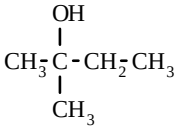
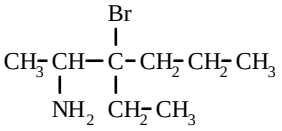
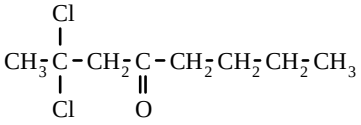
12. Organic Chemistry - 2

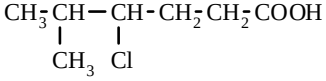
12.1. a) alcohol, 5-methylheptan-3-ol
b) aldehyde, 3-ethylpentanal
c) aldehyde. 2,4,4,5-tetramethylhexanal
d) carboxylic acid, 2-bromobutanoic acid
e) carboxylic acid, octanoic acid
f) carboxylic acid, 2-ethylpentanoic acid
g) ketone, octan-2-one
h) ketone, 1-chloro-4-methylpentan-2-one

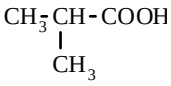
12.2. a) $CH_3-CH_2-CH_2-CH_2-CHO$

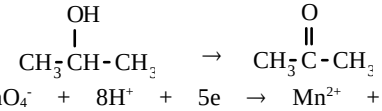
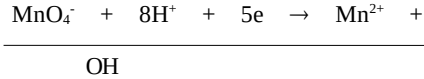
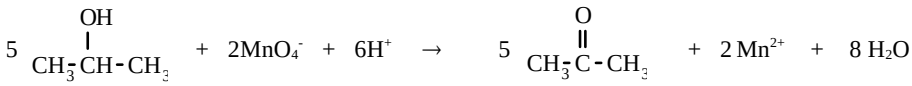
b)


c)


d)


e)


12.3. a) propanal CH_3-CH_2-CHO
b) pentanoic acid $CH_3-CH_2-CH_2-CH_2-COOH$
c) hexan-3-one $CH_3-CH_2-CO-CH_2-CH_2-CH_3$
d) no reaction
e) methylpropanoic acid

f) pentan-3-one $CH_3-CH_2-CO-CH_2-CH_3$

12.4. a)




b) $CH_3CH_2CH_2CH_2OH \rightarrow CH_3CH_2CH_2CHO + 2H^+ + 2e$ x 3
$Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O$

$3\,CH_3CH_2CH_2CH_2OH + Cr_2O_7^{2-} + 8H^+ \rightarrow 3\,CH_3CH_2CH_2CHO + 2Cr^{3+} + 7\,H_2O$

c) $CH_3CH_2CH_2CH_2CHO + H_2O \rightarrow CH_3CH_2CH_2CH_2COOH + 2H^+ + 2e$ x 5
$MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$ x 2

$5\,CH_3CH_2CH_2CH_2CHO + 2MnO_4^- + 6H^+ \rightarrow 5\,CH_3CH_2CH_2CH_2COOH + 2\,Mn^{2+} + 3\,H_2O$

d) no reaction

e) $CH_3CH_2CH_2OH + H_2O \rightarrow CH_3CH_2COOH + 4H^+ + 4e$ x 3
$Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7\,H_2O$ x 2

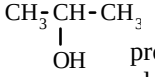
$3\,CH_3CH_2CH_2OH + 2\,Cr_2O_7^{2-} + 16H^+ \rightarrow 3\,CH_3CH_2COOH + 4Cr^{3+} + 11\,H_2O$

12.5. a) $CH_3-CO-O-CH_2-CH_2-CH_3$ 1-propyl ethanoate
b) $CH_3-CH_2-CH_3-CO-O-CH_2CH_3$ ethyl butanoate
c) $CH_3-CH_2-CH_2-CO-O-CH_3$ methyl butanoate

12.6. a) ethyl pentanoate b) 1-propyl propanoate c) ethyl butanoate d) 1-propyl methanoate

12.7. a) $CH_3-CO-O-CH_2-CH_2-CH_3$ b) $CH_3CH_2CH_2CH_2CH_2-CO-O-CH_2CH_3$

12.8. a) $CH_3COOH + CH_3OH$ b) $CH_3-CH_2-CH_2-COO^-Na^+ + CH_3-CH_2-CH_2OH$

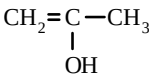
12.9. a) $CH_3-CH_2-CH_2OH$ propan-1-ol

propan-2-ol
$CH_3-O-CH_2-CH_3$ (an ether)

