GCE

Chemistry

Advanced GCE **A2 7882**

Advanced Subsidiary GCE **AS 3882**

Mark Schemes for the Units

June 2009

3882/7882/MS/R/09

Oxford Cambridge and RSA Examinations

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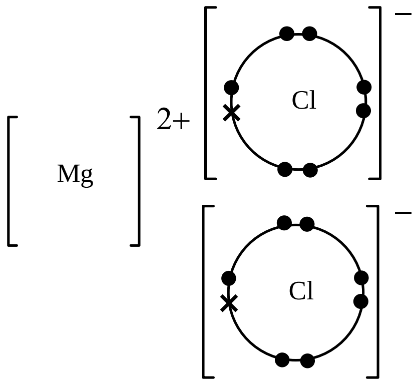
Advanced Subsidiary GCE Chemistry (3882)

MARK SCHEME FOR THE UNITS

2811 Foundation Chemistry

Question			Expected Answers	Marks	Additional Guidance
1	a	i	Atoms or isotopes of same element/same atomic number/number of protons with different numbers of neutrons/different masses✓	1	Not elements with a different no of neutrons
		ii	^{33}S: 16p; 17n; 16e ✓ ^{34}S: 16p; 18n; 16e ✓	2	Mark by **row**
	b	i	M_r = weighted mean mass of an atom/the isotopes of an element ✓ compared with carbon-12 ✓ 1/12th (of mass) of carbon-12/ on a scale where carbon-12 is 12 ✓ *(but not 12 g)*	3	**Allow** 'average mass of atom' or 'mean mass of atom' *alternative **allowable** definitions:* mass of one mole of atoms ✓ compared to 1/12th ✓ (the mass of) one mole/12 g of carbon-12 ✓ $\frac{\text{mass of one mole of atoms ✓}}{\text{1/12}^{\text{th}}\text{ ✓ the mass of one mole/12 g of carbon-12 ✓}}$
		ii	$A_r = 32 \times \frac{94.93}{100} + 33 \times \frac{0.76}{100} + 34 \times \frac{4.29}{100} + 36 \times \frac{0.02}{100}$ **OR** 32.0942 ✓ = 32.09 ✓ to four significant figures	2	**Allow** one mark for A_r = 32.0942 with no working out **Allow** two marks for A_r = 32.09 with no working out If a candidate uses incorrect values in 1st line, then the 2nd mark can still be awarded if the calculated value is from 32.01 to 35.99 expressed to two decimal places. This allows for any %'s the wrong way round in 1st line.
		iii	mass spectrometer ✓	1	**Allow** 'mass spectrometry' **OR** 'mass spectrum', **Allow** 'mass spectroscope' **OR** mass spectroscopy
	c	i	(2) water(s) of crystallisation/ 2 mol of H_2O for 1 mol $CaSO_4$ ✓	1	**Allow** the salt is hydrated, crystals contain water.
		ii	172.2 (g mol^{-1}) ✓	1	**Allow** 172.19
		iii	(+)6 ✓	1	**Allow** lack of + sign but '–6' is wrong
		iv	SO_4^{2-} ✓	1	**Allow** 'SO_4', 2– charge **Allow** '–2'
			Total	**13**	

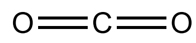
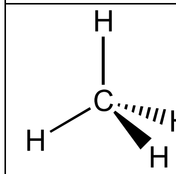
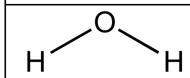
Question			Expected Answers	Marks	Additional Guidance
2	a		(electrostatic) attraction between oppositely charged ions/ specific example given✓	1	**Allow** 'oppositely charged atoms'
	b	i	cation shown with either 8 or 0 electrons ***AND*** anion shown with 8 electrons ***AND*** correct number of crosses and dots for example chosen ✓ Correct charges on both ions ✓ 	2	**For 1st mark,** if 8 electrons shown around cation then 'extra' electron(s) around anion must match symbol chosen for electrons in cation. *Circles not required* **Ignore** inner shell electrons **Allow:** $2[Cl^-]$ $2[Cl]^-$ $[Cl^-]_2$ Do **not** allow: $[Cl_2]^-$ $[Cl]_2^-$ $[2Cl]^-$ Accept correct answers without brackets.
		ii	$1s^22s^22p^63s^23p^6$ ✓	1	**Allow** subscripts
	c	i	attraction between positive ions ✓ and free/delocalised electrons ✓	2	**Allow** 'sea of electrons'; Do **not** allow just 'electrons' 1st mark is for positive ions **OR** delocalised/free electrons anywhere 2nd mark is for 'attraction between the correct charged particles **Allow** labelled diagram showing a scattering of labelled electrons between positive ions for 1st mark
		ii	Al^{3+} compared to Mg^{2+}/ the aluminium ion has a higher charge (density)/there are more delocalised/free/outer electrons (per atom) ✓	1	**Allow** magnesium ion has a smaller charge (density)/there are less delocalised electrons (per atom) ✓ Allow Al has 3 delocalised electrons, Mg has 2 delocalised electrons. ie Do **not** allow just 'Al has more electrons. (it must be clear that these are the outer shell electrons)

	d	**i**	Co has fewer protons (ORA)/ Periodic Table is in order of number of protons ✓	1	**Allow** 'Co has an atomic number (1) less than Ni'
		ii	(On average) **isotopes** of Co have more neutrons than Ni ✓	1	'Isotopes' essential Allow 'In Co, there is a higher proportion of heavier isotopes/ isotopes with a higher mass number' Do not allow just 'higher mass number'
	e	**i**	moles Al = $\frac{2.025}{27.0}$ = 0.075 ✓	1	
		ii	moles H_2 = 1.5 x 0.075 = 0.1125 mol ✓ volume H_2 = 0.1125 x 24 = 2.7 dm^3 ✓	2	**ECF,** 1.5 x answer to **(i)**
		iii	moles HCl = 3 x 0.075 = 0.225 mol ✓ volume HCl = $\frac{1000 \times 0.225}{1.80}$ = 125 cm^3 ✓	2	**ECF**, 3 x answer to **(i) or** 2 x no of moles in (ii) **ECF,** $\frac{1000 \times \text{moles HCl}}{1.80}$
			Total	**14**	

Question			Expected Answers	Marks	Additional guidance
3	a		solid **A**: BaO ✓ solution **B**: $BaCl_2$ ✓ precipitate **C**: $BaCO_3$ ✓ precipitate **D**: AgCl ✓	4	Watch order of letters in the boxes. See the pattern on the left
	b		Ba : C : O = $\frac{60.89}{137} : \frac{10.67}{12.0} : \frac{28.44}{16.0}$ or 1 : 2 : 4 ✓ empirical formula = BaC_2O_4 (or, if you see it, allow $Ba(CO_2)_2$!) ✓	2	If a candidate uses atomic numbers, the ratio is still 1:2:4. The 2nd mark can still be awarded by error carried forward. Although unlikely, a correct answer of BaC_2O_4 with no working should be awarded **both** marks. If candidate shows inverse for ratios: ie Ba : C : O = $\frac{137}{60.89} : \frac{12.0}{10.67} : \frac{16.0}{28.44}$ .....then the candidate can be awarded the 2nd mark **only** for Ba_4C_2O by error carried forward.
	c	i	$Ba(g) \longrightarrow Ba^+(g) + e^-$ equation ✓ state symbols as (g) ✓	2	ignore absence of ‘ $^-$ sign’ on e^- ignore state symbol with e^- **Allow** $Ba(g) - e^- \longrightarrow Ba^+(g)$
		ii	(1st ionisation energy) decreases (down the group) ✓ atomic radii increases/ there are more shells ✓ there is more shielding/ more screening ✓ Increased shielding and distance outweigh the increased nuclear charge/	4	‘down the group’ not required *‘**more**’ is essential* allow ‘more electron repulsion from inner shells’ **Allow** ‘nuclear pull’ not held less tightly. ignore any reference to ‘effective nuclear charge’

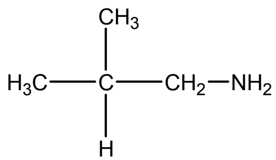
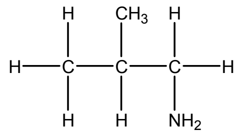
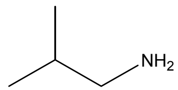
			the nuclear attraction decreases ✓		
	d	**i**	Group 2 (elements) react by losing electrons ✓ Group 7 (elements) react by gaining electrons ✓ (As atoms get larger/more shielding), it is easier to lose electrons **AND** more difficult to gain electrons ✓	3	**Allow** Group 2 form + ions **Allow** Group 7 form – ions **Both** comparisons needed for third mark
		ii	chlorine has displaced or oxidised iodine/iodine forms ✓ $Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$ **OR** $Cl_2 + 2KI \longrightarrow I_2 + 2KCl$ ✓	2	I_2 as a product in an attempted equation scores 1st mark **Ignore** state symbols **Ignore** any reference to iodide
			Total	**17**	

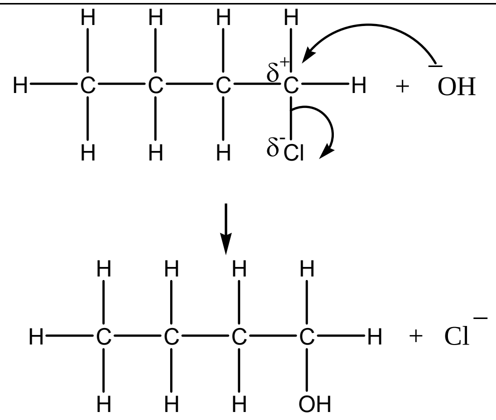
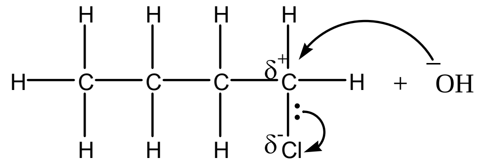
Question			Expected Answers	Marks	Additional Guidance
4			Na has fewer protons/less nuclear charge ✓ electrons added to the same shell *OR* screening/shielding remains the same or similar ✓ Na has less attraction/ less pull	3	**Allow** Mg has more protons/more nuclear charge **Allow** 'across a period, nuclear charge increases/protons increase' A comparison must be included **Allow** a comparison in terms of 'effective nuclear charge' *OR* 'shielded nuclear charge' **ignore** reference to distance **Ignore** comparison of atomic number **Ignore** comparison of nuclear size 'Na charge is less' OR 'Mg charge is greater' is not sufficient **Allow** Mg has more attraction/more pull **Allow** 'across a period, more attraction/more pull' A comparison must be included
			iodine exists as small molecules /I_2/simple molecular structure ✓ van der Waals' forces/intermolecular forces (must be broken) ✓ diamond exists as a giant structure ✓ covalent bonds (must be broken) ✓ Strength of forces linked to boiling point: van der Waals' forces are weak/ small amount of energy to break van der Waals' forces/ covalent bonds are strong/ large amount of energy to break covalent bonds ✓	5	**Allow** induced dipole/instantaneous dipoles interactions 'giant covalent structure' scores both 'diamond marks **Allow** lattice for giant structure Mark this anywhere.

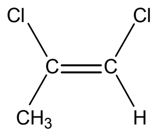
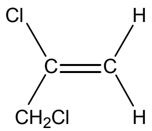
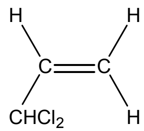
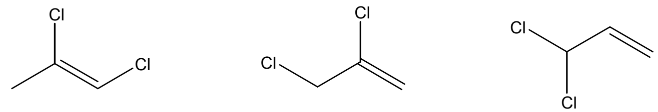
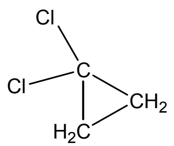
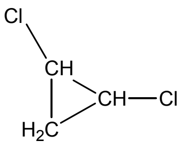
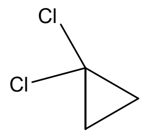
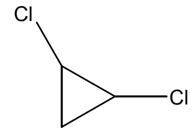
				7	**Allow** bond angles +/- 0.5° **For full marks must say repel at least once.**	
			CO_2: linear/bond angle = 180˚/ diagram✓ two areas of electron density repel ✓		**Allow** 2 bonds/bonding pairs repel	Acceptable diagrams: 
			CH_4: tetrahedral/bond angle =109.5˚/diagram ✓ four bonded pairs repel ✓		**Allow** 4 bonds repel	 four bonds shown with at least 2 wedges, one in; one out For bond into paper, accept: 
			H_2O: non-linear/bond angle =104.5˚/ diagram ✓ two bonded pairs and two lone pairs repel/ diagram ✓ lone pairs repel more (than bonded pairs)✓		**Allow** 2 bonds and 2 lone pairs repel	

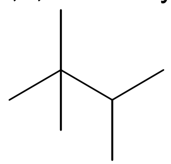
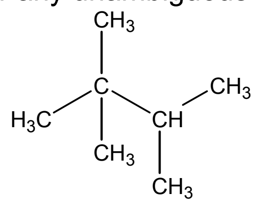
				QWC – At least two sentences that show legible text with accurate spelling, punctuation and grammar so that the meaning is clear. ✓	1	QWC mark **must** be indicated with a tick or cross through the Quality of Written Communication prompt at the bottom of page 9. **Then scroll up to start of question, counting ticks.** **Watch out that you have counted ticks on BOTH pages 8 and 9** Mark **QWC** anywhere within Q4
				Total	**16**	

