Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

| Question	Expected Answers	Marks
1 **(a)**	<table><tr><td>isotope</td><td>protons</td><td>neutrons</td><td>electrons</td></tr><tr><td>^{12}C</td><td>6</td><td>6</td><td>6</td></tr><tr><td>^{13}C</td><td>6</td><td>7</td><td>6</td></tr></table> ✓ ✓	**[2]**
(b) **(i)**	mass spectrometry ✓	**[1]**
(ii)	mass of an isotope compared with carbon-12 ✓ 1/12th of mass of carbon-12/on a scale where carbon-12 is 12 ✓ *mass of 1 mole of the isotope/mass of 1 mole of carbon-12 is equivalent to the first mark* *"mass of the isotope that contains the same number of atoms as are in 1 mole of carbon-12" ⟶ 1 mark (mark lost because of mass units)*	**[2]**
(iii)	12 x 95/100 + 13 x 5/100 OR 12.05 ✓ = 12.1 (mark for significant figures) ✓ (12.1 scores both marks)	**[2]**
(c)	$1s^2 2s^2 2p^2$ ✓	**[1]**
(d)	CO_2: correct covalent bonds around carbon ✓ outer shell electrons correct ✓ (must be 'dot AND cross' or electron source clearly shown (different coloured for source?)	**[2]**
(e) **(i)**	calcium hydroxide/$Ca(OH)_2$ ✓	**[1]**
	$Ca(OH)_2(aq) + CO_2(g) \longrightarrow CaCO_3(s) + H_2O(l)$ ✓✓ 1st mark for $CaCO_3(s)$ State symbol essential here 2nd mark for rest of equation. Ignore state symbols	**[2]**
(f)	$CaCO_3 \longrightarrow CaO + CO_2$ ✓ state symbols not required	**[1]**
(g) **(i)**	moles CO_2 = 1000 /44 mol = 22.7 mol ✓ volume CO_2 in 2000 = 22.7 x 24 = 545 dm^3 ✓	**[3]**
(ii)	reduction = 545 x 60/100 = 327 dm^3 ✓	
		Total: 17

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Question	**Expected Answers**	**Marks**
2 **(a)**	......$Ca(s)$ + ...2 ✔ $HCl(aq)$ ....$CaCl_2(aq)$ + .$H_2(g)$. ✔ (g) not required for H_2	**[2]**
(b)	In Ca, oxidation state = 0 ✔ and In $CaCl_2$, oxidation state = +2 ✔ Oxidation number increases from Ca to $CaCl_2$	**[2]**
(c)	correct dot and crosses ✔ correct charges ✔	**[2]**
(d) **(i)**	white precipitate/goes white ✔	**[1]**
(ii)	Ag^+ + Cl^- $\longrightarrow$ $AgCl$ ✔ *state symbols not required*	**[1]**
(e) **(i)**	moles HCl = 2.0 x 50/1000 = 0.10 ✔	**[1]**
(ii)	moles Ca = ½ x moles HCl = 0.050 ✔ mass Ca = 40.1 x 0.050 = 2.00 g / 2.005 g ✔ (accept 40 x 0.050 = 2.0 g) (mass Ca of 4.0 g would score 1 mark as 'ecf' as molar ratio has not been identified)	**[2]**
(iii)	Ca has reacted with water ✔ Ca + $2H_2O$ $\longrightarrow$ $Ca(OH)_2$ + H_2 ✔✔ *state symbols not required* 1st mark for H_2 2nd mark is for the rest of the balanced equation	**[3]**
		Total: 14

Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

Question	Expected Answers	Marks
3 **(a)** **(i)**	O ✓	**[1]**
(ii)	Al ✓	**[1]**
(iii)	P ✓	**[1]**
(iv)	C/Si ✓	**[1]**
(v)	N/P ✓	**[1]**
(vi)	Mg ✓	**[1]**
(vii)	Na ✓	**[1]**
(viii)	Si ✓	**[1]**
(b) **(i)**	Energy change when each atom in 1 mole ✓ of gaseous atoms ✓ loses an electron ✓ (to form 1 mole of gaseous 1+ ions).	**[3]**
(ii)	increasing nuclear charge/number of protons ✓ electrons experience greater attraction or *pull* / atomic radius decreases / electrons added to same shell /same or similar shielding ✓	**[2]**
(iii)	In B, electron being removed is at a higher energy / In Be, electron being removed is at a lower energy ✓ An s electron is lost in Be AND a p electron is lost in B ✓	**[2]**
(iv)	IE (of Na): 100 - 500 kJ mol^{-1} ✓ electron is in a different shell /further from nucleus/new shell/ more shielding ✓ (**not** sub-shell or orbital) /	**[2]**
		Total: 17

| Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit <u> </u> = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument	
Question	**Expected Answers**	**Marks**
4 **(a)**	uneven distribution of electrons ✓ instantaneous /oscillating/changing/temporary/transient/ dipole on one atom ✓ causes an induced/resultant dipole on another molecule/atom ✓ chlorine gas; bromine liquid; iodine solid/ volatility decreases from $Cl_2 \longrightarrow Br_2 \longrightarrow I_2$/ boiling point increases from $Cl_2 \longrightarrow Br_2 \longrightarrow I_2$/ stronger forces are broken from $Cl_2 \longrightarrow Br_2 \longrightarrow I_2$ ✓ number of electrons increases down group ✓ greater/more van der Waals' forces / induced dipole-dipole interactions / forces between the molecules ✓	**[6]**

(b)	Reactivity decreases down group/ $Cl_2 > Br_2 > I_2$ /
	
	Cl_2 displaces Br_2 AND Br_2 displaces I_2 ✓
	
	chlorine: Cl_2 + bromide $\longrightarrow$ yellow ………/ orange ………. ✓
	bromine: Br_2 + iodide $\longrightarrow$ darker orange/brown ✓
	                or purple in organic solvent
	$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓
	$Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ ✓
	       (*or full equations*)
	
	Cl_2 is stronger oxidising agent than Br_2
	AND Br_2 is stronger oxidising agent than I_2 /
	
	Cl_2 has greater attraction for electrons than Br_2
	AND Br_2 has greater attraction for electrons than I_2 ✓
		[5 max]

QoWC:	**At least two sentences** that show legible text with accurate spelling, punctuation and grammar so that the meaning is clear. ✓ (Mark this from anywhere within Q4)	**[1]**
		Total: 12

1.
(a)   (i)   24.7/12 : 2.1/1: 73.2/35.5
              2.06 : 2.1 : 2.06   ✓

       CHCl   ✓

       (ii)   (CHCl = 12 + 1 + 35.5 =) 48.5   ✓

               48.5 x 3 = 145.5   ✓

Any two from

(b)   (i)

1,1,3 -trichloro   3,3,3-trichloro   2,3,3-trichloro   1,3,3 -trichloro   ✓✓
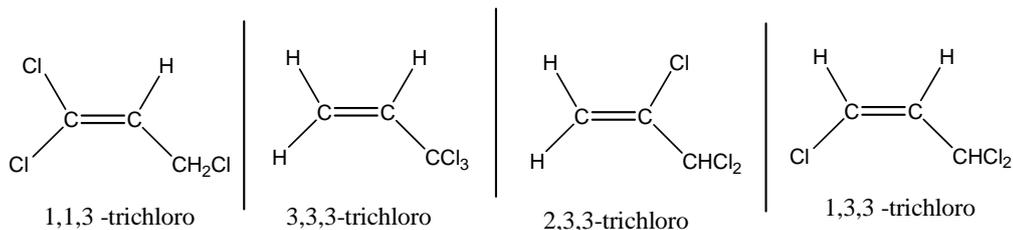
       (ii)   1,2,3-trichloropropene   *3 marking points:*   ✓✓
                       (trichloropropene scores 1 mark ✓)   • *correct numbers 1,2,3*
                                                                  • *trichloro*
                                                                  • *propene/prop-1-ene*
                                                                  any two gets 1 mark

(c)   (i)
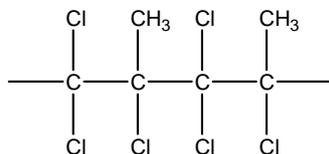
       1 mark if backbone contains 4 carbons with 'end-
       bonds' and a reasonable attempt has been made
       e.g used the wrong isomer…. max = 1 mark   ✓✓

       (ii)   non-biodegradable   ✓

               toxic fumes evolved <u>when burnt</u>   ✓

               HCl or Cl• or chlorinated organic compounds such as $COCl_2$ also evolved when
               burnt   ✓

                                                                   [Total: 13]

2.
(a)   (i)

✓
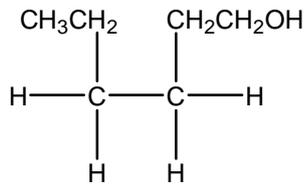
(ii)
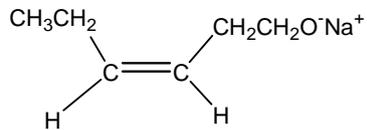
charges are not necessary

allow the alkoxide ion

✓

(iii)
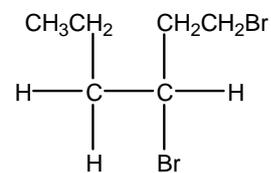
Both correct products gets 3 marks

✓✓✓
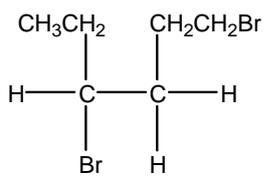
One correct product gets 2 marks

If neither of the above is correct then one mark can be awarded for any of:
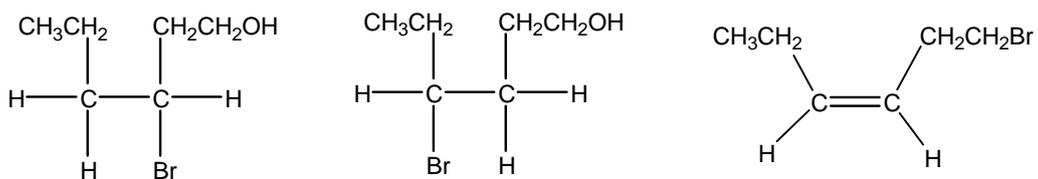
max of two marks

(b)   (i)   decolourises   ✓

(ii)
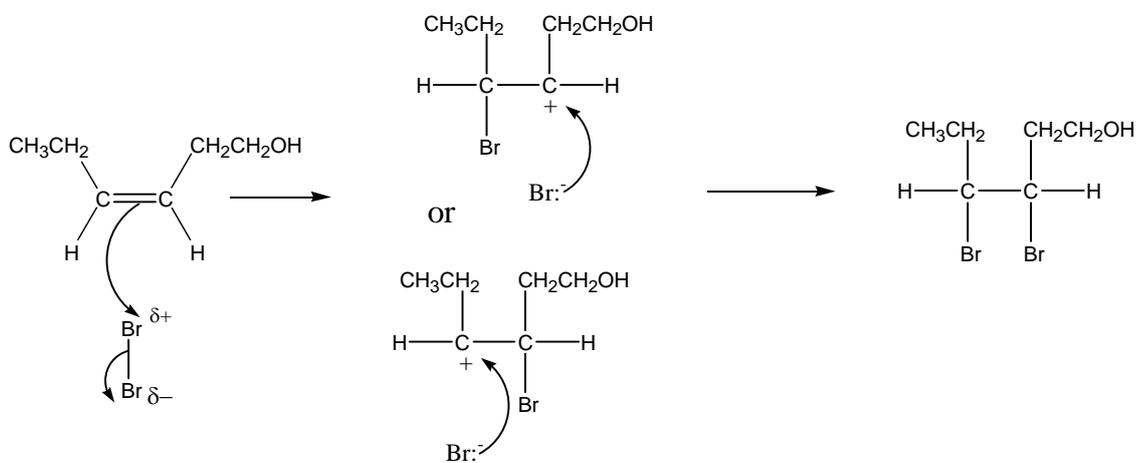
curly arrow from C=C bond to bromine   ✓

dipoles on Br_2 or curly arrow to show movement of bonded pair of electrons   ✓

intermediate carbonium ion/carbocation   ✓

curly arrow from lone pair on the Br^- ion to carbonium ion ($Br^{\delta-}$ loses 1 mark)   ✓

[Total: 10]

3.   (a)   (i) C_4H_{10} ✓

(ii) $C_4H_{10} + 6\frac{1}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$ ✓
                    (CO_2 & H_2O as products   ✓)

(iii)   propan-2-ol   ✓

(b)   (i)
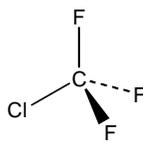
require an attempt at a 3D structure and bond angles must clearly not be 90°.

require at least one 'wedge' bond or one 'dotted' bond

✓

✓

(ii)   108 –111°   ✓

(iii)   volatile/low boiling/gas/non-toxic/non-flammable/unreactive/liquefied under pressure/inert   ✓

(iv)   homolytic = bonded pair split <u>equally</u>/ each retains 1 electron   ✓

fission = <u>bond</u> breaking   ✓

(v)   C-Cl (no mark) because it is the <u>weaker bond</u>   ✓

(vi)   Cl•   ✓

•CF_3 (allow CF_3•)   *(lack of 'dots' penalise once)*   ✓

[Total: 12]

4.

(a) $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$ ✓✓
                    $(C_2H_5OH \ \& \ CO_2$ ✓$)$
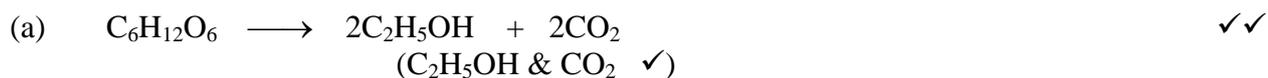
(b)
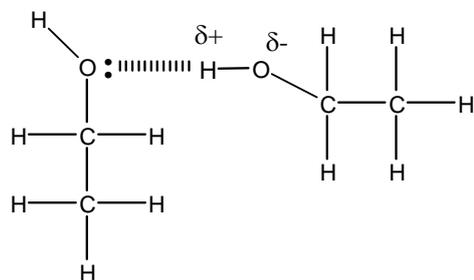
dipoles   ✓

hydrogen bond between O in
one O-H and H in the other O-H   ✓

lone pair from O involved in the
H-bond   ✓

(c)   (i)   (volatile components) can escape/distil out   ✓

              ethanal is most volatile/b pt less than 60 ^{o}C/partial oxidation   ✓

       (ii)   (volatile components) cannot escape/ refluxed   ✓

              complete oxidation will be achieved/oxidised to the acid   ✓

(d) $C_2H_5OH + 2[O] \longrightarrow CH_3COOH + H_2O$ ✓✓
                      $(CH_3COOH + H_2O$ ✓$)$
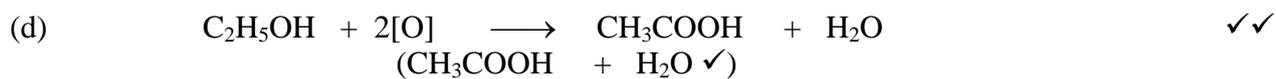
(e)   spectrum C   ✓

               spectrum C only shows absorption at 1700 cm^{-1} for the C=O   ✓

               the other two spectra contain the OH group absorption at approx 3000 cm^{-1} ✓

[Total: 14]

5.

identifies the three process as cracking, reforming, isomerisation	✓
recognises the need for high temperature or a catalyst	✓
equation for cracking	✓
equation for isomerisation	✓
state that reforming converts chains into rings/cyclic compounds	✓
equation for reforming (balanced with H_2 could score two marks)	✓

sub-section mark = 6

oil is finite/non-renewable	✓
ethanol is renewable/sustainable	✓
from plants/crops/sugar cane/sugar beet/glucose/sugar/fermentation	✓
$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$	✓

sub-section mark = 4

QWC

- organise relevant information clearly and coherently, using specialist vocabulary when appropriate (minimum of 4 from cracking/ isomerisation/ reforming/ renewable/ feedstock/ finite/fermentation/non-renewable/sustainable/zeolite/bimetallic catayst/ etc)

- reasonable spelling, punctuation and grammar throughout   ✓

[Total: 11]

1(a)   any two from

produces heat/ exothermic/ produces high temperature (1)

has low toxicity (1)

is easily ignited/ easily flammable/ burns easily (1)   [2]

(b)(i)   reaction carried out at 298K and 1 atm pressure (or other relevant
units) (1)   [1]

(ii)   enthalpy change when 1 mole (1)

(of substance) is burnt in excess oxygen (1)   [2]

(iii) $4CO_2 + 5H_2O$ at lower energy than reagents (1)

E_a marked correctly (1)

ΔH marked correctly (1)   [3]

(c)(i) $4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$

reagents and products (1)

state symbols (1)   [2]

(ii)
                            X
$4C + 5H_2 \rightarrow C_4H_{10}$

4(−394)   5(−286)   −2877

$4CO_2$ $5H_2O$

cycle (1)

correct values (1)

answer (1)

X - 2877 = 4(-394) + 5(-286)

X = -129 (kJ mol^{-1})   [3]

[Total: 13]

2(a)   if the **conditions** on a system in **equilibrium** are changed (1)

the equilibrium moves to try to minimise the effects of the change (1)
[2]

(b)(i)   time less (1)

E_a lowered (1)   [2]

(ii)   time less (1)

more collisions/ particles **exceed E_a** (1)   [2]

(iii)   time more (1)

particles are **further apart** and therefore less (frequent) collisions (1)
[2]

(c)(i)   no effect because it only increases rate of reaction (1)   [1]

(ii)   moves to LHS/ more N_2 and H_2/ less NH_3 (1)

forward reaction is exothermic (1)   [2]

(iii)   moves to LHS / more N_2 and H_2/ less NH_3 (1)

fewer moles on RHS (1)   [2]

(d)   temperature is compromise – high gives better rate but lower yield (1)

danger/costs of higher pressure not justified by increased rate/ by
increased yield / 200 atm gives a high rate and a high yield (1)   [2]

[Total: 15]

3(a) acids are proton/ H$^+$ **donors** (1)

a strong acid is completely dissociated but a weak acid is partly dissociated (1)

HCl → H$^+$ + Cl$^-$ (1)

CH$_3$COOH ⇌ CH$_3$COO$^-$ + H$^+$ (1)   [4]
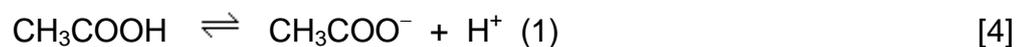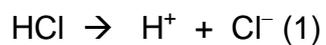
(b)(i) hydrogen/ H$_2$ (1)   [1]

(ii) marks are for reason

(to produce hydrogen at the same rate), each acid must have the same concentration of H$^+$ (1)

the ethanoic acid was more **concentrated** (1)   [2]

[Total: 7]

4(a)(i) $C_8H_{18} + 121/2O_2 \rightarrow 8CO_2 + 9H_2O$

reagents and products (1)

balancing (1)   [2]

(ii)   from nitrogen in air and oxygen (1)   [1]

(b)(i)   any two from Pt/ Rh/ Pd   [1]

(ii)   adsorbed (1)

bonds within molecule weakened (1)

desorbed/ description (1)   [3]

(iii) $CO + NO \rightarrow 1/2N_2 + CO_2$

reagents and products (1)

balancing (1)   [2]

(c)   ozone/ NO_2/ nitric acid (1)   [1]

[Total: 10]

AS Practical 2813/03
Mark Scheme - January 2005

Skill P: 16 marks max   *19 marks possible*

A   *Tests for acidity*   *(5 marks max)*

Award marks for best two tests only. Indicators are not acceptable.