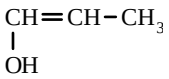
12.9 b) $CH_3 - CH_2 - CHO$ propanal

$CH_3 - CO - CH_3$ propanone


cyclopropanol

$CH_2 = CH - CH_2OH$ 1-hydroxyprop-2-ene


2-hydroxyprop-1-ene


1-hydroxyprop-1-ene

c) $CH_3 - CH_2 - COOH$ propanoic acid

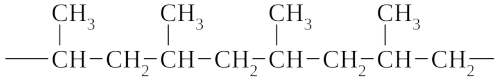
$CH_3 - CO - O - CH_3$ methyl ethanoate

$HCO - O - CH_2 - CH_3$ ethyl methanoate

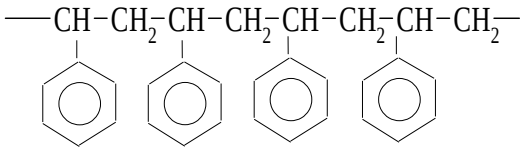
Also, a series of compounds with
- one double bond and two alcohol groups
- a three membered ring and two alcohol groups
- one alcohol group and an aldehyde or ketone group

12.10. a) $- CCl_2 - CCl_2 - CCl_2 - CCl_2 - CCl_2 - CCl_2 -$

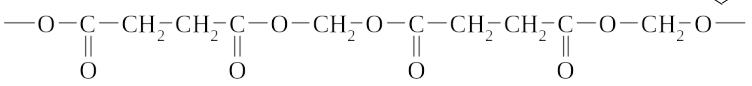
b)



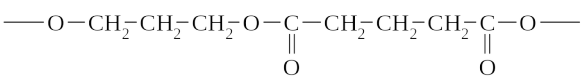
c)



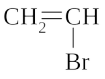
12.11. a)



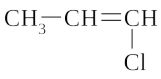
b)



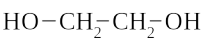
12.12 a)

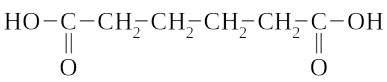


b)

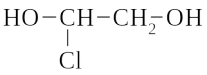


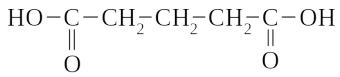
c)





d)





12.13. a) glycerol b) detergent c) fat d) soap e) fatty acid

12.14 a) C_6H_6 b)

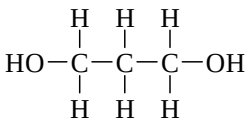

(benzene)

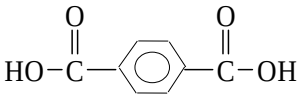
12.15. a) C_6H_7N b) C_6H_7N c) NH_2

12.16. C_3H_3O

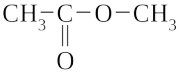
12.17. A 12.18. E 12.19. D

12.20.

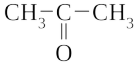




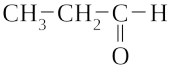
12.21 a) $C_3H_6O_2$ b) 73.4 c) $C_3H_6O_2$ d)



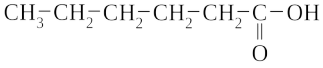
12.22. a ketone:


propanone

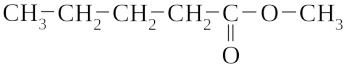
an aldehyde:

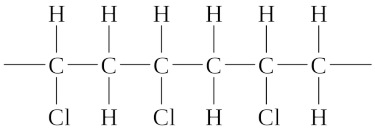

propanal

a carboxylic acid:


hexanoic acid

an ester:

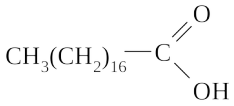

methyl pentanoate

12.23. 

12.24 $C_6H_8O_7$ 12.25. B 12.26. E

12.27. a) $CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3 + H_2O$ - sweet smelling odour produced, mixture remains colourless
b) $CH_3COO^-(aq) + H^+(aq) \rightarrow CH_3COOH(aq)$ - solution remains colourless, vinegar-smelling odour produced.

