PENRHOS COLLEGE

STRIVE FOR THE HIGHEST

YEAR 12 CHEMISTRY

STAGE 3

2012

MARKING GUIDE

Answer ALL questions in Part 1 on the separate Multiple Choice Answer Sheet provided, using a blue or black pen or a 2B or B pencil. Each question in this part is worth 2 marks.

ANSWER SHEET

NAME: ___________________________________

TOTAL MARKS : 50

SECTION 1 : MULTIPLE CHOICE

Put a cross through the letter after selecting the most appropriate answer.

1.	A	B	C	**D**					
2.	A	**B**	C	D	14.	A	B	C	**D**
3.	A	B	**C**	D	15.	A	B	**C**	D
4.	A	B	C	**D**	16.	**A**	B	C	D
5.	A	**B**	C	D	17.	A	**B**	C	D
6.	**A**	B	C	D	18.	A	B	**C**	D
7.	**A**	B	C	D	19.	A	**B**	C	D
8.	A	B	C	**D**	20.	A	B	**C**	D
9.	A	B	C	**D**	21.	A	B	C	**D**
10.	**A**	B	C	D	22.	**A**	B	C	D
11.	A	B	**C**	D	23.	A	**B**	C	D
12.	A	**B**	C	D	24.	**A**	B	C	D
13.	**A**	B	C	D	25.	A	B	C	**D**

Answers/Solutions

Section One: Multiple Choice Questions **[50 marks]**

1d	2b	3c	4d	5b	6a	7a	8d	9d	10a	11c	12b	13a
14d	15c	16a	17b	18c	19b	20c	21d	22a	23b	24a	25d	

Section Two: Short Answer Questions

Section One

Section Two: Short Answer **[Total=70 marks]**

Question 26 **[12 marks]**

(a)
Equation
$Na_2CO_3 + Cu(NO_3)_2 \rightarrow 2\ NaNO_3 + CuCO_3$ **(1 mark)**
$Cu^{2+} + CO_3^{2-} \rightarrow CuCO_3$ **(1 mark)**

Observation
A blue liquid is added to a colourless liquid. A green precipitate forms in a colourless liquid **(1 mark)**

(b)
Equation
No Reaction (since 2-methyl-2-propanol is a tertiary (3^0) alcohol **(2 marks)**

Observation
No visible change (the orange solution remains orange) **(1 mark)**

(c)
Equation
$Na + CH_3COOH \rightarrow CH_3COONa + H_2$ **(1 mark)**
$2Na + 2CH_3COOH \rightarrow 2\ CH_3COONa + H_2$ **(1 mark)**
[Note: $2Na + 2H^+ \rightarrow 2Na^+ + H_2$ accept for 1 mark only]
Observation
silver/grey solid dissolves, colourless solution formed, colourless, odourless gas produced. Test tube becomes hot. **(1 mark)**

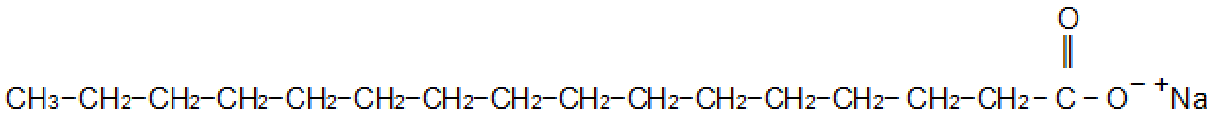
(d)
Equation
$2HCl + NiCO_3 \rightarrow NiCl_2 + CO_2 + H_2O$ **(1 mark)**
$2H^+ + NiCO_3 \rightarrow Ni^{2+} + CO_2 + H_2O$ **(1 mark)**

Observation
Green solid dissolves to produce a green solution, colourless, odourless gas produced. **(1 mark)**

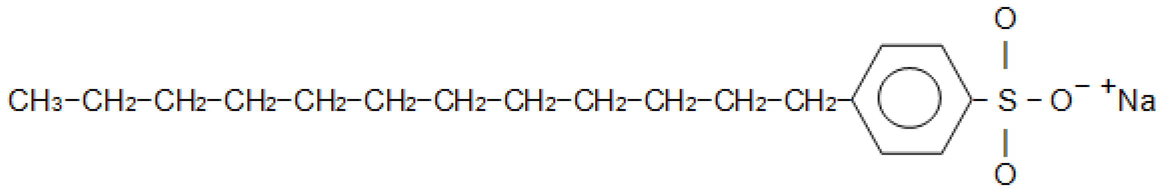
Question 27 **[9 marks]**

a) (i) Describe with the aid of a diagram one difference in structure between soaps and detergents

