GCE MARKING SCHEME

CHEMISTRY
AS/Advanced

SUMMER 2015

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2015 examination in GCE CHEMISTRY. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

CH1

SECTION A

1.	Ne	10p, 10n, 10e (1)	
	O^{2-}	8p, 10n, 10e (1)	[2]
2.	(a)	^{222}Rn	[1]
	(b)	Time taken for half of the atoms in a radioisotope to decay (or similar)	**[1]**
	(c)	Mass = 0.25 g (1)	
		Moles = 1.11×10^{-3} (1) do not accept 1×10^{-3}	[2]
3.	(a)	The mass of one mole of compound	[1]
	(b)	$\Delta H_f = -417$ kJ mol^{-1}	[1]
4.	(a)	Measure the volume of CO_2 produced / mass of CO_2 lost at constant time intervals	[1]
	(b)	No effect since concentration of acid has not changed	[1]

Total Section A [10]

SECTION B

5. (a) **2p** | ↑ | ↑ | ↑ | [2]

2s | ↑↓ | (1 mark for labelling, 1 mark for arrows)

(b) (i)

N	O
$\frac{25.9}{14}$	$\frac{74.1}{16}$
1.85	4.63 (1)
1	2.5

N_2O_5 (1) [2]

(ii) $2NH_3 + 2O_2 \longrightarrow N_2O + 3H_2O$ [1]

(iii) Moles $Ca(NO_3)_2 = 5.40 \times 10^{-3}$ (1)

Moles gas = 1.35×10^{-2} (1)

Volume gas = 0.324 dm^3 (1) [3]

(c) Moles $Ca(NO_3)_2$ = 0.0256 (1)

Moles H_2O = 0.102 (1)

x = 4 (1) [3]

Total [11]

6. (a) (i) Energy required to remove one mole of electrons from one mole of atoms / to form one mole of positive ions from one mole of atoms (1)
in the gaseous state (to form 1 mol of gaseous ions) (1)
(Accept correct equation) [2]

(ii) Cross between Na and Mg crosses [1]

(iii) P only has unpaired electrons, S has a pair of electrons in 3p orbital (1)
Repulsion between the paired electrons makes it easier to remove one of the electrons (1) [2]

(b) (i) Effective nuclear charge is greater / electron being removed from a positive ion [1]

(ii) Accept from 6000 to 9000 [1]

(c) Lines are formed from electron being excited and jumping up to a higher energy level (1)
Falling back down to the n = 2 level (1)
Emitting energy / photon of light (1)
Lines become closer since the electron energy levels of a hydrogen atom become closer (1) [4]

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

Total [12]

7. (a) (i) Sample is bombarded by high energy electrons / electron gun used on sample (1)
Electron knocked out (to form ions) (1) [2]

(ii) So no more than / only 1 electron is knocked out [1]

(iii) No difference (1)
Same number of electrons (in the outer shell) (1) [2]

(b) (i) $\frac{(7.25 \times 6) + (92.75 \times 7)}{100}$ (1)

6.928 (1) (accept 6.93) [2]

(ii) $^{6}Li^{+}$ since lower mass / lower m/z / lighter
do not accept 'smaller' [1]

(c) (i) $M_r(NH_4)_2SO_4$ = 132.18 (1)

Moles = 0.0156 (1) [2]

(ii) Moles LiOH = 0.0312 (1)

Concentration $= \frac{0.0312}{0.0298} = 1.05 \text{ mol dm}^{-3}$ (1) [2]

(iii) Atom economy $= \frac{34.06}{180.08} \times 100$ (1)

= 18.9 % (1) [2]

Total [14]

8. (a) Benefits:

Stops fossil fuels from running out
Reduces CO_2 emissions / greenhouse emissions / global warming / effect of global warming
Reduces SO_2 emissions / acid rain
There will be an investment in new technology

Difficulties:
Dependence on fossil fuel/Unlikely to meet current demand
Renewable energy currently more expensive
Reliability of supply from renewables
Major development in energy efficiency technologies required
Opposition by vested interests
(Maximum 3 marks from list, but need examples of both) (3)

Consideration and discussion of benefits/difficulties (1) [4]

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]

(b) (i) I As temperature increases yield decreases
As pressure increases yield decreases [1]

