Higher Chemistry – question paper 2018

Question 1a (i)

1. The elements of group 7 in the periodic table are known as the halogens.

(a) Going down group 7 the electronegativity of the halogens decreases.

(i) State what is meant by the term *electronegativity*. **1**

Higher Chemistry – Course Report 2018

Comments on candidate performance

Many candidates found it difficult to state what is meant by the term electronegativity.

Candidate A

The attraction between the positive nucleus and the negative electrons

Candidate B

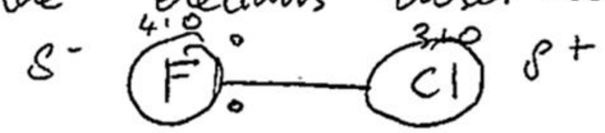
A measure of attraction a bond has for the electrons in a bond

Candidate C

The attraction an atom has for electrons in a bond.

Candidate D

Electronegativity is the force of attraction 2 covalently bonded atoms have for electrons. Atom with higher electronegativity will have the electrons closer to it.



Higher Chemistry – question paper 2018 Question 1 a (ii) (ii) Explain why electronegativity values decrease going down group 7. **1**

Higher Chemistry – Course Report 2018 Comments on candidate performance No comment in course report.

Candidate A

as more electron shells are added the inner electrons shield the outer ones, the nucleus gets larger.

Candidate B

Because the number of energy levels increase, which decreases the nucleus' pull on its outer electrons

Higher Chemistry – question paper 2018

Question 1 (b)

(b) Explain **fully** why the boiling points of the halogens increase going down group 7.

In your answer you should name the intermolecular forces involved. 3

Higher Chemistry – Course Report 2018

Comments on candidate performance

Questions that require more detailed answers are signalled by the words 'explain fully' or 'explain clearly' and are worth a minimum of two marks.

Candidates need to be made aware that, to gain full marks for the question, a detailed explanation needs to be given.

Candidate A

Going down group 7 boiling points increase as there are more / stronger intermolecular forces present. These intermolecular forces are known as London Dispersion Forces. Boiling point will increase as it is these forces that need to be overcome in order for a substance to boil.

Candidate B

They increase as ~~[scribbled]~~ the number of electrons in the ~~outer~~ energy levels increase meaning there is more ~~[scribbled]~~ London dispersion forces between molecules, this means the atoms are more strongly attracted to each other so more energy is needed to be put in for the bonds to break

Higher Chemistry – question paper 2018

Question 2 (c) (i)

2. (continued)

(c) Silicon tetrachloride can be used to make silicon nitride (Si_3N_4), a compound found in many cutting tools.

(i) Silicon nitride has a melting point of 1900 °C and does not conduct electricity when molten.

Explain **fully**, in terms of structure and bonding, why silicon nitride has a high melting point. **2**

Higher Chemistry – Course Report 2018

Comments on candidate performance

Candidates found question 2 (c) (i) demanding – 'explain fully, in terms of structure and bonding, why silicon nitride has a high melting point', demanding.

Candidate A

- silicon exists as a covalent network which is much stronger than a covalent molecular substance
- nitrogen has a triple bond between atoms which also requires more energy to break

Candidate B

Silicon is a covalent network so has strong covalent bonds. more energy is needed to break these bonds meaning they have high melting points

Candidate C

Silicon nitride must ~~because~~ be a covalent network as it has such a high melting point and is not ionic as it does not conduct while molten.

The covalent network means that to melt the compound, several covalent bonds must be broken and not intermolecular bonds. Covalent bonds are very strong and take a lot of energy to break which is why ~~which~~ high temperature is needed.

Candidate D

Silicon nitride ~~contains a covalent network~~ exists as a covalent network ~~which~~ so requires a great amount of energy for ~~the ba~~ it's bonds to be broken therefore ~~requiring~~ resulting in a high melting point.

Candidate E

Silicon is a covalent ~~structure~~ network with strong covalent bonds, which require great amounts of energy.

Higher Chemistry – question paper 2018

Question 2 (c) (ii)

(ii) An equation for the formation of silicon nitride is shown.

