Mark Scheme - 1.1 Formulae and Equations

1.

(a) (i) Number of moles of HCl = $\frac{80 \times 0.20}{1000}$ = 0.016 (1)

Number of moles of calcium needed = 0.008 (1)

Number of moles of calcium actually used = $\frac{0.40}{40}$ = ~ 0.010 (1)

(∴ calcium is present in excess)

[Calculation could be carried out in grams] [3]

(ii) gas bubbles / effervescence / some calcium 'dissolves' / colourless solution produced [1]

(b) Mass of **E** in solution at 0 °C = 0.13 × 2 = 0.26 g (1)

∴ Quantity precipitated = 1.50 – 0.26 = 1.24 g (1) [2]

(c) (i) Brick red / orange-red [1]

(ii) Cream precipitate (accept off-white precipitate) [1]

(iii) $Ag^+ + Br^- \rightarrow AgBr$ [1]

(iv) Red / brown solution [1]

(v) Calcium bromide is an ionic compound (1)
and contains Ca^{2+} and Br^- ions (1)
Chlorine reacts with the bromide ions in a redox / displacement reaction (1)
Chlorine is a more powerful oxidising agent / has a greater affinity for electrons than bromine (1)
$2Br^- + Cl_2 \rightarrow Br_2 + 2Cl^-$ (1) [5]

QWC: ensure that text is legible and that spelling, punctuation and grammar are accurate so that the meaning is clear [1]

Total [16]

2.

(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)

$R — NH_2$ ⟶ 58.9

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

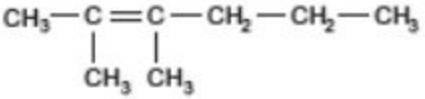
(b) (i) An electron deficient species that seeks out an electron rich / negatively charged / δ- site in a molecule [1]

(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]

3. (a) (i) Cold $Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$ (1)

Warm $3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$ (1)

[2]

(ii) isproportionation [1]

(b) P can (extend the normal octet of electrons) by using 3d orbitals /
P can promote 3s electron to 3d orbital (1)
N cannot do this since it is in the second period / 3d orbitals not available (1)
[2]

(c) The terms involved are: lattice breaking enthalpy which is endothermic (1)

and hydration enthalpy which is exothermic (1)

ΔH solution = ΔH lattice breaking + ΔH hydration (or similar) (1)

If ΔH solution is negative then the ionic solid will be soluble (1)

[4]

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

(d) (i) Iodide (1)
Only one with less positive standard potential than
Fe^{3+}, Fe^{2+} half-cell (1) [2]
(2^{nd} mark can be obtained from calculation value and statement)

(ii) $Pt(s)\,|\,Fe^{2+}(aq), Fe^{3+}(aq)\,||\,Ce^{4+}(aq), Ce^{3+}(aq)\,|\,Pt\,(s)$ (1)

EMF = 1.45 – 0.77 = 0 .68 V (1) [2]

(e) (i) $K_c = \dfrac{[CH_3COOCH_3][H_2O]}{[CH_3COOH][CH_3OH]}$ (1)

No units (1) [2]

(ii) moles = $\dfrac{1.25 \times 32.0}{1000} = 0.04(0)$ [1]

(iii) $[CH_3COOH] = 0.04$, therefore 0.06 used in reaction and

$[CH_3COOCH_3] = 0.06$, $[H_2O] = 0.06$ and

$[CH_3OH] = 0.083 – 0.06 = 0.023$ (1)

$K_c = \dfrac{0.06 \times 0.06}{0.04 \times 0.023} = 3.91$ (1) [2]

(iv) Value of K_c decreases since the equilibrium shifts to the left /
the forward reaction is exothermic [1]

Total [20]

4.

(a) (i) % H = 14.3 (1)

$$C : H = \frac{85.7}{12.0} : \frac{14.3}{1.01} = 7.14 : 14.16 \text{ (1)}$$

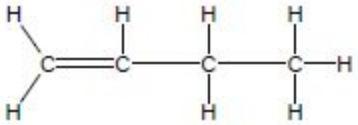
empirical formula = CH_2 (1) [3]

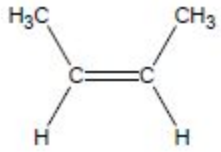
(ii) M_r = 42/ largest fragment has mass 42 (1)

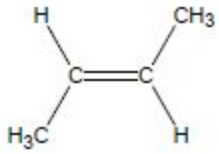
(CH_2 = 14) therefore molecular formula = C_3H_6 (1) [2]

(iii) CH_3 is present [1]

(b) 1 mark for each [3]







Total [9]

5.