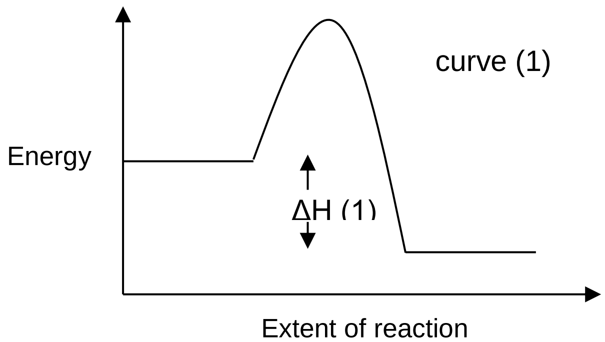
II As temperature is increased, equilibrium moves to the left (1)
Therefore forward reaction is exothermic (1)
As pressure is increased, equilibrium moves to the left (1)
Therefore more gas moles in products (1) [4]
QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate [1]

(ii) If temperature is too low, then reaction is too slow (1)
If temperature is too high, yield is too low (1)
Compromise temperature – acceptable rate and yield (1)
(Accept any two points) [2]

(iii) Heterogenous catalyst [1]

(iv) Lower temperatures could be used (1)
Less energy consumption / increased yield (1)
Equilibrium could be reached more quickly (1)
(Accept any two points) [2]

(v)



[2]

(vi) $\Delta H = E_f - E_b$ [1]

Total [19]

9. (a) Otherwise a temperature change would occur on adding the acid which had nothing to do with the reaction [1]

(b) (i) Best fit lines (1)

Temperature rise = 6.4 °C (1)
(Take value from candidate's best fit lines) [2]

(ii) Volume of acid = 26.0 cm^3 [1]

[If no best fit lines award 0 in (i) and accept 25 cm^3 in (ii)]

(c) Moles acid = 0.02425 (1)

Conc acid = $\frac{0.02425}{0.026}$ = 0.933 mol dm^{-3} (1) [2]

(d) Heat = 51 × 4.18 x 6.4

= 1364 J [1]

(e) $\Delta H = -\frac{1364}{0.02425}$ (1)

= – 56.2 kJ mol^{-1} (1) [2]

(f) Pipette / burette [1]

(g) No further reaction occurs (1)

The excess acid cools the solution (1) [2]

(h) Heat / energy is lost to the environment (1)

Insulation is improved e.g. lid on the polystyrene cup (1) [2]

Total [14]

Section B Total [70]

CH2

SECTION A

1. $(1s^2)2s^22p^6$ [1]

2. 8 electrons in outer shell of all species/ 8 in two F and 0 in Ca (1)

   2+ on calcium ion and 1- on fluoride ions (1) [2]

3. (Electronegativity of an atom is) the tendency of electrons in a covalent bond to be drawn to that atom [1]

4. Cs^+ and Cl^- (or names caesium and chlor**id**e) with Cl^- at each corner and Cs^+ in centre of cube [1]

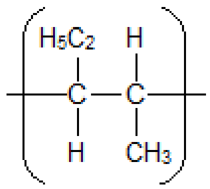
5. Reagent: acidified potassium dichromate / $Cr_2O_7^{2-}$ and H^+
   or acidified manganate(VII) / MnO_4^- and H^+ (1)

   Colour change: from orange to green
   or from purple to colourless (1) [2]

6. 2-chlorobut-1-ene [1]

7. $C_{20}H_{42} \rightarrow C_5H_{10} + C_6H_{12} + C_9H_{20}$ [1]

8.



[1]

Total Section A [10]

SECTION B

9. (a) (i) Potassium bursts into flames sodium does not / potassium darts about surface **more** vigorously than sodium [1]

(ii) 1st ionisation energy decreases as group is descended / as element has higher A_r (1)

(Atom) becomes larger / outer electron further from nucleus / more shielding / less effective nuclear charge (1) [2]

(iii) As group descended outer electron more easily lost [1]

(b) (i) Electronegativity (difference between the atoms) (1)

The bigger the difference the more likely is an ionic bond / ORA for covalent (1) [2]

(ii) Ionic: high electron density centred round ions / shown on diagram (1)

Covalent: high electron density between nuclei/atoms / shown on diagram (1)