A1   Add a suitable metal giving fizzing/ bubbles   [1]
   Allow magnesium or zinc (but not calcium, sodium or copper)
   An <u>observation</u> is required

A2   Hydrogen produced, which pops/explodes with a lighted spill/flame   [1]

A3   Add a named metal carbonate to the solution   [1]

A4   Gas is carbon dioxide **and** it turns lime water milky   [1]

A5   Use an alkali **and** name of a specific example   [1]
   Alternative reagents are acceptable – eg sodium thiosulphate

A6   Neutralisation occurs: observation – gets hot (*both ideas needed*)   [1]

A7   Correct equations **or** ionic equations for any **two** relevant reactions in this section [1]
   *Lime water with CO_2 **or** hydrogen burning are acceptable*

T   *Titration procedure*   *(6 marks)*

T1   Suitable soluble alkali used for titration   [1]
   An insoluble base forfeits marks T1, T2 and T5 automatically

T2   Alkali concentration chosen is between 0.010 and 0.20 mol dm^{-3} **and** justified   [1]

T3   Practical detail of procedure for making up a solution of $MHSO_4$ given   [1]
   Must include weighing, use of distilled/pure water and a volumetric flask

T4   Titration procedure described briefly, including the burette and pipette   [1]

T5   Names the indicator **and** quotes correct end colour when used.   [1]
   Phenolphthalein goes pink if alkali used in burette or colourless if acid in burette
   Methyl orange orange/red/pink (acid in burette) or yellow/orange (alkali in burette)
   Litmus and universal indicators are not acceptable.
   Phenolphthalein is not suitable if sodium carbonate used as alkali
   Alternative named indicators may be credited

T6   Obtains trial **and** two consistent/concordant titres /"within 0.10 cm^3".   [1]

C   *Calculations*   *(4 marks)*

C1   Equation **or** ionic equation for titration reaction   [1]

C2   Justifies the mass of $MHSO_4$ used, by relating it to the concentration of alkali   [1]

C3   Gives a specimen calculation to calculate relative formula mass of **$MHSO_4$**.   [1]

C4 M_r of $NaHSO_4$ (120) **and** $KHSO_4$ (136) both quoted   [1]

S   Safety, Sources and QWC   (4 marks)

S1   Hazard of alkali used is stated ***and*** a related precaution given   [1]
> *NaOH is irritant below 0.5 mol dm^{-3} but corrosive at or above this conc^{n}.*

S2   References to two secondary sources quoted as footnotes or at end.   [1]
> *Book references must have full titles and page numbers*
> *An Internet reference must go beyond the first slash of web address*

S3   **QWC**: text is legible and spelling, punctuation and grammar are accurate   [1]
> *Mark S3 awarded if there are fewer than **five** different errors*
> *Treat an ICT slip in text (eg "cm3") as one error.*

S4   **QWC**: information is organised clearly and accurately   [1]
> - *Is a word count given and within the limits 400 – 800 words?*
> - *Is scientific language used correctly?*
>   *Is there any error of terminology - eg "strong" for "concentrated"?*
>   *Is there an incorrect chemical formula in the text?*
>   *If units are quoted in the text or in calculations are they correct?*
> - *Are the descriptions written logically and without excessive irrelevant material?*

Practical Test: Part B

Page 3   Mainly Skill I - 15 marks

Mass readings   [1]
> ***Check the following points.*** *No mark if there is any error*

- Both mass readings must be listed, with "g" unit
- Masses should be recorded to two (or three) decimal places
- Subtraction to give mass of **H** must be correct

Presentation of titration data   [2]
> ***Check the following <u>four</u> points***. *Subtract **one** mark for each error/omission.*

- Suitably labelled table (initial, final and difference) used to record burette data
- Trial titre is shown and clearly labelled
- All "accurate" burette data (including 0.00) are quoted to two decimal places
- All subtractions are correct
> *A table showing only the titre differences forfeits **both** marks.*
> *A table with only **two** sets of readings forfeits **both** marks*

Self-consistency of titres

Candidate's two ticked titres (as used for the mean) should agree within 0.10 cm^3.   [2]
> Give **one** mark if ticked titres are consistent within 0.20 cm^3
> - *Units, cm^3 or ml, must be given in data table. If no units, subtract **one** mark.*
> - *If there are no ticks shown, subtract **one** mark.*

Mean titre correctly calculated   [1]
> *Mean should normally be calculated from the closest two accurate readings*
> *Candidate must not include the trial when calculating the mean.*

Accuracy and Safety − _7 + 2 marks are available_

- _Work out what the <u>adjusted candidate's titre</u> (**T**) would have been if the candidate had used the same mass of phosphoric acid as the supervisor._
- _Use the conversion chart to award the mark out of 7 for accuracy._

Adjusted titre, **T** = candidate's mean titre x ^{supervisor's mass}/_{candidate's mass}

T is within 1.50 cm^3 of supervisor's mean titre (incl)	[1 mark]
T is within 1.30 cm^3 of supervisor's mean titre	[2]
T is within 1.10 cm^3 of supervisor's mean titre	[3]
T is within 0.90 cm^3 of supervisor's mean titre	[4]
T is within 0.70 cm^3 of supervisor's mean titre	[5]
T is within 0.50 cm^3 of supervisor's mean titre	[6]
T is within 0.30 cm^3 of supervisor's mean titre	[7 marks]

Spread penalty
("Spread" is defined as those titres used by the candidate to calculate the mean)
If the two titres have a spread > 0.50 cm^3, deduct 1 mark.
If the two titres have a spread > 0.70 cm^3, deduct 2 marks (etc).

Safety

H is corrosive/causes burns/blistering [1]

Wash hands thoroughly/ with <u>plenty</u> of water **or** [very] dilute/mild alkali [1]

2 <u>**Pages 4 + 5**</u> **- Skill A** **[11 marks]**

All answers are required to 3 sig fig, **except** sections (d) and (f)

(a) Mass of pure H_3PO_4 = 0.85 x mass weighed out [1]

(b) Mr of H_3PO_4 = 98.1 (_allow 98_) [1]

No of moles of H_3PO_4 weighed out = $^{"a"}/_{98.1}$ [1]

(c) No of moles of H_3PO_4 in titration = $^{"b"}/_{10}$ [1]

(d) Mr of NaOH = 40 [1]

[NaOH] = $^{4.40}/_{40}$ = 0.110 mol dm^{-3} [1]

(e) n(NaOH), correctly calculated using mean titre [1]

(f) Mole ratio NaOH:H_3PO_4 = $^e/_c$ (_some working is essential_) [1]

2 mol of NaOH (_or ecf_) [1]

(g) The second equation is ticked [1]
    No unsupported guesses allowed

Balancing figures in the equation correspond to the mole ratio of the reagents [1]

3   **Test tube tests**   **[4 marks]**

(a)   No reaction/no change   [1]

       Soluble, because no precipitate was observed/ solution was clear   [1]

(b)   White precipitate/ suspension/ solid formed   [1]
            "Goes milky/cloudy" does not score the mark.

       Formation of a precipitate shows that lead phosphate is not soluble   [1]

4.   **Evaluation**   **[14 marks]**

       15 marks are available, but award **maximum 14.**

(a)   To mix the solution *or* ensure that its concentration is all the same   [1]

(b)   Any **two** ideas from those listed below   [2]

- To check that the titration works properly/ gives an end point
    or to check that the volume of titrant is suitable
- It gives opportunity to become familiar with/practise the indicator's colour change.
- It gives a rough titre so that accurate titrations may be carried out more quickly.
- Dropwise addition up to the end point is then required only for final 2 or 3 cm^3.

(c)   Carbon dioxide   [1]

       $2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$ **or** $NaOH + CO_2 \rightarrow NaHCO_3$ [1]

(d)(i)   % error for pipette = $^{0.06}/_{25}$ x 100   [1]

       Error = 0.24%   [1]

  (ii)   % error for mass = $^{0.01}/_{mass\ of\ acid}$ x 100   [1]

       The error is doubled because two mass readings are taken.   [1]

       % error correctly calculated **and** therefore pipette is more accurate   [1]
            A valid alternative comment (eg "both errors are very small") can be credited.

(e)(i) M_r of sodium phosphate = 164   [1]

       Mass of salt = 0.001 x 164 = 0.164 g   [1]

  (ii)   *3 marks may be awarded but there are only 2 on question paper*

       0.54 g is [much] higher than expected   [1]

       Mass of salt expected would be between 0.164 and 0.36 g   [1]

       There is water of crystallisation in the salt   [1]

Abbreviations, annotations and conventions used in the mark scheme	/ = alternative and acceptable answers for the same marking point ; = separates marking points NOT = answers not worthy of credit ( ) = words which are not essential to gain credit ___ (underlining) = key words which <u>must</u> be used ecf = allow error carried forward in consequential marking AW = alternative wording ora = or reverse argument

Marking structures in organic chemistry

When a structure is asked for, there must be sufficient detail using conventional carbon skeleton and functional group formulae (e.g. CH_3, C_2H_5, OH, COOH, $COOCH_3$) to <u>unambiguously</u> define the arrangement of the atoms. (E.g. C_3H_7 would not be sufficient).

If not specified by the question, this may be given as either:

- a **structural formula** – e.g. $CH_3CH(OH)C_2H_5$,
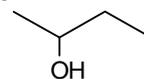
- a **skeletal formula** – e.g.
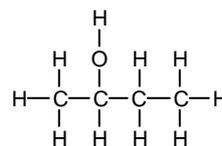
- a **displayed formula** – e.g.
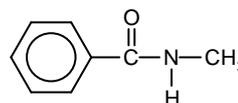
or as a hybrid of these – e.g.

The following errors should be penalised – although each one only loses a maximum of one mark on the paper:

- clearly connecting a functional group by the wrong atom
- showing only 'sticks' instead of hydrogen atoms –

e.g.
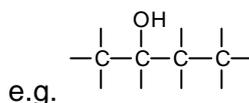
Benzene rings may be represented as   as well as   in any of the types of formula above.

Qu.	Expected answers:	Marks:

1 (a) (i) alkene / C=C double bond
(primary) alcohol / hydroxy(l) ✔ **[1]**

(b) (i) molecules with the same structure / order of bonds … but
different arrangements in space / 3-D arrangment ✔ **[1]**

(ii) cis-trans / geometric ✔ **[1]**

(iii) the double bond does not rotate ✔ **[1]**

(iv) same groups at one end / need different
groups at both ends of the C=C ✔ **AW** **[1]**

(c) (i) a correct skeletal aldehyde is shown on C_1 ✔

rest of the skeletal structure (C_2-C_{10})correct ✔ **[2]**

(ii) $C_9H_{15}CH_2OH + [O] \longrightarrow C_9H_{15}CHO$ ✔ $+ H_2O$ ✔   **NOT** COH, allow $C_{10}H_{16}O$ **[2]**

(d) (i) flavouring / fruity smell etc   **NOT** perfume or sweetener **[1]**

(ii) conc H_2SO_4 ✔
reflux/ distil ✔ **[2]**

(iii) $CH_3COOH + C_9H_{15}CH_2OH \longrightarrow CH_3COOCH_2C_9H_{15} +$ H_2O
      ✔   ✔   ✔   allow $C_2H_4O_2$ and $C_{12}H_{20}O_2$ but **NOT** wrong structures allow ecf on the wrong acid **[3]**

(e)

wavenumber range (cm^{-1})	3230-3550 (for OH)	1680-1750 (for C=O)	1000-1300 (for C-O)
geraniol	present ✔	(absent)	present ✔
aldehyde Y	(absent)	present ✔	(absent)
ester Z	(absent)	present ✔	present ✔

[5]

[Total: 20]

Qu.	Expected answers:		Marks:
2 (a)	any two of … fibres / dyes / explosives / pharmaceuticals etc ✔✔	allow any specific examples as long as they do involve aromatic nitro or amine groups – eg **NOT** nylon, fertiliser etc	**[2]**
(b)	temp 50-60° ✔ concentrated (acids) ✔	allow abbreviations for concentrated	**[2]**
(c)	$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$ reactants ✔ products ✔	allow a balanced equation for multiple nitration at any positions	**[2]**
(d) (i)	a pair of electrons … ✔ … (electrons) move / transferred / a (covalent) bond breaks/forms ✔		**[2]**
(ii)	it accepts a pair of electrons (from the benzene) ✔	**NOT** a 'lone' pair	**[1]**
(iii)	$H(^+)$ (on the ring) is replaced by $NO_2(^+)$ ✔	allow 'substitutes' ignore $^+$ charges	**[1]**
(iv)	it is not used up / reformed at the end **AW** ✔		**[1]**
(e)	π-bonding electrons are <u>delocalised</u> ✔ **six** π-electrons in benzene ✔ **four** π-electrons in the intermediate ✔ π-electrons are not over one carbon atom / over **five** carbon atoms / p-orbitals in the intermediate ✔ π-electrons are over the **complete** ring / **all around** the ring **all six** carbon atoms/ p-orbitals overlapping ✔ **Quality of written communication** for at least two sentences/statements with legible text and correct spelling, punctuation and grammar ✔	this must be stated in words to compare benzene and the intermediate	**[6]**

[Total: 17]

| Qu. | **Expected answers:** | **Marks:** |

3 (a) **1st stage**
aromatic amine / named aromatic amine / structure ✔
sodium nit<u>rite</u> / nitrous acid ✔
HCl/H_2SO_4 (but not conc) /H^+ ✔
at <10°C ✔

which forms a <u>diazonium</u> salt / ion ✔

2nd stage
the product from the first stage mixed with the phenol **AW** ✔
(in excess) hydroxide / alkali ✔

if more than four are given, mark any wrong reagents, conditions first

allow correct formulae for the reagents

[7]

(b) (i)

✔

allow any benzene rings as well as N=N circled, as long as no other groups are

[1]

(ii) …16… carbon and ……10….. hydrogen atoms
   ✔   ✔

[2]

(c) Na / NaOH / OH⁻ etc ✔

[1]

(d)

✔   ✔

allow 1 mark if they are both correct, but in the wrong boxes

only penalise a slip with SO_3^- Na^+ once

[2]

[Total: 13]

33

Qu.	Expected answers:	Marks:

4 (a) (i)

$H_2NCHRCOOH$ / ✔   allow R CH NH_2 and COOH in any order

[1]

(ii) they both have the group / or in words ✔   **NOT** just "they both have NH_2 and COOH"

R group is H in glycine and CH_2CH_2COOH in glutamic acid ✔

[2]

(b) $-NH_3^+$ ✔

-COOH and side chain unaffected ✔

   one $-COO^-$ ✔

both $-COO^-$ ✔

H_2N- and rest of molecule ✔

[5]

(c) **glutamic acid/molecule with optical isomers …**

… is <u>chiral</u> ✔

… has four different / distinguishable groups attached to a carbon ✔   **NOT** just "different atoms"

… the mirror images/isomers cannot be superimposed **AW** ✔

one diagram showing **two** 3-D bonds not opposite each other, and not with angles looking like 90° ✔

3-D diagram of the other isomer (allow ecf on one 3-D error) ✔

all groups correctly connected for glutamic acid in both diagrams ✔

glycine
only has three different groups / two groups are the same / 3-D diagram used to show symmetry ✔

7 marks

quality of written communication
for correct use and organisation of at least **one** technical term:
*(in the correct place), non-superimposable, enantiomer, stereoisomer(ism), tetrahedral, assymetric ✔

[8]

[Total: 16]

| Qu. | Expected answers: | Marks: |

5 (a) (i) addition (polymerisation) ✓ **NOT** additional **[1]**

(ii)

✓ **[1]**
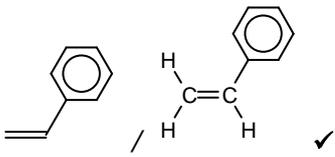
(iii) π-bond breaks ✓

many molecules join / a **long** chain forms /
equation to show this using 'n' ✓ **[2]**

