Higher Chemistry

Past Paper Answers – Book 1

Revised Higher 2013

Revised Higher 2014

2013

(revised)

2013 Revised Higher Marking Instructions

Multiple Choice

1. B — Attraction for bonding electrons (electronegativity) increases ↗ across periodic table.

2. D — Others are all covalent networks. Sulfur = S_8 molecules

3. C — electron arrangements: A - K^+ = 2,8,8
K = 2,8,8,1
B - Cl^- = 2,8,8
Cl = 2,8,7
C - Na = 2,8,1
Na^+ = 2,8
D - O = 2,6
O^{2-} = 2,8

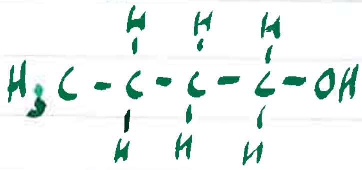
4. C — must have permanent dipole for polar covalent bonds.

5. D — low bpt/mpt: weak forces between particles.

6. D — 2× OH: greatest degree of intermolecular H-bonding.

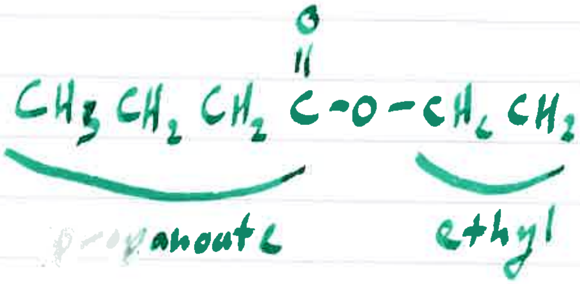
7. A. — Highest in electrochemical series.

8. C — butan-1-ol

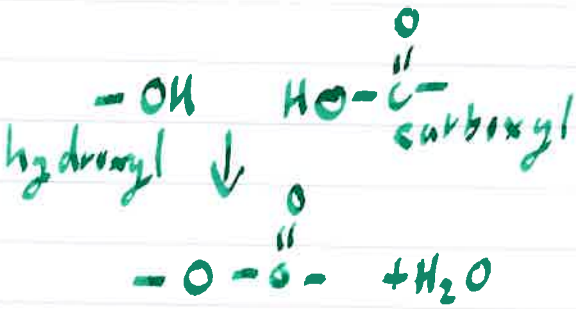


9. D C=O in molecule: carboxylic acid or ester. No esters in choices!

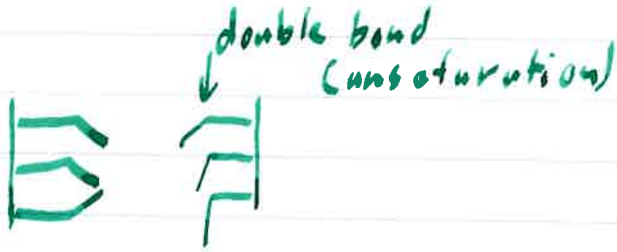
10. B



11. A

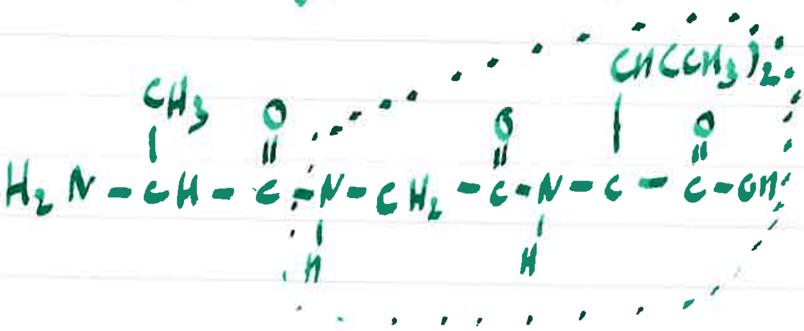


12. C



"bad" packing → low mpt.

13. D



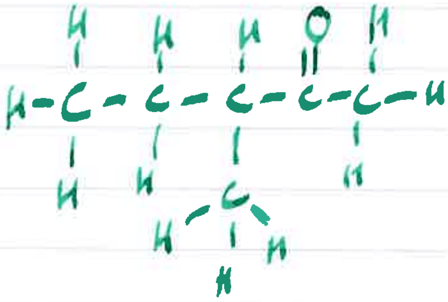
14. C OH groups in erythrose = polar
polar solvent needed ("like dissolves like")

15. A That's what happens ☺

16. C

primary alcohols $\xrightarrow{[O]}$ aldehydes $\xrightarrow{[O]}$ carboxylic acids.

