CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

# CHEMISTRY



## MARK SCHEME

### 14 HYDROCARBONS

| SCORE | PERCENTAGE |
| --- | --- |
| / | % |

STEMUP

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# Paper 1 Multiple Choice Answers: Hydrocarbons

| Question | Paper | Q. No. | Answer |
|---|---|---|---|
| 817 | 9701_m22_qp_12 | 39 | C |
| 818 | 9701_s21_qp_12 | 23 | B |
| 819 | 9701_w21_qp_12 | 21 | A |
| 820 | 9701_w21_qp_12 | 23 | A |
| 821 | 9701_s20_qp_12 | 19 | A |
| 822 | 9701_w20_qp_12 | 28 | D |
| 823 | 9701_m19_qp_12 | 22 | B |
| 824 | 9701_s19_qp_11 | 18 | C |
| 825 | 9701_w19_qp_11 | 21 | C |
| 826 | 9701_s18_qp_11 | 3 | C |
| 827 | 9701_s18_qp_12 | 21 | B |
| 828 | 9701_s17_qp_12 | 22 | C |
| 829 | 9701_s16_qp_11 | 23 | B |
| 830 | 9701_s16_qp_12 | 11 | D |
| 831 | 9701_s16_qp_13 | 23 | B |
| 832 | 9701_w16_qp_12 | 23 | C |
| 833 | 9701_s15_qp_11 | 29 | B |
| 834 | 9701_w15_qp_11 | 22 | D |
| 835 | 9701_s21_qp_12 | 21 | D |
| 836 | 9701_s21_qp_13 | 21 | B |
| 837 | 9701_s21_qp_13 | 22 | B |
| 838 | 9701_w21_qp_11 | 20 | A |
| 839 | 9701_w21_qp_11 | 21 | B |
| 840 | 9701_s20_qp_11 | 22 | C |
| 841 | 9701_s20_qp_11 | 24 | A |
| 842 | 9701_s20_qp_11 | 27 | B |
| 843 | 9701_s20_qp_12 | 25 | A |
| 844 | 9701_s20_qp_12 | 28 | C |
| 845 | 9701_s20_qp_12 | 30 | C |
| 846 | 9701_s20_qp_13 | 28 | A |
| 847 | 9701_w20_qp_11 | 21 | D |
| 848 | 9701_m19_qp_12 | 21 | A |
| 849 | 9701_s19_qp_11 | 22 | B |
| 850 | 9701_s19_qp_12 | 20 | C |
| 851 | 9701_s19_qp_12 | 23 | A |
| 852 | 9701_s19_qp_12 | 26 | C |
| 853 | 9701_s19_qp_13 | 22 | B |
| 854 | 9701_s19_qp_13 | 23 | D |
| 855 | 9701_w19_qp_11 | 20 | A |
| 856 | 9701_w19_qp_11 | 22 | D |
| 857 | 9701_w19_qp_12 | 22 | B |
| 858 | 9701_s18_qp_12 | 1 | C |
| 859 | 9701_s18_qp_12 | 20 | A |
| 860 | 9701_s18_qp_13 | 21 | D |
| 861 | 9701_w18_qp_12 | 24 | C |
| 862 | 9701_m17_qp_12 | 23 | C |

# Paper 1 Multiple Choice Answers: Hydrocarbons (continued)

| Question | Paper | Q. No. | Answer |
|---|---|---|---|
| 863 | 9701_s17_qp_11 | 22 | B |
| 864 | 9701_s17_qp_13 | 25 | D |
| 865 | 9701_w17_qp_11 | 22 | A |
| 866 | 9701_w17_qp_11 | 29 | D |
| 867 | 9701_w17_qp_12 | 22 | B |
| 868 | 9701_w17_qp_12 | 23 | A |
| 869 | 9701_s16_qp_11 | 30 | A |
| 870 | 9701_s16_qp_12 | 22 | A |
| 871 | 9701_s16_qp_12 | 23 | A |
| 872 | 9701_s16_qp_13 | 21 | C |
| 873 | 9701_w16_qp_12 | 20 | C |
| 874 | 9701_s15_qp_11 | 22 | A |
| 875 | 9701_s15_qp_11 | 23 | A |
| 876 | 9701_s15_qp_12 | 22 | D |

99. 9701_m21_ms_22 Q: 2

| Question | Answer | Marks |
|---|---|---|
| 2(a) | kills bacteria/microbes/micro-organisms | 1 |
| 2(b)(i) | $Cl(g) - e^- \rightarrow Cl^+(g)$ | 1 |