12.28. a) sulfuric acid b) oxalic acid c) benzoic acid d) tetrahydroxozincate ion

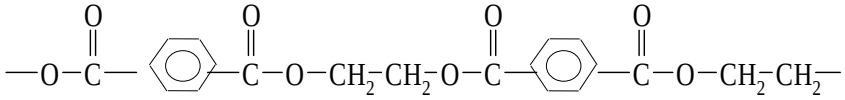
12.29. 

12.30. Oxidation half-equation $CH_3CHOHCH_3 \rightarrow CH_3COCH_3 + 2H^+ + 2e$
Reduction half-equation $Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O$
Redox equation $Cr_2O_7^{2-} + 8H^+ + 3CH_3CHOHCH_3 \rightarrow 2Cr^{3+} + 7H_2O + 3CH_3COCH_3$

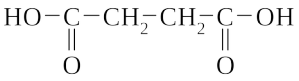
12.31.

	Your chemical test. Describe fully	What you would observe in each case
$Cu(NO_3)_2$ and $CuSO_4$	Dissolve both in water, add a solution of barium nitrate to each	with $Cu(NO_3)_2$ - no precipitate forms
		with $CuSO_4$ - precipitate forms
$MgCl_2$ and $ZnCl_2$	Dissolve both in water, then slowly add a solution of sodium hydroxide to each	with $MgCl_2$ - a white precipitate forms
		with $ZnCl_2$ - a white precipitate forms, but it then dissolves when excess NaOH is added.
CH_3CH_2OH and CH_3COOH	Test both with moist blue litmus paper	with CH_3CH_2OH - litmus not affected
		with CH_3COOH - litmus turns red

12.32. Oxidation half-equation $CH_3CHO + H_2O \rightarrow CH_3COOH + 2H^+ + 2e$
Reduction half-equation $Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O$
Redox equation $Cr_2O_7^{2-} + 8H^+ + 3CH_3CHO \rightarrow 2Cr^{3+} + 4H_2O + 3CH_3COOH$

12.33. 

12.34. a) 4-methylhexanal b) ethyl propanoate c) butanal d) 1-propyl methanoate

12.35. a) HO - CH_2 - CH_2 - OH  b) condensation c) H_2O

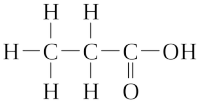
12.36. a) C : H = 90.49/12.01 : 9.48/1.008 = 7.53 : 9.40 = 1 : 1.25 = 4 : 5
i.e. the **empirical formula is C_4H_5**
b) Hydrocarbons have an even number of hydrogens (or there would be an uneven number of electrons in this molecule)

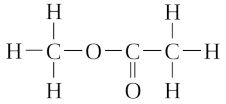
12.36. c) molecular formula = n x empirical formula i.e. n = 105/53 ≈ 2
so **molecular formula = C_8H_{10}**

d) 

12.37. B 12.38. C 12.39. E 12.40. A 12.41. D

12.42. a) i) B ii) A iii) C
b) i) detergents
ii) When a detergent is added to washing water, the detergent ions (surfactant molecules) surround the grease and oil with the non-polar "tails" attached to the grease, and the polar ends left exposed to the water. With agitation, small grease blobs surrounded by detergent ions are produced. These blobs are able to mix, and possibly dissolve in the water because they act as polar substances (due to the polar ends of the ions projecting from them). Thus, the grease can be rinsed away.

12.43. a) It is a carboxylic acid containing 3 C atoms i.  name: propanoic acid

b)  name: methyl ethanoate

12.44. Substance A: ethyl ethanoate Substance B: sodium ethanoate
Substance C: ethanol Substance D: ethanoic acid

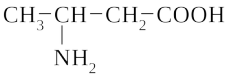
12.45 D	12.46 A	12.47 D	12.48 C	12.49 A
12.50 B	12.51 A	12.52 A	12.53 A	12.54 D
12.55 D	12.56 C	12.57 A	12.58 D	12.59 A
12.60 B	12.61 C	12.62 D	12.63 D	12.64 E
12.65 D	12.66 D	12.67 A	12.68 A	12.69 B
12.70 D	12.71 E	12.72 C	12.73 B	12.74 A
12.75 B	12.76 B	12.77 C	12.78 B	12.79 D
12.80 A	12.81 D	12.82 C	12.83 E	12.84 D
12.85 D	12.86 E	12.87 E	12.88 E	12.89 C