17. B



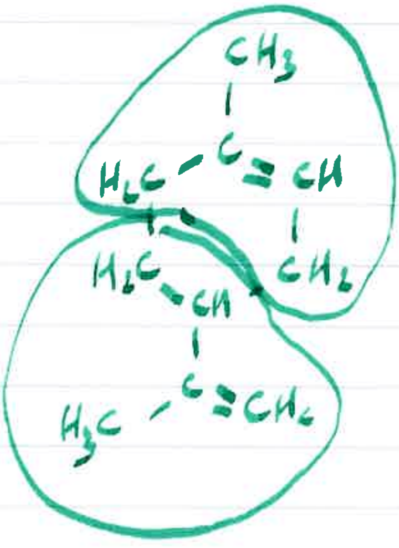
3-methyl pentan-2-one.

hexanal.

18. C

ester links broken = hydrolysis.

19. B



20. A

$MgBr_2$ - 4 moles Br^- => 2 mol Mg^{2+}

total = 3 mol.

$MgSO_4$ - 1 mole Mg^{2+} => 1 mol SO_4^{2-}

21. A

$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l)$

100 cm³ ↑ used up (complete) 200 cm³ ↑ liquid

22. D

true at equilibrium.

23. C

Fewer moles of gas on left than right.

24. B

Atom economy = 100%
position lies to left => biased towards reactants.

25. A

these increase rate:
- Lowering activation energy
- increasing frequency of collisions
- decreasing particle size
- increasing temp.
- increasing conc.
- increasing surface area.

26. B

products lower than reactants
↳ exothermic.
low activation energy
↳ likely at room T

27. A

$E_c = \frac{E_h}{n_f}$

$n_f = \frac{E}{E_c}$

$= \frac{-72.7}{-727} = 0.1$ moles.

$m = n \times GFM$
$= 0.1 \times 32$
$= 3.2g$

CH_3OH
↳ 12×1
1×4
16×1
$= 32g$

29. A

$C(s) + H_2(g) + O_2(g) \rightarrow HCOOH(l)$ a

~~$CO_2(g) + H_2O(l) \rightarrow HCOOH(l) + \frac{1}{2}O_2(g)$~~ - b

$C(s) + O_2(g) \rightarrow$ ~~$CO_2(g)$~~ c

$H_2(g) +$ ~~$\frac{1}{2}O_2(g)$~~ $\rightarrow$ ~~$H_2O(l)$~~ d

Hess' Law.

29. B

pipette + burette most accurate
pipette - only stated volume ($50 cm^3$)

30. D

$Al_2(CO_3)_3(s) + 6KCl(aq)$

↑ solid ↑ solution

Written

1a i

$K(g) \rightarrow K^+(g) + e^-$ One mole of electrons from one mole of atoms in the gas state.

ii. Potassium has electron arrangement 2, 8, 8, 1

Chlorine has electron arrangement 2, 8, 7

- The electron removed from potassium is from a shell further from the nucleus and is therefore more shielded by the inner electrons. The attraction from the positive nucleus for this electron is weaker than the equivalent in Chlorine so it is easier to remove.

b. 8 (no. of OH groups).

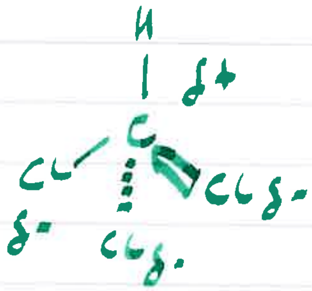
2a. It reacts with radicals to produce non-radical molecules.

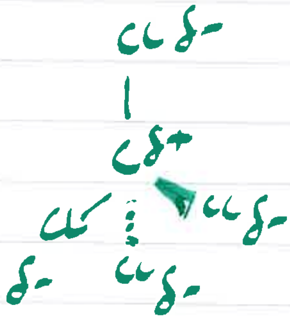
b. $C_6H_8O_6 (aq) \rightarrow C_6H_6O_6 (aq)$

$C_6H_8O_6 (aq) \rightarrow C_6H_6O_6 (aq) + 2$ · balance H with H^+

$C_6H_8O_6 (aq) \rightarrow C_6H_6O_6 (aq) + 2H^+ (aq) + 2e^-$ · balance charge with e^-

3a.

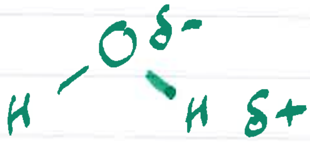




polar
permanent dipole
-permanent dipole
attractions between
molecules.

non-polar
(dipoles cancel)
London forces only
between molecules.