(b) alternating ✓
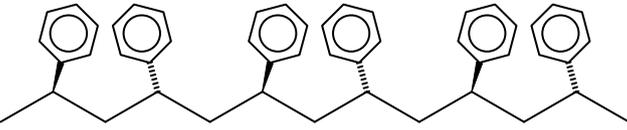
all four side groups placed above the chain with an alternating
arrangement clearly shown by use of 3-D bonds ✓✓

where 1 mark is for an incorrect diagram, but "(alternating) 3-D
/spacial arrangement of side chains" stated in words **[3]**

(c) atactic has side chains irregular / random(ly arranged in space/3-D) ✓
ora

atactic has weaker intermolecular / Van der Waals' forces
between the chains ✓ **ora**

chemically sensible suggestion why irregular side chains could give
weaker forces – eg because chains can't get as close / less surface
contact ✓ **AW ora**

NOT just
"weaker
bonds"

[3]

[Total: 10]

| Qu. | Expected answers: | Marks: |

6 (a) (i) Find the m /e of …. ✔
... the peak furthest to the right / with highest m /e or mass ✔

allow attempts to cater for the ^{13}C peak **[2]**

$C_2H_3O_2$ /empirical formula has M_r = 59 ✔
so M_r of molecular formula is $^{118}/_{59}$ = 2 /twice the empirical formula ✔ **[2]**

(b) (i) OH <u>peak</u> disappears (with D_2O / on the second spectrum) **[1]**

(ii)

The relative peak area is shown by the number above the peak
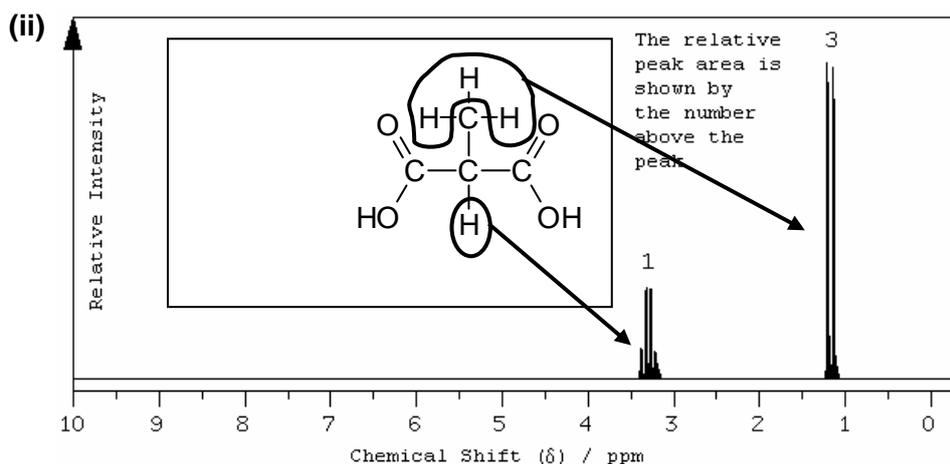
peak at 3.3ppm identifed as due to the CH ✔

assignment must be for this structure (not just R-CH₃ etc)

peak at 1.2ppm identified as due to the CH₃ ✔

protons (and not the carbon) on the groups are identified ✔

can be by Ha, Hb etc

relative peak areas / numbers above the peaks show …
the number of (equivalent) protons in each group / three protons
on one carbon and one on the other carbon ✔ **AW**

quadruplet / 1:3:3:1 splitting (of the peak at 3.3ppm) shows…
three protons on the neighbouring/adjacent carbon ✔

doublet / 1:1 splitting (of the peak at 1.2ppm) shows …
one proton on the neighbouring /adjacent carbon ✔ **[6]**

(iii) no of peaks: one ✔

if the wrong structure is chosen allow ecf for:

splitting: none ✔

all four protons equivalent / in the same environment ✔

two peaks ✔,
splitting ✔✔ (as last 2 marks for part **(ii)**) **[3]**

[Total: 14]

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Question	**Expected answers**		**Marks**	**Additional guidance**
1 **(a)** **(i)**	Electron affinity -696 (1 mark); Atomisation of Cl_2 +244 (1 mark); From top to bottom 2nd IE +1150, 1st IE +590, atomisation of Ca +178 formation -796 (1 mark)		3	**Allow** 244, 1150, 590 and 176 i.e. without plus sign
(ii)	-796 - 178 - 590 - 1150 - 244 + 696 (1); **But** -2262 (with no working) (2)		2	**Allow** ecf from the wrong figures on the Born-Haber cycle 1 error **max one mark** 2 errors **0 mark**
(iii)	Magnesium fluoride more exothermic than calcium chloride / ora because Ionic radius of Mg^{2+} is less than that of Ca^{2+} / charge density of magnesium ion is greater than that of calcium ion / ora (1); Ionic radius of F^- is less than that of Cl^- / charge density of fluoride ion is greater than that of chloride ion / ora (1); Stronger (electrostatic) attraction between cation and anion in MgF_2 than in $CaCl_2$ / stronger ionic bonds in MgF_2 (1)		3	Answer must refer to the correct particle. **Not** Mg or magnesium has a smaller radius or fluorine has a smaller radius **Allow** magnesium or fluorine has a smaller ionic radius
(b)	**Any two from** For second ionisation energy the electron lost is closer to the nucleus / AW (1); For second ionisation energy the electron is lost from a particle that is already positive (1); For second ionisation energy there is one more proton than electron (1) So outer electron more firmly attracted to the nucleus (1)		2	**Allow** ora
			Total = 10	

Question	Expected answers	Marks	Additional guidance
2 (a)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ (1); Has an incomplete set of 3d electrons (1)	2	**Allow** 3d orbitals are not completely occupied / incomplete 3d sub-shell **Allow** has half-filled d orbitals
(b) (i)	**Any two from** Variable oxidation state / variable valency (1); Act as catalysts (1); Form complexes / form complex ions (1); Form coloured compounds (1)	2	**Not** high melting point / good thermal and electrical conductors / high density etc
(c)	Iron (II) ions give a green ppt (1); Iron (III) ions give an orange-rust ppt (1)	2	Precipitate must be used once **Allow** solid instead of ppt
(d)	$4Fe^{2+} + O_2 + 4H^+ \rightarrow 4Fe^{3+} + 2H_2O$ Correct reactants and products (1); Correct balancing (1)	2	
(e) (i)	Copper may react with potassium manganate(VII) / iron(III) ions formed in titration may be reduced back to iron(II) ions by the copper (1)	1	
(ii)	MnO_4^- gains electrons and is reduced / Mn oxidation state changes from +7 to +2 so it is reduced (1); Fe^{2+} loses electrons and is oxidised / Fe oxidation state changes from +2 to +3 so it is oxidised (1)	2	
(iii)	Moles of $MnO_4^- = 4.50 \times 10^{-4}$ (1); Moles of $Fe^{2+} = 5 \times$ moles $MnO_4^- / 2.25 \times 10^{-3}$ (1); Mass of Fe = moles of $Fe^{2+} \times 55.8 / 0.1256$ (1); Percentage = 18.6 % (1)	4	**Allow** answers that use 56 for A_r of Fe this gives 18.7 **Allow** ecf
		Total = 15	

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Question	Expected answers	Marks	Additional guidance
3 (a)	(Pale blue solution) to a (light) blue ppt (1); with excess dark blue solution (1)	2	
(b)	Octahedral shape with clear indication of 3D either by construction lines or wedges etc (1); 90° (1)	2	**Ignore** mistakes with the ligands question focuses on octahedral and the bond angle
(c)	Water molecule 2 lone pairs (and 2 bond pairs) (1); Water ligand 1 lone pair and 3 bond pairs / lone pair is now a bond pair / water has one less lone pair when it is a ligand (1); Lone pairs repel more than bond pairs (1)	3	**Not** atoms repel
		Total = 7	

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Question	Expected answers	Marks	Additional guidance
4	**Twelve from** **Chemical formula** Correct formula of all oxides – MgO, Al_2O_3, SO_2 or SO_3 (1); Number of outer electrons per atom increases / oxidation state of element increases (1); **Structure and bonding – Any three from** Correct bonding – MgO is ionic, Al_2O_3 has intermediate bonding and SO_2 or SO_3 are covalent (1); Correct structure - MgO and Al_2O_3 both giant structures, SO_2 or SO_3 simple (1); Ionic 'dot-and-cross' diagram for MgO or Al_2O_3 (1); Covalent 'dot-and-cross' diagram for SO_2 or SO_3(1); **Action of water – Any four from** MgO reacts water to give an alkaline solution (1); because the oxide ions react with water molecules / $MgO + H_2O \rightarrow Mg(OH)_2$ / $O^{2-} + H_2O \rightarrow 2OH^-$ (1); Al_2O_3 does not react with water / does not dissolve in water (1); SO_2 or SO_3 reacts to give acidic solutions (1); $SO_2 + H_2O \rightarrow H_2SO_3$ / $SO_3 + H_2O \rightarrow H_2SO_4$ (1) **Melting points** MgO or Al_2O_3 has electrostatic attraction between ions (1); SO_2 or SO_3 has van der Waals forces / has permanent dipole-permanent dipole attraction / instantaneous dipole (1); Comparison of strength of forces in ionic and simple molecular e.g. strong and weak / comparison of forces in Al_2O_3 and simple molecule (1) **And** QWC – one mark for a well ordered and structured answer. Property clearly linked with explanation on at least two occasions (1)	13	**Ignore** any other formulae **Allow** marks from diagrams e.g. dot and cross or lattice **Allow** Al_2O_3 ionic bonding with covalent character / polar covalent (1) **Allow** attraction between positive and negative ions / attraction between magnesium ions and oxide ions **Allow** strong ionic bonds and weak intermolecular forces
		Total = 13	

Mark Scheme	Unit Code	Session	Year	Version
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Question	Expected Answers	Marks
1.(a)(i)	All points correctly plotted✓ Smooth curve through their points ✓ The line may stop at 40° but, if continued should descend steeply.	2
(ii)	Mark the optimum shown on their graph (about 32°)✓. It must not be 30 or 35.	1
(iii)	Heat/thermal vibrations disrupts the tertiary structure ✓ and changes shape of enzyme/active site ✓ reducing efficiency. AW	2
(b)(i)	Any two points from ✓✓ • Enzyme can be used continuously/reused • Enzyme/products easily separated • End product inhibition minimised • Thermal stability of enzyme often increased but not at extreme temperature • Optimum temperature may go up leading to faster reaction	2
(ii)	Papain would catalyse the hydrolysis of gelatin, (destroying the immobilising support). AW✓	1
(c)	Advantage: removes/dissolves protein stains✓Accept gelatin/jelly stains, but not pineapple. Disadvantage: cannot be used above 40°/might catalyse hydrolysis of protein fabric eg silk/possible allergic reaction ✓.	2
	Question total	10

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Scheme				
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Question	Expected Answers	Marks
2.	**Look for 9 marks from the following.** **DNA is a long chain polymer with alternating deoxyribose and phosphate groups✓ (Give 1 mark for sugar-phosphate). In words or clear diagram. These are linked through the 3' and 5' carbons on the deoxyribose (or diagram) ✓** **Each deoxyribose carries a base on the 1' carbon (or diagram)✓** **Parallel strands of DNA are held together (in a double helix) by hydrogen bonding between complementary base pairs (specified as CG, AT)✓ and by van der Waals attraction between the (delocalised) rings on the bases✓.** **Cellulose is made from long linear chains ✓ of glucose molecules joined by 1-beta-4✓ glycosidic links . Correct diagram✓.** **Hydrogen bonding holds adjacent parallel chains✓ together - diagram showing use of appropriate hydrogen and oxygen atoms✓.** **The QWC is for correct use of the terms hydrogen bonding and glycosidic link, in context.✓**	**9** **1**
	Question total	**10**

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3.(a)(i)	**Metal atom/ion bound in porphyrin/haem-like ring structure/complex✓**	**1**
(ii)	**Mg (instead of Fe)/ not protein/other difference✓**	**1**
(b)	**CH_3OH or $C_{20}H_{39}OH$ ✓**	**1**
(c)	**Four protein/polypeptide chains ✓, <u>each</u> with a haem group✓, group together to form full protein**	**2**
(d)	**Any three marks from:** **Oxygen binds <u>reversibly</u> ✓** **To the iron/Fe ✓** **Binding occurs when partial pressure/concentration of oxygen is high in lungs ✓** **Oxygen is released when partial pressure/concentration of oxygen is low in cells ✓**	**3**
	Question total	**8**
Question	**Expected Answers**	**Marks**

Scheme				
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4.(a)(i)	‾‾‾‾‾ ‾‾‾‾‾ **Two hydrocarbon/long chain fatty acid tails**✓ **One charged/ionic/phosphate head O ✓**	**2**
(ii)	**Van der Waals forces/instantaneous dipole induced dipole AW✓. Not hydrophobic attraction.**	**1**
(iii)	**A bimolecular layer has two phospholipid layers (tail to tail) / diagram ✓ AW✓**	**1**
(b)(i)	**Hydrolysis with hot✓ _aqueous_ sodium hydroxide solution /alkali✓(Hot alone earns no mark).**	**2**
(ii)	**$C_3H_5O_3(OCC_{17}H_{33})_3$ + 3 NaOH → $C_3H_8O_3$ + $3C_{17}H_{33}COONa$** **Correct formula for soap ✓ and balance ✓** **Using structures is acceptable. Ecf if acid is used in (i).**	**2**
(iii)	**‾‾‾‾‾ is a hydrocarbon/alkyl tail ✓** **O is COO⁻ ✓ (accept COONa etc but COOH only as ecf from (ii)).** **Polar head and non-polar tail /hydrophilic and hydrophobic earns 1 mark.**	**2**
		10
	Question total	

Mark Scheme	Unit Code	Session	Year	Version

Mark Scheme

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5.

(a)   **HOH$_2$CCHOHCHOHCHOHCHOHCHO**

Or vertically. Ignore stereochemistry ✓   **1**

(b)   **Look for α–glycosidic link** ✓
Rest of molecule ✓

   2

(c)   **Either (heat) with aq HCl** ✓
   Or by use of maltase ✓   **1**

(d)   **Maltose has many hydroxyl groups** ✓ **available for hydrogen bonding** ✓ **to water.**
In starch many of these OH groups are tucked away inside the structure/helix ✓ **and are not available.**   **3**

            Question total   **7**

            PAPER TOTAL   **45**

Mark Scheme

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1.(a)(i)	By oxidation and reaction with water✓ $$SO_2 + 0.5O_2 + H_2O \longrightarrow H_2SO_4 \checkmark$$ Accept formation of sulphurous acid and subsequent oxidation for the first mark. If they split the process and provide two equations give the second mark. If they only go as far as sulphurous acid give max one mark.	2

(ii)	Find two marks for the correct answer by any viable route eg
	
	Moles of H_2SO_4 = moles SO_2 = 1.2 x 10^{13} /64
	                     /= 1.87 x 10^{11} mol ✓
	Mass of H_2SO_4 = 98 x 1.2 x 10^{13}/64 g
	
	             = 1.84 x 10^{13} g
	             = 18 400 000 tonnes ✓
	Max ½ if answer given to 4 or more sig figs.
		2

(b)	Dissolves/erodes them ✓ Not corrosion. $CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$ ✓ Accept H_2CO_3	2
(c)(i)	$CaCO_3 + H_2CO_3 \longrightarrow Ca(HCO_3)_2$ One ✓ for either H_2CO_3 or $Ca(HCO_3)_2$ and ✓ for rest. Accept $H_2O + CO_2$	2
(ii)	Limestone is basic and CO_2 acidic AW ✓. Accept answer based on proton transfer. Question total	1 9

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Question	Expected Answers	Marks
2.(a)	Lower part of atmosphere/first 10 to 16 km of atmosphere above earth.✓ Accept any figure in this range.	1
(b)(i)	Electromagnetic/UV radiation. Accept sunlight/light energy✓, but not radiation alone. Accept h = Planck's constant and f=frequency.	1
(ii)	✓	1
(iii)	It has an unpaired electron ✓	1
(c)	Oxygen split by solar radiation/equation ✓ Oxygen atom/radical combines with oxygen molecule/equation ✓ (no need to mention energy sink M)	2
(d) (i)	Ozone adds to double bonds ✓ and breaks them/forming carbonyl compounds ✓	2
(ii)	Cracking /perishing/becoming brittle AW✓	1
(e) (i)	It absorbs infrared radiation. AW ✓	1
(ii)	Concentration/residence time is low ✓	1
(f)	Does not produce toxic organochlorine compounds AW ✓.	1
	Question total	12

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3.	Look for 9 points from the following: • Landfill anaerobic – Incineration aerobic ✓ • Landfill gas can be burnt to provide energy as heat or electricity – incineration provides heat and electricity directly ✓ • Landfill releases greenhouse gases (methane and carbon dioxide✓) slowly – incineration releases greenhouse gas CO_2 fast✓. • Landfill produces toxic hydrogen sulphide ✓ - incineration can produce acidic HCl, SO_2 and NO_x by burning polymers/plastics✓. • Landfill has about ten times the bulk of incineration ash✓. • Need to control leachate (of heavy metal ions or soluble organic compounds) from landfill ✓ - need to control temperature of incineration to prevent dioxin etc formation✓ and need to scrub/clean flue gas from incineration to prevent acid rain etc ✓. • Non –biodegradable plastics persist a long time in landfill – destroyed by incineration✓. • Landfills unsightly/attract rodents/ smelly ✓. The QWC mark is for good organisation with at least two similarities or comparisons clearly stated. Question total	**9** **1** **10**

Question	Expected Answers	Marks

4. (a)	2:1 clays have no hydrogen bonding between layers ✓
	    and water can easily enter swelling the clay✓
	    it can leave equally easily causing clay to contract✓
	1:1 clays are hydrogen bonded between layers ✓ (detail of this – between OH on octahedral sheet and O on tetrahedral sheet AW ✓) and water cannot get in.
	Find any 4 marks
		4