Soap **(1 mark)**



Detergent **(1 mark)**



Difference in structure: **(1 mark)**

Detergents are sulfonate salts while soaps are carboxylate salts. (detergents have a benzene ring

Similarity in structure: **(1 mark)**

Both have a non-polar hydrophobic end and a hydrophilic polar ionic end.

(ii) Explain how the cleaning action of soaps and detergents differs in "hard water

Hard water contains $Ca^{2+}_{(aq)}$ $Mg^{2+}_{(aq)}$ or $Fe^{3+}_{(aq)}$ ions.

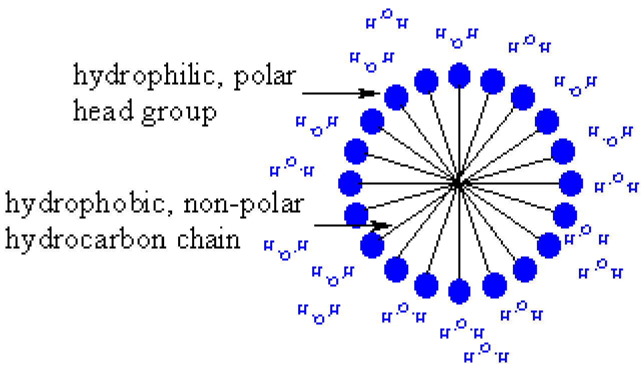
Soaps do not function in hard water as $Ca^{2+}_{(aq)}$ ions precipitate the anionic surfactant,

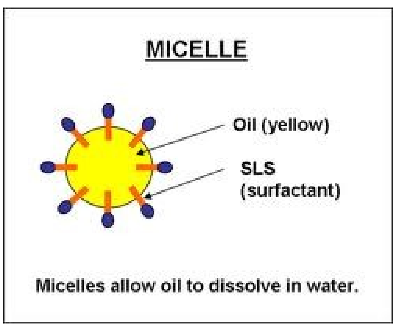
(1 mark)

whereas the anionic surfactant of a detergent does not form a precipitate with hard water.

(1 mark)

b) Explain how soap can wash oil from your hands? ". A diagram may be useful.





When soap is added to water,

the non-polar (hydrophobic) end of the soap molecule forms forces of attraction (dispersion forces) with the non- polar impurity like oil, **(1 mark)**

the polar (hydrophilic) end forms forces of attraction (ion-dipole) with the polar water molecules. **(1 mark)**

The result is that the non-polar stain and polar water are united through the soap.

(1 mark)

Agitation (rubbing the hands together) causes the oil to go into solution.

(1 mark)

Question 28 **[4 marks]**

Chemical test: **Add bromine water/solution to both cyclohexane and cyclohexene** **(1 mark)**

Observations: **The orange/red solution is decolourised by cyclohexene** **(1 mark)**
whereas it remains orange/red with cyclohexane **(1 mark)**

Equation: $C_6H_{10} + Br_2 \rightarrow C_6H_{10}Br_2$ **(1 mark)**

Question 29 **[7 marks]**

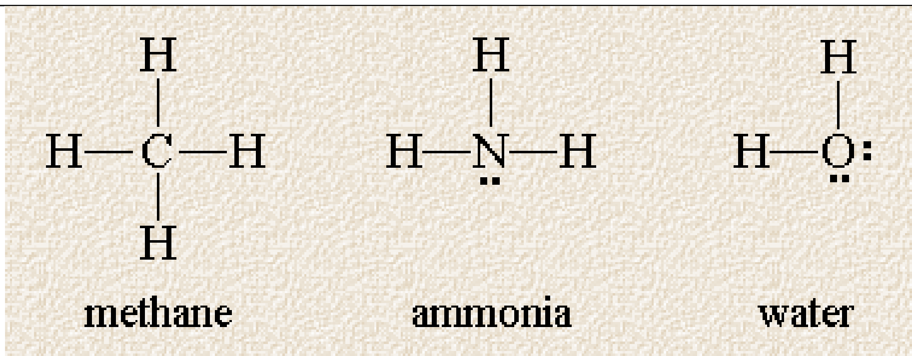
a) **2, 8, 8** **(1 mark)**

b)
(i)
Energy required to remove a mole of electrons **(1 mark)**
from a mole of atoms in the gaseous state **(1 mark)**
(ii)
As each successive electron is removed, the attractive force of the nucleus increases as there are successively more protons (+ve charges) relative to the number of electrons.
(1 mark)