$3SiCl_4$	+	$16NH_3$	→	Si_3N_4	+	$12NH_4Cl$
mass of one mole = 170·1 g		mass of one mole = 17·0 g		mass of one mole = 140·3 g		mass of one mole = 53·5 g

Calculate the atom economy for the formation of silicon nitride. **2**

Higher Chemistry – Course Report 2018

Comments on candidate performance

No comment in course report.

Candidate A

170·1 + 17

= 187·1g

$$\frac{\text{desired products}}{\text{All reactants}} \times 100$$

$$\frac{140 \cdot 3}{187 \cdot 1} \times 100$$

= 74·98%

Candidate B

atom economy = $\frac{\text{mass of desired product}}{\text{total mass of products}} \times 100$

$= \frac{140.3}{622.3} \times 100$

$= 22.5\%$

Candidate C

Mass of products	Mass of reactants
= 140.3g	= 3 × 170.1
	= 16 × 17
	= 782.3

$= \frac{140.3}{782.3} \times 100 = 17.9\%$

Higher Chemistry – question paper 2018

Question 2 (d) (i)

(d) Aluminium, another element in the third period, also forms a chloride. Aluminium chloride is prepared by reacting aluminium metal and chlorine gas.

Chlorine gas is produced by the reaction between hydrochloric acid and sodium hypochlorite. The chlorine is then passed over heated aluminium foil, forming aluminium chloride as a hot gas. The hot aluminium chloride gas and unreacted chlorine gas are passed into a flask where the aluminium chloride cools to a fine white powder.

For safety it is important that any unreacted chlorine gas can escape from the flask.

(i) Complete a labelled diagram to show an apparatus suitable for carrying out this preparation. **2**

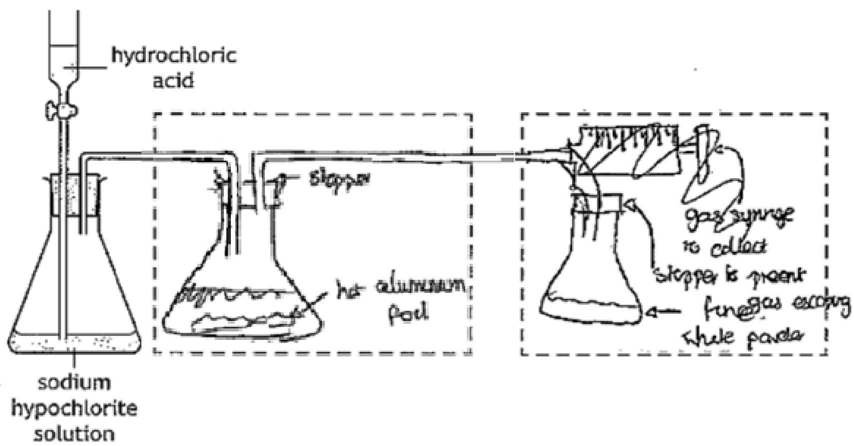
Higher Chemistry – Course Report 2018

Comments on candidate performance

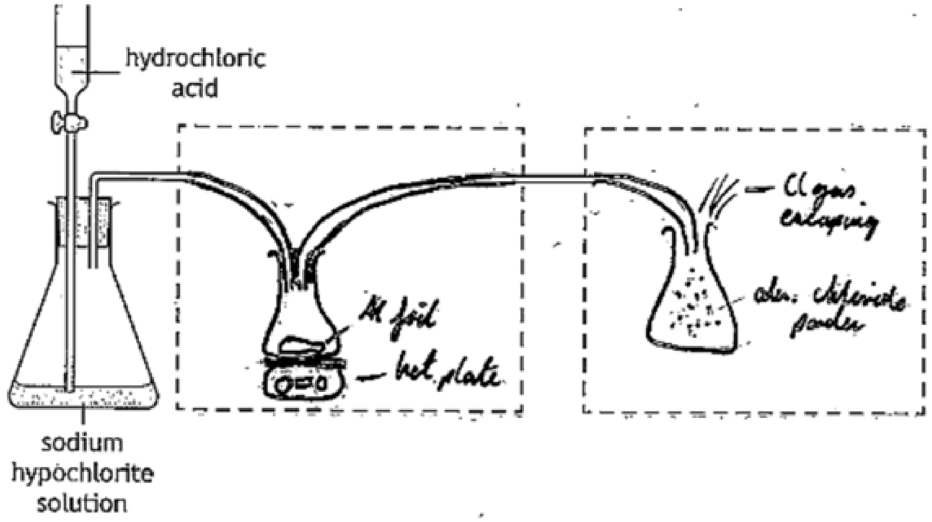
Approximately 10 marks were allocated to the assessment of knowledge and skills relating to the Researching Chemistry unit. Apparatus and techniques that candidates should be familiar with were listed in the *Higher Chemistry Course and Unit Support Notes*.