- Water is polar so dissolves polar substances



b. $\Delta H = \Sigma$ bonds broken $- \Sigma$ bonds formed.

$= [4(C-H) + (Cl-Cl)] - [3(C-H) + (C-Cl) + (H-Cl)]$

$= [(4 \times 412) + 243] - [(3 \times 412) + 338 + 432]$

$= [1648 + 243] - [1236 + 338 + 432]$

$= 1891 - 2006$

$= -115 \text{ kJ mol}^{-1}$

values from 2014 Data Book.

4ai. • Fehling's / Benedict's solution
• Acidified dichromate
• Tollens reagent.

ii. Carboxylic acid 

bi. To keep oil & water components mixed.

ii. 

c. 1·0g → 1.4mg. ↘↗ 4·76g → ? mg

28% of 17 = 17 × 0·28 = 4·76g

? × 1 = 1·4 × 4·76

= 6·67mg

d. Open question. Could mention

• polar / non-polar
• solubility.
• flame tests for metals.

5a. $\% \text{ atom economy} = \frac{\text{mass prod}}{\text{mass reacts}} \times 100$

$= \frac{180}{138 + 102} \times 100$

$= \frac{180}{240} \times 100$

$= 75\%$

b. $C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + C_2H_4O_2$.

	$C_7H_6O_3$	$C_9H_8O_4$
n	0·036	0·036
m	5·02g	6·55g
GFM	138g	180.g.

$n = \frac{m}{GFM}$

$= \frac{5.02}{138}$

$= 0.036$

$m = n \times GFM$

$= 0.036 \times 180$

$= 6.55g$

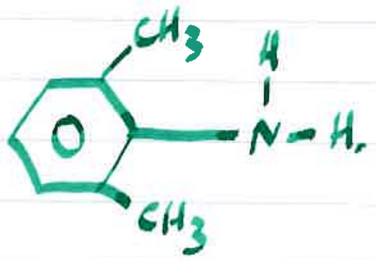
$\% \text{ yield} = \frac{\text{Actual}}{\text{theoretical}} \times 100$

$= \frac{2.62}{6.55} \times 100$

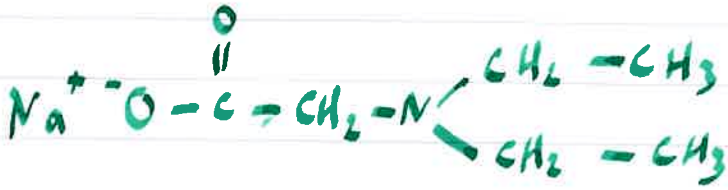
$= 40\%$

6ai Carboxyl

ii.



iii.



HO^- removes acidic H^+ to give H_2O.

b. • Change on right hand side → add ~18
  • compare lidocaine & mepiracaine.
• Change on left hand side → add ~89
  • compare procaine & lidocaine

compare mepiracaine & X. Change on LHS to subtract ~89.

$$\begin{array}{r} 114 \\ -89 \\ \hline 25 \end{array}$$ minutes.

c. $1{\cdot}0\,cm^3 \rightarrow 10mg$
$?\,cm^3 \rightarrow 315mg$
$? \times 10 = 1 \times 315$
$? = \frac{315}{10} = 31{\cdot}5\,cm^3$

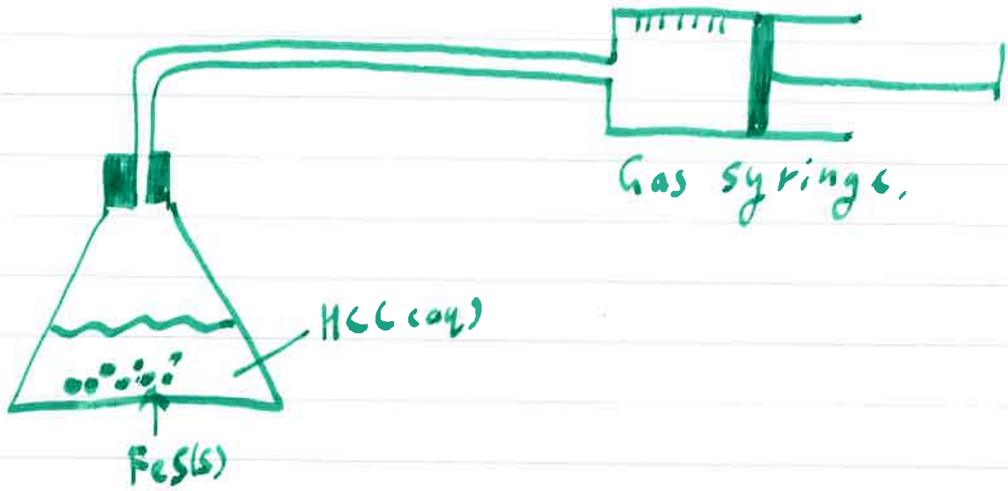
$1kg \rightarrow 4{\cdot}5mg.$
$70kg \rightarrow 315mg$

di, benzocaine is more polar than
tetracaine. It is also smaller.

ii. The lidocaine & caffeine peaks overlap

iii. Small (half-sized) peak at ~ 2.38 min.