(b)(i)	Particles1 to 100 nm/not visible with microscope/ do not sediment or filter. ✓	**1**
(ii)	By addition of aluminium sulphate or aluminium ions ✓ (do not allow plain aluminium) <u>Either</u> neutralises ✓ negative charge on colloid particles ✓ allowing them to coagulate and form a floc/precipitate ✓ <u>Or</u> forms a gelatinous precipitate ✓ of aluminium hydroxide/formula ✓ Which absorbs other ions and solids ✓	**4**
(c)(i)	Answers should be in terms of the equilibrium: ClayK (s) + H$_2$O(l) = clayH(s) + OH$^-$(aq) + K$^+$(aq) ✓ State symbols not essential for the mark. Or ✓ for negative charge on clay attracts K$^+$. If the aqueous potassium ion concentration falls , the potassium ions must be released from the reserves in the clay ✓ to reestablish equilibrium ✓	**3**
(ii)	Hydrogen ions could replace cations on the ion exchange surface of clays ✓ releasing nutrient ions which could then be leached away and lost ✓/releasing toxic ions eg aluminium ✓ AW	**2**
	Question total	**14**
	Paper total	**45**

57

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Question	Expected Answers	Marks
1 (a) (i)	The presence of ^{13}C	**1**
(ii)	1.1% of all carbon is ^{13}C Ratio of M to M+1 peak allows us to calculate number of carbons present in molecule	**1** **1**
(b)	^{37}Cl ^{81}Br	**1**

(c) (i)	Species present : $CH_2{}^{79}Br{}^{35}Cl^+$,
	          $CH_2{}^{81}Br{}^{35}Cl^+$, $CH_2{}^{79}Br{}^{37}Cl^+$
	          $CH_2{}^{81}Br{}^{37}Cl^+$
	(if no mass number shown assume ^{79}Br or ^{35}Cl)
		Any 3 correct 2
		Any 2 correct 1

(ii)	Ratio ^{79}Br : ^{81}Br is 1 : 1 Ratio ^{35}Cl : ^{37}Cl is 3 : 1 Hence M : (M+2) : (M+4) is 3 : 4 : 1	 **1**
(d)	(M-45) corresponds to a loss of C_2H_5O (or to $C_2H_5{}^+$) (M-43) corresponds to a loss of C_3H_7 (or to CH_2OH^+) Check logic carefully **A** is $CH_3CH(OH)CH_2CH_3$ **B** is $CH_3CH_2CH_2CH_2OH$	**1** **1** **1**
		Total: 10

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Question	Expected Answers	Marks
2 (a) (i)	Accept paper, column or thin-layer chromatography	**1**
(ii)	The R_f value	**1**
(iii)		**1**
(b) (i)	Retention time	**1**
(ii)	 (or mirror image)	**1**
(c) (i)	Partition	**1**
(ii)	Gas or liquid distributes itself between the mobile phase (carrier gas) and the stationary phase (hydrocarbon on silica) Different components are held more or less strongly on the stationary phase, separating them Some consideration of molecular size/volatility/bonding to stationary phase	**1** **1** **1** **1** **Total: 10**

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Question	Expected Answers	Marks
3 (a)	Electrons are excited to higher energy levels. When they drop back, energy is emitted as radiation	1 1
(b)	Electrons occupy discrete energy levels / levels are quantised	1
(c)	Use of $E = hc/\lambda$ $\dfrac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{1.25 \times 10^{-7}} = 1.59 \times 10^{-18}$	1 1
(d) (i)	Chromophore	1
(ii)	$CH_3CH=CH_2$ CH_3CH_2OH and	3 x 1 All 5 ringed=0 4 ringed=1 max
(e)	Vitamin A contains an extensive delocalised system / conjgraion. The energy levels in this are closer together than in compound **C** Energy is absorbed in the visible region in vitamin A rather than the uv region as in **C**	1 1 1
		Total: 12

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Question	Expected Answers	Marks
4 (a)	Use of correct logic e.g. use of M+1 to calculate carbons, deduction of oxygen from mass peak etc. No of carbons = $\dfrac{0.13 \times 100}{2.00 \times 1.1}$ = 5.9 => 6 If x = 6 then y = 116 – (6x12 +32) = 12	1 **Use of 1.1 => 1** 1 **[3]**
(b)	***Any 9 points, but must use data from the spectra.*** From ir spectrum peak at 1750 cm^{-1} suggests C=O and peaks at 1250 or 1180 cm^{-1} suggest C-O No –OH peak N.m.r. spectrum shows 4 proton environments Singlet at 3.6δ suggests –CH$_3$ <u>next to an oxygen atom</u> Triplet at 0.9δ suggests –CH$_3$ next to a carbon with 2Hs Triplet at 2.2δ suggests –CH$_2$- next to –CH$_2$- <u>and an oxygen atom</u> Complex peak at 1.5δ due to 4 protons suggests two similar –CH$_2$- groups Mass spectrum shows loss of CH$_3$CH$_2$- at 87 and loss of CH$_3$O- at 85 Structural formula of **D** CH$_3$CH$_2$CH$_2$CH$_2$CO$_2$CH$_3$ QoWC – organising relevant information clearly and coherently, using specialist vocabulary when appropriate e,g. absorption, splitting pattern	 1 1 1 1 1 1 1 1 1 1 1 **[9 max]** 1 **Total: 13**

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Question	**Expected Answers**	**Marks**

1 (a)	Vanadium used in alloys for strength Vanadium(V) oxide used as a catalyst (Don't accept just the word catalyst)	**1**
(b)	Diagram to show: V/V^{2+} system Hydrogen electrode (Pt, H_2 and H^+ must be labelled) Salt bridge + voltmeter + complete circuit Temp 298K, concentration 1 mol.dm^{-3}, pressure 1 atm All 3 = 2 marks; any 2 = 1 mark	**1** **1** **1** **2**
(c) (i) **(ii)**		

	V^{2+}	VO_2^+	VO^{2+}	V^{3+}
Oxidation Number	+2	**+5**	**+4**	+3
Colour	lilac	yellow	**blue**	**Green**

		4
	Correct calculation of cell potential as –0.44 V Because it is –ve, reaction not feasible Alternative: V better reducing agent than Zn Because the $E^{\ominus}$ for V/V^{2+} is more -ve	**1** **1**
		Total: 12

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Question	**Expected Answers**	**Marks**
2 (a) (i)	Central ion surrounded by molecules/ions/ligands	**1**
(ii)	Molecule/ion with a lone pair of electrons Able to form a dative covalent or co-ordinate bond / which can be donated	**1** **1**
(b)	Two lone pairs/ able to form two dative covalent / co-ordinate bonds	**1**
(c)	Stereoisomerism – same atoms with same order of bonds but a different spatial arrangement / same structure but different arrangement of atoms Both isomers drawn for cis / trans Both isomers drawn for optical (must be mirror images) (all diagrams to show 3-D arrangement) Enantiomers/non superimposable mirror images **Rotate** plane polarised light in opposite direction by same number of degrees (any two for 1 mark)	**1** **2** **2** **1** **1**
		Total: 11

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	__	= (underlining) key words which **must** be used to gain credit
	ecf	= error carried forward
	AW	= alternative wording
	ora	= or reverse argument

Question	Expected Answers	Marks
3 (a) (i)	Two orbital boxes higher and 3 orbital boxes lower Correct arrangement of electrons (see additional sheet)	**1** **1**
(ii)	One lower energy and one higher energy d-orbital shown (see additional sheet)	**2**
(b)	 Electrons promoted from low to high energy d-orbitals Energy involved lies in visible region of spectrum / needs visible light Some of the visible light is transmitted / absorbed Idea that colour depends upon the actual wavelengths transmitted / energy gap Need at least one unpaired d-orbital or Cu^+ $1s^22s^22p^63s^23p^63d^{10}$ Only Cu^{2+} has an unpaired electron or Cu^{2+} $1s^22s^22p^63s^23p^63d^9$ QWC: communicates by using at least 3 terms from the following list d-orbitals, visible, spectrum, transmitted, wavelength, energy gap, unpaired electron, high or low energy, absorbed, d-sub shell	**1** **1** **1** **1** **1** **1** **1**
(c)	Compound absorbs green/yellow Blue and red transmitted (to give purple) (allow all colours absorbed except violet/blue and red for 1 mark)	**1** **1**
		Total: 13

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Question	Expected Answers	Marks
4 (a) (i)	$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightleftharpoons 2Cr^{3+} + 3I_2 + 7H_2O$ All species correct (ignore electrons for this mark) Equation balanced (penalise if electrons not cancelled out)	**1** **1**
(ii)	Brown colour disappears $S_2O_3^{2-}$ reacts with I_2 (to form colourless I^-) Green colour remains due to Cr^{3+} (must say what gives green colour)	**1** **1** **1**
(b) (i)	Oxidation Number of Cr on both sides = +6 Oxidation Number does not change therefore not redox	**1** **1**
(ii)	Orange to yellow (both needed for 1 mark)	**1**
(iii)	Any suitable **named** acid or correct formula eg H_2SO_4	**1**
		Total: 9

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	ecf	= error carried forward
	AW	= alternative wording
	ora	= or reverse argument

Question		Expected Answers	Marks
1	(a)	$K_p = \dfrac{p(SO_3)^2}{p(SO_2)^2 \times p(O_2)}$ ✓✓ 1 mark for correct powers but wrong way up. 1 mark for square brackets	[2]
	(b)	An increase in pressure moves equilibrium to the right because there are less gaseous moles on the right hand side ✓ Increased pressures are expensive to generate/safety problems with walls of containers/enables gases to flow ✓ K_p gets less with increasing temperature ✓ SO_2 and O_2 increase/SO_3 decreases ✓ Equilibrium ⟶ left to oppose increase in temperature ✓ Forward reaction is exothermic or ΔH is −ve /reverse reaction is endothermic or ΔH is +ve because K_p gets less with increasing temperature ✓ QoWC: organises relevant information clearly and coherently, using specialist vocabulary where appropriate ✓	[6] [1]
	(c)	$3.0 \times 10^2 = \dfrac{p(SO_3)^2}{10^2 \times 50}$ ✓ $p(SO_3) = \sqrt{(3.0 \times 10^2 \times 10^2 \times 50)} = 1225$ kPa ✓ %(SO_3) = 100 × 1225 /(1225 + 10 + 50) = 95% ✓	[3]
	(c) (i)	$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ ✓✓ ZnS, O_2 as reactants **and** SO_2 as a product: 1st mark. ZnO **and** balance: 2nd mark	[2]
	(ii)	ZnS is more available than S. ✓	[1]
			Total: 15

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	ecf	= error carried forward
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	ora	= or reverse argument

Question			Expected Answers	Marks
2	**(a)**	**(i)**	O_3: 1 and C_2H_4 ✓	**[1]**
		(ii)	2 ✓	**[1]**
		(iii)	rate = $k[O_3][C_2H_4]$ ✓	**[1]**
	(b)	**(i)**	measure gradient/tangent ✓ at t = 0/start of reaction ✓	**[2]**
		(ii)	$k = \dfrac{rate}{[O_3][C_2H_4]}$ ✓ $k = \dfrac{1.0 \times 10^{-12}}{0.5 \times 10^{-7} \times 1.0 \times 10^{-8}} = 2 \times 10^3$ ✓ $dm^3\ mol^{-1}\ s^{-1}$ ✓	**[3]**
		(iii)	2 mol CH_2O forms for every 0.5 mol O_2 / stoichiometry of $CH_2O : O_2$ is **not** 1:1 ✓	**[1]**
		(iv)	rate increases ✓ k increases ✓	**[2]**
	(c)	**(i)**	each atom has two unpaired electrons ✓	**[1]**
		(ii)	2 oxygen atoms bonded by double bond ✓ third oxygen bonded by a covalent bond and outer shells correct ✓ For 2nd mark, all O atoms must have an octet. A triangular molecule would have 3 single covalent bonds for 1st mark but the origin of each electron must be clear for 2nd mark	**[2]**
		(iii)	amount of O_3 in 150 kg = $150 \times 10^3/48 = 3.13 \times 10^3$ mol ✓ amount of Cl radicals in 1 g = $1/35.5 = 2.82 \times 10^{-2}$ mol ✓ 1 mol Cl destroys $3.13 \times 10^3/2.82 \times 10^{-2} = 1.11 \times 10^5$ mol O_3 1 Cl radical destroys 1.11×10^5 O_3 molecules ✓ (calculator: 110937)	**[3]**
				Total: 17

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Question	**Expected Answers**	**Marks**
3 (a) (i)	proton donor ✓	**[1]**
(ii)	partially dissociates ✓	**[1]**
(b)	$C_6H_5OH(aq) + OH^-(aq) \rightleftharpoons C_6H_5O^-(aq) + H_2O(l)$ acid 1 base 2 ✓ base 1 acid 2 ✓ *1 mark for each acid-base pair*	**[2]**
(c) (i)	$K_a = \dfrac{[C_6H_5O^-]\,[H^+]}{[C_6H_5OH]}$ ✓	**[1]**
(ii)	concentration = 38/94 ✓ = 0.40 mol dm^{-3} ✓ *(first mark for M_r of phenol – incorrect answer here will give ecf for remainder of question)* $1.3 \times 10^{-10} \approx \dfrac{[H^+(aq)]^2}{0.40}$ ✓ *('=' sign is acceptable)* $[H^+] = \sqrt{\{(1.3 \times 10^{-10}) \times (0.40)\}} = 7.2 \times 10^{-6}$ mol dm^{-3} ✓ $pH = -\log[H^+] = -\log 7.2 \times 10^{-6} = 5.14$ ✓ **3 marks**: $[H^+]$✓; pH expression✓; calc of pH from $[H^+]$ ✓ **Common errors**: Without square root, answer = 10.28 ✓✓✗ Use of 38 as molar concentration does not score 1st 2 marks. This gives an answer of 4.15 for 3 marks ✓✓✓	**[5]**
(d)	 / NaOH /Na✓ weak acid/base pair mixture formed ✓	On structure, 1 mark for O Na on either or both phenol groups. **[2]**
		Total: 12
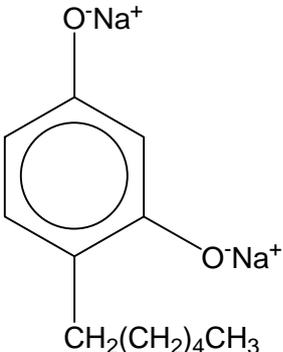
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Question	**Expected Answers**	**Marks**
4 **(a)**	graphs are of pH against volume acid/alkali added with scale and units ✓ sharp rise between two slight rises ✓ equivalent point > 7 ✓ sharp rise after addition of 25 cm^3 of alkali ✓ start pH = 2.9 ✓ finish pH = 12 $\rightarrow$ 13 ✓	**[6]**
(b)	phenolphthalein changes colour in the pH range corresponding to the sharp rise in the titration curve ✓ methyl orange changes colour **before** the sharp rise ✓	**[2]**
(c)	sharp rise in pH after addition of 12.5 cm^3 NaOH ✓ pH start is higher than 2.9 ✓	**[2]**
(d)	moles HCl in 23.2 cm^3 = 0.200 x 23.2/1000 = 4.64 x 10^{-3} ✓ moles **B** in 25 cm^3 = moles HCl = 4.64 x 10^{-3} ✓ moles **B** in 250 cm^3 = 4.64 x 10^{-3} x 10 = 4.64 x 10^{-2} ✓ 4.64 x 10^{-2} mol **B** has a mass of 4.32 g molar mass of **B** = 4.32/4.64 x 10^{-2} = 93 g mol^{-1} ✓ 93 – 16 = 77 ✓ Therefore **B** is phenylamine / $C_6H_5NH_2$ ✓ *There may be other valid structures that are amines. These can be credited provided that everything adds up to 93.* *Answer could be a primary, secondary or tertiary amines.*	**[6]**
		Total: 16

A2 Practical 2816/03
January 2005: Mark Scheme

Skill P   16 marks (out of 19 available)

C   Chemical tests (6 marks)

Mark each test by "notional half marks" if there are two small errors

C1   Test for sulphate: add barium nitrate/chloride to give a white precipitate.   [1]
         Reagent and observation required

C2   Any **two** of the points below are needed for mark C2
         • Precipitate (barium sulphate) identified by name or formula
         • Any correct "molecular"/ionic equation for the reaction
         • Adding dilute hydrochloric/nitric acid as well as the barium ions   [1]

C3   Test for NH_4^+ ions: <u>heat</u> with an alkali to obtain a gas that turns red litmus blue.   [1]
         Heat is necessary for this mark

C4   Gas is ammonia **and** a relevant equation given   [1]

C5   Test for acidity: add a suitable metal **and** get fizzing/hydrogen   [1]
         Sodium and calcium (etc) are not suitable.
         A specified metal carbonate (evolving CO_2) is suitable as alternative

C6   Test for H_2 gas ("pop" with flame) **and** an ionic **or** "molecular" equation given   [1]
         Lime water goes milky if metal carbonate was used
         *Equation for lime water test (**or** burning hydrogen) is credited as an equation*

D   Determination of concentration (9 marks)

D1   Makes up a "known"/standard solution of <u>any</u> relevant compound   [1]
         Weighing the solid, use of pure water to make up and a volumetric flask are all required.

D2   Calculates a suitable mass of iron(III) ammonium sulphate to make up a solution. [1]
         The iron(III) ion solution must not be more concentrated than 0.1 mol dm^{-3}

D3   Makes up mixtures of aq Fe^{3+} with aq CNS^-
         and measures absorbances using the colorimeter   [1]

D4   Details of compositions of suitable mixtures given   [1]
         At least 6 mixtures must be used with detail of their make up.