Apparatus and techniques that candidates should be familiar with for 2018-19 are listed in the *Higher Chemistry Course Specification*.

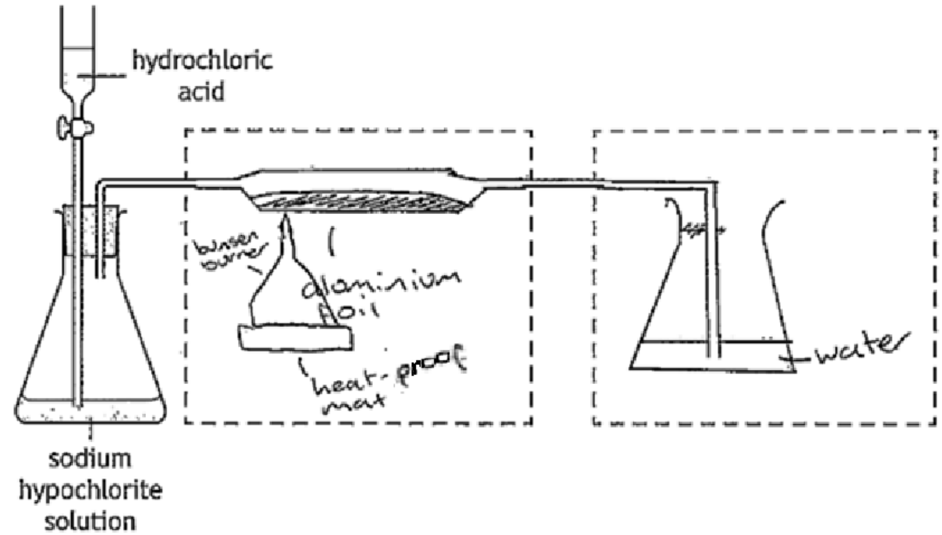
Candidate A



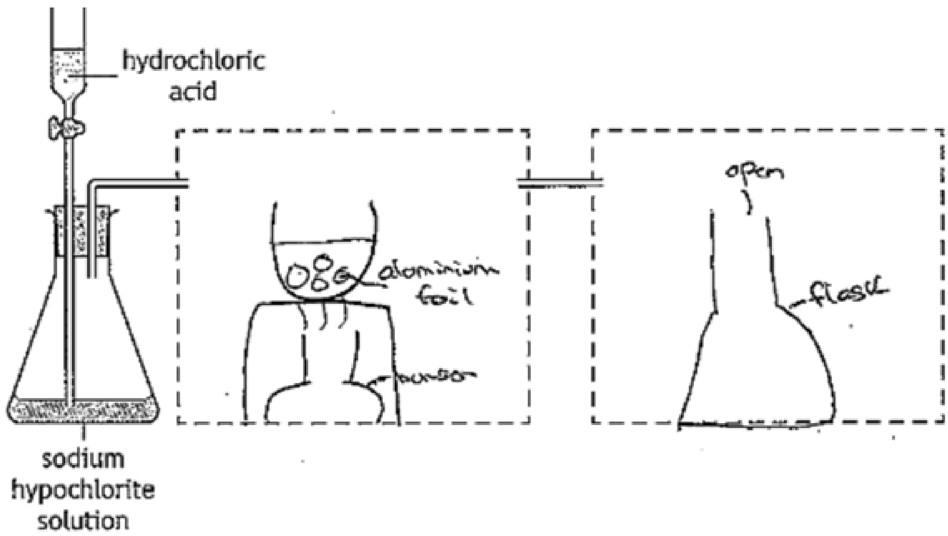
Candidate B



Candidate C



Candidate D



Higher Chemistry – question paper 2018

Question 2 (d) (ii)

(ii) Explain why the aluminium foil needs to be heated at the start of the preparation, despite the reaction being highly exothermic. 1

Higher Chemistry – Course Report 2018

Comments on candidate performance

Many candidates had difficulty explaining why aluminium foil needs to be heated at the start of this reaction.