7 ai



ii. $FeS_{(s)} + 2HCl_{(aq)} \rightarrow FeCl_{2(aq)} + H_2S_{(g)}$

n 0.003   0.003

m

GFM 57·9

V   0.079L.

MV   24L.

Fe S
→ 32.1
→ 56·8
87·9

m = n × GFM

= 0.003 × 87.9

= 0.26g

$n = \frac{V}{MV}$

= 0.003

bi. Covalent molecule (insoluble, low bpt).

ii. Aluminium sulfide + water → Hydrogen sulfide + aluminium hydroxide

$Al_2S_3 + 6H_2O \rightarrow 3H_2S + 2Al(OH)_3$

Al × 2	:	Al × 2
S × 3	:	S × 3
H × 12	:	H × 12
O × 6	:	O × 6

8a. $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

$$\begin{aligned}
CO_2(g) &\rightarrow CO(g) + \tfrac{1}{2}O_2(g) & +283 \\
3H_2O &\rightarrow 3H_2 + \tfrac{3}{2}O_2(g) & +726 \\
CH_4(g) + 2O_2(g) &\rightarrow CO_2(g) + 2H_2O(g) & -803 \\
& & \underline{\underline{206\ kJ\,mol^{-1}}}
\end{aligned}$$

b. Temp : Decrease (exothermic reaction)

Pressure : Increase (fewer mol. of gas in product)

9a. $9.0\ cm^3$ (adds up to 10.0 with Cu^{2+} sol.)

b. C greatest intensity.

no moles $Cu^{2+} = 0.1 \times 2.5 = 0.25 mol$
" " $NH_3 = 0.1 \times 7.5 = 0.75 mol$

$NH_3 : Cu^{2+}$
$0.75 : 0.25$
$4 : 1$

4 NH_3 molecules

10a. $I_2 + 2e^- \rightarrow 2I^-$ balance with e^-

bi. Sample 1 is not concordant.

ii. $I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

n	0.0009075	0.001815
c		0.1
v	0.02	0.01815

$c = \frac{n}{v}$ $\quad n = cv$

$= 0.1 \times 0.01815$

$= \frac{0.0009075}{0.02}$ $\quad = 0.001815$

$= 0.045 \text{ mol l}^{-1}$

iii. $n = cv$
$= 0.1 \times 0.25$
$= 0.025$ moles.

$m = n \times GFM$
$= 0.025 \times 158.2$
$= 3.96g$

$Na_2S_2O_3$
23×2
32.1×2
16×3
158.2

- Weigh 3.96g of sodium thiosulfate and dissolve in minimum volume of water in a beaker.
- transfer to $250cm^3$ standard flask with rinsings.
- Make up to mark with water.

11a i. Fermentation

ii. "Best fit" line Density 0.9818 g cm^{-3}
conc 10.2%.

b i. $14 \xrightarrow{\times 1.75} 24.5$

$20 \xrightarrow{\times 1.75} 35$

$65 \xrightarrow{\times 1.75} 113.75$

ii. 195L → $1300 0.70 → 46%.

vol. cask strength required for 0.7L $= 0.7 \times \frac{46}{65}$

$= 0.495L.$

195L → $1300
0.495L → ?

$195 \times ? = 0.495 \times 1300.$

$? = \frac{644}{195}$

$? = \$3.30$

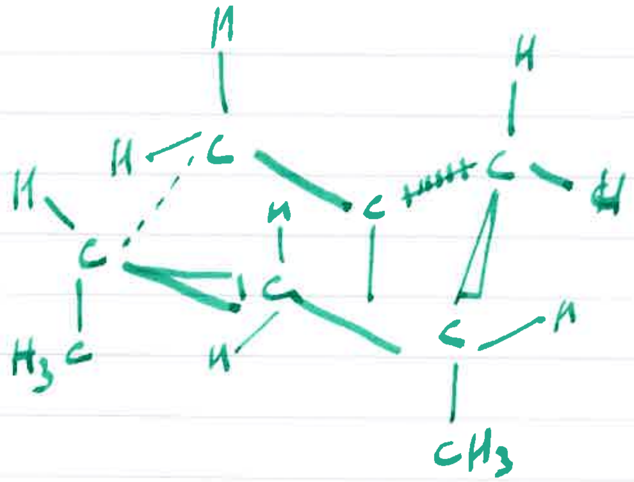
iii. 5-butyl-4-ethyltetrahydrofuran-2-ol

c i. Additon (H_2O across double bond

ii. Nowt, nothing, nada, inside of ring donut.