D5   **Two** details of the colorimeter   [1]
         • *Sketch diagram **or** brief description of components of the instrument*
         • *Use blue/green (or "complementary") filter for white light source*
         • *Mixtures put into a cuvette/special cell for measurement*
         • *Colour intensity is proportional to the absorbance*

D6   Complex produced is <u>red</u> **and** has formula $[Fe(H_2O)_5(SCN)]^{2+}$ [1]
         An equation for the reaction showing $[Fe(SCN)]^{2+}$ scores the mark

D7   Background theory of ligand substitution *or* origin of colour   [1]

D8   Shows a sketch graph of results
         and interprets where the curve becomes horizontal/maximum
         or reads off absorption of "unknown" iron(III) solution from a calibration curve   [1]
               The axes of the sketch graph in either case must be suitably labelled

D9   Shows how *x* in iron(III) salt is calculated from its concentration and mass.   [1]

S   4 marks for safety, sources and QWC

S1   Hazards *and* safety stated for *two* "unsafe" chemicals used in the procedure   [1]
               Any "standard" precaution (such as wearing safety specs) is acceptable.
               Penalise an overstatement of the hazard.

S2   References to two secondary sources quoted as footnotes *or* at end.   [1]
         ▪ *Book references must have full title and page numbers*
         ▪ *Internet reference must go beyond the first slash of web address*
         ▪ *Accept one <u>specific</u> reference to a "Hazcard"*

S3   **QWC**: text is legible *and* spelling, punctuation and grammar are accurate   [1]
               Allow only five different errors in legibility, spelling, punctuation or grammar.

S4   **QWC**: information is organised clearly and coherently   [1]
         • *Is a word count given and within the limits 400 – 800 words?*
         • *Is scientific language/terminology used correctly? (Allow one error)*
         • *Are the descriptions presented logically and without undue repetition?*

Practical test (Part B)

<u>Part 1</u>   **Mainly Skill I**   **(12 marks)**

<u>Mass readings</u>   [1]
- Both mass readings must be listed with units shown (somewhere)
- All masses should be recorded to two (or three) decimal places
- Subtraction to give mass of **E** must be correct.

<u>Presentation of titration data</u>   [2]
- Correctly labelled table used to record burette data
- Trial titre is shown **and** clearly labelled
- All "accurate" burette data are quoted to at least 0.05 cm^3 (i.e. 2 decimal places)
- All subtractions are correct

<u>Self-consistency of titres</u>   [1]
- Candidate's two best titres should agree within 0.15 cm^3.
- Units, cm^3 or ml, are given somewhere (**once** in or alongside the table is sufficient)

<u>Mean titre</u> correctly calculated, with "cm^3 or ml" unit given   [1]

<u>Accuracy and Safety</u> – 6 + 1 marks are available

Work out, using the steps below, what the <u>adjusted candidate's titre (T)</u> would have been if the candidate had used the same mass of Y as the supervisor.

Adjusted titre, *T* = candidate's mean titre x $^{\text{supervisor's mass}}/_{\text{candidate's mass}}$

T is within 1.20 cm^3 of mean supervisor's value	[1 mark]
T is within 1.00 cm^3 of mean supervisor's value	[2]
T is within 0.80 cm^3 of mean supervisor's value	[3]
T is within 0.60 cm^3 of mean supervisor's value	[4]
T is within 0.40 cm^3 of mean supervisor's value	[5]
T is within 0.25 cm^3 of mean supervisor's value	[6 marks]

<u>*Spread penalty*</u>
    If the two "best titres" have a spread > 0.40 cm^3, deduct 1 mark.
    If the two "best titres" have a spread > 0.60 cm^3, deduct 2 marks.
    If the two "best titres" have a spread > 0.80 cm^3, deduct 3 marks from accuracy (etc)

One **safety precaution** stated **and** explained briefly   [1]
    However, the precaution must be <u>related</u> to [one of] the irritant/harmful materials.

Part 2   Calculation   (11 marks)

(a) Mr of $KMnO_4$ = 158   [1]

$[KMnO_4]$ = $^{3.00}/_{158}$ = 0.0190 mol dm^{-3} [1]

$n(KMnO_4)$ = $^{0.0190 \text{ x titre}}/_{1000}$ = 4.4 x 10^{-4} mol (0.00044 approx)   [1]
Correct answer only (if no working is shown) scores 2 marks

(b) MnO_4^- + 8H$^+$ + 5e$^-$ → Mn^{2+} + 4H$_2$O   [1]

(c)   Fe^{2+} - e$^-$ → Fe^{3+} (*or* Fe^{2+} → Fe^{3+} + e$^-$)   [1]

Clear explanation of 1:5 mole ratio
or combined equation: MnO_4^- + 8H$^+$ + 5Fe^{2+} → 5Fe^{3+}→ Mn^{2+} + 4H$_2$O   [1]
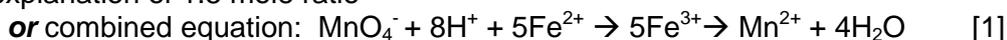
(d) $n(Fe^{2+})$ in 250 cm^3 = 50 x "a" = 0.022 mol (approx)   [1]

(e) Mr = $^{mass}/_{moles}$ (formula quoted *or* numbers substituted)   [1]

Mr calculated correctly from data obtained (should be 392)   [1]

(f)   Mr of **x**H$_2$O = 392 (*or* answer "**e**") – 152 – 132 *(or 380 – 152 – 132)*   [1]
380 is the "rescue" answer suggested on the question paper

x = $^{108}/_{18}$ *(or $^{96}/_{18}$)* = 6.00 *(or 5.33)*   [1]

Part 3   Test tube tests   (7 marks max)

(a)   **2 marks**

Green precipitate/solid formed   [1]

Fe^{2+} + 2OH$^-$ → Fe(OH)$_2$ [1]

(b)   **3 marks**

Green precipitate   [1]

Precipitate/mixture goes brown at the top/on the surface
or [slight] fizzing/bubbles of gas   [1]

Iron(II) carbonate   [1]
Carbon dioxide is acceptable if "gas" observation is quoted

(c)   **2 marks**

Observation: no change
or pale pink/orange/yellow colour formed   [1]

Fe^{3+} ions are not present

or SCN^- ions are used to test for Fe^{3+} [1]
If pink colour was observed, this answer must be "Fe^{3+} ions are present"

4. Evaluation (14 marks, max)

(a) 3 marks

$n(BaSO_4) = {}^{0.22}/_{233}$ [= 0.00094(4) mol] [1]

$n(\mathbf{E}) = 0.5 \times 00094 = 0.00047(2)$ mol [1]

M_r of $\mathbf{E} = {}^{0.17}/_{0.00047} = 360$ [1]
Answer = 180/181 will normally score 2 marks (ecf) if some working is shown

(b) 4 marks

% accuracy $= {}^{0.01 \text{ or } 0.02}/_{0.22} \times 100$ [1]
Two weighings are normally done, so 0.02 is cumulative error

Inaccuracy = 9.09% [1]

Use a greater mass of solid
or use a balance reading to 3 (or more) decimal places [1]

Correct calculation of new % error, for modification suggested [1]

(c) Maximum of 9 marks awarded on answers to (c) and (d)

A *Completeness of drying*

A1 Residue (or paper) may not be dry *or* water may still be present [1]

A2 Heat [residue and paper] for a longer period *or* heat them more strongly [1]

A3 Keep heating and weighing until two consecutive weighings are equal
or the residue should be heated to <u>constant mass</u> [1]

B *Filtration problems (2 marks only)*

B1 Some solid may pass through [pores in the] filter paper
or residue on the filter paper needs to be washed [1]

B2 Warm prior to filtration to coagulate precipitate *(reason required)*
or cool to reduce solubility *(reason required)*
or use finer filter paper *or* thicker/multiple paper. [1]

C *Ensuring that the reaction has been completed*

C1 Not all of **E** might have reacted
or not all barium sulphate might have been precipitated [1]

C2 Use more barium chloride [1]

C3 <u>Excess</u> barium chloride must be used [1]

D   *Repeated readings*

D1   Repeat the experiment   [1]

D2   Take mean of readings *or* obtain consistent readings   [1]

D3   Consistent/averaged readings are evidence of <u>reliability</u>   [1]

(d)

*Any marking points **not** already earned in (b) or (c) can be awarded in part (d).*

E1   The burette/pipette is accurately <u>calibrated/manufactured</u>   [1]
           A reference to tolerances scores E1

E2   % error of one piece of equipment <u>correctly calculated</u>   [1]
           Pipette tolerance is 0.04/0.06 cm³: burette tolerance is 0.05/0.1 cm³

E3   End point colour change for the titration reaction is sudden/sharp/easy to see   [1]

E4   Correct discussion of <u>cumulative</u> errors from multiple readings
           – all gravimetric measurements are subject to high % error   [1]

Chief Examiner's Report

General Comments

Again, entries increased, particularly for AS units. Foundation Chemistry continues to be the main AS unit for this session as the natural first examination for AS candidates. Candidates are entered for Foundation Chemistry in the January session from about half the OCR Centres for this specification.

The entry for Chains and Rings continues to be dominated by resit candidates. Many Centres are clearly teaching Chains, Rings and Spectroscopy as the first module for A2, using this module as a vehicle for improving Chains and Rings performance. Several Centres are re-entering nearly all their candidates for Chains and Rings in January of the A2 year.

A significant number of Centres are also making use of the January session of the A2 year for a How Far, How Fast? resit. This is perhaps surprising as the linked A2 module, Unifying Concepts, has by far its main entry in the June session.

For A2, Chains, Rings and Spectroscopy is by far the largest entry and, for many Centres, it is the natural teaching progression from AS Chemistry. More candidates enter this unit for the first time in the January session that the June session.

The most popular optional units continue to be Biochemistry and Transition Elements. Because of its small entry, Gases, Liquids and Solids is no longer being offered in the January session. From 2006, Environmental Chemistry, as the other low entry option, will also not be offered at the January session.

Overall. the standard of response seen on the examination papers continues to improve and there is strong evidence that many teachers are using the available mark schemes as a method of improving candidate performance. The responses from candidates of some Centres almost universally mirrored the mark scheme responses.

This increase in performance was perhaps tempered by some very weak scripts across all units. There was certainly evidence of candidates resitting examinations, having carried out no preparation at all. This inevitably leads to a lower mark than that achieved on the first sitting of a unit.

Entry to modules

Centres are again reminded of the codes that are to be used for entry in those units of assessment with more than one component.

AS

2813	A	How far, how fast? + Coursework
2813	B	How far, how fast? + Carry forward coursework mark
2813	C	How far, how fast? + Practical exam

A2

       2816   A   How far, how fast? + Coursework

       2816   B   How far, how fast? + Carry forward coursework mark

       2816   C   How far, how fast? + Practical exam

Options

       2815   A   Trends and patterns + Biochemistry

       2815   B   Trends and patterns + Environmental chemistry

       2815   C   Trends and patterns + Methods of analysis and detection

       2815   D   Trends and patterns + Gases, liquids and solids

       2815   E   Trends and patterns + Transition elements

2811: Foundation Chemistry (Written Examination)

General Comments

Overall the performance of the candidates was of a good standard, certainly in line with that of previous years. Students' answers to question 4 and in particular part (a) displayed an encouraging improvement in the candidates' ability to structure an essay and to discuss the relevant details using scientific language. In addition, question 4 did reveal, however, the tendency on the part of some candidates to provide additional information, which is not relevant to the question. Although, to some extent, this is understandably exam technique, it is disappointing that the more able students did not have sufficient confidence in their answers to prevent their supplying spurious details. Many candidates had clearly learnt the standard definitions and were able in the case of 1(b)(ii) to modify these when needed. Overall, there was an impression that some students, whose overall marks in the paper were high, still lacked a certain depth of knowledge. Thus, it was not uncommon to find such students proposing chemical nonsense in parts 3(a) or 2(d)(ii).

Comments on Individual Questions

1)   (a)   Almost all candidates completed the table correctly and gained both marks.

      (b)   In (i), the vast majority of students refer to using a mass spectrometer or obtaining a mass spectrum.

          In (ii), many students had learnt the definition for relative atomic mass and their score here depended on their ability to adapt this to the required definition for relative isotopic mass. This was clear from the number of candidates whose definition still referred to the average mass. There appeared to be much less confusion between a single isotope and a mole of an isotope in terms of their comparison with the carbon-12 standard.

          In (iii), nearly all candidates carried out the calculation successfully but far fewer were correct in giving the answer to three significant figures. The most common error, not surprisingly, was to round down to 12.0.

      (c)   Although the majority of answers were accurate, it was noteworthy and somewhat concerning that a number of students failed to answer this correctly.

      (d)   Most students gave a correct dot-and-cross diagram for CO_2.

      (e)   In (i), many candidates could not recall the chemical responsible for lime water. Calcium and calcium carbonate were among the more commonly encountered incorrect answers.

In (ii), it was clear that some students did not make the link between part (i) and (ii) of this question and so, having given an incorrect answer in (i), they now gave an equation involving $Ca(OH)_2$. Of those who generated $CaCO_3$ as a product the most common error was to write it as aqueous rather than solid.

Overall, most students found part (e) challenging and few achieved all three marks here.

(f) Most candidates responded to the theme of part (e) by writing a correct equation for the thermal decomposition of calcium carbonate.

(g) In (i), many candidates struggled here. Although some relied on equations involving only 1000 and 24, most realised that the molar mass of CO_2 was involved in the calculation, but still failed to carry out the simple evaluation of the number of moles of CO_2. Those who failed at this first hurdle did at least, however, salvage a mark by multiplying the number of moles they had calculated by 24 dm^3.

In (ii), the scripts showed a great deal of confusion on the part of candidates attempting this part. By far the most common error was to arrive at a value, which was 40% of the answer to part (i). This presumably arises from a misreading of the question as 'to cut CO_2 emissions *to* 60% of the 2000 value'.

2) (a) Most students identified H_2 as the missing product and most were able to balance the overall equation.

(b) Many candidates provided the correct oxidation state for calcium as the metal and as the chloride. Some attempted to answer the question solely in terms of oxidation being loss of electrons and did not refer to oxidation states.

(c) This was generally well answered. Candidates should be careful if choosing to write 2[Cl] that they then do not give the chloride a double negative charge.

(d) Although some students were able to give the correct observation, few were able to supply the ionic equation, most finding this part of the question extremely challenging. A very small number of candidates provided a full balanced equation involving $CaCl_2$ and $AgNO_3$, others gave equations that formed $AgCl_2$, but many proposed equations that were simply chemical nonsense.

(e) Part (i) was handled well and most students arrived at the correct answer.

In (ii), as expected, the most common error was to fail to account for the 1:2 stoichiometry of the reaction. Other errors arose from using the molar mass of $CaCl_2$ or the atomic number of Ca.

Part (iii) proved to be excellent at probing the candidates' deeper understanding of the reaction. It was the most difficult question on the paper. Very few students proposed that the additional calcium would react with the water. Instead, the most popular answer was that the Ca would react with the excess

HCl. In some cases, either an error in the preceding calculation led students to concluded that excess HCl was present, or they failed to take into account the stoichiometry and so reasoned that the number of moles of Ca being less than that of HCl [as calculated in parts (i) and (ii)] meant that some HCl was available for further reaction. Others proposed explanations that involved calcium reacting with either $CaCl_2$ or H_2, generated by the initial reaction.

3)   (a)   In general, candidates found these questions in order of increasing difficulty. Thus, most were able to identify elements correctly from information about their electronic configuration (i)–(iii) but found identifying C and N in parts (iv) and (v) more challenging. A significant number of candidates proposed argon as having the highest boiling point and the largest atomic radius. The answer to part (vii) often conflicted with the candidates statement about the trend in atomic radii which they made as part of their answer to (b)(ii) and (b)(iv). This shows a tendency on the part of such candidates to treat each part of the course independently and so not become aware of the simple underlying concepts.

    (b)   Part (i) for most candidates was clearly a well rehearsed answer and they obtained full marks. Overall the Examiners saw fewer errors in this standard definition that has been the case in previous years. As usual the most common error was to fail to identify that *each* atom in a mole of atoms has lost an electron.

Part (ii) was again this was well answered. Candidates who did drop a mark generally failed to identify that the rising nuclear charge is the cause of the atomic properties, such as change in radius *etc*, that they correctly described.

Candidates found part (iii) of the question more difficult. Although many students correctly identified that ionisation from different subshells was involved, fewer went on to state the relative energies of the orbitals from which the electrons were removed. Some candidates, failing to state this, did draw attention to the shielding of the 2*p* electron by the filled 2*s* sub-shell or to the electron-electron repulsion that exists between the 2*s* electrons in Be, both of which have their part to play in determining the energies of the respective orbitals.

In (iv), the most common error was to relate the ionisation energy of Na to that of Ne. Consequently many candidates correctly described how the electron was now in a new shell and further from the nucleus, but proposed a value for the ionisation energy that was less than that of Ne rather than that of Li.

4)   Candidates tended to answer one part of this question significantly better than the other part. To some extent it was clear that this was specific to the Centre.

    (a)   Overall the answers to this part were well constructed and most students set out their discussion under the two suggested areas. Most candidates conveyed the idea of the occurrence of instantaneous dipoles and many were able to attribute this to fluctuations in the electron distribution. Fewer candidates described how a dipole would thus be induced in a neighbouring molecule.

Most students were able to recall correctly the physical states of chlorine, bromine and iodine and many discussed this in terms of an increase in the magnitude of the van der Waals' interaction. Fewer candidates, however, linked

this to an increase in the number of electrons. A significant number of students were clearly unfamiliar with the term, volatility, and consequently contradicted themselves. Hence they gave a correct trend in the boiling point of the halogens down the group but stated that this showed an increase in volatility. Some candidates confused volatility with reactivity.

