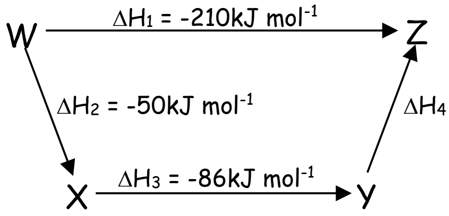
Grade Awarded	Mark Required (/100)	% candidates achieving grade
A	71	30.1%
B	59	25.2%
C	47	22.5%
D	41	7.3%
No award	<41	15.0%

Section:	Multiple Choice	Extended Answer
Average Mark:	21.0 /40	38.9 /60

2015 Revised Higher Chemistry Marking Scheme

MC Qu	Answer	% Pupils Correct	Reasoning
1	D	90 NewH=84	☒A Neon is a noble gas with a full outer shell and does not need to form ions. ☒B Neon is a noble gas and is monatomic not diatomic. ☒C Neon is a noble gas and does not need to form bonds to get a full outer shell. ☑D Nitrogen, oxygen, fluorine and neon are all gases at room temperature.
2	A	85 OldH=80	☒A Iodine is a non-metal element with no electrical conductivity ☑B potassium is a metal with a low melting point (63°C) and high electrical conductivity ☒C silicon dioxide is a covalent network and has no electrical conductivity ☒D potassium fluoride is ionic and has no electrical conductivity as a solid
3	C	91 OldH=85 NewH=89	☒A First ionisation energy forms a 1+ ion from the element in the gaseous state ☒B First ionisation energy forms a 1+ ion from the element in the gaseous state ☑C 1st ionisation energy: removal of one mole of electron from one mole of atoms in the gaseous state. ☒D Element must be single atoms in the gaseous state before ionisation
4	B	86 OldH=81	Group 3 elements have a low 3rd ionisation energy and a very high 4th ionisation energy • removal of the 3rd electron creates a full outer shell • removal of the 4th electron breaks into a full outer shell
5	A	78 OldH=74 NewH=62	☑A X-Y: activation energy (E_a) for the forward reaction ☒B Y-X: would give a negative value but activation energy (E_a) must be endothermic ☒C Y-Z: would be the enthalpy change (ΔH) for the reverse reaction ☒D Z-Y: would be the enthalpy change (ΔH) for the forward reaction
6	C	46 NewH=38	☒A OH^- would react with both Br_2 or I_2 as OH^- is above both on ECS $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$ $Br_2 + 2e^- \longrightarrow 2Br^-$ *upper reaction reverses* $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$ $Br_2 + 2e^- \longrightarrow 2Br^-$ *add together and cancel electrons* $Br_2 + 4OH^- \longrightarrow 2Br^- + O_2 + 2H_2O$ $O_2 + 2H_2O + 4e^- \longrightarrow 4OH^-$ $I_2 + 2e^- \longrightarrow 2I^-$ *upper reaction reverses* $4OH^- \longrightarrow O_2 + 2H_2O + 4e^-$ $I_2 + 2e^- \longrightarrow 2I^-$ *add together and cancel electrons* $I_2 + 4OH^- \longrightarrow 2I^- + O_2 + 2H_2O$ ☒B SO_3^{2-} would react with both Br_2 or I_2 as SO_3^{2-} is above both on ECS $SO_4^{2-} + 2H^+ + 2e^- \longrightarrow SO_3^{2-} + H_2O$ $Br_2 + 2e^- \longrightarrow 2Br^-$ *upper reaction reverses* $SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$ $Br_2 + 2e^- \longrightarrow 2Br^-$ *add together and cancel electrons* $Br_2 + SO_3^{2-} + H_2O \longrightarrow 2Br^- + SO_4^{2-} + 2H^+$ $SO_4^{2-} + 2H^+ + 2e^- \longrightarrow SO_3^{2-} + H_2O$ $I_2 + 2e^- \longrightarrow 2I^-$ *upper reaction