12. Open question. Could mention
- Structures of fats & oils.
- Solubility of fats and oils
- structures of proteins.
- Denaturing proteins.

13a.



"axial" = sticking up or down.

bi. Larger group, more strain.

ii. $3 \cdot 8 \times 2 = 7 \cdot 6 \, kJ mol^{-1}$

2014

(revised)

2014 Revised Higher Marking Instructions

Multiple Choice

1. B — Low energies required for ionisation 1-3, high for 4 => group 3.

2. C — Electronegativity decreases across table ↙

3. D — Lowest electronegativity difference between ions

4. B — Largest number of electrons (34 for Cl_2) => biggest "wobble"

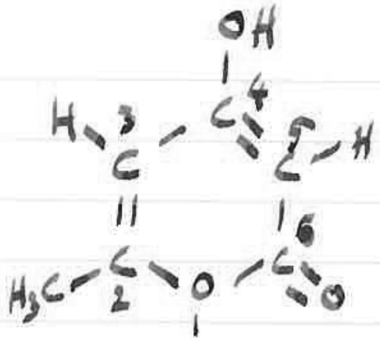
5. A — Symmetrical molecule, dipoles "cancel"

6. A — caryophyllene is non-polar (C-H only) so a non-polar solvent is needed.

7. D — F_2 at the bottom of the electrochemical series (p 12 of Data Booklet). Therefore very strong oxidising agent.

8. A — Al is becoming Al^{3+} in equation => oxidised so is reducing agent

9. B.



10. C

esters commonly used as solvents, perfumes & flavourings.

11. D

-C(=O)- = carbonyl -C(=O)-O- = ester link.

12. B

more O atoms = Oxidation.

13. C

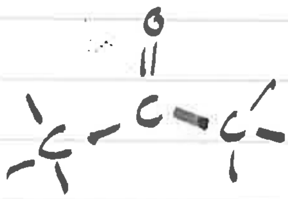
Only Van-Der-Waals forces are broken when a protein is denatured (no "proper" bonds)

14. D

Benzaldehyde is less polar. Therefore less soluble in water and more volatile ([illegible] Forces between molecules).

15. D

Ketone functional group:



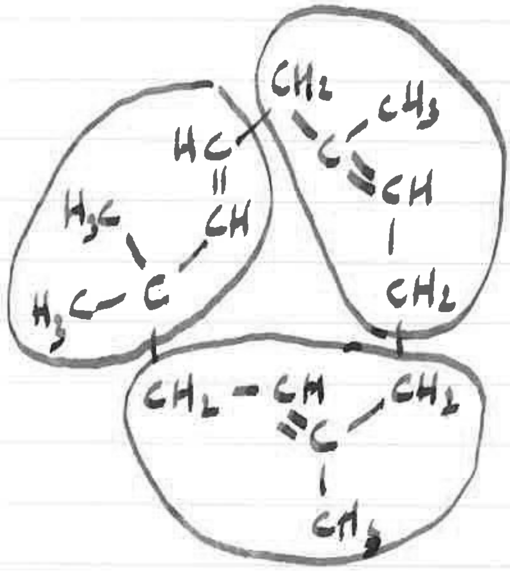
16. B

"Head" is polar
"Tail" is non-polar.

17. D

A → no long chain
B → symmetric → non-polar
C → carboxylate would ionise.

18. B



19. B.

$n = \frac{m}{GFM} = \frac{128.2}{64} = 2.0 \text{ moles}$

SO_2
→ 32×1
→ 16×2
64.

A: H_2
→ 2×1
2

$n = \frac{m}{GFM}$
$= \frac{2}{2} = 1 \text{ mole.}$

B: He
→ 4

$n = \frac{m}{GFM}$
$= \frac{8}{4} = 2 \text{ moles.}$

C: O_2
→ 16×2
32

$n = \frac{m}{GFM}$
$= \frac{32}{32} = 1 \text{ mole.}$

D: Ne
→ 20.2

$n = \frac{m}{GFM}$
$= \frac{80.8}{20.2} = 4 \text{ moles.}$

20. A

$X + Y \rightleftharpoons W + Z$

rates equal
concs. constant but not necessarily equal.