| Question | Answer | Marks |
|---|---|---|
| (b)(ii) | **M1:** increasing proton number but similar shielding<br>**M2:** greater attraction of nucleus (for outer / valence electrons) | 2 |
| (c)(i) | **M1:** (thermal stability) decreases (down group)<br>**M2:** (H—X) bond energy / strength decreases | 2 |
| (c)(ii) | (+)6, (+)4, –2 | 1 |
| (c)(iii) | halides are better / stronger / more able reducing agents / are more easily oxidised **down group** | 1 |
| (d)(i) | when a species is both oxidised and reduced | 1 |
| (d)(ii) | $Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$ | 1 |
| (e)(i) | <br>**M1:** 2 × coordinate bonds in the right place<br>**M2:** all other bonds | 2 |
| (e)(ii) | **M1:**<br>• ($AlCl_3$ / solid) disappears<br>• misty / steamy fumes<br>• temperature increases<br><br>**M2:** hydrolysis | 2 |
| (f)(i) | simple / molecular **AND** covalent | 1 |

| Question | Answer | Marks |
|---|---|---|
| (f)(ii) | **M1:** 11.54 ÷ 143.4 = 0.0805<br>**M2:** so ratio **Z**:Cl is 1:4 / $n$ = 4 | 2 |
| (g)(i) | (free-)radical substitution | 1 |
| (g)(ii) | ultraviolet (UV) light / sunlight | 1 |
| (g)(iii) | $(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ | 1 |
| (g)(iv) | $Cl^\cdot$ **AND** $CH_2Cl_2$ | 1 |
| (g)(v) | termination | 1 |
| (g)(vi) | $CHCl_3$ **OR** $(CH_2Cl)_2$ | 1 |

100. 9701_w19_ms_21 Q: 1

| | | |
|---|---|---|
| (a)(ii) | It oxidises chlorine from –1 to 0 | **1** |
| (a)(ii) | effervescence / fizzing / bubbling<br>**OR**<br>green gas formed<br>**OR**<br>solid dissolves / disappears / soluble | **1** |
| (b) | **M1:** decreases (down the group)<br><br>**M2:** increasing induced dipoles<br><br>**M3:** greater number of electrons | **3** |
| (c)(i) | **M1:** $Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$<br><br>**M2: chlorine** is oxidised and reduced | **2** |
| (c)(ii) | $NaClO_3$ / sodium chlorate(V) | **1** |
| (d) | **M1:** chloric(I) acid / hypochlorous acid / HClO<br><br>**M2:** kills bacteria / micro-organisms / microbes | **2** |
| (e)(i) | ultra-violet (light) / sunlight | **1** |
| (e)(ii) | $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$ | **1** |

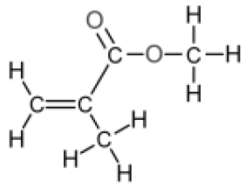
101. 9701_w19_ms_21 Q: 3

| | | |
|---|---|---|
| (a)(i) | cracking | **1** |
| (a)(ii) | enthalpy change of combustion / $\Delta H_c$ is high / large energy release (per mole / per unit mass)<br><br>**OR** combust / burn easily | **1** |
| (a)(iii) | $C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$ | **1** |
| (a)(iv) | **M1**: infrared spectroscopy<br><br>**M2:** Compare / measure (characteristic) wavelengths | **2** |
| (b)(i) | $C_4H_4S(l) + 6O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l) + SO_2(g)$<br><br>• correct species<br>• balancing<br>• state symbols<br>Award one mark for two correct bullet points, award two marks for all three correct. | **2** |
| (b)(ii) | **M1** (enthalpy change when) 1 mol of a substance<br><br>**M2** EITHER burns / combusts / reacts in excess air / oxygen<br>OR completely burns / combusts / reacts in air / oxygen | **2** |
| (b)(iii) | **M1** m = 200 and $\Delta T$ = 37.5–18.5<br><br>**M2** $Q = mc\Delta T = 200 \times 4.18 \times (37.5 - 18.5) = 15\,884$ (J) | **2** |
| (b)(iv) | **M1** mol of thiophene used<br>= 0.63 / 84.1 OR $7.49(1\,082\,045) \times 10^{-3}$<br><br>**M2** calculation ÷ 1000 AND negative sign<br>$\Delta H_c = \frac{-\textbf{(iii)}}{\textbf{1000}} \div n = \frac{-\textbf{(iii)}}{\textbf{21000}} \div (0.63 / 84.1)$<br>= –2120 (–2120.39) (kJ mol$^{-1}$) | **2** |