reverses* $SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e^-$ $I_2 + 2e^- \longrightarrow 2I^-$ *add together and cancel electrons* $I_2 + SO_3^{2-} + H_2O \longrightarrow 2I^- + SO_4^{2-} + 2H^+$ ☑C Fe^{2+} is above Br_2 so would react with Br_2 but Fe^{2+} is below I_2 so no reaction $Fe^{3+} + e^- \longrightarrow Fe^{2+}$ $Br_2 + 2e^- \longrightarrow 2Br^-$ *upper reaction reverses* $Fe^{2+} \longrightarrow Fe^{3+} + e^-$ $Br_2 + 2e^- \longrightarrow 2Br^-$ *Multiple to equalise electrons, add together & cancel electrons* $Br_2 + 2Fe^{2+} \longrightarrow 2Br^- + 2Fe^{3+}$ $I_2 + 2e^- \longrightarrow 2I^-$ $Fe^{3+} + e^- \longrightarrow Fe^{2+}$ *upper reaction reverses* $2I^- \longrightarrow I_2 + 2e^-$ $Fe^{3+} + e^- \longrightarrow Fe^{2+}$ *Multiple to equalise electrons, add together & cancel electrons* $2I^- + 2Fe^{3+} \longrightarrow I_2 + 2Fe^{2+}$ ☒D Mn^{2+} would not react with either Br_2 or I_2 as Mn^{2+} is below them on ECS $Br_2 + 2e^- \longrightarrow 2Br^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ *upper reaction reverses* $2Br^- \longrightarrow Br_2 + 2e^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ *add together and cancel electrons* $2MnO_4^- + 16H^+ + 10Br^- \longrightarrow Br_2 + Mn^{2+} + 8H_2O$ $I_2 + 2e^- \longrightarrow 2I^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ *upper reaction reverses* $2I^- \longrightarrow I_2 + 2e^-$ $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ *add together and cancel electrons* $2MnO_4^- + 16H^+ + 10I^- \longrightarrow I_2 + Mn^{2+} + 8H_2O$

7	C	25 OldH=26	**gfm** Na = 23g mol^{-1} **mass** = 4.6g **Molar Volume** = 24 litres mol^{-1} **Volume** = 4.8litres **no. of mol** = $\frac{\textbf{mass}}{\textbf{gfm}} = \frac{4.6g}{23g\ mol^{-1}}$ = 0.2mol **no. of mol** = $\frac{\textbf{Volume}}{\textbf{Molar Volume}} = \frac{4.8\ litres}{23\ litres\ mol^{-1}}$ = 0.2mol $4Na + O_2 \longrightarrow 2Na_2O$ 4mol 1mol 2mol 0.2mol 0.05mol 0.05mol of O_2 reacts with 0.2mol of Na ∴ 0.15mol of O_2 (out of 0.2mol) is unreacted
8	D	96	☒A structure shown is 3-methylbutan-2-ol ☒B structure shown is 4-methylpentan-2-ol ☒C structure shown is 2-methylbutan-2-ol ☑D structure shown is 2-methylpentan-2-ol
9	A	33 NewH=29	☑A propanol does not react with NaOH but sodium propanoate would form in the neutralisation reaction between alkali (NaOH) and acid (ethanoic acid) ☒B all ethanoic acid would react with NaOH to form a salt plus water ☒C no propylethanoate would be formed as H^+ ions are required to form esters ☒D ester theoretically formed would be propylethanoate not ethylpropanoate
10	D	60	☒A essential oils can be used in cleaning products as they dissolve grease ☒B essential oils are widely used because of their distinctive aromas ☒C essential oils release their aromas due to their volatile nature. ☑D essential oils are not soluble in water as they are largely hydrocarbon based
11	C	77 NewH=74	The –OH bond in erthyromycin can be reacted with a carboxylic acid to form an ester by a condensation reaction.