21. C.

Endothermic reaction
↳ high temp required.
More moles of gas on right hand side
↳ low pressure required.

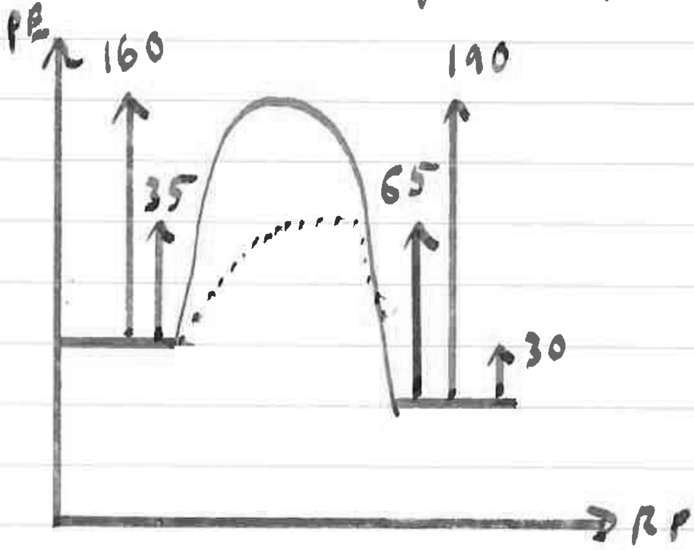
22. A.

Half mass ⇒ line ends at half-volume of product.
Lump ⇒ slower (less steep) compared to powder.

23. A

Area under curve R is twice as large → more moles.
R shifted to right → higher T

24. C



25. C

$E_h = Cm\Delta T$

$n = cV$

$= 1 \times 0.1$

$= 0.1$ moles.

so × 10 for 1 mole of $CuSO_4$.

26. C

Correct definition – one mole of subtance burnt completely.

27. B

Hess' Law. C(graphite) → C(diamond)

$C(graphite) + O_2(g) \rightarrow CO_2(g)$ -394

$CO_2(g) \rightarrow C(diamond) + O_2(g)$ $+395$

$+1$

28. D

A
D
C
B

↑ more polar, higher R.f.

29. D

correct technique: 

30. C

Accurate equipment: volumetric flask
pipette
burette.

2 a i. The enzyme is denatured (changes shape)

ii. The H:O ratio has increased. Hydrogen has been gained.

iii. $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

n	5·56	$\xrightarrow{\times 2}$	11·12
m	1 kg		511·52 g
GFM	180		46

$n = \frac{m}{GFM}$ $\quad$ $m = n \times GFM$

$= \frac{1000}{180}$ $\quad$ $= 11.12 \times 46$

$= 5·56$ $\quad$ $511·52\,g$

$\%\ yield = \frac{actual}{theoretical} \times 100$

$= \frac{445}{511·5} \times 100 = \underline{87\%}$

b. energy density = energy per kilogram.

C_2H_5OH

$12 \times 2 = 24$
$6 \times 1 = 6$
$16 \times 1 = 16$
46g.

$-1367 \rightarrow 46g.$
$? \rightarrow 1000g.$

$46 \times ? = -1367 \times 1000$

$? = \frac{-1367000}{46}$

$? = \underline{29717}\ kJ\,kg^{-1}$

c. % alcohol = change in specific gravity × f.

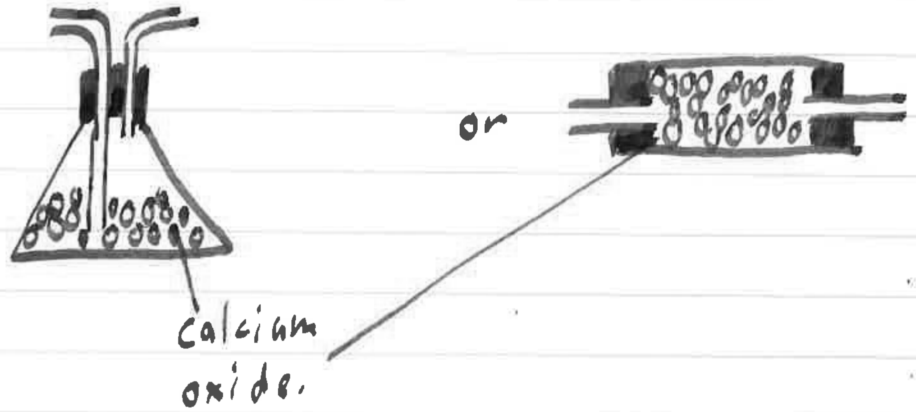
$= (1035 - 10005) \times f.$

$= 30 \times f.$

$= 30 \times 0.129$

$= \underline{\underline{3.87\%}}$

4a.