Candidate A

So that molecules leave the foils in the form of gas.

Candidate B

Aluminium doesnt have the sufficient energy to heat up in ~~[illegible]~~ the oxygen (air) so there for a suitable heating method would have to be used

Candidate C

Aluminium must be heated at the start of the preparation as it needs to be at a high temperature as reactants must have more energy than products for the reaction to be succesfully endothemic

Candidate D

The activation energy needs still to be overcome first to begin.

Higher Chemistry – question paper 2018

Question 3 (c) (ii)

(c) The chemical reaction involved in the experiment is shown.

$C_6H_5COOH(s)$ benzoic acid	+	$CH_3OH(\ell)$	→	$C_6H_5COOCH_3(\ell)$ methyl benzoate	+	X
mass of one mole = 122 g		mass of one mole = 32 g		mass of one mole = 136 g		

(ii) In a laboratory experiment, a student used 5·0 g of benzoic acid and 2·5 g of methanol to produce methyl benzoate.

Explain why benzoic acid is the limiting reactant.

You must include calculations in your answer. **2**

Higher Chemistry – Course Report 2018

Comments on candidate performance

No comment in course report.

Candidate A

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

$n = \frac{5}{122}$

$n = 0.04$

Metanol

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

$n = \frac{2.5}{32}$ 2

$n = 0.078$

$n = 0.08$

$C_6H_5COOH : CH_3OH$

1 : 1

[0.04] : 0.04

0.08 : [0.08]

CH_3OH is excess by 0.04 which makes benzanoic acid the limiting reactant

Candidate B

benzanoic acid

$n = \frac{5}{122} = 0.04$

methanol

$n = \frac{2.5}{32} = 0.07$

molar ratio 1:1

0.04 moles : 0.04 moles

0.04 moles of benzanoic acid reacts with 0.04 moles of Methanol however there are 0.07 moles of ethanol ∴ benzanoic acid is limiting and methanol is in excess, there is not enough benzanoic acid to fully react with methanol

Candidate C

122g : 32g

9.53125 : 2.5g

For 2.5g of methanol to fully react it requires 9.53125g of benzoic acid but there is only 5.0g present so benzoic acid is the limiting reactant.

Candidate D

Benzoic Acid = $n = \frac{m}{gfm} = \frac{5}{122} = 0.041$ moles

Methanol = $n = \frac{m}{gfm} = \frac{2.5}{32} = 0.078$ mols

∴ Benzoic Acid is the limiting reactant

Higher Chemistry – question paper 2018

Question 3 (c) (iii)

(iii) The student produced 3·1 g of methyl benzoate from 5·0 g of benzoic acid. Benzoic acid costs £39·80 for 500 g.

Calculate the cost, in £, of the benzoic acid needed to make 100 g of methyl benzoate using the student's method. **2**

Higher Chemistry – Course Report 2018

Comments on candidate performance

No comment in course report.

Candidate A

3·1 → 5

·1 → 1·61

100 g → 161 g

500 → £39·80

1 g → £0·0796

161 → £12·82

Candidate B

500g → £39·80

1g → $\frac{39 \cdot 8}{500}$

100g → $\frac{39 \cdot 8}{500} \times 100$

= £7·96

Candidate C

~~3.1g ——> 5~~

5g ——> 3.1g

1g ——> 0.62

100g ——> 62g

500 ——> 39.80

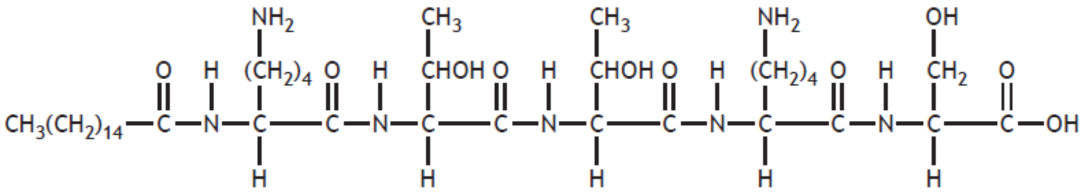
1 ——> 0.0796

62 ——> £4.94

Higher Chemistry – question paper 2018

Question 6 (c) (ii)

(c) Palmitoyl pentapeptide-4 is also used in skin creams.