12	B	63 NewH=50	Oil with lowest melting point will have the highest number of C=C double bonds ∴ highest number of C=C double bonds would react with the most iodine ∴ highest iodine number
13	C	89	fat $\xrightarrow{\text{hydrolysis}}$ glycerol + 3x fatty acid 1mol 1mol 3mol
14	D	72	☒A The diol and diacid produced would be formed from the hydrolysis of a polyester ☒B The diamine and the diacid produced are formed from the hydrolysis of a polyamide ☒C the monomers drawn are not amino acids (which have $–NH_2$ and –COOH groups) ☑D the monomers drawn are both amino acids with an $–NH_2$ group and a –COOH group
15	A	92	☑A butan-2-ol: secondary due to 2 carbons attached to the carbon with the –OH group ☒B The carbon with the –OH group is only ever attached to 1 other carbon – not secondary ☒C 2-methylpropan-1-ol: primary due to 1 carbon attached to the carbon with the –OH group ☒D 2-methylpropan-2-ol: tertiary due to 3 carbons attached to the carbon with the –OH group
16	B	81 NewH=79	☒A Glycerol formed has three –OH hydroxyl bonds but no –COOH carboxyl groups ☑B Glycerol formed has three –OH groups on a different carbon each ☒C different fatty acids produced by hydrolysis of oils, not just $C_{17}H_{35}COOH$ ☒D different fatty acids produced by hydrolysis of oils, not just $C_{17}H_{33}COOH$
17	A	64 NewH=58	☑A oxidation: increase in oxygen : hydrogen ratio in molecule ☒B reduction: decrease in oxygen : hydrogen ratio in molecule ☒C hydrolysis: molecules splitting into smaller molecules with H_2O added at break ☒D condensation: small molecules joining to form larger molecule with H_2O removed
18	B	92	Peptide and amide links are the same group chemically • Peptide links are found in proteins • Amide links are found in polyamide polymers e.g. nylon, kevlar O H ‖ | – C – N –
19	A	80	Reaction / Type / Explanation X / Hydration / Hydration: Addition of H_2O across a C=C double bond Y / Oxidation / Oxidation: primary alcohol $\longrightarrow$ aldehyde

20	C	80	Amine group | Carboxyl group | Carbonyl group | Amide/Peptide link 
21	A	69 OldH=64 NewH=58	$\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4$ $\Delta H_4 = \Delta H_1 - \Delta H_2 - \Delta H_3$ $\Delta H_4 = -210 - (-50) - (-86)$ $\Delta H_4 = -74 kJ\ mol^{-1}$ But ΔH for Z to Y = +74kJ mol^{-1} 
22	D	73 OldH=70 NewH=62	☒A $2I_{(g)} + 2e^- \rightarrow 2I^-_{(g)}$ should have ΔH = 2x-349kJ = -698kJ ☒B $2I_{(g)} + 2e^- \rightarrow 2I^-_{(g)}$ should have ΔH = 2x-349kJ = -698kJ ☒C $I_{2(g)} \rightarrow 2I_{(g)}$ should have ΔH = +243kJ ☑D all steps have the correct enthalpy changes: Enthalpy of sublimation $I_{2(s)} \rightarrow I_{2(g)}$ ΔH = +60kJ Bond dissociation of I_2 $I_{2(g)} \rightarrow 2I_{(g)}$ ΔH = +243kJ 2xelectron affinity of iodine $2I_{(g)} + 2e^- \rightarrow 2I^-_{(g)}$ ΔH =-698kJ
23	A	88 OldH=87 NewH=89	☑A at equilibrium rate of the forward reaction = rate of reverse reaction ☒B at equilibrium the concentration of reactants and products are constant not equal ☒C both forward and reverse reactions continue at equal rate at equilibrium ☒D catalysts do not change the position of equilibrium
24	B	84 OldH=83	☒A Forward reaction: 2mol gas → 1mol gas ∴forward reaction decreases pressure ☑B Forward reaction: 2mol gas → 2mol gas ∴no change in pressure ☒C Forward reaction: 3mol gas → 2mol gas ∴forward reaction decreases pressure ☒D Forward reaction: 4mol gas → 2mol gas ∴forward reaction decreases pressure
25	C	33 OldH=40	The red colour will fade as equilibrium shifts to right. ☒A Equilibrium shifts to left as product (H^+) is added to equilibrium ☒B Equilibrium shifts to left as product (Br^-) is added to equilibrium ☑C Equilibrium shifts to right as product (Br^-) is removed by $Ag^+Br^-_{(s)}$ precipitation ☒D Equilibrium shifts to left as product (OBr^-) is added to equilibrium
