AQA A-LEVEL CHEMISTRY · 7405

CHEMISTRY



MARK SCHEME

3.2.3 GROUP 7, THE HALOGENS

SCORE	PERCENTAGE
/281	%

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Q1.

C

[1]

Q2.

Marks awarded for this answer will be determined by the quality of written communication as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking. **Additional tests limits to lower mark within a level.** This would include, for example, adding silver nitrate to the already identified sodium carbonate. Use of hydrochloric acid with silver nitrate also limits to lower mark within a level as this would not be a logical sequence/method that would work.	
Level 3 5-6 marks	All stages are covered and each stage is generally correct and virtually complete. Answer is communicated coherently and shows a logical progression from Stage 1 to Stages 2 and 3 to identify all three compounds in a logical sequence with results and equations for all compounds stated. **Covers 2 tests with matching observations, conclusions and equations**
Level 2 3-4 marks	All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR two stages are covered and are generally correct and virtually complete. Answer is communicated mainly coherently and shows a logical progression from Stage 1 to Stages 2 and 3. **Covers 2 compounds** Isolated tests on named compounds – max LEVEL 2
Level 1 1-2 marks	Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR only one stage is covered but is generally correct and virtually complete. Answer includes isolated statements but these are not presented in a logical order.

Indicative Chemistry Content

Stage 1 Suggested tests
1a Add named acid to all 3
1b Add water / make into a solution
1c Add $AgNO_3$

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Ignore addition of NH_3 / Ignore additional test for CO_2 produced

Stage 2 Expected observations - conclusions
2a Na_2CO_3 will fizz with acid
2b NaCl gives white ppt with $AgNO_3$
2c NaF shows no (visible) change / no ppt
Additional incorrect observations loses point

Stage 3 Equations – state symbols must match method
3a $Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$ … or ionic
3b $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
… or ionic
3c correct state symbols

[6]

Q3.

(a) Ba^{2+} OR Sr^{2+}

1

Award M1 if barium named in M1 then used Ba^{2+} in the equation

M2 SO_4^{2-} (aq) + Ba^{2+} (aq) ⟶ $BaSO_4$ (s)

1

(b) OH^-

Award M1 if hydroxide named in M1 then used OH^- in the equation

1

Mg^{2+} (aq) + $2OH^-$ (aq) ⟶ $Mg(OH)_2$ (s)

1

[4]

Q4.

C

[1]

Q5.

C

[1]

Q6.

A

[1]

Q7.

(a) Enthalpy change or heat energy change when 1 mol of solid ionic compound/substance or 1 mol of ionic lattice

1

is formed from its gaseous ions.

1

Allow: enthalpy change for:

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$M^+ (g) + X^- (g) \longrightarrow MX (s)$ or $Ag^+ (g) + I^- (g) \longrightarrow AgI (s)$

CE=0/2 if describing wrong process (e.g. ΔH of lattice dissociation or ΔH of formation / or heat energy required)

Ignore heat energy released

(b) lattice dissociation energy= (112 + 464 + 293) = + 869 ($kJmol^{-}1$)

1

lattice formation energy = − 869 (kJ $mol^{-}1$)

(+)869 = 1 mark

1

(c) AgI contains <u>covalent</u> character

CE=0/2 if atoms/molecules

For M1, allow the following:

not completely ionic / ions not spherical / ions distorted / some covalent bonding

1

Forces / bonds (holding the lattice together) are stronger

Ignore covalent bonds stronger (than ionic bonds)

Ignore electronegativity

Ignore references to energy

1

(d) $AgNO_3$
<u>yellow</u> ppt

Ignore ammonia/acidified/nitric acid/sulfuric acid

1

or

Cl_2 or Br_2
brown solution/black ppt

M2 dependent on correct M1 but mark on from Ag^+ or Tollens

1

[8]

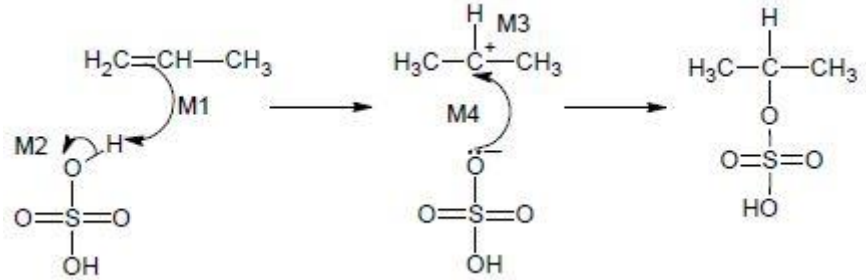
Q8.

(a) <u>electrophilic addition</u>

ALLOW phonetic e.g. electrophylic, electrophillic

1

(b)



M1: must show an arrow from = of C=C towards the H atom of the H–O bond or HO that is part of H–O–S–… on a compound with molecular formula H_2SO_4

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M1 could have arrow to H^+ in which case **M2** would be for an independent H–O bond break on a compoundwith formula H_2SO_4

ALLOW CH_3–C^+ etc for carbocation

No need for hydrogensulfate to be displayed

*If H_2O used as electrophile – max **M3** ONLY*

M2: must use an arrow to show the breaking of the H–O bond

***M2** ignore partial charges unless wrong*

M3: is for the correct carbocation structure

*NOT **M3** if primary carbocation shown.*

M4: must show an arrow from a lone pair of electrons on the correct oxygen of the negatively charged ion towards the positively charged carbon atom

***M4** NOT HSO_4*

credit as shown (or $^-$:OSO_2OH)

or as :OSO_3H – in which case negative charge can be shown anywhere

*ecf from H_2SO_3 in **M1***

NB: The arrows are double-headed

***IGNORE** subsequent use of water to hydrolyse hydrogensulfate*

4

(c) minor product = $CH_3CH_2CH_2OSO_3H$

ecf from 1° in (b) for $CH_3CH(OSO_3H)CH_3$

ecf from alcohol as product in (b)

ecf from side chain such as –$OHSO_3$ or –HSO_4 in (b)

1

(d) (major) product formed via more stable carbocation OR secondary carbocation more stable (than primary)

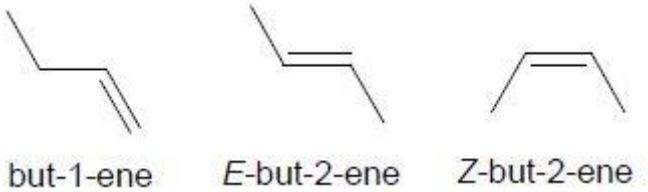
1

Due to electron-releasing character / (positive) inductive effect of two alkyl / methyl groups (as opposed to one)

1

ALLOW 'more' alkyl groups in place of 'two' alkyl groups

(e)



*matching name **and** formula for each mark*

One 'salvage' mark available for 3 correct structures or 3 correct names if no other mark awarded

*use of trans **and** cis can score 1/2 for the two but-2-ene structures*

3

(f) butanone

ALLOW butan-2-one

1

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oxidising agent

ALLOW electron acceptor but NOT electron pair acceptor

1

(fractional) distillation

ALLOW gas <u>chromatography</u>

1

(g) white / misty / steamy fumes

NOT gas evolved / effervescence

1

acid/proton donor

1

(h) iodine / I_2

IGNORE state symbols

1

sulfur / S / S_8

*If name **and** formula given they must both be right*

1

hydrogen sulfide / H_2S

1

[19]

Q9.

This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3

All stages are covered and the explanation of each stage is generally correct and virtually complete.

Stage 2 is supported by correct equations.

Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. The steps in stage 3 are in a logical order.

5-6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3-4 marks

Level 1

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, **OR** only one stage is covered but the explanation is generally correct and virtually complete.

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Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1-2 marks

Level 0

Insufficient correct chemistry to warrant a mark.

0 marks

Indicative Chemistry content

Stage 1 Apparatus

- *Boiling tube likely to be too small for 50.0 g solid plus acid*
- *Use a (large / medium / 250 ml) beaker instead*

Stage 2 AgCl Prep

- *HNO_3 will form soluble $AgNO_3$ so max AgCl not obtained*
- *Use HCl instead*
- *Method doesn't say how much acid should be used*
  Or
  Use excess acid / Add acid until no more bubbles evolved

Stage 3 Making pure dry solid

- *Decanting means solid wet / contaminated with HNO_3 / acid or decanting means some solid lost*
- *Instead use filter and then wash with distilled water*
  (and then dry)

[6]

Q10.

(a) $SrCl_2$> ICl > Br>

If wrong can award 1 for one in the correct 'position'

2

$SrCl_2$ strong ionic bonds / (strong electrostatic attraction between opposite ions)

1

Lattice so many strong bonds to overcome

1

ICl has dipole-dipole between molecules – weaker than ionic bonds

1

Br_2 has van der Waals forces between molecules – much weaker

Accept London / dispersion / induced dipole forces

1

(b) $Cl_2 + H_2O \rightleftharpoons HCl + HClO$

OR $2Cl_2 + 2H_2O \rightleftharpoons O_2 + 4HCl$

OR $Cl_2 + H_2O \rightleftharpoons 2H^+ + Cl^- + ClO^-$

1

Kills bacteria

1

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Wasteful as most potable water not used for drinking - used in washing clothes etc

OR Some people suffer eye irritation / Some people find the taste unpleasant

OR can react with organic compounds to produce harmful substances

Allow 'it is potentially toxic as it can be if over concentrated'

1

(c) $6Br_2 + P_4 \longrightarrow 4PBr_3$

Accept 4P for P_4

1

Pyramidal shown in a diagram (but the name of the shape isn't needed)

1

100–108°

Actual value is 101° (hence larger range of values allowed)

1

(d) Tetrahedral shown in a diagram (but the name of the shape isn't needed)

1

109.5°

Accept 109° or 109°28'

1

[14]

Q11.