Consequently more energy is required to overcome this increasing nuclear attraction.
(1 mark)
(iii)
More energy is required to remove the 2nd electron than the 1st electron because the 2nd electron is from an inner shell
(1 mark)
Since the 2nd electron is from an inner shell compared to the 1st electron, it is closer to the nucleus, therefore there is increased nuclear attraction. (shielding effect of inner shell electrons is also less)
(1 mark)

Question 30 **[9 marks]**

(a)

Lewis structure			
Shape and polarity	**Tetrahedral & non-polar**	**Pyramidal & polar**	**V-shaped & polar**

(6 x 1 mark each)

(b)

(i) **Hydrogen bonds** **(1 mark)**

(ii) **Dispersion forces** **(1 mark)**

(iii) **Hydrogen bonds are far stronger than dispersion forces, consequently more energy is required to break the hydrogen bonds than is required to break the dispersion forces.** **(1 mark)**

Question 31 **[7 marks]**

(a)

(i)

Atomic radius decreases from left to right across a period **(1 mark)**

(ii)

From left to right across a period electrons are being added into the same principal energy level and so any screening effect is insignificant. **(1 mark)**

From left to right across a period there is an increase in nuclear charge (proton number) **(1 mark)**

This increasing nuclear charge causes a greater force of attraction on the electrons, causing a decrease in atomic radius. **(1 mark)**

(b)

(i) S **0.099 < radius < 0.110 nm** **(1 mark)**

(ii) Ga **0.130 < radius < 0.174 nm** **(1 mark)**

(c)

As atomic radius decreases the nucleus becomes closer to the surface of the elements. **(1 mark)**

consequently the attractive force for a shared electron pair of electrons (electronegativity) increases. **(1 mark)**

Question 32 **[9 marks]**

(a)

According to Le Chatelier's Principle when the kidneys remove $HCO_3^-{}_{(aq)}$ the position of equilibrium will move in a direction so as to partially counteract the imposed stress

(1 mark)

Position of equilibrium will shift to the left to partially counteract the removal of $HCO_3^-{}_{(aq)}$

(1 mark)

This leads to an increase in $[H_3O^+]$ **(1 mark)**

Increasing the $[H_3O^+]$ causes a lowering of pH thus counteracting alkalosis **(1 mark)**

(b)

When you are hyperventilating or breathing at a very accelerated rate, your body is expelling carbon dioxide faster than your body can produce it.
This causes the position of equilibrium to shift to the right so as to partially counteract this stress

This causes the pH of the blood to INCREASE **(1 mark)**
H_3O^+ will be consumed and the $[H_3O^+]$ will decrease **(1 mark)**
Consequently the pH rises thus the making the blood more alkaline **(1 mark)**

(c)

Breathing in and out of a paper bag increases the $[CO_2]$ in the air which causes an increase in $[CO_2]$ in the blood. **(1 mark)**

This causes the position of equilibrium to shift left increasing the $[H_3O^+]$ and lowering the pH of the blood in the process. **(1 mark)**

Question 33 **[5 marks]**

Compound	Boiling points in order (1=highest, 5=lowest
$CH_3CH_2CH_2CH_2CH_2CH_3$	**4**
$CH_3CH_2CH_2COOH$	**1**
$CH_3CH_2CH_2CH_2(CH_3)_2$	**5**
$CH_3CH_2CH_2CH_2CH_2OH$	**2**
$CH_3CH_2CH_2CH_2CHO$	**3**

(1 mark)

The boiling point of $CH_3CH_2CH_2CH_2CH_2CH_3$ (straight chain compound) is higher than that of $CH_3CH_2CH_2CH(CH_3)_2$ (branched compound) because it has a larger electron cloud.