Intermediate: high electron density between nuclei/atoms but higher nearer one of them / ions with electron distortion of negative ion (1) [3]

(c) (i) Calcium [1]

(ii) Calcium chloride/ $CaCl_2$ – error carried forward (ecf) from (i) [1]

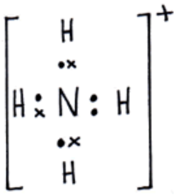
(iii) White precipitate/ solid – ecf from (i) [1]

(iv) $Ca^{2+} + 2OH^- \rightarrow Ca(OH)_2$ (ignore state symbols) – ecf from (i) [1]

Penalise incorrect metal once only in (c)

Total [13]

10. (a) The last/valence electron entered a p orbital/sub-shell [1]

(b) (i) 

do not penalise missing + sign [1]

(ii) 109° – 110° (1)

Pairs of electrons move towards positions of minimum repulsion/ of maximum separation (1) [2]

(iii) $\mathbf{4}NH_3 + \mathbf{5}O_2 \rightarrow \mathbf{4}NO + \mathbf{6}H_2O$ [1]

(c) (i) In this reaction nitrogen (1) has been reduced because its oxidation number has changed from (+) 5 to (+) 3 (1) [2]

(ii) Moles $NaNO_3$ = 4.40/ 85 = 0.0518 (1)

Moles oxygen = 0.0259 (1)

Volume of oxygen = 0.0259 × 24 = 0.62 (dm^3) (1)

Ecf throughout [3]

(d) Mass in solution at 30°C = 96/2 = 48 (g) (1)

Mass that crystallised = 65 – 48 = 17 (g) (1) [2]

Total [12]

11. (a) (i) δ– on Br and δ+ on C attached (1)

Arrow from lone pair on OH^- to δ+ on C (1)

Arrow from C-Br bond to Br (1)

Correct alcohol + Br^- (1) [4]

(ii) Nucleophilic substitution [1]

(iii) The bond breaks and both the electrons go to one of the bonded atoms/ the bond breaks and ions are formed. [1]

(b) (i) Sodium hydroxide in ethanol/ alcohol [1]

(ii) Elimination/ dehydrohalogenation [1]

(iii) Structural formulae for but-1-ene (1)

and but-2-ene (1) [2]

(c) A is non-miscible with water/ does not mix with water and B is miscible/ mixes with water/ is soluble in water (1)

A has a longer carbon chain/ is bigger (1)

Hydrogen bonding (1)

Between the OH in alcohol and water (1)

In large alcohols non-polar/ hydrophobic part of molecule is large / OH is less significant part of molecule (1) [5]

QWC: organisation of information clearly and coherently; use of specialist vocabulary such as intermolecular force/ hydrogen bond/ hydrophobic/ non-polar/ miscible [1]

Total [16]

12. (a) Any 3 from 4 points:

Bonding is metallic (1)

This is **attraction** between the sea/ delocalised electrons and the positive ions (1)

Al^{3+} has more electrons in the sea than Na^{+} / Al^{3+} has a higher charge density than Na^{+} (1)

More energy is needed to overcome forces in Al (1) [3]

QWC: legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning [1]

(b) (Brown) iodine is formed (1)

Equation: $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$ / $Cl_2 + 2KI \rightarrow 2KCl + I_2$
(ignore state symbols) (1)

Chlorine is a better oxidising agent than iodi**ne**/ has a greater affinity for the electron/ chlorine has oxidised iod**ide** (1) [3]

(c) Ammonia is easily liquefied because it has a high boiling temperature (compared with ethane) (1)

Ammonia contains hydrogen bonds (1)

Ethane has van der Waals forces/ induced dipole-induced dipole forces (1)

Hydrogen bonds are stronger than van der Waals forces (1) [4]

(d) Reaction produces a mixture of halogenocompounds/ more than one halogen can be substituted / ethane (1)

The mechanism is (free) radical (1)

Any equation with product a polychloromethane/ ethane (1) [3]

QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

Total [15]

13. (a) (i) Mass C = 1.79 × 12/44 = 0.488 (g) [1]

(ii) Mass O = 0.65 (g) ecf from part (i) [1]