A

[1]

Q12.

A

[1]

Q13.

(a) **A** Silver bromide / AgBr

1

B Iron(II) carbonate / $FeCO_3$

1

C Iron(II) sulphate / $FeSO_4$

1

D Carbon dioxide / CO_2

1

Y Iron(II) bromide / $FeBr_2$

1

(b) $Ag^+ + Br^- \longrightarrow AgBr$

Allow equation if state symbols missing but penalise if state symbols are incorrect

1

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(c) $2H^+ + CO_3^{2-} \longrightarrow H_2O + CO_2$

Allow $FeCO_3 + 2H^+ \longrightarrow Fe^{2+} + CO_2 + H_2O$

1

[7]

Q14.

(a) $2NaBr + 2H_2SO_4 \longrightarrow Na_2SO_4 + Br_2 + SO_2 + 2H_2O$

Allow ionic equation

$2Br^- + 2H_2SO_4 \longrightarrow Br_2 + SO_4^{2-} + SO_2 + 2H_2O$

1

Br^- ions are bigger than Cl^- ions

1

Therefore Br^- ions more easily oxidised / lose an electron more easily (than Cl^- ions)

1

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3

All stages are covered and the explanation of each stage is generally correct and virtually complete. Stages 1 and 2 are supported by correct equations.

Answer communicates the whole process coherently and shows a logical progression from stage 1 to stage 2 and then stage 3. The steps in stage 3 are in a logical order.

5–6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3–4 marks

Level 1

Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1–2 marks

Level 0

Insufficient correct chemistry to warrant a mark.

0 marks

Indicative chemistry content

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***Stage 1**: formation of precipitates*

- *Add silver nitrate*
- *to form precipitates of AgCl and AgBr*
- *$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$*
- *$AgNO_3 + NaBr \rightarrow AgBr + NaNO_3$*

***Stage 2**: selective dissolving of AgCl*

- *Add excess of dilute ammonia to the mixture of precipitates*
- *the silver chloride precipitate dissolves*
- *$AgCl + 2NH_3 \rightarrow Ag(NH_3)_2^+ + Cl^-$*

***Stage 3**: separation and purification of AgBr*

- *Filter off the remaining silver bromide precipitate*
- *Wash to remove soluble compounds*
- *Dry to remove water*

6

(c) $Cl_2 + 2HO^- \longrightarrow OCl^- + Cl^- + H_2O$

1

OCl^- is +1

Cl^- is –1

Both required for the mark

1

[11]

Q15.

D

[1]

Q16.

(a) Ethoxyethane is flammable

Accept "to avoid igniting ethoxyethane vapour".

1

(b) Ethoxyethane (vapour) forms a protective layer

Water and ethoxyethane are immiscible.

Do not allow 'ethoxyethane is dense' without further qualification.

1

(c) Acidified potassium dichromate(VI)/$K_2Cr_2O_7$ **M1**

*If incomplete, lose **M1** but mark on. If incorrect CE = 0/3.*

Accept acidified sodium dichromate / $Na_2Cr_2O_7$

1

Observation with 2-methylpropan-2-ol – no colour change **M2**

Accept "stays orange".

1

Observation with 2-methylpropan-1-ol – (orange to) green **M3**

Accept chemically correct alternatives.

1

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(d) i. (Acidified) silver nitrate (solution)

Allow a chemically correct alternative reagent.

1

ii. Cream / off-white precipitate

Allow this alternative with correct observation.

1

Dilute ammonia solution **OR** Conc ammonia solution

Allow this alternative with correct confirmatory reagent or procedure.

1

some ppt dissolves or ppt dissolves

Allow this alternative with correct confirmatory result.

*Do not allow full marks for alternatives without **both** a test and a confirmation.*

1

[9]

Q17.

Filter

Must be in this order

1

Wash (the residue) with water

1

Dry by pressing between filter paper or in air

Allow other suitable methods for drying. If heat is mentioned, method of gentle heating must be specified. Heat, alone, is not sufficient

1

[3]

Q18.

(a) $2Cl^- \longrightarrow Cl_2 + 2e^{(-)}$

Allow $2Cl^- - 2e^{(-)} \longrightarrow Cl_2$

Allow correct equation forming ClO^- *but not* Cl^+

1

(b) $2ClO^- + 4H^+ + 2e^- \longrightarrow Cl_2 + 2H_2O$

Allow HClO in correctly balanced equation

1

(c) $ClO^- + Cl^- + 2H^+ \longrightarrow Cl_2 + H_2O$

allow $HClO + HCl + \longrightarrow Cl_2 + H_2O$

1

(d) Goes brown (or shades of brown)

Allow black ppt/solid but NOT black solution or purple

1

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Due to iodine or I_3^-

Correct ½ equation scores M2 and M3

1

Because I^- oxidised

1

[6]

Q19.

(a) Increasing atomic radius / shielding / number of shells / size (down group) or reverse argument

***NOT** 'molecules'*

1

Decreasing attraction of <u>nucleus/protons</u> for shared (electron) pair / bond electrons

***NOT** if attraction for single electron implied*

1

(b) (i) Electron acceptor / species that accepts electrons / species that gains electrons

***NOT** electron pair*

***NOT** just 'gain of electrons'*

1

(ii) Chlorine 0 to –1 / oxidation state/number of chlorine decreases
AND
Bromine –1 to 0 / oxidation state/number of bromine increases

Penalise if oxidised for chlorine and/or reduced for bromine

Credit oxidation states if labelled on equation

1

(c) (i) $H_2SO_4 + 8H^+ + 8e^{(-)} \longrightarrow H_2S + 4H_2O$

ALLOW $SO_4^{2-} + 10H^+ + 8e^{(-)} \longrightarrow H_2S + 4H_2O$

***ALLOW** fractions/multiples*

***IGNORE** state symbols*

1

(ii) $2I^- \longrightarrow I_2 + 2e^{(-)}$

***ALLOW** fractions/multiples*

***IGNORE** state symbols*

ALLOW $2I^- - 2e^{(-)} \longrightarrow I_2$

1

(iii) $H_2SO_4 + 8H^+ + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2$

ALLOW

$H_2SO_4 + 8HI \longrightarrow H_2S + 4H_2O + 4I_2$

$SO_4^{2-} + 2H^+ + 8HI \longrightarrow H_2S + 4H_2O + 4I_2$

$SO_4^{2-} + 10H^+ + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2$

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$9H_2SO_4 + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2 + 8HSO_4^-$

$9H_2SO_4 + 8NaI \longrightarrow H_2S + 4H_2O + 4I_2 + 8NaHSO_4$

$H_2SO_4 + 8H^+ + 8NaI \longrightarrow H_2S + 4H_2O + 4I_2 + 8Na^+$

$5H_2SO_4 + 8I^- \longrightarrow H_2S + 4H_2O + 4I_2 + 4SO_4^{2-}$

$5H_2SO_4 + 8NaI \longrightarrow H_2S + 4H_2O + 4I_2 + 4Na_2SO_4$

1

(iv) 'Oxidising agent' box ticked

1

(v) $H_2SO_4 + 2NaF \longrightarrow Na_2SO_4 + 2HF$

OR

$H_2SO_4 + NaF \longrightarrow NaHSO_4 + HF$

1

(vi) Fluoride less powerful reducing agent (than iodide)

OR

Fluoride less easily oxidised than iodide

Or reverse argument in either case

***NOT** general group VII trend statement*

***NOT** fluorine/F or iodine/I*

Must be comparative

1

(d) (i) $Cl_2 + H_2O \rightleftharpoons 2H^+ + Cl^- + ClO^-/HCl + HOCl$

***ALLOW** $\longrightarrow$ for $\rightleftharpoons$*

1

(ii) Equilibrium shifts/moves left

1

(Producing) chlorine (which) is toxic/poisonous

Mark independently

1

[13]

Q20.