2812 Chains and Rings

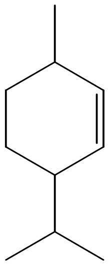
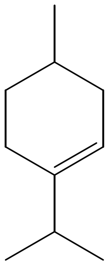
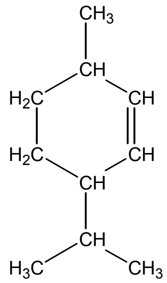
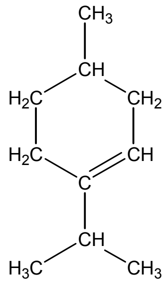
Question			Expected Answers	Marks	Additional Guidance
1	a	(i)	*D* ✓	1	no other acceptable response
		(ii)	*B* ✓	1	no other acceptable response
		(iii)	*D* ✓	1	no other acceptable response
		(iv)	*A and B* ✓	1	no other acceptable response
	b	(i)	 ✓	1	**allow** $(CH_3)_2CHCH_2NH_2$ **allow**  /  **ignore** bond linkage & lack of Hs
		(ii)	ethanol ✓	1	**allow** ethanolic/alcohol/alcoholic/C_2H_5OH **not allow** ethanoic
	c	(i)	electron pair donor/lone pair donor ✓	1	**allow** donator

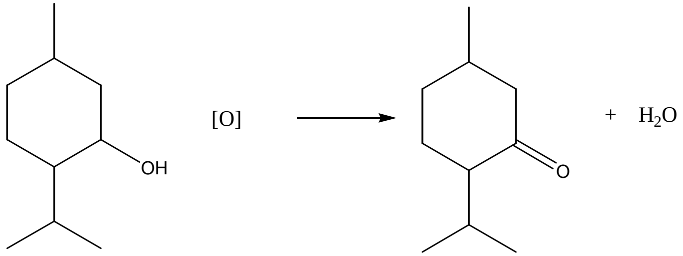
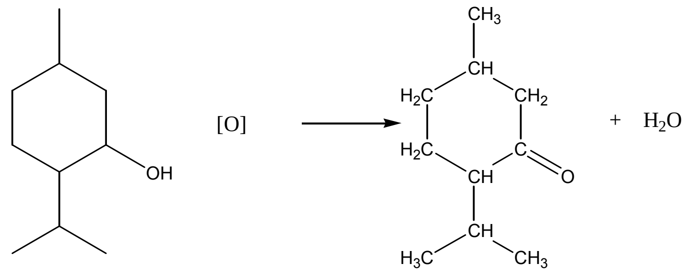
		(ii)	 curly arrow from O of the OH^- to the $C^{\delta+}$ ✓ correct dipole **<u>and</u>** curly arrow from C—Cl bond to $Cl^{\delta-}$ ✓ correct products ✓	3	**ignore** if 2 dots on the C—Cl bond  **allow** lone pairs shown on O and/or Cl **ignore** bond linkage & lack of Hs **allow** max of 2 out of 3 marks if single headed arrows used
				10	

Question			Expected Answers	Marks	Additional Guidance
2	a	(i)	same molecular <u>formula</u> ✓ different structure/structural formula/ displayed formula ✓	2	**allow** same molecular <u>formula</u>, different arrangement of atoms same molecular <u>formula</u> different arrangement in space – scores 1 mark same <u>formula</u>, different structure – scores 1 mark **not allow** same atoms different structure etc
		(ii)	 (1,2-dichloro-)  (2,3-dichloro-)  (3,3-dichloro-)	3	**allow** correct structural formulae such as $CH_3C(Cl)CHCl$, $CH_2ClC(Cl)CH_2$, $CHCl_2CHCH_2$ **allow** correct skeletal formulae 
		(iii)	1,1-dichloropropene ✓	1	**allow** 1,1-dichloroprop-1-ene **do not allow** 1,1-chloroprop(-1-)ene/1-dichloroprop(-1-)ene/dichloroprop(-1-)ene **ignore** commas/hypens **allow** 11dichloroprop1ene
		(iv)	 or  ✓	1	**allow**  or  **do not allow** names
	b		because they have (C=C) double bond which restricts rotation ✓ and <u>each C</u> in the C=C is bonded to (two) different groups or atoms ✓	2	
				9	

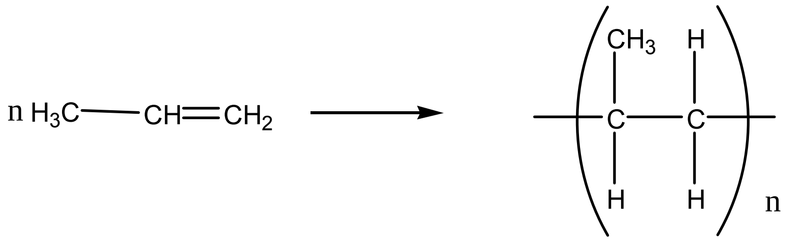
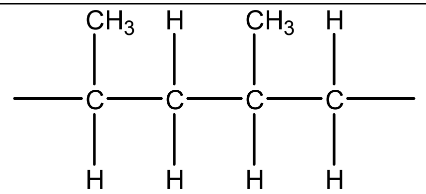
Question			Expected Answers	Marks	Additional Guidance
3	**a**	**(i)**	F ✓	1	no other acceptable answer
		(ii)	van der Waals ✓	1	**allow** vdW/vdw **ignore** spelling of van der Waals **not allow** intermolecular forces/ dipole-dipole/H-bonds
		(iii)	2,2,3-trimethylbutane/  ✓	1	**allow** either name or any unambiguous formula  $(CH_3)_3CCH(CH_3)_2$
	b	**(i)**	(particle/atom/molecule that) contains an unpaired/single electron ✓	1	**allow** …. contains an unpaired electron/has a single unpaired electron **do not allow** a *free* electron **do not allow** an ion with an unpaired/single electron
		(ii)	$Cl_2 \longrightarrow 2Cl^{\bullet}$ ✓	1	**allow** $Cl_2 \longrightarrow Cl^{\bullet} + Cl^{\bullet}$ / $\frac{1}{2}Cl_2 \longrightarrow Cl^{\bullet}$
		(iii)	homolytic (fission)/ ✓	1	**allow** homolysis/ homolytic cleavage
		(iv)	$C_7H_{16} + Cl^{\bullet} \longrightarrow {}^{\bullet}C_7H_{15} + HCl$ ✓ ${}^{\bullet}C_7H_{15} + Cl_2 \longrightarrow C_7H_{15}Cl + Cl^{\bullet}$ ✓	2	**allow** $C_7H_{15}{}^{\bullet}$ no other alternatives
		(v)	${}^{\bullet}C_7H_{15} + {}^{\bullet}C_7H_{15} \longrightarrow C_{14}H_{30}$ or $C_7H_{15}C_7H_{15}$ ✓	1	allow $2{}^{\bullet}C_7H_{15} \longrightarrow C_{14}H_{30}$ or $C_7H_{15}C_7H_{15}$ ✓

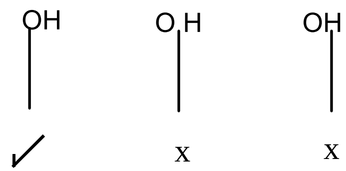
	c	**(i)**	compound **E** has **6** isomers ✓	1	no other acceptable answer
		(ii)	compound **G** has **3** isomers ✓	1	no other acceptable answer
				11	

Question			Expected Answers	Marks	Additional Guidance
4	a	(i)	$C_{10}H_{20}O$ ✓	1	no other acceptable answer
		(ii)	secondary ✓	1	**allow** 2nd ary/circle or underline "*secondary*" on the paper/2°
	b	(i)	 and  ✓ ✓	2	**allow**  and 
		(ii)	ester✓	1	no other acceptable answer
	c	(i)	reagent $Cr_2O_7^{2-}$ ✓ conditions H^+ & heat ✓	2	**allow** dichromate/ sodium or potassium dichromate/ $K_2Cr_2O_7$/$Na_2Cr_2O_7$ **allow** $KMnO_4$ and then corresponding colour change in (ii) **conditions** mark dependent on a reasonable attempt at the reagent acidified/ sulfuric acid/sulfuric acid/ H_2SO_4 warm/ reflux/heat under reflux/distil
		(ii)	orange to green ✓	1	**allow** orange to black/dark green **do not allow** green **allow** purple to green/brown/pink/colourless if $KMnO_4$ used in (i) but do not allow orange to green. mark as "x con"

		(iii)	 ✓	1	**allow** 
		(iv)	lack of peak in range 3230–3550 (cm^{-1}) ✓	1	**allow** lack of <u>broad</u> peak at about 3000 (cm^{-1}) **do not allow** range quoted as 2500 – 3300 (cm^{-1})/approx 3000 (cm^{-1}) **ignore** any reference to C—O/1000 – 1300 (cm^{-1}) **ignore** any reference to discussion of C=O peak
				10	

Question			Expected Answers	Marks	Additional Guidance
5	a		Crude oil can be separated by fractional distillation because the compounds/fractions have different boiling points ✓ (AW) fractionation produces insufficient quantities of the 'petrol' fraction ✓ (AW) **balanced equation** to illustrate cracking ✓ alkenes which are used to produce alcohols or polymers✓ (AW) **balanced equation** to illustrate isomerisation ✓ **balanced equation** to illustrate reforming to obtain cycloalkanes (and arenes) ✓and H_2 ✓ which promote more efficient combustion/ better fuels/increases octane number/reduces knocking/ reduces pre-ignition ✓ * (AW) (*credited once)	8	**allow** different volatilities/ condenses at different temperatures **not allow** more demand **allow** alternate wording (AW) throughout 4 marks for equations – if equations not linked to process, **allow** max of 3 out of 4 **do not allow** just "*more useful*" can award two marks for balanced equation for reforming if both a cyclic compound and H_2 shown. 1 mark if H_2 absent but cyclic compound structure shown **not allow** word equations
			• ethanol is renewable ✓ • obtained from plants/ named plant ✓ • equation for fermentation $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ ✓ • oil-based fuels are finite/take millions of years to form ✓	4	**not allow** obtained from sugar **not allow** oil is non-renewable **allow** an alternative argument based on carbon emission • ethanol is carbon neutral ✓ • obtained from plants which photosynthesise✓ • oil based fuels are **net** carbon emitters ✓
			$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$ ✓	1	**allow** CH_3CH_2OH **not allow** C_2H_6O

QWC			Correctly uses, and spells correctly, at least **three** of: boiling point efficient, renewable additive, finite octane number/rating, fermentation knocking, fossil pre-ignition, carbon neutral cycloalkanes, van der Waals, cyclic , intermolecular arene biofuel volatility, viscosity	1	
	b	(i)	 ✓	1	**allow** n $C_3H_6 \longrightarrow (C_3H_6)_n$
		(ii)		1	**allow** bracket around the two repeat units with or without the following "n"
	c	(i)	reagent: H_2O ✓ conditions: temperature > $100^{o}C$ and a H^+ catalyst ✓	2	**allow** steam and H^+ for both marks **allow** hot aqueous acid for both marks conditions mark is dependent on correct reagent **allow** H_2SO_4/H_3PO_4 **ignore** any reference to pressure

		(ii)	propan-1-ol ✓ and propan-2-ol ✓	2	**allow** any unambiguous formula **not allow** C_3H_7OH or propanol **do not allow** bond linkage must be correct. The bond must clearly go to the O  **do not allow** if Hs are not shown
				20	

2813/01 How Far? How Fast?/Experimental Skills 1 Written Paper

Question			Expected Answers	Marks	Additional Guidance
1	(a)	(i)	respiration (1)	1	**Ignore** aerobic/anaerobic
		(ii)	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (1)	1	**ignore** state symbols **allow** $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$ if specified aerobic/anaerobic in (i), must match in (ii)
	(b)	(i)	(enthalpy change) when 1 mole of a compound/substance/product/molecules is formed (1) from its (constituent) elements (1) in their standard states/ under standard conditions (1)	3	**reject** 1 mole of **element** **ignore** required/produced if standard conditions are quoted, they must be correct do not award this mark if standard AND gaseous
		(ii)	cycle (1) x – 1367 = 2(-394) + 3(-286) (1) x = -279 (kJ mol $^{-1}$)	3	
		(iii)	diagram to show $2CO_2$ and $3H_2O$ at lower enthalpy than C_2H_5OH and $3O_2$ (1) E_a marked correctly (1) ΔH marked correctly (1)	3	**reject** products **ignore** state symbols for E_a and ΔH **allow** lines or double headed arrows single headed arrows must point in the correct direction
	(c)	(i)	(when pressure is increased) more ethene is converted/ equilibrium moves to RHS (1) because there are more (gas) moles on LHS/ ora (1)	2	**ignore** rate arguments **reject** volumes

		(ii)	when temperature is increased less ethene is converted/ equilibrium moves to LHS(1) (this means that the forward reaction is exothermic/produces heat/ increases the temperature) the sign of ΔH is negative (1)	2	2nd mark dependent on 1st mark ecf possible
		(iii)	sends equilibrium to RHS (1)	1	**allow** makes reaction goes to completion **allow** increase yield/maximum conversion
			Total	**16**	