26	D	54 OldH=51	☒A 1mol gas → 2mol gas: products have greater volume than reactants ☒B 1mol gas → 1mol gas: products have same volume than reactants ☒C zero moles of gas → 1mol gas: products have greater volume than reactants ☑D 2mol gas → zero moles of gas: products have less volume than reactants
27	B	76	<u>Bond Breaking Steps</u> 1x H–H = 1x432kJ = 432kJ 1x Cl–Cl = 1x243kJ = 243kJ Total = 675kJ <u>Bond Forming Steps</u> 2x H–Cl = 2x428kJ = 856kJ Total = 856kJ ΔH = ΣBond enthalpies for bonds broken - ΣBond enthalpies for bonds formed ΔH = 675 - 856 ΔH = -181 kJ mol^{-1}
28	C	67	Average temp of reactants = $\frac{18+20}{2}$ = 19°C Temperature of Products = 27°C Change in temperature 27°C – 19°C = 8°C
29	B	28	☒A The flow of cold water should be in the opposite direction to the flow of distillate ☑B A heating mantle would prevent ignition of vapours and the condenser is set up right ☒C The flow of cold water should be in the opposite direction to the flow of distillate ☒D Naked flames from the Bunsen burner could ignite vapours in this technique
30	D	46	☒A Swirling the flask mixes the chemical thoroughly and the end-point is accurate ☒B Using a white tile ensures that the colour changes is accurately determined ☒C Adding solution dropwise at the end ensures the end-point is accurate to one drop ☑D Repeating a titration improves the reliability of a reaction not the accuracy

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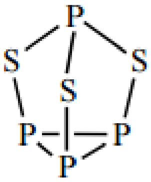
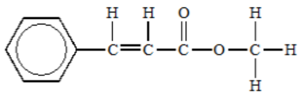
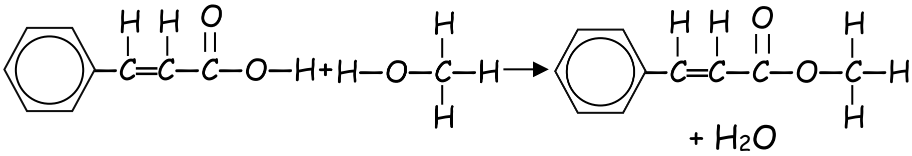
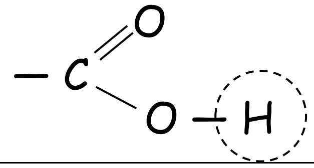
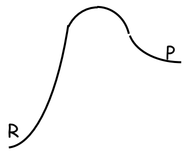
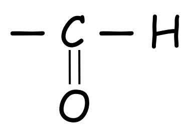
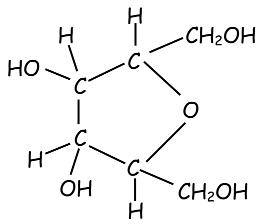
Long Qu	Answer	Reasoning
1a	London dispersion forces covalent bonds	The covalent bonds inside the S_8 rings do not break as the sulphur melts. When sulphur S_8 melts, London dispersion forces between the S_8 rings must be overcome but as these are weak then sulphur has a lower melting point. Silicon dioxide is a covalent network. Covalent bonds must be broken before a covalent network will melt into a liquid resulting in a high melting point.
1b(i)		Any structure for P_4S_3 that obeys the following valency rules: • 3 bonds per P atoms • 2 bonds per S atom
1b(ii)	Increased nuclear attraction/charge or more protons in sulphur nucleus	Sulphur and phosphorus are in the same period of the periodic table and the same shell is being filled with electrons. Sulphur has 16 protons which pull in the outer shell of the sulphur atom further than the 15 protons in a phosphorus nucleus would do.
1b(iii)	Greater number of London dispersion forces between S_8 molecules than P_4 molecules	Both P_4 and S_8 contain non-polar molecules. Both substances are solid at room temperature due to the number of London dispersion forces between the molecules which bring the molecules close enough to be a solid. Sulphur has a higher melting point than phosphorus due to greater numbers of London dispersion forces between molecules of 8 atoms than phosphorus atoms with only 4 atoms inside the molecule.
2a(i)	Diagram showing:	1mark: workable apparatus for passing the steam through the strawberry gum (steam must pass *through* the strawberry gum leaves not just pass over) 1mark: workable apparatus for condensing the steam and essential oil
2a(ii)	(fractional) distillation or chromatography	Distillation separates chemicals with different boiling points. Chromatography separates chemicals due to differences in polarity and size.