bi. $E_{react} = \frac{E_h}{n}$

$E_{react} = \frac{c m_w \Delta T}{n}$

$n = \frac{c m_w \Delta T}{E_{react}}$

$= \frac{4.18 \times 0.210 \times 50}{65}$

$= 0.675$ mole

CaO → 40.1×1, 16×1 / 56.1

$m = n \times GFM$

$= 0.675 \times 56.1$

$= 37.87$ g

ii. $CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)}$

reverse $Ca_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CaO_{(s)}$ $\Delta H = -635$ kJ mol^{-1}

reverse $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H = -286$ kJ mol^{-1}

$Ca_{(s)} + O_{2(g)} + H_{2(g)} \rightarrow Ca(OH)_{2(s)}$ $\Delta H = -986$ kJ mol^{-1}

$Ca(OH)_{2(s)} \rightarrow Ca(OH)_{2(aq)}$ $\Delta H = -82$ kJ mol^{-1}

$CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(aq)}$

$\Delta H = 635 + 286 - 986 - 82 = -147$ kJ mol^{-1}

5a i. $C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq)$

$C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq)$ • balance H with H^+.

$C_6H_8O_6(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2e^-$ • balance charges with e^-

ii. pipette - fruit juice } solutions bein
burette - iodine } used
conical flask - water } water added anyway!

iii. improved reliability (can compare results & calculate average)

iv. $I_2 + C_6H_8O_6 \rightarrow C_6H_6O_6 + 2H^+ + 2I^-$

n $3.175 \times 10^{-5} \rightarrow 3.175 \times 10^{-5}$
c 0.00125 0.00159 $mol\,L^{-1}$
V 0.0254 0.02

$n = cV$
$= 0.00125 \times 0.0254$
$= 3.175 \times 10^{-5}$

$c = \frac{n}{V}$
$= \frac{3.175 \times 10^{-5}}{0.02}$
$= 0.00159\,mol\,L^{-1}$

$n_{1L} = 0.00159$

$m = n \times GFM$
$= 0.00159 \times 176$
$= 0.28\,g$

b. $1\,L \rightarrow 240\,mg$

$0.2\,L \rightarrow ?\,mg$

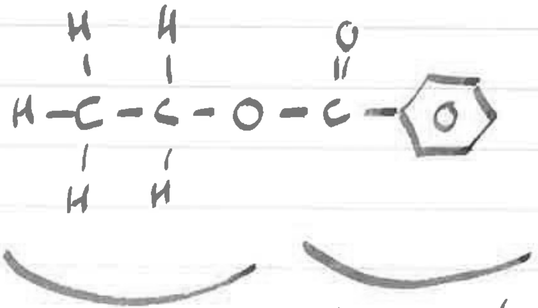
$1 \times ? = 240 \times 0.2$

$? = 48\,mg.$

$\% = \frac{48}{60} \times 100 = \underline{\underline{80\%}}$

6a i. Water bath (<u>not</u> bunsen: too flammable)

ii. Condensation (big molecules combine, small molecule released)

iii. 

ethyl benzoate.

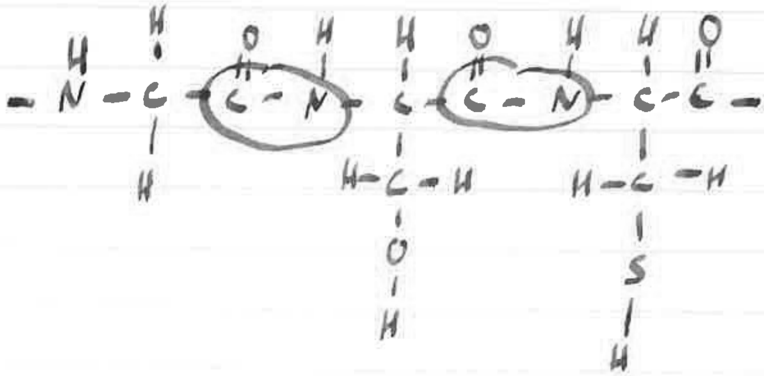
b. $\% \, A.E = \frac{\text{mass prod}}{\text{mass reacts}} \times 100$

$= \frac{144 \times 2}{122 \times 2 + 106} \times 100$

$= \frac{288}{350} \times 100$

$= \underline{\underline{82\%}}$

7a.