Question			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	energy = $mc\Delta T$ (1) = 400 x 4.18 x 13.6 = 22.7 (kJ) (1)	2	need not be actually stated – can be awarded if numbers used correctly if m = 200, allow first mark ignore extra sig figs
		(ii)	number of moles = 0.4 (1) ΔH neut = 56.8 (kJ mol^{-1}) sign ie negative (1)	3	ecf possible from (i) and number of moles in (ii) watch – if 1 used in (i) gives 56.8 stand alone mark
	(b)		$H^+ + OH^- \rightarrow H_2O$ (1)	1	
	(c)		result same for experiments 1 and 2 because the ionic equation/reaction is the same/ both acids are completely dissociated (1) the result for experiment 3 (is less because) ethanoic acid is weak/ not completely dissociated (1) energy is needed to break the bond (and release the H^+) (1)	3	both acids strong is insufficient idea of another ΔH as part of overall reaction must be included
			Total	**9**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)		bonds broken = 2(C=S) + 3(Cl–Cl) = 1086 + 3(Cl–Cl) (1) bonds made = 4(C–Cl) + 2(S–Cl) + (S–S) = 2084 (1) 1086 + 3(Cl–Cl) – 2084 = –272 Cl–Cl = 242 (kJ mol^{-1}) (1)	3	ecf possible on values of bonds broken and bonds made
	(b)		$C(s) + ½ F_2(g) + 1 ½ Cl_2(g) \rightarrow CFCl_3(g)$ formulae and balancing (1) state symbols (1)	2	**Allow** state symbols for species even if formula is not correct/reverse equation
	(c)	(i)	chlorine BUT NO MARK because the C–Cl bond is weaker (than the C–F bond) (1)	1	**accept** the bond enthalpy of C–Cl is less than that of C–F/ it is easier to break the C–Cl bond (than the C–F bond **reject** easier to form Cl free radical some comparison has to be made
		(ii)	homogeneous (1) because the catalyst and the reagents are in the same phase/ same physical state (1)	2	can be scored even if homogeneous not given
			Total	**8**	

Question			Expected Answers	Marks	Additional Guidance
4			diagram labelled with axes and E_a marked (1) curve shape correct – starting at origin and approaching x axis asymptotically (1) curve at higher temperature starting at origin and to RHS and with lower peak than the one at lower temperature (1) statement that, in order to react, the collision energy/ energy of molecules must (be equal to) or exceed E_a (1)	4	*y* axis can be number/ fraction/ percentage of molecules/ particles *x* axis can be energy/ enthalpy not allowed if E_a lowered **reject** more successful collisions **accept** more molecules have enough energy for successful collisions
			Total	**4**	

Question			Expected Answers	Marks	Additional Guidance
5	a		a strong acid is totally dissociated/ ionised (1) $HNO_3 \rightarrow H^+ + NO_3^-$ (1)	2	ignore state symbols ignore equilibrium arrow
	B	(i)	$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + CO_2 + H_2O$ (1)	1	
		(ii)	fizzing/solid disappears/ solid dissolve/ gas evolved/ gas given off (1)	1	
		(iii)	$MgCO_3 + 2H^+ \rightarrow Mg^{2+} + CO_2 + H_2O$/ $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$ (1)	1	**Ignore** state symbols **reject** spectator ions
	c	(i)	ammonia is a base/ is a proton acceptor	1	**allow** is an alkali **reject** has a pair of electrons
		(ii)	M_r of NH_4NO_3 = 80 (1) %N = 35 (1)	2	ecf possible from M_r
			Total	**8**	

2813/03 How Far? How Fast? /Experimental Skills 1 Practical Examination

Plan: 16 marks maximum (out of 19 marks available)

A Gravimetric method – 7 marks

A1 Crucible weighed empty ***then*** crucible weighed with washing soda **[1]**
Crucible or evaporating dish/basin (but not a test tube) must be used
Ignore any reference to use of a lid when awarding A1

A2 Heat gently at first ***and*** reason (to avoid spitting/frothing)
or heat gently at first ***then*** heat more strongly **[1]**

A3 Allow crucible (and contents) to cool with lid on
or allow to cool in a desiccator (***or*** a vacuum container)
or cool before weighing so that convection currents don't affect balance reading **[1]**

A4 (After cooling) weigh the crucible with the anhydrous sodium carbonate in it **[1]**
Candidate must use the word "anhydrous" in a correct context somewhere

A5 Re-heat, cool and re-weigh until mass stays same for complete reaction/dehydration
***Note** - Simple description of **and** reason for the procedure is required.* **[1]**

A6 Equation for thermal decomposition of washing soda crystals **[1]**
$Na_2CO_3.\boldsymbol{x}H_2O \rightarrow Na_2CO_3 + \boldsymbol{x}H_2O$ *(Allow x = 10)*

A7 Shows clearly and correctly how ***x*** is calculated from gravimetric data
and the value for M_r of Na_2CO_3 (= 106) must be stated/shown **[1]**
The calculation must start from the three weighings that would be recorded

B Gas collection method – 8 marks

B1 Reacts weighed/stated mass of washing soda with excess of acid **[1]**

B2 Equation for reaction of sodium carbonate with the acid specified **[1]**
$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O$
or $Na_2CO_3.xH_2O + 2HCl \rightarrow 2NaCl + CO_2 + (x + 1)H_2O$

B3 Calculation of suitable mass of washing soda for the gas collection procedure **[1]**
Candidate must link the calculation explicitly to the capacity of collector.

B4 Specimen calculation of [minimum] quantity of acid to use in procedure **[1]**

B5 Draws a neat diagram of correct apparatus (with some evidence of use of a ruler, if hand drawn), including a suitable method of collection and measurement for the gas **[1]**
Downloaded/ photocopied diagrams are only allowed if the labelling is relevant

B6 Records (final) volume of gas once fizzing has stopped/when syringe stops moving
Visual observation is required to indicate the completion of reaction **[1]**

B7+B8 **Two** accuracy precautions (any **two** from the three below)

- Aware of problem of solubility of CO_2 in water ***and*** gives a remedy **[1]**

Accept use of gas syringe to avoid gas being in contact with [as much] water
Accept collection over warm/hot water

- Use of "inner" ignition tube/ partitioned flask ***and*** suitable reason **[1]**

Two points are needed – both the practical precaution ***and*** *a reason for it*

- Repeat entire experiment until results are consistent/take mean of results **[1]**

B8 may be awarded in expt A (provided the ***whole*** *procedure is repeated)*

S Sources etc – 4 marks

S1 Researches hazard of sodium carbonate ***and*** states a safety precaution **[1]**
[Solid] sodium carbonate is irritant
Accept one routine precaution - safety specs, lab coat, gloves, wash if spilt

S2 Two secondary sources quoted in the text ***or*** as footnotes ***or*** at end of plan. **[1]**
Book reference(s) must have chapter or page numbers Internet reference(s) must go beyond the first slash of web address
Accept ***one*** <u>*specific*</u> *reference to a "Hazcard" (by name or number)*
Allow one reference to a specific past paper (but ***not*** *to teaching notes etc)*

S3 **QWC**: text is legible ***and*** spelling, punctuation and grammar are accurate **[1]**

Award S3 if there are fewer than ***six*** *errors in legibility, spelling, punctuation or grammar.*

S4 **QWC**: information is organised clearly and coherently **[1]**

Is the answer to all three of the following questions positive?
- *Is a word count given and within the limits 450 – 1050 words?*
- *Is scientific language used correctly – allow one error*
- *Are both methods described logically and without excessive repetition?*

Practical Test (B)

Page 3: Part 1 **[12 marks]**

Recording and calculation [5 marks]

All six mass readings shown in table form as two pairs of three **[1]**
Table must be drawn (minimum two vertical and two horizontal grid lines)

All mass readings shown to 2 d.p. *and* unit given (somewhere) **[1]**
Allow readings to 3 d.p., provided that this done consistently

Correct subtractions to obtain both initial masses of $MCl_2.2H_2O$ **[1]**

Mean mass of $MCl_2.2H_2O$ used, correctly calculated **[1]**

Mean mass of anhydrous MCl_2 residue correctly calculated
and mean mass of water lost (= "W") correctly calculated **[1]**
Both answers must be correctly calculated to the number of sig fig quoted

Accuracy [6 marks: 4 + 2]

For the supervisor*, record the mean mass loss to the nearest 0.005 g,*
For the candidate*, check the mean mass loss "W", and note it to nearest 0.005g*
Calculate the difference between supervisor's and candidate's mean mass losses.

- If candidate's mass loss is within **0.020 g** of supervisor's, award **4 marks**
- If candidate's mass loss is within **0.030 g** of supervisor's, award **3 marks**
- If candidate's mass loss is within **0.040 g** of supervisor's, award **2 marks**
- If candidate's mass loss is within **0.060 g** of supervisor's, award **1 mark**

Self consistency *of candidate's results.*
Check the calculation of mass loss (due to water) in both experiments

- If mass loss for expt 1 is within **0.02(0) g** of mass loss in expt 2, award **2 marks**
- If mass loss for expt 1 is within **0.03(0) g** of mass loss in expt 2, award **1 mark**

Safety [1 mark]

Adding water (***or*** diluting) reduces the level of hazard **[1]**

Pages 4+5: Part 2 **[10 marks]**

Mark ***ecf*** *wherever possible from one part of an answer to the next (but* ***not*** *within a part).*
Answers, when required for a mark, should be quoted to ***3*** *significant figures*

(a) No of moles = $^{\text{mean mass of water}}/_{18}$ **[1]**
This is a ***method*** *mark for dividing the appropriate* <u>*mean*</u> *mass from page 2 by 18*
No of moles of water, correctly calculated and expressed to 3 sig fig **[1]**

(b) $MCl_2.2H_2O(s) \rightarrow MCl_2(s) + 2H_2O(g)$

If formulas ***and*** balancing are correct **[1]**
State symbols correct *(mark is conditional on all three formulae being correct)* **[1]**

(c) Answer **(a)** is multiplied by 0.5 **[1]**
There is no ecf if the mole ratio shown in the equation is 1:1

(d) $M_r = {}^{\text{mass of anhydrous salt}}/_{\text{no of moles}}$ **[1]**
Candidate earns this mark by quoting the correct figures.

M_r correctly calculated (to 3 sf) from candidate's own data **[1]**

(e) A_r = answer **(d)** – 71 **[1]**

(f) **M** must be in Group 2 **[1]**

M is barium because its A_r is the closest to 137 (***or*** ecf to the answer to "e") **[1]**
No ecf is allowed for a metal incapable of showing oxidation state +2

Pages 6+7: Part 3 **[8 marks]**

(a) (i) white precipitate/solid/suspension **[1]**

(ii) silver chloride *(named)* **[1]**

(iii) $Ag^+ + Cl^- \rightarrow AgCl$ **[1]**

(b) (i) white precipitate/solid/suspension **[1]**

(ii) aq, aq, aq, s *(all four state symbols correct)* **[1]**

(iii) insoluble [in water] **[1]**

(c) (i)+(ii) white precipitate of MCO_3
NB - *Correct answers to* ***both (i) and (ii)*** *are required for this mark* **[1]**

(iii) $MCl_2 + Na_2CO_3 \rightarrow MCO_3 + 2NaCl$ **[1]**

Pages 8-10: Part 4 (Evaluation) **[14 marks max]**

(a) A lid would prevent/reduce absorption of water [vapour while cooling] **[1]**
No mark for reference to spitting or frothing when heated: it doesn't!

(b) Re-heating makes sure that <u>all</u> the water has been removed **[1]**
Do not allow a vaguer reference to "reaction being finished"

[When all water had been removed] final mass would not change/ stay the same **[1]**

(c) Yellow flame is not hot/strong enough [to drive off the water **[1]**

Yellow flame is sooty ***or*** it would deposit carbon (***or*** a black residue) on crucible **[1]**

(d)(i) 3 marks

Since two weighings are needed, possible total error in mass H_2O lost = 0.02 g **[1]**

Method mark: candidate uses 0.01 (**or** 0.02) ***and*** mean mass of water lost **[1]**
Mean mass must be correctly selected from data on page 3.

% error = $^{0.02 \text{ or } 0.01}/_{\text{mass}}$ x 100, correctly worked out to the number of sig fig quoted **[1]**

(d)(ii) 5 marks max (but only 4 on Qn paper) **–** *mark the **best two** strands*

- Use a larger mass of hydrated salt (***or*** mass used was too small) **[1]**

This reduces the percentage error [in measuring masses] **[1]**

- Use a balance that records to 3 (***or*** "more") decimal places **[1]**

*Do **not** allow a "more accurate" balance or equivalent phrases.*

This reduces the percentage error [in measuring masses] **[1]**
*Do **not** award a mark twice for this statement, even if used in different contexts.*

Candidate uses his/her data to work out the % error in any "improved" reading **[1]**
Specimen calculation is needed to score this mark.