It was noteworthy how many candidates, having given the explanation that was requested, then proceeded to provide unnecessary additional information about the halogens. In particular, many discussed their relative reactivity, evidently having not yet read the question in part (b). Although the mark scheme in no way penalised a candidate for providing such additional information and so, to some extent, tacitly encourages it, it is disappointing to see able students indulge in this exam technique.

(b)   These answers were less well structured. Many students gave the correct trend in reactivity but very few were able to justify this trend. In discussing the reasons behind the decrease in reactivity, many confused the ability of the halogen atom to gain electrons, the electron affinity, with its ability to attract electrons in a bond, its electronegativity. Others attributed the decrease in reactivity to the increase in van der Waals' forces. Many candidates were able to give correctly balanced equations but did not go on to describe the colour change they would have observed. It was encouraging that the accuracy of the equations was much improved on previous years when this has been asked. Less able students were prompted by the phrase 'test tube reactions' to describe the silver nitrate test for the different halides. Some candidates, who clearly knew their chemistry, lost marks here by failing to organise their answer and so, for example, omitted any reactions of bromine.

2812: Chains and Rings (Written Examination)

General Comments

The cohort for this paper consisted of almost exclusively re-sit candidates. Furthermore, the vast majority of the candidates will already have passed their AS year and will almost certainly have completed 2814, Chains, Rings and Spectroscopy, thereby reinforcing their knowledge and understanding of organic chemistry.

The paper produced a good spread of marks with the majority of candidates scoring between 25 and 50. Very few scored below 10 marks; equally the top 5 marks were elusive. The distribution was such that the majority scored between 30 and 45 marks.

The majority of candidates seem to have been well prepared. Candidates displayed good examination technique. There was no evidence to suggest that any candidates ran out of time.

The majority scored the marks allocated for "quality of written communication".

Comments on Individual Questions

1)   (a)   This was an easy start with most candidates scoring full marks in both part (i) and (ii).

        (b)   Both parts discriminated well with part (i) proving to be demanding even for the more able candidates. Very many have the knack of drawing the same isomer twice, often repeated one of the two given in the question. Many also didn't read the question carefully and gave the *trans* stereoisomer rather than a structural isomer. The systematic naming of isomer 1 was demanding for weaker candidates.

        (c)   Part (i) proved to be very straightforward with almost all candidates scoring both marks.

                In part (ii) many scored two out of three marks. It seems that, whenever candidates see any compound containing Cl, it is automatically a threat to the ozone layer.

2)   (a)   Few, if any, scored all five marks. The three marks in part (iii) were particularly elusive.

                Miscopying of the original structure was prevalent and it was common to see the alkene carbon bonded to the methyl component of the ethyl group.

                It was also disappointing to see that Na was often covalently bonded and to the wrong position in (a)(ii).

The correct dibromo-derivative was seldom given (a)(iii).

(b)   Part (i) provided an easy mark for almost all.

In part (ii), credit is to be given to the centres and to the candidates. The mechanism was answered particularly well although some candidates still need to place curly arrows more accurately.

3)   (a)   In (i), very many failed to give the correct molecular formula of methylpropane.

(ii) The complete combustion of butane offered two easy marks for most candidates although a substantial number were unable to balance the eqaution correctly. It was very common to see $4\frac{1}{2}O_2$ instead of $6\frac{1}{2}O_2$.

Part (iii) was well answered.

(b)   In (i) marks were not awarded if there was no attempt to draw a 3D diagram. At a minimum this had to contain at least 1 "wedge-shaped" bond. A surprising number got the bond angle wrong and many did not suggest a suitable property required for a propellant in an aerosol.

In part (iv) most knew the meaning of homolytic fission but lots struggled to put it into words. Parts (v) and (vi) were well answered.

4)   (a)   This was very poorly answered with many showing the products as C_2H_5OH and H_2O.

(b)   This was very well answered with many scoring all three marks.

(c)   Only the most able, or those who had had the opportunity to carry out similar experiments, scored well. Very many failed to understand the principles of distillation and reflux.

(d)   The oxidation of an alcohol to a carboxylic acid still discriminates well with only the most able scoring both marks.

(e)   Candidates find the spectroscopy at AS straightforward and many scored full marks.

5)   This was a straightforward question in two parts.

Most scored well when describing cracking, isomerisation and reforming. A significant number wrote at great length about fractional distillation when it was not required.

The sustainability of ethanol/fossil fuels was well answered except for the balanced equation for the combustion of ethanol. The majority failed to balance this correctly. A substantial number also lost marks by suggesting that ethanol could was renewable because it could be obtained from the hydration of ethene.

A common misconception was that ethanol could be obtained directly from plants.

2813/01: How Far, How Fast? (Written Examination)

General Comments

The paper gave candidates the opportunity to show that they could apply their understanding of chemical concepts in a logical way, as well as being able to use recalled information. Many candidates rose well to the challenge of the former, higher-level skill and some excellent answers to all questions were seen. There was, however, some evidence that knowledge was a little patchy, so that few candidates maintained the highest level of answers across all the questions.

As noted in previous reports, it is often the precision of explanation and care in actually answering the question set that is the difference between the achievement of high and more modest marks. Examples where it was felt that candidates could perhaps have gained more credit if they had attempted to answer the question actually set, rather than their personal interpretation, are considered in the comments on individual questions.

Comments on Individual Questions

1) (a) Although this was intended to be an 'easy' opening question for the paper, many candidates were rather vague. 'Burns cleanly' was commonly suggested and this was felt not to be valid since it is more concerned with the conditions used in burning, rather than a property of butane.

    (b) In (i), most candidates correctly quoted the relevant standard conditions but a significant minority merely responded that conditions should be 'standard' or 'average' without actually giving values.

    In (ii), the definition was generally known. A few candidates could not be awarded one of the points when they included 'enthalpy **required**'.

    In (iii), most diagrams seen were essentially correct. Candidates should ensure that they apply their knowledge to the particular example so that, in this case, $4CO_2$ and $5H_2O$ were needed as products.

    (c) For (i), apart from a few examples in which formation did not appear to be understood, most equations were correct. Some state symbols were omitted or very difficult to decipher. Candidates should realise that the difference between 'g' and 's' is significant in this case.

    For (ii), if the incorrect equation had been given in (i), candidates could gain full credit here for using **their** equation. It was strange to note how many of the hydrogen values were multiplied by 10, even though the correct equation had been given.

    Candidates who attempted to apply numbers to a cycle were generally more

successful in solving the problem than those who merely wrote a string of numbers.

Ans –129 kJ mol^{-1}.

2) (a) Le Chatelier's principle was generally given in an acceptable form, with only very few candidates suggesting that the attempted change in conditions could somehow be totally negated.

(b) For full credit it was necessary to consider the time taken rather than merely to refer to rate in (b). A significant number of candidates failed to discuss time, even though it had been included in bold type in the question in an attempt to avoid this problem.

(c) Some very well expressed answers were seen but many candidates appeared very confused about whether they were discussing the equilibrium position or the rate at which this position was attained. In a significant number of cases contradictory answers were suggested. It seemed that the ideas were **known** but lack of real **understanding** meant that valid conclusions were often not reached.

(d) Some reference to the effects on rate/ yield/ costs/ safe working of changes in temperature and pressure was needed. Many weaker candidates merely referred to the idea of a compromise without specifying why the compromise was needed.

3) (a) Although many candidates stated that a weak acid was only partly dissociated, few included an equilibrium sign in the equation. There was some confusion about the degree of dissociation and the number of hydrogen ions available to be dissociated. This led to some interesting conclusions about the relevant strengths of the two acids.

(b) (i) Nearly all candidates realised that hydrogen would be produced.

(ii) Some excellent answers, showing real understanding of the difference between concentration of the original acid and resultant H$^+$ concentration, were seen. Many candidates however did not seem to understand that there could be a difference. Answers that concluded that the concentrations of the two acids must be the same or that the observation that the rates were the same must be wrong, were common.

4) (a) In (i), it was encouraging to note that most candidates could balance this equation, even though large or non-integral values are involved. Some equations, showing various forms of incomplete combustion, were given.

In (ii), most candidates realised that atmospheric gases were responsible for the formation of NO but a significant number suggested impurities in the fuel or some type of incomplete combustion.

(b)   In (i), two acceptable metals were usually seen but a surprising number of other metals were given. These included iron, lead, aluminium, cobalt, potassium and rubidium.

In (ii), many candidates quoted a 'text book' account of how a heterogeneous catalyst works. Others confused 'absorbed' with 'adsorbed', became very concerned with the nature of honeycombs or merely discussed the function of catalysts, rather than how the heterogeneous one actually achieves the lowering of the activation energy.

(iii) Only the most able candidates were able to pick out and use the correct substances from those given.

(c)   Many candidates ignored 'further reactions occur' and quoted CO. Some however realised the significance of the emission of these substances on the environment.

2813/2: Coursework I (Coursework)

General Comments

There were very few candidates submitting coursework for the first time and the entry consisted mostly of re-submissions aimed at improving on a poor mark obtained previously. Perhaps because of this the standard was very variable and, although occasionally the Moderators were pleased to find work of a high quality, too often it was felt that the candidates had not fully appreciated the depth that was necessary to achieve the highest standards. This was particularly disappointing when it appeared that clear advice offered in the Centre report from the summer session had been disregarded.

Centres generally based the assessment on the exemplar experiments and their associated mark schemes. Nearly all had appreciated that the latest version of the guidance booklet should now be used. From the Summer 2005 examination season it must be emphasised that all coursework will be moderated on this basis. Although changes are generally minor, there are particularly important adjustments to the 'Identification of an organic unknown' and to the 'Determination of a rate equation'. In the former case the assessment has been made more demanding and in the latter there is a change to the way the exercise should be presented to the students. In addition observations are now obligatory within the 'b' strands of skill I. There is also a clear requirement for references to be included at level P7a.

Comments on Individual Skills

Planning

Candidates were usually able to provide an experiment to address the problem that had been posed but fewer were able to provide 'a detailed plan which could be used by others without modification' as specified in P7a. It is not sufficient to outline a procedure from which a procedure might be deduced. The requirement that information should be evaluated (also P7a) means that the reason for the various decisions taken must be justified. Both these criteria often seemed to be ignored in the award of level 7.

Implementing

The 'a strands are usually criteria that only the Centre can judge and it appeared that in rewarding these, too low a standard had been accepted for the 'b' skills. Key observations must be included to award I7b and, in particular, this means the appearance of the product if an organic preparation has been used. It should also be noted that 'clear' is not synonymous with 'colourless' and this is not acceptable for I7b. Where burette readings are made, the initial volume must be included in the results even if the burette is filled each time to the 'zero' mark. This volume will, after all, have been noted. Finally measurements must be expressed to the accuracy possible for the piece of equipment being used.

Analysis

The assessments made were usually reliable and the only issue concerns the appropriate use of significant figures which is expected for A7a.

Evaluating

This is a difficult skill and candidates often struggled to achieve the higher levels. It is hoped that the more structured approach suggested in the guidance booklet will be used to help students at AS. The main area of concern remains the recognition of those errors of procedure and measurement that have a significant effect on the result. This is required to award E5b. It should also be made clear that the mention of a standard procedure cannot be counted as an improvement. For example, using the various washing procedures to ensure volumetric equipment is suitable for use cannot be awarded marks even at the lowest level. Equally statements such as 'use a more accurate balance' must be accompanied by a reason as to why this would be relevant.

2813/03: Practical Examination II (Practical Examination)

General Comments

The number of candidates for this component was small, consisting mainly of students who were re-sitting the AS examination. Scripts earned a range of marks. It was pleasing to note that there were relatively few really weak scripts and, by contrast, there were a number with very high marks. It seems that comments made in previous Examination Reports are being more widely noted by candidates. As usual, the Evaluation section was found to be the most demanding, and Centres are encouraged to give their candidates as much practice as possible on this Skill. There was little evidence that many candidates were unable to finish the examination due to lack of time.

Comments on Individual Questions

Plan   There were many extremely good Plans seen, with a number gaining full marks.

It was encouraging to note that more candidates are now including word counts and more are remembering to quote details of two sources. More candidates appear to be using Hazcards (or similar) for safety data, enabling them to give accurate safety information. Thos who do not do this often make exaggerated claims about the hazards of materials used. For example sodium hydroxide is only corrosive at above concentrations of 0.5 mol dm^{-3} so, at concentrations typically used in titrations, it is only irritant. Candidates are encouraged to word process plans: those who write them by hand are warned that Examiners will, in future, be more strict with semi-illegible writing.

Most candidates were able to describe two tests to show the presence of acid in $MHSO_4$(aq). A common error was the choice of sodium as a metal for the test. Candidates should always describe observations made during tests they carry out. "Hydrogen is produced" is a deduction, not an observation. Writing correct chemical equations for the reactions of $MHSO_4$ proved challenging.

The descriptions of the titration were generally well-ordered and complete. Candidates should check that their quoted indicator colour change corresponds to where the acid and alkali are used in their procedure. A reference to "repeating accurate titrations" is not credited unless candidates refer to the need for consistency in these titres. It was only better candidates who were able to show convincingly how to deduce the relative formula mass from their titration data. Algebraic calculations rarely score because candidates do not define or state what their terms mean with sufficient clarity. Specimen calculations with "made up" numbers are normally easier to follow. However, candidates should not choose 25.0 cm^3 of both solutions, since Examiners are then unable to decide whether the candidate is using the data correctly.

Test Part A significant number of candidates waste marks for presentation of their
      1   readings by failure to quote all data they collect (just giving the difference between burette readings is not sufficient), omitting units and not quoting enough significant figures, which means quoting all weighings and burette readings to two decimal places. The standard of accuracy in the titration, for

which 7 marks were awarded, was generally very good. The majority of candidates are encouragingly well practised in this important manipulative skill. When answering questions on safety, candidates should be willing to use any information supplied on the question paper or on the bottles of chemicals and, if relevant, to refer back to their Plans. Of course, they are not allowed to consult Hazcards during the examination itself.

Part 2	The calculation differentiated well. Many weaker candidates often try to do more than each structured stage requires. They will arrive at the correct answer, but then decide to process their answer further. Understanding of significant figures remains disappointing: many did not follow the rubric instruction to give three significant figures in most answers. Only the best candidates were able to arrive at the correct final answer, a 2:1 mole ratio.
Part 3	Many answers on these test tubes tests were of high quality, but some candidates do not understand the link between insolubility and precipitation. Describing a white precipitate as "going milky" is not credited (except in the case of a lime water test, where colloquial language has become embedded!)
Part 4	The Evaluation on this paper was set in a different style to previous papers, but high marks on the section were still rare. Particularly disappointing was the high percentage of candidates who appear to believe that hydrogen is an acidic gas that exists in air. This suggestion led to some creative attempts at an equation, some even producing sodium metal! Many candidates were able to perform the calculation on the % tolerance of a pipette, but few could apply the same concept to the use of the balance. Not many candidates appreciated that using the balance twice to weigh by difference would increase the % error.

The final question proved to be very challenging. The recent arrival of "water of crystallisation" in the specification may have precluded Year 13 students from being aware of its effect in increasing the mass of a prepared sample of crystals. Further questions on this theme may be anticipated …

2814: Chains, Rings and Spectroscopy (Written Examination)

General Comments

Once again, many candidates were very well-prepared for this examination and demonstrated a good knowledge of the organic chemistry in the specification. It is clear that candidates are more confident with the subject at this stage and have moved on in their understanding since the AS Chains and Rings unit. It is also pleasing to see how many candidates are successfully tackling the spectroscopy questions, and are comfortable with the use of modern analytical techniques. The paper contained some parts in which candidates had to show that they not only knew the specification content, but understood the theory behind it as well. Some do have difficulty in putting explanations into words and any additional practice would be helpful. One aspect of the move to A2 level is that there are fewer structured questions in the paper to provide candidates with the opportunity to put together a coherent explanation of relevant chemistry. Candidates also gained more credit if they were as specific as possible about the reagents and conditions necessary for particular reactions. Vague terms such as 'heat' and 'add acid' often did not score any marks.

Comments on Individual Questions

1) (a) Most candidates had little problem identifying the functional groups in geraniol, but some did not read the question and did not name them.

    (b) The definition of stereoisomerism was not well known. Candidates need to be clear that the structural formula remains the same and it is the spatial arrangement of the groups that differs. Some confuse stereoisomerism with the definition for structural isomerism. In the last part, candidates needed to explain that two identical groups on one carbon of the C=C double bond would not give rise to stereoisomers.

    (c) The oxidation of the alcohol to the aldehyde was generally well known, although some were still putting the terminal hydrogen atom on the skeletal formula. Also candidates should note that the formula of an aldehyde group should be given as 'CHO' and not 'COH'.

    (d) Many knew that esters additives contribute to the smell of the food. To make the ester, it was necessary to state a dehydrating as such as concentrated sulphuric acid and to heat under reflux. Although any acid will catalyse the reaction, aqueous acids will push the reversible reaction towards hydrolysis rather than making a reasonable amount of the ester.

(e) Nearly all candidates found this part relatively easy, with just a few missing the absorption for the C–O bond in the alcohol.

2) (a) Many identified types of material originating from a nitrated benzene ring such as dyes and explosives. However quite a few suggested nylon or fertilisers, which are not generally made from this starting material.

 (b) The conditions required for the nitration of benzene needed a temperature that would prevent further reactions in the range 50-60°. Many knew this, but did not identify that the acids must be concentrated.

 (c) The balanced equation for this reaction was well known.

 (d) Candidates who had learnt this mechanism were perhaps disappointed to see the mechanism on the paper. However it was good to see that many also understood what was happening in each step. Marks were most commonly lost by not specifying that a curly arrow represents movement of an electron pair. Also some described an electrophile as a lone pair acceptor. In this mechanism it accepts a π-bonding pair, not a lone pair.