(ii) Palmitoyl pentapeptide-4 is formed from palmitic acid and three different amino acids.

Molecule	*Number of molecules used to form one molecule of palmitoyl pentapeptide-4*
palmitic acid	1
threonine	2
serine	1
lysine	2

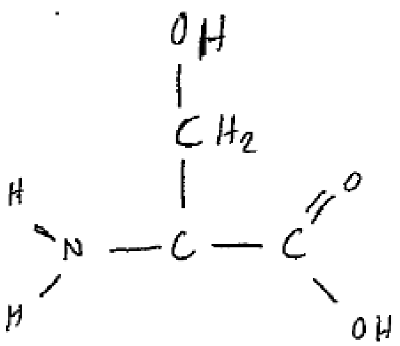
Draw a structural formula for the amino acid serine. **1**

Higher Chemistry – Course Report 2018

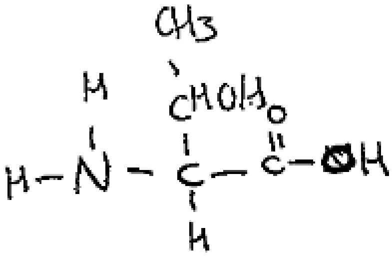
Comments on candidate performance

Question 6 (c) (ii) – Many candidates found it difficult to draw a structural formula for the amino acid serine.

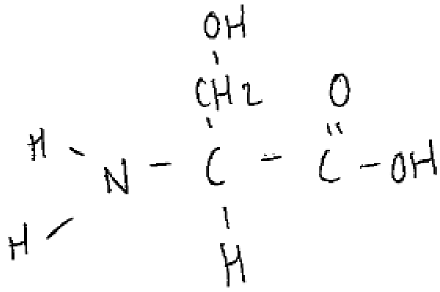
Candidate A



Candidate B



Candidate C



Higher Chemistry – question paper 2018

Question 7 (b) (i)

7. (continued)

(b) (i) Squalene, a triterpene, is included in some flu vaccines to enhance the body's immune response. A single dose of flu vaccine contains 10·69 mg of squalene.

Calculate the mass of squalene required to produce a batch of 500 000 doses of flu vaccine.

Your answer must be given in kg. **2**

Higher Chemistry – Course Report 2018

Comments on candidate performance

Question 7 (b) (i) – Manipulation/conversion of units was done well in this question.

Candidate A

1 dose ⟷ 10·69 mg

k = x10³ 500,000 doses ⟷ $\frac{10\cdot69}{1}$ × 500,000

= 5 345000 mg

m = x10⁻²

= 53450 g

= 53·45 kg

Candidate B

dose
1 → ·10·69
500000 → 5345000
mg mg

mg = 6345000
g = 534500
kg = 534·5

Candidate C

1 dose ⟷ 10·69 mg
500000 doses ⟷ 5345000 mg
= 5345 g
= 5·345 kg.

Candidate D

0.01069kg
10.69mg = 1 dose
x = 500,000

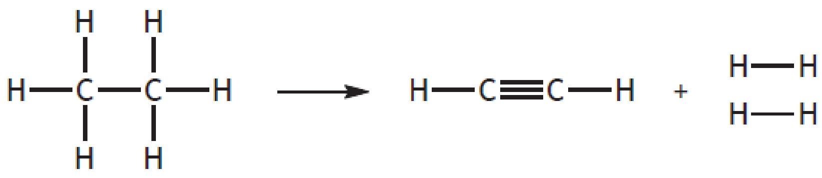
X = 0.01069 × 500,000
x = 5345kg

Higher Chemistry – question paper 2018

Question 8 (a)

(a) The simplest member of the family is ethyne, C_2H_2, used in welding torches.