- Cool the residue in a desiccator **[1]**

Desiccator contains a drying agent ***or*** it contains air that is free of moisture **[1]**

Prevents absorption of water [vapour] by the residue **[1]**

(e) If both of candidate's mass losses were close/ within 0.01g, this shows reliability **[1]**
Mark is awarded for the opposite conclusion if the candidate's readings justify it

(f) **2 marks max** (but only 1 on Qn paper)
*Award any **two** marks from the five ideas below*

Covalent compounds have low melting/boiling points
or a correct reference to weak **intermolecular** forces **[1]**

The solid being heated might evaporate
or the residue obtained might evaporate **[1]**

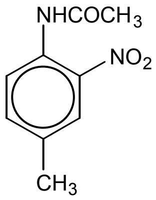
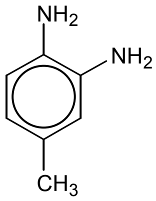
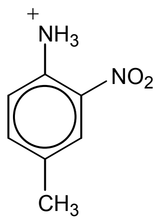
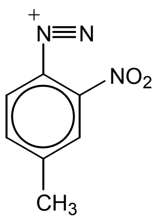
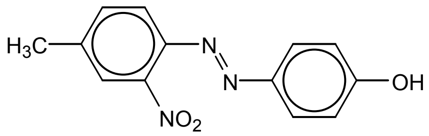
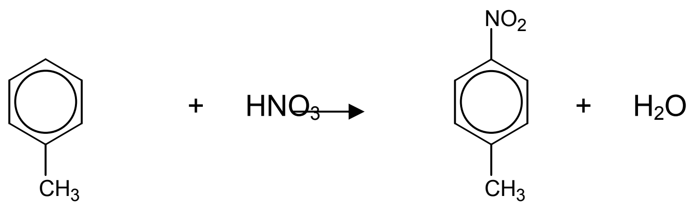
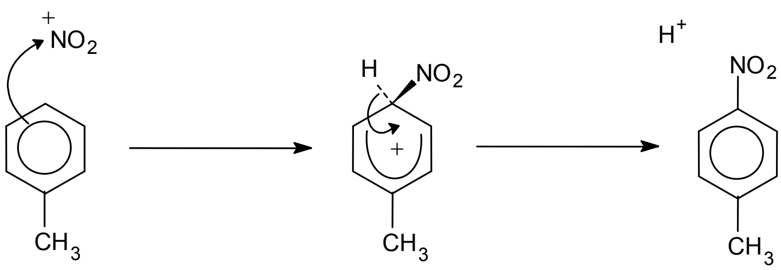
Hydrated covalent chlorides don't exist **[1]**

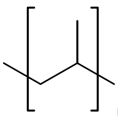
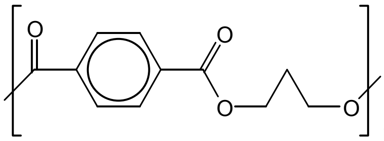
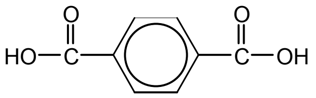
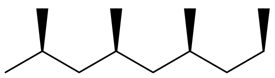
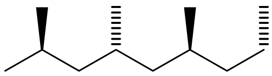
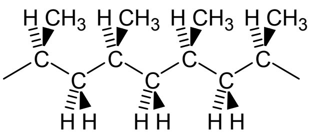
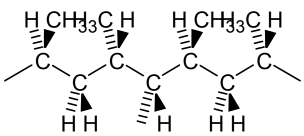
Hydrolysis/decomposition of covalent chloride occurs [when heated] **[1]**

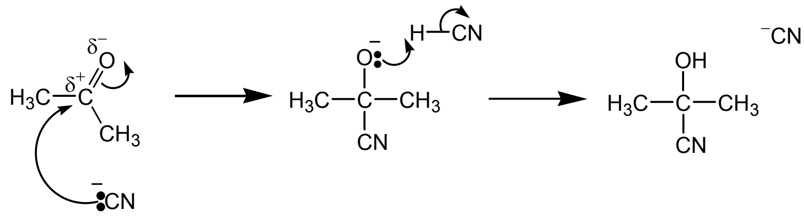
Hydrogen chloride would be produced [when the covalent chloride was heated] **[1]**

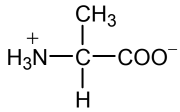
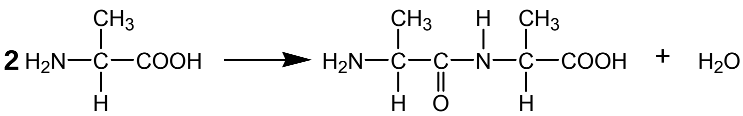
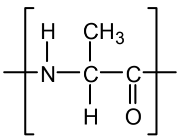
2814 Chains, Rings and Spectroscopy

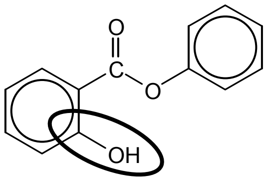
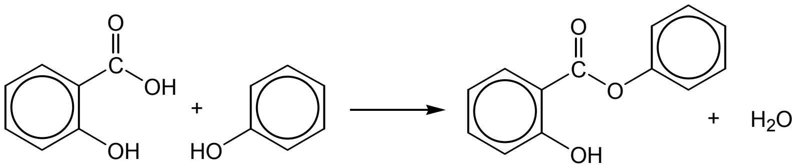
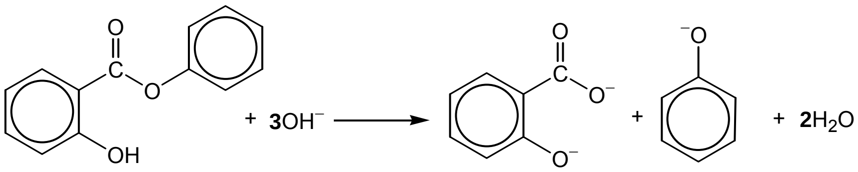
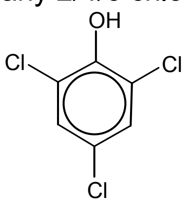
Qu.	Expected Answers		Marks
1 (a) (i)	NaOH/Na/Na_2CO_3/$NaHCO_3$ ✓		[1]
(ii)	…COO^- Na^+ ✓ (rest of the structure the same)	Na^+ is not essential, but do not allow Na-O	[1]
(b)	$CH_3CHClCOOH$ ✓ $FeCl_3$/$AlCl_3$ ✓ equation with HCl ✓		[3]
(c)	**chiral** (stereoisomers are) non-superimposable (mirror images)/asymmetric/correct 3-D diagrams of both isomers of ibuprofen drawn ✓ the chiral centre on ibuprofen is identified, either by a label or shown in the centre of a 3-D diagram of ibuprofen ✓ (is caused by) a C atom with four different groups attached ✓ **disadvantages of producing a mixture** only one isomer may be active/one may be inactive ✓, a higher dose is needed **AW** ✓ the other (stereo) isomer may cause harm/side effects ✓ separation of the isomers may be expensive/difficult ✓ **ANY 6 out of 7 marks**	allow ecf on 3-D or side chain errors	[6]
	QWC mark for at least two sentences with correct spelling, punctuation and grammar. ✓		[1]
			[Total: 12]

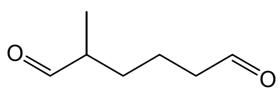
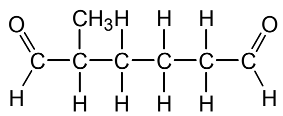
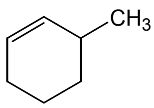
Qu.	Expected Answers	Marks
2 (a)	**A**  ✓ **B**  ✓ or with $–NH_3^+$ or $-NH_3Cl$ on either group on **B** **C**  ✓ **D**  ✓ allow $-NH_3Cl$ on **C** allow $–N{=}N^+$, $-N_2^+$, $-N_2Cl$ but not $-N{\equiv}N^+$ on **D**	[4]
(b) (i)	add to phenol ✓ in alkaline conditions/NaOH (below 10°C) ✓	[2]
(ii)	 *azo group between two benzene rings* ✓ *correct substitients on the rings* ✓ or with $–O^-$ on the phenol allow ecf from any diazonium ion in (a) and allow any phenol and any point of connection to the phenolic ring	[2]
(c) (i)	 ✓	[1]
(ii)	to form NO_2^+ in words/shown by an attempt at an equation using H_2SO_4 ✓ correct equation(s) ✓ eg $H_2SO_4 + HNO_3 \longrightarrow NO_2^+ + H_2O + HSO_4^-$ / $\mathbf{2}H_2SO_4 + HNO_3 \quad NO_2^+ + H_3O^+ + \mathbf{2}HSO_4^-$	[2]
(iii)	 curly arrow from π bond to electrophile ✓ intermediate ✓ curly arrow from C–H bond to π bond ✓	[3]
	[Total: 14]	

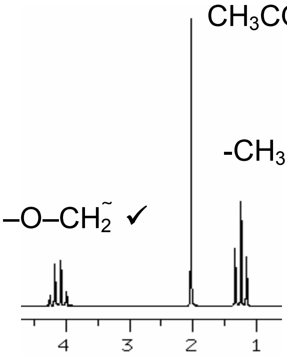
Qu.	Expected Answers		Marks
3 (a)	 n ✓  n ✓	brackets and n not essential allow ecf if no end bonds on both	[2]
(b)	PP is <u>addition</u> … which breaks (C=C) double bond/no other products formed ✓ PTT is <u>condensation</u> …. which produces H_2O or small molecule ✓		[2]
(c)	 ✓ HO—$(CH_2)_3$—OH ✓	or the acid chloride	[2]
(d)	both are polypropene ✓ idea of isotactic (side chains on the same side) and syndiotactic (side chains are on alternating sides) ✓ diagrams for both polymers show correct 3-D with zig-zag backbone and correct wedge/dottybonds ✓ - eg  isotactic  syndiotactic or  	the first two marks can be from incorrect or non-3D diagrams	[3]
(e)	(in PTT but not PP) 1680–1750 (cm^{-1}) ✓ 1000–1300 (cm^{-1}) ✓		[2]
			[Total: 11]

Qu.	Expected Answers		Marks
4 (a) (i)	arrow from **lone pair** of $:\bar{C}N$ to C ✓		
	dipole and curly arrow breaking π-bond on C=O ✓		
	structure of the intermediate ✓	lone pair is not essential on intermediate	
	curly arrow to H of $HCN/H_2O/H^+$ ✓		
	structure of the organic product ✓		
	eg	CN^- product is not essential	
			[5]
(b)	reduction/redox ✓		
	$LiAlH_4$ + ether/Na + ethanol/H_2 + Ni/Pt ✓		
	$CH_3CH_2CN + \mathbf{4}[H] \longrightarrow CH_3CH_2CH_2NH_2$ ✓	allow **2**H_2 in the equation if Na + Ethanol or H_2 + Ni is chosen	
	hydrolysis ✓		
	(reflux/heat with) HCl/H_2SO_4 with some evidence of water eg dil/(aq)/H_2O shown in the equation ✓	allow 'conc' for HCl but not for H_2SO_4	
	equation – eg $CH_3CH_2CN + \mathbf{2}H_2O \longrightarrow CH_3CH_2COOH + NH_3$ / $CH_3CH_2CN + \mathbf{2}H_2O + H \longrightarrow CH_3CH_2COOH + NH_4$ ✓		[6]
			[Total: 11]

Qu.	Expected Answers	Marks
5 (a) (i)	ammonia which is ethanolic/heated in a sealed tube ✓	[1]
(ii)	$CH_3CHClCOOH + NH_3 \longrightarrow CH_3CH(NH_2)COOH + HCl$ ✓ or with any ionisation of the amino groups – eg $CH_3CHClCOOH + NH_3 \longrightarrow CH_3CH(NH_3Cl)COOH$ / $CH_3CHClCOOH + 2NH_3 \longrightarrow CH_3CH(NH_2)COOH + NH_4Cl$	[1]
(b) (i)	structure of zwitterion ✓ eg  	[1]
(ii)	structure of organic product ✓ equation ✓ eg  allow –CONH- for the peptide linkage	[2]
(c) (i)	 ✓ brackets not essential	[1]
(ii)	hydrolysis ✓ (reflux/heat with) HCl/H_2SO_4 with some evidence of water eg dil/(aq)/6M ✓ allow aqueous NaOH/KOH or a protease enzyme	[2]
(d)	two peaks ✓ relative areas 3:1 ✓ due to the $-CH_3$ and -CH ✓ allow ecf on the second and third marks if extra peaks are given for COOH and NH_2	[3]
		[Total: 11]

Qu.	Expected Answers		Marks
6 (a)	 ✓		[1]
(b)	 reactants ✓ products ✓		[2]
(c)	 hydroxybenzoate and phenol as products ✓ ionisation of at least one of the phenol groups ✓ all correct and balanced ✓		[3]
(d) (i)	(electrophilic) substitution ✓		[1]
(ii)	any 2/4/6 chlorinated phenol – eg  ✓	allow chlorination of phenolic esters	[1]
(iii)	lone/non-bonding pair of … ✓ …. electrons from the O delocalised are around the ring ✓ so greater (π-) electron density(around the ring) **ora** ✓ which attracts/polarises the electrophile (more) **ora** ✓	do not allow 'attacked by /susceptible to' electrophiles for the last mark	[4]
			[Total: 12]

Qu.	Expected Answers		Marks
7 (a) (i)	silver mirror (on warming) with *Tollens' reagent/ammoniacal silver nitrate* ✓		[1]
(ii)	add to 2,4-DNPH/Brady's reagent ✓ measure the m.p. (of the solid from 2-4-DNPH) ✓ compare with known values to identify the aldehyde ✓	measure the b.p. (of the aldehyde) gets both the first 2 marks	[3]
(b) (i)	methanal + butanal ✓	allow C_3H_7CHO allow correct names or structures but they must not contradict	[1]
(ii)	propanone ✓ + ethanal ✓		[2]
(c) (i)	*eg*  /  ✓		[1]
(ii)	 ✓		[1]
		[Total:	9]