(iii) C : H : O = 0.488/12 : 0.061/1 : 0.65/ 16 = 0.0407 : 0.061 : 0.0406 (1)

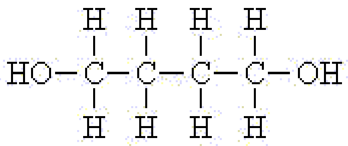
= 2:3:2 empirical formula is $C_2H_3O_2$ (1)

No ecf from incorrect ratios [2]

(iv) *M*r of empirical formula = 59 so molecular formula is $C_4H_6O_4$ so **F** is acid 2/ molecular formula acid 1 is $C_5H_8O_2$ so empirical formula is not $C_2H_3O_2$ molecular formula acid 2 is $C_4H_6O_4$ so empirical formula is $C_2H_3O_2$ [1]

(v) Bromine turns from brown/red-brown to colourless for Acid 1 [1]

(vi)



[1]

(b) (i) *M*r / molecular ion (is 46) [1]

(ii) CH_3 (present) [1]

(iii) OH (present) [1]

(c) Ethene to ethanol: steam (1)

H_3PO_4 (catalyst) (1)

Ethanol to ethene: conc H_2SO_4/ Al_2O_3/ pumice (1)

High temperature > 150°C for H_2SO_4
> 300°C for Al_2O_3/ pumice (1) [4]

Total [14]

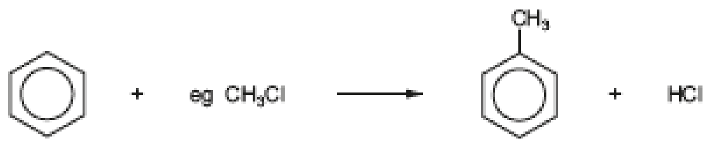
Total Section B [70]

CH4

SECTION A

1. (a) …………blue …….. (1) …………….higher (1) …………higher (1) [3]

(b) (i)



[1]

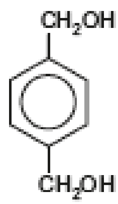
accept C_6H_5 in place of the ring accept equations that show the catalyst

(ii) It acts as a halogen carrier / it helps produce the electrophile/CH_3^+ / increases polarity of the halogenoalkane [1]

(c) There are 6 methyl protons and 4 aromatic protons, hence a ratio of 3:2 (1)
All the methyl protons are equivalent as are all the aromatic protons (1) [2]

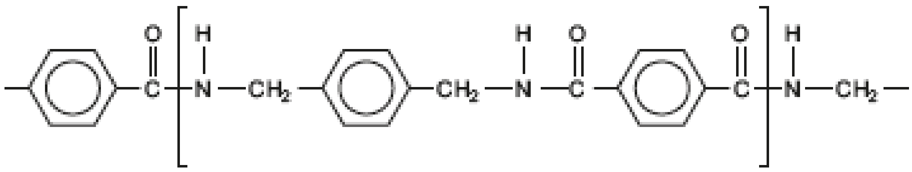
(d) (i) Any 2 from NMR / HPLC / GC / refractive index / mass spectra / boiling temperature [2]

(ii)



[1]

(e) (i)

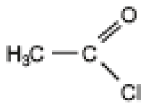


[1]

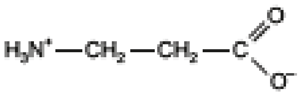
(ii) protein / dipeptide / polypeptide [1]

Total [12]

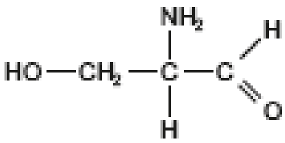
2. (a) (i) Sodium / potassium cyanide [1]

(ii)  [1]

(iii) Sulfuric / hydrochloric acid [1]

(iv)  [1]

(v) eg

 [1]

(vi) $LiAlH_4$ / H_2 / sodium, ethanol [1]

(vii) The nitrogen atoms act as electron pair donors / proton acceptors [1]

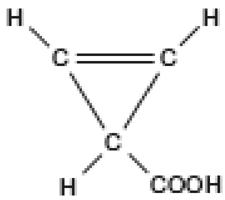
(b) (i) Molecular formula is $C_4H_4O_2$ [1]

(ii) 3 [1]

(iii) C = C / alkene [1]