Ethyne can be produced from ethane.



Using bond enthalpies and mean bond enthalpies from the data book, calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

Higher Chemistry – Course Report 2018

Comments on candidate performance

Question 8 (a), bond enthalpy, and question 8 (b), Hess's Law were well done.

Candidate A

bond breaking

6 C–H = 2472
C–C = 348

bond making

2 H–C = 824
C≡C = 838
2 H–H = 872
– 2552

ΔH = 2820 – 2252
= 568

Candidate B

Bonds broken

H–C ×6 +2472

C–C +348

Bonds made

H–C ×2 −824

C≡C −838

H–H ×2 −872

$\Delta H = 2472 + 348 - 824 - 838 - 872$

$= +286\ kJ\,mol^{-1}$

Candidate C

C–H ×6 = 412 ×6

= 2472

C≡C ×1 = 838

C–H ×2 = 824

H–H ×2 = 872

2534

$\Delta H = 2472 - 2534$

$= -62\ kJ\,mol^{-1}$

Higher Chemistry – question paper 2018

Question 8 (c) (ii)

(ii) The mass of air required to burn 1 g of fuel can be calculated using the relationship shown.

Mass of air, in g = 4·3 × mass of oxygen, in g, for complete combustion of 1 g of fuel

Calculate the mass of air, in g, required to burn 1 g of propyne. **2**

Higher Chemistry – Course Report 2018

Comments on candidate performance

General numeracy calculations set in a chemical context were done well, with the exception of question 8 (c) (ii).

Candidate A

Mass of Oxygen = n × gfm
= 4 × 32
= 128

Mass of air = 128 × 4.3
= 550.4g

Candidate B

$\frac{1}{40}$ = 0.025mol $C_3H_4 \rightarrow 4O_2$
1 → 4
0.025 → 0.1mol

m = n × gfm
= 0.1 × 32
= 3.2g

Candidate C

1mol O_2 = 16
4mol = 64

mass of air = 4·3 × 64
= 275·2g

Higher Chemistry – question paper 2018

Question 9 (c)

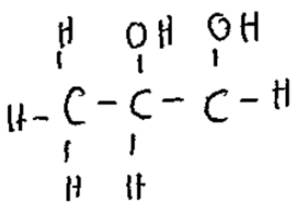
(c) Draw a structural formula for a diol that contains three carbon atoms. **1**

Higher Chemistry – Course Report 2018

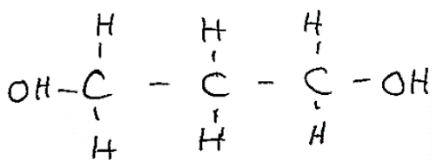
Comments on candidate performance

Question 9 (c) – Many candidates performed well when asked to draw a structural formula of a diol containing three carbon atoms.

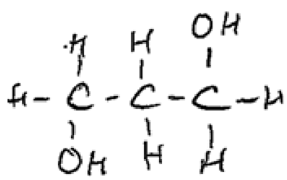
Candidate A



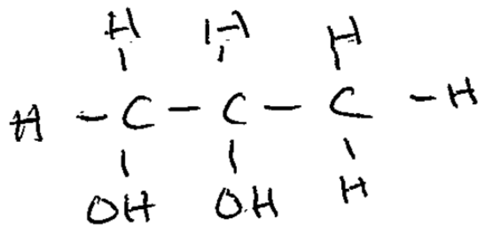
Candidate B



Candidate C



Candidate D



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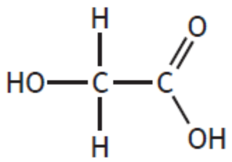
Question 9 (d) (iii) (B)

Ethane-1,2-diol is harmful because it is oxidised in the body to form glycolic acid.



glycolic acid

(B) Glycolic acid can be neutralised by sodium hydroxide to form sodium glycolate.

