Higher Chemistry – Course Report 2018

Comments on candidate performance

Open questions

A significant proportion of candidates did not attempt the open questions; in particular question 10. Candidates would benefit from more opportunities to answer this type of question. Candidates also need to be made aware that there are no definitive answers to open questions. Candidates can give broad answers covering a number of aspects of a question or focus on one particular aspect and give a detailed explanation.

These questions are marked holistically rather than on a number of point's basis (eg 1 point 1 mark; 2 points 2 marks). Marks are assigned according to whether the candidate's answer displays no understanding (0 marks); limited understanding (1 mark); reasonable understanding (2 marks); or good understanding (3 marks). Candidates are not expected to give a perfect answer to gain the full mark allocation for the question.

Higher Chemistry – question paper 2018

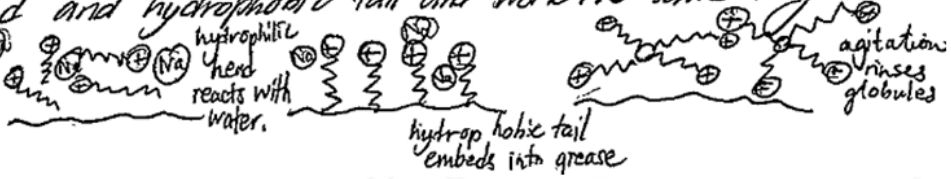
Question 5

Many chemical compounds are related to each other by their structural features, the way they are made and how they are used.

Using your knowledge of chemistry, describe the relationships between fats, oils, detergents, soaps and emulsifiers. **3**

Candidate A

Fats and oils are essential for transportation around our bodies. Fats are saturated and have single C–C bonds which allows maximum LDF between the molecules. Therefore they pack closely together and are solid at room temperature. Oils are unsaturated and have double C=C bonds. They therefore cannot pack as closely together and the LDF is weak between the molecules so they are liquid at room temperature. Soaps are the sodium salt of fatty acids. Soap works in the way that the hydrophilic head is polar so it reacts with the water which is also polar. The tail is hydrophobic so reacts with the grease. The non polar tail embeds itself into the grease as the head reacts with water. This then forms globules with the tails meeting in the middle and the polar heads round the outside. Agitation will then remove the grease. Emulsifiers work in the same way soap does. Emulsifiers are added to mix and stop a layer forming, for example mayonnaise has an emulsifier to prevent a separate layer of oil and water forming. Emulsifiers also have a polar hydrophilic head and hydrophobic tail and work the same way soap does;



Candidate B

Fats are esters

Glycerol is a fat.

Candidate C

Fats & oils are similar to each other in that they both are made up of 3 ester bonds with glycerol and 3 fatty acid chains. However in oils the fatty acid chains all have a 'kink' in them or a C=C.

Emulsifiers are used to keep ~~the~~ two seperate ingredients in food mixed, like mayonnasie for example. They do this because of an ester bond they make.

Detergents and soaps are long non-polar chains with a polar head. They're used to cleanup grease, this is done when the heads of several molecules bung into the ~~grease~~ grease and form a ~~micelle~~ micelle (spelling is defos wrong)

Candidate D

Fats and oils are related through both being part of the diet and having similar ~~form~~ structures except fats are packing in saturates and oils are packing in unsaturates.

Fats and oils are related to soaps, detergents and emulsifiers through soaps being made from fats. Soaps are used to clean grease and oil molecules as they have a polar, hydrophillic head and a non-polar, hydrophobic tail which surrounds oil and grease molecules and allows them to be removed from surfaces.

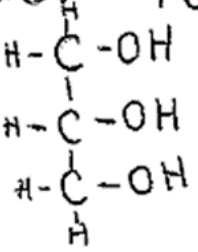
Candidate E

Fats and oils are developed through condensation reactions and are made up of both alcohols and carboxylic acids. The alcohol which forms fats and oils is known as glycerol and then 3 fatty acid molecules have to react with the glycerol to make the final fat or oil. Fats are saturated and so can pack closely together, whereas oils are unsaturated

Soaps are created through reacting a molecule such as sodium hydroxide with a fat or oil to produce a salt of the fatty acid which then becomes useful as a soap. Soaps aid in the cleaning of many products

Emulsifiers are also part of this chain of molecules known as esters. Emulsifiers allow imissible liquids to become missible by provoking water and oil within substances to mix, producing a pure mixture. when all of these molecules ~~are hydrolys~~ undergo hydrolysis Glycerol is always one of the products

Glycerol has a structural formula of



and the ratio of glycerol to fatty acids is 1:3.