Qu.	Expected Answers		Marks
8	**molecular formula from % data and mass spectrum** M_r = 88 ✓ $^{54.5}/_{12.0}$ = 4.54 $^{9.1}/_{1.0}$ = 9.1 $^{36.4}/_{16.0}$ = 2.28 ratio = 2 : 4 : 1 / empirical formula = C_2H_4O ✓ (M_r of C_2H_4O = 44 = $^{88}/_{2,}$ so) molecular formula = $C_4H_8O_2$ ✓ alternative method for the 2nd mark calculating mass out of 88 for each element: 88 x $^{54.5}/_{100}$ = 48 88 x $^{9.1}/_{100}$ = 8 88 x $^{36.4}/_{100}$ = 32 $^{48}/_{12}$ = 4 C $^{8}/_{1}$ = 8 H $^{32}/_{16}$ = 2 O		
	structural formula from n.m.r. spectrum X is an ester ✓ X is ethyl ethanoate/$CH_3COOCH_2CH_3$ ✓ the part of the molecule responsible for each peak identified – eg $CH_3C\tilde{O}$ ✓ -CH_3 ✓ –O–$CH_{\tilde{2}}$ ✓  splitting of one of the peaks is explained in terms of the n + 1 rule – eg '1:2:1 as next to CH_2'✓	allow any method to identify which peak is being referred to the –CH_3 mark is available if methyl propanoate is chosen	[9]
	Well organised answer with any **two** of the following technical terms used correctly: **singlet**, **triplet**, **quadruplet/quartet**		[1]
			[Total: 10]

2815/01 Trends and Patterns

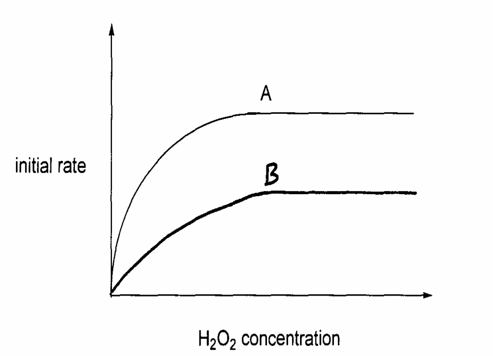
Qu.		Expected Answers	Marks	Additional Guidance
1	(a)	(Enthalpy change of/energy change of) atomisation (1) $Ba(g) \rightarrow Ba^{+}(g) + e^{-}$ (1) <u>Second</u> electron affinity (1) $Ba(s) + ½O_2(g) \rightarrow BaO(s)$ (1)	4	Ss must be correct throughout No multiples
	(b)	Impossible/difficult to get gaseous ions (without them reacting)/difficult to vapourise ions and measure the enthalpy change at the same time/AW (1)	1	
	(c)	Oxide ion is smaller than carbonate ion/oxide ion has a higher charge/electron density/ora (1) (So) stronger attraction between ions in barium oxide/ora (1)	2	**Must** use correct particle but only penalise once
	(d)	**Rb^{+} , Na^{+}, Mg^{2+}, Al^{3+} (1)** and Any two from Idea that polarising power depends on ionic radius and ionic charge/idea that polarising power depends on charge density of ion (1) Rb^{+} is larger than Na^{+}/Na^{+} is larger than Mg^{2+}/Mg^{2+} is larger than Al^{3+}/Al^{3+} smallest radius/Rb^{+} largest radius ora (1) Rb^{+} is less charged than Mg^{2+}/Na^{+} is less charged than Mg^{2+}/Mg^{2+} is less charged than Al^{3+}/Al^{3+} highest charge ora (1)	3	
			10	

Qu.			Expected Answers	Marks	Additional Guidance
2	(a)	(i)	Giant ionic/ionic lattice (1)	1	
		(ii)	Two sodium ions with empty or full outer shell or 2.8 **and** Na^+ (1) Oxide ion with full outer shell or correct 2.8 **and** O^{2-} (1)	2	**Allow** empty or full shell for Na^+ **Allow** $2Na^+$ **Allow** one mark for either correct charges for both ions or correct electronic structures for both ions Not $[Na]_2^+$/$[Na_2]^{2+}$
		(iii)	$Na_2O + H_2O \rightarrow 2NaOH$/$O^{2-} + H_2O \rightarrow 2OH^-$ (1) Water has behaved as a proton donor/H^+ donor (1)	2	
	(b)	(i)	H_2SO_3 (1)	1	
		(ii)	Silicon(IV) oxide has a giant covalent structure/giant molecular/macromolecular (1) Sulphur dioxide has simple structure with van der Waals' forces/simple molecular /simple covalent (1) Covalent bonds are (much) stronger than van der Waals' forces/intermolecular forces/temp dipole-temp dipole/induced dipole – induced dipole (1)	3	**Allow** comparison of forces mark only if associated with the correct forces
				9	

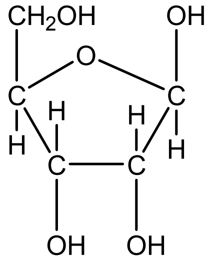
Qu.		Expected Answers	Marks	Additional Guidance
3 (a)		moles of MnO_4^- = 0.000571 (1) moles of H_2O_2 = 0.00143 (1) concentration (of diluted H_2O_2 is 0.143 and of) undiluted is 1.43 mol dm^{-3} (1) Concentration = 48.5 g dm^{-3} (1) (accept range 48.45–48.63 g dm^{-3})	4	**Allow** ecf within the question **Allow** 2 or more sig figs for first three marking points **Allow** 3 or 4 for the last marking point
(b)		$Fe^{2+} \rightarrow Fe^{3+} + e^-$ / Unbalanced full equation with all correct species (1) but $H_2O_2 + 2H^+ + 2Fe^{2+} \rightarrow 2H_2O + 2Fe^{3+}$ (2)	2	**Allow** full marks for the correct ionic equation between H_2O_2 and Fe^{2+} **Allow** correct multiples of equation **Ignore** state symbols
(c)		There is no longer a green precipitate/green solid (1) $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ (1) **or** There is now a red-brown precipitate/orangey brown/brown/rusty solid (1) $Fe^{3+} + 3OH^- \rightarrow Fe(OH)_3$ (1)	2	**Allow** precipitate mark if state symbol given in equation **Ignore** state symbols
(d)	(i)	-1/1-/- (1)	1	**Allow** O_2^-
	(ii)	Oxygen from -1 to -2/0 to -2 which is reduction (1) Oxygen from -1 to 0/-2 to 0 which is oxidation (1)	2	**Allow** 1 mark for either 2 correct ON changes (1 ox and 1 red) OR correct reference to oxidation and reduction from their ON changes
	(iii)	Moles of KO_2 = 14.1 (1) Moles of CO_2 = 7.05 (1) Volume of CO_2 = 168.8 dm^3 (1) Allow range 168 to 169.2	3	**Allow** ecf within question **Allow** 2 or more sig figs for first two marking points **Allow** 3 or 4 sig figs for answer
			14	

Qu.	Expected Answers	Marks	Additional Guidance
4	Properties 3 from Coloured (ions)/coloured (compounds) (1) Catalysts (1) **Several oxidation states (1)** **Paramagnetic (1)**	3	
	Complex ion **Octahedral/clear three dimensional drawing (1)** **Ligand donates a pair of electrons/central atom or ion accepts a pair of electrons (1)** **Coordinate bond/dative bond (1)** **Bond angles (1)**	4	**Allow** tetrahedral or square planar and correct bond angles from a correct example **Allow** bonding marks (2 and 3) from an incorrect complex ion
	Ligand substitution Involves swapping of one ligand for another/exchange of ligands/displacement of ligands (1) Example (1) eg reaction of aqueous iron(III) ions with thiocyanate ions Equation (1) eg $[Fe(H_2O)_6]^{3+}$ + SCN^- → $[Fe(H_2O)_5(SCN)]^{2+}$ + H_2O Observation (1) eg red coloration	4	Correct equation also scores the description of ligand substitution Wrong metal in complex ions can score the description and equation mark
	Quality of Written Communication (1) Use of at least three of the following technical words in the correct context • Catalyst/catalytic • Dative/coordinate • Lone pair/electron pair • Oxidation state/oxidation number • Octahedral/tetrahedral/square planar	1	
		12	

2815/02 Biochemistry

Qu.		Expected Answers	Mark
1)	(a)(i)	Hydrogen bonding✓between C=O and N–H.✓ Or C=O - - - HN ✓ for second mark NB use of COOH, COH, NH_2 is CON.	[2]
	(ii)	Each type and explanation of the bonding earns **one** mark✓✓ AW Ionic: attraction between COO^- and NH_3^+ Disulphide/sulphur bridges : covalent/ –S–S– van der Waals/IDID : between alkyl /hydrocarbon/aryl/non-polar groups 1 mark is given for both types if they have no correct explanations	[2]
	(b)(i)	Fe^{2+} ✓	[1]
	(ii)	To bind/carry oxygen/O_2✓(not ion , not oxygen atom)	[1]
	(c)(i)	O in H_2O_2 (–1 ox number) is oxidised to O_2 (0 ox number)✓ and reduced to H_2O (–2 ox number).✓ Ignore H Give: 1 mark for -2 and 0 for oxygen on the right.	[2]
	(ii)	**A** should show initial increase in rate, then a plateau✓ **B** should show a more gradual increase levelling out at a lower rate than A✓. If labels are reversed or no labels on correct diagram 1 mark, 	[2]
	(iii)	Two from: • Binds to enzyme somewhere other than active site✓ • Distorting shape of active site/protein/ tertiary or 3D structure ✓ (making it less active) • BY combining with free SH or $COOH/COO^-/NH_2$ groups✓ AW throughout.	[2]
	d(i)	Any two of the following: ✓✓ • Easy separation of product and/from enzyme • Continuous use possible /enzyme can be reused • Thermal stability of enzyme improved, can be used at higher temperatures/resists small pH changes • Optimum temperature may be increased • Minimises/prevents end-product inhibition.	[2]
	(ii)	Any one, for example bread making, brewing, production of lactose-free milk, washing powders or fluids etc. Allow use of micororganisms in other contexts✓	[1]

Qu.		Expected Answers	Mark
2)	(a)(i)	Either OCO group or the phosphate✓	[1]
	(ii)	Two of:✓✓ • They allow movement of chemicals(AW) in and out of cells/ selectively permeable • They separate contents of cells from surrounding/hold in cell contents • They allow separate compartments to be formed in cells • Allow some proteins to attach AW throughout	[2]
	(iii)	van der Waals' (IDID) forces.✓	[1]
	(b)	Reducing the number of van der Waals' forces would make the bilayers more flexible at low temperature✓. This could be achieved by one of the following:✓ • Shortening the hydrocarbon chain • Introducing branches to the chain • Introducing double bonds to the chain	[2]
	(c)	Carbohydrates are partially oxidised✓ Formation of carbon dioxide and water is exothermic/ gives off energy✓ Formation of C0/0H bonds is exothermic/ provides energy✓ Allow C-O in this last point	[3]

Qu.		Expected Answers	Mark
3)	(a)(i)	*A glycosidic link that is on the same side of the ring as the CH_2.OH group/ above ribose ring or up in the diagram AW.* ✓	[1]
	(ii)	*Use of dilute HCl/H_2SO_4 (allow conc HCl /acid) or an enzyme).* ✓	[1]
	(b)	 CH_2OHCHOHCHOHCHOHCHO ✓ for each. The ring form must be displayed. The straight form may be as above or displayed or vertical, but allow only one OH the wrong way round.	[2]
	(c)(i)	It involves the elimination of water✓.AW	[1]
	(ii)	To the C_5 oxygen or to C5✓ (Not to H or to the phosphate end)	[1]
	(d)(i)	Any two of: ✓✓ • DNA has base thymidine/T and RNA has uridine/U • DNA has deoxyribose instead of the ribose in RNA • DNA is a larger molecule • DNA forms a double helix; RNA (usually) does not Comparison needed	[2]
	(ii)	Five points from :✓✓✓✓✓ • <u>Hydrogen</u> bonds joining double helix <u>break/</u> van der Waals forces between (stacked) bases in DNA break. • New nucleotides/ (complementary) bases are attached to a single strand of DNA • The complementary base pairs are AU and one of CG/ GC/TA • Hydrogen bonds form between bases • New (phosphate) ester bonds form • Hydrogen bonds between RNA and DNA • Mention of helicase for breaking double helix or RNA polymerase for forming phosphate ester bonds	[5]
		QWC Award this for accurate use of technical terms –<u>describing transcription</u> and two from: hydrogen bonds, , ester, base pair and complementary.	[1]

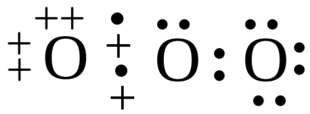
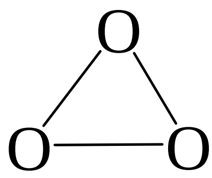
Question No.		Expected Answers	Mark
4)	(a)	*Two reasons from ✓ ✓* • *It has 1,6 (glycosidic) links/bonds* • *Because it is a branched structure, Give this mark if both 1,6 and 1,4 links are mentioned* • *α-glucose* *Give the reason marks independently of the name.* *With 1,6 and 1,4 glycosidic links ✓* *Then the name : amylopectin/ glycogen ✓*	[3]
	(b)	*Glucose has many site<u>s</u>/OH group<u>s</u> for hydrogen bonding to water ✓* *Diagram such as O–H···OH_2 ✓ (beware use of C-H)* *Must not be two water molecules.* *In **C** many OH groups are tied up in glycosidic links ✓* *Many OH groups are involved in hydrogen bonding between chains/ within helical regions/intermolecularly. AW ✓*	[4]