ci. Hydroxyl

cii. Glycerol

$50.0\,cm^3 \rightarrow 5.0\,g$

$? \rightarrow 20.0\,g$

$5 \times ? = 50 \times 20$

$? = \frac{50 \times 20}{5}$

$= 200\,cm^3$ required

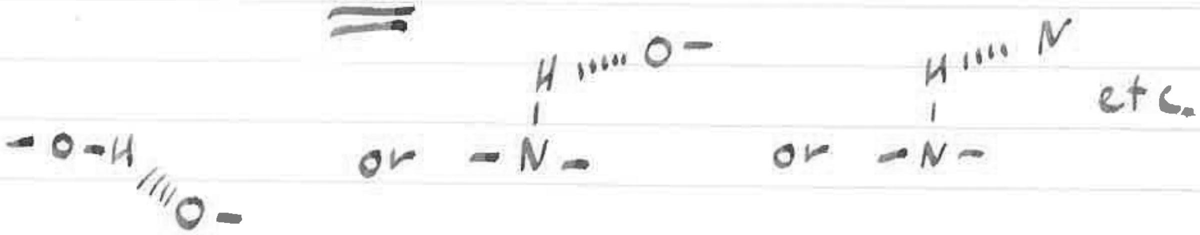
$1\,L \rightarrow £90$

$0.2\,L \rightarrow ?$

$1 \times ? = 0.2 \times 90$

$? = £18$

ciii



d. Open question. Could mention:

- polarity (fat/oil non-polar)
- Breakdown (hydrolysis) with NaOH.
- Use of detergents/emulsifiers.
- Oxidising agents.

8a) Atoms or molecules with unpaired electrons.

ii) UV radiation breaks bonds in molecules

$$A-B \rightarrow A^{\bullet} + B^{\bullet}$$

iii Propagation (free radicals on both sides of arrow)

b)

$O=C=C=C=O$ or

etc.

9a. 14°C.

rate goes from $0.02 s^{-1}$ 38°C to $0.04 s^{-1}$ 52°C.

b. • Particles must collide with energy above the activation energy
• Particles must collide with correct geometry.

10a. • Secondary or tertiary alcohols have lower boiling points than primary alcohols.
• Branched alcohols have lower boiling points than straight-chain alcohols.

b. 139° - predict drop about 20°C compared to hexan-1-ol

11a. $IO_4(aq) \rightarrow IO_3^-(aq)$

$IO_4^-(aq) \rightarrow IO_3^-(aq) + H_2O(l)$ · balance O with H_2O.

$IO_4^-(aq) + 2H^+(aq) \rightarrow IO_3^-(aq) + H_2O(l)$ · balance H with H^+.

$IO_4^-(aq) + 2H^+(aq) + 2e^- \rightarrow IO_3^-(aq) + H_2O(l)$ · balance charge with electrons.

bi. • Crystals dissolved in minimum volume of solvent in a beaker.
• Solution transferred to volumetric (standard) flask.
• Beaker rinsed and rinsings transferred to volumetric flask.
• Solution made up to mark in flask.

ii. "Best fit" line corresponds to concentration of $28\,mg\,l^{-1}$ at Absorbance 0.30.

0.028 g MnO_4^- per litre.

54.9×1
16×4 / 118.9 g

$n = \frac{m}{gfm}$

$= \frac{0.028}{118.9}$

$= 0.000234$.

$m_{Mn} = n \times gfm$

$= 0.000234 \times 54.9$

$= 0.0129\,g$

12 a. $C_3H_6N_6O_6$

$6 \times 16 = 96$

$6 \times 14 = 84$

$6 \times 1 = 6$

$3 \times 12 = 36$

222

$$C_3H_6N_6O_6(s) \rightarrow 3CO_2(g) + 3H_2O(g) + 3N_2(g)$$

	$C_3H_6N_6O_6$	CO_2	H_2O	N_2
n	0·0045 $\times 3 =$	0·0135	0·0135	0·0135
m	1g			
GFM	222g			
V		0·324L	0·324L	0·324L
MV		24L		

$n = \frac{m}{GFM}$ $\qquad$ $V = n \times MV$

$= \frac{1}{222}$ $\qquad$ $= 0·0135 \times 24$

$= 0·0045$ $\qquad$ $= 0·324L$

$V_{Tot} = 0·324 \times 3 = 0·972\,L$

b.

Rule no.	Atoms in $C_5H_8N_4O_{12}$	Apply rule.
1	$5 \times C$	$5CO$
2	$7 \times O$	$4H_2O$
3	$3 \times O$	$3CO_2 + 2CO$
4	$4 \times N$	$2N_2$.

$$C_5H_8N_4O_{12}(s) \rightarrow 2CO(g) + 3CO_2(g) + 4H_2O(g) + 2N_2(g)$$