(iv) Two of the (remaining) protons are in equivalent environments (and one is not) / there are CH and CH_2 present [1]

(v) Possibilities



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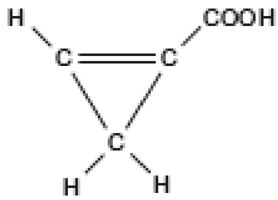
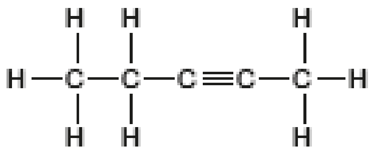
 [1]

Total [12]

3. (a)



[1]

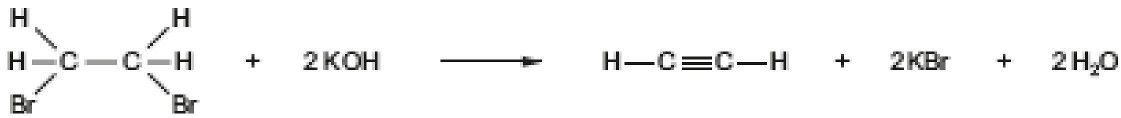
(b) Moles of calcium carbide = 500/64.1 = 7.80 (1)

Moles of ethyne = 7.80

Volume of ethyne = 7.80 × 24.0 = 187 (dm^3) (1) [2]

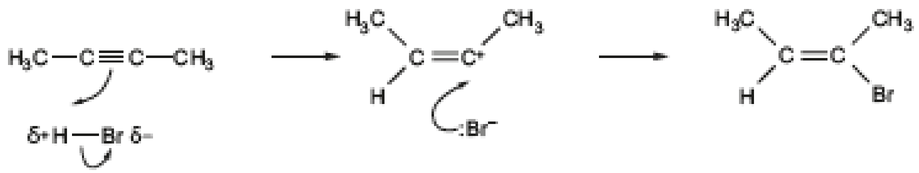
(c) If the process is endothermic left to right then it needs to absorb energy
– hence the high temperature / endothermic reactions need a high temperature [1]

(d)



[1]

(e)

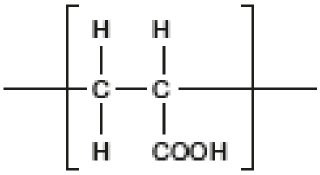


Curly arrows (1), full (1) and partial charges (1) [3]

(f) Any two for (1) each
energy costs / cost of **catalyst** / problems of separation of products /
time taken / availability of starting materials / percentage yield /
atom economy / relative health and safety [2]

(g) $C_6H_5 - C \equiv C - CH_2 - CH_3$ (1) C_1H_1 (1) [2]

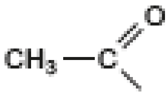
(h) (i)



[1]

(ii) I sulfuric acid / H_2SO_4 / phosphoric acid / H_3PO_4 / Al_2O_3 [1]

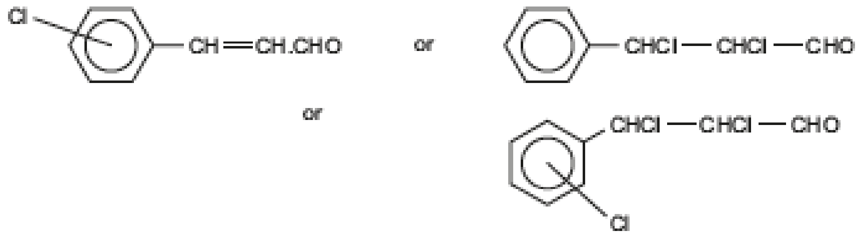
II 3-hydroxypropanoic acid does not show a C = C absorption at **1620–1670** cm^{-1} but this is present in propenoic acid [1]

III The 

/ $CH_3CH(OH)$ group is absent [1]

Total [16]

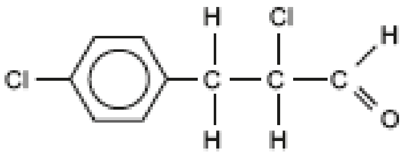
4. (a) (i) Substitution may occur in the ring at a different position (1)
Addition may occur across the double bond (1)



(1)

[3]

(ii)



(1)