12.90 C

12.91. a) 7-bromo-4-ethyloctanal b) 5-methylheptan-2-one c) 5,5-dimethylheptanoic acid d) ethyl propanoate e) methyl pentanoate f) 2-methylhexanoic acid
g) propyl pentanoate h) 1-chloro-6-hydroxyoctan-4-one i) methyl ethanoate
j) 4-aminobutanal k) 3-ethylcyclohexanone l) cyclopentyl ethanoate
m) sodium ethanoate n) magnesium propanoate

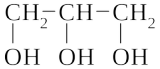
12.92. a) $CH_3 - CH_2 - CH_2 - CH_2 - CO\,OH$ b) $ClCH_2 - CH_2 - CHO$ c) 

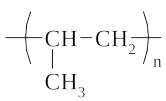
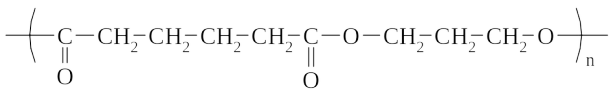
d) $CH_3 - CO - O^-\ K^+$ or KCH_3COO e) $CH_3 - CH_2 - CO - O - CH_3$ f) $H - CO - O - CH_2 - CH_2 - CH_3$

g)  h) $HO\,CH_2 - CH_2 - CH_2\,OH$ i) $Cl\,CH = CH\,Cl$

j) $CH_3 - CO - O - CH_2 - CH_2 - CH_2 - CH_3$

12.93. a) $CH_3 - CO - O - CH_3$ b) $CH_3 - CO - CH_3$

c) a tertiary alcohol cannot be oxidised d)  + $CH_3\,(CH_2)_{16}\,COO^-$ $(+\,Na^+$ or $K^+)$

e)  f) 

g) $CH_3 - CH_2 - CH_2\,OH$ + $CH_3 - CH_2 - CH_2 - COOH$

12.94. Soap as a cleaning agent

A soap is often described as a s**urfactant**. Its function is to assist water to remove g**rease** , o**il** , d**irt** and other water-i**nsoluble** materials that adhere to surfaces.

To understand the cleaning process, the nature of the surfactant needs to be examined. The surfactant is a large ion consisting of a n**egatively** charged end and an uncharged, n**on** -p**olar** end. Polar or charged particles tend to dissolve in p**olar** solvents, whereas non-polar substances tend to dissolve in n**on-polar** solvents. Water is a p**olar** solvent which can form h**ydrogen** b**onds** with the c**harged** end of the surfactant. This c**harged** end is known as the h**ydrophilic** or "water-loving" end of the surfactant. As a result, this end of the surfactant ion tends to d**issolve** readily in water.

On the other hand, the other n**on**- p**olar** end tends not to dissolve in water. However, this h**ydrophobic** or "water-hating" end of the ion can readily mix with n**on** - p**olar** dirt, g**rease** or o**il** Hence the n**on**- p**olar** hydrocarbon end of the surfactant attaches to the n**on**- p**olar** grease or oil while the charged end is h**ydrogen** b**onded** to the water molecules.

When the water is agitated, the o**il** and g**rease** are removed from the surface being cleaned because they are attached by d**ispersion** forces to the h**ydrophobic** end of the surfactant ion. The grease tends to be surrounded by spherical aggregates of s**urfactant** i**ons** whose polar "heads" are directed towards the w**ater** and the non- polar "tails" are attached to the g**rease.**

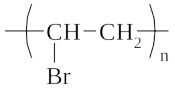
12.95. a) $5\ CH_3CH_2CH_2OH + 4MnO_4^- + 12\ H^+ \rightarrow 5\ CH_3CH_2COOH + 4Mn^{2+} + 11H_2O$

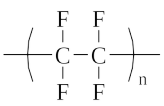
b) $3\ CH_3CH_2CH(CH_3) + 8H^+ + Cr_2O_7^{2-} \rightarrow 3\ CH_3CH_2C(=O)CH_3 + 2Cr^{3+} + 7H_2O$