2815/03 Environmental Chemistry

Qu.		Expected Answers	Mark
1)	(a)(i)	First three points from: Encourages anaerobic conditions/prevents air or oxygen from getting in✓ Prevents escape of landfill gas/minimises odours✓ Stops waste blowing about/ access by gulls or vermin✓ Prevents excess rain entering landfill (which would increase leaching)✓	[3]
	(ii)	Two of the following gases : Hydrogen sulphide or formula ✓ to contain the bad smell/toxic gas✓ Methane or formula✓ to allow use as fuel or for energy/minimise risk of explosion/ minimise effect on global warming✓ Carbon dioxide or formula ✓ to prevent pressure increase in landfill/ minimise effect on global warming. ✓ NB The same reason is not accepted for two gases.	[4]
	(b)(i)	It can contribute to acid rain formation✓ Toxic/poisonous/irritant✓AW.	[2]
	(ii)	$SO_2 + 0.5\ O_2 + 2\ NaOH \longrightarrow Na_2SO_4 + H_20$ ✓ Or doubled	[1]
	(iii)	$4NO + 4NH_3 + O_2 \longrightarrow 4N_2 + 6H_2O$ ✓ Or halved Accept also balanced versions, such as : $2NO + 4NH_3 + 2\ O_2 \longrightarrow 3N_2 + 6H_2O$ ✓	[1]

Qu.	Expected Answers	Mark
2) (a)(i)	Water and/or carbon dioxide is given off✓ by le Chatelier's principle✓ Equilibrium moves to right✓ Producing more insoluble calcium carbonate	[3]
(ii)	100,000 dm^3 contains 100,000 x 0.096 mol of $Ca(HCO_3)_2$ = 9.6 x 10^3mole✓ M_r for $CaCO_3$ =100.1✓ Accept 100 and follow through. This will weigh 100.1 x 9.6 x 10^3 = 9.6 x 10^5g✓ ecf	[3]
(b)	Aluminium ions: to flocculate/coagulate solid particles✓ Either negative charge on surface of particles ✓ is neutralised ✓ Or A precipitate of aluminium hydroxide/formula is formed ✓ which absorbs other ions/ solid particles✓. Chlorine gas : It forms HClO or ClO^-/equation ✓ $Cl_2 + H_2O = HOCl + HCl$ removal of_ bacteria by oxidation✓.	[5]

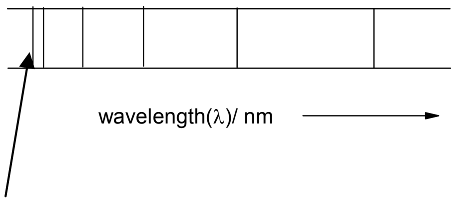
Qu.	Expected Answers	Mark

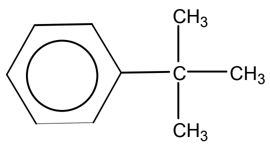
3) (a)(i)	In equations or words: Oxygen molecules split into oxygen atoms✓ photochemically/ with UV✓ Oxygen atoms react with oxygen molecules to form ozone✓ Ozone breaks down (photochemically) to oxygen✓ $O_2 \longrightarrow 2O$ $O_2 + O \longrightarrow O_3$ $2O_3 \longrightarrow 3O_2 \longrightarrow$ or O_3 $O_2 + O$	**[4]**
(ii)	 ignore bond angles or versions based on ring 	**[1]**
(b)(i)	Increases amount of UV reaching the earth's surface/ increases chance of skin cancer etc. AW ✓	**[1]**
(ii)	Any two points ✓✓ from: • Ease of breakdown in troposphere/ by UV • Presence of C-H bond • Residence time/greenhouse factor • Flammability (lack of) AW	**[2]**
(c)(i)	In breaking a covalent bond one electron is left with one atom and one with the other✓	**[1]**
(ii)	Two points from: ✓✓ • Ozone adds to/reacts with double bonds • And breaks them/ forms carbonyl compounds • The rubber cracks/perishes/becomes brittle	**[2]**
(iii)	By using catalytic convertors in cars etc✓ *Equation such as* $2NO + 2CO = N_2 + 2CO_2$ ✓	**[2]**

Qu.	Expected Answers	Mark
4)	Find nine marks from: • In 1:1 clays each layer comprises one aluminate/octahedral sheet and one silicate/tetrahedral sheet ✓ • These sheets are joined by Al-O-Si links✓ • The layers are attracted to each other by hydrogen bonding ✓ • between O atoms on the silicate/tetrahedral sheet and H atoms attached to the aluminate/octahedral sheet✓. • Water and cations cannot easily get in between the layers✓ (Water is not readily absorbed) • In 2:1 clays each layer consists of two silicate/tetrahedral sheets with one aluminate/octahedral sheet in between (or diagram)✓ • The layers are not hydrogen bonded together/are only held together by weak forces of attraction✓ • Water can easily penetrate between the layers✓ (water is readily absorbed - swelling the clay). • Cations can also enter between the layers and become attracted to the negatively charged oxygen atoms within✓ • This negative charge is increased by the replacement of Si(IV) by Al^{3+} in the original structure (or Al^{3+} by Mg^{2+})✓ • Much larger surface for ion exchange in a 2:1 clay✓ (and therefore greater cation exchange capacity than 1:1 clay) The QWC mark should be given for a well organised answer which shows accurate use of two of the following terms in context: hydrogen bonding, sheet, layer, replacement (or substitution), cation.	[10]

2815/04 Methods of Analysis and Detection

Qu.		Expected Answers	Mark
1(a)	(i)	mobile phase = (carrier) gas ✓ stationary phase = (non-volatile) liquid ✓	2
	(ii)	time taken for the component to emerge (after sample injected) ✓	1
(b)		peak **1** = pentane ✓ peak **2** = hexane ✓	2
(c)	(i)	(structural feature that) **absorbs** UV/visible light/energy ✓	1
	(ii)	conjugation/extended delocalised electrons ✓ decrease gap between energy levels ✓ hence absorbs at lower energy/longer λ /in visible region ✓	3
			9

Qu.	Expected Answers	Mark
2(a)	gaps between energy levels are fixed/quantised ✓ hence produce fixed lines corresponding to movement between the fixed energy levels ✓	2
(b) (i)	(lines converge because) the fixed/quantised energy levels get closer at high energy ✓	1
(ii)	 **C** correctly labelled and lines getting closer together at shorter λ ✓	2
(c)	converts kJ to J /E = 3.38 x 10^{-19} J ✓ calculates f = 5.10 x 10^{14} (s^{-1}) ✓ calculates wavelength/λ = 5.88 x 10^{-7} (m) ✓ = 588 nm ✓ (**must be to 3 sig figs**) (allow one mark for using formulae $E = hf$ and $c = \lambda f$)	4
(d)	calibration graph needed /plot intensity ~ known conc./ $[Na^+]$ ✓ measure intensity of sample ✓ deduce concentration/$[Na^+]$ of sample from the graph ✓	3
		12

Qu.		Expected Answers	Mark
3(a)	(i)	^{13}C ✓	1
	(ii)	uses equation $n = 100 (M + 1) \div 1.1M$ ✓ $n = 10$ ✓	2
	(iii)	$M_r = 134$ ✓ 10 Cs = 120, therefore must be 14 H ✓ $C_{10}H_{14}$ ✓ Allow ecf 2 marks for incorrect M_r peak	3
	(iv)	$C_6H_5^+$ ✓	1
(b)	(i)	there must be 3 CH_3s to account for the other 9 Hs and each CH_3 must be joined to a C with no Hs ✓	1
	(ii)	C_6H_5/benzene (ring)/aromatic ✓	1
(c)		 arene ✓ substituent ✓	2
			11

Qu.	Expected Answers	Mark
4(a) (i)	molecular ion/$C_4H_8O_2^+$/CH_3^+ /CO^+/$C_3H_5O_2^+$ ✓	1
(ii)	$CH_3CH_2CH_2^+$/ $C_3H_7^+$/ $CH_3CH_2^+$/ $C_2H_5^+$/CH_2^+/COO^+/ $COOH^+$ ✓ *In parts (i) and (ii) penalise lack of charge once*	1
(b)	isomer **B** ✓ isomer **B** would have OH peak in range 3230–3550 (cm^{-1}) ✓	2
(c)	peaks labelled left to right: H_c H_b H_d ✓✓ if two are the wrong way round ✓	2
(d)	***Similarities*** • same number of peaks (4) /proton environments ✓ • same peak areas 3 : 2 : 2 : 1or same relative heights ✓ • One comment about splitting the $CH_3CH_2CH_2$ chain ✓ ***Differences*** • The acidic proton,-COO**H** (11.0–11.7) and the aldehyde proton, -C**H**O (9.5–10) protons can be distinguished by their chemical shifts/ isomer **D** would have (singlet) at 9.5–10 ppm but isomer **C** would have (singlet) at 11.0–11.7 ppm ✓ • in isomer **C** the acidic proton would disappear if run in D_2O ✓ • terminal CH_2 in the CH_3CH_2**CH_2**– would have different chemical shifts ?/**C** at 2.0–2.9 and **D** at 3.3–4.3 ppm ✓	6
QWC	SPAG – two sentences in which the meaning is clear in answer to part(d)	1
		13

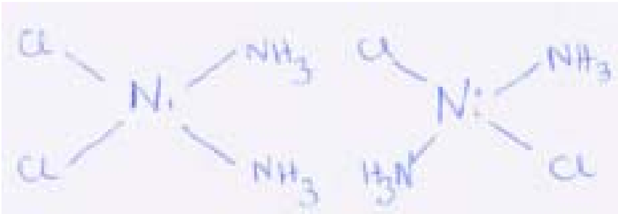
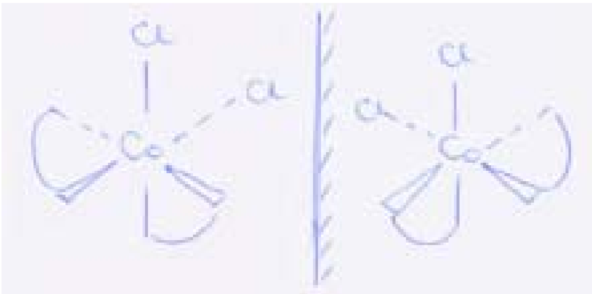
2815/06 Transition Elements

Qu.	Expected Answers	Mark
1 (a)	<table><tr><td>ion</td><td>VO^{2+}(aq)</td><td>V^{3+}(aq)</td><td>**VO_2^+ / VO_3^-**</td></tr><tr><td>colour</td><td>blue</td><td>**green**</td><td>yellow</td></tr><tr><td>oxidation state</td><td>**+4**</td><td>+3</td><td>+5</td></tr></table>	3
(b) (i)	$2V^{3+} + Zn \rightarrow 2V^{2+} + Zn^{2+}$ (allow multiples but not electrons)	1
(ii)	lilac/mauve/purple/violet/magenta	1
(c)	Vanadium(V) oxide/vanadium pentoxide/V_2O_5 **and** Contact process/producing sulphuric acid/oxidation of SO_2 to SO_3	1
	$2SO_2 + O_2 \rightleftharpoons 2SO_3$ (allow multiples and a forward arrow)	1
		Total: [7]

Qu.	Expected Answers	Mark
2. (a) (i)	Orange to yellow.	1
(ii)	(Named) acid/H^+	1
(iii)	**All** oxidation numbers worked out for both sides of equation.	1
	ie Cr=+6, O=-2, H=+1	
(b)	Moles $Cr_2O_7^{2-}$ used = 0.000348 mol	1
	Moles Fe^{2+} = 6 x 0.000348 = 0.002088 mol	1
	250 cm^3 Fe^{2+} = 10 x 0.00209 = 0.02088 mol	1
	Mass Fe = 0.02088 x 55.8 = 1.165104 g	1
	% Fe in sample = 1.165104/1.20 x 100 = 97.1% (3 sf)	1
	Allow consequential marking throughout	
	If candidates use 3 sf from the start then answer is 97.5 %	
	Allow range from 97.0 – 97.5%	
		Total: [8]

Qu.	Expected Answers	Mark
3. (a) (i)	Emf/voltage/potential difference (of a half cell) (not potential)	1
	Combined with a standard hydrogen half cell	1
(ii)	298K/25°C, 10^5 Pa/1 Atm, 1 mol dm^{-3} (all 3 needed)	1
(b)	Voltmeter, salt bridge and complete circuit (salt bridge must be in contact with a solution)	1
	Platinum electrode in the $\frac{1}{2}Cl_2/Cl^-$ half cell (labelled)	1
	Chlorine gas feed and chloride ions in solution	1
(c) (i)	$BrO_3^- + 6H^+ + 5Br^- \rightleftharpoons 3Br_2 + 3H_2O$	
	correct species	1
	balanced	1
(ii)	Yellow/orange/brown (solution) (not ppt or solid or gas)	1
(d)	$Cr_2O_7^{2-}$ has a more positive electrode potential than Br_2 but less positive than Cl_2 /Cl_2 is a better oxidising agent than $Cr_2O_7^{2-}$ but Br_2 is poorer	1
	Credit the working out of cell emf – positive (+0.26) for bromide, negative	
	(-0.03) for chloride	
	(accept lower/higher argument)	
		Total: [10]