Candidate F

Fats + Oils

- In the ester group
- Fats are polar
- Oils are non-polar

detergents + soaps

Candidate G

fats

saturated, closely packed and have high ~~mp~~ melting points.

oils

~~ca~~ unsaturated, loosely packed and have low mpt.

fatty acids from fats can be alkaline hydrolysed to produce glycerol and salt- which is then used to make soaps.

Na/K stearate (soap).

soaps, detergents + emulsifiers

these 3 contain similar structure and work in a similar way. They contain:

Hydrophobic tail	Hydrophillic head
- non polar	-polar
- oil soluble	- water soluble.
- covalent tail	- ionic head.

dirt/grease obsorbed by head/tail + is removed.

emulsifiers prevent emulsion reactions (droplets of one liquid suspended in another).

detergents do NOT produce scum in hard water

Candidate H

- detergents, soaps and emulsifiers all contain a very similar structural formula: hydrophobic tail and a hydrophilic head. This causes a relationship between the detergents and soaps to be identical, shown as they maintain identical cleaning properties.
- fats and oils can be compared as both are ester ~~bonded~~ creations, and both follow a very similar structure. However, fats ~~are~~ are usually at room temperature solids and oils are mainly liquids - this is because fats are more compact and usually are more saturated than oils
- emulsifiers also are almost identical to the structures of detergents and soaps as the emulsifiers ~~contain~~ main are the ~~head of soap~~ hydrophilic head, are soluble in ~~other substances~~ substances other than water. This is used to keep two immiscible liquids together, where as in soap and detergents it is used to split the grease from the plate.

Candidate I

fats and oils are made of glycerol and 3 fatty acids.

Soaps are made when a fat or oil is hydrolysed.

emulsifiers have a similar structure to fats and oils but one or 2 hydroxyl groups has not been reacted with.

They all have a tuning fork shape.

Soaps, deleregents and emulsifiers work in the same way as they have a polar hydrophilic head and a non-polar - hydrophobic tail.

detergents are used in hard water conditions, something soaps can't do.

Candidate J

carboxylic acid & alcohol ~~ester~~ fatty acid

Fats and oils are both products of condensation reaction, they are esters, however, fats are more saturated (less double bonds) and able to pack closer together, oils can't due to kinks caused by double bonds however they are created both by condensation reaction and used in cooking.

Soaps are made by hydrolysis with an alkali of an ester, fats and oils are esters

Detergents are similar, but can lather due to more double bonds,

they both have hydrophobic head and hydrophillic tail

emulsifiers are formed by reacting glycerol w/ 2 fatty acids and not one. this gives them

Higher Chemistry – question paper 2018

Question 10

The molar volume (in units of litres per mole) is the same for all gases at the same temperature and pressure.

Using your knowledge of chemistry, suggest how the molar volume of gases could be measured and compared. Any suitable chemicals and apparatus can be used. Some suggested chemicals and apparatus are given below.

Chemicals	*Apparatus*
hydrochloric acid	gas syringe
zinc	measuring cylinder
magnesium	delivery tube
calcium	stoppers
water	500 cm^3 flask
sodium carbonate	vacuum pump
calcium carbonate	balance
cylinder of hydrogen	burette
cylinder of carbon dioxide	filter funnel

3

Candidate A

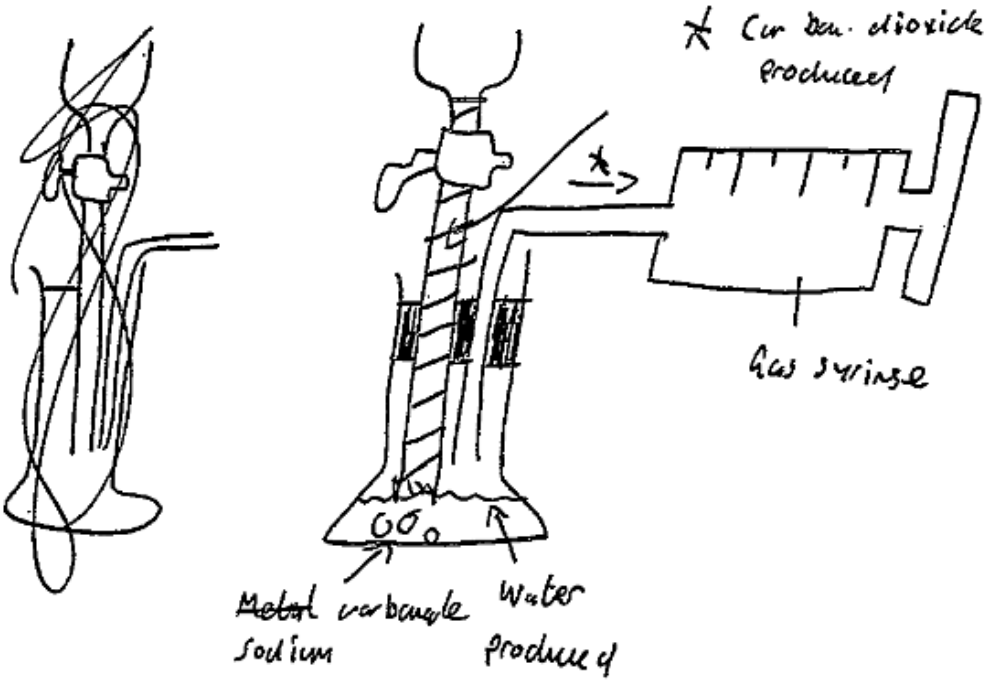
The molar volume of gas can be measured using a measuring cylinder, gas syringe, 500 cm^3 flask or a burette.