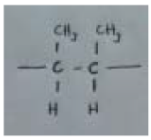
102. 9701_m18_ms_22 Q: 2

| | | |
|---|---|---|
| (a)(i) | simple molecular<br>regular arrangement (of $C_{60}$ molecules) | 2 |
| (a)(ii) | $C_{60}$ has (weak) intermolecular / VdW / London / dispersion / id–id forces (and covalent bonds)<br><br>diamond has covalent bonds<br><br>(diamond's) bonds are stronger<br><br>more energy required / lots of energy to break (covalent bonds in diamond) | 4 |
| (b)(i) | (a molecule / compound that is made up of)<br>carbon and hydrogen (atoms) only | 1 |
| (b)(ii) | add bromine (water) / $Br_2$(aq)<br><br>(brown to) colourless / decolourised | 2 |
| (c)(i) | addition | 1 |
| (c)(ii) | ($n_{C60}$ = 0.144 / 720 =) 2 □ $10^{-4}$ | 1 |
| (c)(iii) | $pV = nRT$ ∴ $\Delta n = (p_1 - p_2)V / RT$<br>$\Delta n$ = (1.00 □ $10^5$ – 2.21 □ $10^4$).100 □ $10^{-6}$ / 8.31 □ 293<br>= 0.00320 | 2 |
| (c)(iv) | ($C_{60}$:$H_2$ =) 2.00 □ $10^{-4}$ : 0.00320 or 1:16<br><br>$C_{60}H_{32}$ | 2 |
| (d)(i) | giant (molecular)<br>(each Si has four) covalent (bonds) | 2 |
| (d)(ii) | $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ | 1 |
| (d)(iii) | $Mg_2Si(s) + 4HCl(aq) \rightarrow SiH_4(g) + 2MgCl_2(aq)$<br>species **AND** balancing<br>state symbols | 2 |
| (d)(iv) | tetrahedral | 1 |
| (d)(v) | $SiH_4 + 2O_2 \rightarrow SiO_2 + 2H_2O$ | 1 |

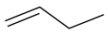
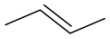
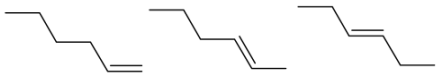
103. 9701_s18_ms_21 Q: 2

| | | |
|---|---|---|
| (a) | Different (hydrocarbon) molecules have different numbers of electrons | 1 |
| | so different strengths / numbers / amount of VdW / IMFs / id-id | 1 |
| (b) | Produces more useful / more valuable / higher demand substances / alkanes / alkenes | 1 |
| (c)(i) | $C_{12}H_{26} \rightarrow 2C_2H_4 + C_8H_{18}$ | 1 |
| (c)(ii) | addition polymerisation | 1 |
| (c)(iii) | *two from*<br>save space in landfill<br>avoid litter<br>prevent eyesore<br>non-biodegradable<br>conserves non-renewable resources<br>harmful incineration products<br>harmful to wildlife | 2 |
| (c)(iv) |  | |
| | correct monomer | 1 |
| | fully displayed | 1 |

104. 9701_s18_ms_22 Q: 3

| | | |
|---|---|---|
| (a)(i) | combustion | **1** |
| (a)(ii) | $C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$ | |
| | correct species | **1** |
| | correct balancing | **1** |
| (b)(i) | cracking | **1** |
| (b)(ii) | -$CH(CH_3)CH(CH_3)$-<br>OR<br> | |
| | even number of C's in correct backbone with 'end bonds' AND no C=C | **1** |
| | $CH_3$ and H on each of two C drawn for 1 repeat unit only AND all the carbons must be tetravalent | **1** |
| (b)(iii) | addition | **1** |
| c(i) | catalytic converter / catalyst | **1** |
| c(ii) | $2CO + NO_2 \rightarrow 2CO_2 + ½N_2$ | **1** |
| c(iii) | (photochemical) smog / fog / haze<br>OR<br>global dimming | **1** |
| (d)(i) | *any 2 from:*<br>lowers pH / increases acidity of rivers / lakes / oceans / seas / soil<br>kills/harms fish OR harms / kills coral / plants / crops / trees<br>leaches (toxic) aluminium (ions / salts) from soil (into rivers / lakes)<br>leaches away soil nutrients<br>damages / weathers / erodes buildings / statues | **2** |
| (d)(ii) | $NO_2 + SO_2 \rightarrow NO + SO_3$ | **1** |
| | $SO_3 + H_2O \rightarrow H_2SO_4$ | **1** |
| (d)(iii) | (it is) regenerated / not used up / undergoes temporary chemical change / recovered unchanged | **1** |
| | $NO + ½O_2 \rightarrow NO_2$ | **1** |

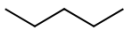
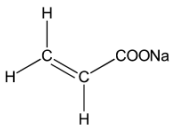
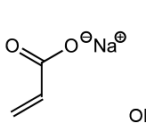
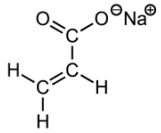
105. 9701_s17_ms_23 Q: 1

| | | |
|---|---|---|
| (a) | (molecules / isomers with) the same molecular formula / same number of atoms of each element | **1** |
| | different structural / displayed formulae / different arrangement of bonds | **1** |
| (b)(i) | 4 | **1** |
| (b)(ii) | 6 | **1** |
| (b)(iii) | molecular = $C_4H_8$ | **1** |
| | empirical = $CH_2$<br><br>using alternative supplied data<br>molecular = $C_6H_{12}$<br><br>empirical = $CH_2$ | **1** |
| (b)(iv) |  | **1** |
| | <br><br>alternative using supplied data: any two<br> | **1** |
| (b)(v) | correct conversions of data to SI / consistent units<br>P = 100 000; V = $25 \times 10^{-6}$; T = 310 | **1** |
| | calculation of $n$ ( = $pV / RT$)<br>$n = \frac{100 \times 10^3 \times 25 \times 10^{-6}}{8.31 \times 310}$ | **1** |
| | calculation of mass $m$ ( = $n \times M_r$) AND answer correct to **3sf**<br>$m = 9.705 \times 10^{-4} \times 56 = 0.0543$ (g) | **1** |
| | Alternative answer for using $C_6H_{12}$:<br>$m = 9.705 \times 10^{-4} \times 84 = 0.0815$ (g) | |
| | **Total:** | **11** |