(a) **M1** acidified potassium dichromate or $K_2Cr_2O_7$ / H_2SO_4

OR $K_2Cr_2O_7$ / H^+ ***OR*** acidified $K_2Cr_2O_7$

M2 (orange to) green solution ***OR*** goes green

M3 (solution) remains orange or no reaction or no (observed) change

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent e.g. "dichromate" or "dichromate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*For **M2** ignore dichromate described as "yellow" or "red"*

*For **M3** ignore "nothing (happens)" or "no observation"*

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Alternative using $KMnO_4$ / H_2SO_4

M1 acidified potassium manganate(VII) / potassium permanganate or $KMnO_4$ / H_2SO_4

OR $KMnO_4$ / H^+ ***OR*** acidified $KMnO_4$

M2 colourless solution ***OR*** goes colourless

M3 (solution) remains purple or no reaction or no (observed) change

*For **M1***

*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green*

3

(b) **M1** (Shake with) Br_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / organic solvent)

M2 (stays) orange / red / yellow / brown / the same

OR no reaction ***OR*** no (observed) change

M3 decolourised / goes colourless / loses its colour / orange to colourless

*If no reagent or incorrect reagent in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

*If incomplete / inaccurate attempt at reagent (e.g. Br), **penalise M1 only and mark on***

*No credit for combustion observations; **CE = 0***

*For **M2 in every case***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear"

***OR* as alternatives**

Use $KMnO_4$ / H_2SO_4

M1 acidified potassium manganate(VII) / potassium permanganate ***OR*** $KMnO_4$ / H_2SO_4

OR $KMnO_4$ / H^+ ***OR*** acidified $KMnO_4$

M2 (stays) purple or no reaction or no (observed) change

M3 decolourised / goes colourless / loses its colour

Use iodine

M1 iodine or I_2 / KI or iodine solution

M2 no change

M3 decolourised / goes colourless / loses its colour

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Use concentrated sulfuric acid

M1 <u>concentrated</u> H_2SO_4

M2 no change

M3 brown

***For M1**, it must be a whole reagent and / or correct formula*

For M1** penalise incorrect attempt at correct formula, but mark **M2** and **M3

With potassium manganate(VII)

*If incomplete / inaccurate attempt at reagent e.g. "manganate" or "manganate(IV)" or incorrect formula or no acid, **penalise M1 only and mark on***

*Credit alkaline / neutral $KMnO_4$ for possible full marks but **M3** gives <u>brown precipitate</u> or solution goes <u>green</u>*

Apply similar guidance for errors in the formula of iodine or concentrated sulfuric acid reagent as those used for other reagents.

3

(c) **M1** Any <u>soluble</u> <u>chloride</u> including hydrochloric acid (ignore concentration)

M2 <u>white precipitate</u> or <u>white solid / white suspension</u>

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

M1 Any <u>soluble</u> <u>iodide</u> including HI

M2 <u>yellow precipitate</u> or <u>yellow solid / yellow suspension</u>

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

M1 Any <u>soluble</u> <u>bromide</u> including HBr

M2 <u>cream precipitate</u> or <u>cream solid / cream suspension</u>

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

***OR* as an alternative**

M1 NaOH or KOH or any <u>soluble carbonate</u>

M2 <u>brown precipitate</u> or <u>brown solid / brown suspension</u> with NaOH / KOH (<u>white precipitate / solid / suspension with carbonate</u>)

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If no reagent or incorrect reagent or insoluble chloride in **M1**,*

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CE = 0** and no marks for **M1**, **M2** or **M3

Allow chlorine water

*If incomplete reagent (e.g. chloride ions) or inaccurate attempt at formula of chosen chloride, or chlorine, **penalise M1 only and mark on***

*For **M2** require the word "white" and some reference to a solid. Ignore "cloudy solution" OR "suspension" (similarly for the alternatives)*

*For **M3***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear" <u>on its own</u>

Ignore "dissolves"

3

(d) **M1** Any <u>soluble</u> <u>sulfate</u> including (dilute or aqueous) sulfuric acid

M2 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

M3 <u>white precipitate</u> or <u>white solid / white suspension</u>

*If no reagent or incorrect reagent or insoluble sulfate in **M1**, **CE = 0** and no marks for **M1**, **M2** or **M3***

Accept $MgSO_4$ and $CaSO_4$ but not barium, lead or silver sulfates

*If concentrated sulfuric acid or incomplete reagent (e.g. sulfate ions) or inaccurate attempt at formula of chosen sulfate, **penalise M1 only and mark on***

*For **M3 (or M2 in the alternative)** require the word "white" and some reference to a solid.*

Ignore "cloudy solution" OR "suspension"

*For **M2 (or M3 in the alternative)***

Ignore "nothing (happens)"

Ignore "no observation"

Ignore "clear" <u>on its own</u>

Ignore "dissolves"

***OR* as an alternative**

M1 NaOH or KOH

M2 <u>white precipitate</u> or <u>white solid / white suspension</u>

M3 remains colourless or no reaction or no (observed) change or no precipitate or clear solution or it remains clear

*If incomplete reagent (e.g. hydroxide ions) or inaccurate attempt at formula of chosen hydroxide, **penalise M1 only and mark on***

*If **M1** uses NH_3 (dilute or concentrated) **penalise M1 only and mark on***

3

[12]

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Q21.

(a) (i) $\mathbf{2}Cl^- \longrightarrow Cl_2 + \mathbf{2}e^-$

Ignore state symbols
Credit loss of electrons from LHS
Credit multiples
Do not penalise absence of charge on electron

1

(ii) +7 ***OR*** 7 ***OR*** VII ***OR*** +VII

Allow Mn^{+7} and 7+

1

(iii) $MnO_4^- + 8H^+ + 5\mathbf{e}^- \longrightarrow Mn^{2+} + 4H_2O$

Ignore state symbols
Credit loss of electrons from RHS
Credit multiples
Do not penalise absence of charge on electron

1

(b) (i) $Cl_2 + \mathbf{2}Br^- \longrightarrow \mathbf{2}Cl^- + Br_2$

OR

$\frac{1}{2}Cl_2 + Br^- \longrightarrow Cl^- + \frac{1}{2}Br_2$

One of these two equations only
Ignore state symbols

1

(ii) (Turns to) yellow / orange / brown (solution)

Penalise "red / reddish" as the only colour
Accept "red-brown" and "red-orange"
Ignore "liquid"
Penalise reference to a product that is a gas or a precipitate

1

(iii) (Chlorine) gains electron(s) / takes electron(s) / accepts electron(s) (from the bromide ions)

OR

(Chlorine) causes another species (Br^-) to lose electron(s)

Penalise "electron pair acceptor"
Not simply "causes loss of electrons"

1

(c) **M1** $\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$

($\mathbf{4}H^+ + \mathbf{4}Cl^-$)

M2 Oxidation state **−1**

Ignore state symbols
Credit multiples

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***M2** consequential on HCl or Cl^- which **must** be the only chlorine-containing product in the (un)balanced equation.*
*For **M2** allow Cl^{-1} or Cl^{1-} but **not** Cl^-*

2

(d) **M1 The relative size (of the molecules / atoms)**

Chlorine is <u>smaller</u> than bromine ***OR*** has fewer electrons / electron shells
*For **M1** ignore whether it refers to molecules or atoms.*

OR It is smaller / It has a smaller atomic radius / it is a smaller molecule / atom (or converse)

***CE=0** for the clip for reference to (halide) ions or incorrect statements about relative size*
Ignore molecular mass and M_r

M2 How size of the <u>intermolecular force</u> affects energy needed
Ignore shielding

The <u>forces between</u> chlorine / Cl_2 <u>molecules</u> are weaker (than the forces between bromine / Br_2 <u>molecules</u>)
(or converse for bromine)
OR chlorine / Cl_2 has <u>weaker / fewer / less</u> (VdW) <u>intermolecular forces / forces between molecules</u>
(or converse for bromine)

***QoL in M2** for clear reference to the difference in size <u>of the force between molecules</u>. Reference to Van der Waals forces alone is not enough.*
*Penalise **M2** if (covalent) bonds are broken*

2

[10]

Q22.

(a) (i) $SrCl_2(aq) + Na_2SO_4(aq) \rightarrow SrSO_4(s) + 2NaCl(aq)$
Allow multiples, including fractions.
Allow ionic equations.
Lose this mark if any of the state symbols are missing or incorrect.

1

(ii) Add nitric acid to the mixture (until in excess)
Do not allow any suggestion that the solution is an emetic.

1

Filter (to isolate strontium sulfate)

1

(b) <u>Insoluble barium sulfate</u> is formed
Allow '<u>removes barium ions as a precipitate</u>'.

1

(c) Add silver nitrate, <u>then dilute ammonia</u> (solution) **M1**
Do not allow answers which imply silver nitrate and ammonia are added at the same time.

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Allow 'add silver nitrate, then concentrated ammonia (solution)'.

*Can score **M1** in the answer for **M3***

1

Cream precipitate **M2**

Allow 'off white precipitate'.

1

No visible change or precipitate dissolves slightly in dilute ammonia **M3**

Allow 'soluble / colourless solution / precipitate dissolves in concentrated ammonia'.

Allow 3 marks for:

*Add dilute ammonia (solution), then silver nitrate **M1***

*No visible change **M2***

*Cream / off white precipitate with silver nitrate **M3***

1

[7]

Q23.

(a) (i) 1.08×10^{-2}

Do not penalise precision but must be to at least 2 significant figures.

Do not accept 1×10^{-2}

1

(ii) $5.4(0) \times 10^{-3}$

Allow (i) / 2

Do not penalise precision but must be to at least 2 significant figures.

1

(iii) 266.6

Lose this mark if answer not given to 1 decimal place.

1

(iv) mass = $5.4(0) \times 10^{-3} \times 266.6 = 1.44$ g **M1**

Allow (ii) × (iii).

1

percentage = $1.44 \times 100 / 2.25 = 64.0$ **M2**

*Allow consequential answer from **M1***

Lose this mark if answer not given to 3 significant figures.