Qu.	Expected Answers	Mark
4. (a) (i)	$1s^22s^2\mathbf{2p^63s^23p^6}$	1
(ii)	White	1
	No d-electrons (to absorb visible light) (not does not have a partially filled d-sub shell)	1
(b) (i)	Dative covalent/co-ordinate	1
(ii)	partially filled d-orbitals (accept a suitable diagram)	1
	(Ligands cause) splitting of d-orbital energy levels/lower & higher energy d-orbitals/implication of a gap/d-electrons promoted	1
	Particular frequency of visible light is absorbed to promote electrons	1
	(need to have idea that only part of visible light is absorbed)	
(c)	Little or no absorbance in violet and blue region (between 400 and 500 nm) rising to maximum absorbance in yellow/orange/red (allow maximum between 600 and 700 nm)	1
		Total: [8]

Qu.	Expected Answers	Mark
5.	Same structural formula/same atoms & order of bonds but a different arrangement in space (not same molecular formula)	1
	Cis and *trans/geometric* and optical both mentioned	1
	Correct 3-D diagrams of *cis* and *trans* isomers	2
	e.g 	
	Cis has same ligands adjacent/at 90^0. *Trans* opposite/at 180^0 (allow this mark from clearly labelled diagrams)	1
	Correct 3-D diagrams of optical isomers.	2
	e.g 	
	Non-superimposable mirror images	1
	Cis-platin used to treat cancer	1
	Binds to DNA	1
	Prevents replication of cancerous cells/cells dividing	1
	Quality of Written Communication.	
	1 mark to be awarded for a minimum of two grammatically correct sentences with good spelling and punctuation.	1
		Total: [12]

2816/01 Unifying Concepts in Chemistry/ Experimental Skills 2 Written Paper

Qu.	Expected Answers	Mark
1(a)(i)	mole fraction x total pressure / contribution of a **gas** to the total pressure / pressure that a **gas** would have alone ✓	1
1(a)(ii)	48 kPa ✓ (24 kPa^{-1} common error)	1
1(a)(iii)	$K_p = \dfrac{(pSO_3)^2}{(pSO_2)^2(pO_2)}$ ✓ ***Do not allow** square brackets.* *Brackets not required. Brackets can be around formulae.*	1
1(a)(iv)	Use of $K_p = \dfrac{33^2}{(39^2 \times 48)}$ to generate a **correct** calculated value of K_p of 0.0149 up to 0.014916173(57) ✓ **Calculated value essential** K_p = 0.015 (to 2 significant figures) ✓ Response of 0.015 would automatically score 1st two marks units from K_p expression in **(iii)**: kPa^{-1} ✓ **ALLOW ECF** for alternative response to **1(a)(ii)** and **(iii)** for **calculated value** and **units**	3
1(b)	K_p decreases ✓ The equilibrium goes to the left/more reactants/less products **because** the (forward) reaction is exothermic **OR** argument based on K_p and numerator/denominator ✓ *Allow reverse argument based on endothermic **reverse** reaction.*	2
1(c)	high pressures: equilibrium moves to (right-hand) side with fewer moles ✓ high pressures are expensive to generate/have safety problems/yield is high enough without increasing pressure ✓	2
1(d)(i)	3.27 x 10^x ✓ accept 3 up to calculator value of 3.27217 3.27 x 10^5 tonnes/327,000 tonnes/300,000 tonnes/3.27 x 10^{11} g ✓ *ie 1st mark is number at start* *2nd mark is for correct powers of 10 **AND** correct units to match*	2
1(d)(ii)	$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$ ✓ *ALLOW multiples, eg* $PbS + 1\frac{1}{2}O_2 \longrightarrow PbO + SO_2$ *Do not allow S as product*	1
	Total:	**13**

Qu.	Expected Answers	Mark
2(a)(i)	OH^-: When $[OH^-]$ increases by 2.5, rate increases by 2.5 ✓, so order = 1 (with respect to OH^-) ✓ ClO_2: When $[ClO_2]$ increases by 3, rate increases by $9/3^2$ ✓, so order = 2 (with respect to ClO_2) ✓ *For both OH^- and ClO_2, explanation and order to be marked independently*	4
2(a)(ii)	rate = $k[OH^-]\,[ClO_2]^2$ ✓ **ALLOW** $r = k[OH^-]\,[ClO_2]^2$ **ALLOW ECF** from **(a)(i)** *rate* = **is essential**	1
2(a)(iii)	$k = \dfrac{rate}{[OH^-]\,[ClO_2]^2}$ **OR** $\dfrac{6.00 \times 10^{-4}}{0.0300 \times 0.0100^2}$ ✓ = 200 ✓ *200 without working scores the first 2 marks* ***ALLOW ECF** from an incorrectly rearranged equation* units: $dm^6\ mol^{-2}\ s^{-1}$ ✓ **ALLOW ECF** from rate equation **(a)(ii) but** the units **must** be derived from the rate equation	3
2(b)(i)	rate equation shows (2 ClO_2 and) 1 OH^- and overall equation shows (2 ClO_2 and) 2 OH^- **OR** Rate equation has a different number of moles of OH^- from overall equation ✓	1
2(b)(ii)	$2ClO_2(aq) + 2OH^-(aq) \longrightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O$ 1 mark for ClO_3^- ✓ 1 mark for total equation (conditional on 1st mark) ✓	2
	Total:	**11**

Qu.	Expected Answers	Mark
3(a)	$C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^-$ ✓ Accept $C_6H_5COOH + H_2O \rightleftharpoons H_3O^+ + C_6H_5COO^-$ ✓ Accept molecular formulae, *ie* $C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^-$ Equilibrium sign **essential**	1
3(b)	$K_a = \dfrac{[H^+][C_6H_5COO^-]}{[C_6H_5COOH]}$ ✓	1
3(c)	concentration = $\dfrac{3.40}{122}$ ✓ = 0.0279 (mol dm^{-3}) ✓ Accept 0.028 up to calculator value of 0.027868852(46) *(first mark for M_r of benzoic acid – incorrect answer here will give ecf for remainder of question)* $[H^+] = \sqrt{(K_a \times [C_6H_5COOH])}$ **OR** $\sqrt{(6.30 \times 10^{-5} \times 0.0279)}$ ✓ = 1.33×10^{-3} (mol dm^{-3}) ✓ pH = –log $[H^+]$ = –log 1.33×10^{-3} = 2.89 ✓ answer = 2.88 if no rounding. **DO NOT ALLOW** 2.9 unless more d.p. shown elsewhere pH **must** be greater than 1 and less than 7 If no square root, pH = 5.76 4 marks If g dm^{-3} used instead on mol dm^{-3}, pH = 1.83–1.84 3 marks *Watch out for evidence of correct M_r as there may be another mark*	5
3(d)	buffer minimises pH changes ✓ **DO NOT ALLOW** pH is constant HA discussion is OK here C_6H_5COOH reacts with added alkali / $C_6H_5COOH + OH^- \rightarrow H_2O + C_6H_5COO^-$ / added alkali reacts with H^+/$H^+ + OH^- \rightarrow H_2O$ ✓ $\rightarrow C_6H_5COO^-/C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^- \rightarrow$ right (counteracts change)✓ $C_6H_5COO^-$ reacts with added acid or H^+ ✓ $\rightarrow C_6H_5COOH/ C_6H_5COOH \rightleftharpoons H^+ + C_6H_5COO^- \rightarrow$ left (counteracts change) ✓ $[H^+] = K_a \times \dfrac{[C_6H_5COOH]}{[C_6H_5COO^-]}$ ✓ = $6.30 \times 10^{-5} \times \dfrac{0.105}{0.125}$ **OR** 5.292×10^{-5} ✓ pH = –log (5.292×10^{-5}) = 4.28 ✓ (calculator: 4.276380164) **ALLOW** 4.3 **OR** ALTERNATIVE APPROACH USING H.H. EQUATION: pK_a = –log 6.30×10^{-5} = 4.20 ✓	1 **EXPL 4** **CALC 3**

	$\text{pH} = \text{p}K_a + \log\dfrac{[C_6H_5COO^-]}{[C_6H_5COOH]}$ **OR** $\text{pH} = -\log K_a + \log\dfrac{[C_6H_5COO^-]}{[C_6H_5COOH]}$ ✓ pH = 4.20 + 0.08 = 4.28 ✓ QWC: correct equilibrium shift discussed at least once ✓	1
	Total:	**16**

Qu.	Expected Answers	Mark
4(a)(i)	0.1 mol dm^{-3} ✓	1
4(a)(ii)	final pH (approximately) 11/equivalence point <7 ✓ **ALLOW** correct reference to shape of curve: ie No vertical part after 7/starts to curve at 7	1
4(a)(iii)	NH_4NO_3 ✓ **ALLOW** $N_2H_4O_3$	1
4(a)(iv)	resazurin ✓	1
4(a)(v)	sharp rise after addition of 12.5 cm^3/half the volume of NH_3 ✓ final pH higher ✓ For 'sharp rise', **ALLOW** neutralisation/equivalence/end point	2
4(b)(i)	$Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2$ ✓ $Mg + 2H^+ \longrightarrow Mg^{2+} + H_2$ ✓ **IGNORE** state symbols **DO NOT ALLOW** $2NO_3^-$ added to both sides of ionic equation	2
4(b)(ii)	With dilute HNO_3: **H** (reduced) from +1 to 0 ✓ With conc. HNO_3: **N** (reduced) from +5 to +4 ✓	2
	Total:	**10**

Qu.	Expected Answers	Mark
5(a)	moles $CaSO_4.0.5H_2O = \frac{500}{145.2}$ or 3.44 mol ✓ mass H_2O = 1.5 x 3.44 x 18 = 92.88/92.9/93 g /92.98 g with no rounding ✓ Correct units of **g** required **ALLOW** 3.44 x 27 = 92.88 (watch **ECF**) **ALLOW** 1 mark for 78.4 g (2nd mark above from 500/172.2 x 1.5 x 18) ***ALLOW*** *$M(CaSO_4.0.5H_2O) = 145\ g\ mol^{-1}$*	2
5(b)	M_r unknown gas = $\frac{28 \times 1.52}{0.60}$ = 71 ✓ molecular formula = Cl_2 ✓ **ALLOW** any gas that exists with an M_r of 71 (if you can think of one) *If M_r is incorrect then gas chosen must have this value for M_r BUT Cl_2 will always automatically score 2nd mark irrespective of what has come before.*	2
5(c)(i)	$C_6H_8O_7$	1
5(c)(ii)	**Moles NaOH** amount of NaOH in titration = $\frac{0.00425 \times 21.35}{1000}$ or 9.07×10^{-5} mol ✓ (calc: 9.07375×10^{-5}) **Moles citric acid** amount of citric acid in 25.0 cm^3 = $\frac{\text{mol NaOH}}{3}$ or 3.02×10^{-5} mol ✓ (calc: $3.024583333 \times 10^{-5}$) **Scaling** amount of citric acid in 250 cm^3 = 10 x 3.02×10^{-5} or 3.02×10^{-4} ✓ **Molar mass** molar mass of citric acid = 192 g mol^{-1} ✓ (or M_r of citric acid is 192) ***Allow ECF from incorrect molecular formula in 5(c)(i)*** **Mass of citric acid in drink** mass citric acid in 250 cm^3 of drink = 3.02×10^{-4} x 192 = 0.0580 g ✓ *If calculator value held throughout, mass = 0.0581 g* *allow **ECF** throughout*	5
	Total:	**10**

2816/03 Unifying Concepts in Chemistry/ Experimental Skills 2 Practical Examination

PLAN (Skill P) **16 marks** (out of 19 available)

G Gas collection – 8 marks

G1 Candidate states meaning of the '100-volume' concentration description
and proves, by giving a calculation, that its concentration is 8.3 mol dm^{-3}
and gives equation for its decomposition: $2H_2O_2 \rightarrow 2H_2O + O_2$ **[1]**

G2 <u>Pipettes</u> <u>justified</u> volume of <u>diluted</u> H_2O_2 into reaction vessel **[1]**
(i) quantity of gas produced must be related to the capacity of the collecting vessel.
(ii) specimen calculation of suitable dilution factor (practical detail not needed)
(iii) use of pipette or burette to measure diluted H_2O_2 into reaction vessel

G3 Add manganese(IV) oxide (dioxide) as catalyst
and mass of MnO_2 doesn't matter because it is a catalyst
or catalysts work by reducing activation energy for the reaction **[1]**
Alternative named catalyst or a named enzyme are acceptable.

G4 A diagram of apparatus with flask, connecting tube and <u>correct</u> collection. **[1]**
No mark if the diagram drawn would not work because of a serious error (eg no bung)
Downloaded/ photocopied diagrams are acceptable ***only if*** *the labelling is relevant*
No G4 if Bunsen burner (or high temperature) used.