(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
78.14	21.86
10.8	1.01
7.235	21.644
1	3

(1)

Empirical formula = BH_3 (1) [2]

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

M_r = 1.232 / 4.46×10^{-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]

6.

(a) (i) Cold $Cl_2 + 2NaOH \longrightarrow NaCl + NaClO + H_2O$ (1)

Warm $3Cl_2 + 6NaOH \longrightarrow 5NaCl + NaClO_3 + 3H_2O$ (1)

[2]

(ii) Disproportionation [1]

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P can promote 3s electron to 3d orbital (1)
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Only one with less positive standard potential than
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EMF = 1.45 – 0.77 = 0 .68 V (1) [2]

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No units (1) [2]

(ii) moles = $\dfrac{1.25 \times 32.0}{1000} = 0.04(0)$ [1]

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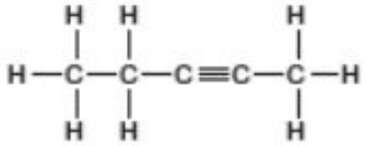
$K_c = \dfrac{0.06 \times 0.06}{0.04 \times 0.023} = 3.91$ (1) [2]

(iv) Value of K_c decreases since the equilibrium shifts to the left /
the forward reaction is exothermic [1]

Total [20]

(a)



[1]

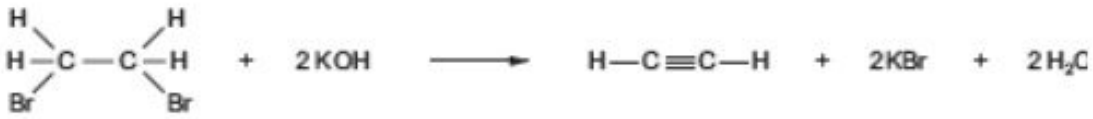
(b) Moles of calcium carbide = 500/64.1 = 7.80 (1)

Moles of ethyne = 7.80

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

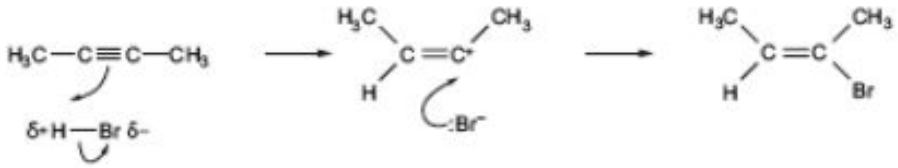
(c) If the process is endothermic left to right then it needs to absorb energy
– hence the high temperature / endothermic reactions need a high temperature [1]

(d)



[1]

(e)

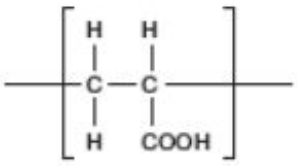


Curly arrows (1), full (1) and partial charges (1) [3]

(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_7H_8 (1) [2]

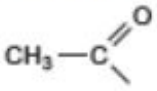
(h) (i)



[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]

7.

(a) A mixture of (many) hydrocarbons / alkanes **[1]**

(b) $C_4H_{10} + 6\frac{1}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$ **[1]**

(c) 109½° **[1]**

(d) H_2O has 2 bonding and 2 lone pair of electrons (1)

CH_4 has 4 bonding pairs only (1)

Repulsion between lone pairs and bond pairs is greater than between bond pairs and bond pairs (1) **[3]**

QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate *QWC* **[1]**

(e) (i) Butane is higher because it has more van der Waals' forces between molecules **[1]**

(ii) Regular array of metal ions surrounded by a 'sea' of delocalised valence electrons (1)

Strong attraction between the positive ions and the delocalised electrons (1)
(Can be obtained from labelled diagrams)

Malleable because when a force is applied the layer of metal ions slide over each other forming a new shape (1)

Conduct electricity since under a potential difference the delocalised electrons flow / the delocalised electrons flow towards the positive potential (1)
[4]

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

Total [13]

8.