*Correct answer with no working scores **M2** only.*

1

(v) 1 Would give an <u>incorrect / too large mass</u> (of silver chloride)

Do not allow 'to get an accurate result' without qualification.

1

2 <u>To remove</u> <u>soluble impurities</u> / <u>excess silver nitrate</u> (solution) / <u>strontium nitrate</u> (solution)

Do not allow 'to remove impurities'.

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Do not allow 'to remove excess strontium chloride solution'.

1

(b) (i) $Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$

Allow $Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg^{2+}(OH^-)_2(s)$

Allow multiples, including fractions.

Lose mark if state symbols are missing or incorrect.

Lose mark if incorrect charge on an ion.

1

(ii) Does not produce CO_2 / gas which distends stomach / does not produce wind / does not increase pressure in stomach

Allow 'prevents flatulence' and 'prevents burping'.

Do not allow 'gas' without qualification.

1

(c) $(CH_3COO)_2Ca \rightarrow CH_3COCH_3 + CaCO_3$

Allow multiples.

Allow propanone as C_3H_6O

Allow $(CH_3COO^-)_2Ca^{2+} \rightarrow CH_3COCH_3 + Ca^{2+}CO_3^{2-}$

1

(d) Ca (salt) - no visible change with sodium chromate(VI) **M1**

Allow 'yellow solution formed' or 'no ppt. forms'.

*Allow **M1** and **M2** in any order.*

1

Sr and Ba (salts) give (yellow) <u>precipitate</u> with sodium chromate(VI) **M2**

Lose this mark if precipitate has an incorrect colour.

1

Sr precipitate (chromate(VI)) dissolves in ethanoic acid / Ba precipitate (chromate(VI)) does not dissolve in ethanoic acid **M3**

*If ethanoic acid is added first, allow access to **M1** and **M3**.*

1

(e) C 42.09 / 12, H 2.92 / 1, N 8.18 / 14, O 37.42 / 16 and S 9.39 / 32.1

Accept any other correct method of working.

If relative atomic mass has been divided by the percentage composition is used then CE = 0 / 2

1

$C_{12}H_{10}N_2O_8S$

Correct answer with no working scores 1 mark only.

1

[15]

Q24.

(a) (i) $\frac{1}{2}Cl_2 + I^- \longrightarrow \frac{1}{2} I_2 + Cl^-$

***Only** these two equations.*

OR

$Cl_2 + \mathbf{2}I^- \longrightarrow I_2 + \mathbf{2}Cl^-$

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1

(ii) (Solution turns from colourless to) <u>brown / red-brown solution</u>

Allow <u>grey / black solid</u>.

Ignore "purple".

1

(b) $\mathbf{2}Cl_2 + \mathbf{2}H_2O \longrightarrow \mathbf{4}HCl + O_2$
($\mathbf{4}H^+ + \mathbf{4}Cl^-$)

Credit multiples.

1

(c) M1 **The relative size (of the molecules / atoms)**
Chlorine is small<u>er</u> than bromine OR has fewer electrons / electron shells
OR It is smaller / It has a smaller atomic radius / it is a smaller molecule / or has smaller M_r
(or converse for bromine)

Ignore general Group 7 statements.

*For **M1** ignore whether it refers to molecules or atoms.*

M2 **How size of the <u>intermolecular force</u> affects energy needed**
The forces <u>between</u> chlorine / Cl_2 <u>molecules</u> are weaker (than the forces <u>between</u> bromine / Br_2 <u>molecules</u> leading to less energy needed to separate the <u>molecules</u>)
(or converse for bromine)
OR chlorine / Cl_2 has <u>weaker / less / fewer forces</u> <u>between</u> <u>molecules</u> ***OR*** chlorine / Cl_2 <u>has weaker / less / fewer</u> <u>intermolecular forces</u>
(or converse for bromine)

***CE=0** for reference to (halide) ions.*

QoL for clear reference to the difference in size <u>of the force between molecules</u>.

*Penalise **M2** if (covalent) <u>bonds</u> are broken.*

2

[5]

Q25.

(a) M1 <u>concentrated sulfuric acid OR c(onc) H_2SO_4</u>

*If no reagent or incorrect reagent in **M1, CE= 0** and no marks for **M2** or **M3***

M2 (cream solid) turns orange
OR <u>orange / red / brown fumes / gas / vapour</u>

*If <u>dilute</u> sulfuric acid **OR** "aq" <u>(alone)</u> **CE=0***

M3 (yellow solid) turns black
OR <u>purple fumes / gas / vapour</u>
OR correct reference to H_2S <u>observation (eg bad egg smell)</u>

*If H_2SO_4 / sulfuric acid given but not stated whether dilute or concentrated, penalise **M1** and mark on for **M2** and **M3***
*If incorrect formula for the acid, penalise **M1** but mark **M2** and **M3***

***OR* as an alternative**

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M1 concentrated ammonia ***OR*** c(onc) NH_3

*If NH_3 / ammonia / aq ammonia given, but not stated as concentrated **OR** if dilute ammonia given, penalise **M1** but mark on for **M2** and **M3***
*Ignore "partially" and ignore "clear" in **M2***

M2 (cream solid) dissolves / solution formed

M3 precipitate remains / does not dissolve / insoluble
OR no reaction / no change / (yellow solid) turns to white solid

*If incorrect formula for ammonia, penalise **M1** but mark **M2** and **M3***

*In **M3** for ammonia.*
ignore "nothing (happens)".
ignore "no observation".

3

(b) M1 $AgNO_3$ ***OR*** silver nitrate ***OR*** any soluble silver salt

*If no reagent **OR** incorrect reagent in **M1**, **CE= 0** and no marks for **M2 OR M3***

M2 white precipitate or white solid / white suspension

*An insoluble silver salt OR Tollens' **OR** Ag **OR** ammoniacal silver nitrate or HCl / $AgNO_3$ **CE= 0** for the clip.*

M3 remains colourless ***OR*** no reaction ***OR*** no (observed) change ***OR*** no precipitate

*For **M1***
*Credit acidified (**OR** HNO_3) silver nitrate for **M1** and mark on.*
*If silver ions or incorrect formula for silver nitrate, penalise **M1** but mark **M2** and **M3***

Credit alternative test for nitrate ions

*For **M2***
*Ignore "cloudy solution" **OR** "suspension".*
*For **M3***
Ignore "nothing (happens)".
Ignore "no observation".
Ignore "clear".
Ignore "dissolves".

3

(c) M1 Br_2 ***OR*** bromine (water) ***OR*** bromine (in CCl_4 / organic solvent)

*If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3***

Either Order
M2 (stays) Orange / red / yellow / brown / the same
OR no reaction ***OR*** no (observed) change
OR reference to colour going to cyclohexane layer

*No credit for combustion observations; **CE=0***
*For **M2 in every case**.*
Ignore "nothing (happens)".
Ignore "no observation".
Ignore "clear".

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M3 decolourised / goes colourless / loses its colour

With bromine (water)
For M1*, it must be a whole reagent and / or correct formula.*
If oxidation state given in name, it must be correct.
For M1 *penalise incorrect formula, but mark* ***M2*** *and* ***M3***

***OR* as an alternative**

Use $KMnO_4/H_2SO_4$
M1 acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$
OR $KMnO_4/ H^+$ ***OR*** acidified $KMnO_4$
M2 (stays) purple or no reaction or no (observed) change

With potassium manganate(VII)
For M1

M3 purple to colourless solution ***OR*** goes colourless

If "manganate" or "manganate(IV)" or incorrect formula or no acid, penalise ***M1*** *but mark* ***M2*** *and* ***M3***

Credit alternative test using **iodine** (for **M1**)
M2 (brown) to purple or accept no change, M3 colourless
Credit alternative test using concentrated $H_2 SO_4$
M2 no change, M3 brown

Credit alkaline / neutral $KMnO_4$ for possible full marks but ***M3*** *gives brown precipitate or solution goes green.*

3

(d) M1 Tollens' (reagent) OR ammoniacal silver nitrate OR a description of making Tollens'
(Ignore either $AgNO_3$ or $[Ag(NH_3)_2^+]$ or "the silver mirror test" on their own, but mark M2 and M3)
M2 silver mirror
OR black solid / precipitate (Ignore silver precipitate)
M3 (stays) colourless or no reaction or no (observed) change

If no reagent or incorrect reagent in ***M1****,* ***CE= 0*** *and no marks for* ***M2*** *or* ***M3***

For M3 in every case
Ignore "nothing (happens)".
Ignore "no observation".

Alternative using Fehling's (solution)
M1 Fehling's (solution) or Benedict's solution
(Ignore $Cu^{2+}(aq)$ or $CuSO_4$ on their own, but mark M2 and M3)
M2 Red solid / precipitate (Credit Orange or brown solid)
M3 (stays) blue or no reaction or no (observed) change

With potassium dichromate(VI)
For M1
If "dichromate" or "(potassium) dichromate(IV)" or incorrect formula or no acid, penalise ***M1*** *but mark* ***M2*** *and* ***M3***

Alternative using $K_2Cr_2O_7/H_2 SO_4$
M1 acidified potassium dichromate or $K_2Cr_2O_7/H_2SO_4$
OR $K_2Cr_2O_7/H^+$ ***OR*** acidified $K_2Cr_2O_7$
M2 (Orange to) green solution OR goes green
M3 (stays) Orange or no reaction or no (observed) change

For ***M3***

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Ignore dichromate described as "yellow" or "red".