G5 Use of ignition tube ***or*** a boat for MnO_2 (***or*** a divided flask) ***and*** reason **[1]**
Reason: stops loss of gas before apparatus has been fully assembled
or *prevents reaction starting* **(or** *stops chemicals mixing) before bung is put on.*

G6 Records (final) volume of gas when fizzing ceases/when syringe stops moving **[1]**
Visual precaution to ensure completion of reaction is required

G7 Repeat whole procedure
and work out average gas volume ***or*** obtain consistent readings **[1]**

G8 Calculation of the concentration of 100 vol H_2O_2 from specimen data **[1]**

T Titration - 7 marks

T1 **Quantitative dilution** of aqueous hydrogen peroxide - practical details **[1]**
Requires use of pipette, distilled water ***and*** *a volumetric/standard flask*

T2 $KMnO_4$ of specified concentration used in the burette **[1]**
Concentration specified must lie between 0.010 - 0.20 mol dm^{-3}
Making up aqueous $KMnO_4$ from solid solute is ***not*** *required.*

T3 Equation for the reaction **[1]**
$2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 5O_2 + 8H_2O$
or $2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \rightarrow 2MnSO_4 + 5O_2 + 8H_2O + K_2SO_4$

T4 Redox theory: H_2O_2 is the reducing agent ***or*** H_2O_2 is oxidised (by $KMnO_4$)
and justification, using oxidation states ***or*** by quoting the ionic half-equation

T5 **Dilution factor** for H_2O_2 that will give a titre between 15 and 40 cm^3 **[1]**
This must be clearly justified by a numerical calculation

T6 Pipette hydrogen peroxide into a flask ***and*** **acidify** with excess sulphuric acid **[1]**

T7 **No indicator** required (*this may be implied*)
and the final/end-point colour is pink
and titrate until two consistent/concordant accurate titres are obtained **[1]**
Accept "titres within 0.05/0.1 cm^3" (unit needed) as alternative to "consistent"

S Sources etc – 4 marks

S1 Researches hazard of sodium carbonate ***and*** states a safety precaution **[1]**
[Solid] sodium carbonate is irritant
Accept one routine precaution - safety specs, lab coat, gloves, wash if spilt

S2 Two secondary sources quoted in the text ***or*** as footnotes ***or*** at end of plan. **[1]**
Book reference(s) must have chapter or page numbers
Internet reference(s) must go beyond the first slash of web address
*Accept **one** <u>specific</u> reference to a "Hazcard" (by name or number)*
*Allow one reference to a specific past paper (but **not** to teaching notes etc)*

S3 **QWC**: text is legible ***and*** spelling, punctuation and grammar are accurate **[1]**
*There must be fewer than **six** errors in legibility, spelling, punctuation or grammar.*

S4 **QWC**: information is organised clearly and coherently **[1]**
Is the answer to all three of the following questions positive?
- *Is a word count given and within the limits 450 – 1050 words?*
- *Is scientific language used correctly – allow one error*
- *Are both methods described logically and without excessive repetition?*

A2 Practical Test (Part B)

Page 3 (Part 1 – Skill I) **[10 marks]**

Presentation of titration data **[1]**
Check the following four bullet points: all must be correct.

- Correctly labelled table (initial, final and difference - *aw*) used to record burette data
- A table grid, showing at least three grid lines, must be drawn.
- All accurate burette data and titres (including 0.00cm^3 at start) are quoted to 0.05 cm^3
- All subtractions are correct *(these must be checked)*

Self-consistency of titres *(all three bullets must be correct)* **[1]**

- Both of the candidate's two **accurate** titres agree within 0.10 cm^3.
- **Units**, cm^3 or ml, must also be given *(**once** in or alongside the table is sufficient).*

- **Three** titres are shown.

Mean titre correctly calculated **[1]**

- *The mean should normally be calculated using the two accurate titres.*
  ***However** the trial may be used if it is closer than one of the accurate readings.*
- *The mean must be correctly quoted **either** to 2 d.p **or** to 0.025/0.075*
- *Unit must be given, with the answer.*

Accuracy – [6 marks]

- *Write down the supervisor's mean titre, rounded to 0.05 cm^3 and ringed.*
  Check that supervisor's subtractions are correct
- *The candidate's own mean should normally be used for assessment of accuracy.*
  Use candidate's mean to nearest 0.05 cm^3
- *Compare the supervisor's mean titre with the candidate's mean titre.*
  Put "δ = __" on the script to show the difference between these two mean titres.
- *Use the conversion chart below to award the mark out of 6 for accuracy.*

Candidate's mean titre is within **1.20 cm^3** (incl) of supervisor's mean titre	**[1 mark]**
Candidate's mean titre is within **0.90 cm^3** (incl) of supervisor's mean titre	**[2]**
Candidate's mean titre is within **0.70 cm^3** (incl) of supervisor's mean titre	**[3]**
Candidate's mean titre is within **0.50 cm^3** (incl) of supervisor's mean titre	**[4]**
Candidate's mean titre is within **0.30 cm^3** (incl) of supervisor's mean titre	**[5]**
Candidate's mean titre is within **0.20 cm^3** (incl) of supervisor's mean titre	**[6 marks]**

Spread penalty
("Spread" relates to the titres used by the candidate to calculate his/her mean)
If the titres have a spread of more than 0.30 cm^3, deduct 1 mark from accuracy mark.
If the titres have a spread of more than 0.70 cm^3, deduct 2 marks from accuracy mark.
If the titres have a spread of more than 1.20 cm^3, deduct 3 (max) from accuracy mark.

Safety [1 mark]
Any **two** precautions stated, from the six listed below

- wash off with [plenty of] water after use (***or*** if spilt)
- dilute before use
- keep off the skin [of the scalp]
- wear an apron *or* overall *or* lab coat
- wear [plastic/latex] gloves
- wear eye protection/safety spectacles (but not "*keep away from eyes*") **[1]**

Pages 4 + 5 (Part 2- Skill A) **[9 marks]**

(a) M_r of hydrated sodium thiosulphate = 248.2 (or 248) **[1]**
*No M_r attempted = no marks at all in **(a)***

No of moles used = $^{15.5}/_{248.2}$ x $^{\text{mean titre}}/_{1000}$ **[1]**
*This is a **method** mark for correct use of 15.5, an M_r and the mean titre/1000*

(b)(i) Correct balancing: $I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$ **[1]**

(ii) No of moles of I_2 = 0.5 x answer **(a)** **[1]**

(c)(i) $2I^- \rightarrow I_2 + 2e^-$ **[1]**

(ii) $2H^+ + H_2O_2 + 2I^- \rightarrow \mathbf{2}H_2O + I_2$ (*ie* 1 mol $H_2O_2 \rightarrow$ 1 mol I_2)
or correct use of electrons to demonstrate 1:1 mole ratio
or correct "molecular" equation: $H_2SO_4 + H_2O_2 + 2KI \rightarrow 2H_2O + I_2 + K_2SO_4$ **[1]**

(d) No of moles H_2O_2 = answer **(b)(ii)** **[1]**

(e) *Conc^n of undiluted H_2O_2 = answer (d) x $^{250}/_{25}$ x $^{1000}/_{10}$* **[1]**
*This is a method mark, for multiplying answer **(d)** by a factor of 1000*

Conc^n of H_2O_2, correctly calculated from data, expressed to 3 sig fig **[1]**
Award this mark for obtaining correct final answer, $[H_2O_2] = {}^{\text{mean titre}}/_{32}$

Page 6 (Part 3 – Skill I) **[6 marks]**

Readings: **presentation - 1 mark** *(All four bullets must be correct)* **[1]**
- Table grid drawn *(minimum of one line drawn horizontally and one line vertically)*
- Initial and final temperatures clearly labelled
- **All** four temperatures recorded to 0.5°C (*ie* one decimal place shown, 0.0 or 0.5)
- Readings recorded as two pairs within **one** table

No reading titles must be repeated/duplicated

Calculations – 1 mark *(All three bullets must be correct)* **[1]**
- Unit of temperature given for **each** of the four readings
- Correct subtractions to give each temperature rise (both written as 0.0 or 0.5)
- Mean temperature rise correctly calculated (to nearest 0.5, 0.25 ***or*** 0.1°C)

Accuracy **– 4 marks (3 + 1):** **[4]**
*Write supervisor's mean temp **rise** (to nearest 0.1°C) in a ring on the script*
*Use the candidate's mean temperature **rise** calculated to nearest 0.1°C.*
- If candidate's mean temperature rise is within 1.0°C of supervisor's → **3 marks**
- If candidate's mean temperature rise is within 1.5°C of supervisor's → **2 marks**
- If candidate's mean temperature rise is within 2.3°C of supervisor's → **1 mark**

- If **both** candidate's temperature rises are within 1.0°C of each other → **1 mark**

Page 7 (Part 4 – Skill A) **[5 marks]**

(a) Heat produced = 25 x 4.2 x mean temp rise **[1]**

Method *mark awarded for correct figures (**or** check answer if no working shown*

(b) $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ **[1]**

(c)(i) $n(H_2O_2)$ used = $^{cV}/_{1000}$ = concentration of H_2O_2 x $^{25}/_{1000}$ **[1]**
This is a method mark for using appropriate figures (but nothing else)

(ii) Enthalpy change calculation: working shown, using candidate's own data **[1]**
ΔH (kJ mol^{-1}) = $^{\text{heat produced}}/_{\text{1000 x no of moles of H2O2}}$
*This is a **method** mark, but the mark is for appropriate figures, not the words*

<u>Negative</u> sign given for ΔH ***and*** answer <u>correctly</u> calculated to 2 or 3 sig fig **[1]**

Answer should be approximately –90 kJ mol^{-1} = $^{4.2 \text{ x temp rise}}/_{[H2O2}$

Pages 8+9: Part 5 (Skill E – Evaluating) **[14 marks max** (out of 17)**]**

(a) **7 marks** *(but only 6 on the question paper. The extra mark is available in (ii))*

(i) Excess KI ensures that all the H_2O_2 reacts **[1]**

Using excess KI speeds up the reaction [with hydrogen peroxide]
or it prevents precipitation of iodine **[1]**

(ii) $n(H_2O_2)$ used = $^{10}/_{1000}$ x 0.88 = 0.0088 mol **[1]**

n(KI) used = $^{80}/_{1000}$ x 0.5 = 0.040 mol **[1]**

Use of mole ratio: H_2O_2 reacts with 0.0176 mol of KI (or 35.2 cm^3 of KI)
and this is less than 0.04 mol (or 80 cm^3) of KI, so excess KI was used **[1]**
If wrong mole ratio (or no mole ratio) is used, maximum 2 marks are available

(iii) Titration was repeated **[1]**
*Reference to **any** factor related to accuracy negates this mark*

It **is** reliable since the titres are consistent (***or*** vice versa) **[1]**
Mark this according to whether student's titres were within 0.10 cm^3

(b) Use a lid/cover for the cup **[1]**

Using thicker plastic/ use two cups/ put lagging around cup/ use Dewar flask **[1]**

(c) **8 marks maximum** *(but 6 on question paper)*
*Mark the best **three** strands.*

C1 The 100 volume solution would react more rapidly/vigorously **[1]**

C2 There would be more spitting /frothing /spray out of the cup **[1]**

D1 The temperature rise would be greater ***or*** reaction would be more exothermic **[1]**

D2 The percentage error in measuring the temperature rise would be reduced **[1]**

D3 Justification of reduced % error (= greater accuracy) using specimen calculation **[1]**

E1 Heat losses would be [much] greater **[1]**

E2 The temperature rise reached during reaction would be [much] greater
or reaction would be more exothermic ***or*** mixture would get hotter **[1]**
Award of E2 is conditional on award of E1

E3 Rate of cooling depends on temp difference between solution and surroundings **[1]**

F1 The heat produced [in the reaction] would be ten times as great **[1]**
*F1 must refer to the heat produced, **not** the temperature rise*

F2 The solution would boil ***or*** some of the solution/water would evaporate **[1]**

Grade Thresholds

Advanced GCE Chemistry (3882/7882)
June 2009 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2811	Raw	60	49	44	39	34	29	0
	UMS	90	72	63	54	45	36	0
2812	Raw	60	44	38	32	27	22	0
	UMS	90	72	63	54	45	36	0
2813A	Raw	120	97	87	77	67	57	0
	UMS	120	96	84	72	60	48	0
2813B	Raw	120	97	87	77	67	57	0
	UMS	120	96	84	72	60	48	0
2813C	Raw	120	91	80	70	60	50	0
	UMS	120	96	84	72	60	48	0
2814	Raw	90	70	61	52	44	36	0
	UMS	90	72	63	54	45	36	0
2815A	Raw	90	73	65	58	51	44	0
	UMS	90	72	63	54	45	36	0
2815B	Raw	90	72	65	58	51	44	0
	UMS	90	72	63	54	45	36	0
2815C	Raw	90	73	66	59	52	46	0
	UMS	90	72	63	54	45	36	0
2815E	Raw	90	75	68	61	54	48	0
	UMS	90	72	63	54	45	36	0
2816A	Raw	120	97	87	77	67	57	0
	UMS	120	96	84	72	60	48	0
2816B	Raw	120	97	87	77	67	57	0
	UMS	120	96	84	72	60	48	0
2816C	Raw	120	91	80	69	59	49	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3882	300	240	210	180	150	120	0
7882	600	480	420	360	300	240	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
3882	32.9	57.4	75.3	88.9	97.9	100	2936
7882	31.7	56.6	74.8	87.6	96.3	100	11875

14811 candidates aggregated this series

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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