(1 mark)

The larger electron cloud, enables $CH_3CH_2CH_2CH_2CH_2CH_3$ to form stronger dispersion forces with adjacent molecules than can the more compact electron cloud of $CH_3CH_2CH_2CH(CH_3)_2$, thus the higher boiling point of $CH_3CH_2CH_2CH_2CH_2CH_3$ (more energy required to break these stronger intermolecular forces)
[the more compact electron cloud of $CH_3CH_2CH_2CH(CH_3)_2$ results in weaker dispersion forces between adjacent molecules, resulting in less energy (lower boiling point) being required to vapourise the molecules]

(1 mark)

$CH_3CH_2CH_2CH_2CH_2OH$ is an alkanol and has hydrogen bonded directly to oxygen. The difference in electronegativity between O and H creates an "extreme dipole" and this allows $CH_3CH_2CH_2CH_2CH_2OH$ to form strong hydrogen bonds with adjacent $CH_3CH_2CH_2CH_2CH_2OH$ molecules. On the other hand $CH_3CH_2CH_2CH_2CHO$ is an alkanal and the hydrogen is not bonded directly to O. The electronegativity of oxygen causes this molecule to form a dipole and this allows $CH_3CH_2CH_2CH_2CHO$ to form dipole-dipole forces between adjacent molecules.

(1 mark)

Less energy is required to break dipole-dipole forces between molecules than is required to break hydrogen bonds between molecules, consequently $CH_3CH_2CH_2CH_2CHO$ has a lower boiling point than $CH_3CH_2CH_2CH_2CH_2OH$.
[more energy is required to break hydrogen bonds between molecules than is required to break dipole-dipole forces between molecules, consequently $CH_3CH_2CH_2CH_2CH_2OH$ has a higher boiling point than $CH_3CH_2CH_2CH_2CHO$]

(1 mark)

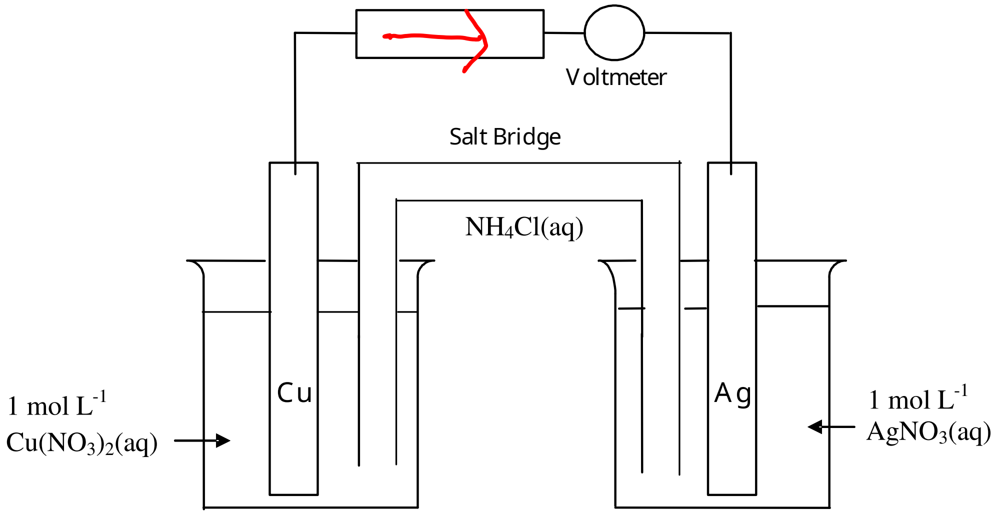
Question 34 **[6 marks]**

(a)

$Ag^{+}_{(aq)} + 1\ e^{-} \rightarrow Ag_{(s)}$ **(1 mark)**

(b)

Electrons move from left to right through the wire. **(1 mark)**



(c)

Salmon-pink metal dissolves **(1 mark)**

Blue solution intensifies in colour (gets more blue) **(1 mark)**

(d)

$NH_4^{+}{}_{(aq)}$ ($Cu^{2+}{}_{(aq)}$)

(1 mark)

(e)