106. 9701_w15_ms_21 Q: 3

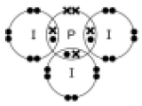
| | | |
|---|---|---|
| **(a) (i)** | structural isomers: (different molecules with) same molecular formula<br>but different structural formulae<br><br>chiral: has a carbon / C attached to 4 different groups / atoms / chains OR has no plane / line of symmetry / has non-superimposable mirror images | [1]<br><br>[1] |
| **(ii)** | $CH_3CH_2CH(CH_3)CH_2CH_2CH_3$<br>3-methylhexane<br><br>$CH_3CH(CH_3)CH(CH_3)CH_2CH_3$ / $(CH_3)_2CHCH(CH_3)CH_2CH_3$<br>2,3-dimethylpentane | [1]<br>[1]<br><br>[1]<br>[1] |
| **(b) (i)** | $C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ | [1] |
| **(ii)** | $C_7H_{16} + 4O_2 \rightarrow 7C + 8H_2O$ | [1] |
| **(iii)** | global dimming / PAN / smog / global warming | [1] |
| **(c) (i)** | (Free) Radical Substitution | [1] |
| **(ii)** | $Cl_2 \rightarrow 2Cl\bullet$<br>OR<br>$Cl_2 \rightarrow Cl\bullet + Cl\bullet$<br><br>$C_7H_{16} + Cl\bullet \rightarrow \bullet C_7H_{15} + HCl$<br>$\bullet C_7H_{15} + Cl_2 \rightarrow C_7H_{15}Cl + Cl\bullet$<br><br>$\bullet C_7H_{15} + Cl\bullet \rightarrow C_7H_{15}Cl$ OR $\bullet C_7H_{15} + \bullet C_7H_{15} \rightarrow C_{14}H_{30}$<br><br>Initiation; Propagation; Termination (used correctly) | [1]<br><br><br><br>[1]<br>[1]<br><br>[1]<br><br>[1] |
| | | |

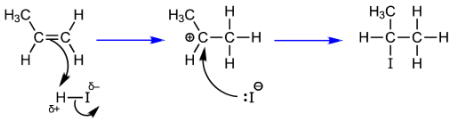
107. 9701_s21_ms_21 Q: 5

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | (compounds / molecules) containing only / entirely carbon and hydrogen (atoms) | **1** |
| (a)(ii) | crude oil | **1** |
| (b)(i) | (thermal) cracking | **1** |
| (b)(ii) | *structure of* ***W***<br> OR $CH_3(CH_2)_3CH_3$ OR  | **1** |
| (c)(i) | $CO_2H$ / carboxylic acid | **1** |
| (c)(ii) | **M1** (add) $Br_2(aq)$ / bromine water | **1** |
| | **M2** (solution) turns (from brown / orange / red to) colourless / decolorises<br>OR brown / orange / red fades | **1** |
| (d) | <br>OR $CH_2CH(CO_2^{(-)}Na^{(+)})$<br>OR $CH_2{=}CH(COO^{(-)}Na^{(+)})$<br> OR  , etc. | **1** |
| (e)(i) | carbon dioxide / $CO_2$ | **1** |
| (e)(ii) | CO / hydrocarbons **AND** toxic / poisonous / harmful to health / (catalyses formation of) photochemical smog | **1** |

108. 9701_w21_ms_22 Q: 1

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | **M1** (HI / I / iodine / hydrogen iodide has a) greater number of electrons<br><br>**M2** greater induced dipoles (between molecules) | **2** |
| (a)(ii) | **M1** bar at HF shows any boiling point above HI on graph<br><br>**M2** *explanation of difference in boiling point of a sample of HF in terms of strength*<br>(sum of) hydrogen bonds (and induced dipoles in HF) are **stronger** than (sum of) induced dipoles (and permanent dipoles in HCl / HBr / HI) | **2** |
| (b) | (enthalpy / energy change) when one mole of a compound is formed<br><br>from its elements in their standard states | **2** |
| (c)(i) | $K_p = \frac{p\mathrm{HI}^2}{p\mathrm{H_2}\ p\ \mathrm{I_2}}$ | **1** |
| (c)(ii) | 28.76 **OR** 28.8 **OR** 29 | **1** |
| (c)(iii) | **EITHER**<br>**option 1** which assumes $\Delta H_{reaction}$ *is (still) endothermic (using the value shown in (b)).*<br><br>**M1** ($K_p$) decreases **AND** endothermic / $\Delta H_{(f)}$ = + / positive<br><br>**M2** reaction favours formation of reactants / hydrogen and iodine OR (product) yield / partial pressure of HI decreases / equilibrium shifts to the left<br><br>**OR**<br>**option 2** which realises that $\Delta H_{reaction}$ *is in fact exothermic (using bond energy data in Data Booklet)*<br><br>**M1** ($K_p$) increases **AND** exothermic / $\Delta H_{(f)}$ = + / negative<br>**M2** reaction favours formation of products / hydrogen iodide yield increases / partial pressure of HI increases / equilibrium shifts to the right | **2** |
| (d)(i) | $4HI + O_2 \rightarrow 2I_2 + 2H_2O$ | **1** |