 (e) Only the most able candidates scored well on this part. Most knew that the π-bonding electrons were delocalised, but many proceeded to give the well-learned explanation of the overlap of p orbitals in benzene, rather than focus on the question asked. Some thought that there were twelve π-bonding electrons in benzene and a good number thought that there were ten or five π-bonding electrons in the intermediate.

3) (a) The practical details of how to make an azo dye were either well known or not known at all. Some still missed out the alkaline conditions needed for the second stage. A few candidates did not read the question carefully enough and explained how to manufacture an azo dye from benzene.

 (b) Most identified the N=N bond as characteristic of an azo dye, although interpreting the skeletal formula to obtain the correct numbers of carbon and hydrogen atoms proved more challenging.

 (c) Most knew that sodium metal or an alkali would ionise the phenolic –OH group on the molecule.

 (d) Working back from the dye given to identify the original phenol and amine was well done by a good number of candidates, although some did lose marks by not being precise enough in drawing the structures of the molecules. The covalent bonds must be shown going to the correct atom in the group. This applies to all structures drawn on the paper, although it is only penalised at the first instance.

4) (a) Most could state the general formula of an α-amino acid, but only a few could put into words that the amino and carboxylic acid groups are attached to the first carbon and that the R group is different in the two examples given.

    (b) The zwitterions were well known by all but the weakest candidates, although a few who had learnt the general case did not ionise the carboxylic acid group on the side chain as well.

    (c) This part was well answered by the majority of candidates and it is clear that most are confident with the explanation of optical isomerism. A few lost marks by not attempting to draw 3-dimensional structures for glutamic acid, and some of those that did, were not sure where the two perspective bonds are relative to the other two bonds. Some candidates would find it useful to practise drawing the 3-D tetrahedral structure to avoid the more subtle errors as shown below.

    correct 3-d   tetrahedral, but   not tetrahedral
    tetrahedral   incorrect 3-d   (90° angle)
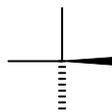
5) (a) Addition polymerisation and the structure of phenylethene were well known. However fewer candidates pointed out that this process involves the π-bond breaking and that many molecules join in order to give a polymer. Many just described addition generally.

    (b) Most knew that a syndiotactic polymer had the side chains alternating, but a common error was then to see the alternating benzene rings drawn below the chain rather than with perspective bonds above the chain as in the example given. As with the stereoisomers above, teachers could usefully encourage their candidates to practise this diagram, as they do find it difficult.

    (c) A pleasing number of candidates could relate the tacticity of the polymer to its melting point, although some lost marks by not precisely stating that intermolecular forces were involved.

6) (a) Many candidates probably knew which peak to use to find the M_r of a compound, but could not put this into words. Stating that you needed to find the 'highest' peak was a common problem. Only a few obtained full credit by identifying that it is the m/e ratio of the peak that is measured. Most could however explain how the empirical formula would be doubled to give a formula which fitted the measured M_r.

    (b) Nearly all knew that D_2O would affect the OH groups on the molecule, although a few did not specify that a peak would disappear from the spectrum. There

were no marks for just choosing the correct structure but most had no problem in identifying this as methylpropanedioic acid. Any method of linking the correct peak with the correct groups on the structure was credited. However one mark was reserved for those who had clearly shown or stated that it was the protons and not the group as a whole causing the peak. The explanation of the splitting patterns and peak areas was well known, although candidates should be encouraged to state clearly which pattern or area they are referring to. For example, answers such as 'the splitting of the peak at 1.2 ppm means one proton on the adjacent carbon' were not credited as the fact that it was a doublet was not identified. The last part of this question proved to be a good challenge for the more able candidates, with only a few of those who recognised that there would only be one peak also appreciating that this would not be split.

2815/1: Trends and Patterns (Written Examination)

General Comments

This examination paper allowed candidates of all ability levels to show positive achievement. The paper had a mean mark of 25 and candidate scores covered almost all of the mark range. There was little evidence, in terms of incomplete answers to question 4, that candidates did not have sufficient time to finish.

Candidates found question 2 the most accessible even though it involved a calculation. The examination paper contained a large proportion of marks that were synoptic in nature and relied on knowledge and understanding of theories, ideas and concepts from other modules within the AS and A2 specification. As in previous examination sessions there was evidence that a significant proportion of the candidates had not fully prepared themselves for the synoptic element of the examination paper.

Many candidates failed to use basic chemical terminology correctly such as atom, ion, molecule, element and compound, for example referring to the atomic radius rather than the ionic radius of an ion.

Comments on Individual Questions

1) This question focused on the Born-Haber cycle and lattice enthalpy.

   (a) Many candidates could score three marks but it was rare for candidates to score all five. The most common error was the failure to use 2 x the enthalpy change of atomisation of chlorine and 2 x the electron affinity for chlorine. The correct answer was -2262 kJ mol^{-1}. A small but significant proportion of candidates gave a positive lattice enthalpy. In order to score full marks for part (iii), candidates had to refer to the difference in ionic radii or the charge density of both the cations and the anions. Many candidates referred to the difference in atomic radii and this was not given credit. Another misconception was that compounds had ionic radii. The final mark was awarded for the connection between the change in lattice enthalpy of the two compounds and the strength of the electrostatic attraction between the ions. A significant proportion of candidates did not appreciate that the lattice enthalpy of magnesium fluoride was more exothermic than that of calcium chloride and referred to a bigger or greater lattice enthalpy with no regard for sign.

   (b) In this part, a small but significant proportion of the candidates referred to the gain of electrons rather than the loss of electrons from a calcium atom. A common misconception was that the nuclear charge increased as electrons were lost, rather than the nuclear charge remained constant but attracted a smaller number of electrons.

2)   This question was generally the most well answered of the four on the examination paper.

     (a)   Many candidates were able to give the electronic configuration for the iron(III) ion, however there was a significant proportion of the candidates who added three extra electrons while others included the 4s electrons. Almost all candidates could explain why iron was a transition element.

     (b)   Most candidates scored full marks for this part question, however a small proportion gave properties of the elements such as strong, hard, or a high melting point; these properties were not given credit.

     (c)   In this part question the majority of candidates could describe the colour changes that occurred but many did not state that a precipitate or an insoluble solid was made and so were not given credit.

     (d)   This part question proved to be the most difficult part question on the paper and candidates rarely scored a mark. The most common misconception was to try and write equations that made iron(III) oxide even though the question asked for iron(III) ions.

     (e)   In part (i) a significant proportion of candidates suggested that copper would react with potassium manganate(VII) or that copper may reduce any iron(III) ions formed in the titration back to iron(II) ions. Both of these answers were given credit. Common answers that were not given credit included that the copper would block the burette or would interfere with the colour change.

In part (ii) answers in terms of both changes in oxidation number or electron transfer were accepted. Although this scored well a common misconception was that hydrogen ions were reduced because they gained electrons.

Even though the calculation was not structured, many candidates were able to get full marks by working out the percentage by mass to be 18.6%. The most common error involved not multiplying the moles of manganate(VII) ions by five to get the amount of iron(II), some candidates missed this step out and other candidates divided by five.

3)   Many candidates answered this question about copper complexes very poorly.

     (a)   In this part, candidates often described the colour changes without stating whether there was a solution or a precipitate formed. The state symbols given in the equations in the stem were not always used by candidates to deduce the observations.

(b)   In this part, many candidates drew an octahedral complex showing the three dimensional nature using wedges and/or dotted line. Drawings not indicating three dimensions were not given credit. Bond angles between 60° and 120° were often quoted. The best answers gave more than one correct bond angle typically both 90° and 180°. Some candidates even showed the bond angles within the water ligands.

(c)   Although similar questions have been asked in previous examination papers many candidates did not refer to electron pair repulsion. A significant number of candidates referred to repelling atoms and bonds. Only a small proportion of the candidates stated specifically that an isolated water molecule has two lone pairs and as a ligand it has only one lone pair. The last marking point related to the difference in repelling power of bond pairs and lone pairs.

4)   Only a very small proportion of the candidates obtained full or nearly full marks for this question. Only the most able candidates were able to coherently organise their answers. There was evidence that some candidates had drawn up a plan before answering the question. Candidates' scores ranged from 0 to 13.

A significant proportion of the candidates did not score the mark available for the quality of written communication in this question. Candidates needed to link a description with an explanation on at least two occasions. Candidates who listed a collection of isolated facts were not credited with the quality of written communication mark. Typically candidates earned the quality of communication mark by relating the melting points of the oxides with their structure and bonding.

The mark scheme had two marks allocated for the chemical formulae, three to the structure and bonding, and four to the action of water on the oxides of magnesium, aluminium and sulphur. In addition there were three marks allocated for an explanation of the melting points of the three oxides.

Most candidates were able to recall the formulae of the three oxides although a small proportion gave the formula of aluminium oxide as Al_2O_6. Many candidates did not attempt to explain the trend shown by the formulae. Those candidates that did explain the trend either used oxidation numbers or the number of electrons in the outer shell.

The most common misconceptions with respect to structure and bonding referred to aluminium oxide. Although a significant proportion referred to intermediate bonding and a giant structure other candidates referred to giant or simple covalent structures.

The reactions of oxides with water were well known by the candidates and often candidates illustrated their answers using chemical equations. A common misconception was that sulphur dioxide reacted with water to make sulphuric acid.

The most demanding part of the question was the linking of the melting point of the oxides with their structure and bonding. Many candidates referred to weak van der Waals forces in sulphur dioxide although a significant proportion of candidates had the misconception that covalent bonds were weak and ionic bonds were strong. A common misconception involving both magnesium oxide and aluminium oxide was that these substances contained strong van der Waals forces.

2815/02: Biochemistry (Written Examination)

General Comments

There was the customary spread of marks from the small entry. Better candidates showed good understanding coupled with a sound knowledge of the factual content, and an ability to read the questions. Many weaker candidates lost marks by giving biological answers rather than biochemical ones in places. Poor expression meant that some lost marks because their answers were vague or contradictory.

Comments on Individual Questions

1) (a) Most candidates scored full marks for (i) and (ii), although several failed to draw the bell-shaped curve that they might have anticipated. Several could not take a reading from their graph, writing 34 when their curve clearly showed 32. In (iii), clear answers linked distortion of tertiary structure or breaking of weak bonds, with an example, to the changing shape of the active site. The word denaturation was not enough.

    (b) In (i) most candidates made useful suggestions based on continuous use, possible increased thermal stability or easy separation of product and enzyme. Vague answers, particularly those relating to cost, did not score. About half the entry made the necessary connections in (ii) and (iii), although some suggested the use of papain to remove grease.

2)   This proved straightforward for those who had learnt the material with scores of 8 or 9 out of 10 not being uncommon. There were many clear diagrams showing the numbering for DNA, and stereochemistry for cellulose, with supporting descriptions. Weaker responses showed knowledge of the structure of only one of the polymers, or leaned too heavily on biological knowledge which had not been asked for.

3) (a) In (i) most pinpointed the presence of a complexed metal ion, although several implied that the magnesium was not ionised. In (ii) the simple response of Mg instead of Fe was expected and given by many. There were numerous alternatives given and accepted, for example, that chlorophyll is not a protein.

    (b) Most candidates worked out the formula of one of the two possible alcohols. Some gave only the name methanol, whilst others wrote down the formula of ethanol or ethanoic acid instead.

    (c)   Most candidates mentioned the presence of four polypeptide chains. Some then revealed muddled thinking by discussing α-helices and β-pleated sheets. Several thought that there was only one Fe or haem group altogether.

    (d)   Better candidates wrote about the reversibility of the binding of oxygen to iron and the effect of changing concentrations/partial pressures of oxygen. Several candidates wrote biological descriptions which did not include these points.

4)   (a)   Many candidates scored both marks in (i) by referring to a phosphate head and fatty acid tails. Few mentioned the charge on the polar head or the hydrocarbon nature of the non-polar chains. Hydrogen bonding was the common mistake in (ii); hydrophobic bonding was not accepted. In (iii) many candidates at all levels described or drew a phospholipid bilayer.

    (b)   Most candidates had met saponification. Many did not get both the necessary conditions of heat and aqueous solution in (i). Several used NaOH under acidic conditions, which will not work. Few were successful with the equation in (ii) and thus with precise detail for both marks in (iii); but nearly all recognised the polar and non-polar ends.

5)   (a)   Most drew an open chain structure for glucose in (i), the commonest incorrect alternatives being fructose or ribose.

    (b)   This was well answered. Nearly all had a correct glycosidic link, and most the correct stereochemistry.

    (c)   Most scored the mark with maltase or an acid, which had to be specified.

    (d)   Answers to this solubility question were generally improved. All mentioned hydrogen bonding; most recognised the presence of many OH groups on maltose; several described how the spare OH groups in starch are tied up by hydrogen bonding within the structure.

2815/03: Environmental Chemistry (Written Examination)

General Comments

There was a wider range of marks than usual from the small entry, with more candidates being successful at the top end. These scripts were characterised by accurate knowledge across the syllabus; answers were expressed well with correct technical vocabulary. At the other end there were, again, too many candidates with only fragmentary knowledge of the content of the specification; these often relied on vague general knowledge or omitted whole questions.

Comments on Individual Questions

1)   (a)   In part (i) a few candidates were successful in describing oxidation followed by reaction with water, or vice versa. Many omitted one stage often compounding errors with incorrect equations, such as $SO_2 + 2H_2O \rightarrow H_2SO_4 + H_2$.

               About a quarter of the entry calculated the mass of sulphuric acid (1.84×10^7 tonne) correctly. The commonest sources of error were an inversion at some point or getting lost in the powers of 10.

    (b)   Most recognised that the acid would erode or dissolve limestone, but few could write the correct equation.

    (c)   There were very few correct equations for the formation of temporary water in (i), but rather more descriptions of dissolved carbon dioxide as an acid and limestone as a base. No-one was successful with an answer based on proton transfer.

2)   (a)   Nearly all scored this mark for the position of the troposphere. The only mistake was to put this at the top rather than the bottom of the atmosphere.

    (b)   Nearly all knew about the term *hf*. Better candidates drew an acceptable dot and cross diagram for NO, the usual mistake being to have only a single bond between the two atoms. Most ended up with an unpaired electron in (iii), the commonest alternative being an unbonded or lone pair.

    (c)   This was well done by candidates of all abilities, although some only gave the first equation of the two.

    (d)   This part on the effect of ozone on rubber was well done; the best candidates

described the eventual formation of carbonyl compounds, which was not required for full marks.

(e) Relatively few candidates knew that greenhouse gases absorb infra-red radiation emitted by the earth in (i). In (ii) most made a sensible suggestion based on concentration. Few remembered that the use of ozone rather than chlorine to treat water avoids the formation of toxic organochlorine compounds.

3) All the candidates knew something about waste disposal and the best were able to use their chemical knowledge to make the required comparisons. Weaker candidates often discussed landfill and incineration separately, with too much vague narrative separating relevant points. Unexpected products of incineration included hydrogen and methane; landfill gases were wrongly seen as an important cause of eutrophication in rivers and lakes. There were unnecessary lengthy explanations of acid rain and the greenhouse effect as well as of eutrophication.

4) (a) This was well answered by most candidates, who showed a good understanding of the ability of 2:1 clays to absorb water between layers, and subsequently lose it under dry conditions.

(b) In (i) about half the entry got the particle size for colloids in the right range. The commonest error was to have the particles visible under the microscope.

There were many good explanations of the use of aluminium sulphate, or aluminium ions (but not plain aluminium) to remove colloidal particles from water. The principle of flocculation was well understood by the better candidates, and most of the others knew the word if not its meaning.

(c) For part (i), about half the entry knew about the negative charge on clays which provides an ion exchange surface. Few were able to answer the question in terms of the equilibrium involved, using instead vague statements such as 'when the plants want nutrients'. Concentrations of potassium ions were rarely mentioned.

Good responses to part (ii) discussed ion exchange and the leaching of nutrient ions. Some candidates sidestepped onto eutrophication again. The weakest left the whole of part (c) blank.

2815/04: Methods of Analysis and Detection (Written Examination)

General Comments

This paper was generally similar in performance to those of previous January sessions, with pleasingly no 'dead' marks, although candidates inevitably found some marks more difficult to score than others. Each of the four questions showed a range of responses, with a number of problems that arose on previous papers tackled more securely by many candidates.

Comments on Individual Questions

1)   This question proved to be the lowest scoring on the paper, with a large number of candidates apparently misreading some of the information and/or questions.

(a)   Part (i) was generally well answered with only a minority of candidates choosing an isotope other than ^{13}C.

In (ii), most candidates knew that the number of carbons atoms present in the molecule could be deduced form the (M+1) peak, but a smaller number referred to the natural abundance of ^{13}C.

(b)   Although many candidates correctly identified the two halogen isotopes, some gave the mass numbers of the isotopes that would produce the M peaks.

(c)   In (i), despite the question asking for the molecular ions, a large proportion of candidates only quoted the halogen isotopes present, and many omitted the charge on the ions.

Part (ii) proved a difficult question with few candidates knowing how to manipulate the relative abundances of the two pairs of isotopes in order to calculate the ratio of the three peak heights.

(d)   Candidates found this question tricky, partly because they did not use all of the information provided. A significant number ignored the fact that the compounds were alcohols. Also, from the formula given, candidates should have deduced that the alcohols were saturated. Further, some ignored the fact that **A** did not produce a peak at *m/e* 43. As a result, it was rare for a candidate to score all three marks here.

2)   This question produced some good answers, but many were spoiled by poor

descriptions in part c)(ii).

    (a)   In (i), few candidates had difficulty in naming a method.

               In (ii), most candidates knew that the R_f value could be used here.

               In (iii), most candidates produced adequate sketches, although a number inverted the expression for the R_f value.

    (b)   In (i), many candidates knew that this was the retention time.

               In (ii), the sketches were less precise and few showed the time from injection to the centre of the given peak. A significant number of candidates talked about the peak area.