$Cu \rightarrow Cu^{2+} + 2\ e^{-}$ $E^0 = -0.34\ V$

$Ag^{+}_{(aq)} + 1\ e^{-} \rightarrow Ag_{(s)}$ $E^0 = +0.46V$

$E^0 = -0.34\ V + (+0.80V) = +0.46V$ **(1 mark)**

Section Three: Extended Answer **Total=80 marks**

Question 35 **[18 marks]**

(a)
(i)

Silver/grey metal burns brilliantly
a white solid is formed **(1 mark)**

(ii)
$2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$ **(1 mark)**

(iii)
There are strong ionic bonds extending throughout the lattice, **(1 mark)**
large amounts of energy are required to break these bonds **(1 mark)**

(iv)
$MgO_{(s)} + H_2O_{(l)} \rightarrow Mg(OH)_{2(aq)}$ *or* $MgO_{(s)} + H_2O_{(l)} \rightarrow Mg^{2+}{}_{(aq)} + 2\ OH^{-}{}_{(aq)}$ **(1 mark)**

pH = 9-14 **(1 mark)**

(b)
(i)
$Mg_{(s)} + 2HCl_{\ (aq)} \rightarrow MgCl_{2\ (aq)} + H_{2(g)}$ *or* $Mg_{(se} + 2H^{+}{}_{(aq)} \rightarrow Mg^{2+}{}_{\ (aq)} + H_{2(g)}$ **(1 mark)**

(ii)
n(Mg) = 1.2 ÷ 24.31 = 0.04936 mol
$n(H_2)$ = n(Mg) = 0.04936 mol **(1 mark)**

n(HCl) = c x V = 2 x 0.05 = 0.1 mol
$n(H_2)$ = ½ x n(HCl) = ½ x 0.1 = 0.05 mol **(1 mark)**
Mg is the limiting reagent (HCl is in excess) **(1 mark)**

(iii)
$V(H_2)$ = n x 22.71 = 0.04936 x 22.71 = 1.12 L **(1 mark)**

(iv)
$n(H^{+})_{initially}$ = 0.1 mol
$n(H^{+})_{reacting}$ = 2 x n(Mg) = 2 x 0.04936 = 0.09872 mol **(1 mark)**
$n(H^{+})_{inxs}$ = $n(H^{+})_{initially} - n(H^{+})_{reacting}$
= 0.1 − 0.09872 = 0.00128 mol **(1 mark)**
$[H^{+}]$ = n ÷ V = 0.00128 ÷ 0.05 = 0.0256 mol L^{-1} **(1 mark)**
pH = $-\log_{10} [H^{+}] = -\log 0.0256 = 1.59$ **(1 mark)**

(c)
(i)
The calcium would be more reactive or react faster than the magnesium **(1 mark)**

(ii)
Calcium is a stronger reductant than magnesium **(1 mark)**

(quoting E^0 values for the 2nd mark)
$Ca \rightarrow Ca^{2+} + 2e^{-}$ $E^0 = 2.87$ V
$Mg \rightarrow Mg^{2+} + 2e^{-}$ $E^0 = 2.36$ V **(1 mark)**

or
electrons in Ca are lost more easily (lower ionization energy value) than in Mg
(1 mark)

because
Ca has a smaller nuclear force on its outermost electrons because it has a greater atomic radius/outer electrons further away from the nucleus and there is greater shielding effect from inner shell electrons in larger atoms i.e. less energy required to remove these electrons compared to those in Mg
(1 mark)

Question 36 **[15 marks]**

(a)

$N_{2\,(g)}$ + $3H_{2\,(g)}$ → $2NH_{3\,(g)}$ **(1 mark)**

(b)

$$K_c = \frac{[NH_3]^2}{[N_2]\,[H_2]^3}$$

(1 mark)

(c)

The iron acts as a catalyst i.e. alters the rate of the reaction **(1 mark)**

Although a catalyst has no effect on the position of equilibrium, using one means that the rate of attainment of equilibrium is increased (equilibrium is achieved/reached faster)
(1 mark)

(d)

According to Le Chatelier's principle, if a stress is imposed on a system at equilibrium the position of equilibrium will shift in a direction so as to partially counteract this stress
(1 mark)

Increasing the pressure will favour a shift in the position of equilibrium in a direction so as to reduce the pressure i.e. the side with less moles (4 moles → 2 moles)
(1 mark)

The shift in the position of equilibrium to the right increases the yield of ammonia
(1 mark)

