Mark Scheme - AS 2.7 Alcohols and Carboxylic Acids

1

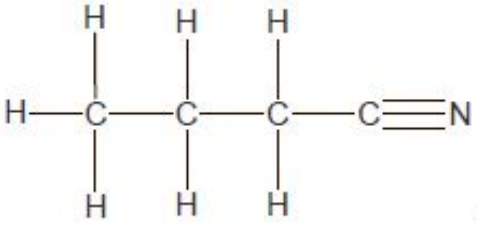
(a) (i) Nucleophilic substitution / Hydrolysis [1]

(ii) Dissolved in alcohol (1) Propene or unambiguous structure (1) [2]

(iii) Potassium manganate(VII) / Potassium dichromate(VI) - must be name (1)
Oxidation (1) [2]

(iv) (Add Potassium dichromate(VI)) and distil off the propanal from the reaction mixture [1]

(b) (i) Step 1: Potassium cyanide in ethanol / Heat (1)
Step 2: Heat with aqueous hydrochloric acid (or other acid) (1)



(1) [3]

(ii) Two points from different bullet points – 1 mark each.

- Atom economy / Amount of waste / Whether waste material was recyclable / Whether waste was toxic.
- Amount of energy required / temperature required / pressure required / conditions used
- Rate of production / time
- Availability of catalyst
- Cost of reactants / Availability of reactants / toxicity of reactants.
- Two step processes usually have lower yields than one step processes / percentage yield [2]
- Purification method / separation

(c) (i) Butanoic acid is $C_4H_8O_2$ so $M_r = 88$ (1)
Percentage carbon = 48/88 x 100 = 54.5%; percentage hydrogen = 8/88 = 9.1%;
Percentage oxygen = 32/88 = 36.4% (At least two of these for 1)
OR empirical formula for butanoic acid = C_2H_4O (1) and
calculate empirical formula from percentage masses = C_2H_4O (1) [2]

(ii) Structure 1 mark + 4 marks for explanations.

- Product is ethyl ethanoate. (1)
- Two points from the following required for each mark– MAX 4 marks
  - Sweet-smelling = ester
  - Peak at 1.0ppm implies – CH_3
  - Peak area 3 = CH_3
  - Peak area 2 = CH_2
  - Triplet shows CH_3 is next to a CH_2 group.
  - Singlet shows CH_3 no hydrogen atoms bonded to adjacent carbon.
  - Peak at 2.1 ppm suggests this is next to C=O.
  - Quartet shows CH_2 is adjacent to a CH_3 group.
  - Peak at 4.0 ppm shows it is –O-CH_2-
  - IR Peak at 1752 cm^{-1} = C=O
  - IR Peak at 2981 cm^{-1} = C-H or O-H
  - Cannot be –OH as we know there is no –OH in NMR spectrum

[5]

QWC: selection of a form and style of writing appropriate to purpose and to complexity of subject matter. (1)

QWC: organisation of information clearly and coherently; use of specialist vocabulary where appropriate. (1) [2]

[20 marks]

2 (a) (i) (2-)Methylpropan-2-ol **[1]**

(ii) 30.1 / 30 **[1]**

(iii) (Concentrated) sulfuric acid / phosphoric acid / aluminium oxide / pumice **[1]**

3 (a) (i) $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$ (state symbols needed)

C(s) allowed as C(gr) or C(graphite) [1]

(ii) (if these elements were reacted together) other products would form/ carbon does not react with hydrogen **and** oxygen under standard conditions [1]

(b) (i) energy = $100 \times 4.2 \times 54 = 22680$ [1]

(ii) moles ethanol = 0.81/46 = 0.0176 (1)

energy change = $\frac{22.68}{0.0176}$ $\Delta H = -1290$ (1)

–ve sign and correct to 3 sf (1) [3]

(c) internet value numerically larger (1)

heat losses / incomplete combustion / thermal capacity of calorimeter ignored (1) no credit for energy loss [2]

(d) (i) $C_3H_7OH + 4\frac{1}{2}O_2 \rightarrow 3CO_2 + 4H_2O$ (ignore state symbols) [1]

(ii) negative enthalpy change means energy in bonds broken is less than that in bonds made [1]

(iii) more bonds broken and made in propanol and therefore more energy released [1]

(e) any 4 from:

both conserve carbon / non-renewable fuel sources / fossil fuels / use renewable sources

(these gas / liquid) suitable for different uses e.g. ethanol to fuel cars

atom economy gasification is less (some C lost as CO_2) / CO_2 produced in gasification is a greenhouse gas

CO is toxic

gasification at high temperature / enzymes need low temperature

enzyme approach therefore saves fuel / gasification needs more energy [4]

3 max if any reference to destruction of ozone layer

QWC [2]
The candidate has selected a form and style of writing that is appropriate to purpose and complexity of the subject matter (1)

Answer has suitable structure (1)

Total [17]

4 (a) (i) ultraviolet / sunlight [1]

(ii) A species with an unpaired electron. [1]

(b) $CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$ (1)
$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$ (1) [2]

(c) (i) Two $CH_3\bullet$ radicals combine (in a termination reaction). [1]