With potassium manganate(VII)
For M1
If "manganate" or "(potassium manganate(IV)" or incorrect formula or no acid, penalise M1 but mark M2 and M3

Alternative using $KMnO_4$ /H_2SO_4
M1 acidified potassium manganate(VII) or $KMnO_4$ /H_2SO_4
OR $KMnO_4$ /H^+ ***OR*** acidified $KMnO_4$
M2 purple to colourless solution OR goes colourless
M3 (stays) purple or no reaction or no (observed) change

*Credit alkaline / neutral $KMnO_4$ for possible full marks but **M2** gives brown precipitate or solution goes green.*

3

[12]

Q26.

Test silver nitrate (solution) **(M1)**

Allow an alternative soluble silver salt eg fluoride, sulfate.

Do not allow 'silver ions' but can access second mark.

Incorrect formula loses this mark but can access second mark.

*Do not allow 'silver' or an insoluble silver salt and **cannot** access second mark.*

Ignore references to acidification of the silver nitrate.

If an acid is specified it should be nitric acid, but allow sulfuric acid in this case as there are no metal ions present.

If hydrochloric acid is used, CE = 0 / 2.

Do not allow 'add water'.

1

Observation white precipitate **(M2)**

Ignore 'cloudy'.

Do not allow 'white fumes' or 'effervescence'.

Do not allow this mark if test reagent is incorrect or missing.

*Allow named indicator paper or named indicator solution for **M1**.*

*Allow correct colour change for **M2**.*

1

[2]

Q27.

M1 and M2 (either order)

Any two from

- purple vapour / gas
- (white solid goes to) black or black / grey or black / purple solid

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- bad <u>egg smell</u> or words to this effect

  Ignore misty white fumes
  Ignore yellow solid
  Ignore purple solid
  Ignore "goes (dark) brown"

M3

*Or multiples for possible equation in **M3***

The <u>iodide ion(s) / they lose (an) electron(s)</u>

OR

$2I^- \longrightarrow I_2 + 2e^-$

M4

Accept "changes by − 8"

Oxidation state of S changes from **<u>+6 to −2</u>** or **<u>changes by 8</u>**

M5

$H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

OR

$SO_4^{2-} + \mathbf{10}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

[5]

Q28.

(a) M1 $Cl_2 + \mathbf{2}Br^- \longrightarrow \mathbf{2}Cl^- + Br_2$

Accept a correct equation using ½ Cl_2 but no other multiples

M2 solution goes <u>orange / yellow</u> (from colourless)

Ignore reference to brown colour
Penalise incorrect observations eg fumes, precipitates

2

(b) M1 $Cl_2 + 2NaOH \longrightarrow NaClO + NaCl + H_2O$

(NaOCl)

Or a correct ionic equation
Ignore reference to "swimming pools" and to "disinfectant"

M2 bleach or kills bacteria / bacteriacide / micro-organisms / microbes

M3 <u>sodium chlorate(I)</u> ONLY

3

(c) M $Cl_2 + H_2O \rightleftharpoons HClO + HCl$

(HOCl)

*Equilibrium symbol **<u>required</u>** in **M1***

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Accept ionic RHS

M2

The (health) benefit outweighs the risk or wtte

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

2

(d) M1 Silver nitrate OR $AgNO_3$ (with or without nitric acid)

*For **M1***

If only the formula is written then it must be correct

If both the formula and the name are written then ignore incorrect attempt at the formula, but penalise an incorrect name

M2 (depends on M1)

white precipitate / white solid

*If the reagent is incomplete eg Ag^+ ions, penalise **M1** and mark on*

M3 $Ag^+ + Cl^- \longrightarrow AgCl$

*Penalise both **M1** and **M2** for alkaline $AgNO_3$ **OR** for the use of HCl to acidify the silver nitrate **OR** for Tollens' reagent*

3

[10]

Q29.

(a) (i) **M1** iodine ***OR*** I_2 OR I_3^-

Ignore state symbols

*Credit **M1** for "iodine solution"*

M2 $Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$

OR

$\frac{1}{2} Cl_2 + I^- \longrightarrow Cl^- + \frac{1}{2} I_2$

Penalise multiples in M2 except those shown

***M2** accept correct use of I_3^-*

M3 redox or reduction-oxidation or displacement

3

(ii) **M1** (the white precipitate is) <u>silver chloride</u>

***M1** <u>must be named</u> and for <u>this mark</u> ignore incorrect formula*

M2 $Ag^+ + Cl^- \longrightarrow AgCl$

*For **M2** ignore state symbols*

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Penalise multiples

M3 (white) precipitate / <u>it dissolves</u>

OR <u>colourless solution</u>

Ignore references to "clear" alone

3

(b) (i) **M1** $H_2SO_4 + \mathbf{2}Cl^- \longrightarrow \mathbf{2}HCl + SO_4^{2-}$

*For **M1** ignore state symbols*

OR $H_2SO_4 + Cl^- \longrightarrow HCl + HSO_4^-$

Penalise multiples for equations and apply the list principle

OR $H^+ + Cl^- \longrightarrow HCl$

M2 hydrogen chloride ***OR*** HCl ***OR*** hydrochloric acid

2

(ii) **M1 and M2 in either order**

*For **M1** and **M2**, ignore state symbols and credit multiples*

M1 $\mathbf{2}I^- \longrightarrow \mathbf{I_2} + \mathbf{2}e^-$

OR

$\mathbf{8}I^- \longrightarrow \mathbf{4}I_2 + \mathbf{8}e -$

Do not penalise absence of charge on the electron

Credit electrons shown correctly on the other side of each equation

M2 $H_2SO_4 + \mathbf{8}H^+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

OR

$SO_4^{2-} + \mathbf{10}H+ + \mathbf{8}e^- \longrightarrow H_2S + \mathbf{4}H_2O$

Additional equations should not contradict

M3 <u>oxidising agent</u> / <u>oxidises the iodide</u> (ions)

OR

<u>electron acceptor</u>

M4 sulfur ***OR*** S ***OR*** S_2 ***OR*** S_8 ***OR*** *sulphur*

4

(iii) **M1** The <u>NaOH / OH^- / (sodium) hydroxide reacts with / neutralises the H^+ / acid / HBr</u> (lowering its concentration)

OR a correct neutralisation equation for H^+ or HBr with NaOH or with hydroxide ion

Ignore reference to NaOH reacting with bromide ions

Ignore reference to NaOH reacting with HBrO alone

M2 **Requires a correct statement for M1**

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The (position of) equilibrium moves / shifts(from L to R)

- to replace the H^+ / acid / HBr that has been removed / lost
- ***OR*** to increase the H^+ / acid / HBr concentration
- ***OR*** to make more H^+ / acid / HBr / product(s)
- ***OR*** to oppose the loss of H^+ / loss of product(s)
- ***OR*** to oppose the decrease in concentration of product(s)

  *In **M2**, answers must refer to the (position of) equilibrium shifts / moves and is not enough to state simply that it / the system / the reaction shifts to oppose the change.*

M3 The (health) benefit outweighs the risk or wtte

OR

a clear statement that once it has done its job, little of it remains

OR

used in (very) dilute concentrations / small amounts / low doses

3

[15]

Q30.

(a) (i) **M1** **0**

M2 **(+) 5**

Accept Roman V for M2

2

(ii) $I_2 + 10HNO_3 \longrightarrow \mathbf{2}HIO_3 + \mathbf{10}NO_2 + \mathbf{4}H_2O$

Accept multiples

1

(b) **M1** $IO_3^- + \mathbf{6}H^+ + \mathbf{5}I^- \longrightarrow \mathbf{3}I_2 + \mathbf{3}H_2O$

For M1, ignore state symbols

Credit multiples

Accept $2\frac{1}{2}I_2 + \frac{1}{2}I_2$ as alternative to $3I_2$

Electrons must be cancelled

M2 $NaIO_3$ ***OR*** IO_3^- ***OR*** iodate ions ***OR*** iodate(V) ions etc.

For M2 Do not penalise an incorrect name for the correct oxidising agent that is written in addition to the formula.

Accept "the iodine in iodate ions" but NOT "iodine" alone

Accept "the iodine / I in iodate ions" but NOT "iodine" alone

2

(c) (i) Iodine ***OR*** I_2

Insist on correct name or formula

1

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(ii) $H_2SO_4 + \mathbf{6}H^+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Ignore state symbols

$SO_4^{2-} + \mathbf{8}H+ + \mathbf{6}e^- \longrightarrow S + \mathbf{4}H_2O$

Credit multiples

Do not penalise absence of charge on the electron

1

(d) hydrogen sulfide

OR H_2S

OR hydrogen sulphide

1

(e) (i) $Ag^+ + I^- \longrightarrow AgI$ ONLY

Ignore state symbols

No multiples

1

(ii) The (yellow) precipitate / solid / it does not dissolve / is insoluble

ignore "nothing (happens)"

OR turns to a <u>white solid</u>

ignore "no observation"

OR stays the same

OR no (visible/ observable) change

OR no effect / no reaction

1

(iii) The silver nitrate is acidified to

- react with / remove <u>(an)ions that would interfere</u> with the test

  Ignore reference to "false positive"

- prevent the formation of other <u>silver precipitates / insoluble silver compounds</u> that would interfere with the test

  Do not penalise an incorrect formula for an ion that is written in addition to the name.