(e)

Building plant which can withstand very high pressures is very costly (expensive) **(1 mark)**
(there are other factors which can be manipulated to increase the yield of ammonia)

(f)

advantage:

Increasing the temperature increases the rate of reaction which means that equilibrium will be achieved in a short period of time.
(1 mark)

disadvantage:

The forward reaction is exothermic (stated in the introduction to the question). Increasing the temperature favours the endothermic process i.e. product of reactants, thus reducing the yield.
(1 mark)

(g)

$n((NH_4)_2SO_4)$ = 3.14 ÷ [2(18.042) + 32.06 + 4(16)] = 3.14 ÷ 132.144 = 0.02376 mol **(1 mark)**

n(naOH) = 2 x $n((NH_4)_2SO_4)$ = 2 x 0.02376 = 0.04752 mol **(1 mark)**

n = cV

[NaOH] = n ÷ V = 0.04752 ÷ 0.0393 = 1.209 = 1.21 mol L^{-1} **(1 mark)**

(h)

PV = nRT

n = PV ÷ RT = 100 x 1.53 x 10^{-2} ÷ (8.314 x (273.15 + 37) = 0.0005933 mol **(1 mark)**

n = m ÷ M

n = 0.0005933 x 17.034 = 0.0101 or 1.01 x 10^{-2} g **(1 mark)**

[Note: − 1 mark if numerical answers in either or both cases are not rounded to 3 sig. figs.]
[Note: − 1 mark for incorrect use of units or no units included]

Question 37 **[18 marks]**

(a) $C_{25}H_{52} + O_2 \rightarrow CO_2 + H_2O$ (1 mark)

$C_{25}H_{52} + 38O_2 \rightarrow 25CO_2 + 26H_2O$ (1 mark)

(b) mass of candle combusted = 175 – 173.2 = 1.8 g

$n(C_{25}H_{52})$ = 1.8 ÷ [(25(12.01) + 52(1.008)]

= 1.8 ÷ 352.666 = 5.103 x 10^{-3} mol (1 mark)

$n(CO_2)$ = 25 x $n(C_{25}H_{52})$ = 25 x 5.103 x 10^{-3} = 0.12759 mol (in 2 min) (1 mark)

$n(CO_2)$ = 0.7 ÷ 44.01 = 0.015905 mol (1 mark)

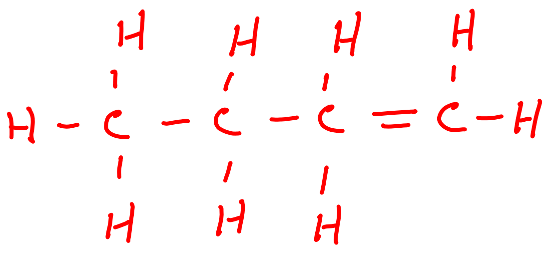
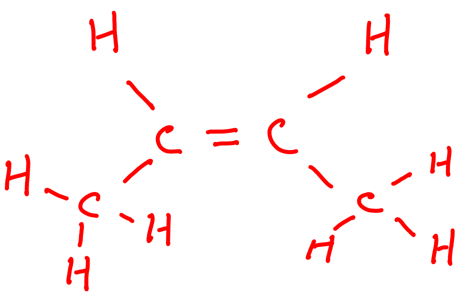
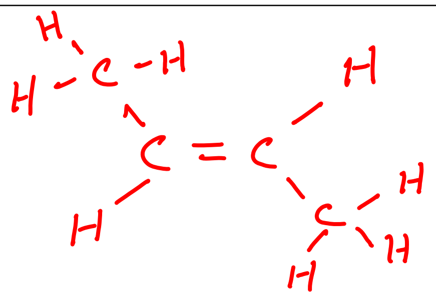
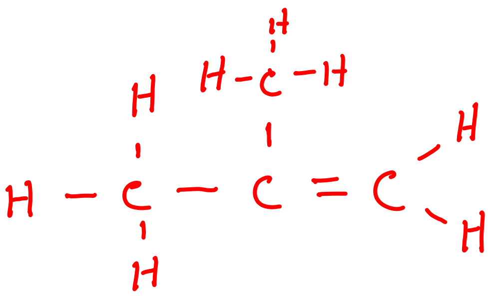
$n(CO_2)$ = 0.12759 mol ≡ 2 min