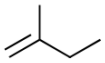
| Question | Answer | Marks |
|---|---|---|
| (d)(ii) | **M1** I / iodine (increases) oxidation number –1 → 0 so oxidation / is oxidised<br>**OR**<br>HI / is oxidised as I (increases) oxidation number –1 → 0<br><br>**M2** O (decreases) oxidation number 0 → –2 so reduction / is reduced | **2** |
| (e) | **M1** pressure increases<br><br>**M2** (pressure goes up as) number of moles/molecules increases in ratio 3 (gas) reactants to 5 (gas) products<br>**OR**<br>pressure is (directly) proportional to number of moles/molecules | **2** |
| (f)(i) | <br>**M1** correct bonding pairs<br><br>**M2** correct number of remaining outer electrons on each atom | **2** |
| (f)(ii) | hydrolysis | **1** |
| (f)(iii) | proton donor / $H^+$ donor<br>fully dissociates / fully ionises | **2** |
| (f)(iv) | $H_2PO_3^-$ | **1** |
| (g)(i) | **M1** 2-iodopropane – formed from a (more) stable (secondary) (carbo)cation/intermediate<br><br>**M2** (because of) greater (positive) inductive effect / (+)I of two alkyl groups<br>**OR**<br>(because of positive) inductive effect / (+)I of more R / more methyl / more alkyl groups | **2** |

| Question | Answer | Marks |
|---|---|---|
| (g)(ii) | <br>**M1** curly arrow from = of C=C to H **AND** curly arrow from bond of H—I to I<br>**M2** curly arrow from lone pair of $I^-$ to $C^{(+)}$ of their intermediate<br>**M3** correct carbocation **AND** product for 2-iodopropane | 3 |

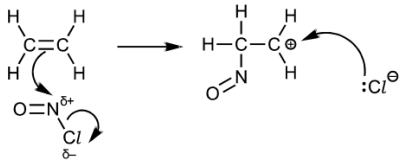
109. 9701_s20_ms_23 Q: 4

| | | |
|---|---|---|
| (a) | **M1** (no reaction) not enough energy<br>**M2** bromine (free) radicals are not produced OR homolytic fission of bromine does not occur. | 2 |
| (b)(i) | free-radical substitution | 1 |
| (b)(ii) | $C_6H_{14}$ + (·)Br → (·)$C_6H_{13}$ + HBr | 1 |
| (b)(iii) | (·)$C_6H_{13}$ + $Br_2$ → $C_6H_{13}Br$ + (·)Br | 1 |
| (b)(iv) | (·)$C_6H_{13}$ + (·)Br → $C_6H_{13}Br$ | 1 |
| (c)(i) | $CH_3(CH_2)_3CH{=}CH_2$ | 1 |
| (c)(ii) | cold **AND** acidified **AND** dilute<br>2 marks for 3 correct conditions<br>1 mark for 2 correct conditions | 2 |
| (d)(i) | addition **OR** reduction | 1 |
| (d)(ii) | **M1** only sigma / σ (bonds) in hexane / alkanes<br>**M2 B** has sigma σ (bonds) and a / one pi / π (bond) | 2 |

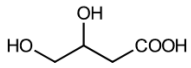
110. 9701_w20_ms_21 Q: 4

| | | |
|---|---|---|
| (a)(i) | **M1:** (Volatility) decreases (down the group) | 2 |
| | **M2:** more electrons so greater intermolecular forces / intermolecular attractions<br>**OR**<br>more electrons so greater VdW **between molecules** | |
| (a)(ii) | (HI has the) lowest bond enthalpy | 1 |
| (a)(iii) | **M1:** HF has permanent dipole(-dipole forces) **AND** HI has ((only)) instantaneous dipole / induced dipole (forces) / permanent dipole(-dipole forces) | 2 |
| | **M2:** IMF's in HI are **weaker** (than IMF's in HF) | |
| (a)(iv) | $3I_2 + 6NaOH \rightarrow 5NaI + NaIO_3 + 3H_2O$ | 1 |
| (b)(i) | HI(g) / $PI_3$ / P and $I_2$ | 1 |
| (b)(ii) | Electrophilic addition | 1 |
| (c)(i) | 2(-)iodo(-)2(-)methylbutane | 1 |
| (c)(ii) | Nucleophilic substitution / $S_N$ | 1 |
| (c)(iii) |  | 1 |
| (c)(iv) | (**L** has) two identical / two methyl groups attached to one end / one carbon of the C=C / double bond | 1 |
| (c)(v) | ethanoic acid / $CH_3COOH$ | 1 |
| (c)(vi) | $CH_3COCH_3 + 3I_2 + 4OH^- \rightarrow$ (**1**)$CH_3COO^-$ + $3H_2O$ + $3I^-$ + **$CHI_3$** | 2 |
| | **M1:** correctly balanced<br>**M2:** $CHI_3$ product | |
| (c)(vii) | yellow ppt / yellow solid | 1 |