- remove (other) <u>ions that react with the silver nitrate</u>

- react with / remove carbonate / hydroxide / sulfite (ions)

  If only the formula of the ion is given, it must be correct

1

(f) (i) An <u>electron donor</u>

Penalise "electron pair donor"

OR (readily) <u>donates / loses / releases / gives (away) electron(s)</u>

Penalise "loss of electrons" alone

Accept "electron donator"

1

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(ii) Cl_2 + **2**e^- ⟶ **2**Cl^-

Ignore state symbols

Do not penalise absence of charge on electron

Credit Cl_2 ⟶ ***2****Cl* $^-$ – ***2****e* $^-$

Credit multiples

1

(iii) For M1 and M2, iodide ions are stronger reducing agents than chloride ions, because

Ignore general statements about Group VII trends or about halogen molecules or atoms. Answers must be specific

M1 Relative size of ions

CE=0 for the clip if "iodine ions / chlorine ions" ***QoL***

Iodide ions / they are larger /have more electron levels(shells) (than chloride ions) / larger atomic / ionic radius

CE=0 for the clip if "iodide ions are bigger molecules / atoms" ***QoL***

OR electron to be lost/outer shell/level (of the iodide ion) is further the nucleus

OR iodide ion(s) / they have greater / more shielding

Insist on iodide ions in M1 and M2 or the use of it / they / them, in the correct context (or chloride ions in the converse argument)

OR converse for chloride ion

M2 Strength of attraction for electron(s)

Must be comparative in both M1 and M2

The electron(s) lost /outer shell/level electron from (an) iodide ion(s) less strongly held by the nucleus compared with that lost from a chloride ion

OR converse for a chloride ion

2

[15]

Q31.

(a) Iodine has more electrons / iodine is bigger (atom or molecule) / iodine has bigger M_r / bigger surface area

1

Stronger / more van der Waals forces / vdw / London / temporarily induced dipole / dispersion forces between molecules

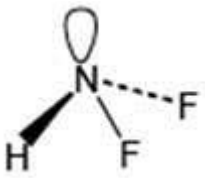
1

Stronger VdW intermolecular forces = M2

If stated VdW between atoms lose M2

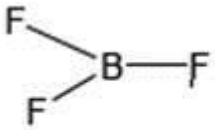
(b) (i)

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Mark is for 3 bp and 1 lp attached to N (irrespective of shape)

1



Mark is for 3 bp and 0 lp attached to B (irrespective of shape)

1

NHF_2 shape - pyramidal / trigonal pyramid

Accept tetrahedral / triangular pyramid

1

BF_3 shape - <u>trigonal planar</u>

Not triangular or triangular planar

1

(ii) 107°

Allow 106-108°

1

(c) Hydrogen bonds

Allow H-Bonds

Not just Hydrogen

Apply list principle eg Hydrogen bonding and dipole-dipole = 0

1

(d) Coordinate / dative covalent / dative

If covalent mark on

If ionic / metallic CE = 0

1

Lone pair / both electrons/ 2 electrons <u>on $N(HF_2)$</u> donated (to BF_3)

Direction of donation needed here

1

[10]

Q32.

(a) $Ca(OH)_2$ OR $Mg(OH)_2$

Ignore name

Could be ionic

1

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(b) NaF or sodium fluoride

OR

NaCl or sodium chloride

Either formula or name can score

Do not penalise the spelling ''fluoride''

When both formula and name are written,

- *penalise contradictions*
- *if the attempt at the correct **formula** is incorrect, ignore it and credit **correct name** for the mark unless contradictory*
- *if the attempt at the correct name is incorrect, ignore it and credit **correct formula** for the mark unless contradictory*

1

(c) NaClO OR NaOCl

Ignore name (even when incorrect)

The correct formula must be clearly identified if an equation is written

1

(d) **Br_2** (ONLY)

Only the correct formula scores;

penalise lower case ''b", penalise upper case ''R'', penalise superscript

Ignore name

The correct formula must be clearly identified if an equation is written

1

(e) **M1** S OR S_8 OR S_2

M2 I_2 (ONLY)

Ignore names

penalise lower case ''i'' for iodine,

penalise superscripted numbers

Mark independently

The correct formula must be clearly identified in each case if an equation is written

2

(f) (i) $CH_3CH_2CH=CH_2$

Structure of but-1-ene. Ignore name

Credit ''sticks'' for C-H bonds

1

(ii) $CH_3CH_2CH_2CH_2OH$

Structure of butan-1-ol. Ignore name

Credit ''sticks'' for C-H bonds

1

(iii) $CH_3CH_2CH_3$

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Structure of propane. Ignore name
Ignore calculations and molecular formula
Credit ''sticks'' for C-H bonds
Ignore the molecular ion

1

(iv) CH_3CH_2Br OR $C_2H_5B_r$

Structure of bromoethane.
Ignore name and structure of nitrile
Credit ''sticks'' for C-H bonds

1

[10]

Q33.

(a) (i) **M1** (yellow precipitate is) silver iodide OR AgI (which may be awarded from the equation)

M2 $Ag^+ + I^- \longrightarrow AgI$ (Also scores M1 unless contradicted)

M3 sodium chloride OR NaCl

For M2
Accept multiples
Ignore state symbols
Allow crossed out nitrate ions, but penalise if not crossed out

3

(ii) The silver nitrate is acidified to

- react with / remove ions that would interfere with the test
- prevent the formation of other silver precipitates / insoluble silver compounds that would interfere with the test
- remove (other) ions that react with the silver nitrate
- react with / remove carbonate / hydroxide / sulfite (ions)

Ignore reference to ''false positive''

1

(iii) **M1 and M2 in either order**

M1 Fluoride (ion) OR F^-

M2 • Silver fluoride / AgF is soluble / dissolves (in water)

• no precipitate would form / no visible /observable change

Do not penalise the spelling ''fluoride'',
Penalise "fluride" once only
Mark M1 and M2 independently

2

(b) **M1** $Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4$

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(or the ions together)

M2 white precipitate / white solid / white suspension

M3 Barium meal or (internal) X-ray or to block X-rays

M4 $BaSO_4$ / barium sulfate is insoluble (and therefore not toxic)

For M1, ignore state symbols

Allow crossed out sodium ions, but penalise if not crossed out

For M2, ignore "milky"

If $BaSO_3$ OR BaS used in M1 and M4, penalise once only

For M3 Ignore radio-tracing

For M4 NOT barium ions

NOT barium

NOT barium meal

NOT "It" unless clearly $BaSO_4$

4

(c) **M1** **2**(12.00000) + **4**(1.00794) = 28.03176

M2 Ethene and CO or "they" have an imprecise $\mathbf{M}_r$ of 28.0 / 28

OR

Ethene and CO or "they" have the same M_r to one d.p.

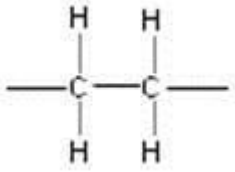
OR

These may be shown by two clear, simple sums identifying both compounds

M3 $C_2H_4 + \mathbf{2}O_2 \longrightarrow \mathbf{2}CO + \mathbf{2}H_2O$

($H_2C=CH_2$)

M4 Displayed formula



M5 Type of polymer = Addition (polymer)

M1 must show working using 5 d.p.for hydrogen

Penalise "similar" or "close to", if this refers to the imprecise value in M2, since this does not mean "the same"

For M3, accept $CH_2=CH_2$ OR CH_2CH_2

For M4, all bonds must be drawn out including those on either side of the unit.

Penalise "sticks"

*Ignore brackets around **correct** repeating unit but penalise*

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"n"

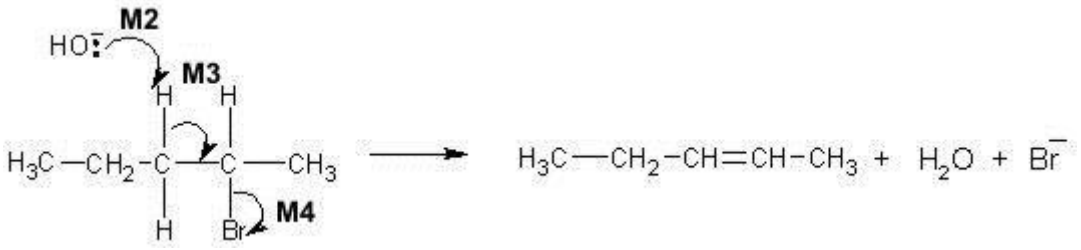
Penalise "additional"

5

[15]

Q34.

(a) (i) **M1** Elimination



M2 must show an arrow from the <u>lone pair on the oxygen</u> of a negatively charged hydroxide ion <u>to a correct</u> H atom

M3 must show an arrow from a C-H bond adjacent to the C-Br bond towards the appropriate C-C bond.
Only award if a reasonable attempt has been made at the attack on the H atom of the appropriate adjacent C-H

M4 is independent provided it is from their <u>original molecule</u>

Award full marks for an E1 mechanism in which **M3** is on the correct carbocation.