For example
To measure the molar volume of a cylinder of nitrogen gas, a delivery tube would be attached to a gas syringe. The delivery tube can also be attached to a measuring cylinder, or a burette. For the delivery tube to be attached to a flask, the flask would need a ~~a~~ stopper to stop gases escaping.

Candidate B

The suggested volume of gas per mole is 24L.

Sodium carbonate and hydrochloric acid can be reacted together. Firstly measure ~~both~~ the volume of hydrochloric acid using a measuring cylinder and the mass of sodium carbonate using a balance. Adding these 2 things will produce sodium chloride (s, aq), carbon dioxide and water. See diagram opposite



Here, the volume of gas produced can be measured using a gas syringe. Using the number of moles previously calculated for the sodium carbonate, ~~we can use mole ratios to compare the number~~ we can calculate the volume in litres of CO_2 produced e.g.:

$$2NaCO_3 + 2HCl \rightarrow 2NaCl + 2CO_2 + H_2O$$

$Na = 1 \times 2 = 2$
$Cl = 1 \times 2 = 2$
$C = 1 \times 2 = 2$
$H = 1 \times 2 = 2$
$O = 6$

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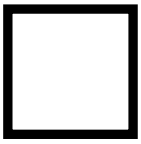
Candidate C

Hydrochloric acid + magnesium ⟶ magnesium chloride + hydrogen

The hydrogen can be collected using a gas syringe to measure how much gas is produced.

A cylinder of nitrogen, hydrogen ~~is~~ OK and carbon dioxide can be collected in a vaccuum pump to measure how much space it can take up.



Candidate D

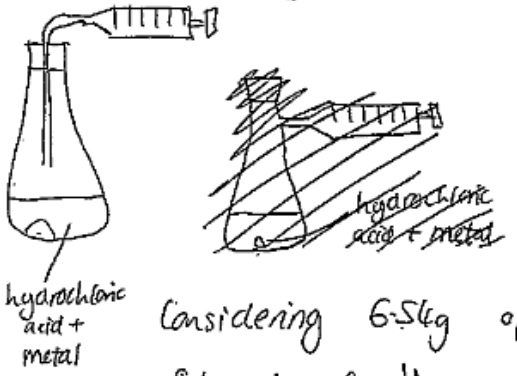
The mass of a gas must first be determined. H_2 has mass 2g per mole. So, firstly, the mass of the gas syringe must be weighed. Then, allow H_2 from the cylinder into the syringe. When it measures 2 g, take a note of the reading. This method can be repeated with all gases, just adjusting such that the mass a reading is taken at is that of 1 mole (44g for CO_2 or 28g for N_2)

For this method to work, the syringe needs to be a vacuum such that molecules in the air don't alter the reading.

Candidate E

$2HCl + Zn \longrightarrow ZnCl_2 + H_2$

Hydrochloric acid reacts with zinc to form zinc chloride and hydrogen gas. This gas could be collected in a gas syringe and measured.



Hydrochloric acid also reacts with magnesium and calcium to form hydrogen gas.
The metal can be measured accurately using a balance.

Considering 6.54g of zinc reacts with excess HCl, 0.1 moles of H_2 will be formed

$n = m/gfm$
$= 6.54/65.4$
$= 0.1$ moles

0.1 moles Zn ⇒ 0.1 mole H_2

Molar volume is calculated by : $V_m = V/n$ so the volume of H_2 gas collected over the number of moles will give the molar volume of H_2.

$2HCl + Na_2CO_3 \longrightarrow 2NaCl + CO_2 + H_2O$

Hydrochloric acid reacts with a metal carbonate to produce a salt, water and CO_2. The CO_2 could be collected in a gas syringe. The number of moles can be calculated as in the previous example. Molar volume is calculated using $V_m = V/n$

With the cylinders of N_2, H_2 and CO_2, the volume can be measured using a gas syringe

the number of moles can be calculated using the density of gases given in the data bodelet.

eg. $100cm^3$ of H_2

density = m/V

$m = 0.00009 \times 100$

$m = 9 \times 10^{-3} g$

$n = m/gfm$

$= 9 \times 10^{-3}/2$

$= 4.5 \times 10^{-3}$ moles

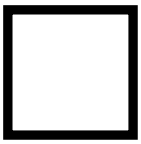
$V_m = V/n$

$V_m = 0.1/4.5 \times 10^{-3}$

$V_m = 22.2 l mol^{-1}$

At the same temperature and pressure, the molar volumes of the gases should all be the same.