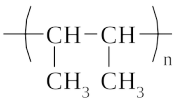
c) $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$

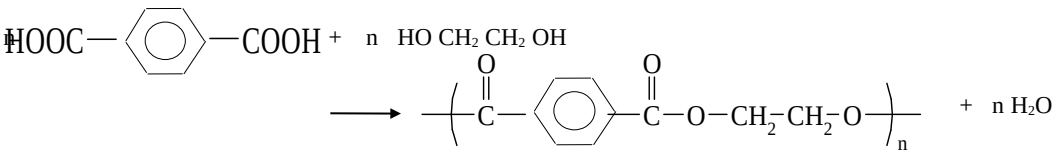
d) $CH_3CH_2OOCCH_2CH_3 + OH^- \rightarrow CH_3CH_2OH + CH_3CH_2COO^-$

e) $CH_3OH + CH_3COOH \rightarrow CH_3OOCCH_3 + H_2O$

12.96. a)  poly(bromoethene)

b)  poly(tetrafluoroethene)

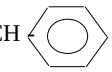
c)  poly(but-2-ene)

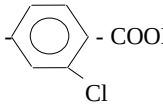
12.97. a) 

b) $n\ HO - (CH_2)_4 - COOH + n\ HO - (CH_2)_4 - COOH \longrightarrow (O - (CH_2)_4 - CO - O - (CH_2)_4 - CO)_n + n\ H_2O$

12.98. a) $CH_2 = CH_2$

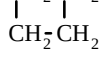
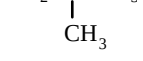
b) $HOOC - (CH_2)_6 - COOH + HO - (CH_2)_3 - OH$

c) 

d) 

e) $CH_2 = CH\ Cl$

12.99. a) CH_2 b) 56, C_4H_8

c) $CH_2 = CH - CH_2 - CH_3$ $CH_3 - CH = CH - CH_3$  

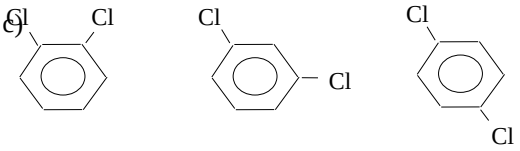
d) $CH_3 - CH = CH - CH_3$

12.100. a) C_2H_6O b) 46, C_2H_6O c) $CH_3 - CH_2OH$

12.101. a) CH_3O b) 62.0, $C_2H_6O_2$ c) $HO - CH(OH) - CH_3$ $HO - CH_2 - CH_2 - OH$

12.102. a) C_3H_9N b) 59, C_3H_9N c) $CH_2(NH_2) - CH_2 - CH_3$ $CH_3 - CH(NH_2) - CH_3$

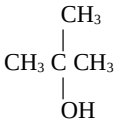
12.103. a) C_3H_2Cl b) $C_6H_4Cl_2$ c)



12.104. a) $C_4H_{10}O$ b) $C_4H_{10}O$

c) $HO - CH_2 - CH_2 - CH_2 - CH_3$ $CH_3 - CH(OH) - CH_2 - CH_3$ $CH_2(OH) - CH(CH_3) - CH_3$ $CH_3 - C(CH_3)(OH) - CH_3$

d)



12.105 $CH_3CH_2CH_2COOH$ $CH_3CH(CH_3)COOH$ $CH_3CH_2C(=O)OCH_3$ $CH_3C(=O)OCH_2CH_3$

butanoic acid methylpropanoic acid methyl propanoate ethyl ethanoate

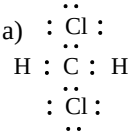
12.106 $CH_3 - CH_2 - CH_2 - CHO$ butanal $CH_3 - CO - CH_2 - CH_3$ butanone

12.107 a) i) carboxylic acid ii) ketone iii) primary alcohol iv) secondary alcohol
v) aldehyde vi) ester vii) secondary alcohol viii) tertiary alcohol

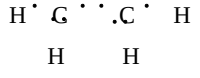
b) i) pentan-1-ol. $CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - OH$ ii) 3-methylbutan-2-ol $CH_3CH(OH)CH(CH_3)CH_3$