N.B. These are double-headed arrows

For M1, accept "Base elimination" but <u>no other prefix</u>.

*Penalise **M2** if covalent KOH*

*Penalise **M4** for formal charge on C of C-Br or incorrect partial charges on C-Br*

Ignore other partial charges

Penalise once only in any part of the mechanism for a line and two dots to show a bond.

*<u>Max any 2 of 3 marks **for the mechanism**</u> for wrong reactant (or wrong product if shown).*

Accept the correct use of "sticks" for the molecule except for the C-H being attacked

4

(ii) **Structure for pent-1-ene**

$CH_3CH_2CH_2CH=CH_2$

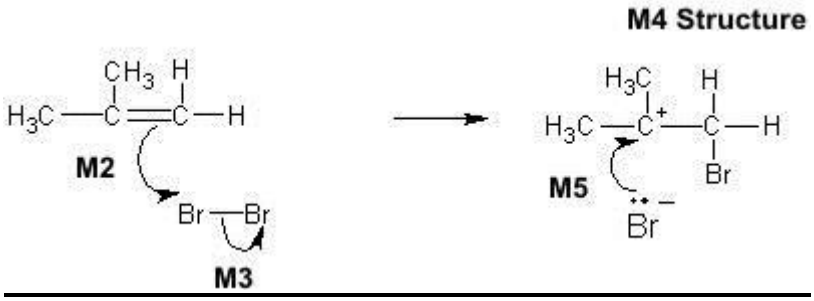
Penalise C_3H_7

Accept correct "sticks"

1

(b) **M1 <u>Electrophilic addition</u>**

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M2 must show an arrow from the double bond towards the Br atom of the Br-Br molecule

M3 must show the breaking of the Br-Br bond.

M4 is for the structure of the tertiary carbocation with Br on the correct carbon atom.

M5 must show an arrow from the lone pair of electrons on the negatively charged bromide ion towards the positively charged carbon atom.

N.B. These are double-headed arrows

For M1, both words required.

For the mechanism

M2 *Ignore partial negative charge on the double bond.*

M3 *Penalise partial charges on Br-Br bond if wrong way and penalise formal charges*

Penalise once only in any part of the mechanism for a line and two dots to show a bond

Max any 3 of 4 marks ***for the mechanism*** *for*

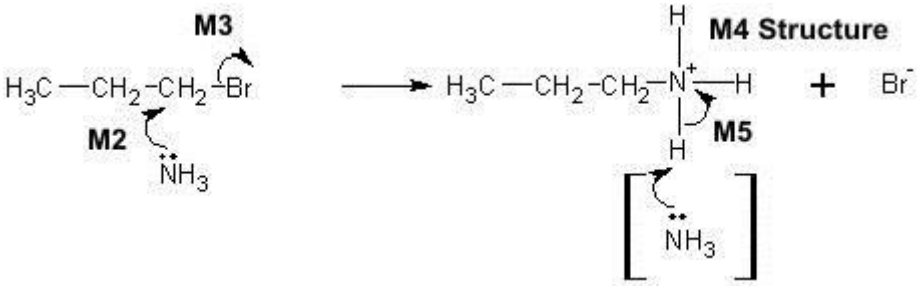
wrong organic reactant or wrong organic product (if shown) or primary carbocation.

If HBr is used, max 2 marks ***for their mechanism***

Accept the correct use of ''sticks''

5

(c) **M1 Nucleophilic substitution**



M2 must show an arrow from the lone pair of electrons on the nitrogen atom of an ammonia molecule to the C atom.

M3 must show the movement of a pair of electrons from the C-Br bond to the Br atom. **M3** is independent provided it is from their original molecule

M4 is for the structure of the alkylammonium ion, which could be a condensed formula. A positive charge must be shown on/or close to, the N atom.

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M5 is for an arrow from the N-H bond to the N atom.

Award full marks for an S_N1 mechanism in which M2 is the attack of the ammonia on the intermediate carbocation.

N.B. These are double-headed arrows

*For **M1**, both words required.*

*Penalise **M2** if NH_3 is negatively charged.*

*Penalise **M3** for formal charge on C or incorrect partial charges*

The second mole of ammonia is not essential for M5; therefore ignore any species here.

Penalise once only for a line and two dots to show a bond.

*Max any 3 of 4 marks **for the mechanism** for wrong organic reactant (or wrong organic product if shown)*

Accept the correct use of ''sticks''

5

[15]

Q35.

(a) Hydrochloric acid = **C**

1

Barium chloride = **A**

1

(b) Barium sulfate is insoluble

1

$CuSO_4 + BaCl_2 \rightarrow BaSO_4 + CuCl_2$

Accept multiples.

Accept ionic equation.

Do not penalise lack of state symbols, but if used they must be correct.

1

(c) CO_2 / Carbon dioxide

1

(d) Reagent 1 silver nitrate (solution)

Ignore lack of reference to acidifying prior to addition of silver nitrate solution.

1

Observation 1 White precipitate

1

Reagent 2 (dilute) ammonia solution / aqueous ammonia

*Do not accept addition of **ammonia** only.*

1

Observation 2 (Colourless) solution

Allow ppt dissolves.

Do not allow 'goes colourless' or 'goes clear'.

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Chlorine and no visible change or solution does not become orange scores M3 and M4.

1

(e) Gloves / wash hands after use

Ignore 'eye protection'.

Do not accept 'do not ingest the chemicals', 'wipe up spillages', 'use a fume cupboard', 'wear a lab coat' (list principle).

1

[10]

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Q1.

Many students (47.6%) got this correct although a significant number thought that bromide ions were reduced in the reaction of sodium bromide with concentrated sulfuric acid.

Q2.

Students found this challenging and did not always express their ideas clearly. Many approached this question as if they already knew which compound was which. A good number did not appreciate that the compounds were solids and so they should make them into solutions. The best students realised that acid should be added first to identify the sodium carbonate and that this solid can then be discarded from further tests. A large number of students realised that silver nitrate would be the best reagent that could be used to determine which solid was sodium chloride and which was sodium fluoride. Additional use of ammonia solution was not necessary in this case. Equations were well written, although did not often include state symbols as required. A high number of students felt that concentrated sulfuric could be used to determine which solid was which despite the fact that all three solids would give very similar observations. The question discriminated particularly well.

Q3.

(a) The correct ion was identified quite often but the equation was much less well answered.

(b) Even good students struggled with this question. The context of the ion test was the reverse of the common way of asking the question and, as such, poorly understood.

Q4.

63.6% of students gained this mark. This proved to be a relatively easy practical question requiring little application of knowledge.

Q5.

This mark was gained by 71.7% of students, showing that this is one of the easier physical property trends to remember.

Q6.

Only 42.2% of students selected the correct answer. Perhaps many students did not appreciate that a range of sulfur-based products are formed in the reaction.

Q7.

(a) The definition was only given by the best students. Some students gave definitions of other enthalpy changes, particularly the enthalpy of formation of a substance. Many students missed the idea that a solid was being formed and some thought that the solid ionic lattice was formed from one mole of gaseous ions.

(b) Many students were uncertain about the sign of the enthalpy change for lattice formation and +869 kJ mol^{-1} was a common wrong answer.

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(c) Many students understood that the lattice was not perfectly ionic and had some covalent character. Linking the covalent character with stronger bonding eluded all but the strongest students.

(d) The reagent silver nitrate was well known, and this was generally followed by the correct colour of the precipitate. Some students used a more reactive halogen as the reagent and this was given full credit; however, observations for this were less well known.

Q8.

(a) 78% of students gained this mark.

(b) With nearly 40% of students scoring full marks, this question illustrated that the skill of representing mechanisms is good. When confusion arose it generally involved attempts to show mechanisms involving water and producing the alcohol, when the final product in this case should be propyl hydrogensulfate. The most common omissions were the curly arrow to show breaking of the H-O bond in H_2SO_4 and/or the negative charge on the HSO_4^- ion. The bonding/order of atoms in H_2SO_4 was also sometimes confused, with structures such as $H{-}O{-}HSO_3$ seen.

(c) Most students who showed a secondary carbocation structure in part (b), were able correctly to show the structure of a primary carbocation here. If a primary ion structure had been shown in (b), 'ecf' was allowed for those (relatively few) students.

(d) Most students gained the first mark here, but only 17% achieved full marks. A simple statement that a secondary carbocation is more stable than a primary was sufficient for the first mark (although many students mistakenly referred to the greater stability of the final product instead). For the second mark, the explanation needed to make clear that the positive inductive effect was greater in the secondary carbocation due to it having **more** alkyl groups attached to the C+.

(e) This was another question that proved trickier than expected, with a roughly even split between 0, 1, 2 and 3 marks. 'Butan' or 'bute' were often seen as incorrect stems of names and a very common error was for the same isomer of but-2-ene to be drawn twice, with one named as *Z*-but-2-ene and the other as *E*-but-2-ene.

(f) Butanal was a common wrong answer for the by-product and the fact that sulfuric acid acts as an oxidising agent was not well recognised.

(g) Although the oxidising ability of concentrated sulfuric acid did not seem to be recognised often in part (f), it was often, incorrectly, suggested here, with most students concentrating on this aspect and failing to recognise that sulfuric acid does not oxidise a chloride ion.