2b		 Methyl cinnamate is the ester formed from cinnamic acid and methanol
2c(i)	Answer to include:	**gfm** cinnamic acid = 148g **no.** of mol = $\frac{\text{mass}}{\text{gfm}} = \frac{6.5g}{148g}$ = 0.0439mol **gfm** methanol = 32g **no.** of mol = $\frac{\text{mass}}{\text{gfm}} = \frac{2.0g}{32g}$ = 0.0625mol cinnamic acid + methanol → methyl cinnamate + water 1mol 1mol 1mol 1mol 0.0439mol 0.0439mol (+0.0186mol leftover) Cinnamic acid is the limiting reactant as all 0.0439mol of cinnamic acid is used up in the reaction. 0.0186mol methanol is left over in the reaction.
2c(ii) Part A	52%	Cinnamic acid + methanol → methyl cinnamate + water 1mol → 1mol 148g → 162g 6.5g → 162g x $^{6.5}/_{148}$ = 7.1g (theoretical) % yield = $\frac{\text{actual}}{\text{theoretical}} \times 100 = \frac{3.7}{7.1} \times 100$ = 52%
2c(ii) Part B	£24.59	Cinnamic acid + methanol → methyl cinnamate + water 6.5g → 3.7g (at 52% yield) 6.5g x $^{100}/_{3.7}$ → 100g =175.7g 250g cinnamic acid costs £35.00 175.7g cinnamic acid costs £35.00 x $^{175.7}/_{250}$ = £24.59

3a	forms hydrogen bonds with water	Hydrogen bonding is formed when N—H, O—H or H—F bonds interact with water molecules. These bonds are highly polar allowing the compounds containing these bonds to be soluble in a polar solvent like water.
3b(i)	Any one carboxyl group circled similar to:	
3b(ii)	H^+ ions are not produced until dissolved in water	Acidity and alkalinity are water-based systems and no pH can be measured if water is absent. When water is added to solid citric acid, H^+ ions will dissociate from carboxyl group and can then react with hydrogencarbonate ions.
3c(i)		Endothermic reactions take energy from the surroundings and lower the temperature in those surroundings. On a potential energy diagram the products are higher than the reactants. Exothermic reactions give heat to the surroundings and raise the temperature of the surroundings. On a potential energy diagram the products are lower than the reactants.
3c(ii)	Answer to Include:	1st Mark: Volume/mass of water 2nd Mark: Change in temperature or initial and final temperature
3d	4.29 litres	**gfm** $NaHCO_3$ = 84g **n**o. of mol = $\frac{\text{mass}}{\text{gfm}} = \frac{15g}{84g}$ = 0.179mol $C_6H_8O_7 + 3NaHCO_3 \longrightarrow C_6H_5O_7Na_3 + 3H_2O + 3CO_2$ $NaHCO_3$: 3mol, 1mol, 0.179mol; CO_2: 3mol, 1mol, 0.179mol **gfm** CO_2 = (1x12) + (2x16) = 12 + 32 = 44g **V**olume = no. of mol x **M**olar **V**olume = 0.179mol x 24 litres mol^{-1} = 4.29 litres
4a	Citronellol or geraniol or anisyl alcohol	Only peaks B (citronellol), C (geraniol) and E (anisyl alcohol) appear on all three chromatograms
4b	Counterfeit perfumes have lower concentrations of compounds	The area under each peak is proportional to the quantity of that chemical in the sample. The smaller the peak, the lower the concentration of that chemical.
4c(i)	Inert/does not react with molecules	Gas chromatography needs a carrier gas to flow through the separating column. The sample compounds pass through the column at different rates dependent on their attraction to the mobile phase (the helium gas) or the stationary phase (the contents of the column)
4c(ii)	Size of molecules or temperature of column	The smaller molecules will pass through the column more quickly than larger molecules. Increasing the temperature in the column would increase the kinetic energy of the particles and they would pass through the column more quickly.
4d(i)	Terpenes	Terpenes are formed when multiple units of isoprene join together.
4d(ii)	3,7-dimethylocta-1,6-dien-3-ol	3,7-dimethylocta-1,6-dien-3-ol 3,7-dimethyl: $-CH_3$ groups on carbon C_3 and C_7; octa-1,6-dien: 8 carbons with 2xC=C on C_1 and C_6; 3-ol: -OH group on C_3
4e	1.7g	1kg body mass allowed 0.10mg coumarin 75kg body mass allowed 0.10mg coumarin x $^{75}/_{1}$ = 7.5mg coumarin = 0.0075g coumarin 4.4g coumarin contained in 1000g cinnamon powder 0.0075g coumarin contained in 1000g cinnamon powder x $^{0.0075}/_{4.4}$ = 1.70g cinnamon powder

5	Open Question Answer to Include:	**3 mark answer:** Demonstrates a **good understanding** of the chemistry involved. A good comprehension of the chemistry has provided in a logically correct, including a statement of the principles involved and the application of these to respond to the problem. **2 mark answer:** Demonstrates a **reasonable understanding** of the chemistry involved, making some statement(s) which are relevant to the situation, showing that the problem is understood. **1 mark answer:** Demonstrates a **limited understanding** of the chemistry involved. The candidate has made some statement(s) which are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.