In both additions a secondary carbocation is formed therefore 'equal chances' /
the energy for the formation of the carbocation is similar in both cases (1)

[2]

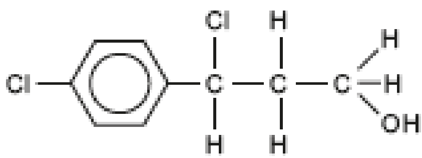
(iii) 'acidified dichromate' / H^+ and $Cr_2O_7^{2-}$ [1]

(iv) Although it contains a chiral centre (1) an equimolar / racemic mixture has been produced in the reaction (1) rotation is (externally) compensated (1)

Any 2 from 3 [2]

QWC *Selection of a form and style of writing appropriate to purpose and to complexity of subject matter* [1]

(v) $LiAlH_4$ / lithium tetrahydridoaluminate(III) / lithium aluminium hydride (1)
Do not accept $NaBH_4$



(1)

[2]

(b) (i) Gas bubbles / effervescence (1) Identifies carboxylic acid group (1) [2]

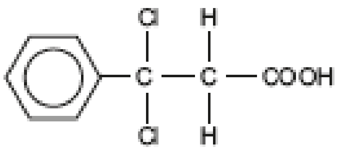
(ii) The bond between the ring and the chlorine atom is stronger than the aliphatic C–Cl bond or vice versa (1)
This is due to interaction between a **lone pair** of electrons on the chlorine atom and the ring electrons (1) [2]

(c) Compound 1 cannot give the m/z fragment value 77 ($C_6H_5^+$) (1)

Compound 2 has a chiral centre (1)

Compound 3 is rapidly hydrolysed by water / has a chiral centre (1)

Possible correct answers



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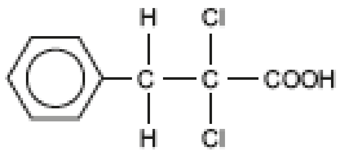


(1)

[4]

QWC Legibility of text; accuracy of spelling, punctuation and grammar; clarity of meaning [1]

Total [20]

5. (a) Number of moles of nitrogen = 1.00/23.2 = 0.0431 (1)
thus number of moles of the amine is also 0.0431

M_r of the amine = mass / number of moles = 2.54 / 0.0431 = 58.9 (1)

$R — NH_2 \longrightarrow 58.9$

16.02 $\therefore$ R = '43' $\therefore$ Formula is $CH_3CH_2CH_2NH_2$ or $(CH_3)_2CHNH_2$ (1) [3]

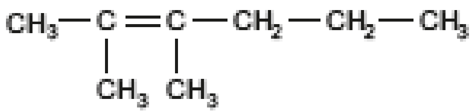
(b) (i) An electron deficient species that seeks out an electron rich / negatively charged / δ- site in a molecule [1]

(ii) 3-methylphenylamine [1]

(iii) These types of group are called **chromophores / azo** (1)
and are responsible for the production of colour in compounds as found in **azo-dyes** (1) [2]

(c) (i) Nucleophilic addition and elimination / condensation (1)
The products are orange/ red/ yellow (1) [2]

(ii) R_f values 2.5 / 7.2 = 0.35 and 3.5 / 7.2 = 0.49 (1)
Ketones are propanone and pentan-2-one (1)

Alkene **W** is  (1)

The name is 2,3-dimethylhex-2-ene (1) [4]

QWC Information organised clearly and coherently, using specialist vocabulary where appropriate [1]

(iii) The equation / information shows that R and R^1 are different alkyl groups.
2-methyl-3-ethylpent-2-ene has both R and R^1 as ethyl groups [1]

(d) (i) $CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$ [1]

(ii) Mass of ethanoic acid = 0.45 × 60 = 27 g [1]

(iii) There is no indication of the time necessary to reflux the mixture / method of heating / mention of dangers from fire [1]

(iv) It acts as a catalyst / dehydrating agent / necessary to remove water / move the position of equilibrium to the right [1]

(v) To react with (any remaining) ethanoic acid [1]