111. 9701_m19_ms_22 Q: 1

| | | |
|---|---|---|
| (a) | strong triple bond / strong N≡N<br>OR high activation energy / $E_a$<br>OR non-polar | 1 |
| (b)(i) | $3Mg + N_2 \rightarrow Mg_3N_2$ | 1 |
| (b)(ii) | solid disappears | 1 |
| (c)(i) | (it is used to make) fertilisers | 1 |
| (c)(ii) | **M1** CaO displaces $NH_3$ (from its salt / $NH_4^+$)<br><br>**M2** CaO is a stronger base / more basic (than $NH_3$) | 2 |
| (d)(i) | <table><tr><td>NO</td><td>$NO_2$</td></tr><tr><td>(+)2 / (+)II</td><td>(+)4 / (+)IV</td></tr></table> | 1 |
| (d)(ii) | **M1** $\frac{1}{2}N_2 + O_2 \rightarrow NO_2$<br><br>**M2** $Mg(NO_3)_2 \rightarrow MgO + 2NO_2 + \frac{1}{2}O_2$ | 2 |
| (d)(iii) | **M1** $+82 (= E_{o=o} - 2E_{N\rightarrow O}) = (+)496 - 2 \times E_{N\rightarrow O}$<br><br>**M2** $E_{N\rightarrow O} = \frac{1}{2} \times (496–82) = \frac{1}{2} \times 414 = 207$ (kJ mol$^{-1}$) | 2 |
| (e) | <br>**M1** curly arrow from C=C to $N^{\delta+}$<br>**AND** curly arrow from N—Cl to $Cl^{\delta-}$<br><br>**M2** intermediate<br>**AND** curly arrow from lone pair on $Cl^-$ to C(+) | 2 |

112. 9701_m19_ms_22 Q: 4

| | | |
|---|---|---|
| (a) | 3-chloroprop-1-ene | 1 |
| (b)(i) | ultra-violet (light) / sun(light) | 1 |
| (b)(ii) | $CH_2{=}CHCH_3 + Cl^\bullet \rightarrow CH_2{=}CHCH_2^\bullet + HCl$<br>OR $C_3H_6 + Cl^\bullet \rightarrow C_3H_5^\bullet + HCl$ | 1 |
| (b)(iii) | free-radical (substitution) reactions are uncontrolled<br>OR further chlorination / substitution occurs | 1 |
| (b)(iv) | $SOCl_2$ OR $PCl_5$ OR $PCl_3$ OR c(oncentrated) HCl | 1 |
| (c)(i) | cold, dilute acidified $KMnO_4$ / potassium manganate(VII) | 1 |
| (c)(ii) | **M1** catalyst<br>**M2** ethanoic acid / $CH_3CO_2H$ | 2 |
| (c)(iii) | nucleophilic substitution / $S_N2$ | 1 |
| (c)(iv) | <br>**M1** hydrolysed nitrile on straight-chain 4C backbone<br>**M2** 3,4-diol | 2 |
| (d) | **M1** major product formed from more stable intermediate / carbocation<br>OR<br>(intermediate has) 2°carbocation which is (more) stable<br><br>**M2** (positive) inductive effect / (+)I of alkyl groups (on the intermediate) | 2 |