12.108 a) $HC \equiv CH + HCl \rightarrow CH_2 = CHCl$ b) addition reaction
c) $n\ CH_2 = CHCl \rightarrow -(CH_2 - CHCl)_n-$ d) addition polymerisation reaction

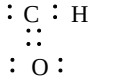
12.109 a)



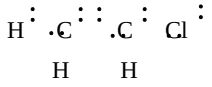
b)



c)



d)



12.110 a) air, sulfur b) hydrogen, nitrogen c) animal fat, sodium hydroxide d) cryolite, bauxite

12.111

IUPAC name	Structural formula
a) 2-chlorohexan-1-ol	$CH_3CH_2CH_2CH_2CH(Cl)CH_2OH$
b) methyl propanoate	$CH_3 - CH_2 - CO - O - CH_3$
c) but-1-ene	$CH_3 - CH_2 - CH = CH_2$
d) pentan-2-one	$CH_3 - CH_2 - CH_2 - CO - CH_3$

12.112 a) $CH_3 - CHBr - CH_2Br$ b) $CH_3 - COOH$ c) $CCl_3 - CCl_3$ d) CH_3OH (or $CH_3 - COONa$)

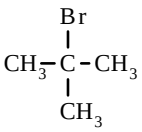
12.113 a) i) $CH_3CH(OH)CH_3$ ii) $CH_3 - CH_2 - O - CH_3$

b) A: propanal $CH_3 - CH_2 - CHO$ B: propanoic acid $CH_3 - CH_2 - COOH$

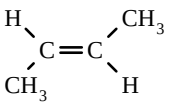
12.114 a) propanone $CH_3 - CO - CH_3$ b) 1,2-dibromopropane $CH_3 - CHBr - CH_2Br$
c) ethyl propanoate $CH_3 - CH_2 - CO - O - CH_2 - CH_3$

12.115 a) (1) methyl propanoate (2) butanoic acid
b) (3) $CH_3 - CO - O - CH_2 - CH_3$ c) 1-propyl methanoate $H - CO - O - CH_2 - CH_2 - CH_3$
(or 2-propyl methanoate, or methylpropanoic acid)

12.116 a)



b) $CH_3 - CO - O - CH_3$ c)



12.117. $CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e$ $\quad Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O$

Overall redox equation $2Cr_2O_7^{2-} + 16H^+ + 3CH_3CH_2OH \rightarrow 4Cr^{3+} + 11H_2O + 3CH_3COOH$

12.118 a) propan-2-ol b) butanone

12.119 a) $CH_3 - CH_2OH + CH_3 - CH_2 - CH_2 - COOH \rightarrow CH_3 - CH_2 - CH_2 - CO - O - CH_2 - CH_3$

b) $CH_2 = CH_2 + HCl \rightarrow CH_2Cl - CH_3$

12.120 Acidified potassium permanganate solution - with the first substance, the purple colour would become colourless, with the second substance, no reaction would occur i.e. the purple colour would remain

12.121 a) $H - CO - O - CH_3$ b) methyl methanoate c) ethanoic acid

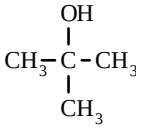
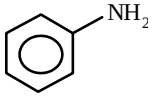
12.122 Oxidation half-equation $CH_3CH_2CHO + H_2O \rightarrow CH_3CH_2COOH + 2H^+ + 2e$

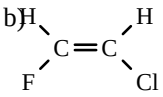
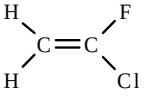
Reduction half-equation $Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O$

Redox equation $Cr_2O_7^{2-} + 8H^+ + 3CH_3CH_2CHO \rightarrow 2Cr^{3+} + 4H_2O + 3CH_3CH_2COOH$

12.123 a) $H_2C - OOCC_{17}H_{35}$ / $HC - OOCC_{17}H_{35}$ / $H_2C - OOCC_{17}H_{35}$ b) $H_2C - OH$ / $HC - OH$ / $H_2C - OH$ $+ C_{17}H_{35}COONa$

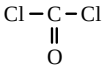
12.124 a) $- CH_2 - CH_3$ b) $CH_3-CH_2-CH(CH_3)-CH_2-COOH$ c) $CH_3 - CH_2 - CHO$