6a	Answer to include:	1st Mark: Sodium lauryl sulphate has both a hydrophobic/oil-soluble part and a hydrophilic/water-soluble part 2nd Mark: Correct identification of ionic head as hydrophilic/water-soluble part of molecule and hydrocarbon tail as hydrophobic/oil-soluble part of molecule. 3rd Mark: Description of how this results in globule/ball-like structure with oil/grease held inside globule or mention or emulsion
6b(i)	24.8	A line of best fit should be drawn on the graph which ignores the obvious rogue result. When viscosity = 1.5 then the %NaCl (by mass) on the best fit straight line = 2.25% $1cm^3$ handwash contains 1.1g 1litre handwash = $1000cm^3$ handwash $1.1g \times {}^{1000}/_{1}$ = 1100g 100% mass of handwash = 1100g 2.25% mass = $1100g \times {}^{2.25}/_{100}$ = 24.75g sodium chloride
6b(ii)	Mass of sodium chloride becomes too high the viscosity will decrease	The viscosity peaks at 3.9 units at around 3.15% NaCl (by mass). If the NaCl increases beyond this point then the viscosity starts to decrease and NaCl is being wasted.
6c	green	E133 absorbs wavelengths corresponding to Violet, Indigo and Blue. E102 absorbs wavelengths corresponding to Red, Orange and Yellow. $\therefore$only the wavelengths corresponding to green are transmitted.
7a		Aldehyde groups contain a carbonyl (C=O) group with a hydrogen atom attached. The carbon in the aldehyde group is always carbon number one in any numbering system assigned to an aldehyde when naming the compound.
7b		Problem Solving Question
7c	Condensation	Condensation Polymerisation: small molecules (e.g. glucose) joining up to make a larger molecule (e.g. starch) with a small molecule (e.g. water) removed at the joins.
7d	Answer to include:	Amylopectin molecules are unable to pack closely together due to shape and can separate more easily. (It has more readily accessible –OH groups.) Amylose molecules pack closer together and more difficult to separate.
8	Open Question Answer to Include:	**3 mark answer:** Demonstrates a **good understanding** of the chemistry involved. A good comprehension of the chemistry has provided in a logically correct, including a statement of the principles involved and the application of these to respond to the problem. **2 mark answer:** Demonstrates a **reasonable understanding** of the chemistry involved, making some statement(s) which are relevant to the situation, showing that the problem is understood. **1 mark answer:** Demonstrates a **limited understanding** of the chemistry involved. The candidate has made some statement(s) which are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.

9a(i)	Flow chart complete with:	1st Mark: calcium carbonate; ammonia; carbon dioxide; calcium oxide 2nd Mark: sodium hydrogencarbonate; ammonium chloride; water; sodium carbonate
9a(ii)	Calcium chloride/ byproducts can be sold	The calcium chloride can be sold for profit even though it is not the main product of the Solvay Process. If the calcium chloride is not sold for profit then it would have to be responsibly disposed of at a cost.
9b	Adding Na^+ shifts equilibrium to right	Brine contains Na^+ ions. Na^+ ions are a reactant in the reaction. When a reactant is added to a reaction at equilibrium, the equilibrium shifts to the right to make additional products and remove the additional Na^+ ions.