113. 9701_s19_ms_22 Q: 4

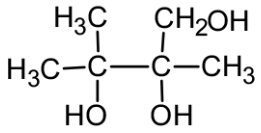
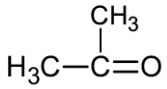
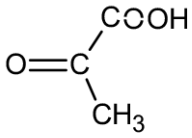
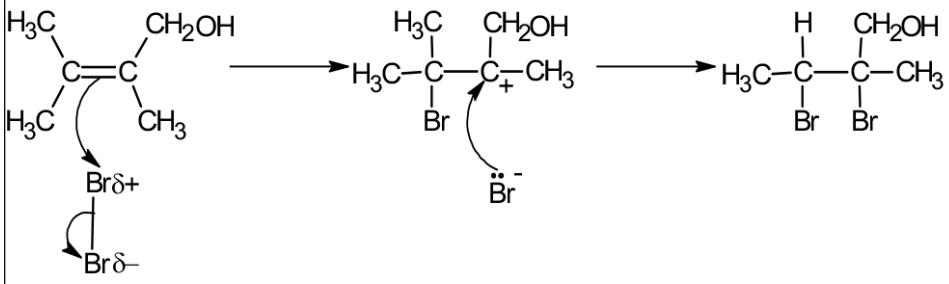
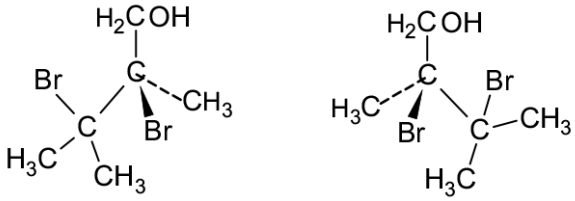
| | | | | |
|---|---|---|---|---|
| (a) | name of source crude oil / petroleum | | | **1** |
| | outline of separation of hydrocarbons<br>(separation of molecules according to) different boiling points | | | **1** |
| (b)(i) | cracking | | | **1** |
| (b)(ii) | $2C_7H_{16} \rightarrow C_4H_{10} + C_6H_{14} + 2C_2H_4$ | | | **1** |
| (c) | | *method 1* | *method 2* | |
| | **M1** | 1 / 28 (= 0.035714) | 1 : 88 / 28 (= 3.14286) | **1** |
| | **M2** | 2 × M1 (= 1 / 14 = 0.07143) | M1 / 44 (= 0.071429) | **1** |
| | **M3** | M2 × 24 = 1.7 $dm^3$ | M2 × 24 = 1.7 $dm^3$ | **1** |
| (d)(i) | unpaired electron(s) | | | **1** |
| (d)(ii) | homolytic (fission) | | | **1** |
| | one electron goes to each chlorine / atom<br>OR<br>pair of electrons is shared out (equally between the two atoms) | | | ***1*** |
| (d)(iii) | propagation | | | **1** |
| (d)(iv) | $CH_4 + (\bullet)Cl \rightarrow (\bullet)CH_3 + HCl$ **OR** $CH_4 + (\bullet)Cl \rightarrow HCl + CH_3(\bullet)$ | | | **1** |
| (d)(v) | ***M1*** *identify bond types in alkanes and alkenes*<br>bonds in alkanes are (all) sigma / σ<br>AND<br>alkenes have (C = C made of) sigma AND pi / σ AND π | | | **1** |
| | ***M2*** *electrons in π (of the C = C) are responsible for the reaction*<br>electrophiles are attracted to / attack to electrons in **pi /** π<br>OR<br>electrophiles react with **pi /** π | | | **1** |

114. 9701_S15_ms_22 Q: 3

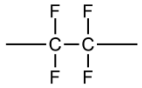
| | | |
|---|---|---|
| **(a) (i)** | Bond breaking = C*l*-C*l* = 242<br>C-H = 410 = 652 kJ | [1] |
| | Bond forming = C-C*l* = 340<br>H-C*l* = 431 = 771 kJ | [1] |
| | Enthalpy change = 652 – 771 = –119 | [1] |
| **(ii)** | UV / High T / sunlight | [1] |
| **(iii)** | Initiation<br>$Cl_2 \rightarrow 2Cl\bullet$ | [1] |
| | Propagation<br>$C_2H_6 + Cl\bullet \rightarrow \bullet C_2H_5 + HCl$<br>$\bullet C_2H_5 + Cl_2 \rightarrow C_2H_5Cl + Cl\bullet$ | [1]<br>[1] |
| | Termination<br>$\bullet C_2H_5 + \bullet C_2H_5 \rightarrow C_4H_{10}$ | [1] |
| | All three names correctly assigned | [1] |
| **(b) (i)** | ethene | [1] |
| **(ii)** | KOH / NaOH | [1] |
| | ethanolic **AND** heat / reflux | [1] |
| **(iii)** | $H_2$ **AND** Pt or Ni (catalyst) | [1] |
| | | |

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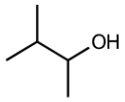
115. 9701_S15_ms_23 Q: 4

| | | |
|---|---|---|
| **(a) (i)** |  | [1] |
| **(ii)** | <br> | [1]<br>[1] |
| **(b) (i)** | <br>M1 = 2 curly arrows<br>M2 = intermediate ion<br>M3 = Br with –ve charge, lone pair and curly arrow to C+ | [1]<br>[1]<br>[1] |
| **(ii)** | dipole is induced by proximity to C=C | [1] |
| **(iii)** | Optical | [1] |
| **(iv)** |  | [1+1] |
| | | |