1 mol ≡ 2 ÷ 0.12759

0.015905 mol ≡ 2 ÷ 0.12759 x 0.015905 = 0.249 min

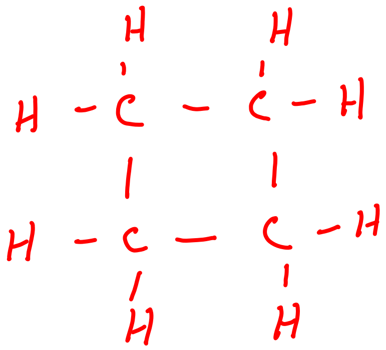
= 0.249 min or 15.0 sec (1 mark)

(c)

Structural formula	*IUPAC Name*
	Butene
	*cis*-2-butene
	*trans*-2-butene
	2-methyl-1-propene

(8 x 1 mark each)

(d)

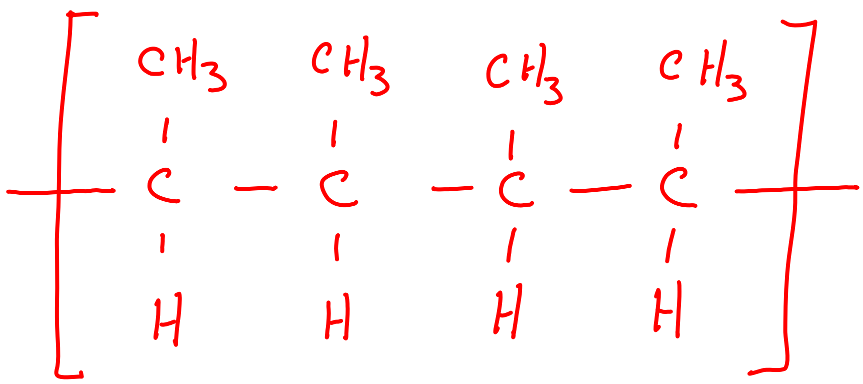
Structural formula	*IUPAC Name*
	**Cyclobutane** **(may also draw methyl cyclopropane)**

(2 x 1 mark)

(e)

Addition polymerization **(1 mark)**

(f)



(1 mark)

Question 38 **[10 marks]**

The amount of iron, as Fe^{2+}, present in a multivitamin tablet may be determined by titrating against potassium permanganate, $KMnO_4$. In one determination, two tablets were dissolved in 20.00 mL of distilled water in a conical flask. This required 15.85 mL of 0.002500 M potassium permanganate solution to reach the equivalence point.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Final reading (mL)	17.06	32.91	17.33	33.19	16.51
Initial reading (mL)	0.85	17.06	1.14	17.33	0.67
Titre volume (mL)	**16.21**	**15.85**	**16.19**	**15.86**	**15.84**

Fill in the table **(1 mark)**

Discard the first value and 16.19 as it is discrepant
Mean titre = (15.85 + 15.86 + 15.84) ÷ 3 = 15.85 mL **(2 marks)**

[Note: Mean titres of 15.99 (using all 5 values) and 15.935 (using 4 values) = zero marks]

$MnO_4^-{}_{(aq)} + 8H^+{}_{(aq)} + 5Fe^{2+}{}_{(aq)} \rightarrow Mn^{2+}{}_{(aq)} + 4H_2O_{(l)} + 5Fe^{3+}{}_{(aq)}$ **(1 mark)**

$n(MnO_4^-) = c \times V = 0.002500 \times 0.015.85 = 3.9625 \times 10^{-5}$ **(1 mark)**

$n(Fe^{2+}) = 5 \times n(MnO_4^-) = 5x\ 3.9625 \times 10^{-5} = 1.98125 \times 10^{-4}$ mol **(1 mark)**

$m(Fe) = n(Fe) \times M(Fe) = 1\ .98125 \times 10^{-4} \times 55.85 = 1.10652 \times 10^{-2}$ g **(1 mark)**