Molar volume is usually around $20-24 l mol^{-1}$



Candidate F

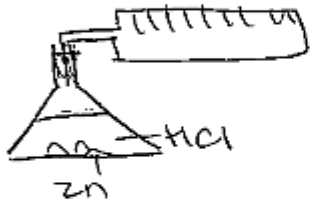
The reaction between zinc and hydrochloric acid can produce H_2 as a gas. To find the molar volume its gas must be measured with a gas syringe (it can also be measured with upturned measuring cylinder). Place the Zn into a conical flask and the hydrochloric acid inside over a water bath at a warm temperature. After heated place a stopper onto the conical flask to prevent the H_2 gas from escaping with a delivery tube to gas syringe so that it could be measured.

The reaction of $CaCO_3$ and oxygen can produce CO_2 as a gas that can be measured in terms of molar gas. In this, case the amount of bubbles can be counted to read the quantity of gas produced. We do this by using the upturned measuring cylinder by placing the $CaCO_3$ in the bottom and ~~[illegible]~~ a delivery tube for the oxygen from the air. By coming the bubbles, the no. of CO_2 gas is now known.

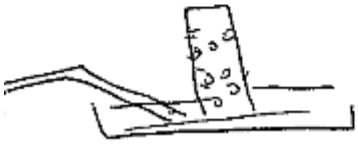
Labelled diagrams

gas syringe:

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$



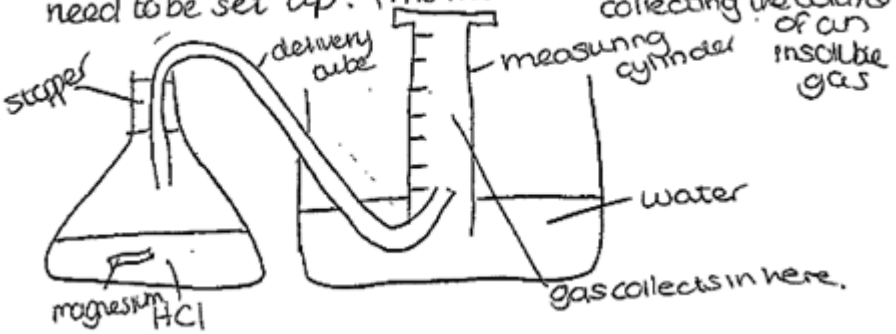
upturned measuring cylinder:



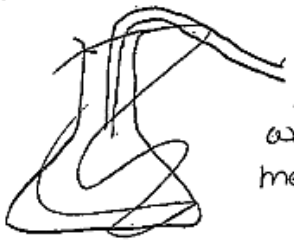
Candidate G

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

To measure the molar volume of gases this equation would need to be used. This divides the volume of the gas by the number of moles. To be able to carry out this calculation we would need to know the volume of the gas and the number of moles. To calculate the number of moles the formula $n = \frac{m}{gfm}$ could be used. To measure the volume of a gas an experiment would need to be set up. This method would work for collecting the volume of an insoluble gas



however to measure the volume of an insoluble gas a different set up must be used, instead of using an inverted measuring cylinder in water a gas syringe must be used instead as if the gas was soluble it would be dissolved in the water and no gas would enter the measuring cylinder.



The number of moles of the gas requires the mass of the gas to be calculated. This is difficult to do as gases are hard to contain and can escape very easily. The easiest way to do so would probably involve weighing a cylinder of the gas using a balance. The gram formula mass of gases are in the data booklet. Both these allow you to calculate number of moles.

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

The number of moles then allows you to calculate the molar volume by dividing the volume of the gas by it.

Candidate H

sodium carbonate	vacuum pump
calcium carbonate	balance
cylinder of nitrogen	cork ring
cylinder of hydrogen	burette
cylinder of carbon dioxide	filter funnel

Magnesium and Zinc can be compared well as they are both metals, with HCl

To test magnesium first you would put magnesium in the HCl and have it in a conical flask with a delivery tube go out over into a tub of water with a measuring cyclinder filled with water and as gas is pumped into it

to make 100 cm^3 of gas

You would then do the same for zinc in HCl and work out molar volume of each using $Vm = \frac{V}{n}$ and compare which metal with HCl made the biggest molar volume gas.