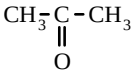
d)  e)  f) $CH_3 - CH_2 - CO - O - CH_3$

12.125 a) trans-1-chloro-2-fluoroethene b)  c) 

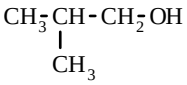
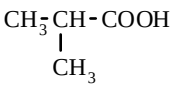
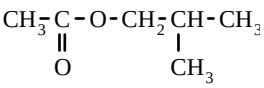
d) $- CHF - CHCl - CHF - CHCl - CHF - CHCl -$ e) $- CH_2 - CClF - CH_2 - CClF - CH_2 - CClF -$

12.126 $C_3H_2NO_2$

12.127 a) CCl_2O b) 98.9. CCl_2O c) 

12.128 a) C_3H_6O b) 57.92, C_3H_6O c) CH_3-CH_2-CHO  

12.129 a) C_2H_4O b) $C_4H_8O_2$ c) $CH_3-CH_2-CH_2-COOH$ butanoic acid $\quad CH_3-CH(CH_3)-COOH$ methylpropanoic acid

12.130 a) 88.0 b) C_3H_6O c) X  Y  Z 

12. Organic Chemistry - 2.

12.21. a) moles of CO_2 = 1.078/44.01 = 0.02449 = moles of C in 'A'
moles of H_2O = 0.441/18.016 = 0.02448 so, moles of H in 'A' = 2 x 0.02448 = 0.0490
mass of C present = 0.02449 x 12.01 = 0.2941 g mass of H present = 1.008 x 0.0490 = 0.04939 g
mass of O present = 0.6047 - (0.2941 + 0.04939) = 0.2612 g
mole of O present in 'A' = 0.2612/16.0 = 0.01632
moles ratio = C : H : O = 0.02449 : 0.0490 : 0.01632 = 1.50 : 3.00 : 1 = 3 : 6 : 2
i.e. the **empirical formula is $C_3H_6O_2$**

b) PV = nRT n = = 0.001862
molar mass = 0.1367/0.001863 = 73.38 g mol^{-1} i.e. **molecular weight = 73.4**

c) molecular formula = n x empirical formula i.e. n = 73.4/74 ≈ 1
so **molecular formula = $C_3H_6O_2$**

12.24. moles of CO_2 = 1.110/44.01 = 0.02522 = moles of C in 'A'
moles of H_2O = 0.303/18.016 = 0.01682 so, moles of H in 'A' = 2 x 0.01682 = 0.03364
mass of C present = 0.02522 x 12.01 = 0.3029 g mass of H present = 1.008 x 0.03364 = 0.03391 g
mass of O present = 0.8062 - (0.3029 + 0.03391) = 0.4694 g

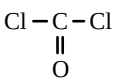
mole of O present in 'A' = 0.4695/16.0 = 0.02934
moles ratio = C : H : O = 0.02522 : 0.03364 : 0.02934 = 1 : 1.33 : 1.16 = 6 : 7.98 : 6.983
≈ 6 : 8 : 7
i.e. the **empirical formula is $C_6H_8O_7$**

12.126. a) In first sample: moles of CO_2 = 2.109/44.01 = 0.04792 = moles of C
moles of H_2O = 0.288/18.016 = 0.01599 so, moles of H = 2 x 0.01599 = 0.03197
mass of C present = 0.04792 x 12.01 = 0.5755 g mass of H present = 1.008 x 0.03197 = 0.03223 g
mass of C in second sample = 0.5775 x 1.061/1.342 = 0.4566 g moles of C = 0.4566/12.01 = 0.03802
mass of H in second sample = 0.03223 x 1.061/1.342 = 0.02548 g moles of H = 0.02548
mole of N in second sample = 0.01263 = moles of N mass of N = 0.01263 x 14.01 = 0.1769 g
mass of O present in second sample = 1.061 - (0.4566 + 0.02548 + 0.1769) = 0.4020 g
mole of O present in second sample = 0.4020/16.0 = 0.02512
moles ratio = C : H : N : O = 0.03802 : 0.02548 : 0.01263 : 0.02512
= 3.01 : 2.017 : 1 : 1.989 = 3 : 2 : 1 : 2
i.e. the **empirical formula is $C_3H_2NO_2$**