(ii) 24.3 ÷ 12 = 2.025 for C 4.1 ÷ 1.01 = 4.059 H 71.6 ÷ 35.5 = 2.017 Cl (1)
CH_2Cl (1) [2]

(d) (i) Nucleophilic substitution [1]

(ii) Methanol has hydrogen bonding between molecules (1)
Chloromethane has van der Waals forces / dipole-dipole forces between molecules (1)
Hydrogen bonding is stronger than Van der Waals/dipole-dipole (1) [3]

(iii) Acidified potassium dichromate / acidified potassium manganate(VII) (1)
Heat /warm (1) (Need correct reagent to gain heat mark) [2]

(e) Compounds B and C are stable enough to reach the ozone layer OR Compound D would not reach the ozone layer as it would decompose in the lower atmosphere. (1)

(The C-Cl forms) Cl• which will decompose the ozone. (1)

Compound A does not contain chlorine, (so it cannot form Cl•) / Compound A has a lower RODP (1)

[3]

Total [16]

5 (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]

6 (a) diagram completed with at least 1 water molecule and indication of interaction between O on one molecule and H on the other (1)

interaction between δ^+ on H and lone pair on O (1)

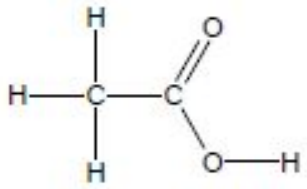
interaction labelled hydrogen bond (1) [3]

(b) (i) reduction/ redox – accept 'oxidation' [1]

(ii) I OH [1]

II OH is also present in water [1]

(c) (i) [1]



(ii) peak at 1650-1750 (1)

due to C=O (1) [2]

Total [9]

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

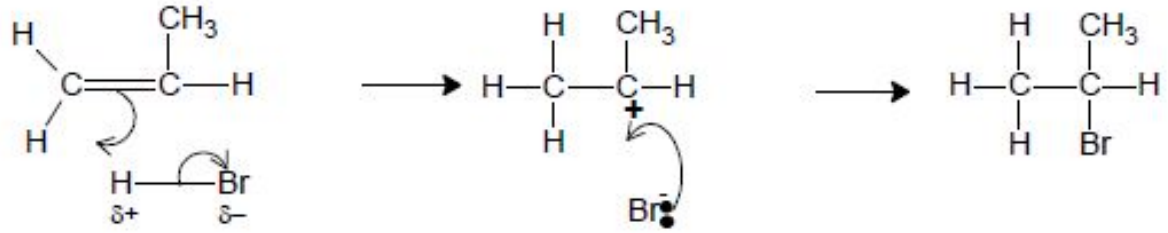
Colour change: from orange to green
or from purple to colourless (1) [2]

8 (a) (i) Molecules with different numbers of carbon atoms have different boiling points. [1]

(ii) Any suitable reaction, e.g. $C_{10}H_{22} \rightarrow C_4H_8 + C_6H_{14}$ [1]

(b) (i) Turns from orange to colourless (no credit for 'red') [1]

(ii) (1) for arrows in first diagram; (1) for arrow in second diagram; (1) for all charges.



[3]

(iii) Ethanol OR Alcohol solution / Heat - both required [1]

(c) (i) Restricted rotation about double bond in but-2-ene but not butane (1)

2 groups attached to each carbon of the double bond are different in but-2-ene but in propene one carbon has the same two groups attached (1) [2]

(ii)

Accept any valid representation [1]

(d) (i) Steam, phosphoric acid catalyst, (1) 300°C, 70 atm pressure (1) [2]

(ii) Butan-2-ol will have IR absorptions at 2500-3550 cm^{-1} / 1000 – 1300 cm^{-1} and butene will not
OR
But-2-ene will have an IR absorption at 1620-1720 and butan-2-ol will not [1]

Total [13]

9 (a) Hydrogen bonding occurs between (1) oxygen, nitrogen or fluorine (1) of one molecule and hydrogen, which is bonded to oxygen / nitrogen / fluorine of another molecule (1)
Alkanes do not contain an O-H, N-H or F-H bond and cannot therefore hydrogen bond to water molecules (1) [4]

QWC *Candidates should have use 'a selection and form of writing appropriate to purpose and to complexity of subject matter'* [1]

(b) (i) The (purified) petroleum is separated by heating (1) due to the different boiling temperatures of different fractions (1)

OR the mixture is vaporised (1) and then condensed according to boiling temperatures (1) (as at the oil refinery) [2]

(ii) $CuCl_2$ Cu +2 CuCl Cu +1 (1)

(reduction occurs when) the oxidation number becomes less positive (1) [2]

(c) (i) Same molecular formula but a different structural formula / structure [1]

(ii) Both of the carbon atoms of the double bond have different atoms / groups bonded to them (1)
There is no free rotation about the double bond (1) [2]

(iii) M_r of compound **A** is 146.3 / 146 (1)

Cost per mole is $\frac{146.3 \times 48 \times 100}{100 \times 73}$ = £96.20 (1)

(Accept £96.00 per mole if M_r of 146 has been used) [2]

Total [14]