9c	20 kJ mol^{-1}	$CaCO_3 + 2NaCl \rightarrow Na_2CO_3 + CaCl_2$ ❶ $CaCO_3 \rightarrow CO_2 + CaO$ ΔH=+178kJ ❷ $CaO + H_2O \rightarrow Ca(OH)_2$ ΔH=-65kJ ❸ $NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$ ΔH=-79kJ ❹ $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$ ΔH=+85kJ ❺ $Ca(OH)_2 + 2NH_4Cl \rightarrow CaCl_2 + 2H_2O + 2NH_3$ ΔH=-20kJ ❶ $CaCO_3 \rightarrow$ ~~CO_2~~ + ~~CaO~~ ΔH=+178kJ ❷ ~~CaO~~ + ~~H_2O~~ $\rightarrow$ ~~$Ca(OH)_2$~~ ΔH=-65kJ ❸x2 $2NaCl$ + ~~$2NH_3$~~ + ~~$2CO_2$~~ + ~~$2H_2O$~~ $\rightarrow$ ~~$2NaHCO_3$~~ + ~~$2NH_4Cl$~~ ΔH=-158kJ ❹ ~~$2NaHCO_3$~~ $\rightarrow Na_2CO_3$ + ~~H_2O~~ + ~~CO_2~~ ΔH=+85kJ ❺ ~~$Ca(OH)_2$~~ + ~~$2NH_4Cl$~~ $\rightarrow CaCl_2$ + ~~$2H_2O$~~ + ~~$2NH_3$~~ ΔH=-20kJ add $CaCO_3 + 2NaCl \rightarrow Na_2CO_3 + CaCl_2$ ΔH=+20kJ
10a	Kill bacteria/fungi	Hypochlorite is added to swimming pool water to kill bacteria and fungi in the water. It also inactivates viruses. It is also added to drinking water but at much lower concentrations.
10b(i)	Answer to include:	1st mark: rinse the burette with (thiosulphate) solution. 2nd and 3rd marks for two of the following points: Fill burette above the scale with thiosulphate solution; Filter funnel to be removed; Tap opened/some solution drained to ensure no air bubbles; (thiosulphate) solution run into scale reading; Reading should be made from bottom of the meniscus
10b(ii)	$2I^- \rightarrow I_2 + 2e^-$	Redox equation: $NaOCl + 2I^- + 2H^+ \rightarrow I_2 + NaCl + H_2O$ Oxidation step: $2I^- \rightarrow I_2 + 2e^-$ Reduction step: $NaOCl + 2H^+ + 2e^- \rightarrow NaCl + H_2O$
10b(iii)	6.20x10^{-5} mol l^{-1}	$S_2O_3^{2-}$ **n**o. of mol = **c**oncentration x **v**olume = 0.00100litres x 0.0124 mol l^{-1} = 1.24x10^{-5} mol $I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$ 1mol 2mol 6.20x10^{-6}mol 1.24x10^{-5}mol $NaOCl + 2I^- + 2H^+ \rightarrow I_2 + NaCl + H_2O$ 1mol 1mol 6.20x10^{-6}mol 6.20x10^{-6}mol 100cm^3 of swimming pool water contains 6.20x10^{-6} mol NaOCl 1000cm^3 of swimming pool water contains 6.20x10^{-6} mol x $^{1000}/_{100}$ =6.20x10^{-5} mol l^{-1}
10c	44.4 litres	45 000 litres of swimming pool water requires 400cm^3 hypochlorite to raise by 1ppm 45 000 litres of swimming pool water requires 800cm^3 hypochlorite to raise by 2ppm 2500000 litres of pool water requires 800cm^3 x $^{2500000}/_{45000}$ = 44444cm^3 =44.4 litres

<table>
<tr><td>10d(i)</td><td>Answer to include:</td><td>1st mark: ammonia is polar and trichloramine is non-polar
2nd mark: electronegativity difference is bigger in N-H bond than N-Cl bond ∴ NH_3 is polar and NCl is non-polar</td></tr>
<tr><td>10d(ii)</td><td>Substance with unpaired electron</td><td>Free radicals are very reactive particles which have an unpaired electron. The free radical will react with a large variety of substances to achieve the pairing of the unpaired electron.</td></tr>
<tr><td>10d(iii)</td><td>propagation</td><td>
<table>
<tr><th>Step</th><th>Reactants
(before Arrow)</th><th>→</th><th>Products
(after Arrow)</th></tr>
<tr><td>Initiation</td><td>No free radicals on Left Hand Side</td><td>→</td><td>Free radicals on Right Hand Side</td></tr>
<tr><td>Propagation</td><td colspan="3">Free Radicals found on both sides of arrow</td></tr>
<tr><td>Termination</td><td>Free radicals on Left Hand Side</td><td>→</td><td>No free radicals on Right Hand Side</td></tr>
</table>
</td></tr>
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