This is for two tablets, so each tablet contains

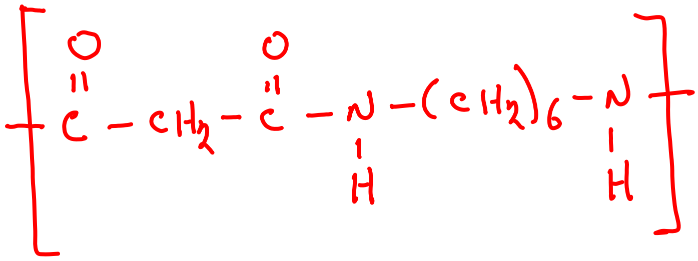
$1.10652 \times 10^{-2} \div 2 = 5.5326 \times 10^{-3} = 5.53 \times 10^{-3}$ g **(1 mark)**

Indicator	**No indicator required, MnO_4^- is self-indicating**
Description of colour change	**Changes from purple to pale pink (colourless)**

(2 x 1 mark)

Question 39 **[19 marks]**

(a)



(1 mark)

(b)

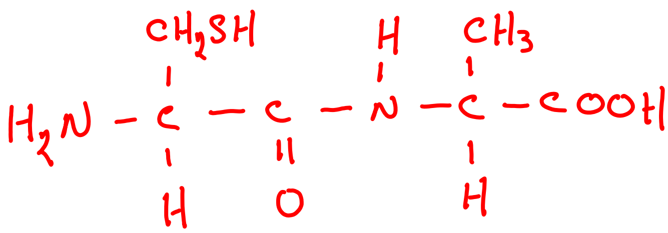
The polyamide is able to form hydrogen bonds between the polymer fibres whereas **(1 mark)**

the polyalkenes can only form dispersion forces between the polymer strands. **(1 mark)**

The hydrogen bonds are much stronger than the dispersion forces the strands and so are capable of holding the strands together. **(1 mark)**

(c)

(i)

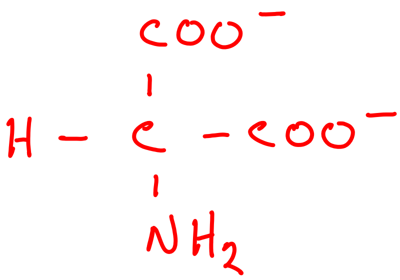


(1 mark)

(ii) **hydrolysis** **(1 mark)**

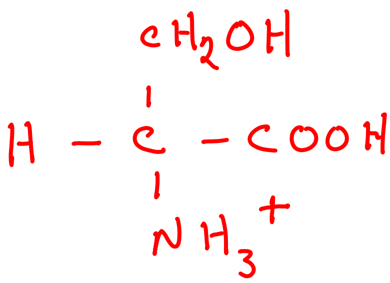
(d)

(i)



(1 mark)

(ii)



(1 mark)

(e)

(i)

$m(C)_{in\ 5.00\ g}$ = 7.48 x (12.01 ÷ 44.01) = 2.041 g

% (C) = 2.041 ÷ 5.00 x 100 = 40.82% (1 mark)

$m(H)_{in\ 5.00\ g}$ = 2.77 x (2.016 ÷ 18.016) = 0.3099 g

% (H) = 0.3099 ÷ 5.00 x 100 = 6.20% (1 mark)

$m(N)_{in\ 3.00\ g}$ = 0.938 x (14.01 ÷ 46.01) = 0.286 g

% (N) = 0.286 ÷ 3.00 x 100 = 9.52% (1 mark)

% (O) = 100 – (40.82 + 6.2 + 9.52) = 43.46% (1 mark)

	C	H	N	O
m =	40.82	6.2	9.52	43.46
n = m/M	40.82/12.01	6.2/1.008	9.52/14.01	43.46/16
n =	3.397	6.15	0.678	2.719
÷ 0.678	5.01	9.07	1	4.01
Formula	5	9	1	4

(2 marks)

Empirical Formula is $C_5H_9NO_4$ (1 mark)

(ii)

n(NaOH) = c x V = 0.500 x 0.0248 = 0.0124 mol (1 mark)

n(glutamic acid)$_{in\ 20\ mL}$ = ½ x n(NaOH) ½ x 0.0124 = 0.00620 mol (1 mark)

n(glutamic acid)$_{in\ 100\ mL}$ = 0.00620 ÷ 20 x 100 = 0.0310 mol (1 mark)

n = m ÷ M

M(glutamic acid) = m ÷ n = 4.56 ÷ 0.0310 = 147 g mol^{-1} (1 mark)