(h) Over 30% of students gained full marks here, but there was also quite a lot of confusion between the products, with carbon suggested as the black solid; iodine, SO_2 or H_2S as the yellow solid; and SO_2 commonly suggested as the gas smelling of bad eggs.

Q16.

The question on Grignard Reagents was challenging and many were unable to use their practical experience to think through the context. Part **(a)** was fairly well done but **(b)** proved more problematic with poor expression often losing the mark. In **(c)**, there was a common mistake in using Tollens' or Fehling's reagent to distinguish the alcohols. Part **(d)** required some careful structuring to achieve full marks and the context of the question

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(comparing bromide and iodide only) was often ignored. The omission of the concentration of the ammonia solution used for the confirmatory test was a common fault.

Q17.

Many answered this question well but a common error was to describe in detail a recrystallisation.

Q18.

This question was answered poorly. Even the half equation in (a) was usually not answered correctly and the more challenging equations in (b) and (c) were only seen from the better students. In (d) the explanation that iodide ions are oxidised wasn't seen very often but a reasonable proportion of students scored some marks on this question.

Q19.

In a definition of electronegativity students must make it clear that they are referring to the attraction between the nucleus and the shared pair of bond electrons. Most students were awarded the first mark but many answers were too vague in their references to gain the second mark. Most of the rest of this question was well answered although there were some issues with balancing charges in the redox equations.

Very few students showed the acids formed in part (d)(i) as being dissociated and this, in turn, seemed to make part (d)(ii) harder than expected because many students failed to spot that addition of acid would shift the equilibrium to the left and so produce toxic chlorine gas. Although there was no specific reference to le Chatelier in the question (which would have given a more specific clue) the stem of part (d) did refer to an equilibrium mixture and this was intended to point students in the right direction.

Q20.

This was a high demand question, since it requires application of chemistry from the specification and a failure to provide a suitable test reagent leads to the loss of three marks in each part. The number of possible answers to distinguish silver nitrate in part (c) was considerable and partial credit was awarded for test reagents that were unsuitable for test-tube tests, but which led to correct chemical observations. Less than one third of students scored all three marks on part (c) and part (d), whereas three quarters scored full marks on part (b).

Q21.

This was a relatively straightforward start to the paper, but the usual errors were made in balancing equations. The idea of oxidation state is relatively well understood. In part (d), students demonstrated a lack of clarity in what happens during the process of boiling, often alluding to bond breakage and rarely referring to the forces between molecules.

Q22.

(a) (i) In this part, it was disappointing to note that there were many instances of missing or incorrect state symbols that were missed or ignored by the marker.

(ii) The logic required in this part again required a careful and sequenced expression of ideas that some found challenging.

The information and test in part (b) and (c) were well known and usually well expressed

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with occasional confusion regarding the concentration of the ammonia solution used.

Q23.

(a) The calculations in parts (i) to (iv) of this part were generally well done although there was some confusion regarding the number of significant figures (both in answers and the marking) and with some lower-scoring students experiencing difficulties in part (iv). However, the ideas underlying part (v) gave a greater challenge and many partial answers were seen (and sometimes incorrectly credited).

(b) In part (b) and (c) were well answered in the main with the usual caveat about state symbols. The formula of propanone was generally well known either as the molecular or structural formula.

(c) In part (b) and (c) were well answered in the main with the usual caveat about state symbols. The formula of propanone was generally well known either as the molecular or structural formula.

(d) The ideas in this part were found to be quite challenging to all but the highest-scoring students and a great deal of confusion was seen regarding colours, solutions and precipitates. In the marking, it is important to appreciate that to gain partial marks the procedure described must be chemically correct; M3 could not be awarded unless there is some correct work up to this point. Answers were often jumbled and contradictory. Many students failed to add sodium chromate solution at the start and so could not gain any marks. Where this addition was done, some students mentioned the formation of a precipitate with the calcium ion solution that then dissolved on addition of water. Many students did not appreciate that the substances were already in solution at the start of the procedure.

(e) As usual, the empirical formula in this part was well done with a few arithmetic errors only.

Q24.

As with a number of other equations on the paper, rather too many of those given in parts (a)(i) and (b) were unbalanced. The observation in part (a)(ii) was answered well and over 80% of all students scored at least one mark in part (c).

Q25.

This type of question demands that students have a good grasp of observational chemistry from the specification. No marks can be awarded in any of the four parts if a suitable test reagent is not known. This limited the marks for some students. No marks are awarded in the observation sections if the response is “nothing” or “no observation”. The least well answered part was part (b) with just over half of all students scoring no marks and only approximately a quarter scoring full marks, By contrast the best answered part was part (d) with only very few students scoring no marks and almost two-thirds of all students scoring full marks.

Q26.

In this Question, a number of students spoiled their answer by including sodium hydroxide in the test reagent. The use of water was occasionally allowed even though it was specifically disallowed in the Marking Guidelines.

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Q27.

This question discriminated well with 52% gaining at least 3 marks and most students recording observations associated with the reaction (required by the question), rather than from other reactions that may be occurring at the same time. The remainder of the question was answered well although some were confused about what was happening to iodide ions in terms of electrons.

Q28.

The chemistry of Group 7 is never answered particularly well. This question was no exception and errors were seen both in the equations and in the observations and explanations. Part (a) was the least well-answered with only 13% gaining both marks. Even in part (d), only 75% of the students gained any of the 3 marks. Students need to be advised to learn the key information from this area of the specification and then to read the full question with care in every case.

Q29.

Parts (a) and (b)(i) required interpretation of inorganic results from what should be familiar chemistry. Those who had learned this area of the specification fared well, although some lost marks from failing to read (and then answer) the full question. The ability of students to work out half–equations in redox processes such as those in part (b)(ii) has improved and this question discriminated well with the better students scoring full marks and many of the weaker students still scoring something.

The question in part (b)(iii) has been asked previously in a slightly different form. It was demanding then and remained so on this occasion, with relatively few students able to recognise the fact that sodium hydroxide will react with the H^+ ions and the position of equilibrium will move from left to right to oppose the decrease in concentration of those ions.

Q30.

Many very good answers were seen throughout this question. In part (b), the oxidising agent was not well answered by some. In parts (c), (d) and (e), the answers requiring observations suggest that not all students have had the chance either to see or to perform these simple experiments. Part (f) was well answered with the correct use of chemical names and terminology.

Q31.

Many candidates answered part (a) well but there were a significant number who did not make it clear that the van der Waals forces were between the molecules. Part (b)(i) differentiated well. There were many examples of the wrong number of lone pairs in both molecules and a frequent occurrence of bi-pyramids in candidates' answers. The angle in part (b)(ii) generated a range of values although the answer to part (c) was given correctly by a majority of candidates. Part (d) was generally well done although several candidates gave the wrong direction for the donation of the lone pair.

Q32.

This question covered a wide range of the specification content. Halogen chemistry is not well-known by students and even when they may know some chemistry they can miss the mark by being unable to write the correct formula. Indicative of this was part (e) with only 18% scoring both marks and 56% scoring zero. The organic structures in part (f) were answered better, although part (f)(i) proved demanding and only 26% obtained this mark.

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Q33.

Inorganic chemistry is a weakness for many candidates and this question proved challenging for some. Not surprisingly sodium bromide was a common incorrect response in part (a)(i).

Only the better candidates knew the reason for acidifying the silver nitrate solution in part (a)(ii) but the inability of this reagent to detect fluoride ions in part (a)(iii) was reasonably well known. Part (b) was a good discriminator; the relatively easy equation and observation marks eluded some. In part (c) most candidates could use the data to arrive at the correct precise Mr value but were less effective in explaining that the Mr values are the same when using one decimal place. The equation for complete combustion of ethene was done well but neither the displayed formula for the repeating unit nor the type of polymer scored highly.

Q34.

Putting three mechanisms together proved to be very discriminating. Weaker candidates were able to score some marks and the best candidates scored all 15. There is always a concern that in these longer Section B questions, candidates might forget to record the name of a mechanism and there was some evidence of that happening here. Partial credit was given in part (a)(i) for a mechanism that used an incorrect starting or finishing compound with much of the focus concentrated on the curly arrows. This guiding principle was applied to good effect in parts (b) and (c). In part (c), centres need to appreciate that full marks will only be awarded in a mechanism of this type if the positive charge on the intermediate is placed on the N atom and not on or adjacent to a hydrogen atom.

Q35.

In part (a) only the highest-scoring candidates scored both marks. Weaker candidates seemed to be guessing.

In this part (b) was, perhaps, the most demanding question of all. Many candidates could not equate the appearance of a precipitate with insolubility, and even the better candidates could not write a correct equation for a very familiar reaction.

The better candidates scored full marks in this part (d). A few lost a mark because they were vague about the concentration of the ammonia solution to be used. A surprising number got the tests the wrong way around, losing two marks. Centres are reminded that if a candidate chooses an incorrect test reagent the mark for the observation can also not be awarded.

The above notes are intended for the small minority of centres experiencing difficulty in meeting the coursework criteria. They must not be allowed to detract unduly from the very healthy overall picture. Given the pressures on centres to deliver the teaching programme, this was once again a very positive and encouraging session. Centres are again warmly commended for the trouble taken to assemble a sample which proved to be easy to moderate. Their efforts continue to be much appreciated by the moderator team.

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