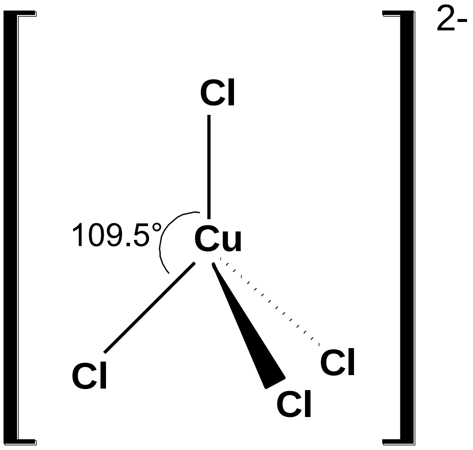
Total [20]

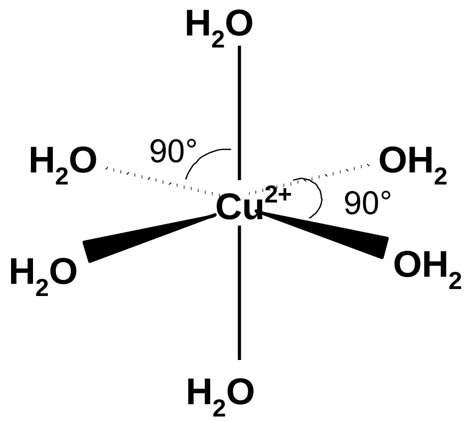
CH5

SECTION A

1. (a) (i) Species with lone pair that can bond to a metal atom/ion (1) [1]

(ii) Must clearly show which atoms are bonded and the 3D structure
1 mark each (2) [2]





(iii) Ligands cause d-orbitals to split into three lower and two higher (1)
Electrons move from lower level to higher level by absorbing some frequencies (1)
Light not absorbed gives colour seen (1) [3]

(iv) $[Cu(NH_3)_4(H_2O)_2]^{2+}$ (1) Royal blue (1) [2]

(b) (i) $K_p = \frac{P_{PCl3}P_{Cl2}}{P_{PCl5}}$ do not accept if [ ] included [1]

(ii) I. 1.3×10^5 (Pa) [1]

II. $P_{PCl5} = 3.0 \times 10^5 - 1.3 \times 10^5 = 1.7 \times 10^5$ (1) (ecf from part I)

$K_p = (1.3 \times 10^5 \times 1.3 \times 10^5) / 1.7 \times 10^5 = 9.9 \times 10^4$ (1)

Pa (1) [3]

III. Endothermic as equilibrium shifts to products when temperature increases [1]

(c) $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ OR

$SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$ (1)

Silicon has available empty d-orbitals whilst carbon does not /
Silicon can expand its octet whilst carbon cannot (1) [2]

Total [16]

2. (a) $2 \times (0) + 3 \times (-394) - (-826) - 3 \times \Delta H^{\theta}_{f}(CO) = -23$ (1)

$2 \times (\Delta H^{\theta}_{f}(Fe)) + 3 \times (\Delta H^{\theta}_{f}(CO_2)) - (\Delta H^{\theta}_{f}(Fe_2O_3)) - 3 \times \Delta H^{\theta}_{f}(CO) = -23$ (1)

$-1182 + 826 + 23 = 3 \times \Delta H^{\theta}_{f}(CO)$

$-333 = 3 \times \Delta H^{\theta}_{f}(CO)$

$-111\ \text{kJ mol}^{-1} = \Delta H^{\theta}_{f}(CO)$ (1) [3]

(b) Gases have higher entropies than solids as the molecules have a greater degree of freedom / disorder [1]

(c) (i) $\Delta G = \Delta H - T\,\Delta S = -23 - (298 \times 9/1000)$ (1)

$= -25.7\ \text{kJ mol}^{-1}$ (1) [2]

(ii) A reaction is feasible when ΔG is negative (1)

No temperature exists where ΔG is positive / ΔG is negative at all temperatures (1) [2]

(iii) Higher temperature used to increase rate of reaction [1]

Total [9]

3. (a) +1 occurs due to inert pair of s-electrons (1)
Inert pair effect becomes more significant down the group (1) [2]

(b) (i)

B	H	
$\frac{78.14}{10.8}$	$\frac{21.86}{1.01}$	
7.235	21.644	(1)
1	3	

Empirical formula = BH_3 (1) [2]

(ii) Number of moles = 1/22.4 = 4.46×10^{-2} moles (1)

$M_r = 1.232 / 4.46 \times 10^{-2} = 27.6$ (1)