12.127 a) moles of CO_2 = 0.970/44.01 = 0.02204 = moles of C
moles of NaOH = 1.04 x 0.0428 = 0.04451 = moles of HCl formed = moles of Cl in compound
mass of C present = 0.02204 x 12.01 = 0.2647 g
mass of Cl present = 0.04451 x 35.45 = 1.578 g
mass of O present = 2.20 - (0.2647 + 1.578) = 0.3573 g
mole of O present = 0.3573/16.0 = 0.02233
moles ratio = C : Cl : O = 0.02204 : 0.04451 : 0.02233 = 1 : 2.020 : 1.013 = 1 : 2 : 1
i.e. the **empirical formula is CCl_2O**

b) PV = nRT n = = 0.03347
molar mass = 3.31/0.03347 = 98.89 g mol^{-1} i.e. **molecular weight = 98.89**
molecular formula = n x empirical formula i.e. n = 98.89/98.91 ≈ 1
so **molecular formula = CCl_2O**

c)



12.128 a) moles of CO_2 = 0.660/44.01 = 0.0150 = moles of C
moles of H_2O = 0.270/18.016 = 0.01499 so, moles of H = 2 x 0.01499 = 0.02997
mass of C present = 0.0150 x 12.01 = 0.1802 g mass of H present = 1.008 x 0.02997 = 0.03021 g
mass of O present = 0.290 - (0.1802 + 0.03021) = 0.07959 g
mole of O present = 0.07959/16.0 = 0.004974
moles ratio = C : H : O = 0.0150 : 0.02997 : 0.004974 = 3.016 : 6.025 : 1 = 3 : 6 : 1
i.e. the **empirical formula is C_3H_6O**

b) moles of O_2 = 1.00/32.0 = 0.03125 = moles of vaporised compound
molar mass of vaporised compound = 1.81/0.03125 = 57.92 g mol^{-1}
i.e. molecular weight = **57.92**
molecular formula = n x empirical formula i.e. n = 57.92/58.07 ≈ 1
so **molecular formula = C_3H_6O**

12.129 a) moles of H_2O = 1.113/18.016 = 0.06178 so, moles of H = 2 x 0.06178 = 0.1236
PV = nRT moles of CO_2 = n = = 0.06176 = moles of C
mass of C present = 0.06176 x 12.01 = 0.7417 g
mass of H present = 1.008 x 0.1236 = 0.1246 g
mass of O present = 1.360 - (0.7417 + 0.1246) = 0.4937 g
mole of O present = 0.4937/16.0 = 0.03086
moles ratio = C : H : O = 0.06176 : 0.1236 : 0.03086 = 2.001 : 4.005 : 1 = 2 : 4 : 1
i.e. the **empirical formula is C_2H_4O**

b) PV = nRT moles of second sample of X = n = = 0.02838
molar mass of X = 2.500/0.02838 = 88.09 mol L^{-1}, i.e. molecular weight = 88.09
molecular formula = n x empirical formula i.e. n = 88.09/44.05 ≈ 2
so **molecular formula = $C_4H_8O_2$**

12.130. a) moles of KOH = 0.0108 x 0.0200 = 0.000216 = moles of Y in the 1.0165 g L^{-1} solution
mass of Y in this solution = 1.0165 x 0.01870 = 0.01901 g
molar mass of Y = 0.01901/0.000216 = 88.00 g mol^{-1}
i.e. molecular weight of Y = **88.0**

b) moles of CO_2 = 0.6532/44.01 = 0.01484 = moles of C in 'Z'
moles of H_2O = 0.2672/18.016 = 0.01483 so, moles of H in 'Z' = 2 x 0.01483 = 0.02966
mass of C present = 0.01484 x 12.01 = 0.1782 g
mass of H present = 1.008 x 0.02966 = 0.02990 g
mass of O present = 0.2870 - (0.1782 + 0.02990) = 0.0789 g
mole of O present in 'A' = 0.0789/16.0 = 0.004931
moles ratio = C : H : O = 0.01484 : 0.02966 : 0.004931 = 3.01 : 6.015 : 1 = 3 : 6 : 1
i.e. the **empirical formula of Z is C_3H_6O**