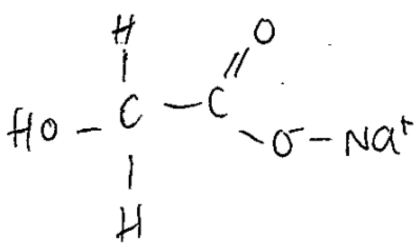
Give a formula for sodium glycolate. **1**

Higher Chemistry – Course Report 2018

Comments on candidate performance

Question 9 (d) (iii) (B) – Many candidates found it difficult to write a formula for sodium glycolate.

Candidate A



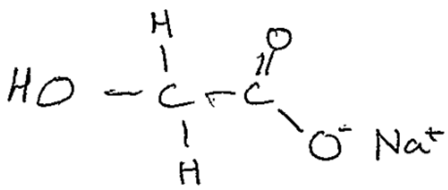
Candidate B

$CH_2(OH)COONa$

Candidate C

$NaC_2H_4O_3$

Candidate D



Higher Chemistry – question paper 2018

Question 11 (c) (ii)

(c) Three samples were prepared as described in **step 2**. Each sample was titrated with 0·0010 mol l^{-1} sodium thiosulfate solution.

The results are shown below.

Sample	*Volume of sodium thiosulfate* (cm^3)
1	10·0
2	9·4
3	9·6

(ii) Calculate the number of moles of iodine released from 50 cm^3 of the standard salt solution. **2**

$$I_2(aq) \quad + \quad 2Na_2S_2O_3(aq) \quad \rightarrow \quad 2NaI(aq) \quad + \quad Na_2S_4O_6(aq)$$

Higher Chemistry – Course Report 2018

Comments on candidate performance

Question 11 (c) (ii) – Many candidates found it difficult to calculate the number of moles of iodine.

Candidates should be encouraged to set working out clearly, as partial credit can be given for correct working.

Candidate A

$$n = \frac{50\ cm^3}{[illegible]^3} \qquad 0{\cdot}05\ L = [illegible]$$

$C = 0{\cdot}0010\ mol\ l^{-1}$

$n = 0{\cdot}0010 \times 0{\cdot}05\ L$ ~~[illegible]~~

$= 0{\cdot}00005$ moles ~~[illegible]~~

$Na_2S_2O_3$

$= 0{\cdot}000025$ moles iodine

Candidate B

$$= \frac{9{\cdot}5}{1000} \times 0{\cdot}0010$$

$=$ ~~[illegible]~~

$= 4{\cdot}75 \times 10^{-6}$; $9{\cdot}5 \times 10^{-6}$

$n = c \times v$

$$c = \frac{n}{v} = \frac{4{\cdot}75 \times 10^{-6}}{\frac{50}{1000}} = 9{\cdot}5 \times 10^{-5}$$

Higher Chemistry – question paper 2018

Question 12 (b) (i)

(b) There are different methods of producing phenol.

(i) In the early 1900s, phenol was produced by the following reaction.

$$C_6H_6 + H_2SO_4 + 2NaOH \rightarrow C_6H_5OH + Na_2SO_3 + 2H_2O$$

benzene: mass of one mole = 78·0 g

phenol: mass of one mole = 94·0 g

Calculate the mass of phenol, in kg, produced from 117 kg of benzene if the percentage yield is 90%. **2**

Higher Chemistry – Course Report 2018

Comments on candidate performance

Question 12 (b) (i) – No comment in course report.

Candidate A

$\frac{117}{0\cdot078} = 1500$

$0\cdot094 \times 1500 = 141$ kg

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

$90\% = \frac{\text{actual}}{141} \times 100$

$0\cdot9 = \frac{\text{actual}}{141}$

$0\cdot9 \times 141 = 126\cdot9$ kg

Candidate B

$m = 117\ kg$
$= 117000g$
$gfm = 78$
$\frac{m}{gfm} = n$
$n = 1500$ moles

→ $n = 1500$ moles
$gfm = 94g$
$n = \frac{m}{gfm}$
$n \times gfm = m$
$m = 141000g$
$= 141kg$

Candidate C

$90\% = \frac{?}{0.141kg}$

~~[illegible]~~
~~[illegible]~~
~~[illegible]~~
$= 0.1269\ kg$

$78g \rightarrow 94g$
$1g \rightarrow 1.205..$
$1kg \rightarrow 0.001205128$
$117kg \rightarrow 0.141kg$

90% of 0.141