116. 9701_w18_ms_21 Q: 3

| | | |
|---|---|---|
| (a)(i) | **M1** gas / vapour (particles / molecules) in **equilibrium** (with liquid / solid)<br>**M2** greater proportion of gas (particles) than liquid (particles) (in comparison to a liquid of lower vapour pressure) | **2** |
| (a)(ii) | –17.(0) (kJ $mol^{-1}$) ✓✓✓<br>**M1** $\Delta H_r = x(-482.2) + y(-92.3) - v(-103.2) - w(-273.3)$ where $x$ $y$ $v$ and $w$ are integers $\geqslant 1$ (ignore stoichiometry)<br>**M2** use of correct stoichiometry where $x = 1$ $y = 2$ $v = 1$ and $w = 2$ | **3** |
| (a)(iii) | **M1** in a different phase / state from reactants<br>**M2** a substance that speeds up a (chemical) reaction<br>**M3** catalyst is regenerated / not used up / undergoes temporary chemical change / recovered unchanged | **3** |
| (b)(i) | **Human activity** creates / additional / more/increase / thicker layer in greenhouse gas(es) / $CHClF_2$<br>**OR**<br>**Human activity** has an impact on climate change / temperature at earth's surface / temperature of sea | **1** |
| (b)(ii) | **M1** traps (more)heat<br>**M2** (in the atmosphere leading to) greater global warming or wtte | **2** |
| (b)(iii) | ozone depletion / thinning | **1** |
| (c)(i) | addition | **1** |
| (c)(ii) |  | **1** |
| (c)(iii) | molecule unreactive / inert | **1** |
| (c)(iv) | non-biodegradable<br>creates toxic / harmful gases / HF / $CO_2$ / CO **if burnt** | **2** |

117. 9701_m16_ms_22 Q: 4

| | | |
|---|---|---|
| **(a) (i)** | $\underline{C_4H_{10}}$ | [1] |
| **(ii)** | $\underline{C_4H_9}$ | [1] |
| **(iii)** |  | [1] |
| **(b)** | $C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$ | [1] |
| **(c)** | sulfur dioxide would be produced on combustion<br>(which contributes to) acid rain | [1]<br>[1] |
| **(d)** | M1 = **H** has more / greater / stronger van der Waals' / intermolecular forces than **G** / ora<br>M2 = (because) **H** has more electrons (than **G**)<br>M3 = **J** has hydrogen bonding (between molecules)<br>M4 = strong(er) / great(er) forces require AND high / more energy to overcome | [1]<br>[1]<br>[1]<br>[1] |
| **(e)** | NaOH(aq) | [1] |
| | | |

118. 9701_s16_ms_23 Q: 3

| | | |
|---|---|---|
| **(a) (i)** | vaporise / boil / turn to gas | [1] |
| **(ii)** | increasing molecular size / no of carbon atoms per molecule / length of carbon chain | [1] |
| **(iii)** | increasing b.pt / decreasing volatility<br>increasing viscosity<br>increasing density<br>increasing depth of colour<br>decreasing flammability / decreasing 'cleanliness' of flame owtte | [1]<br>[1] |
| **(b) (i)** | $C_{12}H_{26} \rightarrow 2C_2H_4 + C_8H_{18}$ | [1] |
| **(ii)** | ethene use = <u>making</u> polythene / plastic / polymers<br>feature of ethene = double bond / unsaturated<br>octane / alkane use = fuel / petrol<br>feature of octane / alkane = flammability / releases energy when burned / combusted | [1]<br>[1]<br>[1]<br>[1] |
| **(c) (i)** | (produced by) reaction of (atmospheric) oxygen and nitrogen<br>due to high temperature / engine provides energy / combustion provides energy | [1]<br>[1] |
| **(ii)** | $2NO + 2CO \rightarrow N_2 + 2CO_2$ / $NO + CO \rightarrow \frac{1}{2}N_2 + CO_2$ | [1] |
| **(iii)** | $NO + \frac{1}{2}O_2 \rightarrow NO_2$<br>$NO_2 + SO_2 \rightarrow SO_3 + NO$<br>$SO_3 + H_2O \rightarrow H_2SO_4$ / $2H^+ + SO_4^{2-}$ / $H^+ + HSO_4^-$ | [1]<br>[1]<br>[1] |
| **(iv)** | lowers pH of rivers / lakes / kills fish<br>leaches (toxic) aluminium from soil (into rivers / lakes)<br>leaches away soil nutrients<br>damage to buildings / statues / trees / plants / crops<br>ocean acidification / damage to coral | [1]<br>[1]<br>[1]<br>[1]<br>[1] |
| | | |

119. 9701_s21_ms_21 Q: 6

| Question | Answer | Marks |
|---|---|---|
| (a) | addition | **1** |
| (b) | **M1** *catalyst* = sulfuric acid / phosphoric(V) acid | **1** |
| | **M2** *conditions of reaction* = steam / heat (and pressure) | **1** |
| (c) | <table><tr><td></td><td>σ</td><td>π</td></tr><tr><td>$C_3H_6$</td><td>8</td><td>1</td></tr><tr><td>$C_3H_8O$</td><td>11</td><td>0</td></tr></table> | **2** |
| (d)(i) | **M1** more stable = $CH_3C^+(H)(CH_3)$  | **1** |
| | **M2** less stable = $CH_3CH_2C^+(H_2)$ /  | **1** |
| | **M3** greater (positive) inductive effect of two alkyl groups<br>OR greater electron donation of two alkyl groups owtte | **1** |
| (d)(ii) | propan-2-ol | **1** |
| (e)(i) | elimination | **1** |
| (e)(ii) | **M1** NaOH / KOH | **1** |
| | **M2** ethanolic solution / ethanol / alcohol + heat | **1** |