(a) (i) 2 mol of ethanol gives 1 mol of ethoxyethane (1)

Moles of ethanol = $\frac{69}{46}$ = 1.5

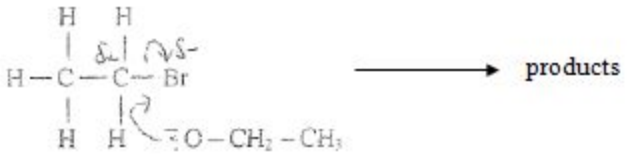
∴ Moles of ethoxyethane if theoretical yield = 0.75
∴ Moles of ethoxyethane if 45% yield = 0.75 × 0.45 = 0.34 (1)

Mass of ethoxyethane = 0.34 × 74 = 25g (1) allow error carried forward

[3]

(ii) Ethene / C_2H_4 [1]

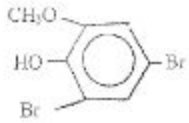
(iii)



(1) for correct curly arrows (1) for correct δ^+ and δ^- [2]

(iv) They need to have an N–H / O–H / F–H bond / a highly electronegative atom bonded to hydrogen [1]

(b) (i) For example



[1]

Accept any polybrominated species
Do not accept a monobrominated species

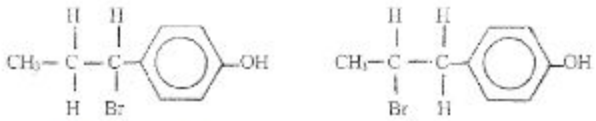
(ii) Bromine decolorised / orange to colourless / white solid [1]

(c) Reagent Iron(III) chloride solution / $FeCl_3$ (1)

Observation Purple coloration / solution (1) [2]

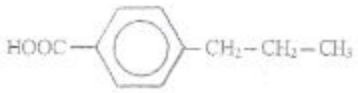
(d) (i) $C_{10}H_{12}O_1$ [1]

(ii)



[1]

(e) Displayed formula, for example



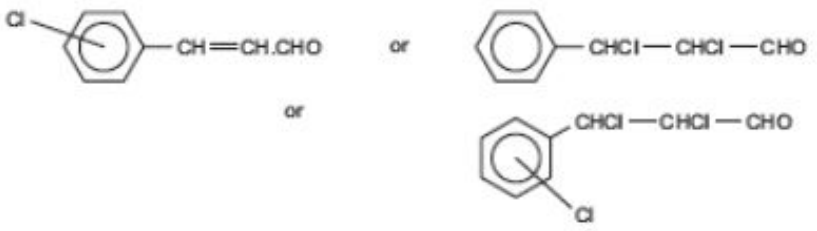
(1)

Functional group carboxylic acid (1) [2]

Total [15]

9.

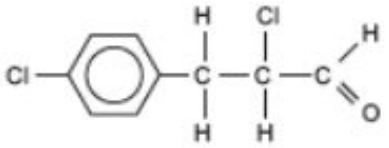
(a) (i) Substitution may occur in the ring at a different position (1)
Addition may occur across the double bond (1)



(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]

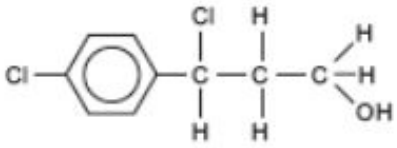
(iii) 'acidified dichromate' / H^+ and $Cr_2O_7^{2-}$ [1]

(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

(1)

[4]

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

Total [20]

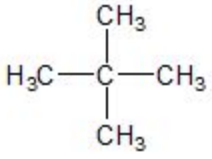
10.

(a) (i) Petroleum is heated/evaporated (1)
Fractions condense at different temperatures / separated into fractions with different boiling temperatures (1)

[2]

(ii) C_5H_{12} (1)

Branched chain therefore



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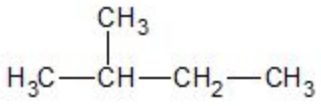

(1)

[2]

(b) (i) It enables more useful compounds to be made from the compound [1]

(ii) $C_9H_{20} \rightarrow CH_4 + C_4H_6 + C_4H_{10}$ [1]

(c) (i) UV light [1]

(ii) A step during which a radical reacts and another one is formed [1]

(iii) $Cl\bullet + CH_4 \rightarrow \bullet CH_3 + HCl$

[or $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$] [1]