    (c)   In (i), many candidates correctly described the process as partition.

               In (ii), few candidates thought of four points to give in their answers. Omission of the two phases was common, as was any indication of the key factors in the separation, such as molecular size, volatility or interaction with the stationary phase.

3)   Candidates produced better answers to this section on uv/visible spectroscopy than in previous January sessions.

    (a)   This question was generally answered well, with most candidates appreciating that electrons needed to be excited before they could produce an emission spectrum.

    (b)   This was again well answered, with few candidates unable to state that energy was quantised or that only discrete energy levels existed in atoms.

    (c)   Although a pleasing number of candidates correctly evaluated the energy, a significant number had difficulty in either transforming the expression, or in expressing 125 nm in standard form.

    (d)   In (i), few candidates had trouble in naming *chromophores* here.

               In Part (ii), the task was to recognise which molecules contained *n* or π electrons, and nearly all candidates correctly chose propene. There was less unanimity over the second choice, and only around half the candidates chose both benzene and ethanol as their other compounds.

(e)   This part proved the most taxing with some candidates struggling with the logic required. Almost all candidates recognised the structural difference between vitamin **A** and compound **C**. Correct logic was required in terms of the increased delocalisation in vitamin **A,** energy levels in the molecule that are closer together, and hence less energy required for the promotion of electrons.

4)   There were opportunities for candidates to score good marks on this question yet, disappointingly for many candidates, this was the lowest scoring question. Despite the wealth of data provided, and the indication of 9 marks for part **b)**, many candidates chose to give four or five pieces of incomplete data and little more. The mark for Quality of Written Communication was often withheld due to a lack of cohesion and the absence of appropriate technical terms.

(a)   Although most candidates used the mass spectrum and correctly deduced the values of x and y, some chose an incorrect M value from the mass spectrum.

(b)   Candidates could answer this part by using any of the data **from the spectra provided**. This meant, however, that vague ranges for absorptions quoted from the *Data sheet* were not sufficient without reference to particular absorptions from the spectra.

There were at least 11 marking points for correct deductions leading to a logical structure consistent with the information given about compound **D** and the spectral evidence. Disappointingly, many answers lacked precision or gave incomplete or contradictory information.

2815/06: Transition Elements (Written Examination)

General Comments

This paper seemed to score well. There were few poor scripts and candidates attempted the majority of questions. Most scripts were legible and the general quality of diagrams was good. There was no evidence that time was a factor in this component. One important point to emphasise is that, at this level, candidates are expected to draw 3-D diagrams to show the structure of transition metal complexes. Far too many candidates are drawing diagrams which suggest a planar arrangement of bonds

Comments on Individual Questions

1)   (a)   A majority of candidates suggested the use of V_2O_5 as a catalyst in the Contact Process. The word catalyst alone was not credited, nor were non defined uses such as 'saws' or 'tools'.

         (b)   Many good diagrams were drawn. Common errors included the use of a platinum electrode in a solution of V and V^{2+} and missing some or all of the standard conditions.

         (c)   Some excellent scores were seen to part (i). A few candidates mixed up the colours of the two oxidation states required.

                 In (ii), surprisingly few candidates used the standard electrode potentials given to answer this question. A more common approach was to consider the relative strength of each species as an oxidising or reducing agent but there was considerable confusion as to which species was an oxidising agent and which was a reducing agent.

2.   (a)   Both parts of this question were well answered.

         (b)   Most candidates understood the term 'bidentate' but a few gave imprecise answers by stating 'more than one' lone pair of electrons.

(c)   Few candidates scored full marks on this part of question 2. There was some confusion about stereoisomerism in that many candidates thought that the isomers had a different structure. Many candidates did not refer to optical isomerism at all or chose the *trans* isomer before drawing the mirror images. It was common to see 'optical isomers are non superimposable' without the words 'mirror images'.

A significant number of candidates drew square planar complexes with some ingenious arrangements of ethanediamine as a monodentate ligand. As mentioned in the general comments, there are still candidates drawing non 3-D diagrams to show the arrangement of bonds in complexes.

3.   (a)   In (i), most candidates knew the splitting arrangement but some gave the incorrect electron configuration or simply left the boxes empty.

In (ii), many candidates knew the basic shapes of d-orbitals but they were less sure about which were at lower and higher energy after splitting. Candidates who knew the shape of the $3d_z{}^2$ orbital often drew it on the axes labelled as y.

(b)   Most candidates answered this part of question 3 using sentences containing the appropriate technical terms and the majority of candidates scored the mark awarded for the quality of written communication. Good candidates were able to explain fully why complexes of Cu^{2+} are coloured whilst those of Cu^+ are not, but weaker candidates did not realise that visible light was absorbed and few related colour to the size of the energy gap between the split d-orbitals. A common misconception was that the d-orbitals do not split at all in copper(I) complexes.

(c)   Very few candidates obtained both marks for this question. Many candidates talked about purple light being transmitted rather than violet and red.

4.   (a)   Many candidates were able to combine the half equations given to construct the overall redox equation. A few candidates managed to have iodine on the LHS, i.e. as a reagent rather than a product.

Part (ii) proved to be quite challenging. Many candidates failed to link sodium thiosulphate to iodine titrations. Some thought that thiosulphate and thiocyanate were the same species. Better candidates, who did realise that thiosulphate would decolorise iodine, often did not realise that the final colour would be green due to Cr^{3+} ions.

(b)   Part (i) was generally well answered although a few candidates thought that the oxidation state of hydrogen and oxygen changed in this reaction.

Part (ii) was well answered by the majority although quite a few candidates suggested orange to green.

In (iii), most candidates chose a suitable named acid for this. The word 'acid' on its own was not credited.

2816/1: Unifying Concepts in Chemistry (Written Examination)

General Comments

As in January 2004, Centres with an entry of only one student dominated the entry - likely resits from last June 2004.

The quality of the work seen was poorer than in January 2004 suggesting that many candidates had insufficient preparation for this examination. Only one Centre provided a large number of candidates and the quality of the work seen from these was significantly better than that seen in the majority of other scripts. These students better represented the full ability range.

Comments on Individual Questions

1)   (a)   This was answered well by most candidates. Weak candidates used square brackets or showed an expression for K_p and this was penalised

        (b)   The responses seen often demonstrated an excellent understanding of chemical equilibrium. However a significant number of candidates were unable to structure their responses and it was indeed disappointing to see the equilibrium being shifted in the wrong direction or even confusion between exothermic and endothermic. Some candidates ignored the data in Table 1.1 entirely. The first part to this question proved to be the most problematic for candidates. The Examiners required both a reasoned statement that increased pressure favours the products and also recognition of the limitations of using high pressures.

        (c)   Able candidates successfully calculated an equilibrium SO_3 yield of 95%. Unfortunately many candidates lost their way with this calculation. Most disappointing was the inability of many to rearrange the K_p expression and also poor calculator skills when taking a square root.

        (d)   In (i), most Candidates were able to construct an equation for the reaction of ZnS with O_2 to form SO_2 for the first mark. Only the best candidates gave the oxide of zinc as the other product, the majority obtaining zinc instead.

                In (ii), the Examiners expected a response in terms of the increased availability of zinc sulphide over sulphur.

2)   (a)   Most candidates scored all three marks in this part with comparative ease.

In (i), the majority of candidates correctly stated that the gradient or tangent was required but it was surprising that many ignored the emphasised reference to the 'initial' rate. Weak candidates often responded in terms of half-life.

In (ii), many candidates correctly calculated the correct answer of 2000 dm^3 mol^{-1} s^{-1}. However, as in 1(c), it was disappointing that many candidates were unable to rearrange the rate equation and it was common to see the inverse value of 0.0005 in the final answer.

In (iii), most correctly responded in terms of the stoichiometry of methanal and oxygen.

Part (iv) was usually answered correctly although some candidates were reluctant to state that the reaction rate and the rate constant would **both** increase.

(c)   Candidates found part (i) extremely testing with very few able to recognise that an oxygen free radical has two unpaired electrons. Most incorrectly guessed that two oxygen radicals were formed.

In (ii), there were many inventive responses seen and the Examiners accepted a correctly-bonded structure with the correct number of electrons throughout. It was essential that the electrons from each oxygen atom were shown differently. The commonest error was to see a central oxygen atom bonded to two others with single bonds but with an extra electron added to each outer oxygen atom in an attempt to make an octet. The ideal solution required a central oxygen atom with a double bond to one oxygen atom and a dative covalent bond to the other.

Part (iii) discriminated extremely well. The weakest candidates used numbers at random and it was common to see the Avogadro constant introduced. Although many were able to correctly calculate the number of moles of ozone or chlorine free radicals, only the most able were able to arrive at the correct answer of 111,000 molecules.

3)   (a)   Most candidates gained both marks easily.

(b)   This part was answered well by the majority of candidates but there was evidence that some had little idea of the meaning of acid-base pairs.

(c)   In (i), the Examiners required a K_a expression using phenol and the phenoxide ion. Responses in terms of HA were not credited. In (ii), the majority were able to calculate a pH value using a well-rehearsed method based on $\sqrt{(K_a \times [HA])}$. Only the better candidates identified that the concentration given was in g dm^{-3} and that conversion to mol dm^{-3} was required to produce the correct pH of 5.14. Consequently the majority incorrectly used 38 g dm^{-3} in the K_a expression and this response gave as incorrect pH value of 4.15.

(d)   Many candidates identified that the phenoxide would be required and the commonest responses seen were mono- or di-sodium salts, sodium or sodium hydroxide. These were all credited. Comparatively few then went on the state that this would produce a weak acid and its conjugate base.

4) (a) Although most candidates attempted to plot a titration curve, marks were often lost be carelessness and poor graph-plotting skills. Candidates were expected to plot a rising curve from a pH of 2.9 to a maximum pH of 13. A sharp rise was expected after addition of 25 cm^3 of the aqueous sodium hydroxide. It was essential that labelled axes were added with appropriate scales. Common errors showed a maximum pH of 14 (impossible to reach with 0.100 mol dm^{-3} NaOH) and sloppy plotting of the starting pH. Axes were often poorly labelled with non-linear scales. Consequently the Examiners awarded the maximum 6 marks comparatively rarely.

   (b) Most candidates correctly stated that phenolphthalein is suitable as it changes colour over the rapid pH change. Far fewer candidates stated that methyl orange would be unsuitable, as it would change colour **before** the rapid pH rise.

   (c) To secure both marks here, candidates were expected to identify that 12.5 cm^3 of NaOH(aq) would be required and that the starting pH would be greater than 2.9. It was common to see vague responses such as 'the curve would move to the left', 'less NaOH would be needed', 'the rise would be less steep'. These responses were not credited.

   (d) It is refreshing to see how confidently some candidates are able to handle questions using the Mole Concept in the second year of the Chemistry A level course. Consequently many candidates correctly produced a molar mass of 93 g mol^{-1}. A common mistake was an answer of 930 g mol^{-1} by ignoring the ten-fold dilution. Unfortunately the weakest candidates made little progress beyond calculating the number of moles of HCl. The best candidates went on to confidently derive the structure of **B** as phenylamine to score the final 2 marks. Many candidates derived structures but unfortunately these were often acids with molar masses different from 93 g mol^{-1}.

2816/2: Coursework 2 (Coursework)

General Comments

There were very few candidates submitting coursework for the first time and the entry consisted mostly of re-submissions aimed at improving on a poor mark obtained previously. Perhaps because of this the standard was very variable and, although occasionally the Moderators were pleased to find work of a high quality, too often it was felt that the candidates had not fully appreciated the depth that was necessary to achieve the highest standards. This was particularly disappointing when it appeared that clear advice offered in the Centre report from the summer session had been disregarded.

Centres generally based the assessment on the exemplar experiments and their associated mark schemes. Nearly all had appreciated that the latest version of the guidance booklet should now be used. From the Summer 2005 examination season it must be emphasised that all coursework will be moderated on this basis. Although changes are generally minor, there are particularly important adjustments to the 'Identification of an organic unknown' and to the 'Determination of a rate equation'. In the former case the assessment has been made more demanding and in the latter there is a change to the way the exercise should be presented to the students. In addition observations are now obligatory within the 'b' strands of skill I. There is also a clear requirement for references to be included at level P7a.

Comments on Individual Skills

Planning

Candidates were usually able to provide an experiment to address the problem that had been posed but fewer were able to provide 'a detailed plan which could be used by others without modification' as specified in P7a. It is not sufficient to outline a procedure from which a procedure might be deduced. The requirement that information should be evaluated (also P7a) means that the reason for the various decisions taken must be justified. Both these criteria often seemed to be ignored in the award of level 7.

Implementing

The 'a strands are usually criteria that only the Centre can judge and it appeared that in rewarding these, too low a standard had been accepted for the 'b' skills. Key observations must be included to award I7b and, in particular, this means the appearance of the product if an organic preparation has been used. It should also be noted that 'clear' is not synonymous with 'colourless' and this is not acceptable for I7b. Where burette readings are made, the initial volume must be included in the results even if the burette is filled each time to the 'zero' mark. This volume will, after all, have been noted. Finally measurements must be expressed to the accuracy possible for the piece of equipment being used.

Analysis

The assessments made were usually reliable and the only issue concerns the appropriate use of significant figures which is expected for A7a.

Evaluating

This is a difficult skill and candidates often struggled to achieve the higher levels. It is hoped that the more structured approach suggested in the guidance booklet will be used to help students at AS. The main area of concern remains the recognition of those errors of procedure and measurement that have a significant effect on the result. This is required to award E5b. It should also be made clear that the mention of a standard procedure cannot be counted as an improvement. For example, using the various washing procedures to ensure volumetric equipment is suitable for use cannot be awarded marks even at the lowest level. Equally statements such as 'use a more accurate balance' must be accompanied by a reason as to why this would be relevant.

2816/03: Practical Examination II (Practical Examination)

General Comments

The number of candidates entered for this component was relatively small, representing a limited number of Centres. Therefore, this report will include only the main observations on scripts written for this component. There was a very wide variation in the standard of the scripts.

Comments on Individual Questions

Plan   Most candidates wrote good answers for the analytical tests in the first part in the Plan. The few marks lost were for failure to give correct equations: wrong charges on ions were a common fault here. In addition, some candidates omitted the important requirement that heat is needed to test for ammonium ions with alkali. Since candidates have opportunity to research these details, they are expected to report them accurately.

Many candidates wrote good descriptions of the colorimeter experiment, despite the fact that the context was different to that in the specification. Inevitably, some candidates lost marks through lack of detail, but only a few were completely unable to adapt their understanding of this technique. When discussing safety, some candidates over-state the hazard of materials they are using. For example, aqueous barium chloride (in dilute solution) is not described as "toxic" on Hazcards. In future Examiners will be stricter on the semi-legible writing seen on a few handwritten plans.

Test   Part   It was pleasing to note a very high standard of accuracy from almost all
        1   candidates on this titration. Some candidates waste marks on this part by elementary errors, such as failure to include all readings, omitting units or not quoting measurements with suitable precision.

        Part   Despite the routine nature of this redox calculation, weaker candidates soon
        2   floundered. However, most candidates made easy work of it, deducing correctly that $x = 6$ in the formula of the double salt.

        Part   Some commercial samples of iron(II) ammonium sulphate do give a trace of
        3   colour when added to thiocyanate ions, presumably due to aerial oxidation of Fe^{2+} ions, but others do not. Accordingly, in (c), both positive and negative observations were credited.

        Part   Able candidates were able to score very well on the Evaluation section,
        4   although weaker candidates were often reduced to vague generalisations. In (a) very few candidates spotted that 1 mole of E would produce 2 moles of barium sulphate. In (b), even fewer realised that, since the mass of barium sulphate is

obtained from the difference between two mass readings, its potential error would be doubled to 0.02 g. Some candidates considered the need to ensure that excess barium chloride was used, or were aware of problems with complete drying of the filter paper and residue, in (c). However, many candidates scored good marks by adapting the procedure through repeating readings and complete drying of the residue. A few candidates referred to alleged difficulties removing the solid from the filter paper, thereby showing a lack of knowledge as to how this technique would be carried out.

Advanced GCE Chemistry 3882/7882
January 2005 Assessment Session

Unit Threshold Marks

Unit		Maximum Mark	a	b	c	d	e	u
2811	Raw	60	46	40	34	29	24	0
	UMS	90	72	63	54	45	36	0
2812	Raw	60	46	40	34	29	24	0
	UMS	90	72	63	54	45	36	0
2813A	Raw	120	93	83	73	64	55	0
	UMS	120	96	84	72	60	48	0
2813B	Raw	120	93	83	73	64	55	0
	UMS	120	96	84	72	60	48	0
2813C	Raw	120	87	77	67	57	48	0
	UMS	120	96	84	72	60	48	0
2814	Raw	90	69	62	56	50	44	0
	UMS	90	72	63	54	45	36	0
2815A	Raw	90	67	59	52	45	38	0
	UMS	90	72	63	54	45	36	0
2815B	Raw	90	66	59	52	46	40	0
	UMS	90	72	63	54	45	36	0
2815C	Raw	90	69	61	53	45	38	0
	UMS	90	72	63	54	45	36	0
2815E	Raw	90	69	62	55	48	41	0
	UMS	90	72	63	54	45	36	0
2816A	Raw	120	95	85	75	65	55	0
	UMS	120	96	84	72	60	48	0
2816B	Raw	120	95	85	75	65	55	0
	UMS	120	96	84	72	60	48	0
2816C	Raw	120	91	79	67	56	45	0
	UMS	120	96	84	72	60	48	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
3882	300	240	210	180	150	120	0

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

	A	B	C	D	E	U	Total Number of Candidates
3882	12.75	33.75	58.00	75.25	93.75	100	400

	Maximum Mark	A	B	C	D	E	U
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
7882	24.78	55.75	81.42	92.04	98.23	100	113