Molecular formula = B_2H_6 (1) [3]

(c) Outer/valence shell of electrons is not full / does not have an octet [1]

(d) $B_5H_9 + 15H_2O \rightarrow 5H_3BO_3 + 12H_2$ [1]

(e) The compound is less stable than the elements [1]

(f) Any 3 from 4 points for (1) each

All atoms the same in graphite / BN alternate in boron nitride (1)
Atoms in layer of BN lie above each other but are not in graphite (1)
B—N bonds are polarised (or indicated dipole) but graphite is non-polar (1)
p-electrons in BN are localised but in graphite are delocalised (1) [3]

QWC Organisation of information clearly and coherently; use of specialist vocabulary where appropriate [1]

(g) Mass number = 7 Atomic number =3 [1]

Total [15]

SECTION B

4. (a) Filtration [1]

(b) $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ [1]

(c) (i) Carbon O.S. at start = +3; Carbon O. S. at end = +4 [1]

(ii) $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$ [1]

(d) Colour change of manganate(VII) is used to indicate the change [1]

(e) Volume of manganate(VII) = 27.92 cm^3 (1)

Moles manganate = 27.92 × 0.020 / 1000 = 5.584 × 10^{-4} mol (1)

Moles oxalate = 5.584 × 10^{-4} × 5/2 = 1.396 × 10^{-3} mol (1)

Concentration = 1.396 × 10^{-3} / 25 × 10^{-3} = 0.0558 mol dm^{-3} (1) [4]

(f) (i) $K_a = \frac{[H^+][HCOO^-]}{[HCOOH]}$ [1]

(ii) $[H^+]^2 = K_a \times [HCOOH] = 1.8 \times 10^{-4} \times 0.2 = 0.36 \times 10^{-4}$ (1)

$[H^+] = 6.0 \times 10^{-3}$ mol dm^{-3} (1)

pH = $-\log [H^+]$ = 2.22 (1) [3]

(iii) A buffer keeps the pH almost constant when **small amounts** of acid or base are added (1)

$HCOOH \rightleftharpoons HCOO^- + H^+$ (1)

Adding acid shifts the equilibrium to the left which removes H^+ /
Adding base removes H^+ shifts equilibrium to right which replaces H^+ (1)
OR answer in terms of H^+ reacting with methanoate from
sodium methanoate when acid added (1) and methanoic acid replacing H^+
when base removes H^+ (1)

MAX 3 [3]

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

(g) (i) Orange to green [1]

(ii) CrO_4^{2-} (1) Yellow (1) [2]

Total [20]

5. (a) Lead(II) iodide or PbI_2 (1) Bright yellow (1) [2]

(b) $2Cu^{2+} + 4I^{-} \rightarrow 2CuI + I_2$ (1)

The precipitate is copper(I) iodide (stated or clearly indicated by state symbols) (1) [2]

(c) Bromine has a more positive E^{θ} than iodine so it is a stronger oxidising agent (1)

Bromine is able to oxidise iodide (1)

Bromine has a less positive E^{θ} than chlorine so it is a weaker oxidising agent (1)

Bromine is not able to oxidise chloride (1)

MAX 3

OR Calculate EMF for each reaction (1 each) and state that positive EMF means reaction is feasible (1) [3]

QWC Legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning [1]

(d) 1 mark for each two products or observations

$KHSO_4$ HI H_2S SO_2 S I_2 [MAX 2 for products]

Yellow solid rotten egg smell steamy fumes

Black solid or brown solution or purple fumes

MAX 3 [3]

(e) (i) Measure time taken for a sudden colour change (1)
Rate = 1 ÷ time (1) [2]

(ii) I. pH 1 has a concentration of H^+ ten times higher than pH 2. [1]

II. Order with respect to H_2O_2 = 1 (1)
Order with respect to I^- = 1 (1)
Order with respect to H^+ = 0 (1) [MAX 2 for the stated orders]
Rate = $k[H_2O_2][I^-]$ (1) [3]

III. k = 0.028 (1) $mol^{-1}dm^{3}\,s^{-1}$ (1) [ecf from rate equation] [2]

IV. Rate equation is unchanged and increasing temperature increases the value of the rate constant [1]

Total [20]

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